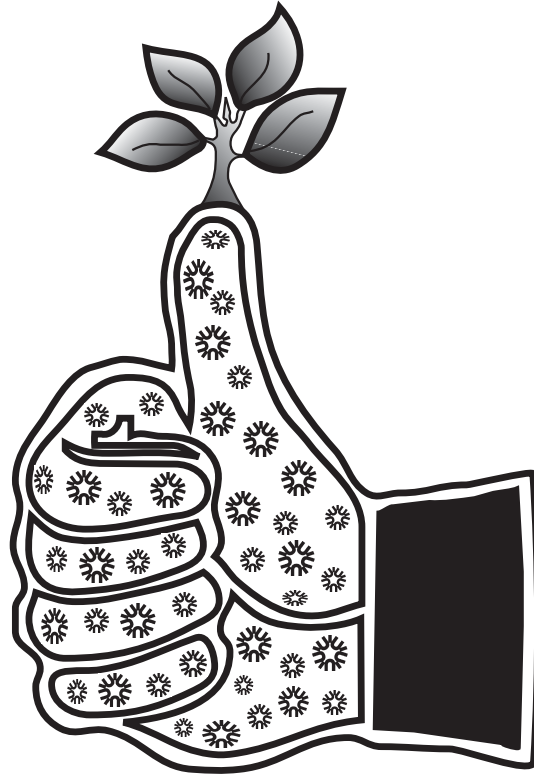

The Idaho

Master Gardener Program

Handbook



IDAHO
master gardener

7th Edition

The University of Idaho Extension's *Idaho Master Gardener Program Handbook* was prepared by a committee of University of Idaho educators:

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Chapter 1

Introduction and Policies



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Introduction and Policies

Idaho Master Gardener Program Guidelines

University of Idaho Extension's Idaho Master Gardener Training Program
Susan M. Bell, Extension Educator, Ada County, Boise

The University of Idaho (UI) Extension's Idaho Master Gardener Program gives gardeners an opportunity not only to improve their horticultural knowledge and skills but also to serve their communities. "Helping people grow" is the motto of the program. University of Idaho Extension (UI Extension) conducts the Idaho Master Gardener Program through participating county offices in Idaho under the direction of UI Extension educators.

I. University of Idaho Extension

UI Extension is an educational resource partnership that extends research and technology to the people of Idaho. UI Extension helps people help themselves by bridging gaps between research and everyday problems.

Mission: The mission of UI Extension is to provide informal educational programs to help Idaho residents improve their economic status and quality of their lives. The UI College of Agricultural and Life Science's mission is to support economic growth and enhance the quality of life for the people of Idaho by: (1) preparing students to be innovative leaders in a global society, (2) helping people improve their lives through research-based education and leadership development focused on issues and needs, and (3) providing new knowledge to support agriculture and enhance the understanding of natural and human resources.

Background: Land-grant universities and UI Extension were developed through three congressional acts:

- The Morrill Act of 1862 created colleges and universities to provide classical, scientific, agricultural, and engineering education.
- The Hatch Act of 1887 expanded the educational mandate of the colleges to include research.

- The Smith-Lever Act of 1914 established Cooperative Extension to provide educational services in all states.

Cooperative Extension is a national educational network designed to extend technical expertise and university research findings to people, which permits them to improve their homes, families, farms, businesses, and communities. Cooperative Extension is the largest and considered the most successful educational organization in the world, and delivers programs that are modeled and duplicated worldwide.

Funding: The word "Cooperative" in the title results from the three-way funding partnership among local, state, and federal governments. In addition, contributions of time, talent, and supplies from volunteers, businesses, and private organizations enable programs such as Idaho Master Gardener to operate.

Personnel: Over 60 county extension faculty, based in 42 county extension offices and the Fort Hall and Coeur d'Alene Indian Reservations, presently serve Idaho. Backed up by subject matter specialists, researchers, and support personnel at 10 research and extension centers and on the UI campus, UI Extension educators deliver programs throughout the state. These professionals work with the people of Idaho to address agricultural, natural resource, youth, family, and environmental issues. Collaborative relationships with countless agencies, groups, and individuals make possible a vast array of innovative educational programs. Idaho Master Gardeners are the second largest volunteer group (4-H is the largest) with which Cooperative Extension works in Idaho.

Idaho Master Gardener Volunteers: In Idaho more than 1,000 experienced Master Gardeners volunteer their time each year, with about 300 new gar-

deners trained annually to be Idaho Master Gardeners. In partnership with the University of Idaho's College of Agricultural and Life Sciences, credit and certificate courses are available to Idaho Master Gardeners across the state.

Administration: Idaho Master Gardener educational programs in Idaho are guided by UI Extension educators from the University of Idaho as part of its land-grant mission in cooperation with the Department of Plant, Soil and Entomological Sciences at the UI's College of Agricultural and Life Sciences.

All extension programs are administered through four extension districts in Idaho: Northern (I), Southwestern (II), Southcentral (III), and Eastern (IV). Many programs are planned at the district level in collaboration with volunteers.

II. Purpose

The UI's Idaho Master Gardener Program is an educational opportunity designed to meet the gardening information needs of the community. The program's purpose is to provide technical assistance and information in the area of home horticulture to people in the community through qualified volunteers: Idaho Master Gardeners.

Applicants receive basic horticultural training on a variety of topics. To become an Idaho Master Gardener, the applicant must complete a minimum of 30 hours of classes and an additional minimum of 30 hours of practicum/hands-on training. Individuals must receive a satisfactory grade on exams or must demonstrate competency for the course content to the satisfaction of the program coordinator. Returning Idaho Master Gardeners may continue their training annually after certification. Many counties offer Advanced Idaho Master Gardener training.

The UI's Idaho Master Gardener Program is based on a philosophy of shared ownership. UI Extension educators, staff, and volunteers share vision, ideas, and responsibilities for the program. However, the ultimate responsibility for the Idaho Master Gardener Program is with UI Extension educators as they are held legally accountable for operation of the program.

III. Volunteer Commitment

The type of hands-on training chosen is based on a mutual decision of the supervising UI Extension educator and the Idaho Master Gardener trainee. At least part of the volunteer hours of service must be

spent at or arranged through the county extension office. Certified Idaho Master Gardeners share their knowledge free with individuals, groups, at schools, or in community service roles but may accept reimbursement for mileage and materials.

IV. Trade-Related Professionals

Industry professionals are welcome to extend or supplement their knowledge and credentials through UI training programs. However, professionals must consider carefully the volunteer commitment to the program. If volunteering is not feasible, reimbursement for training and materials, or in-kind support of the program may be negotiated. Since these are volunteer programs, only a limited number of trade applicants are accepted in any one training session.

It is inappropriate to solicit by any means for personal business or gain at or during University of Idaho Extension volunteer meetings, training sessions, or other functions.

V. Certification and Recertification

The applicant will receive certification upon successful completion of the Idaho Master Gardener classroom instruction, examinations, and hands-on training. Certificates and identification badges that verify program status and satisfactory program completion are provided at the discretion of each county Master Gardener Program. Certification as an Idaho Master Gardener is valid for only one year. When appropriate, recertification for additional years is encouraged through the Advanced Idaho Master Gardener course.

Individuals who completed Master Gardener training in other states and choose to become an Idaho Master Gardener must provide a letter of recommendation from their previous county or state Master Gardener Program coordinator. In addition, they must schedule an entrance interview with the UI Extension educator or program coordinator responsible for the Idaho Master Gardener Program in their county. In the interview they will mutually agree to the necessary training to be certified in an Idaho Master Gardener Program.

VI. Use of Title

The title "Master Gardener" is to be used only and exclusively with University of Idaho Extension's Idaho Master Gardener Program and not for commercial purposes. Persons are expected to iden-

tify themselves as participants in the Idaho Master Gardener Program only when performing volunteer work affiliated with the program. The training, experience, and certification gained in the Idaho Master Gardener Program may be used and listed as qualifications when seeking employment.

VII. Position Description/Application

Each Idaho Master Gardener must complete and sign an Idaho Master Gardener application and opportunity contract (see pages 1-9 and 1-11) before any volunteer work is begun. Read the position description as it outlines the requirements of the position and the methods of supervision.

VIII. Fees

A nominal fee is charged to cover the cost of resource materials and other literature received during Idaho Master Gardener training. Fees may vary from one county to another.

IX. Training Dates and Locations

Contact your local University of Idaho Extension office for specific time, dates, and location for Idaho Master Gardener training.

X. College Credit

This is a certificate program of the University of Idaho. Applicants accepted into the Idaho Master Gardener Program may, for an additional fee, obtain Continuing Education Units (undergraduate or graduate credit) from the University of Idaho College of Agricultural and Life Sciences. Contact the Department of Plant, Soil and Entomological Sciences academic unit through your UI Extension office for more information about this opportunity.

Extra classwork and/or practicum work may be required for a satisfactory grade. Ask your county's Idaho Master Gardener Program coordinator.

XI. Impact and Accountability

UI Extension needs to know what you have done as an Idaho Master Gardener in order to give you credit for your volunteer service and measure the effectiveness of the program. Use the Volunteer Activity Record (see page 1-13) to keep track on an ongoing basis of your volunteer contribution of hours, activities, and contacts. "Hours" is the total number of volunteer hours you have spent on Idaho Master Gardener activities. "Contacts" refers to the number of people you assist as a volunteer.

XII. Liability Insurance

Only authorized volunteers are entitled to the protection of the University of Idaho's liability insurance program. Authorized volunteers are persons who have been asked to perform a specific function by a UI employee with the authority to recruit assistance. The volunteer is then protected only while acting within the scope and course of this authorized volunteer service.

To ensure that the liability insurance program will respond to a claim against an alleged volunteer, it is absolutely essential that the university be able to document that the person was, in fact, appropriately authorized and acting within the scope and course of the requested service. To ensure documentation of all bonafide authorized volunteers, please follow these procedures:

1. Make sure a job description is on file for each Idaho Master Gardener volunteer; the job description should include whether the volunteer will be driving UI vehicles while performing job duties. Identify the person to which each volunteer position reports, and identify whether the individual in that position is a UI employee or another volunteer.
2. Volunteers, other than Idaho Master Gardeners, recruited individually by a UI volunteer or employee for specific individual tasks must have an individual agreement or letter of authorization from the UI employee to be covered by liability protection.
3. Keep a list of names and positions for authorized volunteers recruited, individually or in a group, by another volunteer authorized to recruit. Have both the volunteers who recruited them, as well as the UI employee in charge of the project, sign the list. Be sure that the job descriptions for any volunteers authorized to recruit others indicate that authority.

The purpose of all this is to have a clearly documentable chain identifying who was recruited, by whom they were recruited, and what they were recruited to do.

XIII. Workers' Compensation Insurance

Workers' compensation insurance is provided by the Idaho State Insurance Fund for authorized volunteers in public employment.

The definition of a volunteer for purposes of workers' compensation insurance is an authorized

person approved by a UI department head who is under the direction and control of that UI person in the performance of volunteer duties. A roster of volunteer person's names, including dates and hours of volunteer work, must be maintained by the UI department in order for workers' compensation insurance to be in effect.

XIV. Information Is Important

Whether through phone calls, home visits, plant clinics, presentations, newsletters, emails, websites, or other efforts, the information given out by Idaho Master Gardener volunteers must be unbiased and research-based; it must be accurate, current, and when possible taken from University of Idaho College of Agricultural and Life Sciences publications and research. Our mandated focus and emphasis is to extend the information being developed at the University of Idaho or other land-grant universities to the people of Idaho.

Use the UI horticultural publications listed in this manual. They are available from your county's UI Extension office, or write Publications, University of Idaho, Moscow, Idaho 83844-2240, call (208) 885-7982, fax (208) 885-4648, or email calspubs@uidaho.edu. You can also check, and in some cases download, the online publication and video catalog on the UI Educational Communications website (<http://info.ag.uidaho.edu>).

XV. Recommendations

Idaho Master Gardeners are asked to use tact and give constructive advice when advising home gardeners. Best results come from guiding people in their decisions. In each case please give biological, cultural, and chemical options for pest management. Then encourage the clientele to choose the best option for themselves. Often there is more than one solution to a pest problem.

Because we are the research-based division of the university, it is sometimes necessary for Idaho Master Gardeners to do the research on specific pest concerns. Always check a minimum of three sources that agree before giving out advice. Be sure of your recommendation before you give it!

UI Extension's Idaho Master Gardeners make recommendations only in the areas of home horticulture, home vegetable and fruit culture, ornamentals, turf, and tree and landscape care. They are not expected to make recommendations in areas for

which they are not qualified. Questions concerning the commercial green industry or commercial farm crops should be referred to the county's UI Extension educator.

When it is necessary to make recommendations that include the use of chemicals (insecticides, herbicides, and fungicides), Idaho Master Gardeners should follow published product labels and/or UI recommendations. Cultural problems not specifically covered by UI recommendations may be handled by suggesting treatments that an experienced Idaho Master Gardener considers appropriate. Refer questions about commercial pest control to the county's UI Extension educator.

XVI. Volunteer Service Opportunities

Idaho Master Gardeners assist in many areas of the community through demonstration gardens, horticulture classes, landscape design, information booths, and at the UI Extension office. Below is a sample list of some practicum opportunities in which Idaho Master Gardeners are involved.

- Presenting educational programs/demonstrations on gardening to adults.
- Helping at gardening education events: workshops, clinics, trade shows.
- Presenting gardening classes to school youth.
- Working at 4-H plant science events or training sessions.
- Staffing information booths at fairs, field days, and horticultural education events.
- Helping teach Idaho Master Gardener classes.
- Reading gardening articles and summarizing them for Idaho Master Gardeners and faculty.
- Writing newsletters and information sheets on gardening.
- Maintaining a website for the county's Idaho Master Gardener Program.
- Organizing Idaho Master Gardener plant clinics.
- Making garden or landscape site visits.
- Organizing community service projects related to gardening, including landscape design and maintenance.
- Organizing an Idaho Master Gardener mentoring program for your county.
- Filing, helping with bulk mailings, and working at the UI Extension office.
- Answering garden calls at your home or at your county's UI Extension office.

XVII. Volunteer Guidelines

Idaho Master Gardeners represent the University of Idaho. Accurate and quality work is expected. These guidelines are basic for any professional, whether volunteer or paid.

1. Be punctual, trustworthy, and reliable! Follow through with your commitments and responsibilities. Call if you will be delayed or cannot be there.
2. Maintain a friendly, warm, courteous attitude toward the public.
3. Communicate effectively with clients, staff, fellow volunteers, and faculty. Be a capable and positive team member.
4. Be cooperative with the volunteers of other Extension volunteer programs. We are all on the same team.
5. If you have not received enough information about your volunteer assignment, take the time to ask more questions before beginning a task.
6. Accuracy is important and greatly appreciated.
7. Dress appropriately for the volunteer activity in which you are involved.
8. Be sure to make your child care arrangements for the time you have committed to work as a volunteer. In some cases, it is not appropriate for safety or security reasons to bring children to certain events or activities.
9. Follow UI Extension affirmative action policies, which forbid discrimination against anyone because of their race, color, gender, national origin, religion, age, or disability.
10. Enjoy your volunteer time. Volunteering is rewarding and satisfying.

XVIII. Termination of Volunteer Services

You are a representative of University of Idaho Extension and as such have agreed to abide by its policies and expectations. If your behavior is not acceptable or not in the best interests of UI Extension, the volunteer program, or our clientele you may be reprimanded or asked to leave the program.

The following behaviors observed at or on the premises of any program or function, or while you are acting as a UI Extension volunteer, will not be tolerated:

- Criminal acts
- Profanity

- Illegal or inappropriate use of mind-altering substances (alcohol or drugs)
- Harassment
- Discrimination
- Abuse of any kind toward a fellow human

The above actions may constitute cause for disciplinary action or immediate dismissal.

XIX. Master Gardeners in Other Counties, States, and Countries

The Idaho Master Gardener Program is now operating in over 20 Idaho counties. Some counties accept and train Master Gardeners from other counties. Those Master Gardeners who are trained in Idaho return their time in the counties where they are trained or by arrangement with the UI Extension educator in the county where they reside. Before out-of-county applicants are accepted into an Idaho Master Gardener Program, the UI Extension office in your resident county is contacted and arrangements are made concerning the administration of your volunteer activities. It is important to recognize that each county program is different and has different resources available to implement the program.

As an Idaho Master Gardener you will be on the county's Idaho Master Gardener mailing list and will receive all the mailings for one year after completion of your training. You will continue to receive these mailings as long as you recertify and remain active. You are invited to all functions, activities, and educational programs as well.

Every two years there is an International Master Gardener Conference. You are eligible to join the national and international Master Gardener organizations as a certified Idaho Master Gardener. Usually in even years a Western Regional Master Gardener Conference is held, which is a source of great ideas to bring back to your communities. Take advantage of these opportunities and ask at your UI Extension office for conference information.

XX. Volunteer Benefits

As a UI Extension Idaho Master Gardener volunteer, you have many benefits. One major benefit is becoming part of a national volunteer network. Whether you live in Idaho or in another part of the country, you are part of UI Extension as a volunteer. You have use of the resources of the system and can be a resource to others.

This networking benefit includes your fellow Idaho Master Gardeners and the faculty and research facilities at the University of Idaho. You are welcome on campus. Tours of plant science facilities and all the research and extension centers can be arranged.

This networking benefit also includes other volunteers such as 4-H Leaders, Master Food Preservers, Master Clothing Teachers, and commodity groups. Another benefit is reduced prices or free admittance to seminars, classes, and workshops that need volunteer help.

Idaho Master Gardener volunteers benefit by increasing leadership, organizational, decision making, and problem solving skills. Experienced volunteers report that they have made lasting friendships, increased their public relation skills, become more effective at work or home, and have been well prepared for new employment or other volunteer opportunities.

UI Extension faculty and staff benefit by acquiring fresh, new ideas and gaining satisfaction from reaching more people through volunteer efforts. They gain an increased understanding of the community and clientele, while achieving greater influence and increasing their own confidence in programs such as the Idaho Master Gardener training.

And, last but not least, there are certain tax benefits to volunteers who itemize state and federal income tax returns. Since these may change annually, you will need to update what kinds of expenses are deductible and what are not.

XXI. You Are Important

Each volunteer is vital to the success of our program—no matter what kind of volunteer work you do. There is no such thing as a small or unimportant

job. You bring skills that are unique and special, that really add to the educational effort in your area. You are a valuable part of our team.

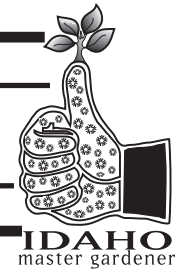
Each year counties try to recognize the special things you do. Your name badge is recognition of your educational accomplishment. Wear it with pride. You are important to us!

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Idaho Master Gardener Program

Position Description



Purpose of the Idaho Master Gardener Program

To extend horticultural education through trained and certified volunteers.

Brief Description of Idaho Master Gardener Responsibilities

Volunteers answer questions in person and over the telephone about vegetable gardening, fruit trees, ornamentals, lawns, insects, and other related home horticultural topics. They also assist with public horticultural projects in the community. Volunteers may assist in the preparation of home horticulture classes.

Requirements

- Applicant should have an interest and some knowledge or skills in basic gardening, ornamental horticulture, or general plant-related topics.
- Applicant should be able to communicate effectively with the public.
- Applicant must be available to participate in the Idaho Master Gardener classroom training (a minimum of 30 hours).
- Applicant must be available to complete an additional (minimum of 30 hours) of hands-on practicum training during the spring and summer (April through September). At least part of this hands-on training must be spent at the UI Extension office.
- Applicant is responsible to the UI Extension educator-in-charge of the Idaho Master Gardener Program. All outside project work must be approved first with the educator-in-charge to receive Idaho Master Gardener credit.
- Applicant must follow University of Idaho horticultural recommendations and cooperate with the county's UI Extension staff.
- Applicant must meet all requirements for certification.

Supervision

- The UI Extension educator-in-charge of the Idaho Master Gardener Program provides supervision and educational support to the volunteer Idaho Master Gardener.
- The UI Extension educator will assign, review, and assess hands-on practicum work for the Idaho Master Gardener trainee, or advanced volunteer.
- The UI Extension educator will provide in-service training, furnish space, and other needed support materials when the Idaho Master Gardener volunteer works in the UI Extension office.

Idaho Master Gardener Program

Application



I would like to be considered for University of Idaho Extension’s Idaho Master Gardener Training Program. I understand that if accepted into the Idaho Master Gardener Program, I am required to complete a minimum of 60 hours of training (30 classroom and 30 hands-on). This training must be completed by October 1 of the current year unless prearranged with the UI Extension educator in charge.

Participants not able to complete 30 hours of volunteer service should not sign up for the Idaho Master Gardener Program.

Name (please print) _____ Date _____

Address _____ Zip _____

Phone (day) _____ Phone (evening) _____

Signature _____ Date _____

How did you learn about the UI Extension Idaho Master Gardener Program?

Years of gardening experience? _____ Where else have you gardened before moving here?

Have you ever been in a Master Gardener Program in Idaho or another state? Yes No

If yes, indicate where and year(s).

Please list all horticultural schooling you have received (school, topics, and dates, if possible).

Please list your areas of specialization or interest (vegetables, roses, greenhouse, herbs, etc.).

Are you affiliated with any gardening clubs or horticulture-related groups? If so, please list.

(continued)

Why do you wish to become an Idaho Master Gardener?

What do you expect from this class?

How might you use your volunteer time to help others in the community?

How would you rate your “people skills” (ability to work with others)?

Excellent Good Fair

How would you rate your gardening skills?

Expert Intermediate Beginner

Are you knowledgeable in growing any of the following? Please check.

House plants Herbs Turf
 Vegetables Annual flowers Shrubs
 Tree fruits Perennial flowers Ground covers
 Berries Ornamental trees Other (specify) _____

How do you receive garden information? Please check.

Garden magazines Nursery/garden center personnel Family/friends/neighbors
 Newspaper articles University/college professors Garden clubs
 Extension bulletins Extension office staff Master Gardeners at extension office
 TV/cable stations Radio stations Garden websites/computer programs

Are you employed now? Yes No Full-time? Part-time?

Are you retired? Yes No Semi-retired? Yes No

Check the skills you are good at:

Public speaking Artistic
 Teaching Photography
 Writing Manual labor
 Computing/webmaster Marketing/media work
 Typing, filing Other (specify) _____

I would like to take this class for Academic credit (+ fee)
 Continuing Education Units (CEU + fee)

Return this form to the

University of Idaho Extension Office

in your county

Chapter 1, The Idaho Master Gardener Program Handbook

Idaho Master Gardener Program

Opportunity Contract



Return this form to the UI Extension Office in your county.

I wish to become a University of Idaho Extension Idaho Master Gardener. I understand I must complete the classroom instruction, finish all quizzes and exams, complete all lab work, and complete volunteer hands-on training to become certified. I realize that part of my hands-on training hours must be spent at the UI Extension office. I also understand that I can sign up for more than one hands-on project and volunteer more than the required number of hours.

If I am accepted as an Idaho Master Gardener trainee, I will abide by all regulations and recommendations of University of Idaho Extension. I agree to give University of Idaho pest control recommendations even if they include synthetic chemical pesticides.

I understand that as an Idaho Master Gardener, I am considered a volunteer representative of the University of Idaho. Therefore, the University of Idaho will assume liability for my pest control recommendations, but **only** if my recommendations are limited to control measures that are approved by the University of Idaho for home and garden use and listed in UI Extension publications.

Signature _____ Date _____

Name (please print) _____

Address _____ Zip _____

Phone (day) _____ (evening) _____

Hands-on Horticultural Service

All Idaho Master Gardeners are required to sign up for one or more days per week of volunteer service at the UI Extension office in the spring and summer. Indicate the days and months that are convenient for you. You will be contacted for specific dates. You can complete your volunteer service as quickly as you desire.

| Month | Monday | Tuesday | Wednesday | Thursday | Friday | Sat/Sun |
|-----------|--------|---------|-----------|----------|--------|---------|
| April | | | | | | |
| May | | | | | | |
| June | | | | | | |
| July | | | | | | |
| August | | | | | | |
| September | | | | | | |
| October | | | | | | |

My schedule is flexible. I can be available almost anytime with advance notice.

(continued)

Select several project areas of interest to you.

Plant Clinic

- Plant clinic (identifying plant problems)

Garden Projects

- City beautification
- 4-H/youth garden projects
- Weed/insect collection
- Demonstration garden
- Senior citizen garden project

Support Activities

- Artwork, calligraphy
- Photo album, photography

Communications/Writing

- Garden newsletter articles
- Newspaper articles
- Publicity for Master Gardener Program

Landscape Design/Maintenance

- Extension office landscape
- Other landscapes (must be approved by the Master Gardener coordinator)

Speaker's Bureau

- Speaker/presenter (topic): _____

-
- For youth groups only
 - For adult groups only
 - Audience make-up is not crucial

Special Events

- Information booths
- Fund raising events
- Garden tours

Office Assistance

- Filing/organizing paperwork
- Typing, mailing, stapling, collating
- Telephone answering

Other

- Special project (topic): _____

Return this form to the

University of Idaho Extension Office

in your county



Volunteer Activity Record

Name _____ Date _____

For program year _____ Ending _____

Check one: 4-H Leader Master Gardener Livestock Master Master Food Preserver

| What You Did And When | | | Number of Contacts Made | | | | | | | | | |
|-----------------------|------------------------|--------------|-------------------------|--------|-------|-------|----|---|---|---|---|----|
| Date | Summary of Activity | Hours Earned | Male | Female | Adult | Youth | W | N | H | A | B | HC |
| 4/16/99 | Vegetable Presentation | 6 | 12 | 18 | 29 | 1 | 25 | 1 | 2 | 1 | 1 | 2 |
| 4/22/99 | Plant Clinic | 8 | 5 | 3 | 8 | | 8 | | | | | |
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Codes: W= Caucasian N = Native American H = Hispanic B = Black HC = Handicapped A = Asian

If you need help filling out this form, please ask!
 Please complete this Volunteer Activity Record each year of volunteer service and turn it into your University of Idaho Extension Office as directed by your program coordinator or UI Extension educator. Please record specific accomplishments that you are most proud of on the back of this sheet. Time to toot your own horn...let us know what you have done for your community!

Idaho Master Gardener Program

Tax Records for Volunteer Service



This certifies recognition of the volunteer service performed within UI's Idaho Master Gardener program.

— UI Master Gardener —

Idaho Master Gardeners receive training from UI educators in solving and giving advice on yard, garden, and houseplant problems. Volunteer service within the UI program is performed by Idaho Master Gardeners in various ways (e.g., Master Gardener clinics, assistance in a county extension office, speaking to groups, plant problem consultations by telephone, and other methods arranged with UI Extension staff members).

Charlotte V. Eberlein, Director
University of Idaho Extension

Directions for claiming deductions: List the amount you claim as a deduction in Schedule A under "Contributions" (other than cash). This statement certifies that you have performed volunteer service. File this statement with your records. You should also keep a record of when and where your service was performed. Keep a record of mileage (read tax instructions to determine how many cents per mile is allowed). You may also list supplies you purchased and used within the Idaho Master Gardener program. Keep this information with your records to verify your deductions in case your tax return is audited.



University of Idaho Extension helps people develop their leadership skills and use research-based knowledge to improve their economic status and quality of life.

Helping People Grow.

Chapter
Basic Botany

2



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Chapter 2

Basic Botany



J. A. Robbins and S. M. Bell

JoAnn Robbins, Extension Educator, Jerome County

Susan M. Bell, Extension Educator, Ada County

I. Divisions of Plant Sciences

Plant science embraces several plant-related sciences:

- *Agriculture* is the study of plants in relation to field crop production.
- *Agronomy* is the science of crop management and includes the study of soils.
- *Horticulture* is the science of growing fruits, vegetables, flowers, and other ornamental plants.
- *Botany* is the science that studies all phases of plant life and growth.

A thorough understanding of botany is necessary to understand the other plant sciences. Master Gardeners need botanical knowledge in order to use correct terminology when referring to plant parts and plant identification and to understand why and how plants live, grow, and respond to their environment.

II. Divisions of Botany

The science of botany has many subject areas:

- *Plant physiology* deals with the functioning, their mechanisms of response, and the physical and biochemical processes of plants.
- *Morphology* deals with the origin and function of plant parts while *anatomy* considers plant structures.
- *Taxonomy* deals with plant classification and naming.
- *Plant ecology* is the study of the complex relationships of plants in biological communities.
- *Plant geography* studies the distribution of plants throughout the world.
- *Plant pathology* is the study of plant diseases.

III. Plant Classification

Plant classification and the scientific naming of plants help us identify plants exactly. The plant classification system groups plants with similar characteristics together and then creates sub-groups with more similar characteristics. Within those sub-groups more subdivisions or groupings are made by getting even more specific. This process continues until a single plant with unique characteristics is named.

A. Plant Groups and Sub-Groups:

1. Kingdom (plants)
2. Division (seed plants, non-seed plants)
3. Sub-divisions (angiosperms, gymnosperms)
4. Class (monocot, dicot)
5. Order (a large group of like individuals)
6. Family
7. Genus
8. Species
9. Variety or cultivar

Master Gardeners usually work with the classification of plants at the family level and below. The common names of plants are often not precise enough to identify them exactly. Sometimes a common name refers to two or more entirely different plants. Only scientific nomenclature allows an exact understanding of which plant is being discussed.

B. Family

In a family of plants, similarities occur primarily among its members' flowers but also leaves and other plant parts. For example, the rose family, Rosaceae, includes members of the genera *Rosa* (rose), *Malus* (apple), *Prunus* (plum), *Fragaria* (strawberry), and many others. They all have similar flowers with five

petals and many stamens. Some other large families are Asteraceae (sunflowers), Ranunculaceae (buttercup), Poaceae (grasses), and Fabaceae (pea and bean family).

C. Genus

Genus is a subdivision of family and the plants of the same genus share similarities mostly in flower characteristics and genetics. Plants in one genus usually cannot breed with plants in another genus.

D. Species

Species is a group of individual plants interbreeding freely and having many (or all) characteristics in common.

E. Variety, Cultivar, and Hybrid

1. Variety

A plant growing in the wild within a species that is different in some particular characteristic from other members of that species. A variety, when grown from seed, will maintain all of its particular characteristics.

2. Cultivar

This word is a contraction of *cultivated variety*. Propagation of cultivars results in little or no genetic change in the offspring, which preserves desirable characteristics. If propagated asexually or vegetatively, cultivars are termed clones, and if propagated by seeds they are termed lines. Seeds of clones will not produce plants with the same desirable characteristics as the cultivar. Cultivars are generally selected by botanists and horticulturists and maintained under cultivation.

3. Hybrid

A hybrid results from a cross between two different species or well-marked varieties within a species. Hybrids grown in a garden situation will not breed true-to-form from their own seed. For example, supersweet hybrid corn cannot be reproduced by saving seed from this year's crop. The seed will produce a different type or several different types of corn, but none will have all the characteristics of the original hybrid plants.

F. Nomenclature

1. As an example, the complete classification of the Black Chokecherry is:

| | |
|---------------|--------------------|
| Kingdom: | Planta |
| Division: | Spermatophyta |
| Sub-division: | Angiospermae |
| Class: | Dicotyledonae |
| Order: | Rosales |
| Family: | Rosaceae |
| Genus: | <i>Prunus</i> |
| Species: | <i>virginiana</i> |
| Variety: | <i>melanocarpa</i> |

The genus, species, and variety names appear either in italics or underlined. The first letter of the genus name is capitalized; but the species and variety are written in all lower case letters.

2. Cultivars are indicated by placing the cultivar name in single quotation marks or by preceding the cultivar name with the abbreviation *cv.* (do not use both). The first letter of the cultivar name is capitalized, but the name is not italicized or underlined. An example is the Colorado blue spruce, *Picea pungens* 'Glauca' or *Picea pungens cv.* Glauca.
3. Hybrids created intentionally, or by crossing in nature (natural interbreeding), are designated with an "x" between the genus and species. An example is *Forsythia x intermedia*, which is a cross between *F. suspensa* and *F. viridissima*.
4. A binomial name is a plant's genus and species and may be followed by the initial of the authority for describing and naming the plant. For example, *Solanum tuberosum* L. indicates that Carl von Linne (Linnaeus), a Swedish physician, described and named the white (Irish) potato. Linnaeus proposed a system of nomenclature for plants in 1732 based primarily on flowers and/or reproductive parts. This system has persisted to the present day.

IV. Plant Classification According to Life Cycle

Plants are also classified by life cycle (e.g., how long it takes a plant to develop from a seed to a flowering plant).

A. Annuals

Annuals are plants that grow, mature, flower, produce seed, and die all in one season. Zinnias are annual plants. They complete their life cycle in one year.

B. Biennials

Biennials take 2 years or a part of 2 years to complete their life cycle. During the first season, biennials grow as a vegetative plant that overwinters as a hardy rosette of basal leaves. During the second season, the plant flowers, produces seeds, and then dies. Parsley is an example of a biennial plant.

C. Perennials

Perennials live for more than 2 years. Herbaceous perennials have soft, non-woody stems while woody perennials have woody stems. Woody perennials can either keep their leaves through the winter (evergreen) or lose them and grow new leaves in the spring (deciduous). Tender perennials die back each winter and a new plant grows from the roots each spring.

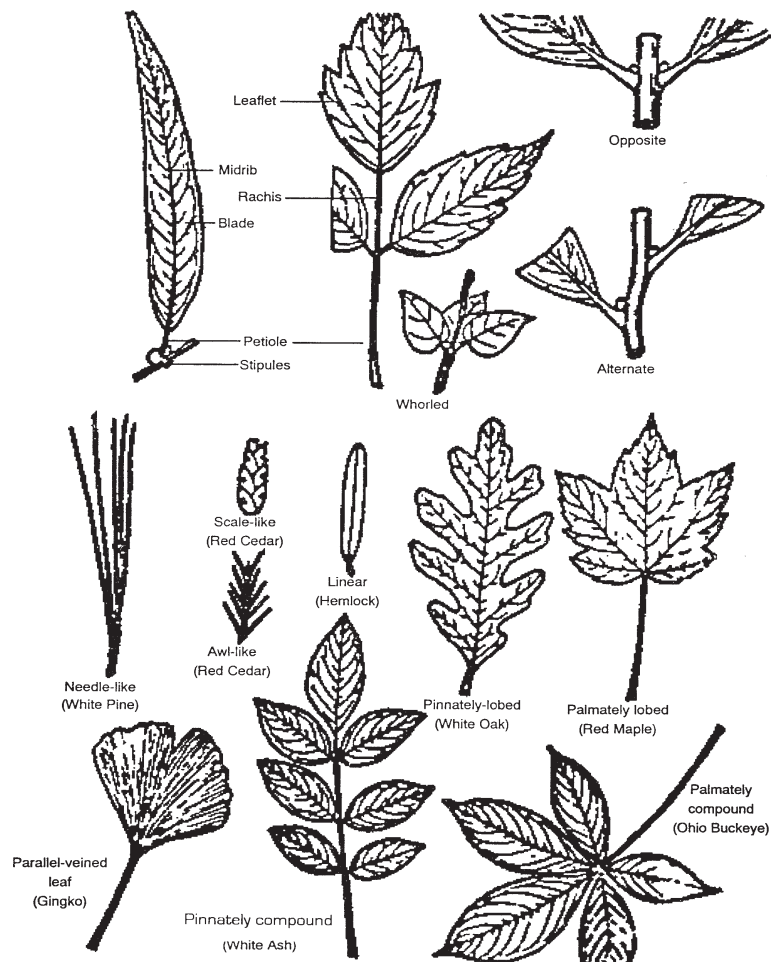


Fig. 1. Parts, types, and positions of leaves.

V. Plant Parts and Their Functions

A. Vegetative Parts

1. Leaves—Leaves are the photosynthetic (food manufacturing) organs that produce carbohydrates to provide energy for the plant to live and grow. Leaves are also a site of respiration, which is the process by which carbohydrates are converted into energy. Another function of leaves is transpiration, or the loss of water as vapor. Transpiration helps to regulate leaf temperature and helps to carry water up the plant from the roots.

- a. Parts of a leaf: Leaf parts include the *blade*, the flat thin part, and the *petiole*, which attaches the blade to the stem. The pattern of attachment of leaves to the stem is *opposite*, *alternate*, or *whorled*. Leaf arrangement is an identifying feature of plants. There are two common leaf classifications: *simple*, a single leaf, or *compound*, a leaf with two or more leaflets (Fig. 1). Leaf shapes, edges (margins), tips, bases, and vein patterns also have specific terminology used to describe these characteristics (Fig. 2).

- b. Leaf structure: Several layers of cells make up the leaf blade. The outer cell layers on top and bottom are the *epidermis*. They serve as protection for the inner leaf tissue. Some plants have hairs called *trichomes* that are extensions of the epidermal cells. A waxy layer on the epidermis is called the *cuticle*. It protects the leaf from dehydration and prevents penetration of some disease-causing organisms (Fig. 3).

Specialized epidermal cells on the undersides (and sometimes upper sides) of leaves form *stomata*, or openings into the leaf (singular of stomata is stoma). Cells on either side of each stomate are called *guard cells*. They swell to open the stomate or shrink to close it. Conditions that promote large water losses from

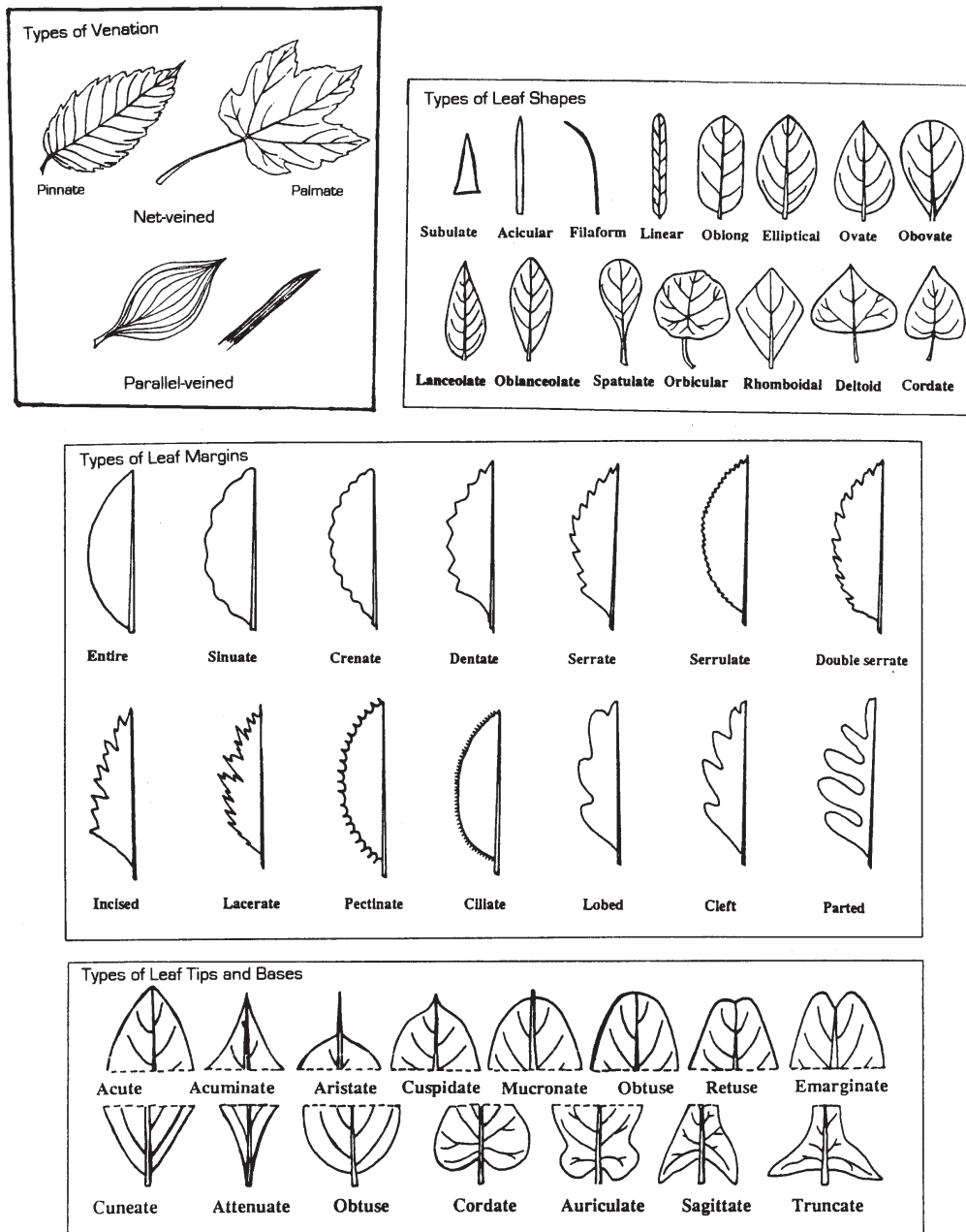


Fig. 2. Terminology describing leaf characteristics.

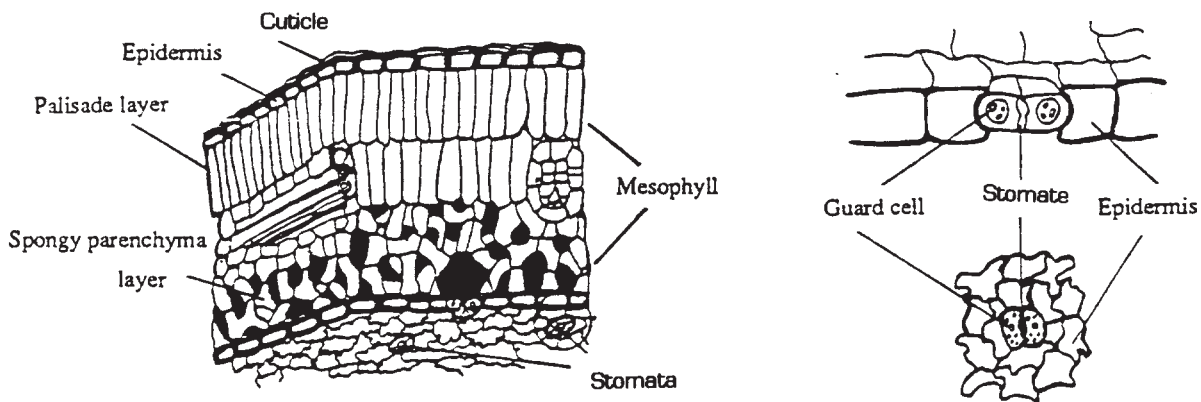


Fig. 3. Leaf structure.

plants (high temperature, wind, and low humidity) cause the guard cells to close. Open stomata also allow the exchange of carbon dioxide and oxygen between the air inside and outside of the leaf.

In between the epidermis layers is the *mesophyll* where photosynthesis occurs. The *palisade* layer of cells is the upper layer of the mesophyll, and the lower layer is the *spongy parenchyma*. Inside the mesophyll cells are the *chloroplasts* where actual photosynthesis occurs.

Vascular bundles, that transport water, nutrients, and sugars to and from the leaf, enter the leaf through the petiole and spread throughout the blade. Their distribution determines the *venation* or the pattern of veins in the leaves. The principle vein patterns are parallel veins found in the monocotyledon group, and net veins found in the dicotyledon group (Fig. 2).

- c. Functions of the leaf: The leaf is the primary site of photosynthesis in most plants (Fig. 4). Plants are able to take solar energy and turn it into chemical energy. Without photosynthesis, life on earth would not exist. It is the single most important chemical process on earth because all other life forms depend on this process for survival. The *photosynthesis formula* is:

Carbon dioxide + water (in the presence of light)
produces carbohydrates (sugars) + oxygen

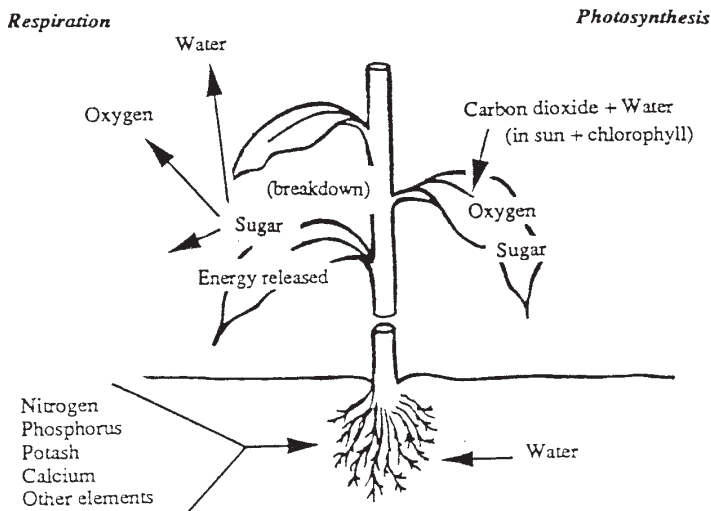


Fig. 4. Functions of the leaf.

Carbon dioxide enters the leaf through the stomata. Photosynthesis requires natural or artificial light and water that comes through the roots. The photosynthetic process occurs in the chloroplasts that contain the chlorophyll cells. Oxygen and water are released through the stomata, and the end products, carbohydrates, are converted to sugars and starches for transport and storage throughout the plant.

Leaves are also one site of *respiration* in the plant. Respiration is the process by which carbohydrates are converted into energy. This energy builds new tissues, maintains the chemical processes, and allows growth within the plant. With this production of energy, sugars and oxygen are converted to carbon dioxide, water, and a small amount of heat. Respiration occurs in all cells and at night as well as during the day.

The loss of water through the leaf stomata is called *transpiration*. The transpired water comes from the photosynthetic process and also from water in the cells. Transpiration pulls water from the roots with dissolved nutrients through the plant. It also provides evaporative cooling for leaf tissue.

2. Stems—The stem of a plant supports the above-ground plant parts and is a pathway for water, nutrients, and carbohydrates.

- a. Parts of the stem: All stems have *nodes*. A node is an area of active growth (Fig. 5). Leaves occur on the stem at the node. Where the leaves meet the stem is called an axil. Buds

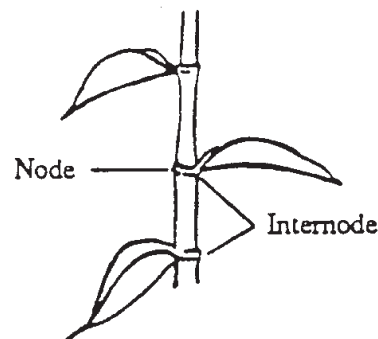


Fig. 5. Parts of the stem.

develop into leaves or flowers at a node. The area between nodes is called an *internode*. Internodes can be lengthy or very small depending on the genetics of the plant and environmental conditions.

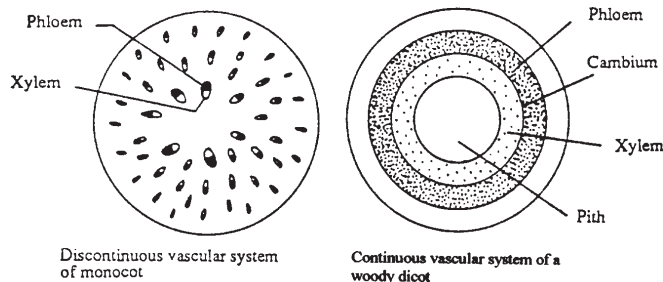
- b. Types of stems: *Crowns* are compressed above-ground stems. Examples are dandelions and strawberries. The leaves and flowers are on very short internodes.

Spurs are short, stubby stems common on fruit trees such as apples and pears. These spurs produce the fruiting buds on these trees.

A *stolon* is a horizontal stem, either fleshy or semi-woody, that runs along the soil surface. An example is the stem that attaches the strawberry plant to its plantlets. It is also called a runner. Some types of grass form stolons.

Below-ground stem variations include *tubers* (potatoes), *rhizomes* (bearded iris), *tuberous stems* (tuberous begonias), *corms* (crocus), and *bulbs* (tulips) (see Chapter 18, "Herbaceous Ornamentals").

- c. Internal structure of the stem: The *vascular system* inside the stem transports water, minerals, and sugars (Fig. 6). The *xylem* vessels conduct water and minerals, and the *phloem* tubes carry sugars. Water moves primarily from the roots to the top of the plant. Sugars move from areas of manufacture or storage to use or to other storage areas in the plant. The arrangement of the vascular system in a dicot is continuous. It forms rings inside the stem with



Cross-section of Stem

Fig. 6. Vascular system arrangements.

the phloem near the outside, or bark, and the xylem toward the inside (Figs. 6 and 7). In monocots, paired xylem and phloem form bundles that are scattered throughout the stem (Fig. 6).

Between all functional phloem and xylem is a layer of cells called the *cambium*. These cells divide and produce xylem toward the inside of the stem and phloem toward the outside of the stem. Stem girth of woody perennial plants increases mainly by the activity of these cambium cells.

- d. External structure of the stem: In non-woody plants the *epidermis*, or outer single layer of surface cells, protects the stem. As in leaves, this layer is usually cutinized, or waxy, and on young stems it has stomata. Below the epidermis are layers of supporting and strengthening cells that surround the vascular tissue (Fig. 7). These cells may contain chloroplasts so that they can photosynthesize. Some of these tissues can divide and form new tissue when wounded, providing a protective mechanism for the stem.

Woody plants form *bark*, or *cork*, on the outside of their stems. *Cork cambium* produces this bark and is located just below the bark layers (Fig. 8).

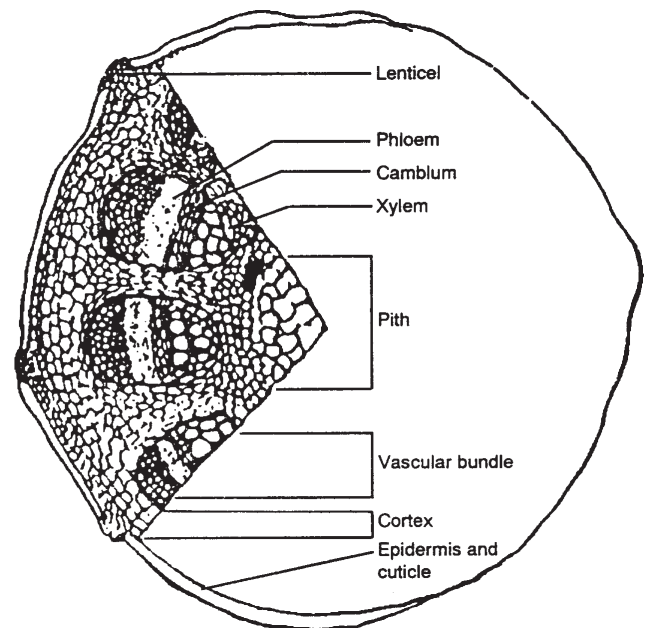


Fig. 7. Cross section of a herbaceous dicot stem.

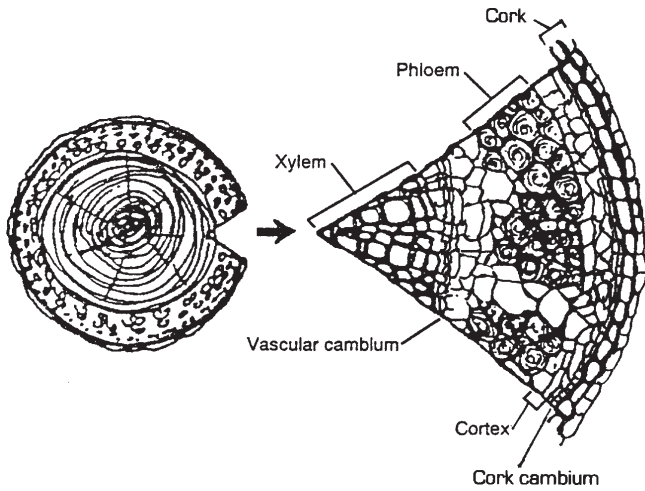


Fig. 8. Cross section of a woody stem.

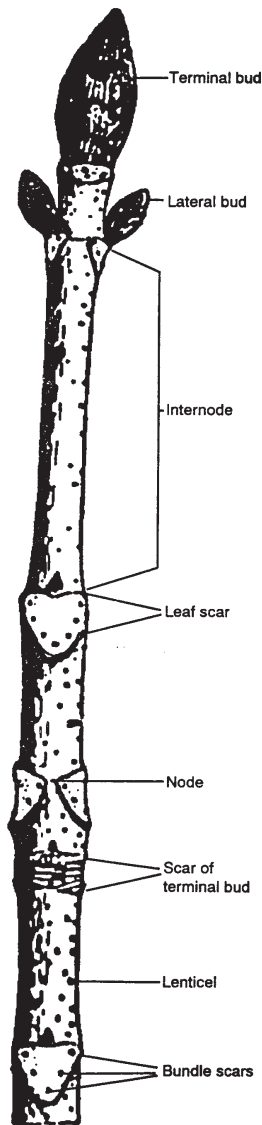


Fig. 9. Types of buds.

This cambium forms cork, or bark cells, that become coated with water resistant materials, die, and build up into a thickened, protective layer. The bark cells resist desiccation, disease, insects, and extreme temperatures. Only dicots produce the type of growth depicted in Fig. 8. On young twigs and small trunks of many kinds of trees and shrubs, *lenticels*, or pore openings, allow the outward and inward movement of gases.

3. Buds—A *lateral* or *axillary* bud is an undeveloped shoot or flower that is found at the node. If the bud is at the tip of shoots, it is called a *terminal bud* (Fig. 9). Buds may continue to grow after they are formed, or they may stop growing and remain dormant until the following spring. Buds on many plants require a certain duration of cold temperature below a certain degree before they will grow in the spring. During dormancy, buds can tolerate very low temperatures without damage. However, once the plant has had enough cold temperature to satisfy that requirement for growth, a new bud can be easily damaged by subsequent cold temperatures. Non-growing buds of tropical and subtropical plants do not have a temperature requirement for growth.

a. Types of buds: *Vegetative* buds develop onto shoots, *flower* buds produce one or more flowers, and *mixed* buds produce both shoots and flowers. Buds that do not grow for long periods of time can become embedded in the enlarging stem tissue and are *latent* buds. These buds grow only when conditions necessary for their growth occur, such as drastic pruning. Not all plants have latent buds.

b. *Adventitious* buds develop in locations that buds usually don't occur. An example is the buds found on root pieces used for propagation; roots do not have buds. Underground parts that do have buds are considered underground stems, such as rhizomes or tubers.

4. Roots

Roots absorb nutrients and moisture, anchor the plant in the soil, furnish physical support for the stem, act as transport systems to move water and minerals to the stem, and serve as food storage organs. Roots profoundly affect the size and vigor of the plant, method of propagation, adaptation to soil types, and responses to cultural practices and irrigation. Roots make up a large proportion of the total plant; about 20 to 30 percent of the total volume of the plant is roots, depending on the nature of the root and the growing conditions. Since individual roots may be so small, however, roots can account for up to 90 percent of the surface area of a plant!

a. Structure of roots: Roots have an actively growing area at the tip that produces new cells. Behind this active region is the *zone of elongation* where the cells expand. Behind this zone is the *region of maturation*, where the enlarged cells turn into the various root tissues. The epidermis of this young region forms *root hairs* that replace old root hairs destroyed as the

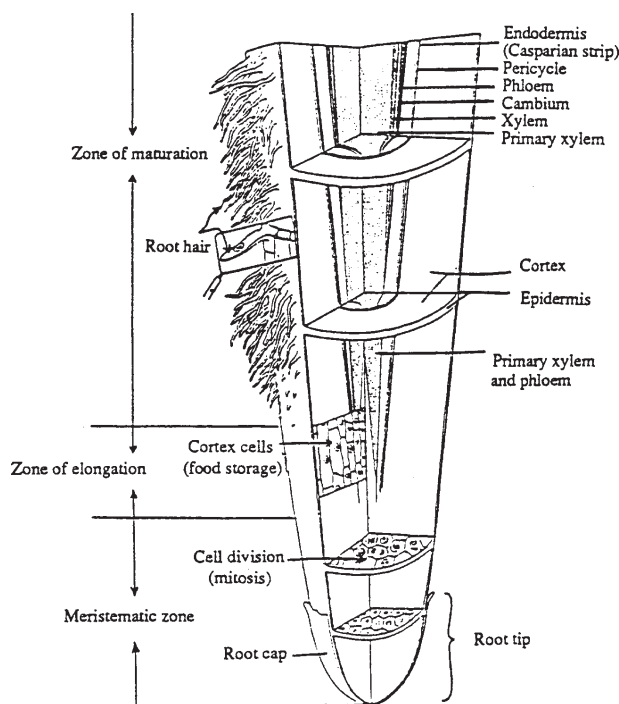


Fig. 10. Root structure.

root penetrates the soil (Fig. 10). Most water absorption occurs in the area of the root hairs.

The internal structure of roots is different from stems. A *root cap* protects the root as it pushes through the soil. The cells of the cap slough off and are replaced by others as roots grow downward. The epidermis protects the root surface, contains the root hairs, and is responsible for the absorption of water and minerals dissolved in water. *Cortex cells*, beneath the epidermis, help move the water from the epidermis and are active in food storage. The vascular tissue (xylem and phloem) is in the center of the root and conducts nutrients, sugars, and water.

b. Kinds of root systems: After the primary root emerges from the seed, it may continue to grow straight down and become a *tap root*, or it may branch, forming *secondary roots*, and become a *fibrous* root system with many side, or lateral, roots (Fig. 11). The taproot can be encouraged to branch by removing or breaking the *apical root meristem*, or growing point of the root. This often happens when seedlings, trees, and other plants are transplanted. This process favors a fibrous root system. Many of the functional feeder roots of woody plants extend only into the top 18 inches of soil. The depth that tree roots penetrate depends on the types of tree and soil, and water status. A dense compacted layer in the soil or a high water table will restrict or terminate root growth.

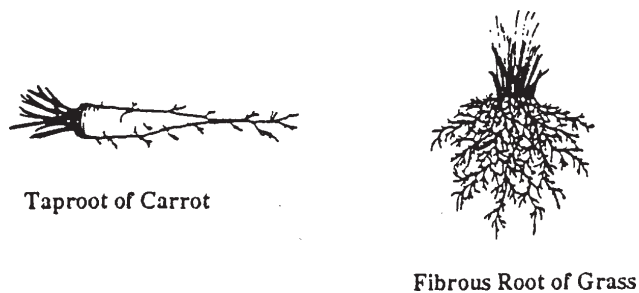


Fig. 11. Types of roots.

c. Types of roots: Some unusual roots are *aerial roots*, which develop on stems above ground. If they reach soil they will become ground roots. The aerial roots of some orchids contain chlorophyll for photosynthesis and absorb moisture and nutrients from the air.

Adventitious roots are those that form at any place on the plant other than the primary root system. They may arise from cells adjacent to vascular bundles, cambium, or young phloem cells. They also form on other plant parts besides stems, such as leaf petioles or leaf blades or even on older root pieces. The ability of many plants to produce adventitious roots allows the propagation of plants vegetatively.

B. Sexual Reproductive Parts

Plants reproduce in many ways, from a simple cell splitting into two identical individuals (clones) to the complicated floral structures found in higher plants. *Gymnosperms* (conifers) have a reproductive system that differs from *angiosperms* (flowering plants). We are concerned here with the most highly evolved reproductive system, that of the angiosperms or flowering plants.

1. Flowers—Flowers are the specialized plant structures adapted for sexual reproduction in plants. After fertilization by pollen, parts of the flower develop into a fruit that bears the seed(s). Formation of flowers is still poorly understood. Flowering may be caused by a stimulus such as day length, plant age, temperatures, stress, and other factors.

a. Parts of the flower: Complete flowers have four parts: sepals, petals, stamens, and pistils, which are all borne on a receptacle (Fig. 12).

- *Sepals* are the outer covering of the flower when it is in the bud stage. They are leaf-like in structure and are usually green, however, they can be colored and look like petals, as in tulips. They may fold back as in roses or remain upright as with carnations. Together, all the sepals form the *calyx*.

- The *petals* are the floral structures inside the sepals. Together, all the petals form the *corolla*. Petals are usually brightly colored and often contain *nectaries* that secrete nectar. The color and nectar attract insects to pollinate the flowers. Collectively, sepals and petals form the *perianth*.

- The *stamen* is the male part of the flower and is inside the petals. Each stamen consists of a *filament* tipped with an *anther*. The anther produces the *pollen*.

- The *pistil* is the female component of the flower. It is in the center of the flower and has three parts: the *stigma*, the receptive surface that receives the pollen; the *style*, a tube connected to the stigma; and the *ovary*, attached to the lower end of the style. The ovary contains *ovules* that develop into seeds after pollination and fertilization have occurred.

b. Types of flowers: A complete flower has all four parts: sepals, petals, stamens, and a pistil. Flowers with both stamens and pistils are called *perfect flowers*.

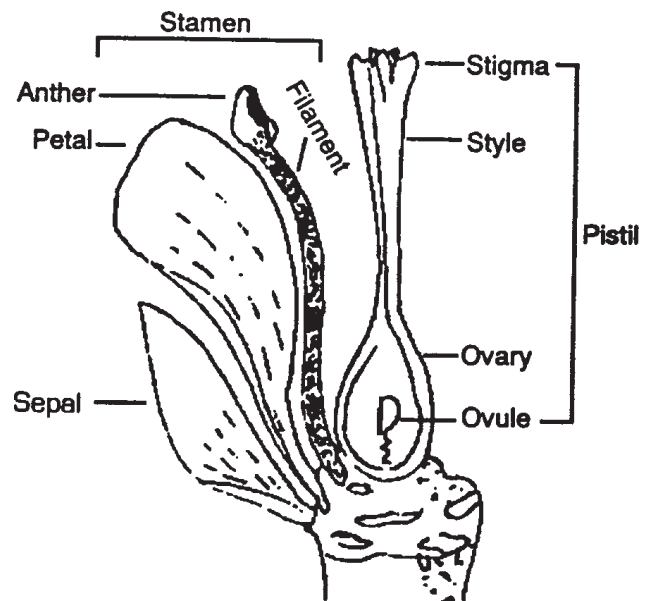


Fig. 12. Flower structure.

Incomplete flowers lack one or more of the four parts. Flowers with no pistils (stamens only) are *staminate* or *male flowers*. Flowers with no stamens (pistils only) are *pistillate* or *female flowers*. These flowers are called *imperfect* because they lack either the pistils or the stamens.

If a plant has imperfect flowers and male (staminate) and female (pistillate) flowers occur on the same plant, the plant is termed *monoecious*. Corn is an example of a monoecious plant. If the male and female flowers occur on separate plants the plants are called *dioecious*. Holly is an example of a dioecious plant.

- c. Arrangement of flowers: If a stalk bears a single flower, such as a tulip, it is a *solitary* flower. Multiples or clusters of flowers are arranged in *inflorescences*. Some of these flower clusters are shown in Fig. 13.
- d. Fertilization of flowers: Once a flower is formed, the first step in fertilization is *pollination*, the transfer of pollen from an anther to a stigma. If the anther and stigma are in the same flower or if the anther and stigma are in different flowers on the same plant or in

different flowers on different plants of the same species, variety, or cultivar, this is all called *self-pollination*. Only when the anther and the stigma are in different flowers on plants of different species, varieties, or cultivars does *cross-pollination* occur. Pollination occurs by insects or, in plants with inconspicuous flowers, by wind.

Once the pollen lands on the stigma, the pollen grain germinates and begins to grow a *pollen tube* that penetrates through the style (Fig. 14). In the tube are the male *sperm* that will unite with the female *egg* in the ovule. Fertiliza-

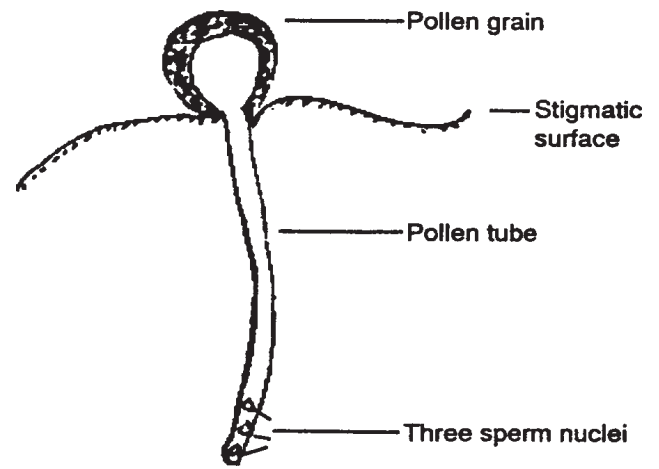


Fig. 14. The process of fertilization.

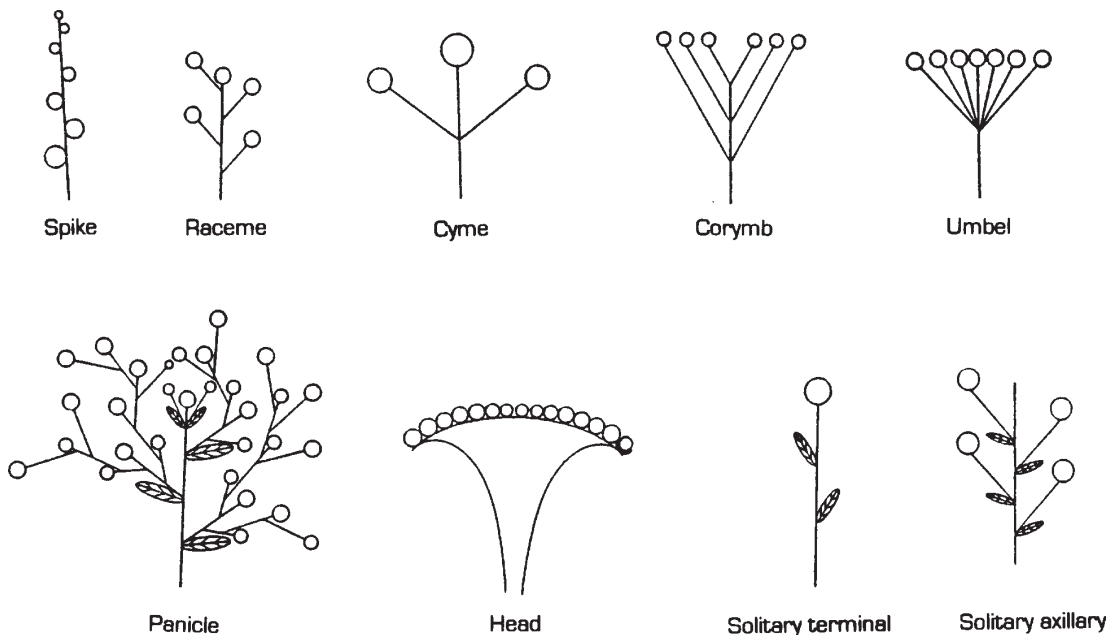


Fig. 13. Types of inflorescences.

tion occurs when sperm unites with the egg and an embryo begins to grow.

A plant is *self-fertile* if it produces seed with its own pollen. It is *self-sterile* if it needs pollen from another species, variety, or cultivar (e.g., cross-pollination) for fertilization to occur. Often self-sterility is due to *incompatibility* or a condition where the pollen will not grow through the style.

2. Fruits—Once pollination occurs and the embryo begins to develop, the formation of a fruit begins and seeds develop within the fruit. Fruits can develop from all the various parts of the flower, not just the ovary. Fig. 15 shows some fruit types.

a. Fruit growth and development: Botanically speaking, the true fruit is just the enlarged ovary. However, once fertilization is accomplished, the true fruit and, sometimes, various associated tissues begin to grow into what we recognize and call a fruit. Food materials

move from other parts of the plant into these developing tissues. Hormonal chemicals are involved in fruit growth, but their basic mechanisms are not completely understood. Fruit growth includes both cell division and cell enlargement.

Botanical maturity of a fruit refers to a final stage of development when the fruit is still on the plant and cell enlargement and accumulation of carbohydrates and other flavor constituents is complete. Fruits are often harvested before true botanical maturity as in the case of cucumbers used for pickles. Fruits, such as lima beans used as dry beans, are harvested after true botanical maturity. Optimum harvest time depends upon the intended use of the fruit.

3. Seeds—Seeds are matured ovules and occur as, or in, mature fruits. They come in all shapes and sizes as well as methods

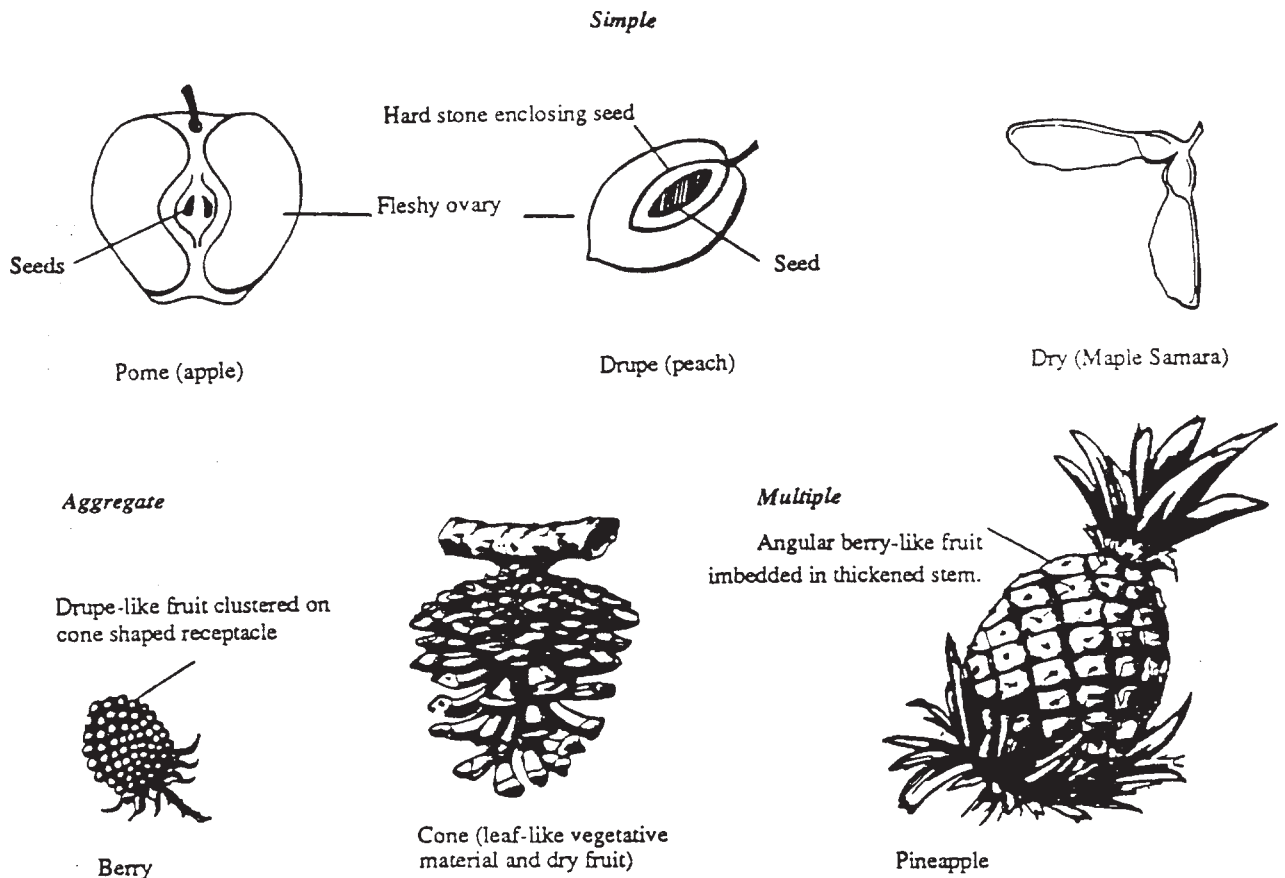


Fig. 15. Examples of fruit types.

of dispersal. Maple seeds (samaras) are carried through the air on wings. Cockleburs have barbs or hooks to catch in clothing or animal fur. Small animals gather, transport, and bury nuts, completing the planting of these seeds. These seeds pass through their digestive tracts of animals, such as coyotes, and are widely disseminated.

a. Parts of a seed: Every seed has three basic parts: an embryo, a food storage tissue, and a seed coat (Fig. 16). The *embryo* is a tiny plant formed during fertilization. It has two growing points, the *radicle* (a tiny root), and the *plumule* (a tiny shoot). The food storage tissue is either one or two cotyledon, which are attached between the two growing points on the embryo. In some seeds (as in corn) the single cotyledon is imbedded in an *endosperm* that is a food-storage area in the seed. The *seed coat* forms the outer layer and provides protection for the enclosed embryo.

b. Seed viability: In order for seeds to grow, the embryo must be viable, or alive. Seeds can remain alive for days or years, depending on the species of plant and the seed storage conditions. Best storage conditions for most seeds are cool and dry. However, seeds of tropical plants will dry out and die if stored under dry conditions.

There are several ways to test if seeds are alive. Cutting open the seed to view the embryo can tell you if it ex-

ists, but not whether it is alive. Seeds that float on water are usually not viable; live seeds will sink. Germinating a sample of seeds can tell you what percent are alive. Make sure seeds tested in this way are not dormant. Using a chemical such as tetrazolium that stains the live parts of the seed red is a good viability test. Removing the embryo from the seed to observe growth in artificial media such as agar is another way to test viability. For home gardeners these last two tests are usually not practical.

c. Seed dormancy: Some seeds, even though viable and planted under the correct conditions, fail to grow. These seeds are exhibiting a feature called *dormancy*. Seed dormancy can result from limiting structural or physiological conditions in the seed coverings (particularly the seed coats) or in the embryo itself, or both. Dormancy is an adaptive feature of some plants to keep the seeds from germinating until conditions exist that favor seedling survival.

Seed coat dormancy is caused by seed coats being impermeable to water and gases or by being too hard to let the embryo emerge. In nature, weathering, the action of microorganisms, or the passage through the digestive tract of an animal can soften the seed covering. Artificial methods to soften the seed coat include *scarification*, scratching or rupturing the seed coat

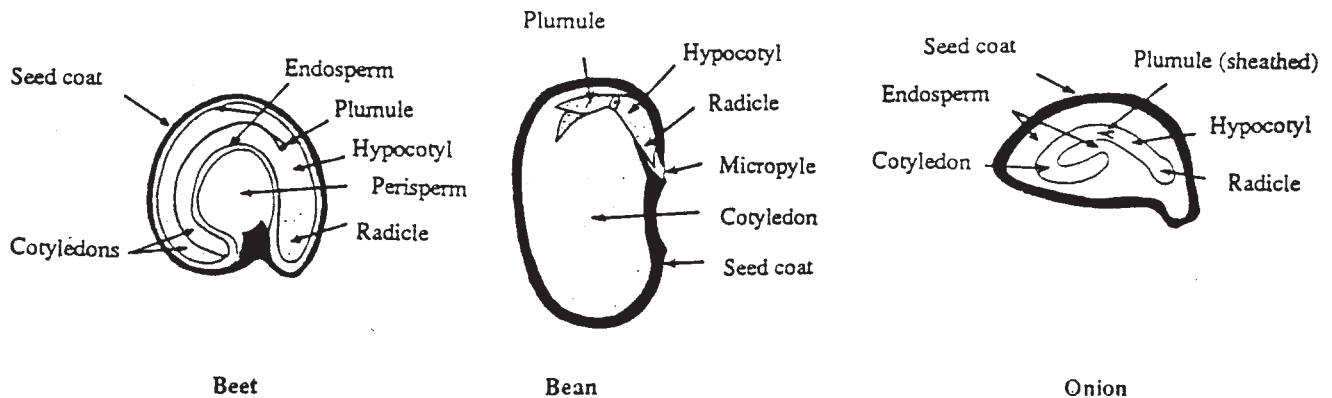


Fig. 16. Parts of a seed.

with sandpaper or nicking it with a knife. *Heat treatments* using boiling water can disrupt the seed coat enough to allow germination. Soaking seeds in concentrated sulfuric acid, called *acid scarification*, softens the seed coat to help overcome seed coat dormancy.

Embryo dormancy is common in seeds of woody perennial plants. A physiological condition in the embryo prevents it from growing. This type of dormancy can be overcome by *stratification*, or chilling seeds under moist conditions. This method mimics the conditions a seed might endure after it fell to the ground in the fall and went through a cold winter on the ground. This type of dormancy keeps the seed from growing in the fall when the resulting tiny plant would be killed by the winter cold.

Some seeds have both a seed coat and embryo dormancy. Treatment to overcome both types of dormancy is necessary to allow germination.

Some seeds fail to germinate because of an *immature embryo*. Enough time after seed harvest must be allowed for the embryo to develop. Embryo maturation can occur while the seed is in storage or after it is planted.

Chemical inhibitors can block germination in seeds. These chemicals may be in the embryo, some other part of the seed, or even in part of the fruit. Removing the seed from the fruit will allow germination in the case of chemical inhibition from fruits. Water

leaching can remove chemicals in seeds or embryos. In nature, heavy soaking rains would accomplish this task and provide an excellent growing condition for the resulting seedling.

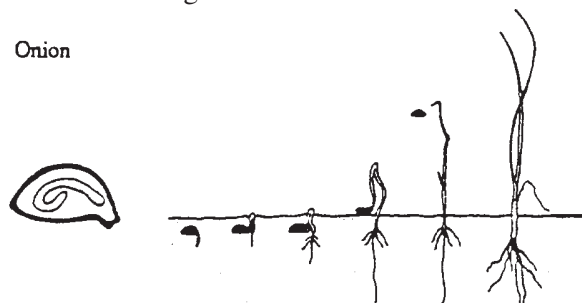
Good reference materials are available to determine what conditions are necessary to germinate a seed. Master Gardeners should use these references to be successful in seed collection and germination.

C. How Plants Grow

1. Seed germination—After planting, certain processes begin in a seed leading to the growth of an entirely new plant. These processes are called *germination* (Fig. 17). The first step necessary to begin the process involves the absorption of water or *imbibition*. The seed swells with the uptake of water, cell enzyme activity increases, growth begins, and the seed coat bursts. The radicle, which will develop into the root, emerges and grows downward into the soil. The portion of the seedling between the radicle and the first leaf-like structure is the *hypocotyl*. The seed leaves or cotyledons are usually the first leafy structure seen, and they enclose a growing point called the *apical* or *shoot meristem* (defined below). Plants with one seed leaf are monocotyledons while dicotyledons have two seed leaves. The storage products within the cotyledons provide energy to support growth of the seedling until photosynthesis begins. New leaves and stem cells are produced and the plant begins to grow taller, or elongate.



Germination of A Dicot



Germination of A Monocot

Fig. 17. Seed germination.

Successful seed germination requires certain environmental conditions: adequate moisture, proper temperature, good aeration, darkness, or, in some cases, light.

2. Differentiation and maturation—Plants continue to grow and develop their structures from meristematic areas (Fig. 18). Various cells form the shape, size, and characteristics of each type of plant. The genetic information that dictates all cellular processes is called *DNA* (deoxyribonucleic acid). DNA is organized into *chromosomes*. The order and organization of the DNA in the chromosomes is responsible for all characteristics of the plant—such as whether it will be woody or herbaceous, annual or perennial, or tall or short.
3. Meristematic areas and growth—Plants have specific meristematic areas where cells actively divide to provide more cells that will expand and develop into other tissues and organs of the plant.
 - a. Apical meristems: *Shoot meristems* are at the very tips of the above-ground parts of the plant. They produce new buds and leaves in a particular pattern at the tip of the stems. The shoot meristem produces cells that eventually form the different tissues of the stem:

the epidermis and the very first xylem and phloem. In some plants, this meristem will produce flower buds at a certain point in the development of the plant. In other plants, this meristem continues to produce only vegetative structures (leaves and stems). If this is the case, flowers are produced on side branches in the axils of leaves some distance below the apex. The shoot meristem allows the plant to grow and increase in height.

Another type of apical meristem is the *root meristem*, located at the tips of roots. The root meristems provide for elongation of the roots and produce the cells that will become the epidermis, cortex, and the xylem, cambium, and phloem of the mature root.

- b. Lateral meristems: *Lateral meristems* are cylinders of actively dividing cells that start just below the apical meristems and are located up and down the plant. One type of lateral meristem is the vascular cambium, which produces new xylem and phloem. Another lateral meristem is the cork cambium, which produces bark on older stems and roots. The stem girth of woody perennial plants increases by the activity of these meristems.

- c. Other types of meristems: Some plants have a *subapical meristem* that produces new cells in the region just behind a shoot meristem. Plants that form rosettes when they first produce leaves and then “bolt” when producing a flowering stalk have subapical meristems. An example is common mullein. The subapical meristem aids in formation of the flowering stalk.

Some other plants, mostly monocots, have active meristematic cells in older mature tissue, separated from the shoot meristem. For example, grasses have *intercalary meristems* just above the nodes in the lower region of the leaf sheaths. These cells divide and provide the growth of the grass leaf from the base.

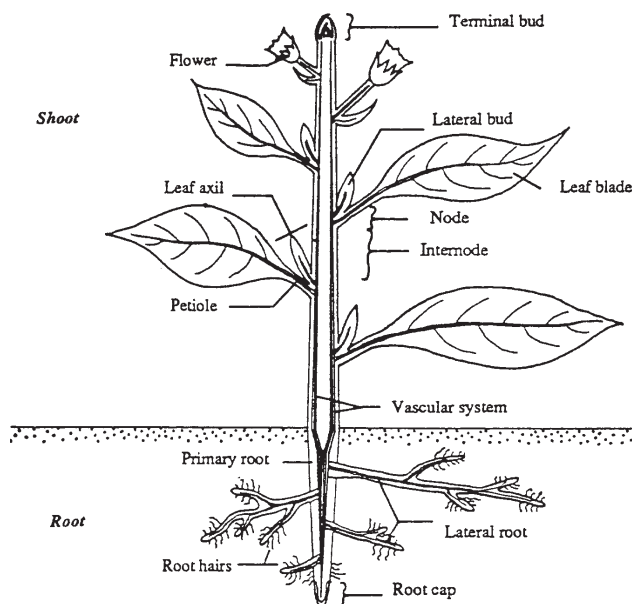


Fig. 18. Parts of a vascular plant.

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Booklets and Pamphlets

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Chapter
Plant Propagation



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Plant Propagation



S. M. Bell

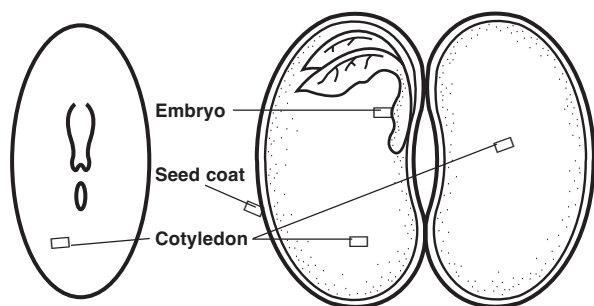
Susan M. Bell, Extension Educator, Ada County, Boise

I. Sexual Propagation

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm (cotyledon), which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate, or begin active growth. In the following section, seed germination and transplanting of seeds will be discussed.

A. Seed

To obtain quality plants, start with good quality seed from a reliable dealer. Select varieties to provide the size, color, and habit of growth desired. Choose varieties adapted to your area that will reach maturity before an early frost. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than nonhybrids and sometimes have specific disease resistance or other unique cultural characteristics. Disadvantages of hybrids: seed cannot be saved as they do not breed true, and they may have a higher fertility requirement.



Bean seed with interior parts indicated

Although some seeds will keep for several years if stored properly, it is advisable to purchase only enough seed for the current year's use. Good seed will not contain seed of any other crop, weed seeds, or other debris. The seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, germination percentage you may typically expect, and notes of any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date or are stored surplus seeds, keep them in a cool, dry place. Do not freeze seed. Laminated foil packets help ensure dry storage. Paper packets are best kept in tightly-closed containers and maintained near 40°F in low humidity. Some gardeners save seed from their own gardens, however, such seed is the result of random pollination by insects or other natural agents and may or may not produce plants typical of the parents. Open pollinated varieties are best for seed saving. Vegetable seeds are discussed in Chapter 19.

B. Germination

Four environmental factors affect germination: water, light, oxygen, and heat.

1. Water—The first step in the germination process is absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water. An adequate, continuous supply of water is important to ensure germination. Once the germination process begins, a dry period will cause the death of the embryo.
2. Light—Light is known to stimulate or to inhibit germination of some seed. The

light reaction involved here is a complex process. Some crops that have a requirement for light to assist seed germination are ageratum, begonia, browallia, impatiens, lettuce, and petunia. Conversely, centaurea, annual phlox, verbena, and vinca will germinate best in the dark (Table 1). Many other plant seeds are not specific in their light or dark requirements.

Seed catalogs and seed packets often list germination or cultural tips for individual varieties. When sowing light-requiring seed, do as nature does and leave them on the soil surface. If they are covered at all, cover them lightly with fine peat moss or fine vermiculite. These two materials, if not applied too heavily, will permit some light to reach the seed and will not limit germination. When starting seed in the home, supplemental light can be provided by fluorescent fixtures suspended 6 to 12 inches above the seeds for 16 hours a day.

3. Oxygen—In all viable seed, respiration takes place. The respiration in dormant seed is low, but some oxygen is required. The respiration rate increases during germination, therefore, the medium in which the seeds are placed should be loose and well aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.
4. Heat—A favorable temperature is another important requirement of germination (Table 1). It not only affects the germination percentage but also the rate of germination. Some seeds will germinate over a wide range of temperature,

Table 1. Seed requirements.

| Plant | Approximate time to seed before last spring frost | Approximate germination time (days) | Optimum germination temperature (°F) | Germination in light (L) or dark (D) | |
|---------------|---|-------------------------------------|--------------------------------------|--------------------------------------|---|
| Begonia | 12 weeks or more | 10 to 15 | 70 | L | |
| Browallia | | 15 to 20 | 70 | L | |
| Geranium | | 10 to 20 | 70 | D | |
| Larkspur | | 5 to 10 | 55 | D | |
| Pansy (Viola) | | 5 to 10 | 65 | D | |
| Vinca | | 10 to 15 | 70 | D | |
| Dianthus | 10 weeks | 5 to 10 | 70 | — | |
| Impatiens | | 15 to 20 | 70 | L | |
| Petunia | | 5 to 10 | 70 | L | |
| Portulaca | | 5 to 10 | 70 | D | |
| Snapdragon | | 5 to 10 | 65 | L | |
| Stock | | 10 to 15 | 70 | — | |
| Verbena | | 15 to 20 | 65 | D | |
| Ageratum | | 8 weeks | 5 to 10 | 70 | L |
| Alyssum | | | 5 to 10 | 70 | — |
| Broccoli | | | 5 to 10 | 70 | — |
| Cabbage | | | 5 to 10 | 70 | — |
| Cauliflower | | | 5 to 10 | 70 | — |
| Celosia | 5 to 10 | | 70 | — | |
| Coleus | 5 to 10 | | 65 | L | |
| Dahlia | 5 to 10 | | 70 | — | |
| Eggplant | 5 to 10 | | 70 | — | |
| Head lettuce | 5 to 10 | | 70 | L | |
| Nicotiana | 10 to 15 | | 70 | L | |
| Pepper | 5 to 10 | | 80 | — | |
| Phlox | 5 to 10 | | 65 | D | |
| Aster | 6 weeks | | 5 to 10 | 70 | — |
| Balsam | | | 5 to 10 | 70 | — |
| Centaurea | | 5 to 10 | 65 | D | |
| Marigold | | 5 to 10 | 70 | — | |
| Tomato | | 5 to 10 | 80 | — | |
| Zinnia | | 5 to 10 | 70 | — | |
| Cucumber | | 4 weeks or less | 5 to 10 | 85 | — |
| Cosmos | | | 5 to 10 | 70 | — |
| Muskmelon | 5 to 10 | | 85 | — | |
| Squash | 5 to 10 | | 85 | — | |
| Watermelon | 5 to 10 | | 85 | — | |

(—) means no specific light or dark requirements.

whereas others require a narrow range. Many seed have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of 50°F and a maximum temperature of 95°F, but an optimum germination temperature of about 80°F. Where germination temperatures are listed, they are usually the optimum temperatures unless otherwise specified. Generally, 65° to

75°F is best for most plants. This often means the germination flats may have to be placed on radiators, heating cables, or heating mats to maintain optimum temperature. The importance of maintaining proper soil temperature to achieve maximum germination percentages cannot be over-emphasized.

Germination will begin when certain internal requirements have been met. A seed must have a mature embryo, contain a large enough endosperm to sustain the embryo during germination, and contain sufficient hormones or auxins to initiate the process.

C. Methods of Breaking Dormancy

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

1. Seed scarification—Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds.
 - a. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat has become thin, the seeds can be removed, washed, and planted.
 - b. Another scarification method is mechanical. You may file seeds with a metal file, rub them with sandpaper, or crack them with a hammer to weaken the seed coat.
 - c. Hot water scarification involves putting the seed into hot water (170° to 212°F). The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then planted.
 - d. You also may try warm, moist scarification. In this case, seeds are stored in

nonsterile, warm, damp containers where the seed coat will be broken down by decay over several months.

2. Seed stratification—Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they overwinter. This so-called “after-ripening” may be accomplished artificially by a practice called stratification.
 - a. The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 1 inch from the top. Place the seeds on top of the medium and cover with 1/2-inch of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator (not freezer). Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag and pot from the refrigerator. Remove the bag and set the pot in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 2 inches tall, transplant them into pots to grow until it is time to set them outside.
 - b. Another procedure for starting seeds uses sphagnum moss or peat moss. Wet the moss thoroughly, then squeeze out the excess water with your hands. Mix seed with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator. Check periodically. If there is condensation on the inside of the bag, the process will be successful. After 10 to 12 weeks, remove the bag from the refrigerator. Plant the seeds in pots to germinate and grow. Handle seeds carefully. Often the small roots and shoots are emerging at the end of the stratification period. Care must be taken not to break these off.

- c. Temperatures in the range of 35° to 45°F are effective for stratification. Most refrigerators operate in this range. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of peaches should be removed from the hard pit. Care must be taken when cracking the pits. Any injury to the seed itself can be an entry path for disease organisms.

D. Starting Seeds

1. Media—A wide range of materials can be used to start seeds, from plain vermiculite or mixtures of soilless media to the various amended soil mixes. With experience, you will learn to determine what works best under your conditions. However, keep in mind what makes a good germinating medium. It should be rather fine and uniform, yet well-aerated and loose. It should be free of insects, disease organisms, and weed seeds. It should also be of low fertility or total soluble salts and capable of holding and moving moisture by capillary action. One mixture that supplies these factors is a combination of 1/3 sterilized soil, 1/3 sand or vermiculite or perlite, and 1/3 peat moss. Do not use garden soil by itself to start seedlings; it is not sterile, it is often too heavy, and it will not drain well.
 - a. The importance of using a sterile medium and container cannot be over-emphasized. The home gardener can treat a small quantity of soil in an oven. Place the slightly moist soil in a heat-resistant container in an oven set at about 250°F. Use a candy or meat thermometer to ensure that the mix reaches a temperature of 180°F for 30 minutes. Avoid over-heating as this can be extremely damaging to the soil. Be aware that the soil will release very unpleasant odors in the process of sterilization. This treatment should prevent damping-off and other plant diseases, as well as eliminate potential plant pests.
 - b. An artificial, soilless mix also provides the desired qualities of a good germination medium. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which are generally free of diseases, weed seeds, and insects. The ingredients are also readily available, easy to handle, light-weight, and produce uniform plant growth. “Peat-lite” mixes or similar products are commercially available or can be made at home using this recipe: 4 quarts of shredded sphagnum peat moss, 4 quarts of fine vermiculite, 1 tablespoon of superphosphate, and 2 tablespoons of ground limestone. Mix thoroughly. These mixes have little fertility, so seedlings must be watered with a diluted fertilizer solution soon after they emerge.
2. Containers—Flats and trays can be purchased or you can make your own from scrap lumber. A convenient size to handle would be about 12 to 18 inches long and 12 inches wide with a depth of about 2 inches. Leave cracks of about 1/8-inch between the boards in the bottom or drill a series of holes to ensure good drainage.
 - a. You can also make your own containers for starting seeds by recycling such things as cottage cheese containers, the bottoms of milk cartons, or bleach containers and pie pans, as long as good drainage is provided. Wash growing containers and implements to remove any debris, then rinse in a solution of one part chlorine bleach to nine parts water. At least one company has developed a form for shaping newspaper into pots, and another has developed a method for the consumer to make and use compressed blocks of soil mix instead of pots.
 - b. Clay or plastic pots can be used and numerous types of pots made of compressed peat are also on the market. Plant bands and plastic cell packs are also available. Each cell or minipot holds a single plant that reduces the risk of root injury when transplanting. Peat pellets, peat or fiber-based blocks, and expanded foam cubes can also be used for sowing.

3. Seeding—The proper time for sowing seeds for transplants depends upon when plants may safely be moved out-of-doors in your area. This period may range from 4 to 12 weeks before transplanting, depending upon the speed of germination, the rate of growth, and the cultural conditions provided. A common mistake is to sow the seeds too early and then attempt to hold the seedlings back under poor light or improper temperature ranges. This usually results in tall, weak, spindly plants that do not perform well in the garden.
 - a. After selecting a container, fill it to within 3/4-inch of the top with moistened growing medium. For very small seeds, at least the top 1/4-inch should be a fine, screened mix or a layer of vermiculite. Firm the medium at the corners and edges with your fingers or a block of wood to provide a uniform, flat surface.
 - b. For medium and large seeds, make furrows 1 to 2 inches apart and 1/8- to 1/4-inch deep across the surface of the container using a narrow board or pot label. By sowing in rows, good light and air movement results, and if damping-off fungus does appear, there is less chance of it spreading. Seedlings in rows are easier to label and handle at transplanting time than those that have been sown in a broadcast manner. Sow the seeds thinly and uniformly in the rows by gently tapping the packet of seed as it is moved along the row. Lightly cover the seed with dry vermiculite or sifted medium if they require darkness for germination. A suitable planting depth is usually about two to three times the diameter of the seed.
 - c. Do not plant seeds too deeply. Extremely fine seeds such as petunia, begonia, and snapdragon are not covered, but lightly pressed into the medium or watered in with a fine mist. If these seeds are broadcast, strive for a uniform stand by sowing half the seeds in one direction, then sowing the remaining seed the other direction to form a crossed pattern.
 - d. Large seeds are frequently sown into a small container or cell pack that eliminates the need for early transplanting. Usually two or three seeds are sown per unit and later thinned to allow the strongest seedling to grow.
4. Seed tape—Most garden stores and seed catalogs offer indoor and outdoor seed tapes. Seed tape has precisely spaced seeds enclosed in an organic, water-soluble material. When planted, the tape dissolves and the seeds germinate normally. Seed tapes are especially convenient for tiny, hard-to-handle seeds. However, tapes are much more expensive per seed. Seed tapes allow uniform emergence, eliminate overcrowding, and permit sowing in perfectly straight rows. The tapes can be cut at any point for multiple-row plantings, and thinning is rarely necessary.
 - a. A homemade “seed tape” can be fashioned from 2-ply toilet paper and paste made with flour and water. Separate the two paper layers, then use a toothpick with a dab of flour paste on it to pick up and place seeds on one of the paper layers. Once all seeds are placed, put the two layers back together while the paste is still wet and roll the “tape” up for later use. The toilet paper, once covered with soil, will rapidly decay leaving no trace.
5. Pregermination—Another method of starting seeds is pregermination. This method involves sprouting the seeds before they are planted in pots or in the garden. This reduces the time to germination, as the temperature and moisture are easy to control. A high percentage of germination is achieved since environmental factors are optimum.
 - a. Lay seeds between two paper towels or on a layer of vermiculite in a shallow pan. Keep them moist and in a warm place. When roots begin to show, place the seeds in containers or

plant them directly into the garden.

While transplanting seedlings, be careful not to break off tender roots. Continued attention to watering is critical.

- b. When planting seeds in a container that will be set out in the garden later, place one seed in a 2- to 3-inch container. Plant the seeds at only one-half the recommended depth. Gently press a little soil over the sprouted seed and then add about 1/4-inch of milled sphagnum peat or sand to the soil surface. These materials will keep the surface uniformly moist and are easy for the shoot to push through. Keep the seedlings in a warm place and care for them as for any other newly transplanted seedlings.
 - c. A convenient way to plant small, delicate, pregerminated seeds is to suspend them in a gel. You can make a gel by blending cornstarch with boiling water to a consistency that is thick enough so the seeds will stay suspended. Be sure to cool thoroughly before adding seeds. Place the gel with seedlings in a plastic bag with a hole in it. Squeeze the gel through the hole along a premarked garden row. Spacing of seeds is determined by the number of seeds in the gel. If the spacing is too dense, add more gel; if too wide, add more seeds. The gel will keep the germinating seeds moist until they establish themselves in the garden soil.
5. Watering—After the seed has been sown, moisten the planting mix thoroughly. Use a fine mist or place the containers in a pan or tray that contains about 1 inch of warm water. Avoid splashing or excessive flooding, which might displace small seeds. When the planting mix is saturated, set the container aside to drain. The soil should be moist but not wet.
- a. Ideally, seed flats should remain sufficiently moist during the germination period without having to add water. One way to maintain moisture is to slip the whole flat or pot into a clear plastic bag after the initial watering.
- The plastic should be at least 1 inch from the soil. Placing a popsicle stick or pencil in the middle of the flat will hold the plastic off the soil and plants. Keep the container out of direct sunlight, otherwise the temperature may rise to the point where the seeds will be harmed. Many home gardeners cover their flats with panes of glass instead of using a plastic bag. Be sure to remove the plastic or glass cover as soon as the first seedlings appear. Surface watering can then be practiced.
- b. Lack of uniformity, overwatering, or drying out are problems related to manual watering. Excellent germination and moisture uniformity can be obtained with a low-pressure misting system or subirrigation (watering from below). Flats or pots must not sit in water constantly as the soil may absorb too much water, and the seeds will rot due to lack of oxygen.
6. Temperature and light—Several factors for good germination have already been mentioned. The last item, and by no means the least important, is temperature. Since most seeds will germinate best at an optimum temperature that is usually higher than most home night temperatures, special warm areas must be provided. The use of thermostatically controlled heating cables is an excellent method of providing constant heat (see Germination section on page 3-2).
- a. After germination and seedling establishment, move the flats to a light, airy, cooler location, at a 55° to 60°F night temperature and a 65° to 70°F day reading. This will prevent soft, leggy growth and minimize disease. Some crops, of course, may germinate or grow best at a different constant temperature and must be handled separately from the rest of the plants. Read as much as you can about the plants you are trying to grow.
 - b. Seedlings must receive bright light after germination. Place them in a window facing south, if possible. If a

large, bright window is not available, place the seedlings under a fluorescent light. Use two 40-watt, cool-white fluorescent tubes or special plant growth lamps. Position the plants 6 to 8 inches from the tubes and keep the lights on for 14 to 16 hours each day. As the seedlings grow, the lights should be raised.

E. Transplanting and Handling

If the plants have not been seeded in individual containers, they must be transplanted to give them proper growing space. One of the most common mistakes made is leaving the seedlings in the seed flat too long. The ideal time to transplant young seedlings is when they are small as there is less danger from transplant shock. This is usually about the time the first true leaves appear above or between the cotyledons (the cotyledons sometimes called “seed leaves” are not true leaves). Avoid letting plants get hard, stunted, or tall and leggy.

1. Seedling growing mixes and containers can be purchased or prepared similar to those mentioned for germinating seed. The medium should contain more plant nutrients than a germination mix. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble houseplant fertilizer at the rate recommended by the manufacturer, about every 2 to 3 weeks after the seedlings are established. Remember that young seedlings can easily be damaged by too much fertilizer, especially if they are under moisture stress.
2. To transplant, carefully dig up the small plants with a knife or wooden plant label. Let the group of seedlings fall apart and pick out individual plants. Gently ease them apart in small groups that will make it easier to separate individual plants. Avoid tearing roots in the process. Handle small seedlings by their leaves, not by their delicate stems. Punch a hole in the medium into which the seedling will be planted. Make it deep enough so that the seedling can be put at the same depth it was growing at in the seed flat.

After planting, firm the soil and water gently. Keep newly transplanted seedlings in the shade for a few days, or place them under fluorescent lights. Keep them away from direct heat sources. Continue watering and fertilizing as in the seed flats.

3. Most plants transplant well and can be started indoors, but a few plants are difficult to transplant. These are generally directly seeded outdoors or sown directly into individual containers indoors. Examples include zinnias and cucurbits, such as melons and squash.
4. Containers for transplanting—There is a wide variety of containers from which to choose for transplanting seedlings. These containers should be economical, durable, and make good use of space. The type selected will depend on the type of plant to be transplanted and individual growing conditions. Small plastic pots may be used, but they waste a great deal of space and may not dry out rapidly enough for the seedling to have sufficient oxygen for proper development.
 - a. Many types of containers are available commercially. Those made out of pressed peat can be purchased in varying sizes. Individual pots are inexpensive and can be planted directly into the garden. When setting out plants grown in peat pots, be sure to cover the pot completely. If the top edge of the peat pot extends above the soil level, it may act as a wick and draw water away from the soil and roots. To avoid this, tear off the top lip of the pot and then plant.
 - b. Compressed peat pellets, when soaked in water, expand to form compact, individual pots. They waste no space, don't fall apart as badly as peat pots, and can be set directly out in the garden.
 - c. In addition, many homeowners find a variety of materials from around the house to use for containers. These homemade containers should be deep enough to provide adequate soil and

have plenty of drainage holes in the bottom.

5. Hardening plants—Hardening off is the process of altering the quality of plant growth to withstand the change in environmental conditions that occurs when plants are transferred from a greenhouse to the garden. Severe sunscald or a stoppage in growth may occur if plants produced in the home are planted outdoors without a transition period. Hardening off is most critical with early crops, when adverse climatic conditions can be expected.
 - a. Hardening off can be accomplished by gradually lowering temperature and relative humidity and reducing water. This procedure results in an accumulation of carbohydrates and a thickening of cell walls. A change from a soft, succulent type of growth to a firmer, harder type occurs.
 - b. This process should be started at least 2 weeks before planting in the garden. If possible, plants should be moved to a 45° to 50°F temperature either indoors or outdoors in a shady location. A coldframe is excellent for this purpose. When put outdoors, plants should be shaded, then gradually moved into sunlight. Start with a 15- to 20-minute exposure. Each day gradually increase the length of exposure time to outside temperatures. Don't put tender seedlings outdoors on windy days or when temperatures are below 45°F.
 - c. Reduce the frequency of watering to slow their growth, but don't allow plants to wilt. Even cold-hardy plants will be hurt if exposed to freezing temperatures before they are hardened. After proper hardening, however, they can be planted outdoors and light frosts will not damage them.
 - d. The hardening off process is intended to slow plant growth. If carried to the extreme of actually stopping plant growth, significant damage can be done to certain crops. For example,

cucumbers and melons will stop all growth, while cauliflower will make thumb-size heads and fail to develop further if hardened too severely.

II. Asexual Propagation

Asexual propagation is the best way to maintain some species, particularly an individual that best represents that species. Clones are groups of plants that are identical to their parent or mother plant. The Bartlett pear (1770) and the Delicious apple (1870) are two examples of clones that have been asexually propagated for many years. The major methods of asexual propagation are cuttings, layering, division, and budding/grafting. Cuttings involve rooting a severed piece of the parent plant; layering involves rooting a part of the parent plant and then severing it later; and budding and grafting is joining two plant parts from different varieties.

A. Cuttings

Many types of plants, both woody and herbaceous, are frequently propagated by cuttings. A cutting is a vegetative plant part that is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant.

1. Take cuttings with a sharp blade to reduce injury to the parent plant. Before using the knife to cut, dip the cutting tool into rubbing alcohol and allow it to dry or use a mixture of one part bleach to nine parts water to disinfect the blade and to prevent transmitting diseases. Remove flowers and flower buds from cuttings to allow the cutting to use its energy and stored carbohydrates for root and shoot formation rather than fruit and seed production.
 - a. To hasten rooting, increase the number of roots, or to obtain uniform rooting (except on soft, fleshy stems), use a rooting hormone, preferably one containing a fungicide. Prevent possible contamination of the entire supply of rooting hormone by putting a small amount in a separate container for immediate use. Do not dip cuttings directly into the original container.

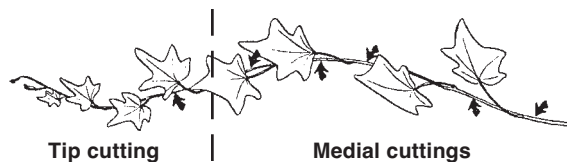
b. If hormone powder is used, only a very light coating is necessary. Tap off any excess onto a sheet of paper.

2. Insert cuttings into a rooting medium such as coarse sand, vermiculite, sterilized soil, water, or a mixture of peat and perlite. A pencil can be used to make a hole in the medium for easier insertion and to prevent the removal of hormone powder from the cut surface.

a. It is important to choose the correct rooting medium to get optimum rooting in the shortest time. In general, the rooting medium should be sterile, low in fertility, drain well enough to provide oxygen, and retain enough moisture to prevent water stress. Moisten the medium before inserting cuttings, and keep it evenly moist while cuttings are rooting and forming new shoots. Place stem and leaf cuttings in indirect light. Root cuttings can be kept in the dark until new shoots appear.

3. Stem cuttings—Numerous plant species are propagated by stem cuttings (Table 2). Some can be taken at any time of the year, but stem cuttings of many woody plants must be taken during the fall or in the dormant season. Tip, medial, cane, single and double eye, and heel are all examples of stem cuttings.

a. Tip cuttings: Detach a 2- to 4-inch piece of stem with two or three nodes, including the terminal bud.

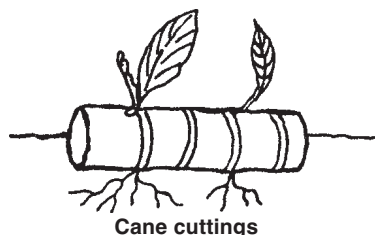


Make the bottom cut 1/4-inch below a node. Remove lower leaves from the cutting that would be in contact with the medium. Dip the stem in rooting hormone if desired. Gently tap the end of the cutting to remove excess hormone. Insert the cutting deeply enough into the media to support itself (about half way). At least one node must be below the surface.

b. Medial cuttings: Make the first cut just above a node, and the second cut just below another node 2 to 4 inches down

Table 2. Selected herbaceous plants that can be propagated from cuttings.

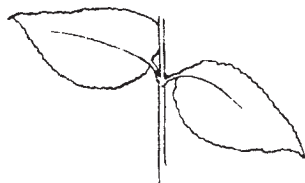
| Plant | | Type of cutting | Approximate time to root (weeks)* |
|-----------------------------|------------------------------------|-------------------------------------|-----------------------------------|
| Common name | Scientific name | | |
| African violet | <i>Saintpaulia</i> spp. | leaf | 3 to 4 |
| Aluminum plant | <i>Pilea</i> spp. | stem | 2 to 3 |
| Aloe | <i>Aloe</i> spp. | leaf | 4 to 6 |
| Aphelandra | <i>Aphelandra</i> sp. | stem | 2 to 3 |
| Arrowhead plant | <i>Syngonium podophyllum</i> | stem | 2 to 3 |
| Begonia | <i>Begonia</i> spp. | stem (fibrous rooted) | 2 |
| | | whole leaf or leaf section (Rex) | 4 to 5 |
| Cactus | <i>Cephalocereus senilis</i> | stem | 3 to 4 |
| | <i>Opuntia microdasys</i> | stem | 3 to 4 |
| Chrysanthemum | <i>Chrysanthemum</i> spp. | stem | 1 to 2 |
| Carnation | <i>Dianthus</i> spp. | stem | 2 to 3 |
| Coleus | <i>Coleus blumei</i> | stem | 1 to 2 |
| Crown of thorns | <i>Euphorbia splendens</i> | stem | 4 to 5 |
| Dahlia | <i>Dahlia</i> spp. | stem or leaf-bud | 3 to 4 |
| Dieffenbachia (dumbcane) | <i>Dieffenbachia</i> spp. | stem | 4 to 6 |
| Dracaena | <i>Dracaena</i> spp. | stem | 3 to 4 |
| Echeveria | <i>Echeveria</i> spp. | stem or leaf | 4 to 6 |
| Euphorbia | <i>Euphorbia</i> spp. | stem | 4 to 6 |
| Fittonia | <i>Fittonia</i> spp. | stem | 2 to 3 |
| Fuchsia | <i>Fuchsia</i> spp. (also hybrids) | stem | 1 to 2 |
| Geranium | <i>Pelargonium</i> spp. | stem | 1 to 2 |
| Hoya | <i>Hoya</i> spp. | stem | 3 to 4 |
| Hydrangea | <i>Hydrangea</i> spp. | stem | 2 to 3 |
| Impatiens | <i>Impatiens</i> spp. | stem | 2 to 3 |



Cane cuttings



Heel cuttings



Single eye (left) and double eye (right) cuttings

the stem. The terminal bud is not necessary for this kind of stem cutting. Prepare and insert the cutting as you would a tip cutting. Be sure to position right side up. Axial buds are always above leaves.

- c. Cane cuttings: Cut cane-like stems into sections containing one or two “eyes” or nodes. Dust ends with fungicide or activated charcoal. Allow to dry several hours. Lay horizontally with about half of the cutting below the media surface, eye facing upward. Cane cuttings are usually potted when roots and new shoots appear. This method is used with dumbcane (*Dieffenbachia*).
- d. Single eye cuttings: The eye refers to the node. This is used for plants with

alternate leaves when space or stock material are limited. Cut the stem about 1/2 inch above and 1/2 inch below a node. Place cutting horizontally or vertically in the medium.

- e. Double eye cuttings: This is used for plants with opposite leaves when space or stock material is limited. Cut the stem about 1/2 inch above and 1/2 inch below the same node. Insert the cutting vertically in the medium with the node just touching the surface.

- f. Heel cuttings: This method uses plant material with woody stems. Make a shield-shaped cut about halfway through the wood around a leaf and axial bud. Insert the shield horizontally into the medium.

- 4. Leaf cuttings—Leaf cuttings are used almost exclusively for a few indoor houseplants. Leaves of most other plants will either produce a few roots but no plant, or they just decay. Covering leaf cut-

Table 2. (cont'd)

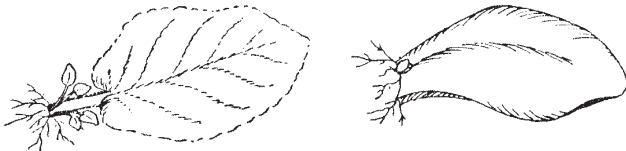
| Plant | | Type of cutting | Approximate time to root (weeks)* |
|-------------------------------|---|------------------------|-----------------------------------|
| Common name | Scientific name | | |
| Ivy | several genera and species | stem | 2 to 3 |
| Jade | <i>Crassula</i> spp. | stem or leaf | 4 to 5 |
| Kalanchoe (bryophyllum) | <i>Kalanchoe</i> spp. | stem or leaf | 4 to 5 |
| Lantana | <i>Lantana</i> sp. | stem | 3 to 4 |
| Monstera (Swiss cheese plant) | <i>Monstera deliciosa</i> | stem | 4 to 5 |
| Mint | <i>Mentha</i> spp. | stem | 2 to 3 |
| Peperomia | <i>Peperomia</i> sp. | leaf, leaf-bud or stem | 4 to 6 |
| | <i>P. obtusifolia</i> | leaf-bud or stem | 4 to 6 |
| | <i>P. obtusifolia variegata</i> | leaf-bud or stem | 4 to 6 |
| Periwinkle (myrtle) | <i>Vinca</i> spp. | stem | 3 to 4 |
| Petunia | Petunia hybrids | stem | 2 to 3 |
| Philodendron | <i>Philodendron</i> spp. | stem | 2 to 4 |
| Piggyback plant | <i>Tolmiea menziesii</i> | leaf with plantlet | 3 to 4 |
| Pothos | <i>Scindapsus aureus</i> | stem | 2 to 3 |
| Poinsettia | <i>Euphorbia pulcherrima</i> | stem | 2 to 3 |
| Sansevieria (snake plant) | <i>Sansevieria</i> spp. | leaf, leaf section | 4 to 6 |
| Velvet plant | <i>Gynura</i> spp. | stem | 1 to 2 |
| Wandering jew | <i>Tradescantia</i> spp. <i>Zebrina</i> spp. | stem | 2 to 3 |

*The indicated time for rooting is only approximate and may be longer under some conditions. Where new shoots must develop in addition to roots, the time required for shoot development is often longer.

Source: Propagating Herbaceous Plants from Cuttings, PNW 151.

tings with a plastic bag will maintain moisture in the medium and humidity around the cutting.

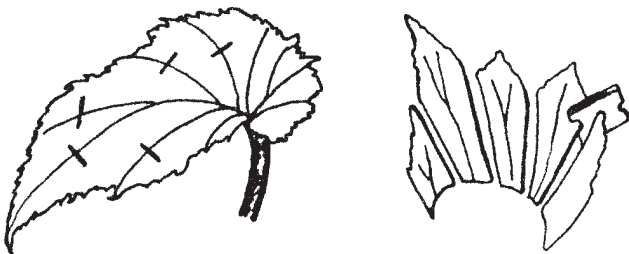
- a. Whole leaf with petiole: Detach the leaf and up to 1 1/2 inches of petiole. Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. The leaf may be severed from the new plants when they have their own roots, and the petiole reused. This method is used for African violets.



Whole leaf with petiole

Whole leaf without petiole

- b. Whole leaf without petiole: This is used for plants with sessile leaves. Insert the cutting vertically into the medium. A new plant will form from the axillary buds. The leaf may be removed when the new plant has its own roots. This method is used with jade plants.
- c. Split vein: Detach a leaf from the stock plant. Slit its veins on the lower leaf surface. Lay and pin the cutting, lower side down, on the medium. New plants will form at each cut. If the leaf tends to curl up, hold it in place by covering the margins with the rooting medium. This method is used with Rex begonias. A plastic bag around the container and leaf will help keep the leaf from drying out.



Split vein

Leaf section

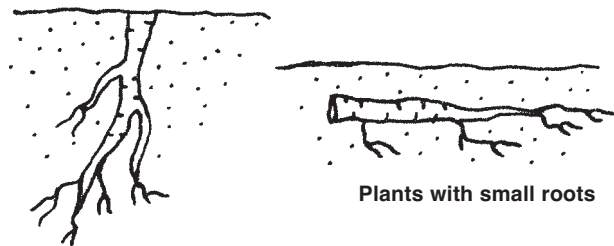
- d. Leaf sections: This method is frequently used with snake plant (*Sansevieria*) and Rex begonias. Cut begonia leaves into wedges with at least one

main vein. Lay leaves flat on the medium. A new plant will arise at the vein.

Cut snake plant leaves into 2-inch sections. Consistently make the lower cut slanted and the upper cut straight so you can tell which is the top. Insert the cuttings vertically into the medium. Eventually a new plant will appear at the base of the cutting. These and other succulent cuttings will rot if kept too moist. No plastic bag is needed around succulents.

5. Root cuttings—Root cuttings are usually taken from 2- to 3-year-old plants during their dormant season when they have a large carbohydrate supply. Root cuttings of some species produce new shoots, which then form their own root systems, while root cuttings of other plants develop root systems before producing new shoots.

- a. Plants with large roots: Make a straight top cut and a slanted cut 2 to 6 inches below the first cut. This will help you determine what portion is the top. Store about 3 weeks in moist sawdust, peat moss, or sand at 40°F. Remove from storage. Insert the cutting vertically with the top approximately level with the surface of the rooting medium. This method is often used outdoors.



Plants with large roots

Plants with small roots

- b. Plants with small roots: Take a 2- to 3-inch section of root. Insert the cutting horizontally about 1/2 inch below the medium surface. This method is usually used indoors or in a hotbed.

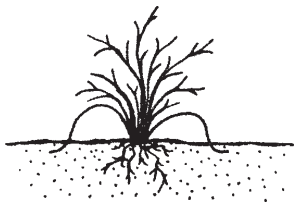
B. Layering

Stems still attached to their parent plants may form roots where they touch a rooting

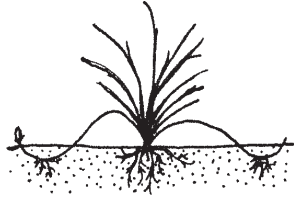
medium. Severed from the parent plant later, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, promotes a high success rate because it prevents water stress and the loss of carbohydrate shortage that plagues cuttings.

Some plants layer themselves naturally, but sometimes plant propagators assist the process. Layering is enhanced by wounding one side of the stem or by bending it very sharply.

1. Tip layering—Dig a hole 3 to 4 inches deep. Insert the shoot and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend, and the recurved tip becomes a new plant. Remove the tip layer from the mother plant and plant it in early spring or fall. Examples: purple and black raspberries and trailing blackberries.

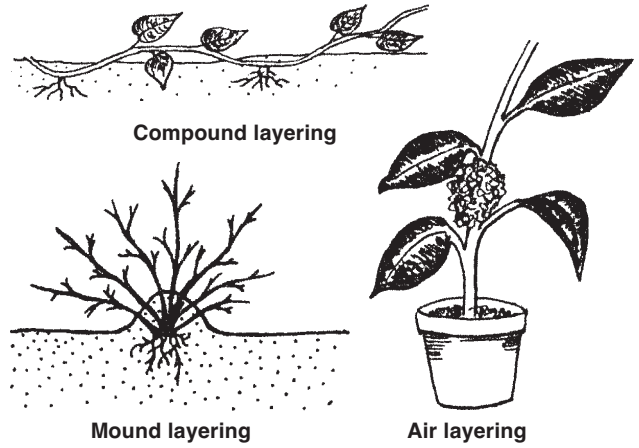


Tip layering



Simple layering

2. Simple layering—Bend the stem to the ground. Cover part of it with soil, leaving the last 6 to 12 inches exposed. Bend the tip into a vertical position and stake it in place. The sharp bend will often induce rooting, but wounding the lower side of the branch may help. Examples: rhododendron and honeysuckle.
3. Compound layering—This method works for plants with flexible stems. Bend the stem to the rooting medium as for simple layering, but alternately cover and expose stem sections. Wound the lower side of stem sections to be covered. Examples: heart-leaf philodendron and pothos.
4. Mound (stool) layering—Cut the plant back to 1 inch above the ground during the dormant season. Mound soil over the emerging shoots in the spring to enhance their rooting. Examples: gooseberries and apple rootstocks.



Compound layering

Mound layering

Air layering

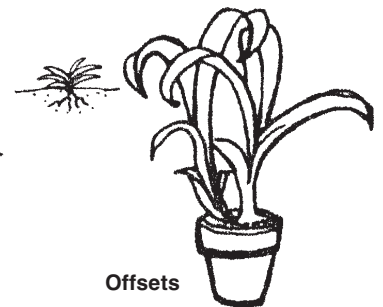
5. Air layering—Air layering is used to propagate some indoor plants with thick stems, or to rejuvenate them when they become leggy. Make an upward slanting cut one half way through the stem just below a node. Hold the slit open with a toothpick laid sideways or a bit of sphagnum moss. Surround the wound with wet, unmilled sphagnum moss. Wrap plastic or foil around the sphagnum moss and tie it in place above and below the wound. When roots pervade the moss, cut the plant off below the root ball. Examples: dumbcane and rubber tree.

Note: The following propagation methods can all be considered types of layering, as the new plants form before they are detached from their parent plants.

6. Stolons and runners—A stolon is a horizontal, often fleshy stem that can root and produce new shoots where it touches the medium. A runner is a slender stem that originates in a leaf axil and grows along the ground or downward from a hanging basket, producing a new plant at its tip. Plants that produce stolons or runners are



Stolons and runners



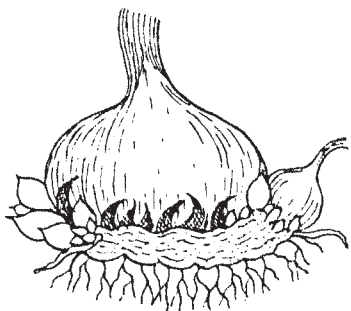
Offsets

propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent, or detached and placed in a rooting medium. Examples: strawberry and spider plant.

7. Offsets—Plants with a rosetted stem often reproduce by forming new shoots at their base or in leaf axils. Sever the new shoots from the parent plant after they have developed their own root system. Unrooted offsets of some species may be removed and placed in a rooting medium. Some of these must be cut off, while others may simply be lifted off of the parent stem. Examples: date palm, haworthia, bromeliads, and many cacti.

8. Separation—Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.

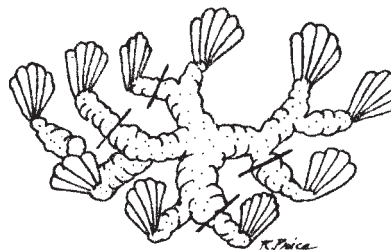
- a. Bulbs: New bulbs form beside the originally planted bulb. Separate these bulb clumps every 3 to 5 years for largest blooms and to increase bulb number. Dig up the clump after the leaves have withered. Gently pull the bulbs apart and replace them immediately so that their roots can begin to develop. Small, new bulbs may not flower for 2 or 3 years, but large ones should bloom the first year. Examples: tulip and narcissus.



Separation corms

- b. Corms: A large new corm forms on top of the old corm, and tiny cormels form around the large corm. After the leaves wither, dig up the corms and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms

with a fungicide and store in a cool place until planting time. Examples: crocus and gladiolus.



Division

C. Division

Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not jointed, gently pull the plants apart. If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Examples: snake plant, iris, prayer plant, and day lilies.

1. Most perennials left in the same place for more than 3 years are likely to be overgrown, overcrowded, have dead or unsightly centers, and in need of basic feeding and soil amendment. The center of the clump will grow poorly, if at all, and the flowers will be sparse. The clump will deplete the fertility of the soil as the plant crowds itself.
 - a. To divide mature clumps of perennials, select only vigorous side shoots from the outer part of the clump. Discard the center of the clump. Divide the plant into sections of three to five shoots each. Be careful not to overdivide; too small a section will not give much color the first year after replanting.
 - b. Divide perennials when the plants are dormant, just before a new season of growth, or in the fall so they can become established before the ground freezes.

D. Grafting

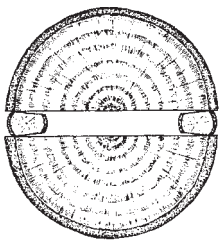
Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant. These

techniques are used to propagate cultivars that will not root well as cuttings or whose own root systems are inadequate. One or more new cultivars can be added to existing fruit and nut trees by grafting or budding.

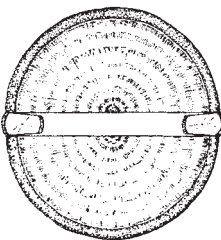
1. The portion of the cultivar that is to be propagated is called the scion. It consists of a piece of shoot with dormant buds that will produce the stem and branches. The rootstock, or stock, provides the new plant's root system and sometimes the lower part of the stem. The cambium is a layer of cells located between the wood and bark of a stem from which new bark and wood cells originate.

2. Four conditions must be met for grafting to be successful: (1) The scion and rootstock must be compatible, (2) each must be at the proper physiological stage, (3) the cambial layers of the scion and stock must meet, and (4) the graft union must be kept moist until the wound has healed.

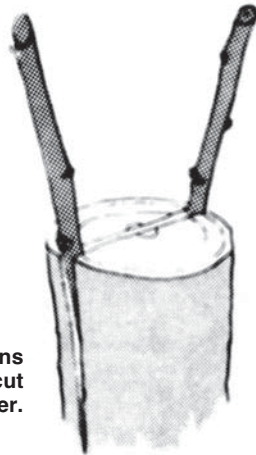
a. Cleft grafting: Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree (usually a seedling). It is especially successful if done in the early spring. Collect scion wood 3/8- to 5/8-inch in diameter. Cut the limb or small tree trunk off at the area that it is to be re-



Cleft graft (correct method on top; incorrect method below)

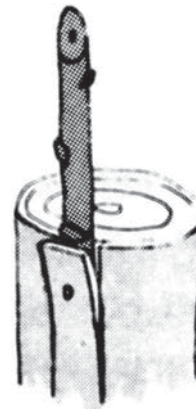


Cleft graft with both scions inserted at slight angles. All cut surfaces should be waxed over.



worked. Make a 2-inch vertical cut through the center of the limb or trunk. Be careful not to tear the bark. Keep this cut wedged apart. Cut the lower end of each scion piece into a wedge. Prepare two scion pieces 3 to 4 inches long. Insert the scions at the outer edges of the cut in the stock. Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.

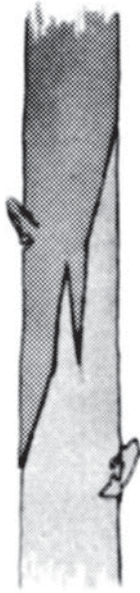
b. Veneer or bark grafting. Unlike most grafting methods, bark grafting can be



Bark graft

used on large limbs, although these are often infected before the wound can completely heal. Collect scion wood 3/8- to 1/2-inch in diameter when the plant is dormant, and store the wood wrapped in moist paper in a plastic bag in the refrigerator. Saw off the limb or trunk of the rootstock to be worked. In the spring, when the bark easily separates from the wood, make a 1- to 2-inch diagonal cut on one side of the scion, and a 1 1/2-inch diagonal cut on the other side. Leave two buds above the longer cut. Slice through the bark of the stock cutting a little wider than the scion. Insert the scion between the bark and wood with the longer cut against the wood. Nail the graft in place with flat-headed wire nails. Cover all wounds with grafting wax.

c. Whip or tongue grafting: This method is often used for material 1/4- to 1/2-



Whip or tongue graft

inch in diameter. The scion and rootstock are usually of the same diameter, but the scion may be narrower than the stock. This strong graft heals quickly and provides excellent cambial contact. Make one 2 1/2-inch sloping cut at the top of the rootstock and a matching cut on the bottom of the scion. On the cut surface, slice downward into the stock and up into the scion so the pieces will interlock. Fit the pieces together, then tie and wax the union.

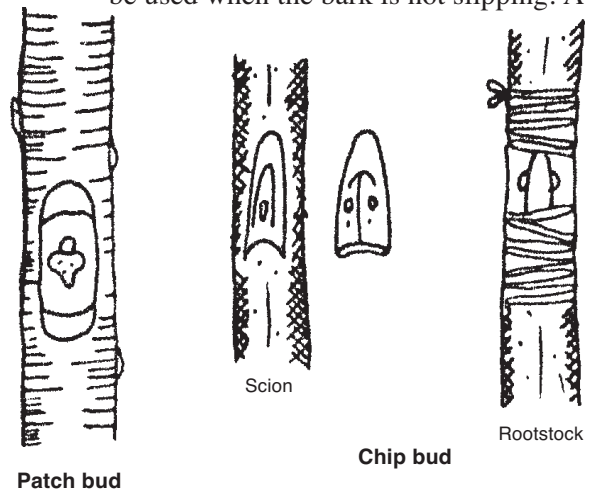
- Care of the graft—Very little success in grafting will be obtained unless proper care is maintained for the following year or two. If a binding material such as strong cord or nursery tape is used on the graft, this must be cut shortly after growth starts to prevent girdling. Rubber budding strips have some advantages over other materials. They expand with growth and usually do not need to be cut, as they deteriorate and break after a short time. It is also an excellent idea to inspect the grafts after 2 or 3 weeks to see if the wax has cracked, and if necessary, rewax the exposed areas. After this, the union will probably be strong enough and no more waxing will be necessary.
- Limbs of the old variety that are not selected for grafting should be cut back at the time of grafting. The total leaf surface of the old variety should be gradually re-

duced as the new grafted variety increases until at the end of 1 or 2 years, the new variety has completely taken over. Completely removing all the limbs of the old variety at the time of grafting will increase the shock to the tree and cause excessive suckering. Also, the scions may grow too fast, making them susceptible to wind damage.

E. Budding

Budding, or bud grafting, is the union of one bud (attached to a small piece of bark) from the scion to the rootstock. It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting.

- Patch budding—Plants with thick bark should be patch budded. This is done while the plants are actively growing, so their bark slips easily. Remove a rectangular piece of bark from the rootstock. Cut a matching rectangular piece with a bud and piece of bark from the scion to cover this wound. If the rootstock's bark is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped, the patch will be held firmly in place.
- Chip budding—This budding method can be used when the bark is not slipping. A



Patch bud

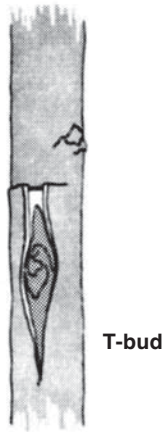
Chip bud

downward cut is made at a 45 degree angle about one quarter through the rootstock. About 1 inch above the first cut, a second cut is made slicing downward and inward until it connects with the first cut. The cuts removing the bud from the bud

stick are made just as those in the rootstock, except the lower cut is made about 1/4-inch below a bud. Fit the bud chip to the stock and wrap the union.

3. T-budding—This is the most commonly used budding technique.

When the bark is slipping, make a vertical cut through the bark of the rootstock, avoiding any buds on the stock. Make a horizontal cut at the top of the vertical cut (in a T shape) and loosen the bark by twisting the knife at the intersection. Remove a shield-shaped piece of the scion, including a bud, bark, and a thin section of wood. Push the shield under the loosened stock bark.



Wrap the union, leaving the bud exposed.

Care of buds—Place the bud in the rootstock in August. Force the bud to develop the following spring by cutting the stock off 3 to 4 inches above the bud. The new shoot may be tied to the resulting stub to prevent damage from the wind. After the shoot has made a strong union with the stock, cut the stub off close to the budded area.

F. Plant Tissue Culture

Tissue culture is a mass of undifferentiated callus tissue growing on an artificial medium, separately from the plant from which it originated. Size increases by cell division. After about 4 to 6 weeks, the mass of cells is large enough to divide into sections and reculture to produce additional tissue cultures. This procedure is usually done in a laboratory or under laboratory conditions. A tissue culture can be started from a variety of plant parts that have cells capable of dividing. Usually tissues near the vascular area of stems and roots proliferate best, but cultures have been started from fruits, endosperm, pollen, and embryos. To read more about this exciting method of propagation refer to books in your local library.

Further Reading

Books

The Virginia Master Gardener Handbook, Virginia Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The Nevada Master Gardener Handbook, University of Nevada Cooperative Extension, phone 702/784-4848.

Wilkins, H. M. 1988. *Plantwatching: How Plants Live, Feel, and Work*. MacMillan Co., New York, NY.

Wilkins, H. M. 1988. *Plantwatching: How Plants Remember, Tell Time, Form Partnerships, and Move*. Facts on File Publications, New York, NY.

Booklets and Pamphlets

CIS 869 Controlling Sunscald on Trees and Vines (25¢)

PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair (\$2.50)

CIS 866 Homeowner's Guide to Fruit Tree Fertilization (35¢)

CIS 881 Success with Very Small Seeds (35¢)

PNW 121 Nutrient Disorders in Tree Fruits (web only)

PNW 164 Propagating from Bulbs, Corms, Tubers, Rhizomes, and Tuberous Roots and Stems (50¢)

PNW 151 Propagating Herbaceous Plants from Cuttings (50¢)

PNW 170 Propagating Plants from Seed (\$2.50)

CIS 841 Seed Germination Test Methods for Home Use (25¢)

CIS 1043 Selecting Grape Cultivars and Planting Sites in Idaho (\$1.00)

PNW 400 Training and Pruning Your Home Orchard (\$1.00)

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Chapter Soils and Fertilizers



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Soils and Fertilizers



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I. Four Basic Soil Components

1. Mineral matter—about 40 to 50 percent of the soil.
2. Organic matter—about 0.5 to 5 percent of the soil.
- 3/4. Air + Water = 50 percent of the soil volume.

Note: Under wet soil conditions there is little air. Under dry conditions there is little water.

II. Three Principal Mineral Constituents in Soils

A. Sand

Particles range in size from 1.0 to 0.02 millimeters (mm). Sands are mainly structural components of soil. They have little or no chemical activity; they do not hold plant nutrients, and they can hold only small amounts of water. Sands are highly permeable to water movement and are considered very droughty.

B. Silt

Particles range in size from 0.02 to 0.002 mm. Silt particles carry a weak negative charge and are capable of holding small amounts of plant nutrients. Due to fine particle size, silty soils hold large amounts of water, and water movement through silty soils is generally quite slow.

C. Clay

Particle sizes are smaller than 0.002 mm. Clay particles carry strong negative charges capable of attracting all positively charged ions in the soil; as a consequence, clays are called the storehouse for plant nutrients. Fine particle size also equates to high water

holding capacity and can result in slow movement of water. Although there may be more total pore space in clay soils than in sands, most of the pore space in clay soils hold water, whereas most of the pore space in sand is large and holds mostly air. When clay soils are compacted, they frequently will take on colors of blue or red and may even have a foul odor. They are then said to be anaerobic (containing little or no oxygen).

III. Soil Texture

Soil textural classification refers to the percentages of sedimentation in the water method for particles of sand, silt, and clay in the soil medium. See Fig. 1 to determine the texture of a particular soil.

IV. Soil Structure

The arrangement of soil particles or their aggregates is referred to as soil structure. If soils are worked when too wet, the aggregates can break down, forming a higher percentage of small pores that hold more water and less air. These soils can be said to be structureless until reaggregation occurs. Soil structure is the aggregation of sand, silt, and clay into shapes with distinct sizes and strengths (Fig. 2).

V. Organic Matter—The Supplier of Plant Foods

Soil organic matter (OM) represents an accumulation of partially decayed and partially resynthesized plant and animal residues. A multitude of adverse soil/plant relationships can be corrected with good management of soil organic matter.

A. Adequate Organic Matter (3 to 5 percent)

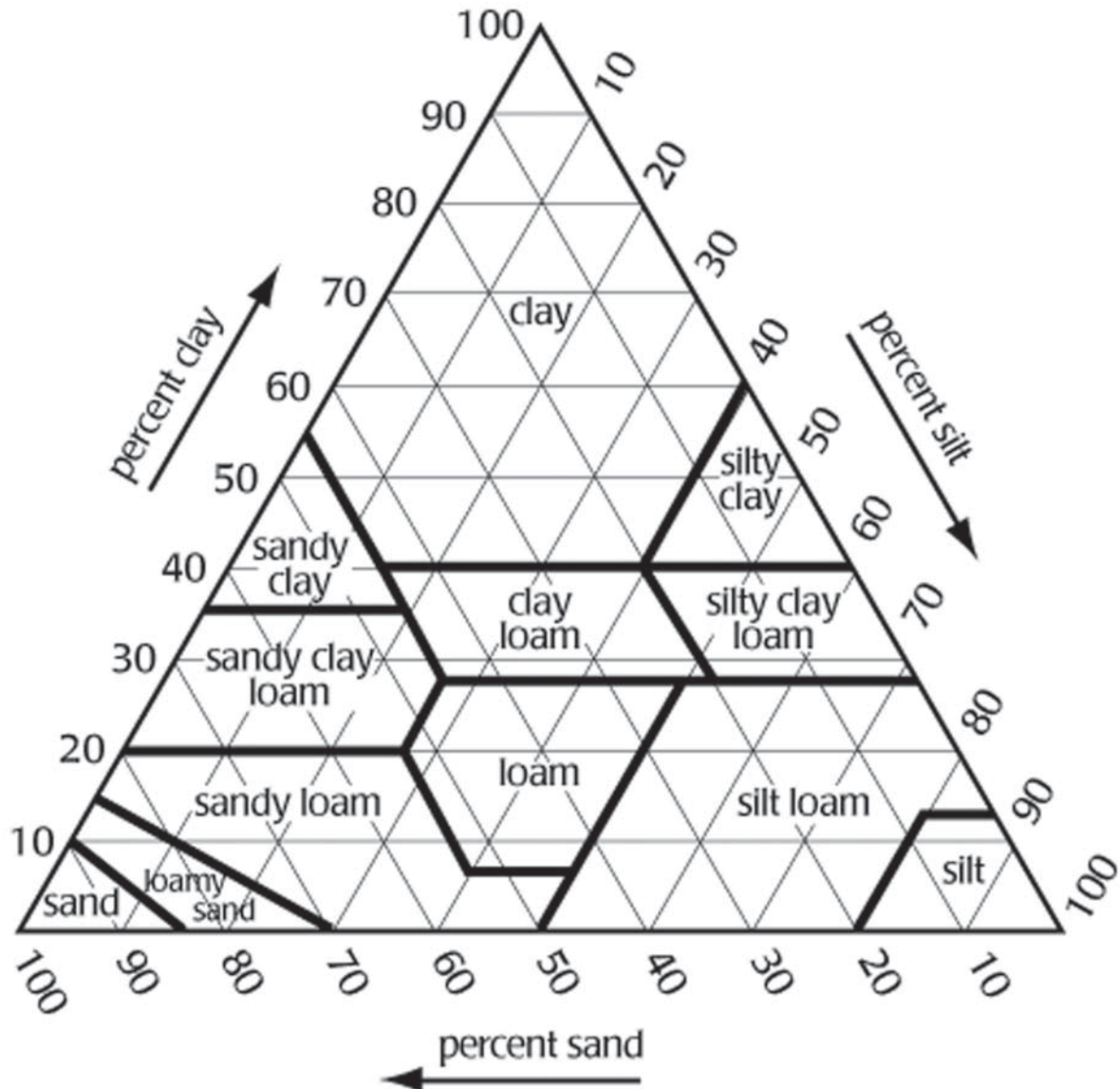
1. Contributes to friable soil through a granulation of soil particles.
2. Provides a major source of three nutrients—nitrogen, phosphorus, and sulfur.
3. Increases water holding capacity.
4. Increases soil air.
5. Regulates nutrient releases.
6. Assures that soils are neither too wet nor too dry and is a buffer against extremes in toxic conditions.
7. Provides an energy source for soil microorganisms (plants and animals).

B. Carbon/Nitrogen (C:N) Ratio

This is an important management tool.

1. Plant residues and manures are made up largely of the following:
 - a. Sugars, starches, and simple proteins that decompose rapidly.
 - b. Crude proteins.
 - c. Hemicelluloses.
 - d. Celluloses.
 - e. Lignin, fats, waxes, etc., that decompose slowly.
2. The rate of decay and release of nutrients to the soil varies greatly, as do the de-

Fig. 1. Guide for soil textural classification.

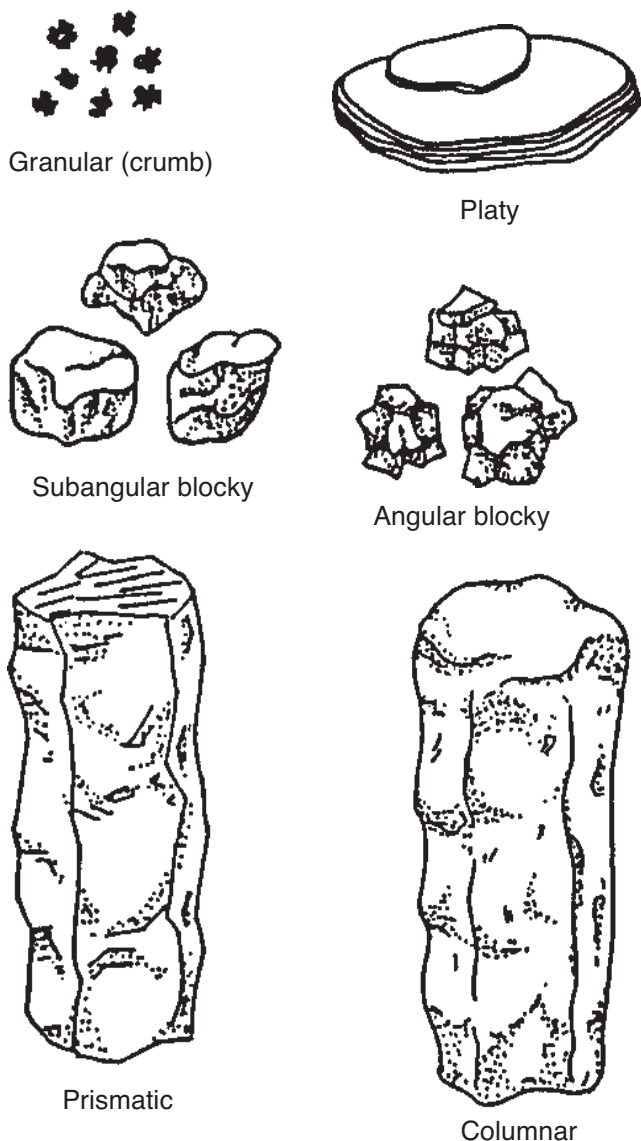


mands of the living soil microorganisms as they “break down” plant residue. Sawdust (made primarily of lignins and cellulose) utilizes vast amounts of energy in merely maintaining the life of the microorganisms that are digesting it. A major product of plant decay is nitrogen (N), while the undigested portion is primarily carbon (C). We like to maintain a ratio in our soil organic matter of about 10 carbons to 1 nitrogen (C:N ratio of 10:1). The C:N ratio for some common mulches is shown in Table 1.

Table 1. Average carbon:nitrogen ratios of products used for mulches.

| Material | C:N |
|-----------------------------|-------|
| Alfalfa hay | 18:1 |
| Pea vines, matured | 29:1 |
| Wheat straw | 373:1 |
| Oak leaves | 26:1 |
| Douglas-fir bark | 491:1 |
| Sawdust, weathered 3 years | 142:1 |
| Sawdust, weathered 2 months | 625:1 |
| Red alder sawdust | 134:1 |
| Peat moss | 58:1 |
| Cannery wastes, solids | |
| Beans | 10:1 |
| Pears | 63:1 |
| Humus | 10:1 |
| Soil bacteria | 6:1 |
| Farm manure | 90:1 |
| Grassland soils | 12:1 |
| Forest soils | 11:1 |
| Fine sandy loam | 7:1 |
| Coarse sandy loam | 25:1 |

Fig. 2. Soil structure consists of various shapes.



VI. pH—An Important Factor

A. Adaptive to Soil Conditions

Each plant species is adapted to specific acidic, neutral, or alkaline soil conditions. When ailing plants fail to respond to fertilizer application, usually this important acid-alkaline relationship (soil pH) is out of balance. The pH scale runs from 0 to 14. Seven is neutral, values below 7 are acid, and those above 7 are alkaline. These numbers represent a mathematical logarithmic term, for example:

- pH 8—10 times as alkaline as pH 7
- pH 7—Neutral
- pH 6—10 times as acidic as pH 7
- pH 5—100 times as acidic as pH 7
- pH 4—1,000 times as acidic as pH 7

B. pH and Nutrient Availability

The chart in Fig. 3 shows how pH affects the availability of nutrients.

C. Correcting Soil pH

1. To make soils more acid—Use soil test values; otherwise apply 10 to 15 pounds garden sulfur per 1,000 ft² or 1 to 1.5 pounds garden sulfur per 100 ft².

- To make soils less acid—Use soil test values; otherwise apply 100 to 200 pounds agricultural lime per 1,000 ft².

Note: The effectiveness of the above recommended soil amendments depends upon their fineness and contact with soil particles. Where possible, thoroughly mix amendments into the top 8 inches of soil.

VII. Ion Exchange

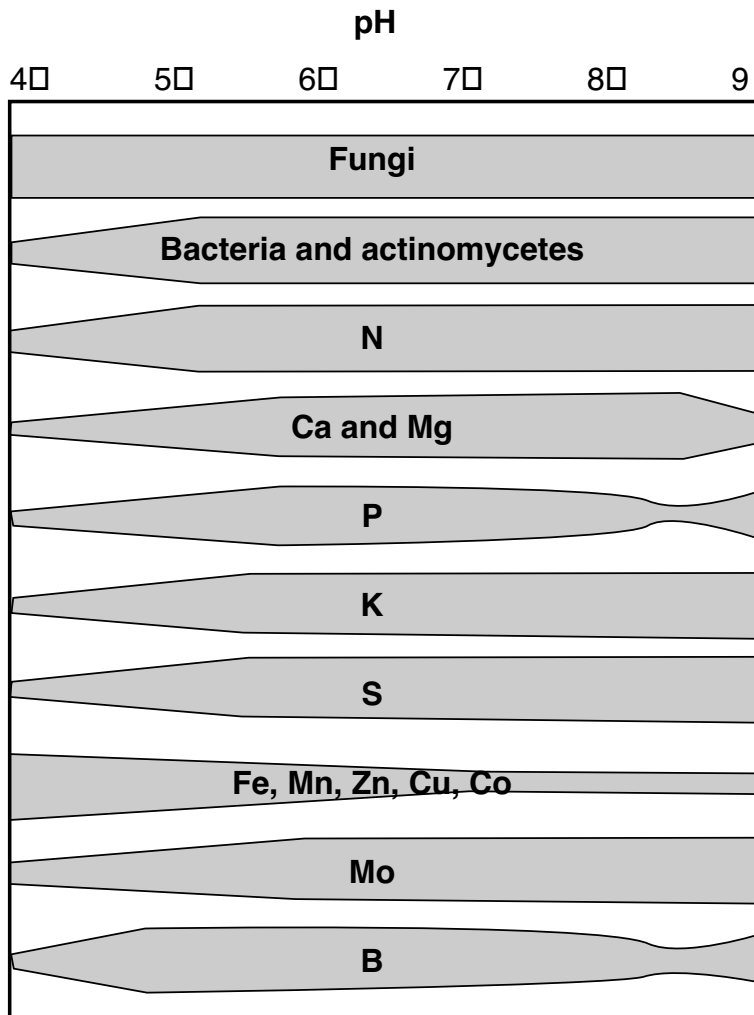
A. Definitions

- Ion**—An electrically charged particle. In soils, an ion refers to an electrically charged element or combination of elements resulting from the breaking up of an electrolyte in solution. Since most soil

solutions are very dilute, many of the salts exist as ions. For example, all or part of the potassium chloride (muriate of potash) in most soils exists as potassium ions and chloride ions.

- Cation**—Positively charged ion.
Example: potassium.
- Anion**—Negatively charged ion.
Example: chloride.
- Cation exchange**—The interaction (exchange) between a cation in solution and another cation on the surface of an active material (clay or organic matter).
- Cation exchange capacity (CEC)**—The sum total of exchangeable cations that a soil can absorb. This term is expressed in milliequivalents per 100 grams soil (meq/100 g).

Fig. 3. The effect of pH on soil microbial activity and the availability of nutrients.



- Idaho soils generally have CECs between 4 and 20 meq/100 g soil.
 - The CEC can hold
 - NH_4^+
 - K^+
 - Ca^{++}
 - Mg^{++}
 Micronutrient cations—Any pesticides that are **positively** charged.
 - The CEC will often prevent positively charged nutrients and pesticides from leaching into groundwater or being carried off by surface waters through erosion and runoff.
- Anion exchange**—The interaction of anions on the surface of an active material with those in solution.
 - Anion exchange capacity (AEC)**—The sum total of exchangeable anions that a soil can absorb expressed in meq/100 g soil.
 - Idaho soils have a low AEC. In fact, most soils have no AEC. AEC is found only in acid soils; therefore, it is not found in Idaho.
 - The AEC can hold
 - NO_3^-
 - SO_4^{2-}
 - H_2PO_4^-

Micronutrient anions—Any **negatively** charged pesticides.

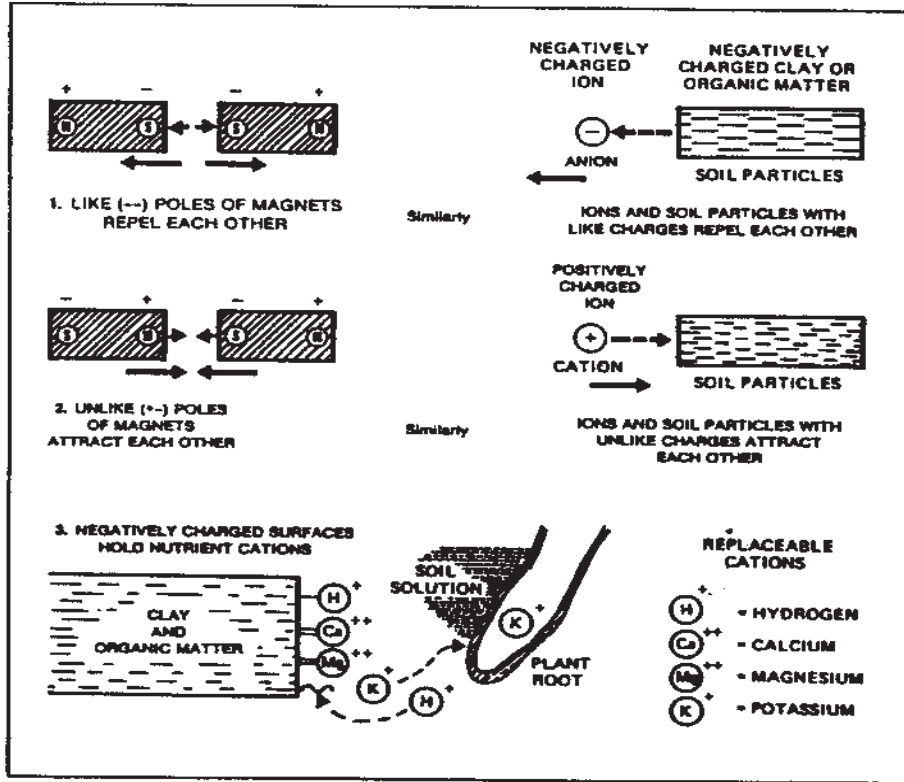
- c. Often the AEC will prevent positively charged nutrients and pesticides from leaching into groundwater or surface waters carrying them off by erosion and runoff as in Fig. 4.
- d. Since soils do not have significant AECs in Idaho, negatively charged nu-

trients and pesticides move with the soil water. Often they are lost by leaching into the groundwater or by surface water runoff.

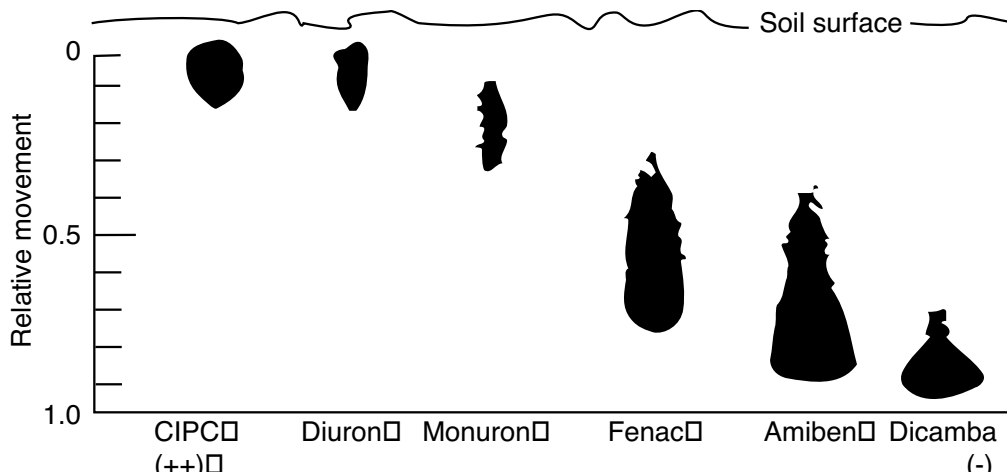
B. Nutrient Mobility

- 1. Nutrients get to plant roots by three major processes.
 - a. Contact exchange.
 - b. Mass flow.
 - c. Diffusion.

Fig. 4. Pesticide—positive charge to negative charge.



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2. Most movement is caused by diffusion (or a concentration gradient).
3. Relative movement of nutrients.

| | |
|--|------|
| Nitrate (NO ₃ ⁻) | X |
| Ammonium (NH ₄ ⁺) | .1X |
| Potassium (K ⁺) | .1X |
| Sulfate (SO ₄ ²⁻) | .1X |
| Phosphate (H ₂ PO ₄ ⁻) | .01X |
4. Why?
 - a. Nitrate and sulfate are anions. A soil with a high CEC actually repels nitrate and sulfate. There is nothing in the system to slow the movement of these nutrients. Organic material slows NO₃⁻.
 - b. Potassium and ammonium are cations. The CEC slows their movement. They take longer to reach a plant's root and are less likely to leach than nitrate and sulfate. The effect makes them 10 times slower in movement, and 10 times less likely to leach.
 - c. Even though phosphate is an anion, it moves extremely slowly; in fact, phosphate moves 100 to 1000 times slower than nitrate, because the phosphate anion is very reactive in soils. It reacts with Ca, Mg, and Al and is easily precipitated. Phosphate anions may move a distance of only 1 inch in soil during an entire growing season.
 - d. Anionic pesticides will probably behave like nitrate in soils; cationic pesticides will probably behave like potassium in soils (Fig. 4).

C. Soil Compactions

Compacted soils have low water infiltration rates. Because the soil's air spaces are disrupted, compacted soils hold smaller amounts of air and water. Compacted soils resist root penetration and are poor media for growth.

D. Water

Regulating the soil water is a major factor in Idaho. Excessive amounts of soil water are as harmful as not enough water. Soil air and soil temperature, two other important essentials to normal plant growth, are directly related to soil water.

E. Air

Plant roots need oxygen from the air. When all of the air space in the soil is filled with water, roots die from lack of oxygen. The small feeder roots are the first to be killed. If air is kept out of the soil long enough, even the larger roots are killed.

F. Root Damage

1. Plants with dead roots may be able to survive the early spring because the plant gets some moisture even through the dead roots. As the days become longer, warmer, and drier, and as the leaves get bigger, the plant runs short of water and wilts. If root damage is severe, the plant dies.
2. Sometimes a few roots near the surface will escape damage, and the plants will get by until the long, comparatively hot days of July and August. Even though the plants are watered, the remaining roots can't keep up with the needs.

VIII. Soil/Water Relationships

A. Water Infiltration Rate

This is the speed that a soil accepts water through the surface in inches per hour. The finer the soil texture, the slower the infiltration rate and vice versa. Infiltration rates of your soil will determine the rate of water application and whether heavy rainfall will enter the soil or run off (Table 2).

B. Permeability Rate

This term refers to the rate of movement of water down through the soil profile. Soil compaction, plow layers, hard pans, clay layers, or changes in soil texture all can influence the permeability rate of the soil.

Table 2. Water holding capacity of soils.

| Soil texture | Water infiltration | Readily available water |
|-----------------|--------------------|-------------------------|
| | (Inches per hour) | (Inches per foot) |
| Coarse sand | 3.0 | 0.7 |
| Fine sand | 2.0 | 0.9 |
| Fine sandy loam | 1.0 | 1.5 |
| Silt loam | 0.5 | 2.0 |
| Clay loam | 0.3 | 2.3 |
| Clay | 0.2 or less | 2.0 |
| Peat and muck | >3.0 | 2.5 |

3. Few trees and shrubs can tolerate wet soils without root damage. Table 3 lists some that you can use in heavy, wet soils.

G. Water Flow in Soils

1. Three factors affect water flow in soils.
 - a. Soil texture: Has a major impact on soil wetting rates and water flow. Fine-textured soils are slower to wet up, and water flow is slower; in coarse textured soils, water flow is much faster, and gravity has a greater effect on water movement.
 - b. Percent saturation of the soil: In saturated soil, water flow is greater; thus, there is a greater potential for leaching.
 - c. Organic matter: As OM increases so does the soil's holding capacity.

H. Leaching in Soils

1. Factors affecting leaching of nutrients/chemicals in soils include:
 - a. Amount of rainfall/irrigation.
 - b. Intensity of rainfall/irrigation.
 - c. Soil texture.
 - d. Cation/anion exchange capacity.
 - e. The percentage of organic matter.

2. A comparison of nutrients distribution with depth—If you broadcast 25 pounds of N, P, K, S, and Zn per acre, add 3 inches of water as per Fig. 5.
3. Fig. 6 shows a comparison of nutrient distribution with depth in different soil textures.
4. Fig. 7 is a comparison of nutrient concentrations in the same soil texture (e.g., sandy loam) with the addition of different amounts of water.

IX. Soluble Salts

Soluble salts (sometimes referred to as soil salinity or ECe) is a measure of the accumulation of salts in the soil. Salts can come from natural salinity of the soil, over applications of fertilizer and manure, wood ashes, high salts in irrigation water, or water evaporating seep areas. To see how soil salinity effects plant growth, refer to Table 4 on page 10.

X. Plant Nutrients

A. Source

From the soil, plants obtain 13 of the 16 elements essential to their growth. The other

Table 3. Trees and shrubs recommended for heavy, wet soils.

| TREES |
|---|
| Paper Birch (<i>Betula papyrifera</i>) |
| Black River Birch (<i>Betula nigra</i>) |
| Sweet Gum or Black Gum (<i>Nyssa sylvatica</i>) |
| Swamp Maple or Red Maple (<i>Acer rubrum</i>) |
| Poplars—roots get into tile drains |
| Willows—roots get into tile drains |
| SHRUBS |
| Swamp Azalea or Swamp Honeysuckle (<i>Azalea viscosa</i>) |
| Dwarf Bamboo (<i>Sasa veitchi</i>) |
| Low Grassy Bamboo (<i>Pleioblastus pumilus</i>) |
| Shrubby Cinquefoil (<i>Potentilla fruticosa</i>) |
| Red Osier Dogwood (<i>Cornus stolonifera</i>) |
| Elderberry (<i>Sambucus</i> , several species) |
| Dwarf Winged Euonymus (<i>Euonymus alatus</i>) |
| English Laurel (<i>Prunus laurocerasus</i>) |
| Bush St. Johnswort (<i>Hypericum densiflorum</i>) |
| Sweet Pepper Bush (<i>Clethra alnifolia</i>) |

Fig. 5. Nutrient distribution with depth—broadcast application of 25 lb of N, P, K, S, and Zn per acre plus 3 inches of water.

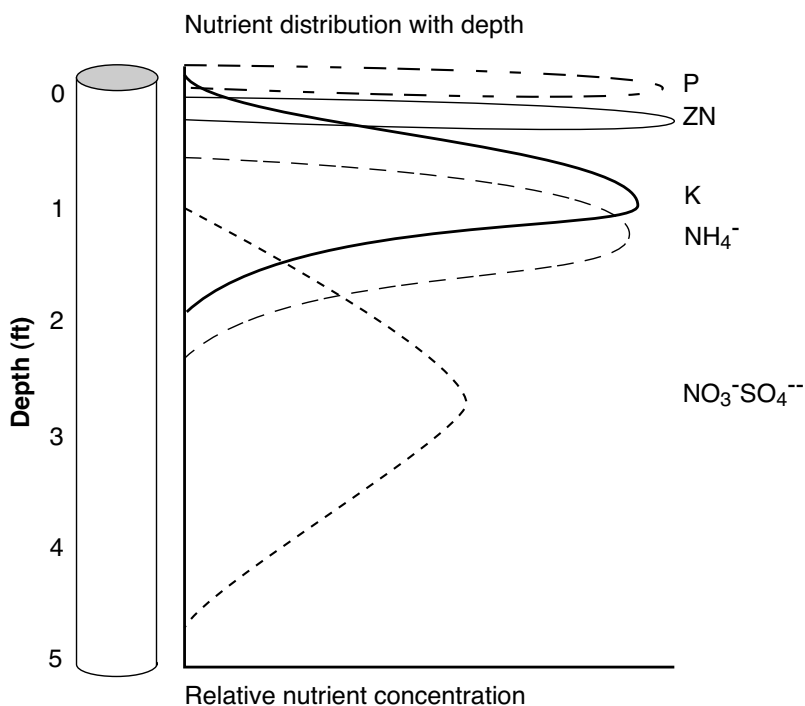


Fig. 6. A comparison of nutrient concentration in different soil textures.

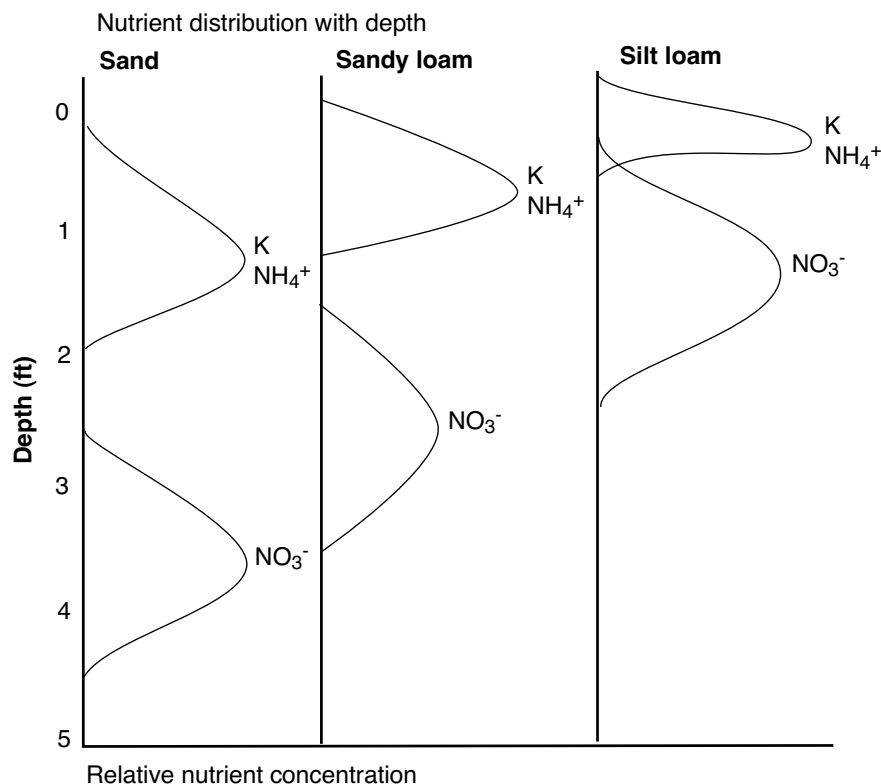
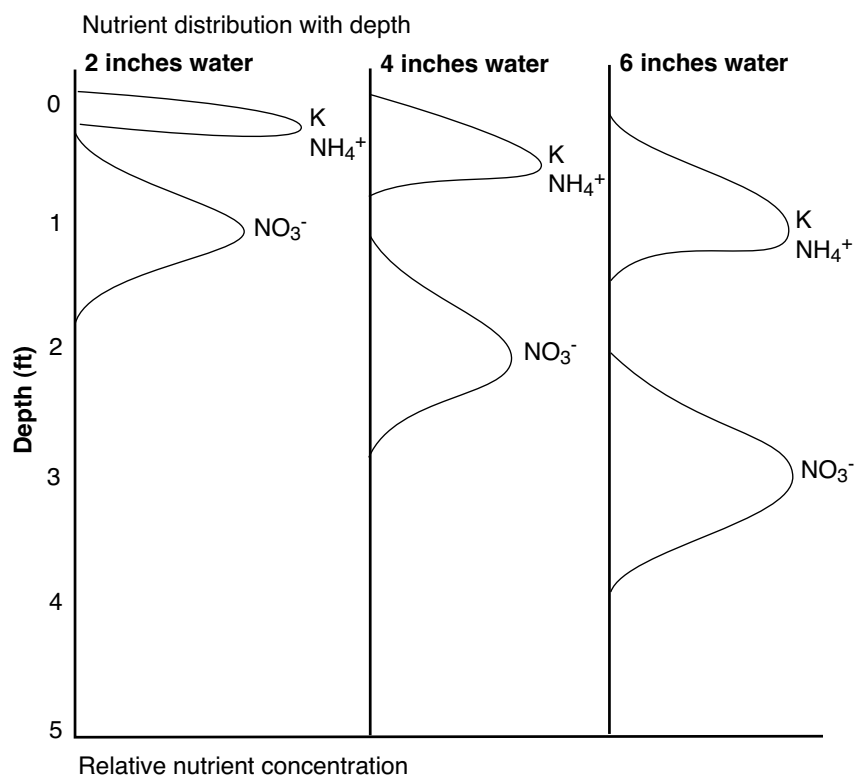


Fig. 7. A comparison of nutrient concentration in same soil texture (i.e., sandy loam) with different amounts of water.



three—carbon, hydrogen, oxygen—come from the water and from carbon dioxide in the air.

B. Element Classification

1. Major macronutrients—Large quantities are required.

- a. Nitrogen (N): Leaches readily.
- b. Phosphorus (P, or in fertilizers, designated as phosphate, P_2O_5): Does not leach, but will move with soil by such means as soil erosion, etc.
- c. Potassium (K, or in fertilizers designated as potash, K_2O): Will leach.

2. Secondary macronutrients—Less quantities required.

- a. Calcium (Ca)
- b. Magnesium (Mg)
- c. Sulfur (S): Will leach.

3. Micronutrients—Small quantities required. These usually are at sufficient levels.

- a. Boron (B)
- b. Copper (Cu)
- c. Iron (Fe)
- d. Manganese (Mn)
- e. Molybdenum (Mo)
- f. Zinc (Zn)
- g. Chlorine (Cl)

C. Functions of Macronutrients and Deficiency Signs

1. Nitrogen

- a. Function: Nitrogen gives dark green color to plants; induces rapid vegetative growth; increases yields of leaf, fruit, or seed; improves qual-

Table 4. Effects of salinity on plant growth.

| ECe (mmhos/cm) | Effect on plants |
|-----------------|--------------------------------------|
| Less than 2.0 | Only very sensitive plants effected |
| 2.0 - 4.0 | Restricts growth of sensitive plants |
| 4.0 - 8.0 | Growth restricted on many plants |
| 8.0 - 16.0 | Only salt tolerant plants grow |
| 16.0 or greater | A few tolerant plants will grow |

| Plant | ECe mmhos/cm (10 % reduction in growth) |
|--------------|--|
| Strawberries | 1.3 |
| Raspberries | 1.4 |
| Beans | 1.5 |
| Carrots | 1.7 |
| Onions | 1.8 |
| Lettuce | 2.1 |
| Peppers | 2.2 |
| Apple/pears | 2.3 |
| Potatoes | 2.5 |
| Sweet corn | 2.5 |
| Cabbage | 2.8 |
| Cucumbers | 3.3 |
| Spinach | 3.3 |
| Tomatoes | 3.5 |
| Cantaloupes | 3.6 |
| Broccoli | 3.9 |

ity of leaf crops; increases protein content of food and feed crops; and feeds soil microorganisms during their decomposition of low-nitrogen organic materials. Nitrogen tends to extend the length of the plant’s maturity period, but too much will cause the plants to fall over (lodge).

- b. Deficiency symptoms: Most Idaho soils are deficient in nitrogen. The plant turns a sickly, yellowish green; displays a distinctly slow and dwarfed growth; and dries up or shows “firing” of the leaves, a process that starts at the bottom of the plant. In plants such as corn and grasses the “firing” starts at the tips of the bottom leaves and proceeds down their centers.

2. Phosphorus

- a. Function: Phosphorus stimulates early root functions and growth; gives a quick and vigorous start to plants; shortens the plant’s maturity period; stimulates bloom and helps seed to form; and strengthens winter hardiness, especially for fall-seeded grasses.
- b. Deficiency symptoms: Many Idaho soils are deficient in phosphorus, especially those soils influenced by volcanic ash. The plants come up and start off slowly. Under conditions of severe deficiency, the leaves, stems, and branches become stunted, particularly in the seedling stage. The plant tends to have small, slender stalks and low yields of grain, fruit, and seed. Phosphorus deficiency leads to a lack of abundant, healthy flower clusters in most annuals, biennials, and perennials.

3. Potassium

- a. Function: Potassium serves as a nutrient regulator; increases vigor, strength, and disease resistance; makes stalks and stems stiffer; helps early roots form and grow; improves winter hardiness.
- b. Deficiency symptoms: Idaho soils are not usually deficient in potassium. A deficiency in potassium may cause the tissue to turn brown and dry up (“fire up”), particularly on the bottom leaves of crops. This sign of potassium deficiency differs from the firing caused by a nitrogen deficiency in that potassium deficiency caused firing around the edge of the leaf. With nitrogen, the firing goes down the center of the leaf. Legumes show potassium deficiency symptoms first in the tip, and then around the leaf edges. Potassium deficiency results in a premature loss of leaves and smaller than normal flowers. Plants such as corn fall down before maturing because of poor stalk development.

4. Sulfur

- a. Function: Sulfur promotes thicker and sturdier roots and leaf stems; and aids in overall leaf color. Sulfur is essential for protein synthesis and nodule formation in legumes.
- b. Deficiency symptoms: Most northern Idaho soils are deficient in sulfur. The deficiency leads to young leaves with a light green to yellowish color; in some plants, older tissue may be affected also. The plants become small and spindly; there is a retarded growth rate and delayed maturity.

5. Calcium

- a. Function: Calcium aids in the development of root structure and helps to correct soil acidity. It is an essential part of the cell wall structure and must be present for the formation of new plant cells.
- b. Deficiency symptoms: Idaho soils usually are nondeficient in calcium. Deficiency results in the death of the growing points on plants, and the root tips are also affected. The deficiency can be recognized by the abnormal, dark green appearance of the foliage, by premature shedding of blossoms and buds, and by weakened stems.

6. Magnesium

- a. Function: Magnesium is essential for photosynthesis, and serves as an activator for many plant enzymes required in growth processes.
- b. Deficiency symptoms: There are adequate quantities of magnesium in the majority of Idaho soils. Magnesium deficiency is most likely to be found in sandy, acid soils; it results in a characteristic interveinal chlorosis (yellowing) in older leaves and a curling of leaves upward along margins.

D. Functions of Micronutrients and Deficiency Symptoms

1. Zinc

- a. Function: Zinc aids in the synthesis of indoleacetic acid (IAA), an important plant growth regulator.

- b. Deficiency symptoms: Zinc deficiencies are rare in northern Idaho, though they occur in southern Idaho. Tree crops, grapes, beans, onions, tomatoes, and corn can be deficient in zinc. The characteristics of this deficiency are decreased in stem length, rosetting of terminal leaves, and reduced fruit bud formation. There also will be mottled leaves (interveinal chlorosis), a dieback of twigs after the first year, and a striping or banding on corn leaves.

2. Iron

- a. Function: Iron is required for the formation of chlorophyll in plant cells; it serves as an activator for biochemical processes such as respiration, photosynthesis, and symbiotic nitrogen fixation.
- b. Deficiency symptoms: Iron deficiencies are not a major problem in field crop production in Idaho. Deficiencies are usually found in southern Idaho on the occasions when they are a problem. They occur most likely in soils with a high pH and poor aeration. Plants most often affected are turf, certain tree crops, and ornamentals. They display interveinal chlorosis of young leaves. Veins remain green except in severe cases. Then there may be twig dieback or the death of entire limbs or plants.

3. Manganese

- a. Function: Manganese assists iron in chlorophyll formation and serves as an activator for enzymes in growth processes. Tree crops may have trouble growing well when the soil has this deficiency.
- b. Deficiency symptoms: Most areas in Idaho are not deficient in manganese, with the exception of the Kootenai River Valley of Boundary County. You can spot manganese deficiency when plants display interveinal chlorosis of young leaves, show a gradation of pale green coloration with darker color next to veins, and display no sharp distinction between veins and interveinal areas (as with iron deficiency).

4. Copper
 - a. Function: Copper is the activator of several enzymes in plants.
 - b. Deficiency symptoms: Copper deficiencies are generally only seen in northern Idaho, and in plants growing on soils containing more than 8 percent organic matter. A deficiency in copper results in stunted growth; die-back of terminal shoots in trees; poor pigmentation; and wilting and eventual death of leaf tips. Copper deficiencies are very difficult to diagnose by sight.
5. Boron
 - a. Function: Boron aids in differentiation of meristem cells; it regulates the metabolism of carbohydrates in plants.
 - b. Deficiency symptoms: Many Idaho soils are boron deficient. The results are a death of terminal growth, which causes lateral buds to develop and produces a “witch’s broom” of thickened, curled, wilted, and chlorotic leaves; soft or necrotic spots in fruit or tubers; and reduced flowering or improper pollination.
6. Molybdenum
 - a. Function: Molybdenum is required by plants for utilization of nitrogen.
 - b. Deficiency symptoms: Northern Idaho soils are widely deficient in molybdenum, but the problems only appear on legumes. The symptoms are the same as those in sulfur and nitrogen deficiencies.
7. Chlorine
 - a. Function: Chlorine is required in photosynthetic reactions in plants.
 - b. Deficiency symptoms: Not deficient in Idaho.

XI. Fertilizers

Every mixed fertilizer or individual material sold has a guaranteed analysis written on the bag stating the amounts of available nitrogen (N), available phosphate (P_2O_5), and soluble potash (K_2O), in that order (Fig. 8). The three numbers always are in percentages by weight.

In addition, certain secondary and micronutrients may also be included and will be so stated.

Caution—Apply the amount that is recommended, or that you know is desirable from past experience.

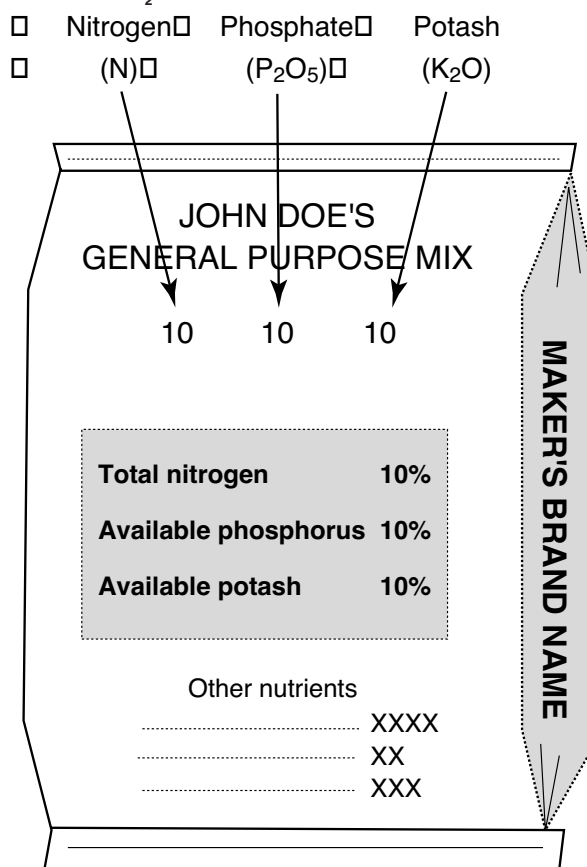
Many brands of fertilizers and nearly as many formulas are on the market. Select a brand that supplies the nitrogen (N), phosphate (P_2O_5), and potash (K_2O) in approximately the ratio your soil test indicates. The exact ratio is not critical. For example, if your test indicates you should use 1 pound of nitrogen (N), 2 pounds of phosphate (P_2O_5) and 1 pound of potash (K_2O), the ratio indicated is 1-2-1; you could use a 10-20-10, a 5-10-5, a 6-10-4, or an 8-17-7 analysis fertilizer. All of these are in approximate 1-2-1 ratios.

XII. Fertilizer Terminology

A. Fertilizer

Any substance added to the soil (or sprayed on plants) to supply those elements required in plant nutrition.

Fig. 8. Information found on a bag of fertilizer. You will find this type of information on all bags. The grade is the summary of the nitrogen, phosphate, and potash (by weight) contained in the bag. This sample contains 10% N, 10% P_2O_5 , and 10% K_2O in addition to other elements.



B. Mixed Fertilizer

A fertilizer that contains two or more of the three macronutrients (N, P, K).

C. Complete Fertilizer

A fertilizer that contains all three macronutrients (N, P, K).

D. Fertilizer Grade

The minimum guarantee of plant nutrient elements in fertilizers expressed in terms of total N, available P (expressed in terms of P_2O_5) and available potassium (expressed in terms of K_2O).

Examples: 16-20-0

16-20-0-14

E. Fertilizer Ratio

The smallest whole number relationship among N, P_2O_5 , and K_2O .

Example: A 5-10-10 grade is a 1-2-2 ratio.

XIII. Fertilizer Calculations

Example 1:

You wish to apply 3 pounds of P_2O_5 to a 1,000 square foot area. Your fertilizer has a grade of 11-55-0 (55 percent P_2O_5).

$$X = \frac{(\text{lb nutrient desired}/1,000 \text{ ft}^2)}{\text{analysis of desired nutrient}} \times 100$$

$$X = \frac{3 \times 100}{55} = \frac{300}{55} = 5.45 \text{ lb 11-55-0}$$

In addition you are adding some nitrogen. 5.45 lb of 11-55-0 x .11 (this is the percentage of N in this fertilizer) = .6 lb N

Example 2:

After taking a soil test, you find that you need to apply 1 pound of actual nitrogen per 1,000 square feet. Your fertilizer has a grade of 16-20-0. How much fertilizer should you apply to put on the nitrogen recommended?

$$X = \frac{(\text{lb nutrient desired}/1,000 \text{ ft}^2)}{\text{analysis of desired nutrient}} \times 100$$

$$X = \frac{(1 \text{ lb N}/1,000 \text{ ft}^2)}{16} \times 100$$

$$X = \frac{1 \times 100}{16}$$

X = 6.25 lb of 16-20-0 per 1,000 square feet

Note: 6.25 lb of a 16-20-0 fertilizer material is needed to supply 1 lb of N. Also, 6.25 lb of 16-20-0 would supply 1.25 lb of P_2O_5 ($6.25 \times .20$).

XIV. Fertilizer Types

A. Nitrogen

1. Gas forms.

- Ammonia (82-0-0) gas: Transported in pressurized containers.

Note: Special application equipment needed.

2. Solid forms.

- Ammonium nitrate (34-0-0 or 33-0-0): Half of N is in ammonium form and half is in nitrate form.

- 80 percent is used in agriculture.
- 20 percent is used in the manufacture of explosives.

- Urea 45-0-0: Rapidly replacing ammonium nitrate as the most widely used fertilizer because of:

- Economy of production.
- Higher percentage N content.
- Fewer pollution problems during manufacturing.

- Ammonium sulfate (21-0-0-24) contains 24 percent sulfur. This fertilizer is popular in areas where sulfur is deficient because it contains sulfur.

- ##### 3. Slow-release solid forms—Reduce nitrogen leaching losses, reduce salt damage to plants, and result in a release of nitrogen at a rate that is optimal for plant growth. These materials are much more expensive, but the increase in nutrient efficiency may offset the increase in cost if used properly.

- Sulfur coated urea (36-0-0-6).
- IBDU (Isobutylidene-Diuria).

4. Nitrogen solutions.

- Solution 32 (32-0-0) contains urea and ammonium nitrate.

B. Phosphorus

- Rock phosphate (0-25-0)—The phosphorus is not readily available on calcareous soils.

2. Triple superphosphate (TSP, 0-44-0 or 0-45-0)—Good, high-analysis phosphorus source.
3. Monoammonium phosphate (MAP, 11-55-0, 13-52-0)—An excellent phosphorus source with low nitrogen/high phosphorus.
4. Diammonium phosphate (DAP, 16-48-0, 19-52-0)—Contains medium nitrogen/high phosphorus and is an excellent mixed fertilizer.
5. Urea-ammonium phosphates (UAP or UAPP, 10-34-0)—Becoming more common; high analysis.

C. Potassium

1. Potassium chloride (KCl, 0-0-60)—Most common potassium source, 60 percent K_2O .
2. Potassium sulfate (K_2SO_4 , 0-0-50)—Second most common source, 50 percent K_2O .
3. Other sources—Potassium magnesium sulfate, potassium nitrate, and wood ash.

D. Sulfur

1. Elemental sulfur—98 percent sulfur, acidifies soils.
2. Nitrogen/sulfur.

| | |
|------------|-----------|
| 16-20-0-14 | 21-0-0-24 |
| 30-0-0-6 | 36-0-0-6 |
| 40-0-0-6 | |

XV. Mulches

Mulches fall into two categories: organic and inorganic.

A. Organic Mulches

Organic mulches includes grass clippings, hay, straw, bark, sawdust, wood shavings, leaves, and newspapers. You can use almost any plant material for mulching as long as it allows air and water to penetrate to the soil below. Coarse-textured material, such as stemmy hay, straw, wood shavings, and chips, are more desirable than fine-textured materials such as leaves and sawdust. If you use fine materials, loosen them occasionally to keep from sealing the soil surface.

B. Inorganic Mulches

Inorganic mulches include plastic films, mat-type weed barriers, aluminum foil, and even old carpets. Although inorganic mulches provide some of the same benefits as organic mulches, you cannot incorporate

them into the soil at the end of the growing season. You must remove them and store them. Perforate plastic films to allow water and air free passage.

C. Effectiveness

The effectiveness of mulches depends upon the material you are using and the weed species involved. You only need a thin layer of mulch to conserve soil moisture, and 2 or more inches to control weeds.

1. Summer mulches—Use summer mulches to control weeds, reduce water evaporation from the soil, stabilize water temperature, and reduce fruit rot on bared soil. Incorporated summer organic mulches into the soil in the fall to improve soil structure.
2. Winter mulches—Use winter mulches to reduce water loss from evergreen plant tissue and to stabilize soil temperatures. This will minimize perennial crop heaving caused by alternate freezing and thawing. Applying winter mulches too early in the fall may result in more winter injury than if you did not apply a mulch.

D. Problems

Organic mulches can introduce weed seeds as a mulch contaminant, or in the case of cereal straw, small grain seed. The mulch may attract rodents, insects, and other pests as an over-wintering site. Mulching too soon in the spring can keep soils cool reducing the growth of warm season crops. If you use bark, wood shavings, sawdust, or straw, it may be necessary to incorporate additional nitrogen fertilizer into the soil in the fall.

XVI. Green Manure and Cover Crops

By definition you grow and incorporate green manure crops into the soil to improve the soil while you grow cover crops primarily to reduce soil erosion and the leaching of nutrients. Usually, green manure crops are annuals and cover crops are perennials, either legumes or grasses. You can incorporate cover crops into the soil and use them as green manure crops.

A. Effectiveness

When managed properly, green manure and cover crops both add nitrogen to the soil for

Table 5. Cover crops and approximate nitrogen released.

| Plant | Percentage of nitrogen |
|----------------------|------------------------|
| Alfalfa | 3.0 - 4.0 |
| Austrian winter peas | 3.0 - 3.8 |
| Oats | 1.3 - 1.4 |
| Rye grass | 1.2 - 1.3 |
| Red clover | 2.8 - 3.2 |

the plants that follow them. See Table 5 for the approximate nitrogen percentages on a dry matter basis of some cover crops used as a green manure. They tend to increase the level of fertility and soil humus. They improve the soil's physical properties of aggregation, porosity, bulk density, and permeability. Their effects are more pronounced on fine-textured soil than on coarse ones.

B. Green Manure

1. The efficiency of using green manure crops depends on the soil, climate, and plant's growth. The conditions favoring microbial growth determines the rate of decay of the organic residues. Warm soil, proper aeration, and ample soil moisture increase microbial growth. The decomposition releases carbon dioxide and weak acids that act on insoluble soil minerals and release nutrients in addition to nutrients from insoluble minerals. The chemical composition of the plants affects their value for green manuring.
2. Green manure crops have little influence on organic matter if cultivation is continuous. In cooler climate, green manure can increase organic matter and nitrogen. In warmer regions, cultivation speeds up the rate of decomposition, and little or no increase of organic matter is observed.
3. Using green manure can lower bulk density of the soil and enhance porosity. Improved aggregation allows more space between soil particles, and therefore, less weight of soil by volume.
4. As grasses and cereal grains reach maturity they can tie up nitrogen, so you should incorporate them into the soil early in the growing season.

C. Cover Crops

1. Use cover crops for alleyways in orchards and vineyards to prevent weeds growing and in gardens for pathways. Usually, they require mowing two or three times a year, fertilization, and sufficient moisture. See Table 6 on the next page for a recommended list of cover crops for Idaho.
2. Cover crops reduce losses from leaching of nitrogen, potassium, and some other nutrients—especially when soils are light and sandy. Good ground cover reduces soil erosion by slowing down the beating action of rain on soil particles reducing water runoff. Plant cover increases the rate that water filters into the soil. Leaves and stems catch the rain and roots open channels for water.
3. Deep-rooted plants, such as some of the legumes, help open up soils with restricted subsoils. Plants grown for short term usually have little effect on heavy subsoils.
4. Perennial sod or cover crops increase soil organic matter and nitrogen. Legumes are superior to nonlegumes.
5. Some negative aspects of cover crops are that they compete with the main crop for nutrients and moisture. They can invade the main crop, so they require maintenance. Also, cover crops can provide a safe haven for gophers, mice, insects, and diseases that can invade the main crop.

Further Reading

Books

- Horticulture Edition of Western Fertilizer Handbook, 1990.* Soil Improvement Committee, California Fertilizer Association, Interstate Publishing.
- County Soil Surveys, Soil Conservation Service.
- Minnich, J., and M. Hunt. 1979. *Rodale Guide to Composting.* Rodale Press.

Booklets and Pamphlets

University of Idaho

- CIS 1066 Composting at Home (\$3.00)
- CIS 1041 Conduct Your Own Garden Research (\$2.00)

- CIS 863 Fertilizer Primer: Terminology, Calculations and Application (\$1.00)
 EXT 686 Fertilizer Questions (\$1.50)
 CIS 922 Fertilizing Gardens (35¢)
 CIS 1068 Fertilizing Landscape Trees (\$1.00)
 PNW 533 Fertilizing with Manure (\$2.00)
 CIS 815 Northern Idaho Fertilizer Guide: Blueberries, Raspberries, Strawberries (Web only)
 CIS 911 Northern Idaho Fertilizer Guide: Northern Idaho Lawns (\$1.00)

- BUL 775 Planning an Idaho Vegetable Garden (\$4.00)
 CIS 865 Quality Water for Idaho: Pesticides and Their Movement in Soil and Water (free)
 EXT 704 Soil Sampling (\$2.00)
 CIS 846 Southern Idaho Fertilizer Guide: Southern Idaho Lawns (\$1.00)
 CIS 1062 Starting a Home Lawn (\$1.50)
 CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments and Potting Mixes (35¢)

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Table 6. Recommended cover crops for Idaho.*

| Common name | Seeding rate | Establishment rate | Nitrogen requirement | Representative cultivars |
|------------------------------|--------------|--------------------|----------------------|---|
| | (lb/acre) | | (lb/acre) | |
| ANNUAL COVER CROPS | | | | |
| Barley (spring) | 120 | fast | 30-50 | Columbia, Steptoe |
| Barley (winter) | 120 | medium-fast | 30-50 | Mal, Scio |
| Buckwheat (common) | 35-60 | medium-fast | 10-20 | Common Gray, Japanese, Silverhull |
| Buckwheat (tartary) | 25 | medium-fast | 10-20 | Common varieties |
| Oats (spring or winter) | 120 | medium-fast | 30-50 | Amity (W), Walken (W), Grey Winter (W), Cayuse (S), Border (S), Kanota (S), Otana (S) |
| Peas (winter or spring) | 120 | medium-fast | by soil test | Austrian Winter (W or S), Melrose (S), Miranda (S) |
| Ryegrass (annual) | 30 | fast | 30-50 | Common variety |
| Wheat (spring) | 120 | medium-fast | 20-50 | Treasure, Bliss, Owens, Dirkwin, Fieldwin, Twin |
| Wheat (winter) | 120 | medium | 30-50 | Basin, Stephens, Dusty, Ute |
| Grain/pea | 80/100 | fast | 20-30 | Use varieties recommended in this table |
| PERENNIAL COVER CROPS | | | | |
| Grasses | | | | |
| Fescue (hard) | 20 | slow | 20 | Durar |
| Fescue (sheep) | 20 | very slow | 20 | Covar |
| Fescue (tall) | 25 | medium | 20 | Alta, Fawn, Forager, Kenhy |
| Perennial rye | 25 | fast | 30 | Elka, Linn, Manawa (H1), Manhattan, Noriea, Pennfine |
| Russian wildrye | 30 | slow | 20 | Vinall, Swift, Cabree, Bozoisky |
| Siberian crested wheatgrass | 35 | medium | 20 | P-27 |
| Standard crested wheatgrass | 25 | medium | 20 | Nordan |
| Forbs | | | | |
| White clover | 4 | medium | 0 | Dwarf types, English wild white clover |
| Strawberry clover | 4 | medium | 0 | Common varieties |

W = winter variety S = spring variety

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Chapter

Horticultural Equipment Management

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Horticultural Equipment Management



G. F. Gardner

George F. Gardner, Former Extension Educator, Bannock County, Pocatello

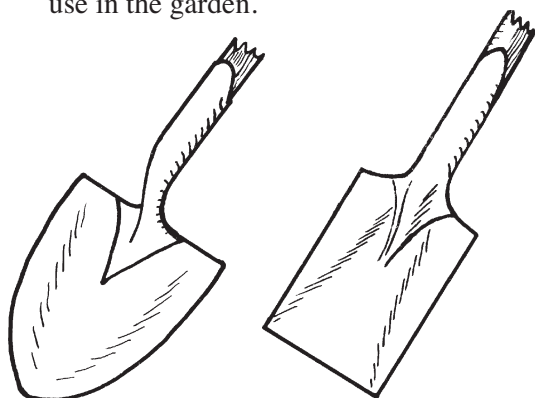
I. Equipment Selection

The type of equipment used to prepare your garden will depend on the size of the garden, as well as your physical ability, time, and budget. Options include a spade or shovel, a power rotary tiller, a small garden tractor, or a full-sized farm tractor.

A. Hand Tools for Cultivating

The minimum equipment needed by most gardeners is a shovel or spade, a hoe, a rake, and a trowel. A wide selection of styles is available. The right choice is one of personal preference and price. You can get the best value by knowing each tool's uses and particular qualities.

1. Shovel—A dish-shaped blade mounted to the handle at an angle and is used for moving soil. A garden shovel with a pointed blade is lighter and smaller than most other shovels and is well suited for use in the garden.



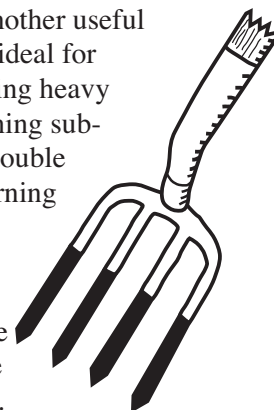
Shovel

Spade

2. Spade—A flat blade and designed for cutting rather than lifting or moving soil. A spade is an excellent tool for shaping straight-sided trenches and edging beds.

Note: Shovels and spades come with long handles in standard or D-shaped styles. Choice of handle style will depend on personal preference: long handles offer greater leverage and are less tiring to use; short handles are often thicker and stronger. For general purpose digging, lifting, and moving, a long-handled shovel is ideal.

3. Spading fork—Another useful digging tool. It is ideal for breaking and turning heavy soil and for loosening subsoil layers when double digging a bed. Turning coarse compost, spreading mulches, and digging root crops are other jobs suitable for a spading fork.

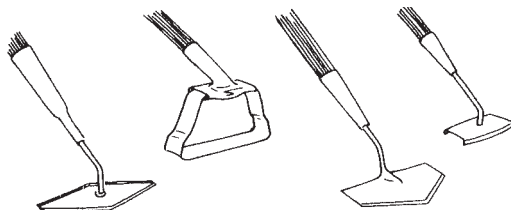


4. Hoe—Essential in any garden for preparing the seed bed, removing weeds, and breaking up encrusted soil. Several different hoe styles are available.
5. Pointed hoe—Has a heart-shaped blade and is lightweight and useful for opening seed furrows and cultivating between plants.
6. Hula—Or action hoe, is very lightweight and maneuverable. It is pushed and pulled just under the soil surface. Because the blade is relatively thin and lacks the clod-breaking capabilities of a heavier hoe, this type of hoe is most eas-



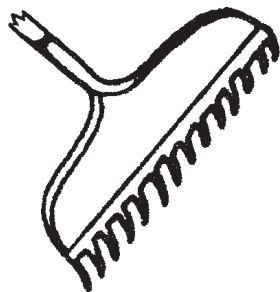
ily used where soil is not compacted and where weeds have not gotten started.

7. Scuffle hoe—Is somewhat more sturdy, and is used with a pushing motion rather than a pushing and pulling motion.



Different kinds of scuffle hoes

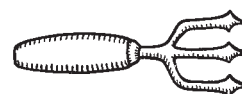
8. Square-bladed hoe—Probably the most commonly used hoe, lends itself well to many garden tasks.
9. Rake—Useful in clearing the garden of rocks and debris. It is also helpful in spreading mulches and smoothing seedbeds. The right rake depends on your size and strength and the uses you intend. As the number of tines increases, the rake weight also increases. Avoid choosing a rake that is so heavy it will tire you after a short period of use. The length of the rake handle is important too. The tip of the handle should come up to your ear when you stand upright. A handle that is too short will make your work harder, causing excess bending and back strain.



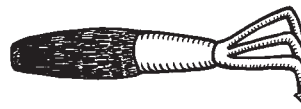
10. Trowel—Used for many digging jobs that do not require a full-sized tool. Especially in the spring, a trowel is perfect for transplanting seedlings and bulbs or digging shallow-rooted weeds.
11. Small hand cultivator—Often sold in sets with trowels, is useful for weeding small areas and between closely-spaced plants.
12. Digger—Also called a weeder, cultivator, or asparagus knife, is a small, useful digging tool. It is indispensable for digging up weeds with long taproots, such as dandelions or Queen Anne's lace; or for prying out Johnson grass rhizomes. It con-



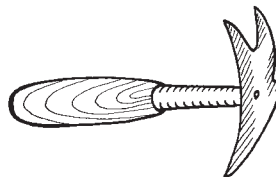
Transplant trowel



Small digging fork



Hand cultivator



Planting—Cultivating hoe



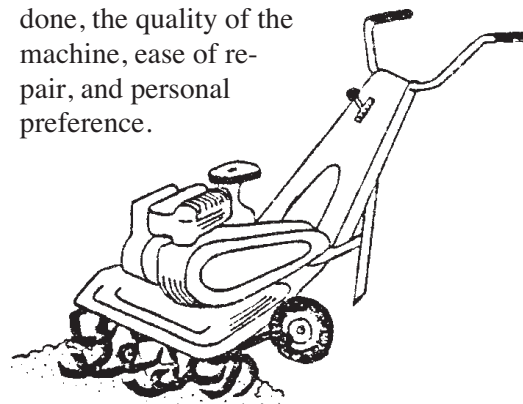
Dandelion digger or asparagus cutter

sists of a 10- to 14-inch long solid metal rod with a two-pronged blade at one end and a handle at the other. This tool is practically indestructible and well worth its price.

13. Pickax—Used to break up extremely stony or hard-packed soil.
14. Mattock—Used to break up soil, but is equipped with a cutting blade for removing large roots. A mattock may also be used to chop up debris for composting.
15. Wheel cultivator—Has a number of attachments for soil preparation and weed control and may prove to be a good investment for those with larger gardens.

B. Power Tools for Cultivation

1. Rototiller—The power rotary tiller is the tool most commonly purchased by gardeners. Whether you need a rototiller depends on the size of your garden, your capabilities, and the intended uses of the tiller. Tiller selection may be based on the nature of the work to be done, the quality of the machine, ease of repair, and personal preference.



The tiller's engine powers rotating blades, or tines, which turn the soil and makes it loose, fluffy, and ready for planting. It can also chop plant debris and mix it into the soil. The ability of the tiller to do these jobs effectively is a function of its weight, strength, design, type of tines, and type of soil.

A heavy, powerful tiller is most effective on stony clay soils, while a smaller tiller is more appropriate in a small garden or a garden with light soil. Very lightweight tillers, known as soil blenders, are designed mainly for raised bed gardening; however, they are not widely available and generally must be mail-ordered. A tiller is a major investment.

Look for tiller features such as: heavy cast iron, steel plate, and tubing; heavy bearings; strong welds used during construction; and easily operable controls. Ask to look at the operator's manual and try to determine how simply a tune-up can be performed. You can save yourself a great deal of trouble and money if you can replace plugs and points yourself. Also consider the locations of service centers and parts dealers. Careful attention to your needs, abilities, and price range is important.

Talk to people who have the types of tillers that interest you. If possible, borrow or rent various types of tillers and send for information before buying. If you are considering the purchase of a used rototiller, plan to do so well ahead of time so you will not be rushed into a purchase. If you know little about tillers, have a mechanically-minded friend evaluate the models you are considering.

Above all, test each tiller for ease of starting and operation. An engine that smokes or runs roughly may require a lot of work. Tines should operate smoothly and freely. Check the welds in the handles to see that they are strong; re-welding may mean that the handles have broken at some time, a common problem in older tillers. Look at the dipstick if there is one; low oil or very sludgy oil

may mean that the tiller has been poorly maintained. The oil and other fluids may also be checked by opening the drain plugs. Look for excessive dirt around the engine or in the air filter. This may also indicate bad maintenance habits.

- a. *Rear-tine tiller*—If gardening is a full-time business or if you have a large garden, it would be wise to purchase a rear-tine tiller. It should be a heavy-duty machine capable of continued operation. The rear-tine tiller is easier to control and is smoother in its cultivating process. It requires less maintenance because it doesn't bounce around; leverage is required for control. New gardeners are sometimes scared away from these tillers because they can run away with them.
 - b. *Front-tine tiller*—If gardening is simply a hobby, or if your garden is small, a front-tine tiller may be suitable. Front-tine tillers are usually light in weight, but may require considerable strength to guide them through the soil. Operating this type of tiller is comparable to handling a large floor polisher such as those used in schools and hospitals. Leverage is required for control. New gardeners are sometimes afraid that these tillers will run away with them. The front-tine tiller may not make as straight a path as the heavier rear-tine type, but it is much easier to turn. The front-tine tiller is easy to use in small gardens and in corner areas.
3. Cordless tools—Most are rechargeable, come with various cultivating attachments, and can make garden chores more pleasurable. Cordless tools are especially useful to those with physical disabilities that limit strength.
 4. Garden shredder—This tool is helpful for a large garden with a lot of plant wastes. Hand-operated shredders are slow but useful if wastes are in small quantities and are not too coarse. Gasoline shredders are quite expensive and may be disappointing to the gardener who wants to

chip branches and other large materials. Shredders are best used for shredding leaves, small branches, and other plant wastes. A chipper, on the other hand, will chip large branches and other coarse materials, but the cost (\$1,000) is high.

C. Wheelbarrow or Cart

A wheelbarrow or cart is handy to have in and around the garden area. It should be easy to handle when full. Durable construction is well worth the cost to ensure a long, useful life. Be sure to choose the size appropriate for your physical abilities and garden needs.

A wheelbarrow generally requires more strength and control than do most garden carts, but many of the small carts generally available are made of relatively flimsy metal and, though inexpensive, are not particularly long-lasting or suitable for heavy items such as rocks.

Consider your needs. If you plan to haul only light straw, leaves, or sawdust, then a small cart is suitable. For heavier jobs, a wheelbarrow or cart is needed.

The newer garden cart models, especially ones with bicycle-type tires, are made of heavy plywood and metal and are well-balanced and easy to maneuver.

Note: These carts do, however, cost a lot (up to several hundred dollars) and a large storage space. Only serious gardeners, or those with other uses for these carts, find them economical. One alternative is to build your own from one of several plans available from gardening magazines or private companies.

D. Watering Equipment

Watering is one job that most gardeners must do at least occasionally. An adequate water supply may make a big difference in garden yields. Purchase of watering equipment depends upon available facilities, water supply, climate, and garden practices. Determine whether cultural practices such as mulching, close plant spacing, shading, or wide-bed planting will meet most of your extra water needs, then purchase watering gadgets accordingly.

1. Spigot—If there is no outdoor spigot near the garden, the expense of having one installed may be greater than the benefits gained, except in very drought-prone areas, or in the case of a gardener who is fully dependent on the season's produce.
2. Rain barrel or garden hose with a fan-type sprinkler—This simple watering equipment will suffice where rainfall is adequate, except occasionally in summer.
3. Water breaker—Useful for small seedlings.
4. Drip irrigation system—In areas where there are extended periods of hot weather without precipitation, the local water supply is likely to be short. Since overhead sprinklers waste water, a drip irrigation system may be in order. Drip irrigation puts water right at the roots and doesn't wet plant leaves, thus helping to prevent disease. Timers are available for automatic drip watering systems, but this type of system is relatively expensive and may be considered a nuisance by some gardeners because of maintenance and replacement requirements.
5. The soaker hose—Probably the least expensive and easiest water system to use. It is fibrous hose that allows water to seep out at a slow rate all along its length. There are also hoses with holes in them that do basically the same thing. A flow regulator usually has to be included with the system so that water can reach the end of the hose, yet not be sprayed out at full force. A special double-wall type irrigation hose has been developed that helps to maintain an even flow.
6. Emitter-type system—Best used for small raised bed or container gardens. With this system, short tubes, or emitters, come off a main water supply hose. Emitters put water right at the roots of the desired plants. This is generally the most expensive form of irrigation and most complex to set up.

E. Seedling and Planting Tools

Depending on the size of your garden and your physical abilities, you may want to consider a row seeder.

1. Seeders—With wheels make easy work of sowing long rows of corn, beans or other vegetables. Seeders are available that make a furrow, drop the seeds properly spaced, and close up the furrow. It is not worth the effort to set up a seeder for small areas. A hand-held seeder is probably a better choice for this type of work.
2. Broadcast seeders—Are available for sowing seeds such as rye or wheat for cover crop, but are generally not necessary for the average home gardener, because broadcasting is easily done by hand once you learn the proper technique.
3. Fluid-sowing kits—Contain presprouted seeds in a gel that prevents drying. These kits may be purchased, but fluid sowing devices may be made inexpensively.

F. Environmental Monitoring Equipment

Serious gardeners often invest in equipment that allows them to monitor the microclimate around the garden or indoors.

1. Rain gauge—An inexpensive device that helps you determine if enough rain has fallen for garden plants.
2. Maximum-minimum thermometer—A costly, but often useful, device to measure soil temperature and internal temperature of a compost pile.
3. Light and watering meters—Can be purchased for indoor plant monitoring. Electronic water meters measure the conductivity of soil, but are often greatly influenced by fertilizers and other salt concentrations, resulting in a variable or inaccurate measurement of water availability. Tensiometers work well for measuring water content.

G. Trellises and Cages

For vining plants, these save space and keep fruits off the ground, reducing plant damage and minimizing the amount of stooping required for harvest. Look for heavy-duty materials and sturdy designs that will stand up to rain, wind, and drying. Wire should be heavy gauge and wood should be treated with nonphytotoxic (nontoxic to plants) materials or materials nontoxic to humans. Metal parts should be rust-proof or rust-resistant.

If you build your own trellises and cages, you may save a considerable amount of money and get better quality.

H. Harvesting Equipment

Varies depending on the size and type of garden, whether food is to be stored, and the way in which it is to be processed.

1. Baskets—Useful to most gardeners. Baskets may be purchased at garden or farm supply stores or sometimes may be scrounged from local grocery stores or fruit stands. Berry baskets for carrying small fruits, baskets with handles for carrying vegetables, and peck or bushel baskets for storing fruits and vegetables are all useful.
2. Fruit pole pickers—Useful and easy to use for tall fruit trees.
3. A sharp knife—For cutting vegetables off plants is handy and helps prevent plant damage.

II. Equipment Purchases and Maintenance

A. Equipment Purchases

When purchasing tools, buy for quality rather than quantity. Your tools will be in frequent use throughout the garden season. Cheap tools tend to break or dull easily and may end up making your job unnecessarily difficult and frustrating. Quality tools will last and tend to increase in value if well kept.

Tools should be lightweight for easy handling, but heavy enough to do the job properly. Metal parts should be of steel, which will stay sharp, will keep their shape, and will outlast softer metals. Consumers' magazines and garden publications frequently have articles explaining what to look for in tools and listing alternatives to local hardware stores, which often carry a single line of tools. Several excellent books featuring garden tools have been published and may be available at the library.

B. Equipment Maintenance

Keeping a tool clean and sharp will increase its usefulness and lengthen its life. Learn the techniques of sharpening each tool and practice them frequently. Professional gar-

deners often carry sharpening stones or files and sharpen their tools every hour or so while working.

Clean tools after each use. One effective method is to keep a five-gallon bucket filled with sand and used motor oil in the tool shed. At the end of the gardening day, remove clinging dirt from tools by plunging them into the oily sand several times. This will keep the tools cleaned and oiled, and will help prevent rusting.

Perhaps the most important step in tool care is to put tools in their proper place. Tools left in the garden will rust and break and can be a safety hazard. Some gardeners paint handles with a bright color to make their tools easy to spot.

III. Cultivation Practices

A. Types of Soil Cultivation

1. Plowing—It once was assumed gardens should be turned yearly with a moldboard plow, mostly for weed and pest control. While garden plowing is still a common practice, turning the soil over completely has been found to be detrimental in some cases. It can cause soil compaction, upset balances of microorganisms, and bury layers of coarse organic material below the influence of insects and microbes, which would otherwise cause the materials to decompose.
2. Chisel plowing—This does not have this disruptive effect, is one alternative, but it is limited to sandy or loamy soils. Many gardeners do not have chisel plows. In addition, gardeners in non-rural areas have trouble finding a person who will plow and disk a garden for a reasonable price.
3. Rototilling—Most home gardens' soil condition is sufficient, as long as plant debris is not excessive. Rotary tilling mixes rather than turns the upper layers of soil. One possible harmful effect of rototilling is the formation of a compaction layer just beyond the reach of the tines. Use of deep-rooted cover crops or double digging can help prevent or alleviate this problem.

4. Hand cultivation—By spading the soil deeply until it is loose and drains easily, prepares the soil.

B. Cultivation Time

Fall tillage has several advantages over the traditional spring plowing. It allows earlier spring planting, since the basic soil preparation is already done when spring arrives. Turning under large amounts of organic matter in fall is likely to result in better decomposition because autumn temperatures are higher than those in early spring, and the process has more time to take place. Insects, disease organisms, and perennial weeds may be reduced by killing or inactivating them through burial or exposure to harsh winter weather. The physical condition of heavy clay soils may be improved by the alternate freezing and thawing, which break up hard clods. Fall tilling alone is not recommended for hillside or steep garden plots since the soil is exposed all winter and is subject to erosion when spring rains come.

If a winter cover crop is grown to improve soil and to prevent erosion, the ground will have to be tilled in the fall to prepare the soil for seed and again in spring to turn under the green manure. A cover crop decreases erosion of the soil during the winter, adds organic material when it is incorporated in the spring, improves soil tilth and porosity, and adds valuable nutrients.

Spring tillage is better for sandy soils and those receiving shallow tilling. Generally, most gardens must be disked or rotary tilled in the spring to smooth the soil for planting.

C. Cultivation Requirements

Work the soil only when the conditions are right. Pick up a handful of soil and squeeze it. If the soil crumbles freely, it should be about right. Take samples at the surface and at a 2- to 3-inch depth at several locations in the garden plot. If the soil is powdery or in clumps, it may be excessively dry and difficult to work. If soil sticks to a shovel, or if the turned surface is shiny and smooth when spaded, it is still too wet. Working soil when excessively wet can destroy soil structure, which may take years to rebuild. Plowing with a tractor when soil is wet is

especaially damaging. It causes the formation of a compaction layer that will inhibit root growth. Soils with adequate humus levels generally make cultivation easier because of their improved structural qualities.

Just before planting, break up large clods of soil and rake the bed level. Small-seeded vegetables germinate best in smooth, fine-surfaced soil. Do not pulverize seedbed soil. This destroys the structure and promotes crusting and erosion problems.

Any addition to the soil that improves its physical or chemical condition is considered a soil amendment. Many types of amendments are available to the home gardener.

Further Reading

- PNW 320 Calibrating and Using a Backyard Sprayer (\$1.50)
- CIS 792 Calibration and Safe Use of Lawn and Garden Pesticide and Fertilizer Applicators (35¢)
- CIS 1054 Low Input Landscaping (\$1.00)
- CIS 1065 Improving Sprayer Accuracy: Simple Methods for Correct Calibration (\$1.00)
- CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes (35¢)
- EXT 726 Weed Control in the Home Garden (50¢)

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Chapter
Plant Management

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Plant Management



S. M. Bell and G. F. Gardner

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I. Plant Selection

Select plants adapted to your cold hardiness zone and growing season. Woody plant materials growing in Idaho can survive most winters without damage if they are rated for zones 2 to 4 for the mountainous areas and zones 4 to 6 for lower elevations (see Fig. 1 and Chapter 15, "Landscaping," Section IIIB). Dormant plants can withstand low temperatures better than those that are not, as long as low minimum temperatures do not last too long.

Plants such as vegetables grown from seed should be selected to fit the length of growing season in your area. Talk to your local extension educator who will know your area. In mountainous areas many microclimates may exist.

II. Plant and Garden Location

A. Plant Location

Choose the right location for the right plant. Determine the best location by reading the growing requirements written on the plant tag, the seed packet, or in a garden book.

Pay close attention to the amount of light and moisture, range of temperature required, and type of soil best suited for the plant.

Avoid planting under house eaves and downspouts. Dripping water can physically damage plants and cause over watered conditions conducive to root rots.

Avoid planting near sidewalks, driveways, white-painted fences, and buildings that can reflect excess light or heat back on to plants to adversely affect growth. Eastern and northern exposures are good for plants that need shade, however, they provide less light

and heat than southern and western exposures. Planting on berms and slopes will greatly affect drainage and influence plant growth. Keep that in mind when selecting and placing plants.

B. Garden Location

A garden positioned higher than the surrounding area usually will not experience the same cold temperature because cold air, being heavier than warm air, flows down to low lying areas. Solid fences, walls, and thickly planted hedges will, however, impede the flow of cold air to cause a frost pocket. Gardens surrounded by these barriers may suffer more cold damage than those areas that allow free drainage of cool air.

III. Plant Site Preparation

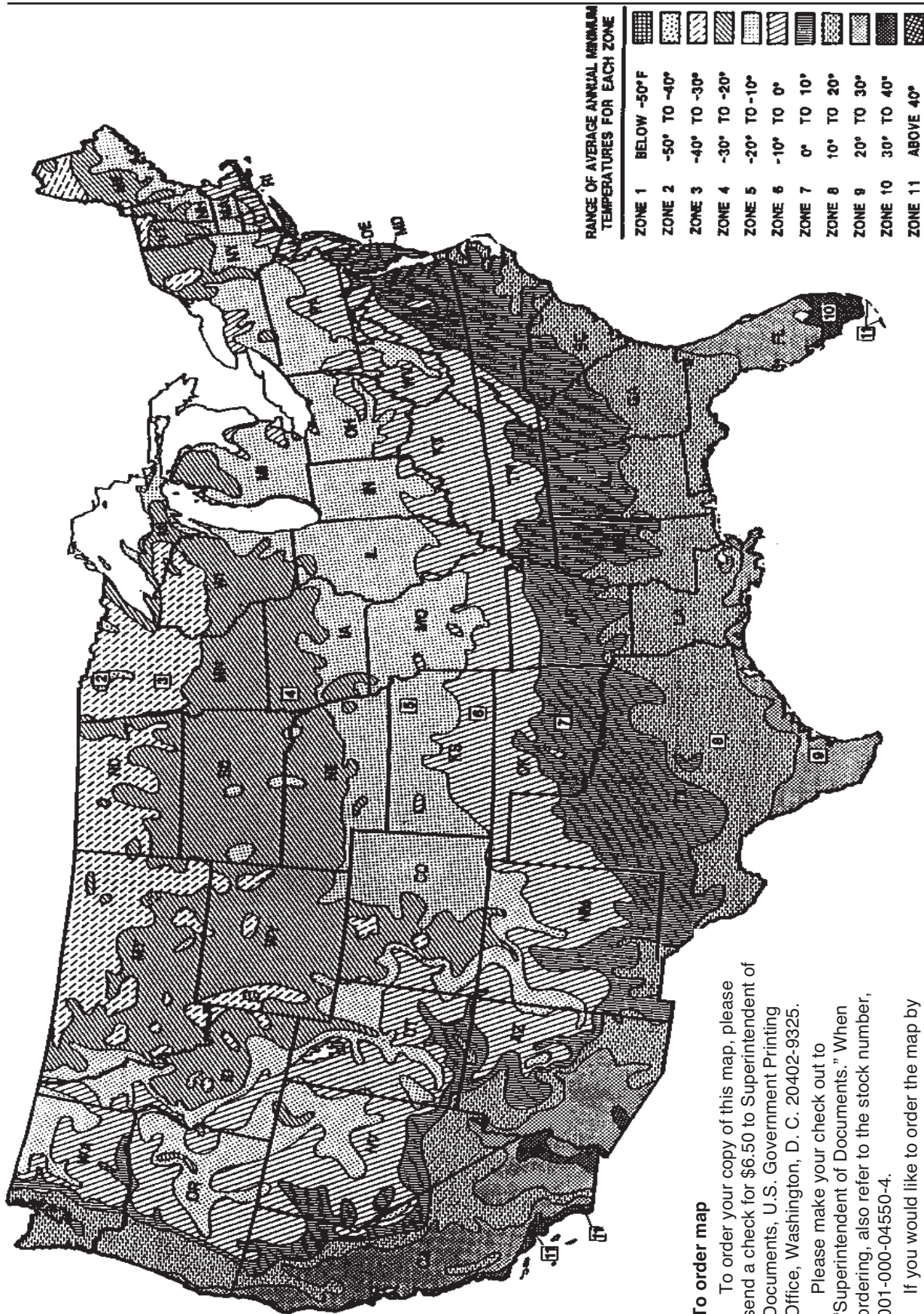
When preparing the planting area, add finished compost (1 to 2 inches) to the entire area if the soil is low in organic matter, very sandy, or heavy clay. Mix it into the top 9 to 12 inches of soil before planting. Adding organic matter each year around plants, even on the soil surface, will improve soil structure as well as water and air movement in the soil. Use of raised beds, mounding, and berms will also improve water and air movement if soils are heavy clay. In areas with high water tables, tile drains can be installed.

IV. Planting Procedures for Seeds and Transplants

A. Seeds

Planting depth is dependent on seed size. Follow the recommendations on the seed packet.

Fig. 1. Zone map.



To order map

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B. Bareroot Plants

This kind of plant has had the soil washed or shaken from its roots after digging.

1. Nearly all bareroot plants are dormant deciduous trees or shrubs. Most mail order plants are barerooted. Many tap rooted plants, such as nut trees and some fruit and shade trees, are barerooted because they are not amenable to balling and burlapping.
2. Plants available in nurseries in early spring with roots wrapped in damp sphagnum moss and packaged in cardboard or plastic containers are also barerooted plants. These need special attention because their roots are tightly bunched in unnatural positions in order to force them into the package.
 - a. Letting the roots dry out is the single greatest reason for failure with bareroot plants. Keep roots in the shade or wrapped in plastic or wet paper until planting time. Heeling a plant into the soil is a good way to hold it temporarily.
 - b. Discard the sphagnum packing and be sure to spread the roots out into a natural cone position when planting.
3. Bareroot plants are planted while they are dormant and are well suited to fall or early spring planting.

C. Balled and Burlapped (B and B) Plants

1. These plants are likely to have grown in nursery rows for some time and have been root pruned so that the root system within the ball is compact. B and B plants often reestablish themselves rapidly.
2. B and B method is primarily used for plants that never lose their foliage (evergreens). Examples of B and B plants are broadleaf evergreens such as rhododendrons or azaleas, and conifers of all types.
3. Many deciduous trees and shrubs, which have branching root systems that are easily contained in a soil ball, are also B and B plants.
4. B and B plants are planted almost anytime that the ground can be worked.

- a. Pay special attention to B and B material planted in the summer. It must be adequately watered to ensure the soil ball does not dry out.
- b. When planting B and B stock, place the plant in the hole with the burlap intact. See Chapter 16, page 16-4, for detailed planting instructions.

D. Container Grown Plants

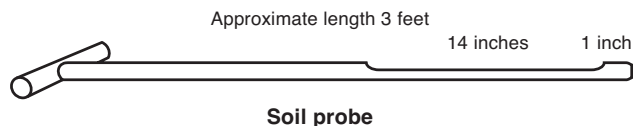
1. These plants are usually grown in the container in which they are sold and are popular in the nursery trade.
2. Container grown plants can be planted anywhere B and B plants are planted. However, because of their appearance, gardeners are often misled into thinking that these plants need little care. Container grown plants need the same careful planting and maintenance as other plants. Proper watering is critical.
3. Container grown plants are removed from the container before planting. See Chapter 16, page 16-4, for more detailed planting instructions.

V. Watering Considerations

A. Variables That Affect Plant Water Requirements

Slope, exposure, temperature, humidity, light intensity, wind, ground cover, mulch, organic matter level, and individual plant requirements are variables that affect water requirements of plants. See Chapter 16, pages 16-2 and 16-3, for more water information on landscape plants. Irrigating the home vegetable garden is covered in Chapter 19, pages 19-12 and 19-13.

1. Inadequate watering causes roots to desiccate and die. The top growth will begin to show abnormal symptoms such as wilting or dry leaf margins.
2. To determine if overwatering or underwatering is the problem, take a shovel or trowel and dig down 8 to 10 inches. An overly wet condition can be determined by a simple moisture hand test. An overly dry condition is self-evident.
3. A soil probe can also be used and will do the job more quickly and effectively. A soil probe can be made from a 1-inch



diameter hollow metal tube, diagonally cut at the “drill” end for easy insertion. “Handles” at the opposite end can be made by drilling a hole for or welding on a smaller diameter solid metal rod that runs perpendicular through the hollow tube to form a “T.”

- a. Push the probe into the area to be tested to a depth of at least 12 inches. Remove the probe. A soil profile will be trapped inside the probe.
- b. In sampling an area, often five to 20 soil profile samples are taken. These are mixed together in a plastic bucket. From that mixture a portion of soil is placed in a plastic bag and sent to a laboratory for analysis (ask your county extension educator for the nearest location).

B. Water Penetration

When plants are watered, the entire root zone should be filled. For trees this may be two to three times the diameter of the crown for width and 2 feet down for depth. Allow the soil to partially dry before your next irrigation.

1. How much drying is allowed will depend on the plant species and its size. If the soil dries too deeply in vegetable and flower gardens, wilting will occur.
2. Gardeners must learn how long it takes the root zones of the various garden plants to be completely moistened.
3. Each plant is different. Experimentation is the key.

C. Soil Type

Soil type or texture is a major factor determining how much water a soil can hold and how quickly a soil can be irrigated. For example, 1 inch of water applied to a sandy soil will penetrate 12 inches, while 1 inch of water applied to good loam will penetrate 6 to 10 inches, and 1 inch of water applied to clay soil will penetrate only 4 to 5 inches.

D. Watering Interval

Sandy soils will allow water to penetrate more quickly than will heavy, dense clay soils. Wetting the entire root zone of a plant growing in a heavy soil may take hours.

1. Sandy loam soil will accept from 1/2 to 3 inches of water per hour.
2. A clay loam may absorb only 1/10 to 3/5 of an inch of water per hour.

E. Water Retention

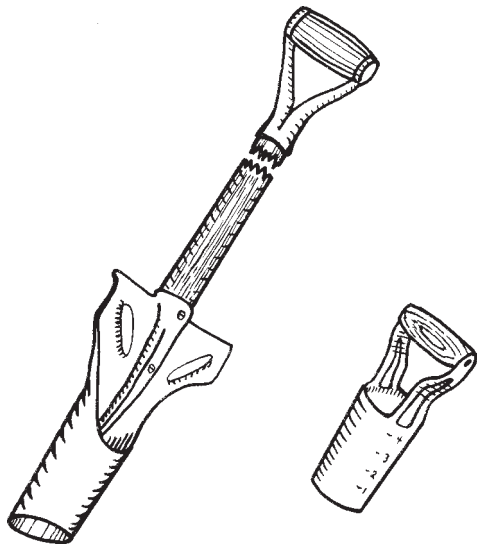
Although light sandy soils will allow quick and deep penetration of water, they dry out more rapidly. Heavy clay soils are more difficult to penetrate with water, but once wet, they dry out much more slowly than sandy soils.

1. You will need to irrigate heavy clay soils far less often than light sandy soils. A general rule is to deep water clay soils to a 12-inch depth once a week and sandy soils to a 12-inch depth once every 2 to 3 days.
2. Soils that receive ample amounts of organic matter (OM) annually may have different water retention levels. For example, amended clay soils may accept water more quickly than the surrounding native soil, while amended sandy soils will hold water longer than sandy soils that have not been amended.

F. Compaction and Thatch

Soils that are compacted or covered with a deep thatch accumulation (in turf) will cause water to run off and be wasted.

1. For compacted areas, such as walkways across the yard and under the canopy of trees, the best treatment is to aerate the soil by removing plugs (core aeration) followed by topdressing with a 1/4-inch layer of humus or good top soil.
2. For trees and shrubs, mulching around them will help reduce future compaction by cushioning foot traffic and water droplets.
3. With compacted landscape soils, adding 1 inch of humus over the surface, or working it carefully into the top 2 or 3 inches of soil, will help restructure the



Bulb planters

surface layers and allow more efficient water penetration. Using a bulb planter (see artwork on next page) to add humus between plants is also helpful.

4. Compacted vegetable garden soil may need 2 to 4 inches of raw OM incorporated each year in the fall to make a difference. If humus is used, only 1 or 2 inches is needed.
5. In thatchy areas of the lawn, using a power rake or dethatcher then a wetting agent to soak through dry organic layers of thatch will allow better water penetration. A thin thatch layer (1/4 to 1/2 inch) is beneficial, but if the thatch layer is thicker than one half inch, consider dethatching. For more information on lawns, see Chapter 14.

G. Interfaces

Interfaces are areas where one soil type stops and another begins. This can prevent water from moving laterally through the soil. Interfaces occur where the soil is altered, for example, amended backfill that is added to the transplant hole changes the original soil. The new medium in the transplant hole will be different from the rootball soil and the surrounding soil. All three of these soils will pick up and hold water differently, which can affect root development and plant growth.

1. For newly planted shrubs and trees, make sure that the soil surrounding the rootball

is kept sufficiently moist to encourage roots to grow out into the surrounding soil. Roots grow where there's moisture and, unless the media in the rootball and planting hole are moist, the roots may never grow out of the original nursery soil. In such a situation, plants may girdle themselves and die.

2. In heavy clay soils, it may be beneficial to slightly amend (but only 25 percent of) the backfill soil for improved aeration and water penetration. Keep in mind that amending the soil in a planting hole too much will encourage an interface problem.
3. In sandy soils, amending 25 percent of the backfill will improve nutrient and water retention.
4. Loamy soil types should not be amended.

VI. Irrigation Method

The irrigation method used to supply supplemental water to plants will depend upon the water sources available. The method you select should be based on the least cost and labor required. Irrigation systems commonly used are flood, sprinkler, trickle, and drip.

VII. Landscape Water Requirements

A. Plant Water Needs

Plant roots grow in soils that contain sufficient moisture. If water is consistently supplied to only the top 2 to 3 inches of soil, that is where the majority of roots will grow.

Note: To determine when a sprinkler has put out 1 to 2 inches of water (an average amount to use per week, if it doesn't rain), simply place several same-sized soup cans at regular intervals starting near the sprinkler head and extending out to the edge of the sprinkler pattern. Take an average of the total amount collected (divide the total amount of water collected by the number of cans set out) within the time the sprinkler was on. This will help you decide watering procedures in the future.

B. Deep Watering

Wetting the soil 12 to 18 inches down will enable the roots of plants to grow further down. There they can withstand temperature extremes and tap into deeper water and nutrient reserves. During periods of drought, deep-rooted plants are less likely to be damaged or killed.

C. Lawns

See Chapter 14, "Turfgrass Establishment and Management," pages 14-13 and 14-14.

D. Shrubs and Trees

Shrubs and trees should be irrigated so that the entire area under the dripline (the area on the ground that starts at the trunk and extends to the end of the branch tips) and beyond is watered thoroughly. Tree root systems can extend out two to three times the size of their crowns!

1. Although the dripline is often referred to, much of the water and nutrient uptake of shrubs and trees is accomplished by roots outside the dripline. Keep this in mind when applying water and fertilizer.
2. Watering woody plants by creating a basin around the trunk is only good for newly planted stock. As root systems expand the watered area must also expand. Watering next to the trunk of large trees does very little for the extensive root system at the dripline and beyond.
3. Shrubs and trees near house foundations, or in southern and western exposures, need special attention. Because of the sun's intensity and the reflected heat from walls in these locations, these plants are subject to greater water stress and may need more frequent watering during hot, sunny weather.

E. Vegetables

See Chapter 19, "Vegetable Culture," pages 19-12 and 19-13. Use mulches whenever possible to reduce surface evaporation and weed competition.

F. Containers

Outdoor containerized plants will have to be watered several times a day during warm, sunny periods.

1. Water when the top 1/2 inch of soil is dry. Water long enough to allow moisture to flow out through the drainage holes. Remove excess water in the drainage dish to reduce the amount of accumulated fertilizer salts in the soil.
2. Plants in containers become potbound quickly and dry out rapidly. If the soil becomes too dry, it may be necessary to soak the entire container in a tub of water until it is thoroughly wet again.
3. Repot containerized plants when the roots become crowded. Use a thick wood or clay container for better root insulation. Plastic and metal containers are not good at insulating root systems.
4. Timed drip irrigation may be effective in keeping outdoor containers consistently moist.

Further Reading

Books

- M. MacCaskey et. al. *Complete Guide to Basic Gardening*. HP Books, Inc., Tucson, AZ.
- D. Raymond. *Garden Way's Joy of Gardening*. Garden Way, Inc., Troy, NY.
- A. C. Sinnes. *All About Fertilizers, Soils and Water*. Ortho Books, San Francisco, CA.

Booklets and Pamphlets

University of Idaho

- CIS 923 Choosing Nursery Stock for Landscaping, Conservation, and Reforestation (35¢)
- BUL 704 Soil Sampling (\$2.00)
- CIS 990 Water Conservation in the Landscape (50¢)

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Chapter 7 Backyard Composting



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Backyard Composting



W. M. Colt, R. Rynk, and J. A. Robbins

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I. Introduction

Composting is the biological decomposition of organic matter. We practice it to recycle unwanted organic materials, such as yard trimmings and food scraps, and to produce compost, a valuable soil amendment. Finished compost takes on many of the characteristics of humus, the organic fraction of soil. Like humus, compost improves garden soils and aids in plant growth.

While composting occurs naturally, human intervention can accelerate it. The quality of the compost and the production speed depend upon several factors that human composters can manipulate.

II. The Composting Process

A. Process Basics

Composting is an aerobic, or oxygen-requiring, process. The microorganisms and other biological decomposers responsible for composting consume oxygen along with the organic materials and produce primarily compost, carbon dioxide, water vapor, and heat (Fig. 1). The heat that is produced raises the temperature of the composting materials.

The oxygen consumed during the process must continually be replaced by air movement through the materials. Because the penetration of air may be inadequate or inconsistent, some decomposition inevitably occurs under anaerobic conditions (without oxygen). Anaerobic decomposition is slower than aerobic decomposition, produces little heat, and creates odorous byproducts. The challenge for the composter is to minimize anaerobic decomposition by creating and maintaining conditions that favor the desired decomposers.

B. Decomposers

Decomposers are the microorganisms and invertebrates that accomplish composting. Naturally occurring microorganisms, such as bacteria, fungi, and actinomycetes, account for most of the decomposition, as well as the rise in temperature that occurs in the compost process. Invertebrate animals, such as mites, millipedes, insects, sow bugs, earthworms, and snails, produce much of the physical decay where the temperature is relatively cool (below 90°F).

Different decomposers prefer different organic materials and environmental conditions. A diverse microbial population represents a healthy compost pile. If the environment becomes unsuitable for a particular decomposer, that organism will become dormant, die, or move to a more hospitable area of the pile. Changing conditions during the composting process lead to an ever-changing ecosystem of decomposer organisms.

1. Microorganisms: food and water.

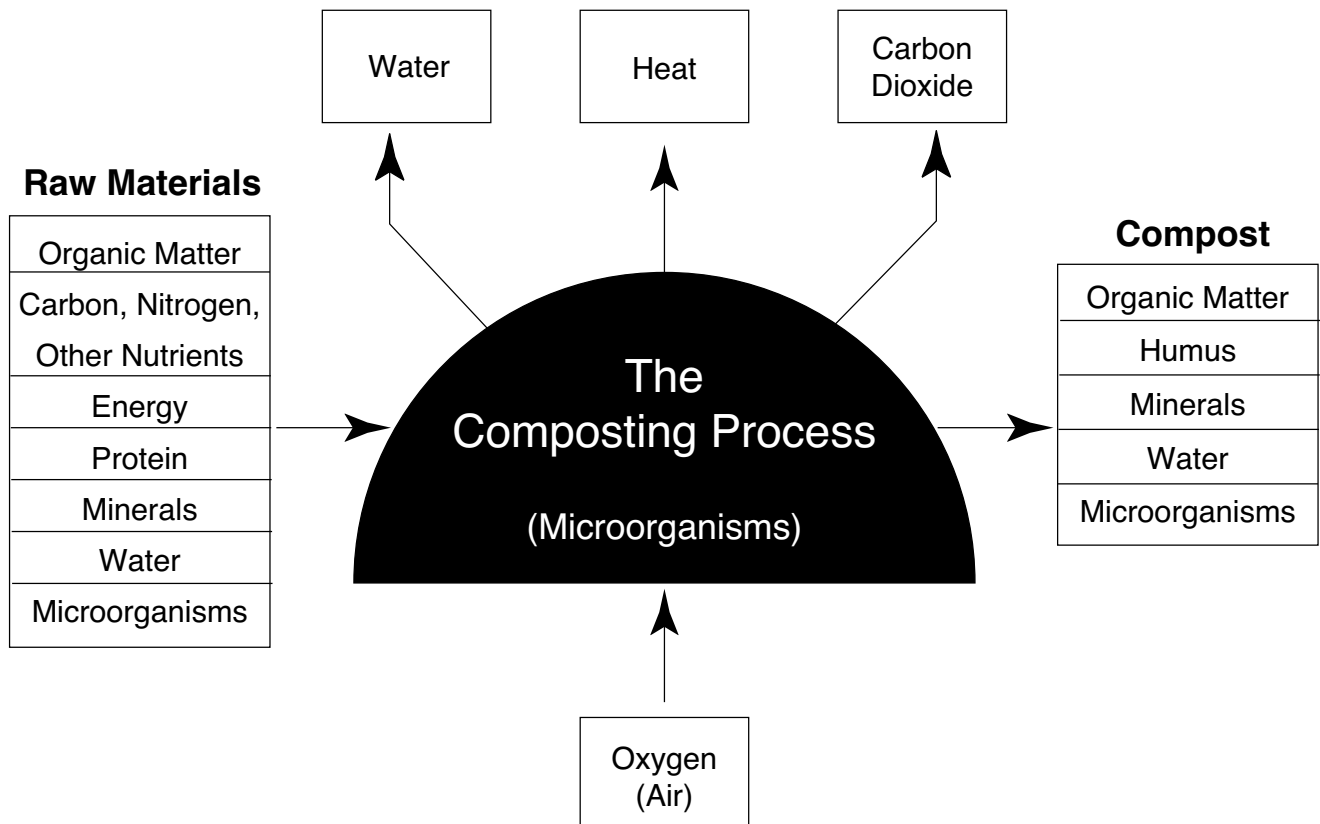
- a. Bacteria are the workhorses of the compost pile. They are the most numerous and active decomposers. Bacteria generally prefer moist conditions and attack the easily decomposed materials such as green vegetation, food scraps, and manure.
- b. Actinomycetes (a branching type of bacteria) and fungi (yeast and molds) attack the more resistant materials that bacteria use less efficiently. Fungi are particularly good at decomposing woody materials. These groups of organism are also more tolerant of dry conditions than bacteria. They become more important near the

end of the process when the resistant organic compounds remain (e.g., cellulose and lignin compounds). The filaments, molds, and spores formed by fungi and actinomycetes are often visible in the later stages of composting.

2. Aerobic vs. anaerobic microorganisms.
 - a. Aerobic organisms provide the most rapid and effective composting. They thrive at oxygen levels greater than 5 percent (fresh air is approximately 21 percent oxygen).
 - b. Anaerobic bacteria prevail when oxygen is scarce. Anaerobic conditions are undesirable in a compost pile because the decomposition products are often odorous. For example, a common product of anaerobic decomposition is hydrogen sulfide that smells like rotten eggs. Other odorous anaerobic products, some with aptly descriptive names like “putrescine” or “cadaverine,” are formed from organic nitrogen compounds.

3. Microorganisms and temperature—Microorganisms are grouped according to the temperatures in which they thrive.
 - a. Psychrophilic organisms work in the lowest temperature range and have an optimum temperature of about 55°F. Mesophilic organisms thrive at temperatures between 70° and 100°F. Thermophilic organisms are heat-loving and operate in a range between 113° and 155°F. If the temperature rises above 140°F, even the thermophilic microorganisms begin to suffer and decomposition slows.
 - b. Aerobic microorganisms are the most important initiators of decomposition and temperature rise within the compost pile. The initial temperature of the compost pile is usually near ambient air temperature. Psychrophilic bacteria typically begin the decomposition. Their activity generates a small amount of heat that increases pile temperature. This change in environment

Fig. 1. The composting process.



allows mesophilic organisms to dominate. In turn, the more rapid decomposition by mesophilic bacteria further increases the pile temperature and creates an environment for the thermophiles to thrive. Later, as the compost matures, temperature decreases, mesophilic bacteria again dominate, and finally psychrophiles and invertebrates return.

- c. Although microorganisms are the primary decomposers in a compost pile, larger organisms also play a significant and beneficial role. Callemacroorganisms, invertebrates, or secondary decomposers, these organisms include nematodes, flat worms, earthworms, snails, slugs, mites, springtails, beetles, ants, fly larvae, grubs, centipedes, millipedes, and sow bugs. Macroorganisms feed on plant tissue, partially decomposed organic matter, or other organisms. In the process, they break particles into smaller pieces, mix and transport nutrients, convert materials into forms that microorganisms can digest, and add their own byproducts and cell tissue to the compost. Macroorganisms are not tolerate of thermophilic temperatures. As temperatures rise above 90°F, they will die, become dormant, or escape to the soil or cooler sections of the pile. They will return after the temperature falls to tolerable levels.

C. Factors Affecting the Composting Process

1. Aeration—Rapid aerobic decomposition can only occur in the presence of sufficient oxygen. Aeration replaces the oxygen-deficient air fresh oxygen-rich air inside the compost pile. It also removes heat, water vapor, carbon dioxide, and other gaseous products of the composting process. Aeration occurs naturally by diffusion, wind, and when warm air (heated by the compost process) rises through the pile and draws in cool, fresh air from the surroundings.
 - a. Porosity: The compost pile's porosity and moisture content affect air movement through the pile. Porosity is a

measure of the spaces between particles within the compost pile. These spaces provide a path for air circulation. Porosity suffers as the composting material becomes wetter because the material in the pile becomes heavier and more compacted. Adding coarse materials, such as leaves, straw, or cornstalks, increases the pile's porosity, resists compaction, and promotes good aeration.

- b. Turning: As composting proceeds and the materials decompose, they shrink in size and begin to settle. Settling reduces the pile's air spaces and restricts aeration. Regular mixing of the pile, referred to as turning, reverses the effects of settling. Although turning recharges the pile with fresh air, its main effect is to fluff up the material. This increases the pile's porosity and improves natural air circulation. Turning also blends the composting materials and breaks apart clumps of materials. Because of these benefits, turning speeds the composting process.
2. Moisture—Microorganisms need moisture. Water serves as a medium for chemical reactions and provides a means for movement of nutrients and microorganisms. On the other hand, too much water makes the materials soggy and heavy, hindering aeration as explained above.
 - a. Generally, a moisture content in the range of 40 to 60 percent provides adequate moisture without limiting aeration. In practice, the acceptable level of moisture depends on the materials that you are composting. Coarse or fluffy materials such as leaves or straw can be wetter than 60 percent moisture content and still aerate well. Absorbent materials may need to be well above 40 percent moisture to compost rapidly.
 - b. The "squeeze" test is an easy way to gauge the moisture level of composting materials. The material should feel damp to the touch, but not dripping wet. Water should drip from the mate-

rial only when you squeeze it tightly in your hand. If you can't squeeze water out, the pile is too dry (see Section IV, Subsection H on "Moisture Management," page 7-12).

3. Carbon-to-nitrogen ratio (browns and greens)—Microbial decomposers obtain many nutrients from the composting materials but carbon (C) and nitrogen (N) are the nutrients that affect the process the most. Microorganisms primarily use carbon compounds as an energy source and ingest nitrogen for protein.
 - a. Because they require a balance of both nutrients, the proportion of carbon to nitrogen is important when combining organic materials to make compost. The ideal ratio (C:N) of these two elements is about 30 parts carbon to 1 part nitrogen by weight. At this 30:1 ratio, microorganisms decompose organic material quickly. When the C:N ratio is higher, the shortage of nitrogen slows decomposition. When the C:N ratio is too low, excess nitrogen is lost to the atmosphere in the form of ammonia gas. In concentrated amounts, this can lead to odor problems. Generally, C:N ratios within the range of 20:1 to 50:1 yield good compost in a reasonable time without odor problems.
 - b. Most composting materials, by themselves, do not contain C and N in the right ratio (Table 1). Still, you can

achieve the desired C:N ratio by mixing several materials together in appropriate proportions. We refer to the materials used and their proportions as a "recipe."

Note: In a backyard or home composting situation, it is impractical for you to be precise when developing recipes. You can roughly predict the C:N ratios of mixtures from estimated C:N ratios of the ingredients as in Table 1. An easier approach is to develop recipes by thinking of carbon sources as "browns" and nitrogen sources as "greens" and then combining brown and green materials in rough proportions. For example, a mix of one to three volumes of browns (dry leaves) to one volume of greens (fresh grass clippings) often produces a C:N ratio in the 30:1 to 50:1 range.

4. Surface area and particle size—Most microbial activity occurs along particle surfaces, where oxygen is available from the adjacent air spaces. Because surface area increases as particle size decreases, chopping, shredding, or cutting material into smaller pieces usually speeds decomposition. There is a limit to this benefit. Smaller particles also decrease the pore size and structure and restricts aeration. Therefore, some compromise is necessary. Usually a mixture of particles in the range of 1/8 inch to 2 inches (in the largest dimension) gives good results.
5. Degradability—The nature of the materials largely determines the speed at which composting occurs. Not all organic materials decompose at the same rate.
 - a. Overall, microorganisms easily digest materials made from sugars, starches, proteins, and fats such as food scraps, manure, and green vegetation. Typically, nitrogen-rich materials or "greens" are the first to decompose in the composting process.
 - b. Materials such as straw and plant stems contain a large amount of cellulose that takes longer to decompose.

Table 1. Typical carbon to nitrogen ratios of selected home composting materials.*

| | Material | C:N ratio |
|---------------|--------------------------------|-----------|
| BROWNS | Dry leaves | 60:1 |
| | Corn stalks | 60:1 |
| | Straw | 80:1 |
| | Shrub trimmings | 50:1 |
| | Waste paper | 400:1 |
| | Wood (sawdust, shavings, etc.) | 500:1 |
| GREENS | Grass clippings | 17:1 |
| | Kitchen scraps | 15:1 |
| | Vegetable culls | 12:1 |
| | Cattle manure | 18:1 |

*These values are only approximations. The C:N ratio of any of these materials varies considerably from one source to the next and as the materials age.

Woody materials contain a biologically resistant compound called lignin. Raw wood products, including sawdust, are particularly difficult to decompose biologically and pass through the composting process with little change. Paper, a wood derivative, decomposes relatively fast because of the processing it receives in the papermaking process. You can improve the degradability of a biologically-resistant material by reducing its particle size and ensuring that adequate amounts of nitrogen and water are available.

6. Temperature—Heat, generated by microorganisms, raises the temperature of the compost pile. Depending on the pile size, moisture content, and the material that you are composting, pile temperatures will rise temporarily to 100° to 120°F and may even surpass 160°F. Temperatures between 90° and 140°F promote rapid composting. Microbial activity decreases as the temperatures reach 140°F or higher. Many of the organisms die when temperatures exceed 160°F.
 - a. Because microbial activity and the heat generated are related directly, temperature is a useful guide in understanding how well composting is progressing. Rising temperatures reflect increased microbial activity. Warm, steady temperatures indicate steady activity. Falling temperatures suggest that the compost microbial activity is decreasing, either because the compost is maturing or because a problem, such as lack of oxygen or moisture, exists.

You can easily measure temperatures in your home compost pile with a dial thermometer with a 12-inch stem (available from garden stores and catalogs). You also can use the clues in Table 2 to judge the temperature level.

- b. Home composting piles tend to be small and are frequently short of nitrogen. Therefore, if high temperatures (above 120°F) are reached at all, they are usually sustained for only short periods of time. Piles typically get hot soon after adding a large load of green material, such as grass clippings, and then gradually cool. High temperatures have the advantage of killing pathogenic organisms and weed seeds. Moderate temperature also result in effective composting, however. It is not important to achieve high temperatures if the materials being composted are not diseased and do not contain many seeds.
7. Time—Depending on the composting method, materials, and conditions, it can take several weeks to several years to produce finished compost. Methods that involve little or no turning usually require more than a year to produce mature compost. With regular turning, adequate moisture, and a good mixture of carbon (brown) and nitrogen (green) materials, compost is ready for use in 3 to 4 months. With daily turnings and highly degradable material, you can reduce the composting time to less than a month. Frequent turning is of little benefit if you are using slow decomposing materials or if the C:N ratio is high (too many browns). These materials need time, more than oxygen, to decompose.

Because an immature compost can cause damage to plants, it is best to be conservative in judging when composting is finished (see Section IV, Subsection K, “Judging When Composting Is Finished,” page 7-12).

Table 2. Indirect clues of compost pile temperature level*.

| Clue | Temperature level |
|--|-----------------------------|
| Material is frozen beneath the surface | Frozen—little activity |
| Pile feels cold, colder than the surrounding air | Low—slow rate of composting |
| Pile feels warm, not hot | Moderate—rapid composting |
| Pile is steaming and hot to the touch | High—rapid composting |
| Pile is hot to the touch and the material inside of the pile looks or smells charred | Too high—undesirable |

*These are rough guidelines. Actual conditions depend on factors such as pile size, materials, and composting stage.

III. Composting Methods

The container and the manner and frequency of turning characterize backyard composting methods. Common backyard methods include piles, bins, ventilated containers, and rotating barrels

A. Piles

1. A freestanding pile or heap is the simplest form of composting, and it works very well. You can add materials to the pile as they become available or stockpile until you have sufficient materials to make a good sized heap. In either case, it is helpful to have two or three piles—one for fresh material, another in the active composting stage, and possibly a third for maturing compost. To generate enough heat to raise the pile temperature, an actively composting pile should be 3 to 5 feet wide and at least 3 feet high. Larger piles retain heat better, but as piles grow in height they become more difficult to aerate.
2. You can turn piles regularly or not at all. A pitch fork is the typical turning device, although you can use other tools to loosen the pile. If the pile receives little or no turning, then add highly degradable materials only in moderation.

B. Bins and Ventilated Containers

Bins are managed in almost the same manner as piles. Compared to piles, bins more neatly contain the composting materials and allow you to stack them higher. Certain types of bins also discourage animal pests and keep rain away from the composting materials. See pages 7-16,17,18 for the wide variety of bins that you can use. They differ in cost, construction materials, ventilation, and ease of turning. Some bins are expensive or require effort to build while others need little assembly and may even be free. Backyard composting bins are sometimes grouped into two basic categories: (1) holding units that let the materials decompose undisturbed, and (2) turning units that allow regular turning of the composting material. The distinction between holding and turning bins easily becomes blurred. Some structures typically used for turning often can

serve as holding units and holding bins can be turned.

1. Holding bins—Generally made of light materials, holding bins are easy to take apart and move. Once the bin is apart, you can turn or harvest the finished compost. Common bin materials include circles of wire fencing or hardware cloth, old wooden pallets tied together, snow fencing, or wire mesh framed in wood. You can make stationary bins with wooden slats or by stacking together landscape timbers, concrete blocks, or rocks. In all cases, the bin should allow air flow through the sides and back. Aeration aids will improve air circulation. Examples include pallets, placing aeration mats or branches under piles and branches, or inserting perforated pipes or wire tubes vertically into the composting materials. Several manufactured holding bins are available. Some are intended to compost food scraps. Most of these are closed containers with air vents in the sides. Others have vents only at the bottom and top of the bin. These bins are not designed to maintain aerobic conditions completely. They control odors by enclosing the materials—and the odor—inside the container. Yard trimmings and food scraps are added at the top, and compost is removed from the bottom.
2. Turning bins—Turning units contain the composting materials while providing easy access for turning. Materials are either turned in place or shifted back and forth between adjacent bins. Turning bins are similar to the stationary holding bins described above, but with features such as an open side, removable walls, and multiple bins. Turning units with a series of three bins are popular. Similar to the three-pile system, one bin contains fresh material, the second actively composted material, and the third holds maturing compost.

C. Barrels and Tumblers

Rotating barrels or drums turn the materials inside as they spin like a clothes dryer (via a

hand crank) or tumble end-over-end. There are many manufactured models, although you can make rotating barrels yourself. One commercial model uses a solar-powered electric motor to continuously rotate the drum. Some drums and multisided tumblers are designed to be rolled along the ground. All of these composting units include some means of aeration plus loading and unloading features. Because you must load the barrels in batches, it is necessary to store fresh materials. As an alternative, you can use two drums—while one drum is composting, the other is being loaded with fresh material. Given a large enough batch of material, rotating barrels should generate high temperatures.

The idea behind rotating barrels is to make turning effortless. Therefore, the material will be turned more often and decompose faster. Several manufacturers claim their product can produce finished compost 2 weeks (although 1 month is a more realistic goal). In order to achieve quick composting, other factors including easily degraded and shredded materials, proper moisture, and C:N ratios must accompany the benefits of frequent turning.

IV. Making and Managing a Compost Pile

Composting is a natural and flexible process. It will take place under a wide range of conditions and methods regardless of either the efforts or neglect of human composters. Nevertheless, good management helps the process along and minimizes nuisances. Management determines how soon the compost is produced. For example, turning a compost pile weekly can yield compost in 1 to 2 months, with adequate moisture content and a good combination of materials.

Without turning, composting takes 6 months to 2 years. You can make excellent-quality compost either way.

A. Materials

Almost all natural organic materials will decompose, but not everything belongs in the backyard compost pile as you can see in Table 3. Generally, you can compost garden vegetation, landscape trimmings, and most plant-derived food scraps without concern.

1. It is prudent to avoid composting plants harboring disease, or treated with persistent herbicides, or carrying many seeds and insects. Also, it is a good idea to keep out certain noxious weeds, including morning glories (bindweed), and grasses (such as quackgrass) with rhizomatous root systems. Backyard compost piles do not reliably produce the high temperatures necessary to thoroughly kill

Table 3. Materials that you should and should not compost (adapted from NRAES-43, “Composting to Reduce the Waste Stream”).

| YES | NO |
|------------------------------|--|
| Aquatic plants | Oily foods (attract pests) |
| Bread | Butter |
| Branches—chipped | Bones |
| Brush—chipped | Cheese |
| Coffee grounds | Fish scraps |
| Corn cobs | Lard |
| Cut flowers | Mayonnaise |
| Egg shells | Meat and poultry |
| Evergreen needles | Peanut butter |
| Fruit | Salad dressing |
| Fruit peels and rinds | Sour cream |
| Garden trimmings | Vegetable oil |
| Grass clippings | Possible sources of disease and weeds |
| Leaves | Cat manure |
| Manure—cattle, horse, rabbit | Dog manure |
| Paper | Diseased plants |
| Sawdust | Plants with rhizomatous roots |
| Straw | Plants with severe insect infestation |
| Sod | Weeds that have gone to seed |
| Tea leaves and bags | Possible sources of toxins |
| Vegetables | Black walnut leaves |
| Vegetable trimmings and tops | Cedar chips, bark, branches |
| Weeds without seeds | Grass treated with persistent herbicides |
| Wood ash | |
| Wood chips | |
| Wool waste | |

rhizomes, weed seeds, and plant diseases. For the same reason, do not add cat and dog manure, which may contain pathogens, to backyard piles. Avoid adding fatty and oily foods because they tend to attract animal pests (rodents, skunks, dogs, and cats). Also, oily foods are quick to decompose and may generate odors.

2. Another group of materials to be cautious about are those that may contain natural or manufactured compounds that are toxic to either plants or the composting decomposers. Examples include grass and vegetation containing persistent herbicides, leaves from black walnut trees, and cedar wood. Even if these materials decompose, the compost might retain some of the toxins. If you want to compost these materials, segregate them from the other materials. Also, use the compost only where the toxins will not have a negative effect. For example, use composted walnut leaves as mulch for walnut trees or use herbicide-treated grass compost as lawn top-dressing.
3. The degradability of materials is also a consideration. Highly degradable materials such as grass clippings, food scraps, and manure, require more turning and attention (see odor control). Slowly degradable materials need shredding and time for composting, even with regular turning. Chop or shred before composting branches, plant stems, and other thick or large particles of material. The less degradable a material is, the more important shredding becomes. Also, chop whole pieces of fruit and vegetables to break the protective barrier of the skin or peel.

B. Additives

Some composters add lime, wood ash, inorganic fertilizers, and organic nutrient sources into compost piles to enhance the compost or the composting process. These additives are not necessary to composting. Depending on the compost pile conditions, they may speed the process or provide no benefit at all.

1. Lime—Rarely helpful to the composting process, lime is added sometimes to neutralize acidic materials and organic acids formed during composting. The effect of these acidic conditions, however, is seldom damaging. Composting decomposers can work at a relatively low pH (acidic) and further decomposition tends to push the pH toward neutral. Lime also encourages ammonia loss, especially if the C:N ratio is low (a lot of greens).
2. Wood ash—Although wood ash adds mineral nutrients to the compost, it has little effect on the composting process. Like lime, wood ash increases pH and encourages ammonia loss. Usually, the composting process is not adversely affected by the amount of wood ash that a household wood stove generates.
3. Inorganic fertilizers—Because backyard composting piles usually lack nitrogen, inorganic fertilizers tend to speed the composting process. The compost is not greatly affected. Inorganic fertilizers should be dissolved in water and mixed into the compost pile. You can only approximate the correct amount of fertilizer to add. For example, a pile of dry leaves generally requires about 2.4 ounces of nitrogen per bushel (about 4 cubic feet). Table 4 lists the corresponding amount of various types of fertilizers. Use less fertilizer as you add more greens to the pile. If you add too much fertilizer, nitrogen will be lost to the atmosphere as ammonia or leached from the pile into the ground. In part, this occurs because the

Table 4. Amount of various nitrogen sources needed to supply 2.4 ounces of nitrogen (adapted from NRAES-43, “Composting To Reduce the Waste Stream”).

| Nitrogen source | Percent nitrogen | Ounces of fertilizer |
|------------------|------------------|----------------------|
| Ammonium nitrate | 33 | 7.0 |
| Calcium nitrate | 15 | 16.0 |
| Urea | 46 | 5.2 |
| Dried blood | 12 | 20.0 |
| Fish meal | 10 | 24.0 |

nitrogen from fertilizer is available to the decomposers more quickly than the carbon from the organic materials.

4. Organic nutrient sources—Concentrated organic sources of nitrogen such as manures, dried blood, fish meal, fish emulsion, and cottonseed meal are better sources of nitrogen. Compared to inorganic fertilizers, these sources release nitrogen that more closely matches the availability of organic carbon.

C. Inoculants

Soil, vegetation, food scraps, compost, and the environment contain the desired organisms in ample quantities to start the composting process. Some composters claim to see faster composting after using inoculants. Others have found no difference. In any case, inoculants, activators, or compost starters are not necessary.

D. Location

The pile should not be in contact with trees, wooden fences, and buildings because the compost will accelerate wood decay and metal corrosion. Also, spontaneous combustion (self-ignited fire) within a backyard composting pile is a remote yet possible danger.

1. Shelter—A sheltered location is an asset because wind both cools and dries the pile. Direct sunlight can be undesirable. Although it provides warmth in the winter, sunlight dries the pile in the summer.
2. Water—The location should provide access to water as you will need to water piles frequently during the summer. You are more likely to keep piles moist if the water source is convenient—for example, within reach of a garden hose. Avoid poorly drained locations that gather standing water because materials will become waterlogged.
3. Space—Finally, the location should provide enough space to turn the pile and to stockpile raw materials and finished compost, if necessary.

E. Volume

A pile or bin should be large enough to generate and hold in heat, yet small enough to allow air to reach its center. As a general

rule, the minimum pile or bin dimensions should be 3 by 3 feet at the base and 3 feet high. Piles and bins that are larger than 5 feet high or 5 feet wide are difficult to aerate and require more turning.

Pile volume is most important during the cold season. Therefore, start new piles in the summer and gradually enlarge them as winter approaches.

F. Building Composting Piles

You can construct compost piles gradually from the ground up by adding material as they become available, and in batches by stockpiling materials until you have accumulated a certain amount. This is rarely an either/or choice—a pile or bin can grow both gradually and in batches. Adding fresh material in large quantities is more likely to produce high temperatures but it also increases the chance of odors and requires more turning.

1. Mixing or layering ingredients—The most important task in constructing a pile is to mix together the appropriate ingredients, including water. Blend brown and green ingredients well for microorganisms to obtain a balance of both carbon and nitrogen. Some composters add materials without mixing and rely on subsequent turnings to blend the ingredients. Others add brown and green materials in successive layers, 3 to 6 inches thick, with the first and last layers consisting of coarse brown materials as in Fig. 2. Another variation intersperses layers of soil, fertilizer, or manure among the brown and green layers. Layering provides an easy and visual way to proportion materials. The layers, however, make a poor blend of materials. Turning is necessary to mingle the brown and green materials together.
2. Burying materials—When adding to piles continuously, bury materials (certain food scraps) that might attract flies and pests 6 inches beneath the surface of open piles and bins. If the pile is not dry or frozen, the material will partially decompose in 1 to 2 weeks. Then you can turn the pile as desired. When adding food materials in large quantities, mix

them into the pile, cover them, and then turn the pile a week or so later. If you are using enclosed bins and barrels, you do not need to bury materials.

3. Insulating the pile—Placing a layer of coarse material at the base of piles and bins improves aeration and insulates them from the colder ground. The base layer also absorbs liquids that may leak from above. Appropriate materials include dry leaves, corn stalks, straw, wood chips, and compost. You also can use these materials to cover the surface of piles. A 3- to 6-inch outer layer protects piles from heat and moisture loss and helps to contain odors.

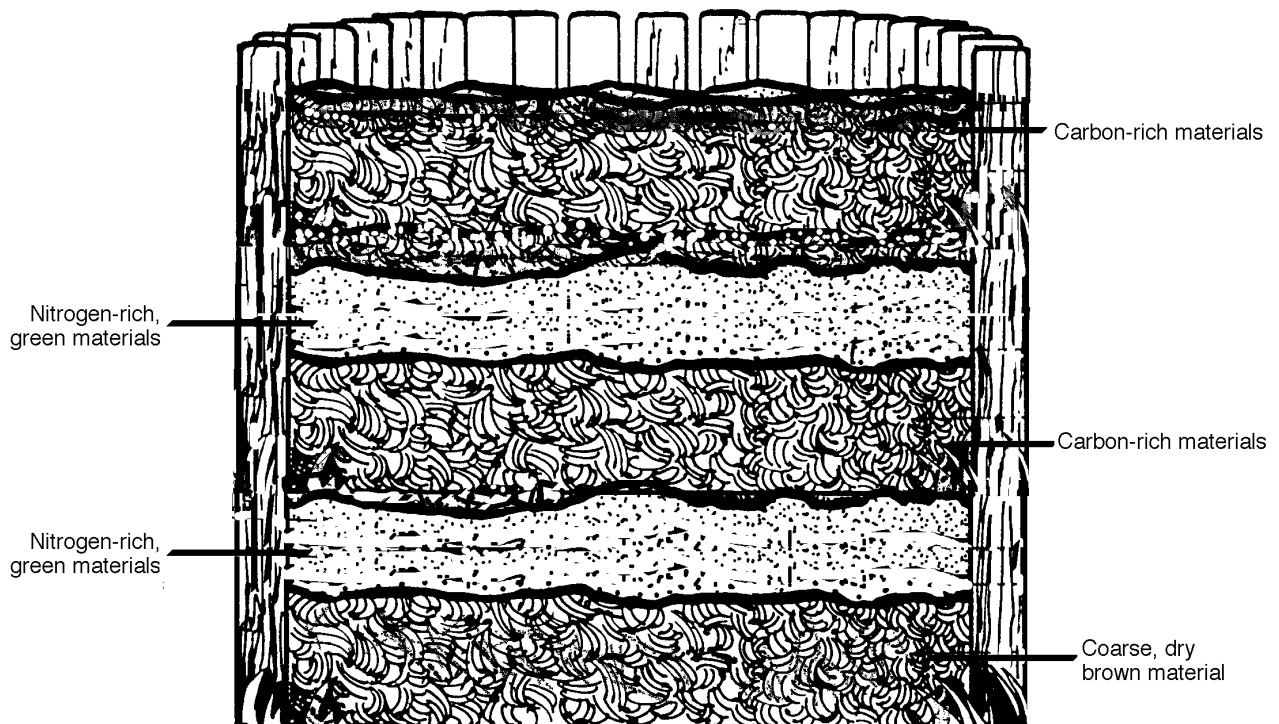
G. Turning

Although turning is not essential to backyard composting, it performs several beneficial functions. It improves aeration by increasing porosity and charging the pile with fresh air. It also blends materials, breaks apart particles, and removes heat, water vapor, and other gases contained in the pile. Turning speeds the process and helps in managing temperature, moisture, and odors.

There are few hard-and-fast rules for turning composting materials. You can do it on a regular schedule (weekly), when you add fresh materials, occasionally at your convenience, or in response to the pile's conditions. Turn piles according to the following guidelines.

1. To speed the process and promote high temperatures—In most cases, the more often you turn a pile, the faster it composts. Therefore, the pile is more likely to achieve high temperatures. Turning is effective with moderately to highly degradable materials. It has limited effect on slowly degradable materials.
2. To blend materials—Turn piles when materials are poorly-mixed, when different sections of the pile show differences in consistency, color, moisture, temperature, or odor.
3. To cool the materials—Turn piles when temperatures become too high (above 140°F).
4. To aerate materials—Turn piles when odors begin to develop (see Subsection I on “Odor Management” on page 7-12) or

Fig. 2. Building compost piles by layering.



when other signs of anaerobic conditions appear such as an unexpected temperature drop or compacted, matted, or slimy-looking materials.

5. To drive off moisture—Turn piles when the materials become saturated from rain or with the addition of wet materials.
6. To add moisture—Turn piles when adding water. Otherwise, water is difficult to distribute throughout the pile.

H. Moisture Management

1. Lack of moisture—The most common ailment of composting piles in arid climates is lack of moisture. Without substantial rain, you must add water to piles (perhaps weekly) to keep the process going. The more you turn a pile, the more water you should add. You can reduce moisture loss by decreasing the turning frequency, sheltering piles from wind and sun, increasing pile size, and using bins with covers and small ventilation openings.
2. Too much water—A less frequent problem, you should turn piles that are too wet to distribute water within the pile and to encourage evaporation.
3. Moisture test—Although the surface of the pile appears dry, the materials a few inches below should look and feel damp. Use the squeeze test to test for adequate moisture (see Section II, Subsection C-2 on page 7-4). If the pile needs water, add it with a trickle hose or sprinkler. Because water moves slowly through the mass of composting materials, turn the compost while adding the water. To conserve fresh water, you can routinely add “used” water from certain household (for example, water from washing or cooking vegetables) and garden activities.

I. Odor Management

Most backyard composting materials present little odor risk. Still, odors can occur as a result of neglect or the wrong combination of materials and conditions. The best way to manage odors is to avoid anaerobic conditions—keep the pile from becoming too wet, turn at the first hint of odors, maintain a mix with at least as much brown ma-

terial as green, and generally maintain good pile porosity.

1. Degradable materials—Highly degradable materials such as grass, manure, and food scraps require particular attention. Mix the materials thoroughly within the pile. If you add these materials in large quantities (more than one-quarter of the pile volume), then turn the pile regularly. Unturned piles and holding bins do not provide the air flow needed to aerobically decompose large quantities of grass, manure, and food. If turning is not practical or if odors are a sensitive problem, it may be best to avoid composting these materials.
2. Correcting odors—The remedy for an odorous pile is to supply more oxygen by turning and by increasing the pile’s porosity (e.g., adding coarse brown materials). Disturbing the pile will release the odorous compounds, so the odor may become more intense for a brief period. If a pile develops strong odors, turning it might aggravate the nuisance. You can allow the odorous pile to decompose undisturbed and the odors should gradually dissipate. Do not add water or fresh material except for an insulating, odor-absorbing layer of coarse dry materials on the surface. Instead, start a new pile. When the odorous pile becomes tolerable, turn it and combine it with a new pile.

J. Troubleshooting

The most prevalent problem associated with backyard composting is slow decomposition. The first suspected cause is excessive drying of piles, followed closely by a lack of nitrogen (not enough fresh green material). Poor aeration caused by wet or compacted materials, also can hinder the composting rate. In this case, odors may accompany the problem. Other occasional difficulties include pests, ammonia-like odors, and extremely high temperatures. See Table 5 for troubleshooting guidelines.

K. Judging When Composting Is Finished

Composting does not stop at a particular point. Biological decomposition of the raw materials and the compost continues almost

indefinitely. The compost becomes usable, and we consider the process finished when the decomposition rate slows to the point that the compost will not create odors nor adversely affect plants as it continues to decompose. Judging when the pile reaches this

point is part of the art of composting. Signs of mature compost include the following:

1. The expected composting time period has elapsed since you last added materials to the pile (see Section II, Subsection C-7 on page 7-6).

Table 5. Troubleshooting guidelines for home composting piles.

| Problem | Possible causes | Clues | Remedy |
|--|--|---|--|
| Rotten odor | Anaerobic conditions because of excess moisture | Pile feels and looks soggy. | Turn pile and/or mix in dry materials. |
| | Anaerobic conditions because of poor porosity and compaction | Pile looks dense, matted, or slimy with few or no large rigid particles. | Turn pile and/or mix in coarse brown materials—straw, chipped wood, etc. |
| Ammonia odor | Too much nitrogen; not enough carbon | Pile includes a lot of grass, food, or manure | Mix in more brown carbon-rich material—leaves, sawdust, etc. |
| Slow decomposition | Not enough moisture | Pile is barely damp to dry inside. | Add water and/or wet materials and turn pile. |
| | Not enough nitrogen, or slowly degradable materials | There is an abundance of brown materials in the pile—wood, leaves, etc. and the pile is not dry. | Add green material or nitrogen fertilizer, or shred materials, or be patient—it will happen. |
| | Not enough oxygen—anaerobic conditions | Pile is dense, looks matted or slimy with hint of rotten odor. | Turn pile. Add coarse or dry material as needed. |
| | Pile is cold—small volume | Pile is less than 3 ft high and the weather is near freezing. | Add fresh material and turn pile. Increase pile size. |
| | Pile is totally frozen | Frozen clumps within the pile | Wait for spring, and then turn. |
| | Compost is mature | Pile conditions are good. | None needed |
| Not reaching high temperatures (over 120°F) | Small volume | Pile is less than 3 ft high. | Increase pile size. |
| | Not enough nitrogen | Pile is more than 3 ft high. Weather is above freezing. | Add green material or nitrogen fertilizer. |
| | Cold weather | Pile is more than 3 ft high; below freezing weather. | Insulate surface of pile with compost, straw, leaves, etc. |
| Pile is too hot (over 140°F) | Pile is too large | Pile is more than 5 ft high. | Divide into smaller piles. |
| | Not enough air flow—poor ventilation | Pile is less than 5 ft high, but fairly dense and moist. | Turn pile. Decrease pile size. |
| | Pile is becoming too dry. Not enough evaporative cooling | Pile is less than 5 ft high and only slightly damp. | Add water and turn pile. |
| Pests attracted to compost pile (flies, bees, dogs, cats, rodents, skunks, etc.) | Exposed food scraps | Food scraps at or near the pile surface | Bury food 6 inches beneath the pile surface. |
| | Meat, fish, or oily foods in the pile | Evidence of digging in the pile | Remove food from pile, or turn into the pile center, or use a pest-proof composting bin. |

2. The pile of compost is consistent and has a dark brown color, crumbly texture, and earthy odor.
3. Except for pieces of wood, the compost shows little evidence of the original yard trimmings and food scraps added to the pile.
4. The moist pile remains cool and does not become warmer after turning.
5. Earthworms and other invertebrates have inhabited the compost pile.
6. The moist compost does not develop offensive or stale odors when stored in a closed plastic bag at room temperature for 2 weeks.

Note: Unfortunately, an unfinished compost can exhibit some of these traits. Therefore, be sure several of these signs (the more, the better) are present before harvesting the compost. To be safe, allow the compost to cure in small piles, about 3 feet high, for a month or two after you judge the process to be complete.

V. Using Compost

Use compost as a soil amendment for flower and vegetable gardens, as a mulch around trees and shrubs, as a top-dressing for lawns, and as a component of potting soil. Most compost will greatly benefit plants, but unfinished compost, or compost stored under anaerobic conditions, can harm seedlings or sensitive plants. Therefore, compost quality is important.

A. Benefits of Compost

1. Improves soil structure—The addition of compost gives soil a crumbly texture and increases the soil's porosity so that plant roots can more easily penetrate it. When mixed with a sandy soil, compost adds moisture and nutrient holding capacity. In heavy clay soil, compost particles bind with clay particles to form loose aggregates of soil that drain better and resist surface crusting and erosion.
2. Buffers pH changes—Most composts have a near-neutral pH and the ability to buffer pH changes in the soil.

3. Attracts beneficial soil organisms—Compost contains a large and diverse population of biological organisms plus organic matter that attracts earthworms and other beneficial soil organisms. These traits contribute to compost's ability to suppress certain soilborne plant disease.
4. Contains trace mineral and plant nutrients—Although compost is not normally considered a fertilizer, it does contain trace minerals and small quantities of major plant nutrients. The amounts of nutrients depend on the materials composted. Typically composts made from yard trimmings have N concentrations in the range of 0.5 to 1 percent with P and K ranging from 0.2 to 0.5 percent. Most of the nitrogen and phosphorus are released slowly, over a period of several years, and in a pattern that tends to follow the growth patterns of plants.

B. Application

See Table 6 for general guidelines for applying compost. Because we use compost primarily as a soil amendment and not as a fertilizer, the amount of compost you apply is not critical. As a rule, use more compost for poorer soils.

1. As a mulch or top-dressing—You can apply compost continually as a mulch or top-dressing for gardens and lawns. The organic matter and nutrients will gradually work their way into the soil.
2. As a soil amendment—The best time to add compost as a soil amendment is when you prepare the garden bed or lawn surface before planting. Mix the compost with soil to at least three times the depth of the thickness of the compost layer that you are applying. For example, mix a 1-inch thick layer of compost into the top 3 to 4 inches of soil; mix a 2-inch layer to a depth of 6 inches or more. If only a small amount of compost is available, incorporate it in seed furrows or mix it with soil for each annual or perennial plant's transplant hole following the 1 to 3 compost-to-soil ratio.
3. As a potting mix—Compost should not comprise more than one-third of the pot-

ting mix by volume. A popular compost-based mix is one part peat moss, one part vermiculite or perlite, and one part compost, by volume.

C. Compost Quality

1. Quality depends on use—The required qualities of a compost depend on its intended use. Compost intended as a top-dressing for lawns should not have particles greater than 1/4-inch in size. It is often necessary to pass a top-dressing compost through a 1/4-inch screen. Compost used as a soil amendment can have large particles but should not contain a high percentage of wood. Soil microorganisms compete with the garden plants for nitrogen as they decompose the remaining wood. Gardens that are amended with wood compost require extra applications of nitrogen fertilizer. Compost that looks and feels more like a collection of small wood chips than soil is better suited as a mulch than a soil amendment. Make this judgment after mixing the compost because small particles tend to settle to the bottom of undisturbed compost piles leaving a blanket of wood particles on the surface.

2. Cure compost before using—Immature compost and compost produced or stored under anaerobic conditions may contain organic acids and alcohols that can harm plants. These conditions are not common in backyard composting because piles and bins tend to be small. Nevertheless, it is wise to cure mature compost for a month or more before using it. Store or cure compost in piles that are relatively short—3 feet or less. If you have stored compost in a large pile, spread it on the ground and allow it to air out for a day or more (the longer, the better). Maturity and other quality factors become increasingly important if you use the compost in a more concentrated manner. For example, compost used in potting mixes requires closer scrutiny than compost used as a soil amendment.

VI. Alternatives to Composting

Composting is not the only way to make good use of home and garden residues. Worm composting produces a high quality soil amendment via a different biological process. Grass recycling, soil incorporation, and mulching are other ways to recycle garden and food residues without the management demands of composting.

Table 6. Guidelines for applying compost.

| Landscape use | Approximate application rate (lb per 1,000 sq ft) | Equivalent thickness of compost | Comments |
|---|---|---------------------------------|---|
| Soil amendment for gardens and lawn establishment | 3,000 to 9,000 | 1 to 3 inches | Mix with soil to a depth of about 4 to 9 inches. Use more compost for poor soils. |
| Soil amendment for planting trees and shrubs | 3,000 to 9,000 | 1 to 3 inches | Mix with soil over an area of 2 to 5 times the root ball width and to a depth of 6 to 10 inches. Use more for poor soils. |
| Top-dressing for lawns | 400 to 800 | 1/8 to 1/4 inch | Broadcast evenly over lawn surface. Best applied after thatching or core aerifying. |
| Top-dressing for gardens and shrubs | 400 to 1,500 | 1/8 to 1/2 inch | Spread evenly then lightly work into the soil. |
| Landscape or garden mulch | 1,500 to 6,000 | 1/2 to 2 inches | Spread evenly over surface. Use the higher rate with coarse woody composts. |
| Potting mix | Not more than one-third by volume | | Blend with peat moss, sand, perlite, vermiculite, or bark. |

Helpful numbers: A 1-inch deep layer covering 1,000 square feet requires about 3 cubic yards of compost. Compost weighs about 30 to 40 pounds per cubic foot (about 800 to 1,000 pounds per cubic yard).

A. Grass Recycling

Usually, the compost pile is not the best destination for grass clippings. The simplest way to recycle grass clippings is to leave them on the lawn. This benefits the lawn by returning nutrients and organic matter to the soil. This alternative also keeps herbicide-treated grass out of the compost pile.

“Grasscycling” works best with proper mowing, fertilizing, and watering practices.

B. Mulching

You can use many organic residues from the home, garden, or landscape as mulches with little or no decomposition or preprocessing. Placing organic mulches on the soil surface controls weeds, reduces evaporation, lessens soil erosion, and moderates the soil temperature (keeps it cooler in the summer, warmer in the winter). Types of yard trimmings that you can use as mulches include grass clippings, leaves, pine needles, and chipped branches and shrub-trimmings. All of these materials are suitable for surface mulching around trees, shrubs, and other perennial plantings.

Shred leaves with a lawn mower or commercial shredder before using them as a mulch. Unshredded leaves tend to limit water and oxygen movement into the soil. Apply fresh grass clippings in layers that are not more than 1 inch thick. Otherwise they will mat together and limit air movement. A brief period of composting or drying can improve the appearance and performance of several mulching materials including leaves, grass clippings, and chipped wood.

C. Worm Composting

Worm composting, or vermicomposting, relies on worms to digest food scraps, paper, manure, and vegetation. In the process the worms leave behind castings that form a high-quality soil amendment called “vermicompost.” The type of worms used are red worms, not common soil dwelling worms.

Worms need a dark, cool, moist, and aerobic environment. Therefore, mix food and “bedding” in shallow layers in closed boxes or bins to compost. The bedding provides a light, airy habitat for the worms. Typical

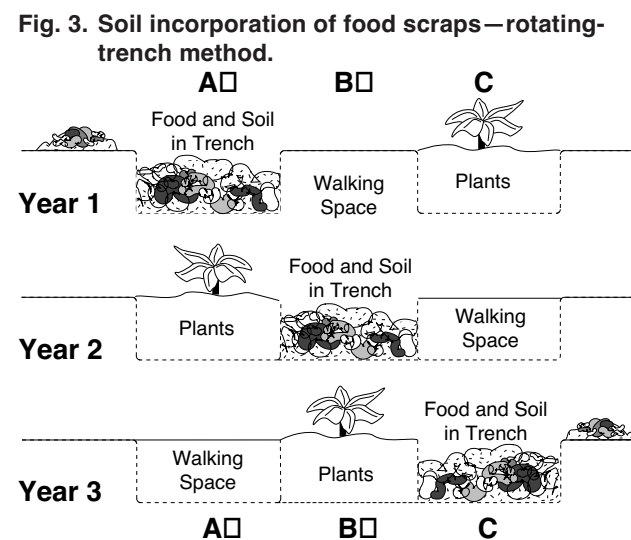
bedding materials include shredded paper, straw, peat moss, and sawdust. Worms work best at temperatures between 50° and 70°F (10° - 20°C), so a basement or other cool space is a good location for a worm bin. If the bin freezes or gets too hot, the worms die. You can harvest and use the compost when the bin contents become fairly uniform, dark, and soil-like in texture. This usually takes 3 to 6 months.

D. Soil Incorporation

Incorporating food scraps into the soil is an alternative method for recycling nonfatty food scraps. Within a month to a year, the food material will decompose to fertilize established or future plantings. The time period depends on the soil temperature, the number of organisms in the soil, and the carbon content of the food. Chop the food scraps, mix with the soil at the bottom of an 8- to 12-inch deep hole or trench, and cover completely with clean soil. One system of soil incorporation rotates garden space among food trenches, rows of crops, and walkways as in Fig. 3. Soil incorporation is difficult, if not impractical, during the winter when ground is frozen or snow covered.

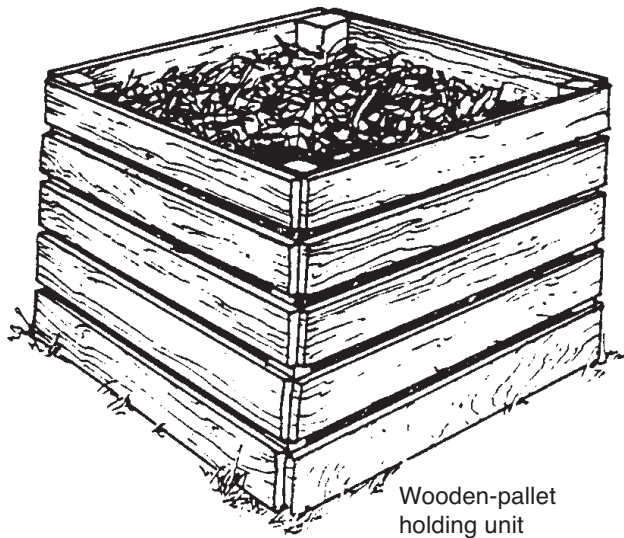
VII. Plans for Constructing Composting Bins

You can make compost bins from readily available materials. Types of enclosures include woven-wire fencing (hog wire, chicken wire, chain link), wood-slat fencing (snow fence), cement blocks, bricks, or scrap lumber.



A. Wooden-Pallet Holding Unit

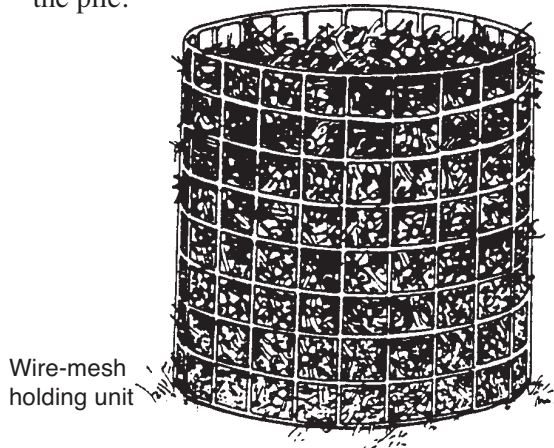
You can build an inexpensive compost bin with wooden pallets or pressure-treated lumber. Used pallets are available from manufacturers and landfills.



Wooden-pallet holding unit

B. Wire-Mesh Holding Unit

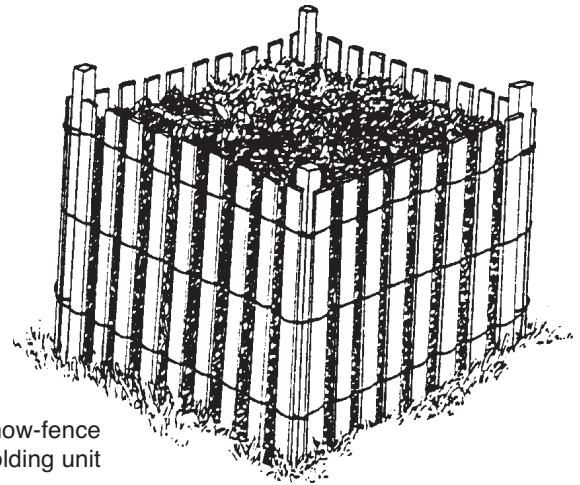
Use either galvanized chicken wire or hardware cloth to build an inexpensive wire-mesh holding unit. (You also can use nongalvanized chicken wire, but it won't last very long.) Posts provide more stability for a chicken wire bin, but make the bin difficult to move. A wire-mesh bin without posts is easy to lift and provides access to the already "done" compost at the bottom of the pile.



Wire-mesh holding unit

C. Snow-Fence Holding Unit

A snow-fence holding unit is simple to make. It works best with four posts pounded into the ground for support.



Snow-fence holding unit

D. Wood-and-Wire, Three-Bin Turning Unit

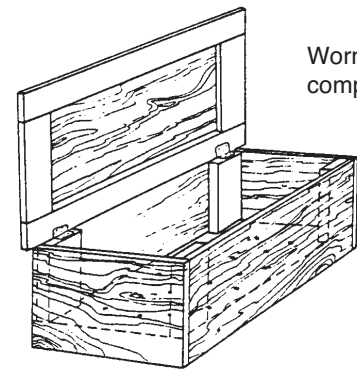
You can use a wood-and-wire, three-bin holding unit to compost large amounts of yard, garden, and kitchen wastes in a short time. Relatively inexpensive to build, it is sturdy, attractive, and should last a long time.

E. Wooden Three-Bin Turning Unit

This turning unit is a permanent, sturdy structure made of pressure-treated lumber.

F. Worm Composting Bin

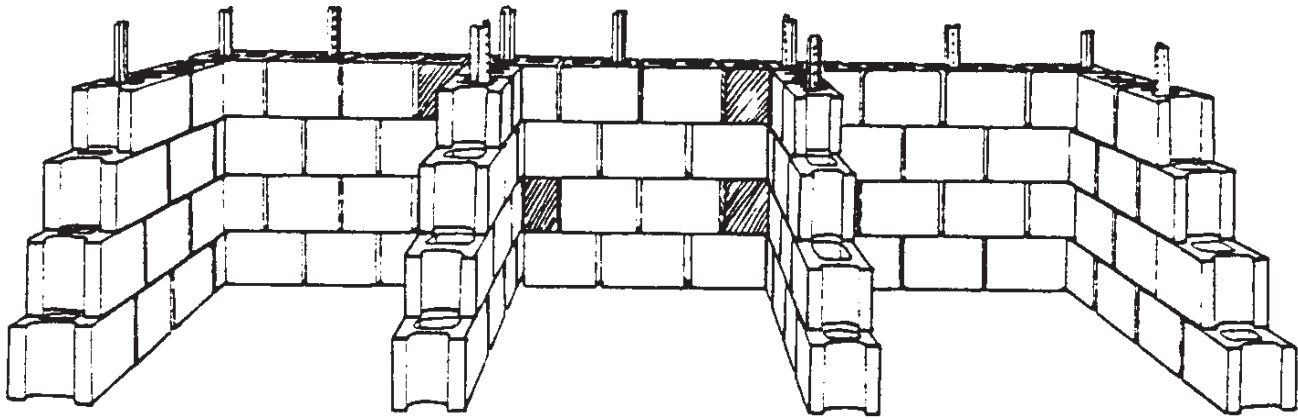
Worm composting is a suitable option for apartment buildings or homes with no yard space. The worms stay in the bin and eat household scraps, and the bin gives off little odor.



Worm composting bin

G. Concrete-Block Holding Unit

A concrete-block holding unit is sturdy, durable, and easily accessible. Leave about 1/2 inch between each block to let in air. Stagger the blocks and drive wooden or metal posts through the holes in the blocks to stabilize the bin.



Concrete-block, three-bin turning unit

H. Concrete-Block, Three-Bin Turning Unit

A concrete-block turning unit looks like three concrete-block holding units in a row. It is sturdy and, if used blocks are available, it is inexpensive to build.

Further Reading

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Urban Home Composting, Rodent-Resistant Bins and Environmental Health Standards. City Farmer, Canada's Office of Urban Agriculture, Vancouver, BC.

Booklets and Pamphlets

University of Idaho

- CIS 1066 Composting at Home (\$3.00)
- CIS 1016 Don't Bag It! Recycle Your Grass Clippings (50¢)
- CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes (35¢)

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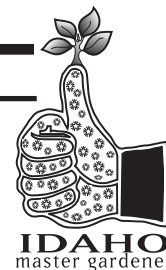
Chapter

Pesticide Management and Safety



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Pesticide Management and Safety



V. J. Parker-Clark

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I. Three Main Objectives of Pest Control

- A. Prevention—Keep a pest from becoming a problem.
- B. Suppression—Reduce pest numbers or damage to an acceptable level.
- C. Eradication—Destroy an entire pest population.

II. Home, Yard, and Garden Pesticides

Pesticides are used to prevent or reduce damage caused by weeds, diseases, insects, mollusk, or vertebrates. **Before** you use a pesticide you should:

- A. Identify the pest. Remember various pests cause similar symptoms; environmental conditions may cause similar symptoms to pests. **Be a detective.** Ask questions to focus in on the most likely possibilities.
- B. Know what other control measures are available (mechanical, chemical, and biological).
- C. Evaluate the benefits and risks of each method of control.
- D. Choose the methods that are most effective and that will cause the least harm to people and to the environment.
- E. Use the methods correctly.
- F. Observe local, state, and federal regulations that apply to the situation.
- G. Observe precautions, restrictions, and preharvest intervals noted on the label.

III. Pest Control Methods

- A. Many factors influence or affect pest control.
 1. Climate.
 2. Natural enemies.
 3. Topography.

4. Food and water.
5. Water supply.
6. Host resistance.
7. Cultural control by mechanical sanitation or crop rotation.
8. Chemical control.

B. The term “pesticide” refers to any substance that is used to control organisms considered to be pests. The following are some of the classes of pesticides available to homeowners:

1. Herbicides—Vegetation control.
2. Insecticides—Insect control.
3. Fungicides—Fungus control.
4. Rodenticides—Rodent control.
5. Acaricides—Mite control.
6. Nematocides—Nematode control.
7. Molluscicides—Snail and slug control.
8. Repellents—Birds, mammals, and insect control.
9. Desiccants and defoliants—For drying plant foliage.
10. Disinfectants—Bacteria and fungi control.

IV. Herbicides

- A. Plant life cycle dictates which chemical to use and when to use it.
 1. Annual—1-year life cycle.
 - a. Winter annuals: Examples are annual bluegrass, henbit, cheatgrass.
 - b. Summer annuals: Examples are crabgrass, pigweed, lambsquarters.
 2. Biennials: 2-year life cycle. Example: mullen.

3. Perennials: Live more than 2 years.
Example: Canada thistle.

B. Types of Herbicides

1. Selective—Specific to certain weeds or groups of weeds.
2. Nonselective—Kills all vegetation.

C. How Do Herbicides Kill?

1. To be effective an herbicide must reach and stick to the leaf, penetrate the surface, move to the site of action, and disrupt a vital process.
 - a. Only 1 percent of the herbicide reaches the plant surface.
 - b. Surfactants help an herbicide stick to the leaf and penetrate the surface.
 - c. Herbicide movement depends on plant age and life cycle and on the mobility of the herbicide.
 - d. Many herbicides are taken up by the roots. Example: triazines.
 - e. Other herbicides are “pre-emergent.” They kill the emerging seedling. To be effective, these herbicides must form a barrier against emerging plants. They will not work if that barrier is disturbed. They will not hurt plants already out of the ground.
2. Nutrient/water movement at various stages of plant growth: In young plants movement is from the roots upward; in older plants movement is from the roots upward and from the leaves downward. In most mature plants, the movement is downward.
3. Types of chemicals.
 - a. Immobile.
 - b. Xylem mobile.
 - c. Phloem mobile.
 - d. Ambimobile (xylem and phloem mobile).

V. Insecticides

A. Classes

1. Organophosphates.
2. Chlorinated hydrocarbons.
3. Carbamates.
4. Botanicals.

B. How do insecticides work?

1. Organophosphates—Affect nervous system.

- a. Several of the organophosphates are systemic. Others are contact.
 - b. Organophosphates are detoxified rapidly in animal tissues and are eliminated rather than being stored in fatty tissues.
 - c. Organophosphates persist in the environment for relatively short periods in soils and plants. They are broken down by the action of plant enzymes, sunlight, air, moisture, and microorganisms. Some microorganisms (bacteria, yeast, and fungi) are capable of using insecticides as an energy source. Information on the pesticide label concerning the interval required between application and harvest (preharvest interval) is a good indication of the persistence of the material.
2. Chlorinated hydrocarbons—Affect nervous system.
 - a. Are not broken down rapidly in animals, so are stored in fatty tissues.
 - b. Are more persistent in plants and soils than other groups of pesticides. Some remain for several years in the soil and for weeks or months in plants. They are not readily attacked by enzymes in plants or microorganisms in the soil.
 3. Carbamates—Affect nervous system.
 - a. Some carbamates are systemics.
 - b. They are rapidly detoxified and eliminated from the animal’s system. Carbamates are not known to accumulate in fat.
 - c. Persistence varies in soils and plants, from a few hours to several weeks.
 4. Botanicals—Derived from plants. Examples: pyrethrum, nicotine (highly toxic), and rotenone (will kill fish). Use same handling and safety precautions for these as you would for any pesticide (see Section X, “Pesticide Hazards,” on page 8-5 and Section XI, “Pesticide Law,” on page 8-8).
 5. The timing of insecticide application depends on the life cycle stage of the insect you are trying to control and on what kind of insecticide you use (systemic or contact).

- a. Example: Aphids feeding on a maple tree. A contact chemical (labeled for aphids on maple) applied directly to the aphids will kill any aphids not in the egg stage.
- b. If a systemic is used, the sap in the tree must be moving to the leaves where the aphids are feeding in order to kill them. Example: A systemic would not kill the adult stage of the leaf skeletonizer because the adult does not feed on the tree. The larval stage does.

Note: You must know the insect life cycle, the plant life cycle, and the “mode of action” of the insecticide you are using to accomplish the most effective and safe control.

VI. Fungicides

- A. Ingredients—Sulfur, captan, triforine, Daconil 2787.
- B. How do they work? By suppression or smothering?

VII. Pesticide Labels

- A. All home, yard, and garden pesticides are made up of materials from one of two categories:
 1. Active ingredient(s)—This component consists of the ingredient that will prevent, destroy, repel, or mitigate any pest.
 2. Inert ingredients—This component consists of a wide variety of materials that do not have any biological effect upon the pest. Some common inert ingredients are petroleum distillates, emulsifying agents (detergent-like materials), spreaders, stickers, clay particles, and even water.
- B. Pesticide labels are required by law to provide the buyer with a list of active ingredients in a product, and a description of the percentages of the total that those active ingredients make up.
- C. Pesticide labels must also state the pest that the product will control and at what rate the product should be applied for safe control of that pest on that plant.
- D. Pesticide labels must also give information about storage, disposal, precautions during

use, symptoms of poisoning, physical hazards, environmental hazards, preharvest intervals, signal words (caution, warning, danger), and first-aid information. These items will be discussed later in this chapter.

VIII. Pesticide Categories

All pesticides are classified as either “general use” or “restricted use.”

- A. General Use Pesticides—Considered minimally hazardous when used according to label directions. All home, yard, and garden pesticides are general use.
- B. Restricted Use Pesticides—Deemed excessively hazardous to the environment or to the applicator.
 1. In Idaho, restricted use pesticides may only be used by those people who have been trained and tested by Idaho Department of Agriculture personnel. These people must show a valid applicator’s license to a chemical dealer before purchase of this category of pesticides.
 2. Application of restricted use pesticides by unlicensed personnel is a violation of Idaho law.
 3. Application of restricted use pesticides in or around the home is risky business, given the high toxicity or wide range of action these chemicals have.

IX. Pesticide Formulations

Pesticide formulations are classified according to the composition of active and inert ingredients and the intended use.

- A. Pesticide formulations requiring no dilution in water. These products include:
 1. Dusts—Active ingredient combined with inert materials such as fine clay particles, talc, etc.
 2. Granules—Active ingredient combined with inert materials such as coarse clay particles, marble chips, or corn cob grit.
 3. Baits—Active ingredient combined with an attractant such as food or scent.
 4. Pest strips—Active ingredient impregnated in a plastic strip that slowly releases pesticide into the atmosphere.
 5. Aerosols—Active ingredient combined with petroleum distillates and propellant gas in a pressurized can.

- 6. Ready-to-use liquids—Active ingredient already diluted with water at the proper use rate.
- B. Pesticides requiring dilution in water. These products include:
 - 1. Emulsifiable concentrates (EC)—Water-insoluble active ingredient, usually in petroleum distillate with emulsifiers. When the distillate is combined with water, it forms an emulsion. Agitation is needed to provide an even distribution of the chemical in water. Emulsifiable concentrates are the most dangerous formulations to handle.
 - 2. Wettable powders (WP)—Water-insoluble active ingredient sprayed on very fine solid particles, usually clay or talc. Add wetters and other adjuvants to aid in the dispersion and suspension of the particles in water. The powders need agitation to mix.
 - 3. Water-soluble liquids (WS)—Active ingredient is dissolved in a concentrate containing alcohol or water. The mix forms a true solution and needs little or no agitation after mixing thoroughly.
 - 4. Dry flowable (DF)—The active ingredient is packaged in granular form. The chemical may or may not be water soluble. DF's are as easy to measure as a liquid and are less likely to contaminate body, clothing, or work area and to be inhaled than either WPs or dusts.

X. Pesticide Hazards

The degree of hazard associated with pesticide use is determined by various factors. The primary concern, however, must be the hazard to the health and welfare of humans. The major factors that determine the hazard of a pesticide to humans, other mammals, and other animals include the following:

- A. Pesticide Toxicity (The degree to which a chemical tends to be poisonous)
 - 1. The toxicity of any substance is expressed in terms of dosage.
 - a. Hazardous doses vary with such factors as age, sex, health, and body weight.
 - b. Dosages are normally expressed in milligrams (mg) of toxicant per kilogram (kg) of body weight (1 kg = 2.2 lb; 1 mg = one millionth of a kg).
 - 2. The toxicity of a pesticide is determined by subjecting test animals (usually mice or rats) to the pure active ingredient.
 - a. A common measure of the estimated toxicity of a pesticide is the dose required to kill half the animals treated with a pesticide. This dose is termed to be the LD₅₀ (lethal dose to kill 50 percent).
 - b. An LD₅₀ is always expressed as mg/kg or g/kg. An LD₅₀ of 3 mg/kg means that a dose of 3 mg of pure toxicant per kg of animal body weight will normally be lethal to half of the test animals.
 - 3. Pesticide classifications based upon LD₅₀ ratings are listed in Table 1. Almost all home, yard, and garden pesticides are category III or IV chemicals. Nicotine has an LD₅₀ of 50 to 60 mg/kg so is a class II chemical. Pyrethrum's LD₅₀ rating is 1,500 mg/kg.

B. Pesticide Formulations

- 1. As previously described, almost all pesticides are marketed in formulations that contain considerably less than 100 percent of the active ingredient. The hazard, therefore, of even a category I chemical in a typical home, yard, or garden formulation would be small.

Table 1. Pesticide classifications based upon LD₅₀.

| Toxicity category | Signal word | Toxicity | Oral LD ₅₀ (mg/kg) | Amount needed to kill an adult |
|-------------------|------------------------|-----------|-------------------------------|--------------------------------|
| I | DANGER POISON (fatal) | Very high | 50 or less | A taste to a teaspoon |
| II | WARNING (may be fatal) | High | 51 to 500 | A teaspoon to a tablespoon |
| III | CAUTION | Moderate | 501 to 5,000 | An ounce to a pint |
| IV | CAUTION | Low | Greater than 5,000 | A pint to a quart or more |

2. Some formulations pose a lower hazard than others, simply because of their physical state. For example, a granular pesticide will normally pose a lower hazard than an emulsifiable concentrate because it is more difficult to ingest or absorb through the skin.

C. Exposure to Pesticides

1. Pesticides can enter the body through one of three methods:
 - a. Through the digestive tract (ingestion).
 - b. Through the respiratory system (inhalation).
 - c. Through the skin (dermal absorption). Eyes absorb almost any chemical that gets into them.
2. The hazard of unnecessary exposure to a pesticide can be reduced by following these guidelines:
 - a. Replace leaky hoses, valves, and connections on sprayer before application. Never use your mouth to blow out clogged lines or nozzles.
 - b. Calibrate and clean application equipment to ensure accurate and safe application.
 - c. Always read the entire label before using a pesticide.
 - d. Pesticide handling and mixing should be done outside. Watch out for wind when mixing or applying pesticides. Avoid breathing dust, and watch out for the splash of liquids or the drift of fumes.
 - e. Refrain from smoking, eating, or drinking while working with pesticides.
 - f. Wear clothing that covers the entire body, including a nonabsorbent hat.
 - g. Wear unlined rubber gloves and eye protection whenever mixing pesticides.
 - h. Before making outdoor pesticide applications: Close all house doors and windows; remove any laundry, toys, lawn furniture, and pet dishes; and keep children and pets out of the sprayed area until the pesticide has dried. If using a dust formulation, keep children and pets out of the area until dust completely settles.

- i. Before making indoor pesticide applications: Remove or cover all food, dishes, utensils, pet dishes, and toys; keep children and pets out of the application area. If you have an aquarium, cover it, and be sure to switch off the aeration pump; cover any openings.
- j. Always apply pesticides in a manner that will minimize pesticide drift onto nontarget vegetation and the property of others.
- k. Wash yourself, your equipment, and your clothing immediately upon completion of pesticide applications. Always wash contaminated clothing separately from other clothing.

D. Pesticide Poisoning

1. People vary considerably in their susceptibility and reactions to pesticides. Children are particularly susceptible because of their small size and weight. A dose that might make an adult sick could be fatal for a child. In addition, a child's body is often less able than an adult's to detoxify some compounds.
2. The common symptoms of pesticide poisoning are headaches, giddiness, nausea, blurred vision, and chest pains. Anyone complaining of these symptoms within 12 hours after exposure to a pesticide should be sent to the nearest medical facility.

Note: It is very important that the pesticide label or container (or at least the name of the compound) also be delivered to the doctor so appropriate first aid can be administered. If the container is transported, carry it in such a way that no further exposure to the victim or others occurs.

3. Emergency first-aid procedures for pesticide poisoning:
 - a. Pesticide in the eyes: Flush eyes with a gentle stream of tap water for at least 15 minutes.
 - b. Pesticide in the mouth: Flush mouth out with tap water for 15 minutes.
 - c. Pesticide spilled on clothing: Remove clothing; wash skin with soap and water.

- d. Pesticide swallowed: Read and follow the first-aid directions on the label. If there are no directions, go directly to the nearest medical facility.

Note: Drinking water or milk will rarely increase the problem and may reduce the potential damage by diluting the chemical.

E. Pesticide Spills

1. Liquids.

- a. The spill should be covered with any substance that will absorb the pesticide (kitty litter, sawdust, sand, dirt, or even disposable diapers).
 - b. After the pesticide has been absorbed, the material should be swept up and placed in a plastic garbage bag within another garbage bag. If the pesticide is a home, lawn, or garden formulation, the bag may be disposed of via your standard garbage collection service.
 - c. The spill area should then be washed with detergent or an ammonia solution. Call Chem Trec toll free at 1-800-424-9300 to find out what to use. Using the wrong solution could generate toxic gases. Prevent any contaminated soil from running into storm drains or open bodies of water.
2. Dry pesticides should be swept up and used or disposed of in accordance with the label instructions. The spill area may also require washing with detergent or a chlorine or ammonia solution.

F. Pesticide Storage

1. Store pesticides in a cool, well-ventilated place that is inaccessible to children and pets. The area should be away from food, feed, and seeds, and should be locked.
2. Store pesticides in their original containers. Never store pesticides in soft drink bottles or other containers that may be confused with foodstuffs. Always maintain a label on the container.

Note: It is illegal to store chemicals in anything other than their original containers.

3. Discard unidentified pesticides.
4. Store liquid pesticides in a place where they will not be exposed to temperatures below freezing or above 80°F. Heat can degrade the active ingredients in dusts, granules, and soluble powders.
5. Be sure caps are secure on bottles or cans and check regularly for leakage.
6. Do not store volatile herbicides with dry pesticides, as the volatile products may contaminate the other products.

G. Pesticide Disposal Options

1. The best way to dispose of excess pesticides is to use them up in accordance with label directions. Buy small quantities—only the amount you can use up in one season.
2. Neutralize the pesticide if there are directions on the label for doing so.
3. Do not dump pesticides into a public sewage system via the sink or the toilet. Do not dump them into a street gutter that drains into open water. Sprayers should also not be drained near a well, pond, irrigation ditch, or stream.
4. Do not discard pesticide or containers where soil, crops, water, or animals can become contaminated.
5. Before disposing of a pesticide container, triple rinse it. The pesticide contaminated water (rinsate) should be used in your sprayer. Never dump rinsate onto the ground, into a drain, or into a gutter.
6. Puncture or crush empty metal containers (except aerosol cans), and bury them in an approved landfill. Do not burn.
7. Empty and triple rinsed containers may be wrapped in newspaper and disposed of via your local garbage collection service. Rinsate should be used for diluting more pesticide, if possible.
8. Anyone wanting to dispose of unused pesticides should contact their local health department for proper disposal instructions.

XI. Pesticide Law

The primary law homeowners should be aware of regarding safe use of pesticides is the Fed-

eral Insecticide, Fungicide, and Rodenticide Act (FIFRA).

- A. This law regulates all pesticides from the time of their manufacture until their ultimate degradation.
- B. The most important part of this law, as it pertains to homeowners, involves the actual use of any pesticide. **FIFRA states, “any use of a pesticide in a manner inconsistent with label instructions is a violation of this Act.”**
- C. All pesticide users should be aware that they are subject to the provision of FIFRA.

XII. Pesticide Recommendations

Before recommending the use of any pesticide, consider the following:

- A. It is illegal to use a pesticide on any site or crop other than those listed on the pesticide label. It also is illegal to recommend a pesticide on a site or crop other than those listed on the pesticide label.

Example: A client asks if it is all right to eat a vegetable that was sprayed with a particular insecticide. You find that the pesticide in question is not labeled for use on this garden product. You tell your client that you cannot recommend eating that vegetable, even though you may feel that the hazard is minimal.

- B. **In your capacity as a Master Gardener, your pesticide recommendations must be made in accordance with the pesticide guidelines provided on the pesticide label.**

Extension publications and the Pacific Northwest pest control guides are based on pesticide labels.

- C. Your pesticide recommendations must be limited to home, yard, and garden pest control. Pesticide recommendations for agricultural or commercial pest problems may be made only by licensed consultants.

Further Reading

Booklets and Pamphlets

University of Idaho

- PNW 320 Calibrating and Using a Backyard Sprayer (\$1.50)
- CIS 792 Calibration and Safe Use of Lawn and Garden Pesticide and Fertilizer Applicators (35¢)
- PNW 512 Farm Safety Series (English) (\$6.00)
- PNW 512S Farm Safety Series (Spanish) (\$6.00)
- PNW 278 First Aid for Pesticide Poisoning (50¢)
- CIS 897 Herbicides for the Home Garden (35¢)
- CIS 781 Laundering Pesticide-Contaminated Clothing and Safety Equipment (35¢)
- CIS 1019 Pesticides for the Home Garden and How to Use Them (\$1.00)
- CIS 861 Quality Water for Idaho: Pesticide Handling Practices to Protect Groundwater (free)
- CIS 865 Quality Water for Idaho: Pesticides and Their Movement in Soil and Water (free)

There is a nominal charge for each of the above University of Idaho publications. To order UI publications, contact your county's UI Extension office or write to Publications, University of Idaho, Moscow, ID 83844-2240, or call (208) 885-7982. Idaho residents add 6 percent sales tax. Also check, and in some cases download, the online publication and video catalog on the UI Educational Communications web site (<http://info.ag.uidaho.edu>).

Oregon State University

- PNW Insect Control Handbook (\$25.00)
- PNW Plant Disease Control Handbook (\$25.00)
- PNW Weed Control Handbook (\$25.00)

These Pacific Northwest handbooks are updated annually. To order, contact your county's Cooperative Extension office or write to Publications Orders, Extension and Station Communications, Administrative Kern A422, Oregon State University, Corvallis, OR 97331-2119.

Washington State University

- EB 1468 Read Pesticide Labels (50¢)
- EB 1386 Safe Disposal of Home Use Pesticides (50¢)
- EB 4734 Using Pesticides Safely in the Home and Yard (50¢)

To order WSU publications, contact your county's Cooperative Extension office or write to Bulletin Office, Cooperative Extension, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

Chapter Basic Entomology



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Basic Entomology



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I. Introduction

The animal kingdom contains many distinct groups called phyla. Each phylum is divided into a number of classes. The insects are in the class Insecta (or Hexapoda—"six feet") within the phylum Arthropoda (jointed foot). The insect class is further divided into orders, families, genera, and finally, species.

Approximately 1 million species of insects have been identified to date. The greatest numbers of these species belong to the beetle, fly, and wasp-bee-ant groups. We generally associate insects with crop loss or disease transmission; however, insects fulfill a useful function in our environment.

Only a small percentage of insects are considered pests of humans and of their animals, crops, or fiber. However, this small number can cause serious crop losses, or transmit serious diseases to humans or animals.

Most insects appear to be beneficial or harmless. Many are predators, such as lady beetles, which live by feeding on pestiferous aphids. Others are parasitic, such as the wasps. Still others, such as honey bees, act as pollinators of crops and also provide us with honey. Many insects are responsible for the decomposition of plant and animal matter. A good example is the carpenter ant. Obviously, when it is attacking the timber of our home it is a pest, however, when it is in the forest mining the wood of old, fallen trees, it is part of nature's recycling program.

Size is quite variable throughout the insect world. The extremes include tiny wasps that are less than a milli-

meter long, and some of the larger long-horned beetles that are as much as 6 inches long.

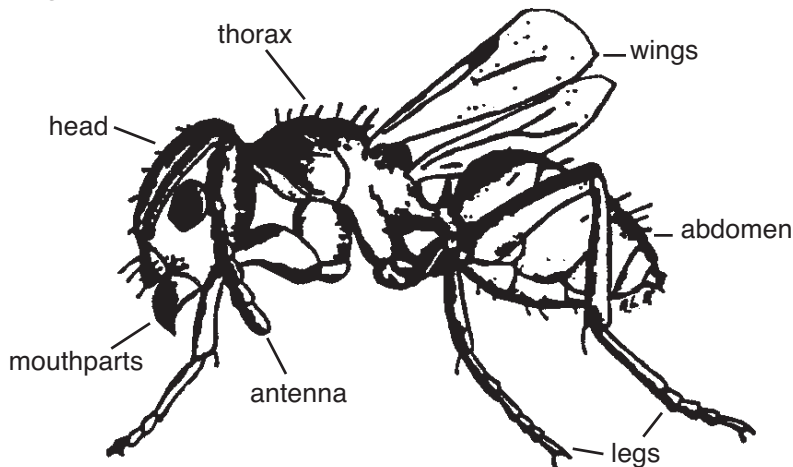
Except for a few common structural features, insects are also variable in appearance. Some have bizarre horns and spines, while others may resemble dead leaves. Some insects are quite attractive like the butterfly, but "beautiful" is hardly the word for a cockroach.

All of this makes insects a fascinating group to investigate, but it also makes the study of insects and their classification somewhat complex. It is important to learn the main differences among insects, so that we can distinguish one group from another. Then we can suggest adequate control procedures and give quality management suggestions.

II. Insect Anatomy

Insects are animals, however, unlike many animals, they have no backbones. They have an **outer** skeleton (**exoskeleton**) instead of the inner skeleton (**endoskeleton**) of most large animals. The following characteristics separate insects from other animals (Fig. 1).

Fig. 1. Parts of an insect.



- A. Insects have three body regions—Head, thorax, and abdomen.
- B. Many adult insects have wings, and insects are the only flying invertebrates.
- C. Adults possess three pairs of legs, all located on the thorax.

III. Insect Development

All insects change during growth by a process called metamorphosis (Fig. 2). Insect near-relatives such as spiders, mites, and centipedes also undergo metamorphosis.

The more highly developed insects make the most complete changes. Beetles, moths, butterflies, wasps, and ants all go through four stages. These are the egg, larva, pupa, and adult. The larva is usually the damaging stage, although adult feeding can be destructive.

Also, it is not unusual for the larval and adult stages of a species to feed on different hosts or different parts of the host. The pupa is a nonfeeding stage; in most cases it is also very inactive.

The lower forms or less-developed kinds of insects change only slightly during metamorphosis. True bugs, aphids, grasshoppers, termites, earwigs, stoneflies, etc., go through only three stages. These stages are the egg, nymph, and adult. Except for size, the nymph and adult closely resemble each other. The major difference is the lack of fully formed wings in the nymph. The nymph and adult generally feed on the same host or host parts.

IV. Insect Classification

There are several methods of separating or categorizing insects.

- A. The professional uses body parts for identification and observes differences in these parts through a microscope. He or she tracks down an insect's identity by using a written insect "key." The anatomy of an insect will place it into a specific insect group called an **order**. If you are around entomological ac-

tivities much, you will often hear the phrase "keying out." This simply means identifying the insect (see MS 109 in "Further Reading").

- B. Insects are also classified by the type of damage they cause. Some examples include "root maggot," "twig girdler," or "crown borer." Destructive insect activities help narrow down the multitude of possible identities and often make insect identification quicker and simpler.

- C. Some insects can be categorized as predators or parasites. Predators and parasites account for much of the reduction of pest insect populations in nature, and, for this reason, are also called beneficials (see PNW 343 in "Further Reading").

Beneficials can be useful, but they usually need some cultural encouragement. Their use requires careful crop management and a degree of tolerance for some crop loss.

1. Predators kill and feed on their prey; they are generally larger than their prey.
2. Parasites are usually smaller and often weaker than their prey; they gradually kill by injecting eggs that develop on, within, or near the insect over a period of time. They may sting and paralyze their prey in order to stock their nests with food for the developing larvae or eggs. The immature parasites will then consume the paralyzed insect at their leisure.

- D. Another form of categorization is by feeding mechanism or mouthpart. The broadest grouping is defined by chewing or sucking mouthparts (Fig. 3).

Fig. 2. Metamorphosis stages in insects.

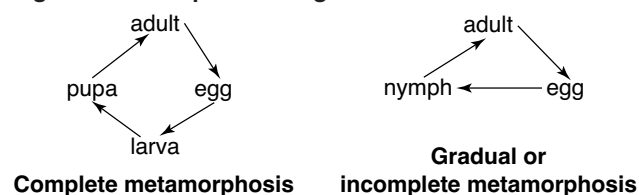
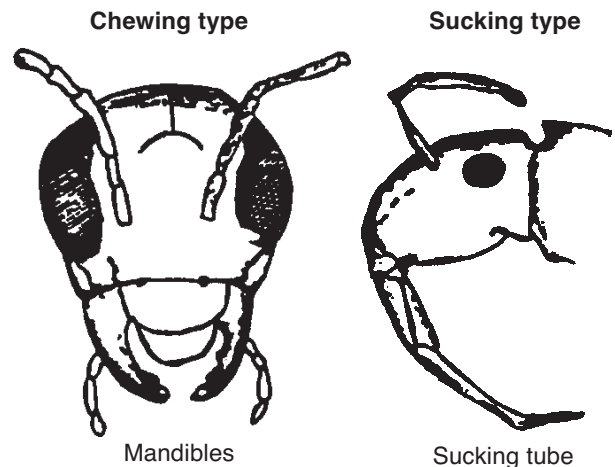


Fig. 3. Insect feeding mechanisms.



Although this manner of separation is somewhat helpful for identification, its greatest value is in determining if a certain kind of pesticide will work. For example, systemic insecticides “generally” do not work as well on chewing insects as on sucking insects. Proper identification is extremely important. If a beneficial insect or a nondamaging insect is improperly identified as a pest, a pesticide application will usually disrupt a natural control agent. The disruption of this beneficial’s activity may induce the need for the chemical. Chances are you may have made an application that did no more for you than cost you money.

Note: Do not make recommendations based on the verbal description of a pest by a client. Too many misidentifications are made this way, and wrong identification leads to ineffective control measures and unnecessary expense or problems. Insist on seeing the pest, or at least its damage, before you volunteer anything.

V. Major Orders of Insects

Major insect groupings under the class level are called orders. Some representatives that you will see are: beetles—Coleoptera; moths and

butterflies—Lepidoptera; flies—Diptera; bees, ants, wasps, hornets—Hymenoptera; true bugs, such as stink bugs—Hemiptera; aphids, scales, and leafhoppers—Homoptera; grasshoppers, crickets, and cockroaches—Orthoptera; termites—Isoptera; earwigs—Dermaptera. There are many other insect orders, but these are representatives of economic importance.

Separating groups of insects may be quite difficult unless you have closely studied examples of the various types. It is important to recognize the structural characteristics that distinguish one insect from another (see “Further Reading”). Use all of the characteristics listed in Table 1 to distinguish each order.

A. Beetles and Weevils—Coleoptera

Some of the typical beetles that you may see are long-horned beetles and flatheaded borers that bore into trees, logs, and lumber. These beetles are variable in color. Long-horned beetles usually have long antennae and are strong fliers. Lady beetles are about 1/4-inch long and are usually red or orange, generally with spots. Lady beetles are beneficial as larvae and adults, since they feed on aphids and other soft-bodied insect and mite pests. Some other common beetles are the pea weevil, an important pest of peas, and click beetles, whose larvae are known to some of you as wireworms.

Table 1. Major order of insects.

| Name of order | Common examples | Wings/mouthparts |
|---------------|---|--|
| Coleoptera | Beetles, weevils | 2 pairs wings or wingless; chewing |
| Lepidoptera | Moths, butterflies | 2 pairs wings; chewing (larvae), sucking, or siphoning (adults) |
| Diptera | Mosquitoes, flies, and gnats | 1 pair wings; chewing (larvae), piercing-sucking, or sponging (adults) |
| Hymenoptera | Wasps, bees, ants, and sawflies | 2 pairs wings or wingless; chewing |
| Hemiptera | Bed bugs, stink bugs, and cinch bugs | 2 pairs wings; piercing-sucking |
| Homoptera | Aphids, leafhoppers, scales, mealybugs | 2 pairs wings or wingless; piercing-sucking |
| Orthoptera | Grasshoppers, crickets, and cockroaches | 2 pairs wings or wingless; chewing |
| Isoptera | Termites | 2 pairs wings or wingless; chewing |
| Dermaptera | Earwigs | 2 pairs wings or wingless; chewing |
| Thysanura | Silverfish, firebrats | Wingless; chewing |
| Thysanoptera | Thrips | 2 pairs wings or wingless; rasping-sucking |
| Collembola | Springtails | Wingless; chewing |
| Psocoptera | Barklice, booklice | 2 pairs wings or wingless; chewing |
| Mallophaga | Chewing lice | Wingless; chewing |
| Anoplura | Sucking lice | 2 pairs wings or wingless; piercing-sucking |
| Siphonaptera | Fleas | Wingless; chewing (larvae), piercing-sucking (adults) |

1. Adults have a hardened, horny outer skeleton.
2. Adults have two pairs of wings; the outer pair is hardened, and the inner pair membranous.

Note: A few beetles are practically wingless, and some have only an outer hard pair of wings.

3. Beetles have chewing mouthparts.
4. Adults usually develop noticeable antennae.
5. Coleoptera larvae have a head capsule and three pairs of legs on the abdomen.

Note: Weevil larvae lack legs on the thorax.

6. Both beetles and weevils go through a complete metamorphosis as in Fig. 4.
7. Some authorities consider the beetles to be the largest group or order of insects in nature.

B. Moths and Butterflies—Lepidoptera

The moth and butterfly group has several damaging members. Cutworms damage many crops. For example, corn earworm larvae, which are greenish or tannish with some stripes and about 1 1/4-inch long when fully grown, cause severe damage to corn and attack a variety of vegetables.

Alfalfa, celery, and cabbage loopers have injurious larvae. They are often known as measuring worms because of their looping action, which gives the impression that they are measuring the plant on which they are feeding.

Another Lepidoteran is the codling moth, which does damage to apples. The peach twig borer is a severe pest of peaches, prunes, plums, and apricots.

1. Adults are soft-bodied with four well-developed, membranous wings covered with small scales.
2. Adult mouthparts consist of a coiled, sucking tube; adults feed on nectar and other liquids.
3. The larvae are caterpillars that are worm-like, and variable in color; they are voracious feeders.
4. The larvae have chewing mouthparts.
5. The larvae have true legs on the thorax and a variable number of prolegs on the abdomen.
6. Lepidopterans undergo complete metamorphosis as in Fig. 5.

C. Flies, Mosquitoes, Gnats, Midges—Diptera

Flies are an important group in terms of their medical effects on humans and animals. Some, such as bot flies, are parasites as immatures on mammals. Some flies, such as the face fly, disrupt or annoy livestock, causing the cows or other animals to stop feeding. Fly maggots or larvae are generally found in manure or other decaying matter.

The flies most commonly encountered are the housefly, the lesser house fly, and the face fly. The grayish adults infest homes, poultry houses, and livestock. The house fly has been suspected of mechanically transmitting such diseases as polio to food surfaces.

Fig. 4. Metamorphosis of a beetle.

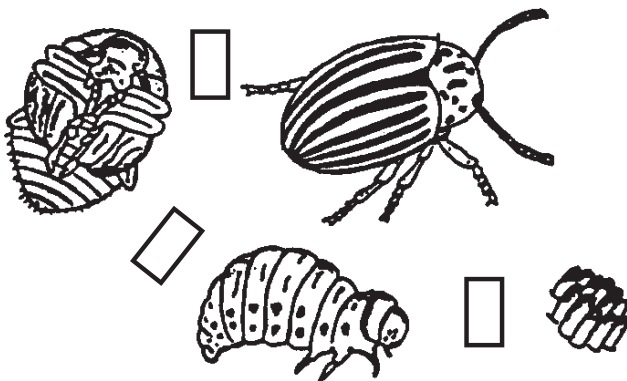
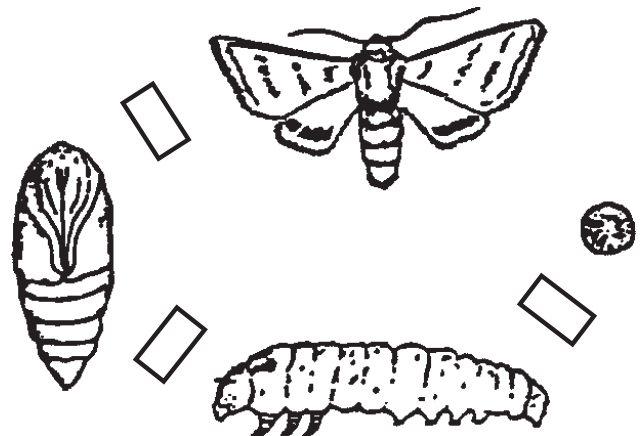


Fig. 5. Metamorphosis of a moth.



Commercial agricultural insect pests in this order include the cherry fruit fly, walnut husk fly, onion and cabbage maggot, and carrot rust fly. Others are often disease vectors, such as mosquitoes or deerflies. Vectors can transmit such diseases as malaria. Mosquitoes are small, slender, long-legged, frail flies. The larvae are elongate and live in water. The adult female is the injurious stage. She feeds by sucking human and live-stock blood by piercing the skin with her long stiletto-like mouthparts.

1. Adults have only one pair of wings and are rather soft-bodied and hairy.
2. Adults have sponging (house fly) or piercing (mosquito) mouthparts.
3. Diptera larvae may have mouth hooks or chewing mouthparts.
4. Most larvae are legless.
5. The larvae of advanced forms, such as the house fly and relatives, have no head capsule, possess mouth hooks, and are called maggots. Lower forms such as mosquito larvae and relatives have a head capsule.
6. Diptera undergo complete metamorphosis as in Fig. 6.

D. Bees, Wasps, Ants, Sawflies, etc.—
Hymenoptera

This group is a large one. Many of its members are important pollinators of agricultural crops, such as the honeybee, leafcutter bee, and alkali bee. Some are important predators, parasites, and scavengers; others are injurious to humans and their crops.

1. Pear slug—The adult is black with yellow markings. The larva is small, slug-like, and feeds on leaves of pear, cherry, and plum.
2. Yellowjackets—The adults have black and yellow markings. They build nests in the ground, or papery structures on trees or under eaves. Their stings are painful and dangerous if you are allergic to them. Many species are beneficial predators.
3. Leafcutting bees—These are small- to medium-sized bees, variable in color. They are noted for their long tongues. One species is an excellent alfalfa pollinator. Leafcutters may defoliate some trees and shrubs.
4. Common ants—Several ants, such as the carpenter ants and the house ants (including the pavement ant and odorous house ant), are in this group. Many are beneficial predators or decomposers.
 - a. The adults have two pairs of membranous wings.
 - b. The adults generally have chewing mouthparts.
 - c. The adults are rather soft-bodied or have slightly hardened bodies.
 - d. The larvae have no legs (wasps, bees, ants) or have legs on the thorax and the abdomen (some sawflies).
5. Hymenoptera undergo complete metamorphosis as in Fig. 7.

E. True Bugs—Hemiptera

Conspire stink bug—A gray or brownish plant bug that is shield shaped. The stink bug feeds on many fruits and vegetables.

Fig. 6. Metamorphosis of a fly.

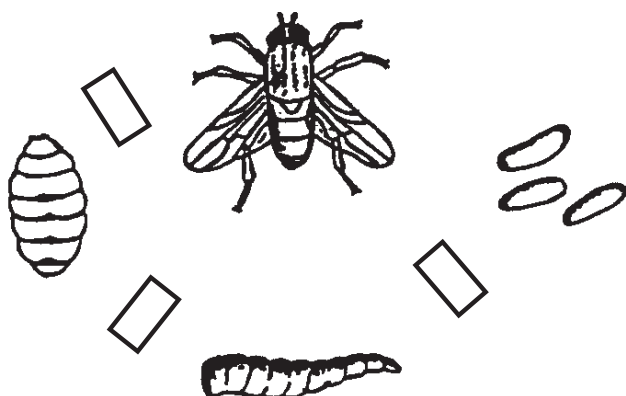
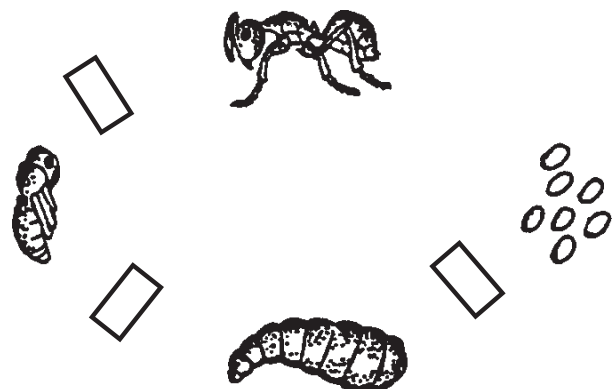


Fig. 7. Metamorphosis of an ant.



1. Boxelder bug—This bug is gray-brown to black with red lines on the under surface and on the lower portion of the outer wings. It feeds primarily on boxelder and can invade homes in early summer or fall.
2. Lygus bug—These bugs are greenish, or brownish black and occasionally yellowish or gray; they are rather slim plant bugs about 1/4-inch long. The head is blotched with black. They are probably the most injurious bugs of seed crops in the United States.
 - a. The adults have two pairs of wings; the second pair is membranous, the first pair is membranous and thickened on the basal half. The nymphs are not fully formed and are called “wing pads.”
 - b. Adults and nymphs usually resemble one another.
 - c. True bugs have piercing-sucking mouthparts.
 - d. Adults and nymphs both are damaging stages.
 - e. True bugs have a gradual metamorphosis (Fig. 8). The stages are egg, nymph, and adult.

F. Aphids, Scales, Leafhoppers, Cicadas—Homoptera

1. Aphid—There are many types, sizes, and shapes of aphids. The giant willow aphid is a large, black species. The pea aphid is a rather large, green species found on alfalfa, peas, clover, sweet clover, and other herbaceous legumes. It may also be pinkish in color. Several species of aphids attack vegetable and tree crops,

including the green peach aphid, which carries the leaf roll virus of potatoes and sugarbeets. The rose aphid, both green and brown forms, are found on many ornamentals. Apple aphids, and green, rosy, and woolly aphids all cause severe damage to apples.

2. Scales—Scale insects are usually quite small and are usually circular or football-shaped. During most of their life cycle, they are protected by a hardened scale covering. San Jose scale is a pest of many fruit trees and ornamentals. Oyster shell scale is a brown cornucopia-shaped scale (horn of plenty) found on ornamental trees and shrubs. Lecanium scale is a large, brown, hemispherical-shaped scale found on trees and woody plants of several types.
 - a. These insects are generally small and soft-bodied, though cicadas are larger and hard-bodied.
 - b. Members may be winged or wingless.
 - c. All stages have sucking mouthparts.
 - d. Many members are carriers of plant pathogens.
 - e. Homopterans have a gradual metamorphosis as the aphid in Fig. 9.

G. Grasshoppers, Crickets, Cockroaches, Camel Crickets—Orthoptera

Some examples of grasshoppers and their allies are migratory and two-striped grasshoppers and the red-legged grasshopper. These are damaging pests of crops and rangeland. The camel cricket, the Jerusalem cricket, and the German roach are also commonly encountered. Crickets also can damage crops. The German cockroach is a metropolitan pest.

1. Adults are moderate to large and are often rather hard-bodied.

Fig. 8. Metamorphosis of a bug.

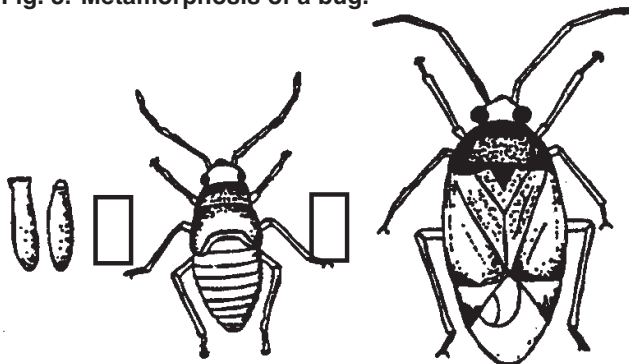


Fig. 9. Metamorphosis of an aphid.

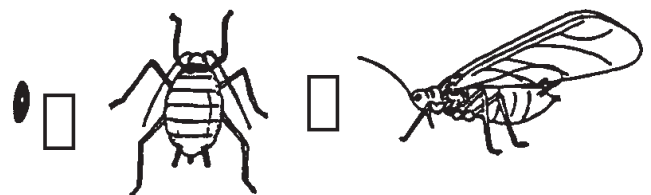
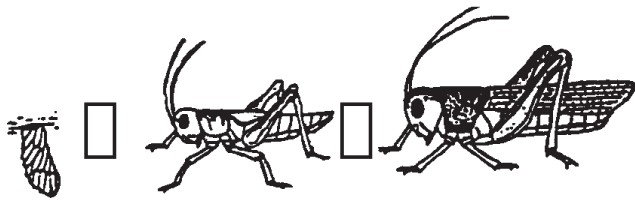


Fig. 10. Metamorphosis of a grasshopper.



2. Adults usually have two pairs of wings. The forewings are elongated, narrow, and leathery; the second pair of wings are membranous with an extensive folded area.
3. Adults and nymphs have chewing mouthparts and are damaging.
4. The hind legs of forms other than cockroaches and walking sticks are enlarged for jumping.
5. Immature stages are called nymphs and, except for being wingless, resemble adults.
6. Orthopterans have a simple metamorphosis as in Fig. 10.

H. Termites — Isoptera

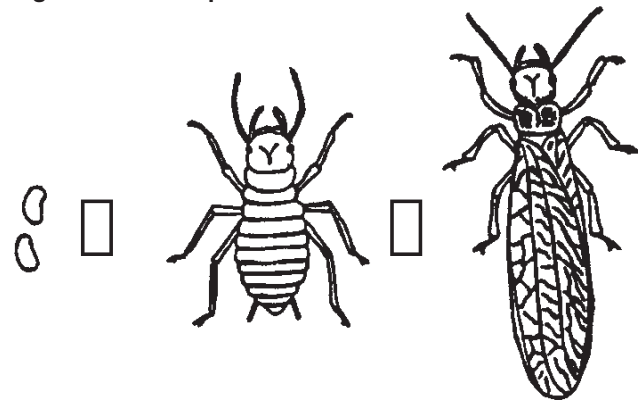
The injurious termites are generally placed in two groups: the dampwood and subterranean types. Both feed on wood and wood products. The dampwood types are usually not primary feeders on sound wood in buildings, while the subterranean types are found in large numbers in sound structures where they may do considerable damage if not detected early and controlled quickly. Colonies of the subterranean type must have a connection with soil to obtain moisture.

1. These are so-called “white ants.”
2. Termites are distinguished from true ants by their thick “waists” and their white or light brown color.
3. Termites have thin, straight antennae; ants have elbowed antennae.
4. Termites have chewing mouthparts.
5. They possess many forms or castes such a worker, soldier, and queen.
6. Termites have a gradual metamorphosis as in Fig. 11.

I. Earwigs — Dermaptera

The European earwig is our only species of earwig. It is occasionally a pest of gardens,

Fig. 11. Metamorphosis of a termite.



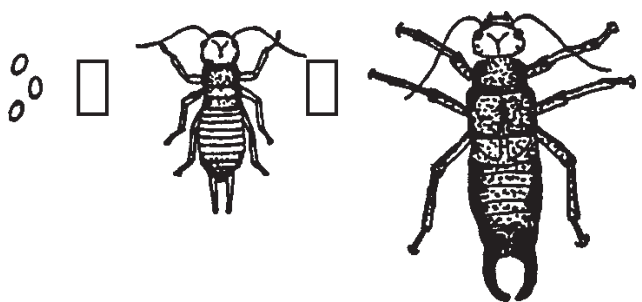
ornamentals, small trees, and houses throughout the state of Idaho, but it may also be beneficial since it often preys upon other insects.

1. Adults are moderately sized.
2. They have chewing mouthparts.
3. Earwigs are elongated, flattened and have strong, movable forceps on the rear end.
4. They have short, hardened outer wings and cover folded, membranous inner wings.
5. Earwigs have a gradual metamorphosis (Fig. 12).

J. Thrips — Thysanoptera

1. Thrips are small with sucking mouthparts that are assisted by a single mandible that aids in rasping the plant tissue.
2. Wings may be present or absent. If present, they are long and narrow and fringed with long hairs.
3. Many feed on ornamentals and some on vegetable crops such as peas and onions. Many are predators on other insects. A few species bite humans.
4. Thrips have a gradual metamorphosis.

Fig. 12. Metamorphosis of an earwig.



K. Silverfish and Firebrats—Thysanura

1. Group members have chewing mouthparts.
2. Thysanura is one of the few insect orders whose members do not possess wings.
3. These insects have bristles on the tip of the abdomen.
4. They are household pests and feed on such items as paste, paper, and crumbs.
5. They have a gradual metamorphosis.

L. Springtails—Collembolla

1. Springtails are minute insects with chewing or piercing mouthparts.
2. They possess an appendage on their ventral (under) side; it operates as a spring to aid the insect in quick escape.
3. These insects are abundant in moist areas, hence the reference to “moving piles of soot” in backyards during the wetter seasons.
4. They feed on decaying organic material primarily but will on occasion attack plants, particularly in greenhouses.
5. Springtails undergo a gradual metamorphosis.

M. Other Orders

Many other insect orders are of no real concern in the home garden. Some of the more common ones are stoneflies—Plecoptera; caddisflies—Trichoptera; dragonflies and damselflies—Odonata; and mayflies—Ephemeroptera. These orders are all associated with aquatic habitats.

Some others you should be aware of include the nerve-winged insects—Neuroptera,

many of which are beneficial predators; book or bark lice—Psocoptera, basically scavengers, but with some species that are stored-products pests; animal lice and sucking lice—Anaplura; and chewing lice—Mallophaga.

VI. Other Insect-Like Creatures

Several noninsect pests may be found in the field and home and include those listed in Table 2.

A. Spider Mites, Spiders, Ticks, and Scorpions—Arachnida

1. Spider mites—These tiny, soft-bodied animals have two body regions, thick waists, four pairs of legs, and are without antennae. Common species include the following.
 - a. The two-spotted spider mite and its near relatives, the Pacific, Atlantic, and McDaniel spider mites. These mites have two spots on the back and have tail-end spots in some species. They may be clear, green, orange, or red. They are usually hard to observe without a hand lens.
 - b. European red mite: This mite is carmine red with white spines.
 - c. Brown mite and the clover mite: These mites are brownish or grayish, flat, and have very long front legs.
2. Spiders—Spiders resemble mites except that most are larger and the two body regions are more clearly distinct from one another (thin waist). Most spiders are beneficial predators. Common pest species include:

Table 2. Noninsect pests.

| Class | Example | Description |
|-----------|----------------------------------|--|
| Arachnida | Spiders, ticks, mites, scorpions | 4 pairs legs; 2 body regions—cephalothorax and abdomen; no antennae; chewing or sucking mouthparts |
| Chilopoda | Centipedes | 15 or more pairs of legs with only 1 pair of legs per body segment; 1 pair of antennae; 2 body regions—head and trunk; body flattened; chewing mouthparts; fast moving |
| Diplopoda | Millipedes | 2 pairs of legs per apparent body segment; 1 pair of antennae; 2 body regions—head, trunk; body rounded; chewing mouthparts; slow moving |
| Crustacea | Sowbugs, pillbugs | 1 pair of legs per body segment; 1 pair of antennae; 2 body regions—head and trunk; chewing mouthparts; roll into ball when disturbed |
| Symphyla | Symphylan, garden centipede | 11 or 12 pairs of short legs; centipedelike animals |

- a. Black widow spider: Shy and likes dank, dark places. This spider spins a characteristically messy web. It is normally a shiny black, moderately sized spider with a reddish or orange hour-glass marking on the underside of the abdomen. Males and immature females can have stripes of red, yellow, and black on the abdomen.
 - b. The hobo spider, sometimes called the aggressive house spider: Is a common light brown spider that is often found in basements. This spider has a painless bite, but sometimes the skin sloughs off in the bite area.
 - c. The brown recluse spider: A poisonous spider which, fortunately, does not occur in the Pacific Northwest, however, it is a potential threat. It is often confused with harmless wolf spiders and other hunting spiders. The brown recluse spider can be recognized easily by a distinct, brown “fiddle case” on a light brown or grayish background.
3. Ticks—Ticks resemble large mites and are important in agriculture and medicine. They are parasites of humans and animals.
- B. Millipedes—Diploda
- Millipedes are generally inoffensive creatures that feed on fungi and decaying plant material. At times, they can be fairly destructive to vegetables or other plants in greenhouses. They are elongate invertebrates with two visible body regions: a head and a body. They generally are rounded in cross section. With the exception of the first four or five segments, all of the body segments possess two pairs of legs. They are relatively slow moving.
- C. Centipedes—Chilopoda
- Centipedes strongly resemble millipedes. They are different in that they have longer antennae, are flattened in cross section, have only one pair of legs on each body segment, and move rapidly. They are beneficial because they prey on other arthropods.

D. Sowbugs and Pillbugs—Crustacea

Sowbugs are highly dependent on moisture, which accounts for their common association with damp habitats. Generally, they feed on decaying plant material, but they will attack young plants in greenhouses and gardens. They are oval with a hard convex outer shell made up of a number of plates.

E. Garden Centipede or Symphylan—Symphla

Members of this group resemble tiny centipedes. Generally, they are a pest of vegetables and found in damp soils rich in organic matter.

Further Reading

Booklets and Pamphlets

University of Idaho

- PNW 343 Beneficial Organisms Associated with Pacific Northwest Crops (\$3.00)
- CIS 989 Carpenter Ants (50¢)
- PNW 186 Cockroaches (\$1.50)
- PNW 550 Encouraging Beneficial Insects in Your Garden (\$1.00)
- MS 109 Keys to Damaging Stages of Insects Commonly Attacking Field Crops in the Pacific Northwest (\$20.00)
- CIS 902 Mosquitoes and What You Can Do About Them (35¢)
- CIS 988 Nuisance Ants (50¢)
- CIS 414 Spiders and Their Relatives (\$1.00)
- CIS 1002 Subterranean Termites (50¢)
- CIS 936 Yellowjackets and Their Control (25¢)

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Insect Management



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Insect Management



V. J. Parker-Clark

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I. Terms and Definitions

- A. **Insecticide**—A chemical used to control, repel, suppress, or kill insects.
- B. **Preharvest Interval**—The amount of time that must elapse (legally) after application of pesticide before harvest takes place.

II. Why Worry About Insect Control?

- A. The average insect population per square mile is estimated to be equal to the world human population.
- B. Destruction of crops by insects in the United States ranges from \$4 billion to \$15 billion annually.
- C. Forest insects destroy more useful timber than do forest fires.
- D. Termites consume about \$100 million worth of wood structures annually.

III. Methods of Insect Control Available to Homeowners

A. Mechanical Insect Control

- 1. Can be used on all insect pests.
- 2. Manual removal of insects and eggs from infested plants.
 - a. Two-block method: Place the insect on one block (wood or stone) and strike with second block. Repeat as needed.
 - b. A soap and water spray (or water alone) is sometimes helpful for control of aphids and similar insects.
 - c. Light traps: Be careful not to use lights that may attract insects to your garden.
- 3. Advantages—Extremely selective; can be slightly to extremely effective, depending upon the species of insect and the crop.

- 4. Disadvantages—Time consuming. Many insect species can fly away or drop to the ground and therefore escape control efforts.

B. Chemical Insect Control

- 1. Specific insecticides control only certain insect species. It is important to know the target species and the crop affected before selecting an insecticide.
- 2. It is particularly important to apply the insecticide properly. This includes carefully measuring the chemical, carefully diluting the solution with the correct amount of water, and taking care not to apply too much or too little spray.
- 3. Apply insecticides only to plant species listed on the product's label. Failure to follow label directions may result in damage to desirable plants or unhealthy residues in foods.
- 4. Always determine the safe preharvest interval for a crop you plan to spray with a given insecticide. This information can be found in one of two written formats on pesticide labels.
 - a. Written out on a pesticide label. For example, Ortho Sevin 5 Dust states that the product should not be applied to cole crops within 3 days of harvest.
 - b. Written as a number between parentheses immediately after the crop listing on the label. For example, Lilly Miller Fruit and Berry Insect Spray has the listing Apples (7), indicating a preharvest interval for apples of 7 days.
- 5. Always read and follow label directions carefully.

6. Advantages—Good to excellent control of insect pests; a minimum of labor is required.
7. Disadvantages—Special application equipment needed; spray programs are often rather inflexible regarding harvest times; beneficial insects often are killed.

C. Biological Insect Control

1. Use of beneficial insects can be difficult to assess for the homeowner. Many insects are offered for sale (particularly ladybird beetles, lacewings, and praying mantids), but success with these introduced predators is often inconsistent. Also, these insects may have to be reintroduced each year in order to maintain a garden's population after winter kill or migration.
2. It is a good idea to be able to identify beneficial insect species in all their growth stages, so as to prevent their unintentional destruction as pests.
3. Advantages—No labor is involved; after the initial release, the population can be self-perpetuating. You can establish biological control, as the predator will target only the pest. For example, *Bacillus thuringiensis* is useful for caterpillars.
4. Disadvantages—Only selected insect species will be controlled; control may often be cyclical or incomplete.

D. Cultural Insect Control

1. For homeowners, the most important cultural control is to maintain good plant health with proper care through an effective water and nutrition system. A healthy plant is better able to withstand insect infestations.
2. Crop rotation breaks plant/insect pest relationships. By varying the location of crops within a garden (when possible), or by not growing certain crop types for a number of years, certain insect pest populations can be drastically reduced.
3. Highly organic soils provide attractive habitat for many soil insects. In addition, insecticides are more rapidly broken down in these soils.

4. Companion crops are often used to repel insect pests, or to attract them away from crops. Don't rely on these methods without constant observation. If they do not work, be prepared to spray, plow, dig up, etc.

- a. Repellent crops are specific as to which plants they protect and which insects they affect. For example, marigolds are useful in repelling cutworms. At best they can be marginally effective; at worst, they will attract unwanted insects to your garden.

Note: Marigolds often attract leafminer butterflies.

- b. Trap crops can quickly become overrun with insects. For example, nasturtiums can attract cabbage aphids away from cole crops. If aphids are not controlled on the trap crop, they will eventually move to the crop you are trying to protect.
5. Weed and volunteer crop control prevents them from becoming an alternative food for insects, particularly before crop emergence. Weed residues can also harbor insect pests.
6. Sanitation in your lawn and garden area is very important, as many insects are attracted to, and overwinter in, plant debris or trimmings. Nonproducing vegetable plants should be removed or turned under as soon as possible after harvest to deny insect pests a "free lunch" or an overwintering site. Clear away planks, cardboard boxes, and overgrown areas; these provide an excellent habitat for pests such as slugs, sowbugs, and earwigs.
7. Resistant crop varieties are sometimes available to the homeowner, although most resistance involves plant diseases and not insects.
8. Using transplants or adjusting seeding dates to avoid emergence of the plant during peak insect populations may help reduce damage.

9. Advantages—Often simple to perform; often accomplished through other good gardening techniques.

10. Disadvantages—Generally incomplete.

E. Regulatory Insect Control (Quarantines)

1. Generally, quarantines take two forms:
 - a. No movement of the host crop allowed out of an area. This method keeps the insect more localized where control programs can be implemented more effectively.
 - b. No movement of the possibly contaminated host crop is allowed into a “clean” area. This keeps the insect out of an area where infestations could be disastrous.
2. Under quarantine laws, government agencies may be allowed to use a part of chemical control under emergency use guidelines.
3. Advantage—By requiring a control effort, the spread of certain pestiferous insects can be slowed, once infestation is identified.
4. Disadvantages—Laws must be enforced to do any good and geographical situations may limit control.

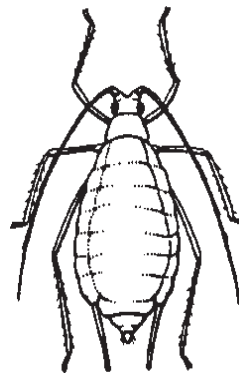
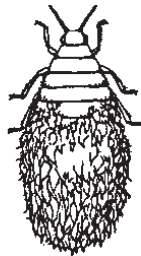
F. Integrated Insect Control

1. The best insect control plans start with the simpler methods, then progress to include aspects from all types of control. For example, a control program for the cabbage maggot may begin with transplants. This approach allows older, more vigorous seedlings to escape infestation.
2. Transplanting is followed by the destruction of plants immediately upon harvest of cole crops. Quick destruction after harvest prevents maggots from completing their life cycle.
3. If cabbage maggots continue to be troublesome, placement of lorsban or Diazinon granules around transplants may be attempted. This method prevents infestation of roots.
4. If maggots still remain a problem, it may be necessary to stop growing cole crops for a season or two or to only grow them every other year. Allowing the field to lie

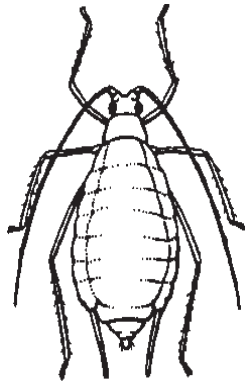
fallow, or switching to another sort of crop, may reduce the population of cabbage maggots in the garden.

IV. Specific Pests

A. Ornamental Pests



1. Balsam woolly adelgid—Appear as white, woolly masses on limbs and trunks of all firs. All active stages have sucking mouthparts and cause damage. Spray timing is important. Spray to ensure adequate control. Sprays may stunt or kill trees. Organic phosphate aphid pesticides do not adequately control adelgids.
2. Spruce aphids—These aphids are dull green with sucking mouthparts. All active stages damage spruce trees, and the damage is frequently very serious. For example, they can cause severe needle drop. Spray in February or late winter.
3. Cooley spruce gall adelgid—Appear as white, cottony masses on firs. They have sucking mouthparts, and all stages cause damage. They tend to alternate between spruces and Douglas-fir. They cause galling on spruces and yellowing and needle distortion on both types of trees. Organic phosphate aphid pesticides do not adequately control adelgids. Treat spruce as the new growth is unfolding in the spring. Treat Douglas-fir in early spring.
4. Rose aphid—Many species of aphids attack the rose, particularly when there is new growth. They cause chlorosis (yellowing green tissue), and they may produce a toxin that kills leaf tissue. Rose aphids excrete honeydew and cause



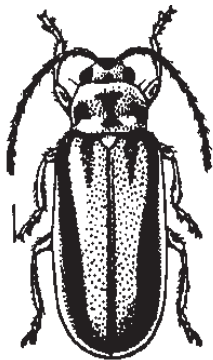
sooty molds. Some people hose plants periodically, but hosing may lead to other problems such as diseases. Check any chemicals suggested for treatment. Some may adversely affect the plant.



5. Root weevil—May be 1/4 to 1/2 inch long. They can be black, brown, or gray. They have chewing mouthparts. Root weevils often attack ornamentals, such as azaleas and rhododendrons, and many garden groups. The white larvae are C-shaped. When the larvae feed on the roots, the plant becomes spindly. Feeding allows entry by root rots. Larvae may also girdle crowns, particularly in containerized plants. Adults appear in June and feed until September. Their effect is less serious. They tend to notch leaves. Though they rarely kill the plant, the result is unsightly. They usually feed at night. Root weevils' fall migrations into homes may cause some owners alarm, but their purpose is hibernation. Spray for adults at regular intervals starting in late June.



6. Elm leaf beetle—Characterized by black and yellow stripes on wing covers of the adults and bodies of the larvae. They generally appear April through August. These beetles live through two generations and may overwinter in homes. They have chewing mouthparts. Both larvae and adults cause damage to elms. The



adults chew small holes in leaves, while the larvae skeletonize leaves. They can cause complete defoliation.

Note: Destroy if found.



7. Leafhopper—Small torpedo-shaped insects with wings held roof-like over the body. Found in a variety of colors. Leafhoppers are active jumpers. They attack a variety of ornamentals, fruit trees, and garden plants, and may be found throughout the growing season. They have sucking mouthparts and feed on the undersides of leaves, which causes white speckling on leaves (hopper-burn). Leafhoppers can transmit virus diseases.



8. Cotoneaster webworm—Small, dark-brown to black caterpillars are the damaging stage. They have chewing mouthparts and hide in dense webs. They tend to skeletonize cotoneaster leaves and can kill or severely damage plants.



9. Fall webworm—Adults are pure white moths, though they occasionally have a few black spots. The larvae are yellowish brown with long, whitish hairs arising from orange and black bumps. They can be identified quickly because they form unsightly tents enclosing entire branches. The chewing mouthparts are damaging. Webworms tend to cause problems only as larvae, and primarily for ornamentals and



fruit trees. The larvae are present from midsummer to fall. Treatment is a problem, because if you remove and burn the branch and the tent, you may destroy the symmetry of the shrub or tree.

10. Juniper webworm—The larvae are light brown with dark brown stripes on the back; they grow to a length of 1/2 inch. The larval stage is the most damaging. Larvae have chewing mouthparts, and they tend to attack junipers and red cedar. They feed in early spring. Webworms can be identified easily because they web the foliage together. Mechanically destroy the larvae when possible.



11. Mourning cloak butterfly—Larvae are large and black with orange spots on their spiny backs. The larval stage is the most damaging. Larvae attack willow, elm, and poplar. They are foliage feeders with chewing mouthparts. These caterpillars are gregarious feeders and are easily controlled by clipping twigs with groups of caterpillars. Simply burn the clippings. Spraying is not necessary if the problem is caught early enough.



12. Tent caterpillars—The larvae are rather attractive, dark, fuzzy caterpillars. The forest tent caterpillar has diamond- or keyhole-shaped spots in a row along the back. The western tent caterpillar is yellow with blue lines. Tent caterpillars congregate in small tents during the day. The larval stage is the damaging stage, seriously defoliating trees of many kinds. Lar-



vae have chewing mouthparts. Tent caterpillars are troublesome in early spring and into summer. Sometimes you can deal with them by clipping tents and by burning. Forest tent caterpillars overwinter as eggs in bands around twigs. Destroy these by crushing them. Or you can spray in early spring; later they may be tough to kill with chemicals.

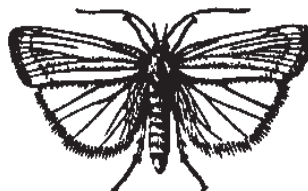
13. Birch leafminer—Only the larvae of the birch leafminer are damaging. They mine and blotch the leaves of birch trees. They have chewing mouthparts. To deal with them, spray just after the leaves unfold in the spring. There are two generations. The second is in mid-July, but if you do a good control job on the first, the second will need only a minor use of spray to control.

14. Scales—Scales are small, with a soft or hard coat surrounding the insect. The covering takes on various forms from hardened armor to soft, cottony masses. They often promote sooty molds, and all active stages are damaging to many plants. They have sucking mouthparts and are stationary (sedentary) feeders. They kill plants or plant parts. In order to treat, find out what scale is present and at what time the active crawling stage is present. Spraying with an insecticide will be effective at that stage. Oil and sulfur dormant sprays are usually the most effective.



B. Lawn Pests

1. Lawn moths—Damage may be mistaken for thatch or fungus problems. The larval stage is the most damaging. Lawn moths have chewing mouthparts.



2. Earthworms, nightcrawlers—These are not insects, but annelids. They are normally considered to be beneficial; however, in certain instances, intense earthworm activity leads to castings being thrown up on the surface, leaving an unsightly lawn.

C. Houseplant Pests

See Chapter 23, "House-plants and Home Greenhouses," Section V, Insect Pests.

D. Tree Fruit Pests



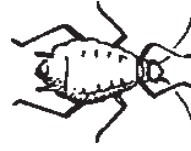
1. Codling moth—The larvae have chewing mouthparts and bore into fruit. Apples and pears are the main hosts. The larval stage is the most damaging. It is extremely important to time sprays properly. Use recommended materials about 10 days after full petal fall and repeat as necessary, depending on materials used and local recommendations.



2. Aphid (woolly apple aphid)—These are reddish aphids covered by white woolly wax. They have sucking mouthparts. All active stages are damaging. These aphids are bark feeders, and their damage interferes with the growth of the tree, often killing a young tree. They also attack roots. Their attacks cause the most serious injury in apple trees, but occasionally they are problems for pear trees.



3. Aphid (not woolly species)—They have sucking mouthparts, and all active stages cause damage. They include the green peach, plum, rosy apple, and green apple aphids. A toxin in the saliva causes various



- plant reactions: leaf curl, leaf cupping, stunting, lumpy fruit, etc.
4. Apple-and-thorn skeletonizer—The larval stage is

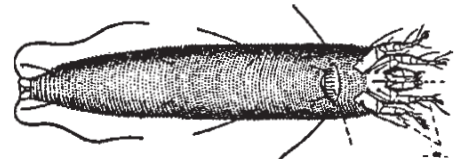


the damaging stage; the larva has chewing mouthparts and skeletonizes leaves. The adult stage is a moth.

5. Fruit leafrollers—The larval stage is the most damaging. Larvae are usually shiny green with a black or brown head. They have chewing mouthparts and feed on the fruit and the leaves of many ornamentals and fruit trees. They tend to bind leaves together with a webbing to form a hiding place.



6. Blister mite—Blister mites are arachnids, not insects. They have chewing mouthparts. The only evidence of their presence is the circular blisters within which these tiny microscopic mites reside. They may become so numerous as to cover an entire



tree. Young shoots suffer the most. Blister mites cause malformation of pear fruit; they also attack apple and cotoneaster trees. The blistered surfaces later turn into scablike areas. They are best controlled during the delayed-dormant period (February or March).

7. Pear psylla—Related to aphids and leafhoppers, pear psylla have sucking mouthparts. Feeding is done by all active stages. The pear psylla secretes honeydew, which may kill leaf tissue and which russets fruit. A sooty mold devel-



ops in honeydew and blackens affected tissue, which leads to “pear decline.” Other problems from psylla include reduced vigor, fruit loss, poor fruit set, and occasionally the death of the tree.

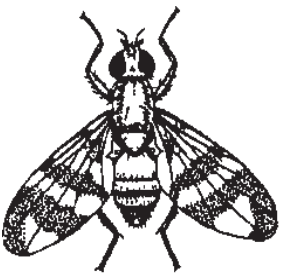
8. Pear slug—A relative of the sawfly bee group, several species of the pear slug are known. The larvae are covered with a slimy material, making them sluglike in appearance. The larval stage is the most damaging. Pear slugs have chewing mouthparts that skeletonize the leaves. Pears, cherries, and roses are hosts commonly attacked by the pear slug or one of its relatives.



9. Cherry fruit fly—The larval stage is the most damaging; the larvae have rasping mouthparts. The adult is a small picture-winged fly. Eggs are laid in fruit starting when the fruit changes to pink or yellow (depending upon the variety). The larvae proceed to feed internally. Breathing holes in fruit point out the presence of the maggots.



10. Walnut husk fly—The larval stage is the most damaging. Larvae attack mainly walnuts, but occasionally attack late peach varieties. The adult is a picture-winged fly. In walnut trees the damage to the husk results in the staining of shells and, at times, the darkening of the kernels. Bitter, shriveled kernels may occur.



11. Peach tree borer—The adult is a clear-winged moth. The larvae are damaging to peaches, nectarines, and plums. Larvae have chewing mouthparts. Their injuries are recognized by jellylike gum mixed with dirt and small pellets of frass excreted by the borers at ground level. This damage can seriously injure a tree or even kill it. Heavily infested trees are so devitalized that the leaves turn yellow in a manner similar to nitrogen deficiency.



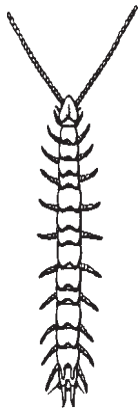
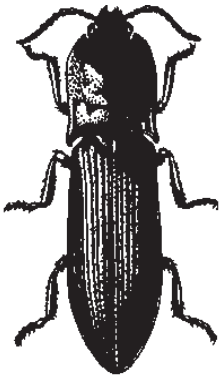
12. Peach twig borer—The adult is a small, gray moth. The damaging larvae are light- to dark-reddish



brown with a black head and yellow-white, ringlike segments around the abdomen. Larvae have chewing mouthparts. They attack developing twigs and burrow down the tender shoots, causing them to wilt and die. Later broods attack fruits. The oriental fruit moth causes similar damage, but is not as widespread in Idaho.

E. Garden Pests

1. Cutworms—The adult is a miller moth. The larvae have chewing mouthparts and are the most damaging stage for garden produce. Many kinds of cutworms exist



4. Earwigs—Often merely a nuisance, though all active stages cause damage. Earwigs have chewing

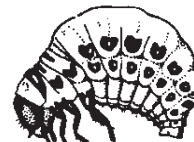
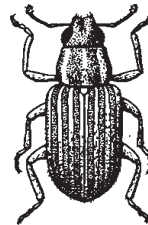
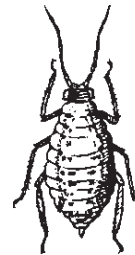


and damage all kinds of plants. Control with chemicals when they are young. The more mature cutworms are difficult to control with chemicals. If cutworms have been a problem, vigorous disking or rototilling in the spring, before planting, will help destroy them. Also avoid persistent weed patches as this is a good source of cutworms.

2. Wireworms—Have rather hard, shiny, golden colored, elongated larvae. The adult stage is a click beetle. The larval stage is the most damaging. Wireworms have chewing mouthparts. They are a soil pest; their feeding stunts crops. They may kill the plant or cause produce to be inedible. Potatoes and bulb crops are particularly hard hit by this pest; however, corn and other crops may be damaged.

3. Garden symphylan (insect relative)—These are soil pests with chewing mouthparts; they tend to attack underground parts of all vegetables, small fruits, and many flowers. All stages of the garden symphylan are damaging; infestations are sporadic. Control of this pest is difficult for the home gardener. When the attack is severe, plants wilt and die.

mouthparts and attack many sorts of plants. They can be scavengers or predators also. The best control methods are various dusts. Apply dust recommended in your area to soil surfaces when you first notice the problem. Repeat if necessary.



5. Flea beetles—There are several species of flea beetles, all of which have chewing mouthparts. Both the larvae and the adults cause damage. The adults attack leaves of many vegetables. The larvae attack roots and tubers. The adults are very tiny beetles and, like fleas, are good jumpers. Use chemical control if necessary.

6. Aphid—All active stages cause damage. The peach aphid is one of the most important aphids. It affects not only peaches but also potatoes. It is a vector of the potato leaf roll virus, which discolors tubers. The asparagus aphid is also becoming important.

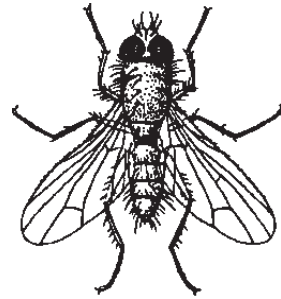
7. Pea leaf weevil—The adult is the damaging stage. The larvae feed on root nodules of peas. Pea leaf weevils have chewing mouthparts. While peas are the preferred host, this weevil will attack other plants such as beans.

8. Colorado potato beetle—Although mainly a pest of potatoes, Colorado potato beetles can feed on tomato, eggplant, and nightshade weeds when potatoes aren't available. Both the larvae and the adults are damaging. These beetles have chewing mouthparts.



9. Asparagus beetle—Rather small beetles with chewing mouthparts, asparagus beetles are steel blue in color with reddish margins and a few yellowish spots on wing covers. Larvae and adults damage young shoots, but they are chiefly a pest of mature plants, which may be completely defoliated.

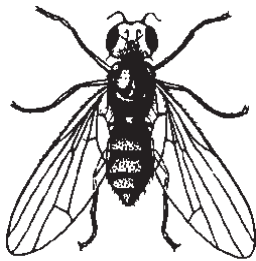
Note: The spotted asparagus beetle is somewhat elongated and red-orange with black spots.



bage maggot, except that onion maggots attack only onions, garlic, and shallots.

12. Cabbage maggot—The adult is a fly. The larval stage is the most damaging. The larvae are small, whitish maggots with rasping mouthparts; they bore into roots and stems of cabbage, broccoli, cauliflower, brussel sprouts, and kale, often killing them. The fleshy roots of radish and turnips may be riddled with holes. Control consists of diazinon or chlorpyrifos (dursban) treatments at the time of transplant or planting.

Note: Be careful. Highly organic or humus soils tend to tie up insecticides such as diazinon and dursban.

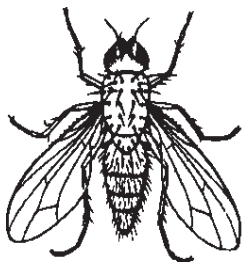


10. Carrot rust fly—The larvae have rasping mouthparts. The larval stage is the damaging one. The adult is a small, nondescript fly, while the larvae are small maggots that burrow into the crowns or roots of carrots, parsnips, and certain weeds. Only highly organic or humus soils harbor this insect. Remove carrots as soon as possible, since the damage will increase if they are left in the ground. A diazinon application will reduce, but not eliminate, the carrot rust fly. However, mid- to late-June plantings tend to reduce damage.

13. Cabbage looper—The adult is a moth. The larvae have chewing mouthparts. They attack many cruciferous plants, as well as fruits, weeds, and ornamentals. They are defoliators.



11. Onion maggot—The adult is a fly. The larval stage is the most damaging. Larvae cause damage with their rasping mouthparts and create problems similar to those caused by the cab-



F. Household Pests

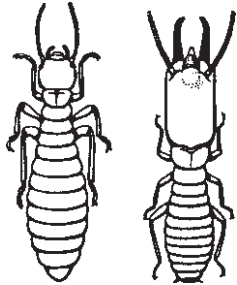
1. Stored products.

- a. Many pests go after stored products. They include the carpet beetle, cigarette beetle or drugstore beetle, Indian meal moth, sawtooth grain beetle, and cockroach. Sanitation is the best control.
- b. Locate the pest sources and clean them out thoroughly. Destroy infested material or heat to 140°F. Vacuum infested drawers and cupboards.

- c. Spray with pyrethrum in and around possible hiding places, but not on or around food.
- d. Maintain a regular spring cleaning program.

2. Structural pests.

- a. Termites: These pests are antlike, but they do not have constricted waists. They usually attack only damp or rotting wood and are an indication of an already existing problem. It is important to treat these pests properly. When carpenter ant or subterranean termite infestations are apparent, it would be wise to contact a reputable PCO (exterminator) to kill these damp wood termites.



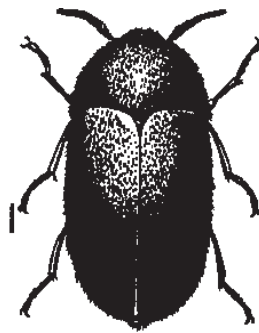
- b. Ants: The most common ant pests are carpenter ants.



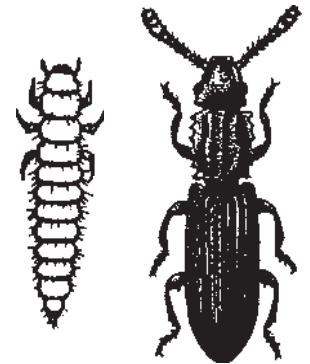
Carpenter ant

3. Nuisance pests.

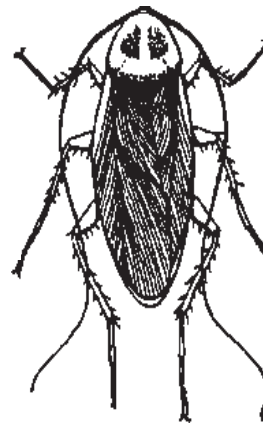
- a. Flies: Flies are common, especially in the summer and the fall. Tight seals around windows and screen doors help. It also helps to maintain general cleanliness, as fly larvae can breed in any kind of refuse. Keep garbage containers clean. Pyrethrum sprays will kill the adults.
- b. Mites: Many mite species, including the clover mite, enter homes in large numbers, causing the inhabitants great alarm. Some scavenging mites, such as grain mites, can get into stored foods. House dust mites can be a source of allergies.
- c. Centipedes and millipedes: Though centipedes are normally beneficial, these elongated, multilegged insect relatives often enter homes and cause annoyance. Centipedes can inflict painful bites, while millipedes can become pests in greenhouses.



Carpet beetle



Sawtoothed grain beetle



Cockroach



Indian meal moth



Millipede



Mite



Centipede

d. Other: Careful caulking, screening, and patching will prevent many problems with wasps, bats, and other home invaders. Many true bugs such as boxelder bug, sage bug, grass bug, and others will invade homes and other structures in the late summer and fall. While they're capable of biting, the true bugs normally are considered nuisance pests. Several beetles are also invaders and become severe nuisance pests. Control is difficult; sweeping or vacuuming is normally recommended. These include grass weevils, root weevils, and the elmleaf beetle (overwinters in large numbers in attics).

G. Spiders

Most spiders are harmless. The black widow is the most dangerous spider in the Northwest. (The brown recluse spider has not been found in Idaho.) The hobo or "aggressive" house spider is common and can cause skin sloughing. For more information about spiders see the University of Idaho College of Agriculture CIS 414, "Spiders and Their Relatives."

Spiders can become numerous in the fall as they seek out overwintering spots. Be sure to seal up basement entries (holes, cracks).

- CIS 628 Insects and Mites Destructive to Berries (50¢)
- CIS 834 Insects and Other Pests in Firewood (35¢)
- MS 109 Keys to Damaging Stages of Insects Commonly Attacking Field Crops in the Pacific Northwest (\$20.00)
- CIS 829 Locust Borer (25¢)
- CIS 902 Mosquitoes and What You Can Do About Them (35¢)
- CIS 988 Nuisance Ants (50¢)
- PNW 326 Preventing and Controlling Powderpost Beetles in and Around the Home (50¢)
- CIS 414 Spiders and Their Relatives (\$1.00)
- CIS 1002 Subterranean Termites (50¢)
- CIS 936 Yellowjackets and Their Control (25¢)

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Washington State University

- EB 1106 Biology and Control of Tent Caterpillars (\$1.00)
- EB 1270 Birch Leafminer (\$1.00)
- EB 1380 Bronze Birch Borer (\$1.00)
- EB 0818 Carpenter Ants: Their Biology and Control (\$1.50)
- EB 1257 Carpet Beetles (\$1.00)
- EB 1068 Cherry Fruit Flies (\$1.00)
- EB 1072 Codling Moth Control (\$1.00)
- EB 0918 Disease and Insect Spray Schedule for Home Orchards—Peaches, Nectarines, Apricots, Plums, Cherries (\$1.00)
- EB 1206 European Earwig Prevention and Control (\$1.00)
- EB 1011 European Pine Shoot Moth (\$1.00)
- EB 0827 Fall Webworm (\$1.00)
- EB 0963 Gypsy Moth (\$1.00)
- EB 0472 Household Insects and Their Control (\$1.00)
- EB 0695 Houseplant Pests (\$1.50)

Further Reading

Books

- Smith, M., and A. C. Carr. 1988. *Rodale's Garden Insect, Disease and Weed Identification Guide*. Rodale Press.
- Berry, R. E. 1978. *Insects and Mites of Economic Importance in the Northwest*. Corvallis, OR: Oregon State University Bookstores, Inc.

Booklets and Pamphlets

University of Idaho

- CIS 729 Apple-and-thorn Skeletonizer (25¢)
- PNW 343 Beneficial Organisms Associated with Pacific Northwest Crops (\$1.00)
- CIS 989 Carpenter Ants (50¢)
- PNW 186 Cockroaches (\$1.50)

- EB 0826 Insect and Mite Control on Ornamentals (\$3.00)
- EB 4361 Maple Bladder Gall Mite (\$1.00)
- EB 0936 Pine Bark Beetles (\$1.00)
- EB 0970 Root Weevil Control on Rhododendrons (\$1.50)
- EB 1485 Snailcase Bagworm (\$1.00)
- EB 1154 Western Boxelder Bug (\$1.00)
- EB 0643 Yellowjackets and Paper Wasps (\$2.50)

For more information or to order, contact your county's Cooperative Extension System office or write to Bulletin Office, Cooperative Extension, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

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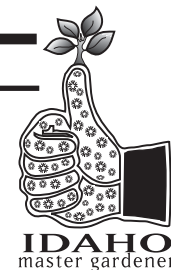
Chapter 11

Rodents, Birds, and Other Pests



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Rodents, Birds, and Other Pests



K. M. Laughlin

Kevin M. Laughlin, Extension Educator, Ada County, Boise

I. Introduction

Some gardeners worry about critters while others consider them part of nature's plan. One gardener's wildlife habitat or sanctuary is another gardener's nightmare or problem.

Over the years you spend tending a garden, you come to realize there are a few shortcuts to preventing animal and other pest problems. Some you need to control; others you learn to live with; and others you learn to share with other gardeners.

In all cases, you need to consider personal pest management objectives, the environment (city or country) in which you are gardening, your neighbors, and how treatments will impact the individual plant as well as the environment.

Proper identification, timing, persistence, and diversification will play an important role in successful pest management plans.

II. Safety in Handling

Recently in Idaho, hantavirus has become a concern for anyone handling vertebrate pests. Also of concern are several other animal-human transferred diseases and parasites including rabies, plague, lyme disease, and Rocky Mountain spotted fever.

If you handle equipment and work in areas where vertebrate pests are a problem, wear or use masks, gloves, and other protective clothing when implementing control measures.

III. Identification

Gardeners often become frustrated with the diverse creatures described in this chapter. Unlike many garden pests that remain in place or

move around slowly (described in other chapters), these pests are marauders, staging hit-and-run attacks on desirable plants, yards, and gardens.

To find acceptable solutions, you must accurately identify the target pest. Most creatures have predictable needs and activities, and you may be able to control or deter them by understanding their habits.

- A. This chapter covers only a few of the most common pests.
- B. Your best source for specific species management is the Nebraska Cooperative Extension System's *Prevention and Control of Wildlife Damage Handbook*. This resource publication covers more than 80 species.
- C. You can obtain more information about specific pests from the U.S. Fish and Wildlife Service, USDA-APHIS Animal Damage Control Specialists, the Idaho Cooperative Extension System, or the State of Idaho Fish and Game Department.
- D. It is unlawful in Idaho to gas, poison, shoot, trap, or otherwise harm any endangered, wild animal, or wild bird species without special permits. Hunting seasons, the Migratory Bird Act, and the Eagle Protection Act regulate other animal harvesting. Before starting a vertebrate pest management program, be sure it is legal. Check with a local game warden for any local shooting and trapping limitations.
- E. Always read the labels of federal and state approved pest control products before implementing control measures. It is illegal to use any pesticide not listed on a label.

The user is responsible for checking the label to see that the site is listed.

- F. Some pest-control measures are traditional or involve folklore repellents. The Cooperative Extension System does not have scientific data to support the use of most, but you may wish to try them.

IV. Vertebrate Pests—Rodents

A. General Rodent Information

Most methods used in controlling rodents are aimed at destroying them. Poisoning, shooting, exclusion, destruction of habitat, trapping, and fumigating are among the methods used. Of these, poisoning is the most popular and probably the most effective and economical. Because rodent control is a diverse and complicated subject, it is beneficial to learn the life cycle of each rodent pest as you encounter it and before management.

1. “Rodent” is rather all inclusive and perhaps a bit deceptive, because all rodenticides or repellents are not registered for all species. This requires accurate identification of the particular pest and careful selection of control materials.
2. Rodenticides differ widely in their chemical nature. Strychnine, indandiones, coumarins (anticoagulants), zinc phosphide, and several others are labeled for commercial use. Of the rodenticides available, the anticoagulants are safest to use around the home, provided you follow label directions and pets don’t accidentally ingest them. This is a particular concern with cats that are good “mousers.” Sold as baits, the animal must ingest them for several consecutive days before they are effective. Several other restricted use rodenticides are available for trained and licensed applicators. Rodent repellents Biomet-12 naphthylene, paradichlorobenzene, polybutanes, polyethylene, R-55 and thiram have

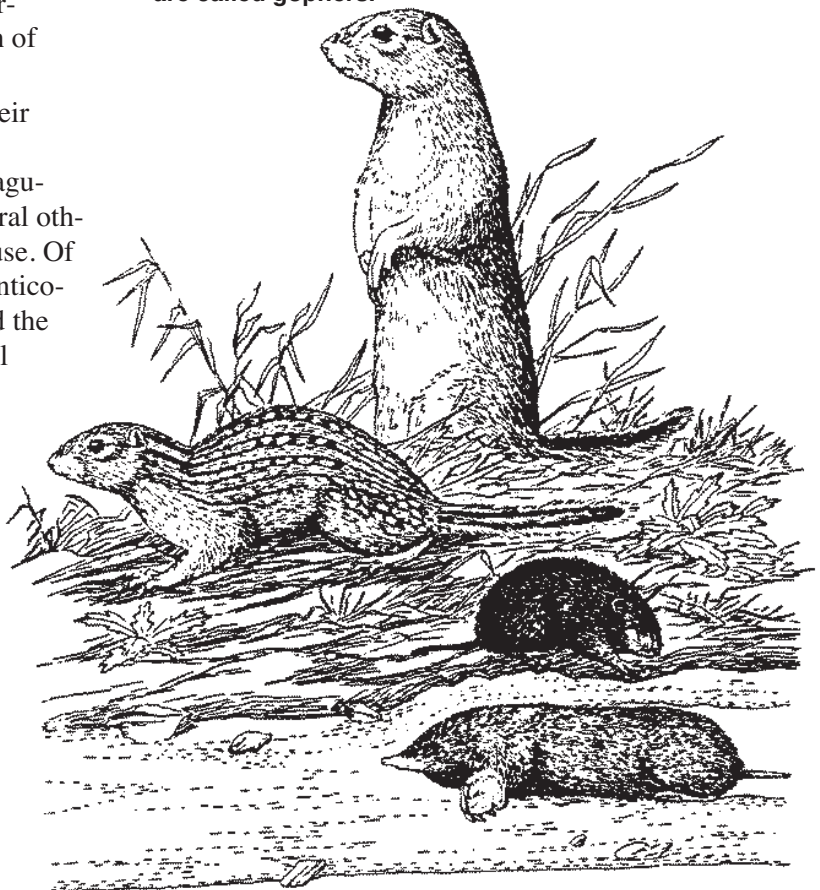
been used with some success against specific rodent species.

B. Ground Squirrels, Chipmunks, and Chucks

These rodents are voracious feeders on lawns, bulbs, and leafy succulent plants during spring and summer. Ground squirrels (Fig. 1) may dig a burrow system with entrances 2 to 3 inches (5 to 8 cm) in diameter. They are particularly troublesome in gardens that border fields or wild lands.

1. The simplest removal method is to fill burrows with water. Reflooding may be necessary to keep them discouraged.
2. Also consider live traps (check daily for relocation), gas bombs (place well back in the burrow after plugging all entrances), and poison baits.
3. Protect bulb beds above ground with a cover of fine mesh chicken wire.
4. Repel rodents by placing moth balls or moth flakes in the runs or holes where they enter buildings.

Fig. 1. Sometimes, the Richardson ground squirrel (from top to bottom), the 13-lined ground squirrel, vole, and mole are called gophers.



5. Chief natural enemies are foxes, snakes, hawks, and owls. Dogs and cats also can work into the control picture.

C. Pocket Gophers and Voles

Pocket gophers burrow through the ground, feeding on root crops and roots of garden plants and do surface damage to lawns and gardens. Voles, as in Fig. 1, primarily do surface damage to grass areas and may girdle woody plants.

Gopher runways run parallel to the ground surface and are located 6 to 10 inches (15 to 25 cm) below ground level. Control is usually easiest in early spring or fall when fresh mounds indicate activity.

1. Place poison baits, fumigant type pellets, or traps in their runs. Locate the burrow with a long screwdriver or probe. Carefully follow the control product or trap label instructions. If trapping efforts fail, line the sides of planting holes with light gauge chicken wire or hardware cloth.
2. Eliminating ground cover reduces population. Soil cultivation destroys burrows and reduces cover.

D. Mice and Rats

Mice or rats can spread disease and viruses, consume and contaminate stored products, and may girdle woody plants by chewing bark (particularly in the winter). Mice eat seed and grain products and grass, and create runways and bare patches on lawns. Damage to lawns can be severe in winters when snow covers the ground for months.

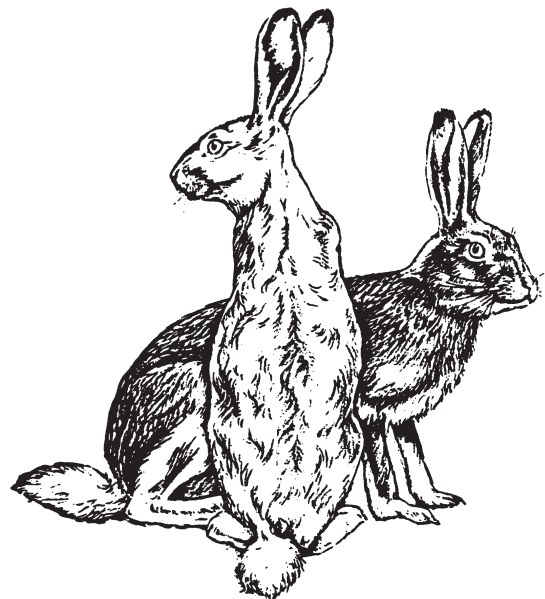
1. Sanitation is your first line of defense. Conduct a general cleaning, eliminate food sources, and destroy rodent nests. Get rid of rock piles, old boards, and junk. Keep piles of wood and lumber up off the ground. Mow lawns regularly and remove long grass and vegetation from adjacent areas. Keep areas around the base of trees and shrubs free of grass and loose mulch where mouse damage is a problem. Store all dried and bagged food in rodent-proof containers. Proper composting of kitchen waste is important. Keep seeds and livestock or pet food in sealed containers.

2. Diligently apply taste and smell repellents to the problem areas. Use live or spring traps or place bait boxes or poison baits where other animals and children cannot reach them. Some rats may become bait shy and others may develop an immunity to anticoagulants, so change the types and active ingredients of poisons when confronted with extended problems. Immunity develops over time and constant exposure to anticoagulants. It may be necessary to prebait. After completing sanitation measures, create bait stations. Place the baits in runways along a wall or fence where rodents often travel or places where rats or mice seek shelter. Check baits frequently to ensure they are fresh, dry, and free of mold.
3. In orchards, field mice feed on trunks of trees, rarely burrowing below ground. If the orchard is mulched, be sure to pull the mulch back a few feet from tree trunks in the fall. To deter field mice, place wire cylinders, tree collars, and plastic or paper wraps around the base of fruit trees.

E. Rabbits

Rabbits will girdle young trees, chew off bark and young twigs of woody plants in winter, and consume leafy plants during summer (Fig. 2).

Fig. 2. Cottontails and jackrabbits can become serious, year-round pests.



1. You can live trap and relocate rabbits. Reduce the rabbit habitat by removing overgrowth on ditches, bushy fence rows, or brush piles within or near garden areas. Rabbits don't like to be far from cover so mowing, brush cutting, and general clean up can help control them.
2. Place guards made of fine mesh (1/4 inch) screens around the base of trees to protect them from rabbit damage. Form the guards into cylinders about 2 inches larger than the diameter of the tree trunk and long enough to protect the tree above the snow line. Tightly woven (no larger than 1-inch mesh wire and at least 30 inches high) fences, well anchored to the ground also work well.
3. Plant "trap" crops like beans away from the garden to divert rabbits. This may provide extra food, however, resulting in more rabbits. Also, onions seem to repel rabbits, so it may help to interplant an occasional row with your crops.
4. Also effective are commercial repellents containing Thiram or Ziram fungicides or other materials sprayed or painted on tree trunks, plants, or shrubs. Blood dust, nicotine, and other repellents are labeled for rabbit control.
5. To discourage rabbits, some gardeners sprinkle dried blood meal around plant roots or spray a cow manure and water solution to reduce interest in particular plants. Others apply powdered rock phosphate, powdered aloes, red cayenne pepper, or fish tankage with bone meal to seedlings as they emerge or as a dust on plants. Some gardeners spray or place coyote, fox, or other animal urine mixtures around garden areas as repellents.

F. Bats

Bats are beneficial insect-eating animals. Occasionally bats get into buildings or attics where they foul the area with odorous feces or guano and disturb the occupants with their nocturnal activities. Bats can carry rabies. Always vaccinate your pets. Do not handle bats. If you must handle them, wear heavy leather or rubber gloves.

1. One or two bats in a house is a problem. Usually, a bat will find its way out by detecting fresh air movement, so the simplest solution is to open windows or doors leading outside. Bats have day and nocturnal roosts that they return to daily. Each species selects roost sites with specific temperatures. If the roosting area is too hot, too cold, or too drafty, they will leave. A single light bulb in the space where they roost may keep it too hot for bats. Another solution is to create a draft by opening doors and windows and using an electric fan. To discourage bats from roosting in one place, scatter 3 to 5 pounds of moth flakes over the floor or hang them in mesh bags from the rafters.
2. The best time to bat proof a building is in the fall or winter when bats migrate to wintering areas. As soon as they leave, seal the openings in eaves and attic louvers with 1/4-inch mesh, narrowly-spaced, parallel tight-wires or fishing-line screen, or boards. Seal narrow cracks with caulking compounds. If you are bat proofing a building, be sure all bats are outside before plugging the last opening. Not all bats will leave at the same time. Consider installing a one-way device to allow bats to leave but not return. Building bat houses for excluded bats may help with the problem the next season.
3. Placing floodlights in the attic or directing them at openings for several nights will not discourage entry. Instead, the lights will attract nocturnal insects such as moths, providing a ready food source for bats.

V. Vertebrates—Other Mammals

A. Raccoon

Raccoons have become adapted to urban and suburban areas, feeding at night at "garbage can" restaurants or from pet dishes (Fig. 3).

1. Raccoons are easy to catch with box traps. Normal fencing will not keep raccoons from your garden; however, electric fencing is particularly effective.

Fig. 3. Raccoons become especially bothersome near harvest for corn, melons and other fruit.



2. Sprinkle black pepper on corn ears before they are ripe. Installing motion lights and leaving radios on in the garden at dusk and dawn may help repel raccoons.

B. Deer

Deer can damage herbaceous and woody plants by browsing (Fig. 4). Orchard and vegetable crop damage are a concern, too.

1. Base your landscaping on deer-feeding preferences to avoid using expensive chemical repellents. Planting resistant or less palatable vegetables, annuals, perennials, trees and shrubs in landscapes will discourage browsing.
2. An inexpensive way to exclude deer is to construct a wire-mesh fence, 7 to 10 feet (2 to 2-1/2 m) high, around small gardens or orchards. A horizontal outrigger—a fence extension—makes it harder for deer to jump fences. Some gardeners have had success with two parallel 5-foot fences with a 5-foot “no deer” area between them. In some areas, electric fences work if constructed with at least five wires. Tightly strung piano wire in the Australian fashion of crossbeams forming an “X” at three heights also works. Deter deer by placing welded-wire fencing around individual trees or plants or types of plants or use other mechanical devices such as rigid tubes (Vexar, Tree Shelters, and Tubex), flexible sleeves, and bud caps.

Fig. 4. To learn more about controlling deer damage and deer-resistant plantings, see the various publications in the “Further Reading” section at the end of this chapter.



3. Several commercial repellents are registered and may be partially successful. They require repeated applications, particularly after rains or watering. Spray contact or taste repellents such as Thiram, Ziram, and capsaican (derivative of chili pepper) on the lower trunks of trees and lower limbs at 2-week intervals.
4. Other methods include sport hunting to reduce populations; live traps for removal by conservation officers or professional biologists; temporary frightening devices such as gas exploders, tethered dogs, fireworks, or a radio left on at night; human hair balls or deodorant soap bars hung at close intervals around valuable plants or around the garden; and blood meal, coyote, or other animal urine sprayed or placed around garden areas as repellents.

C. Skunk

Skunks are protected by law in most states and frequently are found to carry rabies. If possible, avoid handling skunks because they can eject their scent 6 to 10 feet. The persistent odor on clothing, in gardens, or buildings is highly offensive (Fig. 5).

1. One method of control is to exclude skunks from their sleeping or nesting quarters. Sprinkle a thin layer of flour around holes or building entrance areas to form a tracking patch. Examine the area after dark, when the tracks lead out of the

entrance. Close the space off with lumber or fencing, or consider live trapping and relocating the skunk. Leaving a radio on all day in the skunk's nesting area may disturb sleep patterns enough to cause them to relocate.

2. A chemical known as Neutroleum-Alpha is probably the most effective odor neutralizer available. A tablespoon in a water bath works well for pets and humans unfortunate enough to be "hit." Use 2 ounces in each gallon of water to scrub walls, out buildings, basements, outdoor furniture, and the like. You also can use chlorine bleach or household vinegar (diluted 1 to 10 parts water) with a little detergent. Tomato juice is not as effective.

D. Dogs and Cats

Male dogs urinate and kill parts of leafy plants, especially conifers; female dogs' urine may cause dead patches in a lawn. Dogs leave feces on lawns or flower beds and dig in garden beds. Cats can severely damage bark on young trees where they sharpen their claws. They dig in garden soils and leave fecal matter that may transmit parasites or diseases to humans. Cats are the number one enemy of song birds in the garden.

1. Controls include fences; scolding; clapping hands; waving brooms; or spraying the cat or dog with water from a garden hose. A screen around the tree base will obstruct cats as will clipping the cat's claws. Cats will avoid resting or walking on walls or fences with moth crystals sprinkled at regular intervals.

Fig. 5. Skunks are kin to weasels and are not afraid of man.



2. Repellents are almost too numerous to mention including allyl isothiocyanate, amyl acetate, anethole, bittrex, bone oil, capsaican, citrus oil, cresylic acid, eucalyptus, geranium oil, lavender oil, lemon-grass oil, menthol, methyl nonylketone, methyl salicylate, nicotine, pentanethiol, prydine, sassafras oil, and thymol.

VI. Vertebrate Pests—Birds

A. General Bird Information

All birds, in one way or another, are beneficial to man. They can, however, create problems singly or in groups. Birds are important in preventing insect outbreaks and their control of other garden pests benefits most gardens. Man considers birds pests when they consume and destroy fruit and seed crops such as strawberries, sweet cherries, and sunflowers; contaminate foodstuffs or buildings with their feces; and transmit diseases directly or indirectly to man, poultry, or dairy animals.

1. Avicides registered by the Environmental Protection Agency (EPA) for specific species often require prebaiting for several days and the quick removal of dead birds at regular intervals to be effective. Chemosterilents, birth control agents, and repellents are also available. There are three repellent categories: (1) olfactory (odor), (2) tactile (touch), and (3) gustatory (taste). In the olfactory category, gardeners have used naphthalene (moth balls) granules or flakes to repel all domestic animals. Tactile repellents are made of various gooey combinations of castor oil, petroleum, or solvents and applied as thin strips or beads to roosts, window ledges, and resting areas. Taste repellents are varied and have multiple uses. For example, fungicides applied as seed treatments sometimes inhibit seed-pulling birds.
2. To protect sprouting seedlings and maturing vegetables, floating row covers are easy to use and need no supports. Drape cheesecloth, nylon

netting, or other mesh materials over garden crops or fruit trees susceptible to bird damage during ripening. Put these up 2 to 3 weeks before ripening. Place screen or cloth over strawberries and other small fruits.

3. Commercially designed noisemakers are partially effective but not very popular in populated areas. Stakes and flags, continuous string flagging or netting, spiral twirlers, shiny propellers, and other objects that flash in the sunlight, rustle, or rattle as they spin are useful in small areas until birds become accustomed to them.
4. Poisoning is effective but not selective. Invariably, poisons will kill several song or protected birds, so it is not recommended.

B. Yellow-Bellied Sap Sucker

A member of the woodpecker family, sap suckers drill horizontal rows of squarish holes through the bark of spruce, Scots pine, birch, nut trees, and Siberian elm. They feed on sap and sap wood. Hummingbirds will feed on this sap and, like the sap sucker, take advantage of the insects attracted to the ooze. Girdled trees may die. Because sap suckers are a protected species, it is unlawful to kill them; so wrap the damaged trees in burlap and treat with pruning paint. Painting a mixture of cayenne pepper and petroleum jelly on affected areas may discourage continued damage. Noise makers also may scare birds away.

C. Starlings

Exclude starlings (Fig. 6) by closing all openings to less than 1 inch (2.54 cm). Use boards or metal coverings at 45° angles and metal prongs or sticky repellents on ledges or rafters. Attach netting to prevent roosting on buildings or rafters. PVC strips work well to cover door openings. Frightening devices including alarms, distress calls, lights, and bright objects may work. Repellents to protect ripening fruit and poison baits also are available.

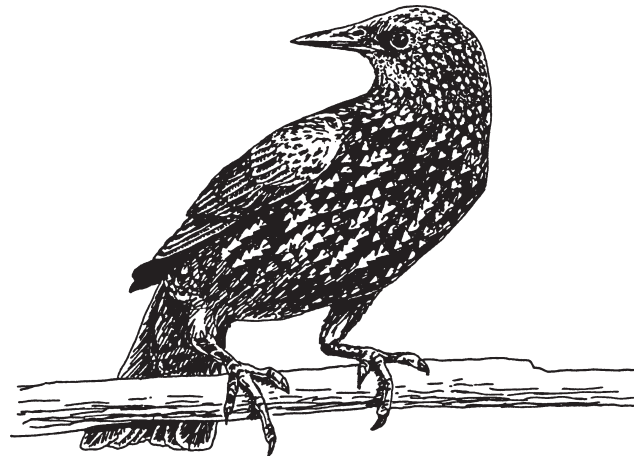
VII. Invertebrates and Arthropods of the Home Yard and Garden

A. Nematodes

Nematodes or eelworms are tiny, unsegmented worms that may be as small as 1/125 inch in length. An impermeable cuticle covers and protects them. They survive during unfavorable periods of cold or heat in protective egg shells. Accurately identifying this pest and learning its specific life cycles (eggs may remain viable in cysts for several years) is the key to proper management.

1. Nematodes cause their greatest damage when soil moisture and temperature are suitable for germination. They frequently will pierce roots and feed on them. They may lay their eggs on roots causing knots to form. Nematodes can transfer diseases between plants. A plant attacked by parasitic nematodes loses nourishment and may appear stunted or die. There are a number of beneficial free living, nonparasitic nematodes associated with root systems of many plants; therefore, finding root knots does not always indicate nematode injury.
2. Control culturally by selecting nematode-free planting stock or resistant plant varieties. You can kill considerable numbers of nematodes by soil solarization, flooding the soil for extended periods, or by permitting the soil to completely dry out. Maintaining high fertility levels or add-

Fig. 6. Starlings can cause damage because of their prolific numbers and flocking habits.



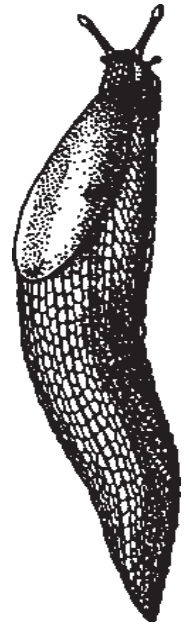
ing organic amendments (peat, manure, and green chop) to garden soils decreases the pest's impact. Some commercial preparations of organisms (bacteria, sporozoa, fungi, viruses, protozoa, predatory nematodes, tardigrades, mites, and springtails) that prey on nematodes are available.

3. Crop rotation is perhaps the most inexpensive, yet effective way to control nematodes. Nematode-suppressive plants such as French marigolds (*Tagetes patula*), asparagus, garlic, and onions have been reported to abate nematodes if they are planted in blocks and used as part of a rotation.
4. Orchard floor management through the use of cover crops in orchards or vineyards can have a significant impact on nematode problems. Sanitation, preventing the movement of soils or water from an infested area of the garden, and planting or harvest dates based on soil temperature with an understanding of nematode life cycles also may help.
5. Gardeners seldom use nematicides unless they encounter greenhouse or cold frame problems. Most of today's chemical nematicides are soil fumigants, volatile halogenated hydrocarbons. There are no nematicidal agents registered for use in the home garden. If this pest problem occurs, you will need to contact a commercial applicator. To avoid damaging other plants, the products must be applied before planting. Chemical applications must have high vapor pressure to spread through the soil and successfully contact nematodes in the water film surrounding soil particles.

B. Slugs and Snails

These are molluscs, not insects. Both have soft bodies and secrete a silvery mucus that appears as trails across the garden. Snails carry a shell about with them. They spend the winter in the soil as eggs. Young and adult slugs often rest in night crawler tunnels. They appear in early spring and multiply rapidly under moist conditions. There are several kinds, but all are similar in ap-

pearance. Their color varies from white to pale yellow to lavender-purple to nearly black with brown spots, specks, and mottlings. They have rasping mouthparts. Slugs are humidity-loving animals that attack all kinds of garden and ornamental plants. They may eat irregular sections or consume entire leaves. There is only one generation per year.



1. Culturally control slugs by eliminating cool, moist, dark hiding places (low-growing weeds, stones, trash, and ground covers) where slugs seek daytime shelter. Keeping the garden dry and plants well spaced can help. Regular hand picking slugs from plants at night, maintaining a border of bare soil, and building copper screens or copper strip barriers that they cannot crawl over may also help. Commercial traps are available. Shallow pans placed at ground level and filled with stale beer are good homemade alternatives. Shingles, boards, and flower pots placed on the ground as hiding places also make good traps; check traps daily and scrape off and destroy the slugs. Commercial preparations of diatomaceous earth can be effective as a protective barrier if kept dry. Among their natural enemies are ladybug larvae, ducks, chickens, snakes, and turtles.
2. You can chemically control slugs by using molluscicides such as metaldehyde baits. Note these baits may attract and be toxic to pets. Improve the bait's effectiveness by placing it under a protective cover such as a 5-inch diameter pie pan. Fresh baits are most effective. Do not allow bait to come in contact with edible parts of plants. Methioacarb (Mesurol) is the most effective of the insecticides registered for use against snails and slugs on ornamentals. Other registered insecticides include Carbaryl and Mexa-carbate.

3. Do not use salt because it contaminates soil and kills plants. A solution of one half household ammonia and one half water in a spray bottle may destroy slugs and snails without harming the soil. Keep the spray solution off leaf surfaces as it can damage plants; however, it will leave nontoxic residues.
4. A mulch of oak leaves or tobacco stem meal will repel slugs and snails. A drenching of wormwood tea will deter them. Hellebore has long been used to keep slugs from grapevines.

C. Earthworms or Nightcrawlers

Earthworms need a moist environment. They are headless, eyeless, toothless, without antennae, and bisexual (they have both male and female reproductive organs). Soils with high worm populations often have high organic matter levels. Saline soils, sandy soils, and soils with a pH of 4.5 or lower usually have few worm problems. Earthworms are normally found in the top 6 to 30 inches of the soil. They come to the surface at night and after heavy rains.

1. Earthworms can grow to 10 inches in length. Most gardeners feel they are beneficial, but for some their burrowing and hard casts make a lawn lumpy and difficult to mow. Earthworms burrow through soil, feeding on organic matter and dead leaves or stems at the soil surface. They decompose thatch, mix organic material through the soil, and aerate the soil with their tunneling.
2. Culturally some lawn maintenance professionals use heavy lawn rollers in the spring before the mowing season, or when problems occur, to level the ground.
3. No chemicals are registered for earthworm control.

Further Reading

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Booklets and Pamphlets

University of Idaho

- BUL 778 A Private Landowner's Guide to Managing Northwest Bluebird Habitat (\$1.50)
- PNW 225 Building an Electric Antipredator Fence (\$2.50)
- CIS 1041 Conduct Your Own Garden Research (\$2.00)
- CIS 1018 Hantavirus (50¢)
- CIS 868 The Potato Rot Nematode (\$1.00)
- CIS 847 Virus and Nematode Diseases of Raspberries (35¢)

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Washington State University

- EB 1147 Animal Damage Control in Washington (\$3.00)
- EB 1677 Animal Warning Devices (\$1.00)
- EB 1602 Attracting Birds of Prey (\$1.00)
- PNW 154 Meadow Mouse Control in Tree Fruit Orchards (25¢)
- EB 1028 Moles (\$1.00)
- EB 0648 Organic Gardening (\$1.00)
- EB 1404 Pocket Gopher Control (\$1.00)
- EB 1663 Ultrasonic and Subsonic Pest Control Devices (\$1.00)

To order WSU publications, contact your county's Cooperative Extension System office or write to Bulletin Offices, Cooperative Extension, Cooper Publications Building, Pullman, WA 99164-5912 or call (509) 335-2857.

Oregon State University

- PNW 225 Building an Electric Antipredator Fence (50¢)
- EC 1429 Controlling Ground Squirrel Damage to Forages and Field Crops, Ditches, and Dams (50¢)
- EC 987 Controlling Moles (75¢)
- EC 1117 Controlling Pocket Gopher Damage to Agricultural Crops (\$1.50)
- EC 1255 Controlling Pocket Gopher Damage to Conifer Seedlings (\$1.50)
- CORN ANIM Pesticide Applicators Training Manual/Animal (\$5.00)
- CORN STRU Pesticide Applicators Training Manual Structural and Rodent (\$8.00)
- FS 372 Slugs (25¢)

To order OSU publications, contact your county's Cooperative Extension System office or write to Publication Orders, Agricultural Communications, Oregon State University, Administrative Services A422, Corvallis, OR 97331-2119 or call (503) 737-2513.

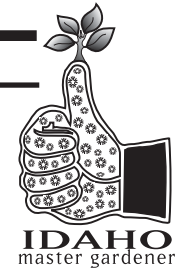
Chapter 12

Plant Disease Diagnosis and Management



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Plant Disease Diagnosis and Management



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I. Introduction to Plant Diseases

Plant pathology or phytopathology is the science dealing with plant diseases and their control.

Plant pathologists study plant diseases caused by fungi, bacteria, viruses, nematodes, and parasitic plants. They also study plant disorders caused by nutrient imbalances, air pollution, and other unfavorable growing conditions.

A. History of Plant Diseases

Plant diseases have had profound effects on mankind through the centuries as evidenced by Biblical references to the blasting and mildew of plants. The Greek philosopher Theophrastus (370-286 B.C.) was the first to describe maladies of trees, cereals, and legumes that we currently classify as leaf scorch, rots, scab, and cereal rust. The Romans were also aware of rust diseases of their grain crops. They celebrated the holiday of Robigalia when sacrifices of reddish-colored dogs and cattle were made in an attempt to appease the rust god Robigo.

With the invention of the microscope in the 17th century, fungi and bacteria associated with plants were investigated. In 1665, Robert Hooke published the first illustration of rust on a rose leaf. Advances in the study of diseases were hampered by the widely held belief in the theory of spontaneous generation. This theory, held by most people in the mid-18th century, considered pathogenic or disease causing microorganisms as products of disease rather than causes of disease.

Epidemics of late blight of potato devastated Ireland in 1845 and 1846. These epi-

demics dramatized the effect of plant diseases on mankind. Tragically, these epidemics caused famine and death for over a million people. Between 1845 and 1860, death and migration accounted for the loss of nearly one-third of Ireland's population.

In 1861, a German botanist, Anton De Bary, proved that a fungus (*Phytophthora infestans*) was the causal agent of late blight of potato. This was a milestone in the study of plant diseases since it showed that a fungus was indeed the cause of a plant disease rather than an organism simply associated with the disease. Two years later, Louis Pasteur proposed his germ theory of disease that finally disproved the theory of spontaneous generation and changed the way modern science investigated the diseases of all living organisms.

B. Significance of Plant Diseases in the United States

A few examples of plant disease epidemics that have resulted in devastating plant losses in the United States include: chestnut blight, introduced in 1904, virtually eliminated chestnut trees from North America; citrus canker, introduced in 1910, and a closely related bacterium called citrus bacterial spot discovered in 1984, resulted in the destruction of millions of citrus trees; white pine blister rust, introduced in 1912, caused large economic losses in the timber industry; and Dutch elm disease, introduced in 1930, continues to destroy large numbers of elm trees from the East Coast to the Pacific Northwest.

As a direct result of severe disease losses from imported diseased plant material, plant quarantine laws were passed by the United States Congress in 1912. The Agricultural Plant Health Inspection Service (APHIS) has quarantine inspectors stationed at points of entry into the country as well as at certain interstate points to intercept produce likely to carry new plant pathogens.

II. Disease Concepts

A. What Is a Disease?

There are many ways to define what a plant disease is. However, simply put, plant diseases involve profound changes within the host that cause a disruption of normal plant function. A good working definition of a healthy plant is one that can carry out its physiological functions to the best of its genetic ability.

Diseases are among the most important factors that can significantly diminish growth and yield, or reduce the usefulness of a plant or plant product. Healthy or normal plants develop and function to the maximum of their genetic potential. However, when plants are adversely affected by continuous irritation by a disease-causing agent, which interferes with normal development and functioning, plants are considered to be diseased. This broad definition excludes injury or damage such as mechanical injury (e.g., lawn mower or weed-eater injury to trees); deer, rodent, and bird damage; hail damage; and lightning injury.

In addition to reduction in growth, yield, and economic or aesthetic value of a plant or plant product, diseases may lead to the death of the whole plant or destruction of the entire crop under conditions favorable for the disease. Diseases may interfere with absorption and translocation of water and nutrients from the soil to the various parts of the plant, may reduce the photosynthetic efficiency of the plant parts, may interrupt the translocation of photosynthetic products through the plant, or may interfere with the reproduction and storage of food reserves in the plant.

Diseases in plants are caused by either living (biotic, parasitic, or infectious) agents called pathogens, or nonliving (abiotic, non-parasitic, or noninfectious) environmental factors. Plant diseases may also be grouped by the causal agent involved (fungal diseases, bacterial diseases, viral diseases, nematode diseases, etc.), the plant part affected (root diseases, seedling diseases, leaf diseases, stem diseases, flower diseases, fruit diseases, tuber diseases, etc.), or the types of symptoms (damping-off, wilts, leaf spots, cankers, blights, galls, root knots, mosaics, storage rots, etc.).

B. Symptoms of Diseases

Symptoms are the visible reactions of a plant to a disease and may suggest a causal agent. A sampling of disease symptoms might include wilting, necrosis, abnormal coloration, defoliation, fruit drop, abnormal cellular growth, or stunting of the infected plant. However, it is important to remember that different disease agents can cause similar symptoms on the same host. An equally important point to remember is that insect feeding can also cause disease-like symptoms on plants.

C. Signs of Diseases

Signs are the visible parts of the pathogen or its products seen on the host that can be used to identify the pathogen. Examples of common disease signs include: the white coating of mycelium visible on powdery mildew-infected leaves, mushroom growth on a tree limb, droplets of bacterial ooze running down a fruit tree twig, nematode cysts on plant roots, or dark fungal fruiting bodies visible in leaf lesions.

D. Causal Agents of Disease

A pathogen is any organism that can cause a disease. Pathogens cause infectious diseases that can spread from an infected plant to a healthy plant. Pathogens that cause infectious diseases include bacteria, fungi, viruses, nematodes, and parasitic plants. Plant disease can also be caused by noninfectious or nonliving factors. Causes of disease by nonliving factors include unfavorable growing conditions, mineral deficiencies, and air pollution.

Pathogens that cannot be cultured apart from their host are classified as obligate parasites. Pathogens that can be cultured apart from their hosts on artificial media are called nonobligate parasites. In general, obligate parasites only attack very specific host plants, whereas nonobligate parasites typically have a wider range of plants they can infect. Some pathogens are restricted to a single plant species, while others infect a single plant genus. Still others attack a large number of hosts from many plant genera.

There are also several levels of parasitism that pathogens can have with their hosts. When a pathogen is capable of infecting a plant, the plant is considered susceptible to that pathogen. If a pathogen cannot infect a plant, then the plant is considered immune to that pathogen. Plants can vary in their response to pathogens from high resistance (very little disease development), to partial resistance (moderate disease development), or high susceptibility (severe disease development). Pathogens can vary in their degree of virulence on a susceptible plant ranging from highly virulent (causing severe disease symptoms) to weakly virulent (causing less disease).

E. Inoculum and Pathogen Dissemination

Inoculum is any part of the pathogen that can cause infection. Examples of inoculum include fungal spores, bacterial cells, virus particles, or nematode eggs. Inoculum that survives the winter and causes the original or primary infection in the spring is called primary inoculum. Secondary inoculum causes additional infections throughout the growing season.

Inoculum is sometimes present at the site where a plant is grown and can also be introduced from an outside source. Inoculum already present at a plant site includes soil pathogens or pathogens that overwinter on perennial weeds. Introduced inoculum includes infected plant material such as infected seeds, wind-blown fungal spores, and inoculum transmitted by insects.

Inoculum can be disseminated passively by wind, rain, and man. Inoculum can also be disseminated actively by insects and nema-

todes or fungal zoospores swimming through water in the soil toward plant roots. Only a fraction of any pathogen's inoculum will ever land on a susceptible host. The vast majority of inoculum lands on material that cannot be infected. Most pathogens produce a tremendous surplus of inoculum.

F. Pathogen Survival

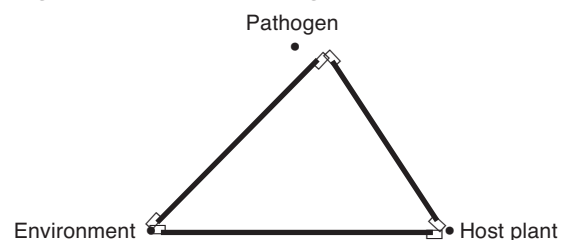
Pathogens in temperate climates must have a way of overwintering when their host plants are dormant or absent. In perennial plants, pathogens can survive in infected plant parts such as roots, bulbs, stems, and bud scales. Annual plants, however, die at the end of the growing season and pathogens must survive in insects, seeds, or as resistant spores.

G. Factors Affecting Disease Occurrence

Diseases in plants are an exception rather than a rule. Three factors, called the disease triangle (Fig. 1), must coincide for a plant to become diseased: the host, the pathogen, and the environment. The interaction between these three factors with time determines the occurrence and severity of a disease. For the disease to occur, the following conditions must be met:

1. The host plant must be of a susceptible species or cultivar at the right stage of development (susceptible host).
2. The pathogen must be of a virulent race or strain and must be present in sufficient numbers (inoculum potential). The presence of appropriate vectors or other agents of dispersal is also necessary.
3. The environmental (atmospheric and soil) conditions such as temperature, humidity, rainfall, wind, moisture, light, soil type, texture and pH, density of planting, aeration, and nutritional status (mineral deficiency or excess) must be favorable for disease development.

Fig. 1. Plant disease triangle.



4. Understanding the various aspects of the host, the pathogen, the environment, as well as their interaction is essential to implement an effective disease management strategy.

III. Diseases Caused by Living (Biotic, Parasitic, or Infectious) Agents

A. Fungi

Commonly known as molds, fungi (singular = fungus) are mostly microscopic organisms that have bodies (mycelium) composed of multi-cellular, thread-like, branched filaments (hyphae) and reproductive structures called spores. Since they do not possess chlorophyll, fungi depend on either dead organic matter or living plants for their growth and reproduction. Some fungi produce vitamins and antibiotics that are useful to us.

A few fungi, like some types of mushrooms and morels, are edible. On the other hand, some fungi thrive on living plants, drawing their nutrition from them and sometimes producing toxins that cause disease and death of the plants they infect. These are called plant pathogenic fungi.

A majority of diseases in plants are caused by fungi. Some examples commonly encountered in home gardens and landscape trees are: brown rot of cherries, apple scab, black spot of rose, snapdragon rust, corn smut, powdery mildew of rose, peach leaf curl, sycamore anthracnose, early blight of potato, Verticillium wilt of tomato, damping-off, and root rot of vegetables.

B. Bacteria and Phytoplasmas

Bacteria (singular = bacterium) and phytoplasmas (formerly known as mycoplasmas or mycoplasma-like organisms) are microscopic, single-celled organisms that cause some of the most destructive diseases in plants. Some bacteria, like those that induce nodulation in leguminous plants, are beneficial to plants because they fix nitrogen from the air into the root nodules in a form that the host plant can utilize for its growth.

Phytoplasmas are a type of bacteria that lack distinct cell walls. Under favorable condi-

tions, bacteria reproduce very rapidly and can cause serious damage in a short period of time. Bacterial pathogens are spread by wind-splashed rain, insects, contaminated seed, or implements. Bacterial diseases are relatively difficult to control because there are very few chemicals that are effective against them.

Some commonly encountered bacterial diseases are: crown gall of rose, grape, apple, cherry, and other ornamental plants; fire blight of apple and pear; soft rot of potato; ring rot of potato; and aster yellows phytoplasma on carrots, tomatoes, onions, lettuce, etc.

C. Viruses

Viruses are infectious agents so small they must be observed through an electron microscope. Particles of these viruses may be in the form of rods, spheres, or threads. They are composed mainly of a nucleic acid core surrounded by a protein coat. Viruses can multiply only in a living host cell and can often spread systemically throughout the infected plant.

Viruses can be transmitted from infected to healthy plants mechanically, through grafts, and by contaminated propagating material. Viruses can also be transmitted by certain organisms, referred to as vectors. In addition to insects (primarily aphids, white flies, leafhoppers, and beetles), virus vectors include mites, nematodes, and fungi in the soil.

Viral diseases are not controlled by pesticide chemicals. Examples of viral diseases are: curly top of tomato, bean, cucurbits, etc.; potato leaf roll; bean common mosaic; and rose mosaic.

D. Nematodes

Nematodes are microscopic roundworms that live in soil as well as water, and survive as eggs or cysts. Most of them are saprophytes, but some infect living plants and cause diseases. Most plant parasitic nematodes feed on the underground parts of the plants (roots, tubers, bulbs, etc.) causing lesions or root knots. However, a few nematodes also affect the buds, leaves, flowers, and stems of plants. Nematodes spread

through contaminated planting material (tubers, seedlings, etc.), manure, soil, water, machinery, and implements. Some nematodes are vectors of plant viruses.

Some examples of plant parasitic nematodes are: root knot nematodes of tomato, potato, beans, and many other plants; root lesion nematodes of corn and potatoes, cyst nematode of sugarbeets; stubby root nematode of corn; stem and bulb nematodes of onion; and foliar nematode of chrysanthemum.

E. Parasitic Higher (Flowering) Plants

Several flower- and seed-producing plants live as parasites on other plants (host plants), deriving their nutrition from them and adversely affecting the host plant's growth and yield. Dodder (also known as strangleweed and devil's hair), for example, parasitizes several garden plants such as potatoes and carrots. It produces orange or yellow vine strands that entwine the stems and other plant parts from which it draws its nutrition through tube-like structures it introduces into the host tissue. Dodder produces abundant seeds that ensure its propagation and spread. Another example of a parasitic plant is dwarf mistletoes on pines.

IV. Diseases Caused by Abiotic (Nonliving, Nonparasitic, or Noninfectious) Agents

A variety of environmental and cultural factors can cause diseases in plants. Since these diseases occur in the absence of pathogens, they do not spread from a diseased plant to a healthy plant.

A. High or Low Temperatures

When plants or plant parts are exposed to high temperatures for prolonged periods, symptoms of scorching or scalding may develop. Some examples are: sunburn or scorching of leaves and sunscald of fruits (e.g., apples, tomatoes, peppers, and melons). Similarly, low temperatures, like frost or freeze, can damage the exposed or sensitive organs (buds, flowers, young fruits, etc.) or may kill the entire plant. Examples include: southwest-side damage to trunks of apple trees; frost damage to blossoms and young apple fruits; russet ring (caused by frost) on apple and pear fruits; winter injury

to trees; and frost damage to tomatoes, beans, potatoes, etc.

B. High or Low Soil Moisture

Too much moisture due to excessive watering, poor drainage, ponding, or flooding may cause plants to turn yellow and be stunted. Potted indoor plants, for example, may show poor development or root rots. Seedlings are vulnerable to damping-off caused by soilborne pathogens under these conditions.

In some indoor or greenhouse plants (e.g., geraniums, begonias) growing under warm, humid atmospheric conditions and excessive soil moisture, a condition known as edema (small, wart-like rusty, corky bumps) can develop on the underside of the leaves, and on the stems. At the other extreme, low moisture or drought conditions can lead to poor development, wilting, and death of plants.

C. High or Low Light Intensity

High light intensity is usually not a problem but low light conditions, especially for indoor plants, can lead to etiolation (spindly or lanky plant growth with chlorotic yellow foliage).

D. Lack of Aeration or Low Oxygen Supply

Low aeration can deprive plant roots of adequate oxygen and can adversely affect their development or even kill the plant. Inadequate oxygen supply during the storage of potato tubers can lead to the development of a condition called blackheart, the browning and death of internal tuber tissue.

E. Air Pollution

Certain chemicals, such as ozone, sulfur dioxide, and nitrogen dioxide are released into the air from factories, power plants, and automobile exhausts. These chemicals can accumulate in the atmosphere in sufficient concentration to cause damage to plants.

Ozone damage appears in the form of mottling, chlorosis, spots, and bleaching of young leaves. This is common in certain regions of the country where there is a high ozone concentration in smog. For example, ozone damage is frequently found on the leaves of beans, petunias, and grapes. Some of the air pollutants responsible for acid rain

cause damage to vegetation in certain regions. In Idaho, however, plant damage due to air pollution is not common.

F. Nutrient Deficiencies

Plants require several major (nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur) and minor (iron, boron, copper, zinc, etc.) elements for normal growth. Deficiency or lack of any of these essential nutrients results in disease symptoms in the plant. Specific symptoms depend on the plant species and the deficient nutrient. If not corrected, a prolonged acute deficiency of essential nutrients can lead to death of the plant.

Common examples of nutrient deficiencies are: nitrogen deficiency in beans, iron deficiency in peaches, zinc deficiency in apple trees, and calcium deficiency in apple fruit (bitter pit). In the home garden, the common blossom-end rot of tomato fruit is caused, in part, by calcium deficiency.

G. Mineral Toxicity

Presence of excessive available amounts of certain minerals in the soil can lead to mineral toxicity to the plants. The extent of injury depends on the mineral, its concentration, and the species of the plant. Excessive amounts of sodium salts in the soil can lead to high pH and to alkali injury (e.g., alkali injury to apple). Plants growing in acidic soils can be injured by aluminum or manganese toxicity.

H. Unfavorable Soil pH

Although many plants can grow in a rather wide range of soil pH, plants growing in soils with unfavorable pH usually show poor growth and mineral deficiency or toxicity symptoms.

For example, iron deficiency symptoms are very common in plants growing in high pH soils in Idaho. Under conditions of high soil pH, iron in the soil becomes unavailable to the plant, thus inducing interveinal chlorosis and yellowing of leaves. The plant may die if the condition remains uncorrected for a prolonged time.

I. Pesticide Toxicity

Some pesticides, if improperly used, can cause serious damage to plants. For ex-

ample, if wettable sulfur is sprayed (for powdery-mildew control) on a very hot day (above 90°F), it will result in injury to the plant phytotoxicity). However, the most common type of chemical injury to plants is due to soil residues or spray drift of herbicides.

Examples of pesticide toxicity are: 2,4-D damage to beans and tomatoes, dicamba (Banvel) damage to vegetables and trees, and glyphosate (Roundup) damage to fruit trees. Some herbicides used as soil sterilants may leave the soil unsuitable for any plant growth for several years.

J. Improper Cultural Practices

Any cultural practice done in the wrong way or at the wrong time can result in significant damage to plants. Injury can result from improper amounts of chemical fertilizer or pesticide or improper chemical mixes in the spray tank. Root pruning can result from excessively deep cultivation; distorted and twisted roots can result from pot-bound conditions of a plant. African violet leaves sprinkled with very cold water develop rings and ring-like patterns that resemble symptoms caused by some viruses.

V. Diagnosing Plant Disease Problems

A. Why Is Diagnosis Important?

Whether in an effort to save existing plants or to prevent problems from recurring, it is important to know “What went wrong?” Diagnosis is the process of gathering information about a plant problem and determining the cause. Once the cause has been determined, it is then possible to recommend a solution or remedy.

Diagnosing plant problems can involve considerable detective work. Sometimes there is insufficient information and other times, the primary cause of a problem is hidden by more obvious, but less-important, problems. Success in diagnosing plant problems depends on how much we know about the host plant, about the plant problems in general, and the quality of information obtained from the client.

For example, 10 tomato plants all similarly damaged, are brought to you. All have yel-

low leaves, stunted growth, and very few feeder roots. You learn from questioning the grower that he applied one-half of a 20-pound bag of 10-10-10 fertilizer to a tomato plot that measures 60 square feet. The grower put 10 pounds of fertilizer on 60 square feet, which translates to a rate of 166 pounds per 1,000 square feet. This is almost 10 times the normal rate of 20 pounds per 1,000 square feet of a 10-10-10 fertilizer. The grower's fertilization rate is enough to kill fine feeder roots. The diagnosis is damage to the roots caused by overfertilization.

B. Basic Steps in Reaching a Diagnosis

1. Identify the plant—The better your plant identification skills the faster you will be able to diagnose a problem. Most references on plant pests and diseases are organized by plant, so knowing the plant is the essential first step in using many reference books.
2. What is normal? Your familiarity with the normal appearance and cultural requirements of the plant will enable you to differentiate normal changes from symptoms of a problem.
3. What is the problem? To make a disease diagnosis, you need to know: the pattern of distribution of the diseased plants or plant parts, the plant species or cultivar involved, the site where the plant is growing (field, orchard, garden, greenhouse, inside the house, etc.), and previous crop history of the site.
For example, uniform damage to many species in an area, to all plants on one side of the field or garden, or to all shoots on one side of the tree indicates that the cause may be an abiotic factor. Also, if the damage is well demarcated in a garden or in a plant, it may suggest that some abiotic factor is involved. On the other hand, if there is evidence of progressive spread of the disease from an initial focus to other plants of the same cultivar or species or to different parts of the plant, it may indicate that an infectious agent is involved.
4. Examine the plant and note symptoms and signs —For a presumptive diagnosis

of diseases in plants, look for the symptoms and signs of the disease. The characteristic internal or external alterations of a plant in response to a disease-causing agent are called symptoms (leaf spot, necrosis, blight, canker, wilt, lesion, gall, witches' broom, rot, chlorosis, mosaic, etc.). Sometimes, the pathogen that causes the disease produces its own characteristic growth or structures on the diseased plant that are of diagnostic value. These are referred to as signs of the disease (mold, mildew, sclerotia, mushrooms, conks, etc.).

5. Tentative diagnosis—Based on your knowledge of the plant and information from reference books, formulate a tentative diagnosis. This will help you focus your examination of the plant and assist in collecting relevant information.
6. Double-check the diagnosis—Once you have arrived at a diagnosis, unless it is an obvious diagnosis, double-check it. Ask other master gardeners or extension educators for their opinions. Read through the reference books about your diagnosis to make certain everything matches. Additional laboratory work may be needed to confirm your diagnosis.
7. Types of plant disease diagnosis—Verbal descriptions by a telephone call or evaluation of a sample provide the most common diagnostic opportunities. However, a site visit provides more complete information.
To make a telephone diagnosis, you must completely rely on information provided by the caller in order to make your diagnosis. There will be common, familiar problems, such as powdery mildew of apples, when a little information easily leads to a correct diagnosis. In other cases, it will be very difficult to make a diagnosis over the telephone and it may be necessary to evaluate a sample.
Much of your diagnostic work as a master gardener will be done with plant samples. Usually, the sample will provide the clues necessary to solve the problem. But when the sample only confirms the

identification of the plant, you must concentrate on acquiring information to reach a diagnosis. Your job will be to learn about the plant's cultural and environmental conditions, the care the plant has received, and whether the sample is representative of the problem affecting the plant.

A site visit provides the greatest opportunity to gather information, but a successful plant diagnosis also depends on a combination of factors: your knowledge of the plant involved, your understanding of the plant's basic cultural requirements, and your recognition of the potential problems that might affect it. It also depends on your ability to gather information, both through observation of the plant and discussion with the client.

VI. Principles of Plant Disease Control

Plant disease control aims at preventing or reducing the amount of damage or economic loss. Most plant disease-control measures are aimed at preventing or protecting plants from the disease rather than curing the plant after it is diseased. By the time the disease symptoms appear, it is often too late to reverse the damage caused by the disease agent. In some cases, acceptable control measures are not available to halt the disease, short of plant removal. Correct diagnosis of the disease is important in order to implement a control strategy to prevent or reduce the incidence of the disease in the next crop cycle.

The various controls for diseases can be classified as exclusion strategies, inoculum reduction methods, use of disease-resistant cultivars, chemical control, and biological controls. Integrated disease-management strategies may utilize any or all of these methods.

A. Exclusion of the Pathogen

Some destructive plant diseases do not occur in our country, state, or region. To prevent import and introduction of these pathogens national, regional, or state regulations, known as quarantines, are put into force. Some examples are the customs and plant health inspection services at airports and check points on highways. In addition, national and state laws regulate the conditions

under which certain crops may be grown and distributed between states and countries. We cannot import several types of plant material from abroad without specific permission and inspection by the appropriate quarantine authority.

An example of a state quarantine is in relation to white rot of onion and garlic. White rot is a very destructive disease of onion and garlic. Once introduced in the soil, the pathogen can survive for over 20 years and there are no satisfactory chemical control measures. At present, our commercial onion growing areas in southern Idaho are free from this disease. Therefore, the State Department of Agriculture in Idaho restricts the importation of onion and garlic bulbs and other related plants for planting in southern Idaho.

Restriction of bean seed from outside of Idaho prevents the introduction of two serious bacterial diseases: halo blight and common blight.

Homeowners can keep some serious plant pathogens out of their yards and gardens by planting only certified, disease-free planting material (seeds, tubers, bulbs, seedlings, nursery stock, etc.). For example, a homeowner can avoid several virus diseases and ring rot of potato by planting certified disease-free tubers.

B. Eradication or Reduction of the Pathogen Population

Serious disease damage to a crop or garden patch can be prevented or reduced by pulling out and destroying the first plant or the first few plants that show the disease symptoms (roguing). This prevents the spread of the pathogen to other healthy plants (e.g., elimination of the first bean plants with mosaic symptoms).

Since some of the root-infecting pathogens remain viable in the soil even after the crop is harvested, avoid planting the same or similar susceptible crop in that part of the garden for the next 2 to 3 years. An appropriate crop rotation in the garden is very essential to reduce the damage caused by root rot and wilt-causing pathogens and nematodes (e.g., *Fusarium* root rot and wilt, *Ver-*

ticillium wilt, and nematodes on tomato).

Eliminating the infected leaves and diseased or dead branches, as well as using clean garden tools and similar methods of sanitation, will prevent the spread and build up of disease-causing organisms.

Other cultural practices, such as growing plants on raised beds and using composted tree bark in the planting medium for containerized nursery stock, help reduce the damage caused by certain soilborne pathogens (e.g., damping-off, root rots, and wilts).

Proper irrigation management can prevent some diseases (e.g., collar rot of apple).

Using the sun's heat during the summer months to reduce some of the soilborne pathogens can be successful in certain regions. In this process, called soil solarization, the soil is cultivated to a fine texture and deeply watered. The moist soil is covered with a clear polyethylene sheet. The sheet's edges are buried to create an airtight environment. The moist soil below the polyethylene mulch heats up and is slowly "cooked." Under sunny weather conditions for at least 4 weeks, this process reduces or eliminates several soilborne pathogens.

Marigolds interplanted with nematode-susceptible crops produce substances in the soil that are toxic to plant parasitic nematodes and thereby reduce the nematode damage to the crop plant.

Controlling insects with insecticides can reduce the spread of some of the diseases caused by viruses that are transmitted by insects (e.g., potato leaf roll virus spread by aphids).

C. Use of Disease-Resistant Cultivars

Where available, use of disease-resistant cultivars is the most cost-effective, safe, easy, and environmentally desirable option for the gardener. In fact, for some diseases (such as curly top of tomato), resistant cultivars offer the only practical control option available. Varieties resistant to one or more diseases are available in several vegetables and fruits (e.g., tomato cultivars with resis-

tance to Fusarium wilt, Verticillium wilt, nematodes, and tomato mosaic virus; and apple cultivars resistant to fire blight).

D. Chemical Protection of Plant

The most common method of direct protection of plants against plant pathogens is through the use of chemicals. Chemicals used for control of fungal diseases are called fungicides, those that control bacterial diseases are called bactericides, and those that control nematodes are called nematocides. No chemicals at this time are effective against diseases caused by viruses.

Certain chemicals, used to control soilborne pathogens, are called fumigants. These are highly volatile chemicals that are toxic to all the living organisms (biocides), including insects, weed seeds, fungi, bacteria, and nematodes. An example of a soil fumigant is methyl bromide. Fumigants need extreme care in handling and application, and therefore, can only be used by certified pesticide applicators.

Based on the mode of action, pesticide chemicals can be classified as follows:

Protectants: These chemicals, when applied to the plants, remain on the plant surface and prevent spore germination and infection of the plant by the pathogen (e.g., sulfur, captan).

Systemics: These chemicals are absorbed by plants and are translocated to other plant parts (e.g., Benlate, Ridomil).

Eradicants: These chemicals can eradicate the pathogen from plant tissue after the infection has occurred; that is, after the penetration by and establishment of the pathogen inside the host tissue (e.g., Rally).

Based on the type of chemical (active ingredient), these pesticides can also be classified as copper compounds, sulfur compounds, dithiocarbamates, benzimidazoles, antibiotics, etc. Disease-control chemicals can be applied as seed treatments, foliar sprays, dusts, fumigants, wound paints, dips, or through irrigation water (chemigation).

The effectiveness of chemical control measures is dependent upon our understanding of the disease cycle, host susceptibility, tim-

ing, mode of application, coverage, and choice of the appropriate product. Timing of the application and thorough coverage of the plant surface are very important for effective disease control. For best results, most chemicals are applied before the pathogen infects the host. Also, most chemical sprays have to be applied several times at regular intervals for best disease control. Always follow the label directions and precautions. Development of pathogen strains resistant to chemicals or antibiotics (e.g., streptomycin-resistant strains of apple fire blight pathogen) can lead to these products becoming ineffective in disease control.

E. Biological Control

The strategy for biological control of plant diseases involves the use of antagonistic microorganisms before or after infection takes place. There has been successful control of crown gall with strain K84 of *Agrobacterium radiobacter*, which produces an antibiotic specific against crown gall bacterium. Commercial biological control agents are available as seed treatments and soil amendments to protect plants against soilborne pathogens.

Currently, the bacteria *Bacillus subtilis* and *Pseudomonas* spp. and the fungi *Gliocladium virens* and *Trichoderma* spp. are the organisms with the most applications in biological control strategies. There is tremendous research interest in developing new biological tools for plant disease control, but research-based options are limited at this time. Genetic engineering of biocontrol microorganisms has sparked wider environmental concerns, which will limit the speed of this new technology's use in plant disease control.

F. Integrated Disease Management

An effective, economical, and sustainable disease management strategy should incorporate all the available approaches of a disease management program. It should include the relevant preventive and control measures appropriate for the crop, such as selection of planting site, selection of the most adapted and disease-resistant variety, crop rotation, pathogen-free planting mate-

rial, seed treatment, appropriate planting date, planting depth and density, irrigation and fertilizer use, weed control, sanitation, timely pesticide applications, proper harvesting, and handling and storage of the produce. The integrated disease management measures selected should be effective (should control the disease), economical (should result in an economic return), and sustainable (should be environmentally sound).

VII. Plant Disease Terms

Anthracnose—Black or brown dead areas on leaves, stems, or fruits (anthracnose of sycamore, maple).

Blackleg—Darkening at the base of a stem (blackleg of potato).

Blight—Rapid death of leaves and other plant parts (fire blight of apple, early blight of tomato).

Brown rot—Soft rot of fruit covered by gray to brown mold (brown rot of cherries, peaches, nectarines).

Canker—Sunken, discolored, dead areas on twigs and branches, usually starting from an injury or wound (*Cytospora* canker of trees, common canker of rose, fire blight cankers).

Chlorosis—Yellowing or whitening of normally green tissue (iron chlorosis of trees).

Crown gall—Excessive, undifferentiated growth that may girdle roots, stems, or branches (crown gall of grapes, rose, apple, cherry).

Curly top/leaf curl/leaf roll—Rolling and curling of leaves and growing point (curly top of sugarbeet, tomato, bean, etc.; peach leaf curl; potato leaf roll).

Damping-off—Stem rot near the soil surface leading to either failed seed emergence or falling over after emergence.

Epidemic—A widespread and severe outbreak of a disease.

Etiolation—Long internodes and pale green color of plants growing under insufficient light or in complete darkness.

Fumigation—The application of a toxic gas or volatile substance to disinfect soil or a container such as a grain bin.

Fungicide—A compound toxic to fungi.

- Host plant—A plant that is invaded by a parasite.
- Host range—The various plants that may be attacked by a parasite.
- Inoculum—The pathogen or its parts that can cause infection.
- Integrated control—An approach that attempts to use all available methods for control of a pest or disease.
- Isolation—The separation of a pathogen from its host by culturing on a nutrient medium or on an indicator plant.
- Lesion—A localized area of discolored or dead tissue (early blight lesions on potato leaf).
- Life cycle—The successive stages of growth and development of an organism.
- Microscopic—Organisms so small that they can be seen only with the aid of a microscope.
- Mosaic—Intermittent yellowish and green mottling of leaves (bean common mosaic, rose mosaic).
- Necrosis—Death of tissue (necrotic area in black spot of rose).
- Organism—A living being.
- Parasite—An organism that lives in or on another organism (host) and derives its food from the latter.
- Pathogen—A disease-causing agent.
- Plant disease—Any lasting change in a plant's normal structure or function that deviates from its healthy state.
- Plant pathology—The study of diseases in plants: what causes them, what factors influence their development and spread, and how to prevent or control them.
- Powdery mildew—Fine, white to gray, powdery coating on leaves, stems, and flowers (powdery mildew of rose, grapes, lilac, and apple).
- Resistance—The ability of a host plant to prevent or reduce disease development by retarding multiplication of the pathogen within the host.
- Root and stem rots—Soft and disintegrated roots and lower portions of the stem, sometimes results in death of plant (root rot of pea, damping-off of seedlings, collar rot of apple).
- Root knots—Swelling and deformation of roots (tomato root knot).
- Rust—Raised pustules on leaves, stems, and fruits; contain yellow-orange or rust-colored spore masses (snapdragon rust, geranium rust).
- Sanitation—The removal and disposal of infected plant parts; decontamination of tools, equipment, hands, etc.
- Saprophyte—An organism that can subsist on nonliving matter.
- Scab—Slightly raised, rough areas on fruits, tubers, leaves, or stems (common scab of potato, apple scab).
- Shot-hole—Roughly circular holes in leaves resulting from the dropping out of the central dead areas of spots (*Coryneum* leaf spot of peach).
- Sign—The part of a pathogen seen on a host plant (moldy growth, spores, etc.).
- Smut—Black masses of spores in galls that may form on stems, ears, etc. (common smut of corn).
- Spore—The reproductive unit of a fungus, similar to the seed of a plant.
- Susceptibility—The condition of a plant in which it is prone to the damaging effects of a pathogen or other factor.
- Symptom—The altered external or internal appearance of a diseased plant (spot, gall, soft rot, etc.).
- Systemic—Spreading internally throughout the plant.
- Vascular pathogen—A disease-causing organism that invades mainly the conductive tissues (xylem or phloem) of the plant.
- Vector—A living organism that is able to transmit or spread a pathogen.
- Virulent—Capable of causing severe disease.
- Wilt—Drooping and drying plant parts due to interference with the plant's ability to take up water and nutrients (*Verticillium* wilts, *Fusarium* wilts).

Further Reading

Books

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Booklets and Pamphlets

University of Idaho

Pesticide Safety

- CIS 792 Calibration and Safe Use of Lawn and Garden Pesticide and Fertilizer Applicators (35¢)
- PNW 512 Farm Safety Series (\$6.00)
- PNW 512S Farm Safety Series (Spanish) (\$6.00)
- PNW 278 First Aid for Pesticide Poisoning (50¢)
- CIS 1030 Idaho Homeowner's Commonsense Guide to Pesticides: Storage and Disposing of Home and Garden Pesticides (\$1.00)
- CIS 781 Laundering Pesticide-Contaminated Clothing and Safety Equipment (35¢)
- CIS 1019 Pesticides for the Home Garden and How to Use Them (\$1.00)

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- CIS 341 Crumbly Fruit in Raspberries (25¢)
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- CIS 847 Virus and Nematode Diseases of Raspberries (35¢)

Tree Fruit

- CIS 729 Apple-and-Thorn Skeletonizer (25¢)
- PNW 282 Bee Pollination of Tree Fruits (75¢)
- CIS 812 Fusarium Root-rot of Orchard Trees (50¢)
- CIS 866 Homeowner's Guide to Fruit Tree Fertilization (35¢)
- PNW 518 How to Reduce Bee Poisoning from Pesticides (\$1.50)
- PNW 121 Nutrient Disorders in Tree Fruits (web only)
- CIS 229 Peach Leaf Curl (25¢)
- CIS 752 Phytophthora Collar-Rot of Orchard Trees (50¢)
- CIS 692 Weed Control in Tree Fruits (25¢)

Ornamentals

- CIS 869 Controlling Sunscald on Trees and Vines (25¢)
- CIS 1068 Fertilizing Landscape Trees (\$1.00)
- EXT 514 Why Is My Evergreen Brown? (50¢)

Gardening

- CIS 292 Blossom-end Rot of Tomatoes (25¢)
- CIS 1051 Late Blight of Potato and Tomato (\$2.00)
- CIS 993 Management of Vegetable Diseases in Home Gardens (50¢)
- BUL 775 Planning an Idaho Vegetable Garden (\$4.00)

Lawns

- BUL 676 Fairy Rings in Turf (50¢)
- CIS 1062 Starting a Home Lawn (\$1.50)
- CIS 1063 Thatch Prevention and Control in Home Lawns (\$1.00)

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Chapter
Weeds

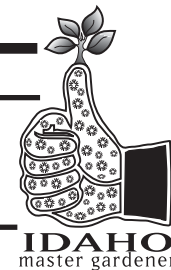
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Chapter 13

Weeds



R. O. Ashley, D. W. Morishita, G. F. Gardner, R. Bradish

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I. Introduction

“A weed is a plant that interferes with the management objectives for a given area of land at a given point in time.”

J. M. Torell

A weed is any plant that is growing where it is not wanted and is more competitive than the surrounding desirable plants. Time, energy, and money for weed control can be kept to a minimum by planning carefully and choosing wisely in practices and materials. Effective weed management involves learning about the weed, understanding the particular site and situation, and employing a diversity of practices to provide desirable results.

Weeds are not only unsightly but also compete with desirable plants for nutrients, water, sunlight, and space. In addition to competing with landscape and vegetable plants, some weeds secrete toxins into the soil which, much like herbicides, damage or inhibit growth of desirable plants. Weeds can ruin lawns, gardens, and flower beds. In some situations, weeds can be such a problem that the only practical weed control is to destroy the entire planting.

Weeds can also provide a “bridge” for insects and diseases from one growing season to another.

When weeds are present, additional applications of insecticides and fungicides may be required.

Weeds have contributed to several other problems in the home landscape environment. Field bindweed, for example, can grow through asphalt causing premature failure of driveways and streets. Weeds contribute to health problems such as hay fever, respiratory problems, and skin irritations. Some weeds puncture bike

tires and injure bare feet. Pets also are affected by weeds. Weed seeds may enter their nostrils and ears causing irritation and infections; weed seeds may become enmeshed in their fur causing discomfort. Often times a veterinarian is needed to remove the seed.

Most homeowners are concerned with weeds that exist near their homes because weeds are a general nuisance, mar the natural beauty of a home site, and decrease the value or marketability of residential properties. Weeds contribute to fire and safety hazards and reduce property values.

Landscapes and yards overgrown with weeds serve as a reservoir of weed seed that can spread to neighboring yards. As a result, some municipalities have ordinances requiring owners to cut down overgrown, weedy lots. A few imported weeds are so invasive and expensive to control that they have been declared noxious and therefore illegal to grow or go to seed.

Although seeds are generally thought of as uninvited guests, weeds do have some limited beneficial characteristics. Weeds can be a source of feed for domestic animals and wildlife, can help prevent erosion, and can add organic matter to the soil.

II. Weed Biology and Classification

The classification of weeds is achieved by grouping together those weeds whose similarities are greater than their differences. For preciseness, weeds are grouped botanically by family, genus, species, and variety. For convenience, weeds are commonly classified in categories such as terrestrial and aquatic, or woody and herbaceous.

Weds also are classified as trees, shrubs, grasses, sedges, and ferns. Weeds are also commonly grouped according to similar life cycles, that is the cycle of life from viable seed to mature plant and the cycle of viable seed formation to death of plants. On this basis, weeds are grouped as annuals, biennials, and perennials.

A. Annual Weeds

These complete a life cycle in one year. Annuals germinate from seed, emerge, grow, flower, set seed, mature and die in one growing season. Annual weeds depend upon the production of large numbers of viable seeds for long term survival. Many successful weed species produce thousands of seeds per plant (Table 1). In addition, weed seed has varying levels of dormancy that contribute to its persistence (Table 2). This characteristic gives weeds the ability to germinate over a period of many years.

1. Annuals that complete a life cycle during the period from spring to fall are referred to as *summer annuals*. The majority of weeds that are found in the garden or in new lawns and landscapes are summer annuals. Examples of summer annual weeds commonly found in yards include different pigweeds, common lambsquarters, hairy nightshade, common purslane,

prostrate spurge, prostrate knotweed, green and yellow foxtail, barnyardgrass, and crabgrass.

2. Annuals that germinate and emerge in the fall, lie dormant during the winter, resume growing in the spring until maturity, and die in the late spring or early summer are referred to as *winter annuals*. Some of the most troublesome winter annual weeds are annual bluegrass, downy brome, and a number of mustards such as shepherd's purse and flixweed.

B. Biennial Weeds

Biennials require two growing seasons to complete their life cycle. Biennials germinate, emerge, and usually form a rosette (radial cluster of leaves lying close to the ground) the first year. During the second year, the plant bolts (produces a flower stalk), flowers, sets seed, matures, and dies. Biennial weeds are not as prevalent as annual weeds in gardens; but they may appear along property borders, in ground covers, and within perennial planting. Biennials that are commonly found in a home garden-landscape site include: sweet clover, common burdock, common mullein, bull thistle, and Queen Anne's lace.

C. Perennial Weeds

These live 3 years or more and reproduce sexually (from seed) and asexually (from vegetative growth). They may or may not flower the first year. Perennials that reproduce from seed are identical to annuals and biennials in the seedling stage and thus are most susceptible to control when they are young. Within a few weeks or months, however, perennials develop vegetative reproductive organs, giving them the ability to propagate and spread asexually. It is this characteristic that makes perennials so difficult to control. Perennials are classified into three different categories based upon how they reproduce.

1. Simple perennials have either a large tap root such as a dandelion or a fibrous root system such as bunchgrass. Simple perennials propagate mostly by seed, but if the roots are broken into pieces, each piece is capable of reproducing new plants.

Table 1. Seed production for common weeds.

| Common name | Number of seeds produced per plant |
|-----------------|------------------------------------|
| Barnyardgrass | 7,000 |
| Green foxtail | 34,000 |
| Redroot pigweed | 117,000 |

Table 2. Germination percentages per year of weed seeds buried 8 inches deep.

| Common name | Life cycle | 1 | 2 | 3 | 4 | 16 | 21 |
|---|------------|----|----|----|----|----|----|
| — Percentage of germination after (years) — | | | | | | | |
| Canada thistle | perennial | 21 | 35 | 15 | 6 | 3 | 1 |
| Green foxtail | annual | 1 | 3 | 6 | 4 | 0 | 0 |
| Quackgrass | perennial | 21 | 0 | 0 | 0 | 0 | 0 |
| Redroot pigweed | annual | 9 | 0 | 1 | 11 | 0 | 0 |
| Velvetleaf | annual | 0 | 0 | 45 | 70 | 75 | 57 |

Gross, W. L., "Viability of Buried Weed Seeds," Journal of Agricultural Research, Vol. 29, No. 7, pp. 349-362.

2. Creeping perennials reproduce by rhizomes (stems) or creeping roots as well as by seed. Quackgrass and field bindweed are good examples.
3. Bulbous perennials reproduce by bulb or nutlike structures and by seeds as well. Purple nutsedge and bulbous bluegrass are examples of a bulbous perennials.

III. Identification

Identification of a weed should be the first step taken in a successful control program. Successful identification of weed species requires that a sample, with as much of the plant as possible, be intact. This includes flowers, stems, leaves, and roots. Careful examination of various plant structures should be used in the identification process to distinguish between “look-a-likes.” A knowledge of where and how the weed was growing also will help in identifying which control measures can be used.

A. Flower

This is the structure most commonly used in classifying and identifying plants. However, weed control measures often must be implemented before flowering. When flowers are present, note the arrangement on the stem, their size, shape, color, the presence or absence of various flower parts, and number of petals. These are all important factors in determining the particular family in which a plant is classified. If the plant has set seed, note characteristics such as size, shape, type of fruit, capsules, pods, burs, hardness, and structure.

B. Leaves and Stem

Weeds also can be identified through careful examination of leaves and stem. Stem woodiness, cross section, and the presence or absence of leaves on the stem should be observed. Stem woodiness is classified as herbaceous (a stem that is not woody), semi-woody, and woody (a perennial stem that is entirely woody such as found in a tree). Cross section of the stem refers to the shape of the stem and is often closely tied to leaf arrangement and leaf shape. Stems may be oval, round, triangular, ridged, square, winged, or grooved. Flowering stem leaves may be absent (dandelion) to uniformly leafy.

C. Weed Structure

Leaf arrangement, type, presence or absence of stipules, petioles, and tendrils, venation, length, shape, surface, and succulence are all important clues for identifying weeds.

D. Roots

All the below ground plant parts can also provide information on the plant. Pull or dig up some of the root system and below-ground plant parts. Determine whether it has a fibrous or tap root system and look for bulbs, corms, tubers, or rhizomes.

Identification of the weed before implementing control practices is important but requires more extensive knowledge than what has been covered in this section.

Weeds of the West, Weeds of Nebraska and the Great Plains, and Weeds 2.0 for Identification of Weeds of the Western United States are several excellent identification references available to help identify weeds. County Extension educators and the UI Department of Plant, Soil and Entomological Sciences also are available to assist in identification of problem weeds and to provide suggestions for their control.

IV. Weed Control Methods

Once the weed is identified and biology of the plant is understood, control measures can be considered. “Silver bullets” and “one-shot control programs” that will control weeds without harming nontarget plants are very rare or nonexistent. An integrated approach to weed control is the most efficient and environmentally safe approach. An integrated approach also uses a combination of cultural, mechanical, physical, and chemical techniques to bring weed populations to an acceptable level. Six methods available to the homeowner include prevention, biological, cultural, mulches, mechanical, and chemical.

A. Prevention

Is the most effective, least costly weed control strategy. Avoid the introduction of weed problems through careful examination of materials that will be used in developing the home landscape or garden.

1. Carefully examine the label on packaged seed and bulk seed. Avoid buying seed

containing weed seed. If noxious weed seed is present, return the seed to the supplier and ask for your money back. It is against the law to sell and propagate noxious weeds. Some seed catalog companies sell “wildflower” mixes that may contain noxious weed seed. The scientific names found in the catalog description and on the seed packet should be compared to the list of noxious weeds listed at the end of this chapter. Report the problem to your county weed supervisor who will contact the Idaho Department of Agriculture to lodge a complaint against the company.

2. Inspect nursery plants and transplants before purchase to avoid introducing roots, rhizomes, or stolons of perennial weeds. Buy your plants from a reliable nursery that sells only weed-free plants.
3. Avoid introducing weed seeds, roots, rhizomes, stolons, and bulbs into the garden and flower beds by using weed-free straw, manure, mulch, compost, and soil. Unless these amendments have been sterilized, they probably contain weed seed. Know the source of these amendments before transporting them to your yard. Selecting sources with relatively low weed populations and avoiding sources with undesirable weed species will pay off in the long run.
4. Tillage equipment can easily spread unwanted weeds to relatively weed-free areas. Clean garden tractors, tillers, hand tools, and other equipment to remove soil, weed seeds, and plant parts. Irrigation water that flows through canals and streams can transport weed seed to your yard. Screen irrigation water from surface sources.
“One year’s seed, seven years of weeds.”
Control vegetative and seed sources around the yard and garden. Destroy weeds before they become established, set seed, and mature.

B. Biological Control

This type of control uses other organisms to control weeds. This is not a very practical solution to many weed problems found in

urban home horticultural settings, but may find some use on small acreages. Geese can be used to remove actively growing weeds in dormant strawberries, asparagus, peppermint, cane berries, and trees. Hogs will seek out fleshy-rooted weeds in fallow. Sheep and goats can control many weed and brush species in pastures. Insects and diseases also can be used to suppress or kill specific weeds; however, this type of control generally lags behind weed populations. Many gardening enthusiasts have been disappointed in the use of insects and diseases to control weeds.

C. Cultural Control

These practices have been found to be effective and cost efficient in a home horticultural setting. Integrating cultural control components with other control measures minimizes the impact of weeds on desirable plants, yet provides acceptable control.

1. Select competitive plants. Use plant competition to minimize weed establishment, growth, and reproduction. A vigorously growing ground cover that is more competitive than the weeds will lessen the weed problem. Generally, weeds are more competitive than the garden crop species during early development. Weed competition during the first 3 to 4 weeks after the garden emerges will have the greatest affect on the garden yield. Vigorously growing garden crops develop canopies that shade weeds, suppress weed germination, and hinder growth. Garden crops that are slow growing and less competitive should be transplanted. Table 3 shows when selected garden crops are most sensitive to weed competition.
2. Anything that would encourage vigorous growth of desirable garden plants to compete with weeds should be implemented. Provide moisture to desirable plant roots, using a method that will reduce or eliminate the moisture to weeds. Rotate crops to break the natural cycle of weeds, insects, and disease. A rotation may include fallowing or omitting crop production for one or more years. Growing different

Table 3. Weed competition period for garden crops.

| Crop | Critical period for weed competition (number of weeks after emergence or transplanting) |
|--------------------------|---|
| Beets | 2 to 4 |
| Cabbage | 3 to 4 |
| Carrots | 4 1/2 |
| Corn | 3 |
| Cucurbit family (melons) | 5 |
| Onions | 12 |
| Peas | 3 to 4 |
| Potatoes | 3 to 4 |
| Row crops not covered | 4 |
| Snap beans | 4 |
| Spinach and lettuce | 3 to 4 |
| Tomatoes | 5 |

Source: Nelson, J. E., G. McKinney, and J. F. Connor. *Home Garden Weed Management*. EB 58. Dec. 1989. Montana State University, Bozeman.

types of plants in the area each year may also be effective. Plant winter cover or competitive plants rather than leaving soil bare.

3. Alter planting dates. Delay planting until after the first flush of weeds has emerged, then use cultivation to remove small weeds. Plant for optimum growth of desired plants while avoiding growing conditions conducive to weed germination and growth. Seeding lawns in late summer and early fall is a good example of this method.

Place and time fertilizer applications to maximize plant growth by banding fertilizer applications. Banding or sidedressing fertilizers near desirable plants promotes optimum crop growth while placing nutrients in a less-available position to weeds growing between the rows.

D. Mulches

These are an extremely effective weed-control tool in the garden and around the home landscape. Mulches are soil coverings such as plastic or straw that prevent sunlight from reaching the soil. A mulch conserves moisture and modifies the microclimate and soil temperature around the plant. Mulches are categorized as natural or artificial: natural

mulches are effective in eliminating annual weeds and reducing the competitiveness of perennial weeds; artificial mulches are effective in controlling both annual and perennial weeds.

1. Natural mulches are applied 2 to 4 inches deep after weeds are removed through cultivation or with an herbicide. They are composed of materials such as bark, grass clippings, leaves, compost, manure, sawdust, wood chips, straw, hay, crushed corn cob, and pine needles. Most natural mulches are considered waste products and are often disposed of in landfills. Many of these mulching materials are free of charge. A visit to your local tree-care expert or gardening store may provide a source.

As with other materials used in the home landscape, the homeowner should examine and avoid mulch material with weed seeds and live vegetative plant parts capable of establishing new weed infestations. The life expectancy of natural mulch will vary from 1 to 3 years depending on the material used, depth of material, and management associated with the landscape or garden.

Live mulches such as grasses and legumes sometimes are used between perennial plant rows. These live mulches are grown to a predetermined stage, killed, and allowed to remain in place to decompose over time. In the garden, natural mulches such as straw can be used in planting of asparagus, cabbage, carrots, cauliflower, lettuce, peas, potatoes, turnips, and other cool season crops to reduce weed competition while maintaining cool soil temperatures.

2. Artificial mulches include plastic, polyester landscape cloth, and sometimes newspaper and tar paper. When artificial mulches are used in a landscape application, natural mulches are applied 1-inch deep on top. The natural mulch hides the artificial mulch and protects it from solar degradation. Polyester landscape cloth should be used in landscape applications rather than plastic or tar paper. Polyester

landscape cloth allows air exchange and moisture percolation through the mulch to the root zone. Natural mulches will stay put on polyester landscape cloth but will have a tendency to slide off plastic. In vegetable garden applications, black plastic is the preferred artificial mulch. It increases the rate at which soils warm during the growing season and it modifies the microclimate for improved growth rates of warm season vegetables such as tomato, muskmelon, watermelon, cucumber, and squash. Black plastic is relatively inexpensive and easy to handle. When black plastic is used, irrigation applications need to be modified from surface or sprinkler applied to drip applications below the plastic. Other colored plastics may enter the commercial market place in the future. Colored plastic mulches such as red has increased tomato yields by 10 to 15 percent over black plastic mulch.

Newsprint also can be used in the garden and can be very effective in reducing weed problems. Newspapers can be turned into the soil at the end of the season unlike black plastic which must be taken up before cultivation. Tar paper can be used to mulch around trees and shrubs, but it is more difficult to apply and is rarely used.

3. A process that has become more popular in recent years is solarization. Solarization uses the sun's energy to raise soil temperatures high enough to kill weeds including seeds, roots, and rhizomes as well as many soil organisms. Solarization is accomplished by laying and anchoring the edges of a sheet of clear plastic over the entire fallowed area to be treated. The soil should be moist to conduct and hold heat, to stimulate weed seed germination, and to prevent dormancy of below-ground vegetative plant parts. The soil should be firm to conduct heat as deeply as possible.

Maximum weed kill depends upon the amount of bright, sunny weather and weed species. The longest day of the year

and most direct solar radiation occurs at vernal equinox, June 21. Plastic should be in position by June 1 and left in place for about 2 months. If precipitation is more than 20 inches per year, solarization may need to be extended into midsummer and may be less satisfactory in such areas.

Late winter and early spring solarization may reduce weed populations before planting, but it is not as effective as late spring and summer solarization. However, the entire growing season is not lost with this type of solarization. The process for accomplishing this type of solarization is as follows:

- a. Till the garden soil and prepare the seedbed in autumn.
- b. Place clear plastic over the garden in midwinter or soon after snow melt. Solar heat will warm the soil under the plastic whenever the days are warm and sunny, causing seeds to germinate. Sprouted weeds will die as daytime temperatures under the plastic rise to temperatures of 100°F to 130°F which should be high enough to kill most species. Weeds may also die from freezing.
- c. Leave plastic in place and continue solarization until planting time. Because tilling the soil after removing the plastic brings more weed seeds near the soil surface, plant without further tillage.

E. Mechanical Control

Includes hoeing, pulling, rototilling, mowing, cultivating, and burning. Mechanical methods are best adapted to eliminating annual weeds depending on the species, the particular location, and the type of implement used. Seedling biennial and perennial weeds also can be controlled mechanically. Once the perennial weed is able to vegetatively reproduce, mechanical control is not very effective. Mechanical methods such as hoeing, mowing, and cultivating cut the plant off at or just below the surface leaving the root or rhizome behind to send up new growth. Deeper tillage such as rototilling or

deep plowing may bring some of the roots or rhizomes to the surface, but even if a small root segment or rhizome remains in moist soil, the weed can establish itself again.

In some instances mechanical control can spread weeds to infest new areas. Effective mechanical control of perennial weeds will require cultivation every 14 to 21 days. This repeated cultivation over 2 to 3 years stimulates root development while depleting stored food (carbohydrates) and eventually the plant dies.

1. Hoeing cuts the plant at or just below the soil surface. Hoes should be kept sharp to reduce the effort of controlling weeds. Often times gardeners will use the hoe to dig or aerate the soil. This is an improper use of this tool. Use a shovel or rototiller to aerate soil. Deep cultivation has a tendency to bring weed seed to the soil's surface providing an excellent environment for weed seed germination. Deep hoeing or tillage in the garden also can damage desirable plants. A proper hoeing technique disturbs the soil very little while removing the weed. Many different hoe styles are available.
2. A hand cultivator or tractor-mounted cultivator generally consists of v-shaped teeth which is used to till soil 1 to 2 inches deep. The action of this tool is similar to the hoe, that is it cuts the weed off at or just below the soil surface and drags the small weed root to the soil surface to dry. Other implements such as disk harrows, sweeps, rolling cultivators, and finger weeder are in this same category.
3. Mowing is an effective way of reducing the amount of seed that weeds will produce and eliminating annuals. The practice must be timed to remove the top before seed is produced. Mowing after viable seed has set can be a good way of spreading weeds to new areas. The vigor and stand density of established perennial weeds can be reduced through repeated mowing, although it requires a long period of time.

4. Hand weeding is effective but is a labor-intensive method of removing weeds growing close to desirable plants. Care must be taken that the pulling of the weed does not damage the roots of desirable plants.
5. Burning or flaming weeds is generally done with a propane torch. Timing of the operation must be such that control is performed before viable seed set. The most effective control of annual weeds is when they are small (about 3 to 5 inches tall). The effect of burning perennial weeds is similar to that of mowing.

Consider carefully where and when this method is used, since it is more difficult to control in tall dry weeds than previous methods outlined. There have been cases in which out-of-control burning operations have burned a straw pile, barn, or home. Check with local ordinances and regulations before burning perennial weeds.

F. Chemical Control

This method can save labor while providing acceptable control. When used correctly, chemical control can be an inexpensive weed control tool. However, it does have some drawbacks. Herbicides can injure or kill desirable plants and are expensive if used improperly.

Extension educators are often asked to investigate injured or dying trees, shrubs, and other desirable landscape or garden plants that "the neighbor sprayed" only to find out that the gardener used herbicide inconsistent with the label's instructions.

Thoroughly read the label of any herbicide. Be sure the beneficial plant to be protected is listed on the label. Timing of the herbicide applications must follow the label instructions. Even an application of 2,4-D for control of weeds in lawns can injure grass if applied during the heat of the summer. **Always read and follow label directions!**

1. Herbicides usually are not used in vegetable gardens for several reasons:
 - No single herbicide can be used safely on all vegetables grown in a garden;

- Some herbicides can persist in the soil and injure sensitive vegetable crops the following year;
 - Spray drift can injure sensitive plants growing in the garden.
2. Herbicides are grouped into families based on chemical properties and how the chemical works to kill the plant. Herbicides also are grouped by when they are applied to control weeds.
- Preemergence herbicides are applied before the emergence of the weed or crop. Herbicides in this group kill weeds as they germinate. These herbicides are further classified as preplant and postplant preemergence herbicides. Preplant herbicides are applied to the soil before planting the desired crop and before the weeds germinate. Postplant herbicides are applied after the desired crop has been planted but before the weeds or crop have germinated.
- Generally, preemergence herbicides are applied to the surface of the soil and either watered in (precipitation or irrigation) or mechanically incorporated into the soil. Failure of these herbicides to work may be the result of poor incorporation because weeds are already germinated.
- Postemergence herbicides are designed to kill emerged weeds. These herbicides may be translocated (e.g., 2,4-D) or may be contact herbicides (e.g., paraquat). Translocated herbicides are applied to foliage or soil. Plants absorb the herbicide through leaves, stems, or roots; and move it through the plant to the site of herbicidal action (where the herbicide works). Translocated herbicides work well on perennial plants because the herbicide is moved to roots and other below-ground vegetative reproductive parts. Contact herbicides are applied to the foliage of the plant. These herbicides kill only where they directly contact the plant and do not move within the plant. Contact herbicides are a poor choice for the control of perennial weeds.

3. Herbicides are further classified as selective and nonselective. If the herbicide kills the weed but does not injure the beneficial plant, then the herbicide is termed selective. If the herbicide injures or kills the weed and beneficial plant, then the herbicide is known as nonselective.
- Herbicides should only be used according to label directions. Registered uses and rates of application are listed on the product label. Improper use or application rate can cause injury or death to nontarget plants even though the product is selective. Selectivity of an herbicide may depend on any one or a combination of the following factors:
- a. Some plants may be able to detoxify the herbicide by metabolizing it into a harmless substance while other plants are killed.
 - b. Foliar-applied herbicides may not be absorbed by leaves or stems because various structures (such as pubescence, and thick waxy cuticles) block the absorption of the herbicide.
 - c. Selectivity of a herbicide may also be due to its placement in the soil. Herbicides such as Casoron, when applied correctly by shallow incorporation, will kill germinating weeds and shallow-rooted weeds. Deep-rooted desirable perennial plants will not absorb the herbicide because the herbicide is placed above the root zone.
4. Soil sterilants are applied to the soil to prevent the growth of weeds and other plants. Some sterilants may be applied to foliage with desired results, but they will leave a long-lasting residue in the soil. The length of time that a sterilant will be effective depends on the rate applied and the persistence of the herbicide.
- Extreme care should be taken when using soil sterilants. Some of these products have a tendency to move with water and can easily be leached from the point of application to root zones of beneficial plants (trees, shrubs, and grass) thus injuring nontarget plants. Soil sterilants are not suggested for use in the yard or gar-

den because they are long lasting and difficult to remove if the homeowner decides to change the use of the treated area.

Fumigants are nonselective and can kill seed and plant parts below the soil surface. Fumigants are not readily available and are only used in greenhouse or commercial operations.

5. Herbicides must undergo a series of tests before the labeling of the product for use by the gardener. These tests evaluate the fate of the herbicide in the environment and potential hazards to the user and nontarget organisms. Determining the fate of the herbicides in the environment include how they degrade, how herbicides move with water (leach), how they bind with soil, how quickly they volatilize and drift, and how toxic they are to fish or other nontarget organisms. The label contains most of this information as well as directions for use. Impact to the environment can be minimized by following **all** of the label instructions and environmental warning statements.

Additional information specific to the behavior of herbicides in plants and soils, use precautions, toxicological properties, and herbicidal use can be obtained from your Extension educator.

V. Herbicide Application Equipment

Several types of application equipment are suitable for weed control. Application equipment ranges in price from inexpensive canister plastic sprayers to elaborate and expensive power sprayers pulled by garden tractors. The most important consideration is to find suitable equipment for the particular job or situation. Choose dependable equipment that will have a long service life and will do the type of job you need. Types of application equipment include:

A. Hand Spray Bottles

Several home and garden herbicides are now packaged in a ready-to-use, disposable applicator spray bottles, much like common glass and window cleaners. They are meant to be used for spot treating small areas or individual weeds.

B. Hose-End Sprayers

These sprayers attach to the end of a garden hose and may be acceptable for soil drenches and preemergence herbicides with a wide margin of safety. Because they are difficult to calibrate and too variable for proper application, hose-end sprayers are not recommended for most herbicides where precision of application is desired.

C. Compressed Air Canister Sprayers

The most common sprayers used by homeowners are 1- to 3-gallon compressed air sprayers. There are metal and plastic models. Both are equally effective, but the plastic model is less expensive. A compressed air sprayer is ideal for spot spraying postemergence herbicides and will provide a reasonably precise application of preemergence herbicides. Problems encountered through the use of this sprayer include nozzle plugging and spray tank corrosion (this is not a problem with plastic or stainless steel sprayers).

Compressed air sprayers do present a safety problem if the pressure in the tank is not equalized with the outside pressure before opening the tank to refill or clean. However, some manufacturers now include a pressure relief valve that eliminates this hazard.

D. Backpack Sprayers

Several models of backpack sprayers are available. These are usually more expensive; but they are versatile, have up to a 5-gallon capacity, and can be maintained at more uniform pressure than canister sprayers. These sprayers are constructed of plastic or stainless steel, but the inexpensive plastic models are preferred. One of the few disadvantages associated with a backpack sprayer is the tendency for the applicator to leak and then soak the wearer's back with herbicide.

E. Power Sprayers

These sprayers are a good investment and ideal for large areas. These sprayers have a pump and regulator to provide constant pressure and a more uniform spray delivery. The spray tank may consist of plastic, fiberglass, stainless steel, galvanized steel, or epoxy-lined steel. These systems usually have

a gun-type nozzle for spot treatments and sometimes a boom for broadcast applications. The disadvantages of power sprayers are similar to those of the backpack sprayers and pressurized canister sprayers.

F. Wick-Wipers

Various makes and models of “wiper” applicators are available, primarily for use in applying a 33 percent solution of glyphosate. Wick-wipers allow accurate placement of herbicide on unwanted plants and avoid problems with spray drift.

G. Granular Applicators

These applicators spread granular herbicide formulations of and fertilizers. Two general types of granular applicators are available to homeowners:

1. The gravity, or drop-type applicator, is best used on level turf areas or on level areas where the soil has been firmed. Use of this type of applicator on a steep hill or loose soil conditions will result in non-uniform applications.
2. The cyclone or whirlybird will operate under almost any type of condition but is affected by wind and tall vegetation.

Note: It is best not to use the same sprayer for both insect and weed control. Some herbicides, such as 2,4-D, are difficult to completely remove from sprayers. If you do decide to use the same sprayer, be sure to wash it with detergent after herbicide use. Then, fill the tank and prime the system with an ammonia solution (1 quart of household ammonia in 10 quarts of water) and let stand. After 12 to 24 hours, rinse and purge the sprayer with clean water until the ammonia solution is totally removed.

VI. Sprayer Calibration

Many people do not calibrate their application equipment and then wonder why their weed control efforts fail. Calibration for an herbicide treatment differs from an insecticide or fungicide treatment. Insecticides and fungicides are applied at a specific concentration while herbicides are applied at a specific rate of product per unit area (e.g., ounces per 1,000 sq ft).

Therefore, the amount of water used is not as important as the amount of herbicide used per unit area as long as adequate coverage is obtained with the water used.

Factors affecting the calibration of a sprayer include pressure, nozzle size, condition, number, as well as the viscosity of the spray, and the speed at which the area is covered. Variable pressure will cause variable sprayer. Therefore, maintaining constant pressure or using a pressure regulator will facilitate a consistent application. The rate of speed that an area is covered should be held as constant as possible to improve the accuracy of the application. Gardeners using hand-held or hand-operated sprayers will operate their sprayers at different pressures and cover areas at different speeds. Therefore, calibration should be done by the individual who will be making the application.

A. Calculating Your Sprayer

Any kind of sprayer can be calibrated by using the following steps:

1. Check the operation of the sprayer. Check for a clogged nozzle and hose, rust in the tank, and leaks. Thoroughly clean and repair the sprayer before calibrating the sprayer.
2. Mark off 100 square feet. (You may want to use 1,000 square feet for more accurate calibration.) Use a string or garden hose to mark off the area.
3. Add a known quantity of water to the sprayer that is sufficient to cover the marked off calibration area.
4. Spray the calibration area exactly as you would spray herbicide. Be sure to walk the same speed and use the same pressure as you would when spraying the herbicide. Remember, you only need to lightly wet the plants. Don't spray until the water drips off.

Note: Many recommendations are given per 1,000 square feet. If 100 square feet is used for calibration, multiply the difference remaining in the tank by 10 to calculate the amount of water that would be required to cover 1,000 square feet.

5. Measure the remaining water in the tank. The difference between what you originally added to the tank and what remains is the amount of water required to cover 100 square feet (or 1,000 square feet).
 - If you applied 18 fluid ounces to a 100 square foot area, 180 fluid ounces or 1.4 gallons of water to cover a 1,000 square foot area.
 - Add the recommended rate of chemical to the amount of water needed to spray 1,000 square feet.
 - Apply the herbicide by walking the same speed and using the same pressure as when you calibrated.

Example: You have sprayed 13 ounces on the 100 square feet.

$$13 \text{ oz} \times 10 = 130 \text{ oz (about 1 gallon)}$$

per 1,000 square feet

Add the recommended amount of herbicide to 1 gallon of water to spray the 1,000 sq ft area.

B. Granular Applicators

These can be calibrated in a similar way as sprayers, but the applicator must use the herbicide granular material in the calibration process. A cement or asphalt driveway or a large plastic canvas sheet can be used to catch the herbicide as it is distributed by the spreader. The surface area of the drive or canvas sheet is measured. Then the applicator is operated in the same manner that it would be operated for the actual application. After completing this calibration application, the granules are swept up and weighed. Adjustments are made to the applicator until the desired amount is being applied in a consistent manner. The operator should note the setting on the applicator so that calibration is not required before each time an application is made. However, calibration should be done whenever the source of the material changes, or at the beginning of the season each year.

VII. Tree Stump Removal

When trees are cut from a landscape, removal of the remaining stumps often becomes a difficult problem.

A. Mechanical Removal

Using heavy equipment, such as a back hoe, to remove a tree stump can be expensive. It also might result in unacceptable damage to turf, ornamentals, or other adjacent vegetation. Failure to remove the complete stump and roots will often result in a proliferation of new shoots.

Some homeowners use an axe or chain saw to cut away stumps. This generally requires a lot of time and energy but can be successful if the trunk is not too large, and if the roots can be removed.

B. Chemical Treatments

Treating tree trunks with an appropriate herbicide concentrate before cutting (or treatment of live stumps after cutting) will kill stumps and roots, and stop sprouts from developing. Use caution when treating trunks or stumps with herbicides. Some herbicides may leach into the root zone of nearby plants. Application of herbicide is usually best accomplished with a paint brush rather than a sprayer. A dead stump will normally decompose in 1 or 2 years. Then, the rotted wood can easily be removed by hand.

VIII. Noxious Weeds

“Noxious weed” means kind of species of any plant having the potential to cause injury to public health, crops, livestock, land or other property, and which is designated as noxious by the director.

Chapter 24, Title 22, Idaho Code, Noxious Weeds

Noxious weeds are weeds that have been declared by law to be noxious. Property owners must not allow noxious weeds to go to seed or propagate on their land. Idaho, through the State Department of Agriculture, determines weeds to be listed as noxious and provides counties the power to administer the law.

Procedures have been set by law and rules promulgated by the State Department of Agriculture which form noxious weed districts. These districts direct noxious weed control efforts within in their jurisdiction. These efforts may include handling complaints, entering property through an established procedure to control noxious weeds, attaching claims against prop-

erty to cover control costs, and cooperating with other agencies and organizations in controlling noxious weeds. The weeds listed in Table 4 are officially designated and published as noxious.

It shall be the duty and responsibility of all persons and nonfederal agencies to control noxious weeds on land and property that they own, in accordance with this chapter and with rules and regulations promulgated by the director of the Department of Agriculture.

Chapter 24, Title 22, Idaho Code, Noxious Weeds

Table 4. Designation of Idaho noxious weeds.

| |
|---|
| Black henbane (<i>Hyoscyamus niger</i> L.) |
| Buffalobur (<i>Solanum rostratum</i> Dun.) |
| Canada thistle [<i>Cirsium arvense</i> (L.) Scop.] |
| Dalmatian toadflax [<i>Linaria dalmatica</i> (L.) Mill.] |
| Diffuse knapweed (<i>Centaurea diffusa</i> Lam.) |
| Dyer's woad (<i>Isatis tinctoria</i> L.) |
| Eurasian watermilfoil |
| Field bindweed (<i>Convolvulus arvensis</i> L.) |
| Hoary cress [<i>Cardaria draba</i> (L.) Desv.] |
| Johnsongrass [<i>Sorghum halepense</i> (L.) Pers.] |
| Jointed goatgrass (<i>Aegilops cylindrica</i> Host) |
| Leafy spruce (<i>Euphorbia esula</i> L.) |
| Matgrass (<i>Nardus stricta</i> L.) |
| Meadow knapweed (<i>Centaurea pratensis</i> Thuill.) |
| Milium (<i>Milium vernal</i> Bieb.) |
| Orange hawkweed (<i>Hieracium aurantiacum</i> L.) |
| Musk thistle (<i>Carduus nutans</i> L.) |
| Perennial pepperweed (<i>Lepidium latifolium</i> L.) |
| Perennial sowthistle (<i>Sonchus arvensis</i> L.) |
| Poison hemlock (<i>Conium maculatum</i> L.) |
| Puncturevine (<i>Tribulus terrestris</i> L.) |
| Purple loosestrife (<i>Lythrum salicaria</i> L.) |
| Rush skeletonweed (<i>Chongrilla juncea</i> L.) |
| Russian knapweed [<i>Acroptiloa repens</i> (L.) DC.] |
| Scotch broom [<i>Cytisus scopariu</i> (L.) Link] |
| Scotch thistle (<i>Onopordon acanthium</i> L.) |
| Silverleaf nightshade (<i>Solanum elaeagnifolium</i> Cav.) |
| Skeletonleaf bursage (<i>Ambrosia tomentosa</i> Nutt.) |
| Spotted knapweed (<i>Centaurea maculosa</i> Lam.) |
| Syrian beancaper (<i>Zygophyllum fabago</i> L.) |
| Tansy ragwort (<i>Senecio jacobaea</i> L.) |
| Toothed spurge (<i>Euphorbia dentata</i> Michx.) |
| White-top [<i>Caradaria draba</i> (L.) Desv.] |
| Yellow hawkweed (<i>Hieracium pratense</i> Tausch) |
| Yellow starthistle (<i>Centaurea solstitialis</i> L.) |
| Yellow toadflax (<i>Linaria vulgaris</i> Mill.) |

Further Reading

Books

- Whitson, T. D. et al. 1991. *Weeds of the West*. The Western Society of Weed Science in cooperation with the Western United States Land Grant Universities, Cooperative Extension Services.
- Stubberdieck, J., G. Y. Friisoe, and M. R. Bolick. 1994. *Weeds of Nebraska and the Great Plains*. Nebraska Department of Agriculture, Bureau of Plant Industry, P.O. Box 94756, Lincoln, NE 68509.
- Weeds of the North Central States*, North Central Regional Publication No. 36, University of Illinois, Agricultural Experiment Station, Circular 718.
- Herbicide Handbook*. 1994. Weed Science Society of America, 1508 West University Avenue, Champaign, IL. Seventh edition.
- Pacific Northwest Weed Control Handbook. Revised annually by Extension Services of OSU, WSU and UI. Order from Extension and Station Communications, OSU, Administration Kern A422, Corvallis, OR 97331-2119.
- Callihan, R. H., R. T. Dobbins, and S. L. Carson. 1993. *Weeds 2.0 for Identification of Weeds of the Western United States*. University of Idaho, Cooperative Extension System, Weed Diagnostics Laboratory.

Booklets and Pamphlets

- PNW 320 Calibrating and Using a Backpack Sprayer (\$1.50)
- CIS 792 Calibration and Safe Use of Lawn and Garden Pesticide and Fertilizer Applicators (35¢)
- CIS 1041 Conduct Your Own Garden Research (\$2.00)
- EXT 723 Herbicides for Lawn Weed Control (50¢)
- CIS 897 Herbicides for the Home Garden (35¢)
- CIS 1019 Pesticides for the Home Garden and How to Use Them (\$1.00)
- BUL 775 Planning an Idaho Vegetable Garden (\$4.00)
- CIS 888 Weed Control in Lawns (50¢)
- EXT 726 Weed Control in the Home Garden (50¢)
- CIS 692 Weed Control in Tree Fruits (25¢)

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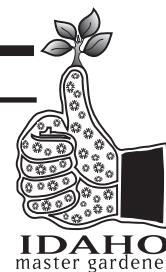
Chapter 14

Turfgrass Establishment and Management



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Turfgrass Establishment and Management



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I. Introduction to Turfgrass Culture

Idaho's climate, soils, and topography are highly variable. The environment varies from warm arid to cool semiarid growing conditions.

Natural vegetation varies from sagebrush and bunchgrass to evergreen forest. Growing a lawn in Idaho requires knowledge of the climate and resources available for establishing and maintaining the desired type of lawn.

Establishing and maintaining the ideal or perfect lawn is a long term commitment of labor, money, and other resources. Wise use of these resources will result in a relatively problem-free living area and will reduce chronic problems that may be difficult to solve once a mistake is made.

Everyone knows what a perfect lawn should look like—a uniformly green carpet free of insects, weeds, and diseases that holds its color for most of the year. Homeowners often desire perfection, but this expectation may have to be adjusted.

The homeowner must decide what type of lawn is really needed. Will it be a showplace, a recreational area, an average lawn, or just some sort of green cover?

What level of maintenance will be given? High maintenance for perfection usually means expending time and money. Are both available, and will they be committed to the project?

What are the limitations of the site? In general, to be successful with turf, at least 4 hours of direct sunlight per day is needed. In low light areas or on steep banks, an alternative to

mowed turf such as ground covers, meadow grasses, or mulches should be considered. Lack of water, poor drainage, or poor soils can also limit quality turfgrass.

II. Soil Considerations

A. Texture

This is the percentage of sand, silt, and clay that make up a soil. Lawns can be established and maintained on essentially any soil texture from sand to clay. Sand, silt, and clay describe the three basic sizes of soil particles that are found in soils (see Chapter 4, "Soils and Fertilizers"). Coarse-textured or sandy soils provide a difficult base for maintaining nutrition and moisture. However, fine textured soils or clay soils can have drainage problems that are difficult to correct.

B. Soil Structure

This refers to the way soil particles clump or hold together (aggregate). All soils, from sand to clay, can be improved by the addition of organic matter. Organic matter, such as livestock manure or plant materials, modifies the soil structure by improving aeration and drainage in soils. In addition to improving the structure of soils, organic matter can also improve the ability of soil to retain nutrients for growing plants (see Chapter 4). Organic matter adds nutrients to the soil as it decomposes and provides a growing medium and food supply for beneficial soil microorganisms.

Expectations of most homeowners are that the lawn they establish will last 20 to 30 years or longer. Consequently, the only chance to modify soil structure and drainage is before lawn establishment. Homeowners should take this opportunity to rototill in 2 inches of compost (well-decomposed organic matter). If decomposed organic matter is not available, organic matter in various forms such as peat moss, rotted sawdust, weathered livestock manure, shredded leaves or straw, dried grass clippings, and other plant materials can be added 3 to 6 months before establishing turfgrass to allow for decomposition. Tough, fibrous materials such as sawdust, leaves, or straw will need an extra application of nitrogen fertilizer to help their breakdown process (see Chapter 7, “Backyard Composting”).

C. Soil Depth

In general, it is best to have at least 1 foot of permeable rooting medium over any hardpan, dense clay, or gravelly subsoil. If only 2 to 4 inches of soil are placed over a cement-like layer of hardpan, turf failure is inevitable because of drainage problems and restricted root growth. Clay subsoil may require tiling to ensure adequate drainage and aeration in the rooting zone. Sandy subsoil with adequate fertility can be used quite well when establishing new lawns.

D. Preplant Fertility

A soil test will give valuable information on nutrient levels and soil pH. Phosphorus, which helps with root development, is best incorporated in the top 4 inches of soil before seeding or sodding since it does not move into the root zone when placed on the surface. Nitrogen and potassium are both soluble in water. Nitrogen will find its way into the root zone as water moves down through the soil. Potassium, although it moves slowly with water, should be incorporated when possible.

In the absence of a soil test, apply the following nutrients per 1,000 square feet before turf establishment. Incorporate to a depth of 4 to 6 inches: 1/2 to 2 pounds of actual nitrogen (N), 2 to 3 pounds of phosphate (P₂O₅), and 1 1/2 to 3 pounds of potash (K₂O).

E. pH

Soil pH in Idaho varies from alkaline to acid. A soil analysis for the particular site where the lawn is to be established will provide information on the soil pH level. Soil pH outside the range where lawn grasses flourish (6.0 to 7.5) can lead to chronic micronutrient deficiencies resulting in poor turfgrass growth. Soils in most areas of southern Idaho are alkaline (7.1 to 8.5), and may require the addition of sulfur to reduce the soil pH to a desired level.

Table 1, along with your soil analysis before adjusting soil pH, will help determine the need for sulfur. Fine-textured soils (clay) will require more sulfur than coarse-textured soils (sand). After the application of sulfur and before seeding, the sulfur should be thoroughly mixed in the top 6 inches of soil. Soils with a pH greater than 8.3 may need gypsum instead of sulfur to reduce pH. In northern Idaho, soils tend to be acidic. If your soil pH is below 6.0, lime is required to raise the soil pH to the desirable level. Table 2 will help you determine how much lime is needed.

Sulfur, lime, or gypsum can be added at the time other amendments are being applied. Consult your county Extension educator if you have questions on altering pH or need information on soil testing.

Table 1. Amount of sulfur required to lower soil pH to 6.5 within the top 6 inches.

| Original pH of soil | Sandy soils | Loamy soils | Clay soils |
|--------------------------------|-------------|-------------|------------|
| — pounds per 100 square feet — | | | |
| 7.5 | 1.0 to 1.5 | 1.5 to 2.0 | 2.0 to 2.5 |
| 8.0 | 2.5 to 3.0 | 3.0 to 4.0 | 4.0 to 5.0 |
| 8.5 | 4.0 to 5.0 | 5.0 to 6.0 | 6.0 to 7.5 |
| 9.0 | 5.0 to 7.5 | — | — |

Source: *Western Fertilizer Handbook*

Table 2. Suggested application levels of finely ground limestone to raise pH of a 7-inch layer of soil.

| Textural class | pH 4.5 to 5.5 | pH 5.5 to 6.5 |
|-----------------------|---------------|---------------|
| Sands and loamy sands | 25 | 30 |
| Sandy loams | 45 | 55 |
| Loams | 60 | 85 |
| Silt loams | 80 | 105 |
| Clay loams | 100 | 120 |

III. Site Preparation

A. Preplant Weed Control

If there are perennial weeds or undesirable grasses on the site, the first step should be weed control. Glyphosate is the most commonly used herbicide material for preplant weed control as it kills many herbaceous weeds within 7 to 10 days without causing a detrimental soil condition for future plant growth. Glyphosate is sold under many trade names including Roundup. More than one application may be necessary for some weeds. Follow label directions.

B. Grading and Surface Preparation

Remove building debris and other trash from the lawn area during lawn construction and grading. Such material causes mowing hazards and blocks root system development. Rotting wood can serve as a nesting site for termites and is often the host of the troublesome “fairy ring” disease in lawns. The subgrade should be sloped away from the house, and the area should be allowed to settle several weeks before seeding or sodding. After establishing the rough grades, roll, rake, and smooth the area to the final grades. Minor surface irregularities will become permanent after the roots have locked soil particles together. The smoother the area, the better the appearance once mowing begins. Allow 2 to 4 weeks for settling before planting. Two or three wetting and drying periods during this time will speed up the process.

C. Drainage

Drainage tile is not often used in Idaho except where hardpans and extremely heavy clay subsoil layers are found. When internal drainage is a problem, and the situation requires a tile drainage system to remove excess water, an adequate outlet should be found before designing the drainage system. Tile lines are laid during lawn construction. Place the tile lines at least 12 to 24 inches below the finished grade and at intervals of 10 to 15 feet. Apply a 4- to 6-inch layer of pea gravel over the tile lines, then layer sand or sandy soil, and finally apply topsoil up to the surface.

In areas of poor drainage, it is especially important to slope the grades away from the house. Water should quickly drain from any paved areas so the pavement doesn't become icy, creating a safety hazard, or remain unusable for hours after irrigation or rain. A 1-foot drop in 50 feet will usually supply adequate surface drainage. Grades steeper than a 1-foot drop in 4 feet may cause mowing and erosion problems. Alternatives to a steep grade include terraces, retaining walls, or planting a ground cover or meadow grass that is not mowed.

D. Installing the Sprinkler System

When supplemental irrigation is necessary and an underground system is desired, install the system after final grading and smoothing. Drainage lines are usually placed 6 to 18 inches deep. Whenever possible, set irrigation pipe below the frost line and normal tillage depth.

IV. Choosing a Turfgrass

A. Cool Season Grasses

These grasses can withstand Idaho's cold winters and perform well under most conditions.

1. Bentgrass—Well-maintained creeping and colonial bentgrasses are the most professional appearing turfgrasses since they can be mowed at very low heights (less than 1/2 inch) and form a dense, tight green carpet as seen on golf greens. Bentgrasses are often found invading other turfs in a home lawn situation, but they are not usually recommended for home lawn use unless their high maintenance levels can be maintained.

Bentgrasses have the highest fertility, water, and mowing requirements of all the cool season grasses. Thatch development is high, consequently, bentgrasses will need frequent dethatching. They are also susceptible to several diseases including red thread, Fusarium blight, and take-all patch. See Table 3 for suggested varieties.

2. Fescues

a. Turf-type tall fescues: These grasses are well adapted to a wide range of

soil conditions. Tall fescues tolerate heat and drought better than most cool season turfgrasses due to their deep root systems (4 to 6 feet). Fescues can withstand traffic and heavy use and are often used on football and other playing fields. The new turf-type tall fescues, especially the new dwarf varieties such as Bonsai and Twilight, are thinner bladed than older varieties.

Since fescues do not spread by stolons or rhizomes, they do not form thatch. Fescues are usually planted as a monoculture (a pure stand of a single species). They do not accept low mowing. Their fertility requirements are low to moderate. See Table 3 for suggested varieties.

- b. Fineleaf fescue: Fine fescues include creeping red fescue, chewings fescue, and hard fescue. Fescues have the finest leaves of any lawn grass. They perform best in shady lawns in mixtures with shade-tolerant Kentucky bluegrasses. These grasses are excellent for

overseeding poor lawns to improve turf quality. In mixtures with other grasses, they add disease resistance to the turf. Fine fescues are adapted to well-drained, infertile soils. Often they are grown on slopes and left unmowed to create a meadow effect. Their fertilization requirements are low to moderate.

The creeping red fescues have a spreading or rhizomatous root system that will easily cover open soil areas to create a lawn. The chewings fescues are bunchgrasses that do not spread. They should be planted thickly enough to ensure a dense and even turf. The hard fescues are also bunch-type, make excellent turf, have extensive root systems, and are drought tolerate. See Table 3 for suggested varieties.

- 3. Kentucky bluegrass—This is probably the most traditionally used cool season grass. Monocultures of Kentucky bluegrasses are not recommended in southern Idaho because of insect and disease prob-

Table 3. Turfgrass cultivars for Idaho.

| Type of turfgrass | Cultivars |
|-----------------------------|---|
| Cool season grasses | |
| Bentgrass | Astoria, Highland, Exeter |
| Turf-type tall fescue | Amego, Arid, Bonanza, Crossfire, Era, Falcon, Finelawn I, Gala, Houndog, Jaguar II, Mirage, Monarch, Mustang, Rebel II, Tarus, Thoroughbred, Titan, Trident, Rebel, Olympic |
| Turf-type dwarf tall fescue | Bonsai, Twilight, Monarch, Shortstop |
| Chewings fescue | Banner, Barfalla, Cascade, Highlight, Jamestown, Koket, Scarlett |
| Creeping red fescue | Atlanta, Cindy, Dawson, Illahee, Pennlawn, Rainer, Ruby, Wintergreen |
| Hard fescue | Biljart, Durar, Reliant, SR 3000, Valda, Scaldis |
| Kentucky bluegrass | Adelphi*, Fylking*, Parade*, Alene, Galaxy*, Park, Aquilla*, Glade*, Pennstar*, Baron*, Liberty*, Ram No1*, Bonnieblue*, Majestic*, Ronde*, Continental*, Merion, Touchdown*, Freedom*, Newport, Victa*, Bango**, Green Ley**, Nuget**, Challenger**, Kenblue**, Plush**, Chateau**, New Blue**, Ronde**, New Star**, Washington**, Classic** |
| | * Improved varieties with low-growth habit and suitable for relatively close mowing. |
| | **Kentucky bluegrass varieties released since 1990. |
| Perennial ryegrass | All Star, Brenda, Diplomat, Derby, Elka, Evening Shade, Fiesta II, Gator, Lindsay, Manhattan II, Norlea, Omega II, Ovation, Pennant, Pennfine, Ranger, Regal, Saturn, SR 4000, Troubadour, Palmer, Prelude, Patriot II, Yorktown II |
| Crested wheatgrass | Fairway |
| Warm season grasses | |
| Buffalograss | Texoka, Sharps Improved, Prairie, 609, Washoe |
| Zoysiagrass | Meyer |

lems. Bluegrasses, however, may be a part of most grass mixtures. Bluegrasses are slow to germinate and establish. They are good at repairing damaged turf areas because of their ability to spread. This can be a problem when flower beds border turf areas. Bluegrasses have a moderate to high fertility requirement.

More than 250 varieties of Kentucky bluegrass have been released through the Idaho Crop Improvement Association (ICIA) Certification Program. A few are listed in Table 3. Patented seed varieties are generally certified and are sold in blends with other varieties.

4. Perennial ryegrass—Turf-type perennial ryegrasses germinate and establish very rapidly. They are extremely wear tolerant, producing beautiful lawns that do not form thatch. Ryegrasses blend well with other grasses and add disease and insect resistance to bluegrass mixes. Ryegrass leaves are fibrous, requiring a sharp mower blade to avoid shredding or tearing the turf. Like Kentucky bluegrass, ryegrasses require moderate to high fertility levels (Table 3).
5. Crested wheatgrass—Crested wheatgrass is a cool season bunchgrass that is not considered a turfgrass, however, it is often used along roadsides and in dryland pastures where turfgrasses would not thrive. This grass is intended for low maintenance and restricted irrigation or natural precipitation situations. Under natural precipitation in southern Idaho, the majority of growth occurs in early spring until midsummer. When moisture deficiencies occur, the plant will go dormant until sufficient moisture is received. Crested wheatgrass will stay green at higher elevations (cooler conditions) if watered through the summer. The variety 'Fairway' has a lower, more spreading growth characteristic than standard crested wheatgrass varieties.

Additional information on cultivar performance (e.g., disease resistance, texture, color, spring green up, etc.) is available through the National Turfgrass Evaluation Program, U.S. Department of

Agriculture, Ag Research Service, Beltsville Agricultural Research Center, Beltsville, MD 20705. Sites in the intermountain region are listed in these reports.

B. Warm Season Grasses

These grasses are not commonly grown in Idaho because their performance is not as satisfactory as most cool season grasses. Warm season grasses go dormant, turn tan or brown with the first frost, and stay that way until the weather warms. In southern Idaho, experiments are being conducted to test their extreme drought tolerance.

1. Buffalograss—These warm season stoloniferous grasses, due to their drought resistance, are becoming popular in the West, even in cool season areas. Buffalograsses are resistant to heat and drought. They are well adapted to a wide range of soils, but especially to alkaline conditions and soils of low fertility. Buffalograsses are slow to establish (1 to 3 years) and they require infrequent mowing. Like most warm season grasses, they have a short growing season (4 to 5 months) in the north due to their inability to withstand cold weather. Hence, during half the year or more in Idaho, a buffalograss lawn will be tan or brown in color (Table 3).
2. Zoysiagrass—One species of zoysiagrass called Japanese lawn grass is cold tolerant. It will persist, even in a subarctic climate, however, it has a very short growing season. Zoysiagrass is adapted to a wide range of soil conditions but grows best on well-drained, slightly acidic soils of medium texture and fertility. Although it is quite tolerant of drought, heat, and cold stress, like most of the warm season grasses, it is slow to green up in spring and late season discoloration begins at 50°F to 55°F. Zoysia is slow to establish. The density and toughness of the grass blades may require a heavy, reel mower. 'Meyer' is the only variety of zoysiagrass suggested for use in Idaho at this time.

Note: Consult with your local Extension educator for the recommended species suited to your area.

V. Establishing the Lawn

A. Seeding Lawns

Seeding is the most inexpensive way to produce a lawn. Start with a well-prepared seed bed and quality seed. The purchase of lawn seed is a long-term investment, and the seed you buy will influence your success in developing a beautiful lawn. It is not possible to evaluate the quality of seed by looking at it. Information that will help you make a wise choice is printed on the seed package. Check the label accompanying the package of seed. Purchase weed-free seed whenever possible.

There are differences in lawn seed, and it pays to compare. The price you pay for seed will represent only a small portion of the total cost of planting, fertilizing, mowing, etc. Don't let low cost be your only consideration when purchasing lawn seed. Choose varieties that have been tested and proven best for your area. Idaho has a seed truth-in-labeling law that requires truth in labeling. The label on the package must include an analysis of the seed it contains. This analysis enables the purchaser to determine the kind of seed contained in the package, to estimate how well it should perform, and to compare its cost-effectiveness with other brands. A sample seed label may look like this:

Kind: Kentucky bluegrass

Variety: Park

Pure seed: 98%

Germination: 85%

Inert matter: 1.2%

Date of test: 6/95

Weed seed: 0.3%

Other crop seed: 0.5%

Lot: IA

Noxious weeds: None

John Doe Seed Co., Idaho Falls, ID

The terminology used on the label is defined below:

Pure seed: The percentage (by weight) that is actually seed of the crop specified.

Germination: The percentage of viable (live) seed.

Inert matter: The percentage (by weight) of chaff, dirt, trash, and anything that is not seed.

Date of test: The date of test should be within the last 15 months.

Weed seeds: The percentage (by weight) of all weed seeds in the sample and the number of noxious weed seeds present. It is against the law in Idaho to sell seed containing noxious weeds. If the seed listed contains noxious weed seeds, avoid purchase of this seed and report it to the Idaho Department of Agriculture.

Other crop seeds: The percentage (by weight) of crop seed other than the crop specified. For example, in tall fescue, this includes orchardgrass and ryegrass. In Kentucky bluegrass, it may include bentgrass, ryegrass, tall fescue, or perennial ryegrass contaminants.

1. Cost-effectiveness—When considering seed lots of similar quality, compare the amount of Pure Live Seed (PLS) in the package. The only thing you really want to pay for is the seed that will grow. To determine the amount of PLS, look at the analysis on the label; multiply the germination percentage by the percentage of pure seed and then multiply by 100 to get the percentage of PLS. For example:

$$\text{Germination} = 85\%$$

$$\text{Purity} = 98\%$$

$$0.85 \times 0.98 = 0.833$$

$$0.833 \times 100 = 83.3\% \text{ PLS}$$

To obtain the cost per pound of PLS, divide the price per pound by the PLS. If the seed costs \$2.25 per pound, then \$2.25 divided by 0.833 equals \$2.72, the actual cost per pound of PLS.

2. Quality—Certified seed is a guarantee from the seller that you will get the kind and variety of lawn seed named on the label. Buying certified seed is a good practice. If the seed is certified, a blue certification label will be attached to the seed package.

Most grass seed sold at the retail level in Idaho will not have a blue certification tag attached to the package. However,

many of the varieties are patented and most originators of these varieties require the variety to be certified in order for it to be marketed. If you find specific varieties listed on the package, the seed probably came from a certified lot and is of good quality. Consumers should still check the label for pure seed, weed seed, inert matter, and other factors which indicate seed quality.

The University of Idaho has worked with the U.S. Department of Agriculture, seedsmen, and the Idaho Crop Improvement Association to develop a program that helps purchasers recognize quality lawn seed. Special labels are placed on packages containing seed that meets very high standards of purity, germination, and freedom from weed and other crop seed. Seed in a package that carries a certified seed label is certified and recommended for use.

3. Seeding methods—Lawn areas can be seeded with a drop spreader or a rotary (cyclone) spreader. Drop spreaders are more accurate than rotary spreaders and allow planting along driveways, sidewalks, and flower beds without wasting seed. The spreader should be calibrated to deliver the appropriate seeding rate. Only very small spots can be seeded by hand, as it is difficult to obtain an even distribution of seed using this method. Because the seeds of different grasses vary in size, weight, and growth, there is considerable variation in seeding recommendations. Follow directions on the seed package or use the guidelines shown in Table 4. Choose your seeding method, as discussed above, but ensure uniform distribution by dividing the recommended seed amount into two equal parts. Sow one-half of the seed in one direction and the second half in the opposite (perpendicular) direction. A light raking will mix the seed into the soil surface. Do not rake heavily or the seed will be covered more than the necessary 1/8- to 1/4-inch. A light rolling will make a firm seed-to-soil contact, which promotes germination.

4. When to sow—The optimum time for seeding turf in southern Idaho is in the fall, August 15 to September 30. Fall seeding has a much higher success rate than spring seeding for many reasons. The warm days and cool nights of fall are ideal conditions for seedling growth. There is less weed competition in the fall than in spring. Lawns seeded in the fall will be well rooted and have sufficient top growth in spring to be drought and heat tolerant by summer.

Be sure that seeding is completed early in the fall so that the grass is well established before winter. In some areas of Idaho, grass seed is sown on top of the soil just before winter snows. This is a viable method of seeding grass, especially in dry areas or where the growing season is short.

Spring seeding (April-May) is used for establishing warm season grasses, for seeding cool season grasses if you live in northern Idaho, or if you missed the fall seeding time. Seed as soon as the ground can be safely worked. If the seed is sown too early, when the soil is too cold and damp, slow, irregular germination will result. There is also strong competition from germinating weeds during the spring. When practical, wait until weed seeds germinate, cultivate the soil to kill them, and then sow the grass seed.

Establishing turfgrass by seeding in mid-summer is difficult because of high tem-

Table 4. Seeding rates for turfgrass.

| Species | Seeding rate Pounds per 1,000 square feet |
|--------------------|--|
| Cool season | |
| Bentgrasses | |
| Colonial | 0.5 to 2.0 |
| Creeping | 0.5 to 1.5 |
| Kentucky bluegrass | 1.0 to 2.0 |
| Perennial ryegrass | 4.0 to 8.0 |
| Fine fescue | 3.0 to 5.0 |
| Tall fescue | 4.0 to 8.0 |
| Warm season | |
| Buffalograss | 3.0 to 6.0 (burs) |
| Zoysiagrass | plugs or sprigs only |

peratures, quick moisture evaporation, and drought stress conditions. Seeding can only be successfully achieved in mid-summer if supplemental irrigation is available, and the seeded area is well supplied with moisture several times a day to encourage seedling establishment.

5. **Mulching**—This is the practice of applying plant materials or other foreign matter (such as fiberglass sheeting) to a seedbed to reduce erosion and provide a more favorable germination and seedling environment. While mulching is not essential for lawn establishment, it will help prevent surface erosion, especially on sloped sites. Mulch also moderates temperature fluctuations at the soil surface, reduces crust formation, and reduces surface evaporation. Humidity levels at the soil surface are increased with mulch, and seed loss or seed displacement from wind, birds, and rain (or irrigation) is reduced.

Not all mulches serve all of these functions, and some are better than others. Which material is selected depends on specific requirements at each site, cost, availability of materials, and ease of handling. A light mulch of weed-free straw or grass hay will encourage faster seed germination. Early season cuttings of hay are preferred, as they are less likely to contain weed seeds. Use a rate of 75 to 100 pounds per 1,000 square feet; make sure 50 percent or more of the soil is visible after mulching. The straw or hay need not be removed after seedlings emerge.

6. **Watering**—Failure to provide sufficient moisture is a major cause of unsuccessful turf establishment. After planting, if rainfall is inadequate, the upper 1 inch of soil must be kept moist with daily, light irrigations for the first 2 to 3 weeks. After the seed germinates and seedlings develop enough to mow, the lawn can be watered less frequently, but more deeply (8 to 12 inches deep) to encourage good root development and adequate soil aeration. Improved soil aeration accompanies

the reduction in irrigation frequency. As water evaporates, is used by the plants, and drains from the soil, air is pulled into the soil. Plants require adequate amounts of oxygen in the root zone for respiration.

7. **Mowing**—Start mowing as soon as the grass is tall enough to cut (over 1 inch). Set the mower at the proper cutting height for your species and keep the blade sharp. Immature stands are mowed by the one-third rule used on established turf—no more than one-third of the shoot growth is removed at each mowing. Avoid mowing when it is muddy because the wheels can pull seedlings out of the ground. Frequent mowing will help control annual weeds and limit clipping accumulation that might smother the new turf.

8. **Overseeding**—Reseeding bare spots or thickening sparse turf by overseeding is usually done in late summer or early fall, however, on small areas that are kept moist during germination, overseeding can be done anytime. For spot seeding, work up the area with a hard-tined rake or shovel. Mix a starter fertilizer into the soil, and sow the grass seed. When overseeding thin turf, rake the area first to loosen compacted soil and ensure a good seed-to-soil contact.

Changing grass species can also be considered overseeding when the following technique is used. Kill the established turf by using a glyphosate herbicide, mow as close as possible after the turf dies, and seed into the dead turf. This practice has been very successful in changing Kentucky bluegrass lawns to tall fescue. Keep in mind that if soil problems exist before seeding, such as dry spots from compaction or puddling due to poor drainage, they will exist with the new turf as well. Improve poor soil conditions through major renovation and resort to the more conventional method of seedbed preparation.

B. Sodding

This offers the instant beauty of a lush, weed-free lawn that can be used about 3

weeks after installation. It gives a head start against lawn weeds and there's no need for mulching the turf area. Sod may be an important consideration for a family in a new home where children need a safe, clean place to play or where the lot must be protected against erosion due to its slope. The cost of sod is about six times more than grass seed. Other considerations are the labor involved to install the sod correctly and whether the grass species or cultivars you desire are available in sod.

If you have the opportunity, examine the sod before ordering. Check for consistency in turf texture and for the presence of weeds or diseases that can indicate a poorly maintained sod crop. There should be a uniform color and thickness to the sod. When the sod is delivered, examine several rolls before accepting it.

Several types of sod are available for residential landscapes. The basic types are Kentucky bluegrass blends, Kentucky bluegrass-fine fescue mixtures, Kentucky bluegrass-perennial ryegrass mixtures, Kentucky bluegrass-tall fescue mixtures, and tall fescue monocultures. Each type of sod is best suited to particular uses and geographic areas.

The easiest way to install sod is to hire a landscaper, but if you decide to save money by doing your own sodding, follow the steps below. Do not skimp on soil preparation, site grading, or watering.

1. Soil preparation—Preparations for seeding and sodding are essentially the same. Make sure the site is prepared before scheduling delivery of the sod. Sod is heavy; it weights about 50 pounds per square yard. Sod arrives on wooden pallets each stacked with 50 square yards of grass. Pieces are typically 18 inches wide and 24 inches long. Pieces vary with the particular cutting machine used, but usually three pieces make 1 yard.

Try to be on site when the sod arrives so that the pallets can be positioned to minimize the distance rolls must be carried for installation. Plan to lay the sod immediately. If there is a short delay, keep the rolls moist, but not wet, in a shady loca-

tion. For a long delay, it is best to unroll the sod on cement or a sheet of plastic to avoid having it root into itself or into soil where it will not be laid.

2. When to lay sod—Landscapers lay sod successfully almost year-round, except during the winter. Sodding in spring or early summer, while grasses are growing rapidly, allows quick rooting. In dry areas or during hot weather, supplemental irrigation will be necessary to establish the sod. Before planting, water the soil 6 inches deep. It is important to schedule this watering in advance to avoid a muddy site when sod installation begins. Do not lay sod on dry soil. Even if sod is watered immediately after being laid on dry soil, root growth will be retarded.

3. Installation—If you plan to lay the sod yourself, be prepared to squat or kneel on a wide board to protect and prevent compaction of the soil surface as you work. Handle sod with care to avoid tearing and excessive stretching. Lay the first strip of sod along a straight edge such as a driveway or sidewalk. If there are only curves, lay at a right angle to the curve or use a string to establish a straight line. Butt joints tightly together to prevent root drying, but do not overlap. On the second row, stagger the joints similar to the way bricks are laid.

Use a sharp knife to cut sod to fit curves, edges, and sprinkler heads. Try to avoid using short or narrow leftover pieces because they tend to dry out rapidly. If two pieces are not long enough to butt together, mound soil against the exposed sod edges to protect them from drying.

When sodding slopes, start at the bottom. If the slope is very steep, peg both ends of the sod strip with wooden pegs. Allow the pegs to remain until sufficient rooting has occurred to stabilize the soil. When watering sodded slopes, take care to avoid starting erosion around or underneath the sod.

Do not wait to water until the whole lawn is sodded; the first laid strips may be dried out by then. As you complete a

conveniently large area of sod, water lightly. Continue to lay sod and water previously sodded sections until installation is complete.

4. Rolling and watering—Roll the lawn after laying all the sod. Rolling eliminates irregularities and establishes a good contact between the sod and soil. Water the completed lawn thoroughly. The soil should be moist to a depth of 6 inches after irrigating. Irrigate daily until the sod becomes rooted, usually in about 10 days. Keep people off the lawn for 3 to 4 weeks until the grass is well anchored.

After the sod is established, decrease watering frequency but increase the amount of water per application. Deep (8 to 12 inches), infrequent watering is best for developing healthy, deep-rooted turf (see Section VI for more information on irrigating).

5. Mowing and fertilizing—Make sure the blade is sharp on your mower. Begin mowing new sod after it is well rooted and growing. Use the one-third mowing rule referred to earlier in this chapter. Six weeks after installation, apply 1 pound of actual nitrogen per 1,000 square feet. Thereafter, follow the fertilizer recommendations listed in Section VI of this chapter for your particular turf species.

C. Vegetative Planting

Some grasses may not be available in seed or sod, instead they may be produced vegetatively using plugs, sprigs, or stolons. Many warm season grasses are established vegetatively, while occasionally cool season grasses are repaired using plugs.

1. Plugging—This is the planting of turf using sections of sod varying in size from small cores 1/2 inch across, such as those extracted during core aeration, to large round or square plugs measuring 2 to 4 inches or larger and 1 to 3 inches deep (Fig. 1). Several variations in plug sizes are available depending on the plugging equipment used and the area to be propagated or repaired.

Plugs are a quick way to repair damage on golf courses and athletic fields. Plug-

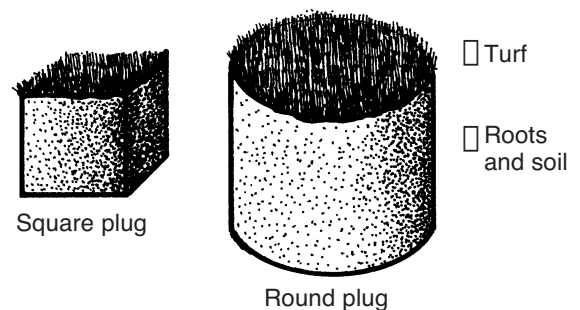
ging can be used to propagate new turfgrasses in bare soil or to introduce a new species into an existing turf. For example, a Kentucky bluegrass lawn can be converted to zoysiagrass by planting plugs. The conversion, which is usually slow, can be accelerated by adjusting cultural practices to favor the introduced turfgrass.

Plugs are planted mechanically or by hand in an upright position (with the exception of the small cores taken during core aeration). The tops of the plugs should be flush with the soil surface. Zoysiagrass is most commonly propagated by plugging, but any stoloniferous or strongly rhizomatous turfgrass can be started in this way.

Cores taken during core aeration are usually broadcasted onto a planting bed and rolled to crush them and provide a smoother surface. The cores are highly susceptible to desiccation, consequently, the planting bed must be kept continually moist until rooting has taken place.

2. Sprigging—A sprig is a section of stolon with two to four nodes. Sprigs are usually planted in 2- to 3-inch deep rows with a portion of the sprig above the soil surface. Sprigs, unlike plugs and sod, are free of soil. Hence, they are more prone to desiccation. Sprigging is primarily used for propagating stoloniferous warm season grasses, but it is also used for creeping bentgrass. Sprigs can be planted mechanically in furrows or plunged into the soil individually using a notched stick.

Fig. 1. Types of plugs.



3. **Stolonizing**—Stolonizing is a method of broadcasting the sprigs and then top-dressing or lightly discing the area to partially cover the stolons. To reduce desiccation of the sprigs, stolonizing is done in 3- to 4-foot strips followed immediately by top-dressing and light irrigation.

VI. Maintenance of Established Turf

The wide variety of microclimates and soil types in Idaho make it difficult to formulate a uniform program of lawn maintenance. The basic factors required for maintaining a lawn are discussed in this section. However, the recommendations may need to be modified for your particular location.

In addition to considering the genetic potential of a turfgrass for your lawn, important factors in maintaining high-quality turf should include an annual program of mowing, fertilization, weed control, irrigation, and leaf raking. In addition to these, the following cultural practices may be necessary in some years: dethatching, pH adjustment, aeration, disease control, and insect control.

A. Genetic Potential

The potential for a lawn to provide a quality surface is dependent upon the varieties of grass in the lawn. New, improved varieties are released each year. Periodic infusion of improved varieties into the existing turf will increase the chances of producing a high quality lawn. The best maintenance program is not likely to produce a quality lawn if inferior turfgrasses dominate the stand.

B. Mowing

This is the most basic of all turfgrass cultural practices since it influences many other cultural operations. Frequent mowing (once or twice weekly) is recommended to avoid removing more than one-third of the grass blades at any one time (Table 5). The one-third rule is especially important during periods of midsummer stress on cool season turfgrasses. Violations of the one-third rule are of less consequence during non-stress periods such as cool weather. Mow new lawns early in their development and don't allow excessive growth to accumulate on established lawns between mowings.

Scalping, or mowing lower than the recommended rate is not advisable at any time of year because of the stress it causes turf. Often a brown, scorched appearance follows close cutting due to the removal of grass blades that shade and protect the delicate crowns.

Mowing, in general, is detrimental to turfgrasses because it reduces carbohydrate production and photosynthesis. It also causes a temporary cessation of root growth, temporarily increases water loss from cut leaf ends, and because the leaves are cut, creates the potential for more disease infection. To reduce the loss of photosynthesizing tissue in the blades, mowing should be done frequently to remove as little of the green area of each leaf as possible. In shaded areas, photosynthesis is not as active as in the sun, therefore, grasses in these areas are not mowed as frequently. Turf in hot, sunny areas should also be cut somewhat taller especially during the summer to reduce evaporation from the soil surface.

The benefits of mowing, on the other hand, are to encourage lateral bud growth and tillering. (Tillering is the formation of new aerial shoots from axillary buds located along the crown.) When tillering increases, the grass becomes finer, the sod gets thicker and more dense, and the turf's overall appearance is more attractive.

Some grasses are easy to cut, while with others it is difficult to get a clean cut.

Table 5. Recommended mowing heights.

| Species | Height in inches |
|--------------------|------------------|
| Cool season | |
| Bentgrasses | |
| Colonial | 0.3 to 0.8* |
| Creeping | 0.2 to 0.5 |
| Kentucky bluegrass | 1.5 to 3.0 |
| Perennial ryegrass | 1.0 to 2.0 |
| Fine fescue | 1.5 to 2.0 |
| Tall fescue | 2.0 to 4.0 |
| Warm season | |
| Buffalograss | 1.0 to 2.0 ** |
| Zoysiagrass | 0.5 to 1.0 |

*Note: Use the higher end of range in summer on cool season grasses.

**Buffalograss can be left unmowed for a meadow look.

Ryegrasses (due to their fibrous vascular bundles) and zoysiagrass (due to the leaf silica content), are difficult turfgrasses to cut cleanly if your mower blade is not sharp. In contrast, bentgrass, and Kentucky bluegrass are easy to mow.

C. Removing Clippings

Whether to catch clippings or not has long been an argument in lawn culture. Clipping removal is necessary on golf greens, but on home lawns it is optional. Clippings are a source of plant nutrients, especially nitrogen. Short clippings left on the lawn will filter through the grass and decompose. As high as 20 to 30 percent of a lawn's nitrogen requirement can be derived from clippings left in place. Leaving clippings eliminates one fertilizer application per year. Conversely, regular removal of clippings will necessitate the application of additional fertilizer to compensate for nutrient removal. Clippings are not the cause of thatch in most grasses. Long clippings, however, should be removed to avoid suffocation of the turf beneath.

D. Irrigation

To know how to irrigate properly, you must know your soil's texture, structure, and depth. The surest way to determine when to irrigate is to feel the soil in the root zone area by using a soil probe, trowel, or shovel. Check to see if the soil at a 12-inch depth feels damp, like a wrung-out sponge. The soil should crumble easily when tapped, yet should form a ball when pressed inside your fist. It should not hold together in a tight, wet, mud ball or be bone dry. Learning to "read" your turf is important too. A blue-green turf color, failure of blades to spring back when walked on, and lack of dew formation on turf at night are signs of excessive dryness.

1. Timing of irrigation—Night watering uses water efficiently due to less evaporation. However, fungus problems may increase with night watering because humidity and moisture levels on and around plants remain high for hours. Early morning watering is a better choice because plants have a chance to dry off before

evening. Daytime watering is not encouraged, especially on hot or windy days, because of high evaporation rates and water displacement.

2. How much water to apply—Various turfgrasses differ in their water requirements and drought resistance. Warm season grasses such as buffalograss will thrive with only a once-a-month deep watering while Kentucky bluegrass will probably need a once-a-week deep watering to thrive. Soils differ in their ability to hold water. Clay soils hold water longer than sandy soils. Clay soils can be watered once a week and hold water for the entire week while sandy soils may need to be watered two or three times per week to maintain some moisture.

Apply water slowly to prevent runoff and achieve good infiltration, especially on slopes to encourage deep rooting. Water long enough for moisture to reach a soil depth of 8 to 12 inches. Kentucky bluegrass and perennial ryegrass have the ability to develop root systems 12 to 18 inches deep. Tall fescues can develop roots up to 6 feet deep!

Avoid overwatering as it can cause many problems, including nutrient leaching and root rots. If you squish around on your turf 24 hours after watering, or if you see standing water on your lawn, you may be overwatering or have a drainage problem. Excessive water might also be indicated by a yellowish-green grass color. Waterlogged turf will develop a shallow root system due to the lack of oxygen in the soil. Shallow-rooted turf will not be able to handle temperature extremes.

Check watering amounts using the "can" method. Place four to five same-sized, flat-bottomed cans (such as soup cans) in a line equally spaced in one sprinkler pattern. The reason for using several cans instead of one is that nozzles do not spray an equal amount of water over the entire pattern. Start within a foot or two of the sprinkler head and continue to the end of the watering pattern. To determine average sprinkler output over a designated

period of time, collect and measure the total amount of water in the cans and divide by the number of cans used.

Example: You watered for 30 minutes and collected 4 inches of total water from four cans. Four cans divided into 4 inches equals 1 inch of water being applied in 30 minutes). A good watering rule is to apply no more than 1 to 2 inches of water per week.

Whenever possible, replace only the water used by the turf. During hot, dry summer days a turf may consume more than 2/10 inch of water per day. Two inches of water per week is recommended for most turf during the heat of summer in dry, rainless areas. The amount of water needed will be 1 inch or less per week when the weather is cool, especially in spring and fall or on cloudy, overcast days.

Under water stress, the turf may wilt. Just before wilting, however, grass leaves will turn a grayish blue-green color and the turf will no longer spring back after being walked on. If you notice these symptoms, water immediately. A little stress will not kill turf, but watering before these symptoms is best. During severe drought conditions, cool season grasses often protect themselves from desiccation by going into a dormant state.

E. Fertilization

A soil test is a good way to begin determining fertility needs. Contact your local Extension office or a laboratory listed in the telephone Yellow Pages about soil testing.

An adequate fertility program can reduce weeds, lawn moss, and certain diseases. Plus, the lawn will be dense, well-colored, and of manageable growth. Overfertilizing should be avoided since it increases thatch development and surface and groundwater contamination. An overfertilized lawn will grow rapidly and require more water and more frequent mowing. Succulent, fast-

growing turf is also more susceptible to diseases and insects.

Fertilizers can provide nitrogen to plants immediately or over an extended period of time. The amount that can be safely applied at one time depends upon the availability of the nitrogen. The portion of the nitrogen that is slowly available is listed on the fertilizer bag as Water Insoluble Nitrogen (WIN). For example, a 30-10-10 fertilizer with 5 percent WIN actually provides 5/30 or 1/6 of its nitrogen in the slow-release or slowly available form. A 50-pound bag of this material would provide 15 pounds of total nitrogen ($.30 \times 50 = 15$ pounds) of which 2.5 pounds ($.05 \times 50 = 2.5$) would be slowly available (WIN).

If no WIN is listed on the fertilizer label, assume that it is all water-soluble or quick-release (quickly available) nitrogen, unless the fertilizer contains sulfur-coated urea. Sulfur-coated urea fertilizers provide slowly available nitrogen, but the fertilizer label does not list it as WIN.

Statements on the fertilizer bag such as "contains 50 percent organic fertilizer" do not mean that the fertilizer is 50 percent slowly available. It is impossible to calculate the amount of WIN from this information.

Source of fertilizer nitrogen also has other characteristics that should be considered when purchased and used. Those with high "burn potential" should be watered into the lawn with 1 to 1 1/2 inches of water. If applications are to be made when soils are cold, those which cause a "rapid" response should be used. Also, homeowners should be aware of the leaching potential of the materials used. Table 6 summarizes these characteristics.

On established turf, a fertilizer ratio of 3-1-2 or 3-1-1 is recommended. Examples of these ratios are: 15-5-10, 15-5-5, 30-10-20, and 30-10-10. If these analyses cannot be found, select the fertilizer with the closest analysis to the ratio. If your soil test results indicated adequate amounts of phosphorus or potassium, you may only need to apply a nitrogen fertilizer such as 21-0-0.

1. How much to apply? Different turf species require different amounts of fertilizer to thrive. Examine Table 7 for recommended fertilizer rates for your particular grass type.

When making fertilizer applications, avoid applying more than 1 1/2 pounds of nitrogen (N) per 1,000 square feet per application. Inorganic sources of nitrogen, when used at larger rates, can burn the turf and contaminate surface and groundwater due to leaching. To reduce nitrogen loss and maintain some level of longevity to nitrogen fertilizers, use a slow release, granular material whenever possible as part of your fertilizer program. Organic nitrogen sources, on the other hand, can be applied at a rate as high as 2 pounds N per 1,000 square feet per application without the risk of burning due to the slow release nature of the material.

Note: Lower more frequent rates of quick-release N fertilizer can be used on sandy to sandy loam soil.

For even fertilizer coverage, apply granular or pelleted fertilizer with a cyclone or drop spreader. Drop spreaders are more

Table 7. Recommended fertilizer rates for turfgrass.

| Species | Pounds of nitrogen (N) per year |
|--------------------|---------------------------------|
| Cool season | |
| Bentgrasses | |
| Colonial | 3.0 to 6.0* |
| Creeping | 4.0 to 8.0 |
| Kentucky bluegrass | 2.0 to 6.0 |
| Perennial ryegrass | 2.0 to 6.0 |
| Fine fescue | 1.0 to 2.0 |
| Tall fescue | 2.0 to 4.0 |
| Warm season | |
| Buffalograss | 0.5 to 2.0 |
| Zoysiagrass | 1.5 to 3.0 |

*The fertilizer range is determined by cultural practices such as irrigation and clipping removal. Lawns maintained with limited irrigation will need less fertilizer than irrigated lawns. Likewise, lawns where clippings are left will need less fertilizer than lawns where clippings are removed.

efficient and easier to use along driveways and walks. Remember to overlap the wheel areas to avoid leaving noticeable stripes. Hand spreading of fertilizer, except for small areas, is not recommended because of uneven coverage.

2. Time of application—In general, it is best to apply two applications of fertilizer during the fall (September through Novem-

Table 6. Characteristics of common turfgrass nitrogen sources.

| Fertilizer source | N content percentage | Leaching potential | Burn potential | Low temperature response | Residual effect |
|--------------------------------------|----------------------|--------------------|----------------|--------------------------|-----------------|
| Inorganic | | | | | |
| Ammonium nitrate | 33-34 | High | High | Rapid | Short |
| Calcium nitrate | 16 | High | High | Rapid | Short |
| Ammonium sulfate | 21 | High | High | Rapid | Short |
| Organic | | | | | |
| Urea | 45-46 | Moderate | High | Rapid | Short |
| Urea solutions | 12-14 | Moderate | High | Rapid | Short |
| Sulfur coated urea | 14-38 | Low | Low | Moderate | Moderate |
| Resin coated urea | 24-35 | Low | Low | Moderate | Long |
| Isobutylidene diurea (IBDU) | 30-31 | Mod. low | Low | Moderate | Moderate |
| Methylene urea and urea formaldehyde | 38 | Low | Low | Low | Mod. long-long |
| Natural organic | | | | | |
| Activated sewage sludge | 6 | Very low | Very low | Very low | Long |
| Manure | 3-10 | Very low | Very low | Very low | Long |
| Other natural products | 3-15 | Very low | Very low | Very low | Long |

ber). Fall fertilization is very important to encourage turf vigor and spring green up. Follow with a third application in late spring (May) and, if needed, make a final application in June. Avoid fertilizing cool season grasses in the heat of summer (July and August) when they tend to go semidormant. Fertilizing to stimulate growth when turf physiologically needs to slow down or “rest” is stressful and over time the turf will thin out and weaken.

F. Aeration

Coring or core aeration is also called aerification. It involves removing cores or plugs of turf and soil with the purpose of improving compacted soil. Aeration is accomplished by using power or hand-driven machines that remove cores of soil 1/4 to 1 inch across and 3 to 4 inches long. The holes in the turf are made 4 to 6 inches apart. Aeration should be done on well-moistened soil. Tines usually do not penetrate to the needed depth in compacted dry soil. Cores can be left to decompose in place or collected and removed. If left in place, crush the cores with a roller or rake them into the soil. They will help reduce thatch. Lawns exposed to heavy traffic may require aeration at least twice during the season. Spring and early fall are the best times to aerate. Aeration may be done every month if needed, as long as the soil is not frozen or too wet. If done properly, aeration does not harm the lawn or roughen the turf. Equipment rental centers usually have lawn aeration equipment available.

Many benefits are derived from core aeration; the following is a list of the most obvious:

1. Increased soil aeration and water penetration.
2. Stimulated root and shoot growth.
3. Reduced soil compaction.
4. Increased germination of overseeded grasses.
5. Improved turfgrass response to fertilizers and better fertilizer infiltration.
6. Reduced thatch, especially where soil cores are reincorporated or where top-

dressings follows coring. However, core aeration alone is not a recommended way to control thatch.

G. Thatch

Thatch is a brown, fibrous, spongy layer located between the soil and the grass blades. Thatch accumulation is a natural process. As grass plants grow, new tissues are produced and as old tissues die, it is sloughed off. Thatch is the accumulation of plant tissues high in lignin, such as dead stems and roots. Thatch accumulates when dead grass parts exceed the rate of decomposition. Leaving grass clippings on the lawn is *not* the cause of thatch for most cool season grasses. Less than 1 percent of thatch is composed of grass blades. Grass blades tend to be succulent and decompose rapidly. An exception is some of the warm season grasses.

1. Benefits and disadvantages of thatch—
A thin layer of thatch (1/4 to 1/2 inch thick) is beneficial as it helps decrease soil moisture evaporation and soil temperature fluctuations. Thatch also helps retain nutrients and insulates the soil and roots from compaction by cushioning footfalls and equipment used on the turf. Thatch that is more than 1/2 inch thick, however, can be detrimental because it will restrict water, air, fertilizer, and pesticide movement into the soil. Roots of the grass plants will grow in thick, dense thatch instead of the soil, making the turf less heat and drought tolerant. Turf insects and many diseases find thick thatch a good home.
2. Causes of excessive thatch—Good conditions for organic matter accumulation and poor conditions for its decomposition create thatch. Overfertilizing can encourage thatch formation because turf is growing (and dying) at a faster rate. Excessively wet or dry conditions and cool weather also encourage thatch buildup. Under these conditions, soil microorganisms that assist with thatch breakdown cannot live or function well. Stoloniferous grasses naturally form more thatch during normal growth.

Bentgrasses, especially when mowed too high, can accumulate excessive thatch. Kentucky bluegrass, for example, is a high thatch former while creeping red fescue is a medium thatch former. Perennial ryegrass and turf-type tall fescue do not develop much thatch since they are bunchgrasses.

3. How to remove thatch—Preventing thatch buildup with good turf management practices is the best method of controlling thatch. Use proper fertilizer and irrigation rates to create the well-balanced conditions needed for grasses to grow moderately. If dethatching becomes necessary, use a power rake or vertical mower (also called a verticutter). Vertical mowing (verticutting) is cutting with blades or tines that move vertically to the soil surface. Hence, vertical mowing is cutting and slicing the turf vertically to rip thatch and turf. Use the power rake once in one direction and once in the opposite (perpendicular) direction.

Late summer or fall is the preferred time for dethatching because it causes the lawn to look rough or ragged. Damage caused by thatch removal may require overseeding. Follow dethatching with fertilization and irrigation to minimize the rough look of the lawn after dethatching. The old thatch that is brought up should be removed. Top-dressing with a sand/peat mixture, compost, or topsoil is optional after dethatching. When thatch is extreme (1 inch or more), it is easier to remove the lawn and reseed or resod the area.

H. Top-dressing

Refers to the practice of spreading a thin layer (1/4 inch) of soil, compost, humus, or sand and peat mix over the turf or soil. Top-dressing is used to control thatch and help level turf surfaces and cover seeds, stolons, or rhizomes during turf propagation. Top-dressing is a common golf course maintenance operation that has a home lawn application.

Usually a drop spreader is used for top-dressing. After the material is dropped,

brushes, rakes, or special drag mats are used to work the topdressed material into the turf. When using top-dressing to control thatch, first verticut or power rake the area, then topdress. For controlling thatch, top-dressing is applied at 3- to 6-week intervals as many times as needed.

I. Weed Control on Established Turf

The first step to any successful weed control is to identify the weed. Weeds have different life cycles and sometimes need different control measures. Annual weeds, for instance, are much easier to control than perennial weeds. Hoe an annual weed at ground level and it dies; do the same to a perennial weed and it comes back from the root left in the soil.

Some control methods will save you time and money. For example, mowing slightly higher will shade out germinating annual broadleaf weeds so that herbicide use can be avoided. Also, mowing the top off annual broadleaf weeds before they form seed will reduce their population. Because competition is an important factor in seed germination and plant survival, one of the best weed deterrents is a dense stand of turfgrass. Hand pulling, using boiling water, or applying a commercial herbicide on individual weeds can give an economical and selective method of control without broadcasting herbicide material over the entire turf.

Organic methods of control such as hoeing and hand pulling are practical for annual weeds, however, perennial weeds can be difficult to control without herbicide use. Weekly removal of top growth is an old practice that reduces root vigor on persistent weeds. This method, unfortunately, may take more than one year to eliminate some weeds.

If herbicides are to be used, make sure the grass is established and growing vigorously before treatment. Always read and follow the herbicide label carefully for your own safety and the health of your plants. Avoid spray drift by not using excessive pressure. Avoid spraying on windy days when wind velocity exceeds 2 to 3 miles per hour. For the health of your landscape plants, avoid

applying herbicides, such as Banvel (dicamba), near the root zones of desirable trees and shrubs. To avoid contaminating desirable plants, always use a separate sprayer designated for herbicide use only. Timing is important for effective weed control. Weeds, whether annuals or perennials, are more easily controlled when they are small. Spring (April-May) is a good time to spray summer annuals, while early fall (September) is the best time to spray winter annuals and some perennials. Tough perennial weeds such as Canada thistle or field bindweed (wild morning glory) may take several herbicide treatments if herbicide materials are applied early in the season. Summer and early fall applications may be more effective on these weeds since they are most susceptible to herbicides after their flower buds have formed. Annual grasses such as crabgrass are usually treated with a preemergent material in March before the seeds have a chance to sprout.

Two types of herbicides are used on turf: *selective herbicides* are those that eradicate certain plants but not all plants (2,4-D, MCP, Banvel); *nonselective herbicides* are those that eradicate all plants (Roundup). Preemergent herbicides that kill seeds before they emerge, such as Dacthal, fit into the nonselective category.

The control of perennial weeds can be a continuing problem on new turf or thin, unhealthy turf. For more information on weed control methods, refer to University of Idaho Extension publication CIS 888, *Weed Control in Lawns*. For more information on specific herbicide controls, see CIS 723, *Herbicides for Lawn Weed Control*.

J. Turf Renovation

This will be needed for deteriorated lawns and any turf areas where sods are too poor to save. Renovation will also be needed for extremely weedy or thatchy lawns, and lawns with structural faults such as poor drainage or extreme compaction. Renovation will, in the long run, minimize the frustration and cost that goes along with trying to keep these turf areas alive.

To renovate a turf, the sod is either destroyed with a nonselective herbicide or taken out with a sod cutter. Next, plowing or rototilling follows and soil amendments are added if necessary. Grading, smoothing and seeding or sodding are the final steps as discussed in Sections III and V of this chapter.

K. Turf Problems

1. Insects and insect control—Many different types of insects are present in a lawn. Most of these are not harmful to the grass. Insect control is not necessary unless the population of undesirable insects builds up enough to cause visible damage to the lawn.

Close examination, on hands and knees, is the best way to identify insect pests in a damaged lawn. You may be able to see the insect in action. If you think you have an insect problem, your local Extension office can help identify the pest and suggest control measures.

The most common above-ground insect pest in Idaho lawns is sod webworm, these insects feed on grass leaves and stems. Below ground, the most common pests are white grub larvae and billbug grubs which feed on plant stems and roots. Sod webworms are the larval or caterpillar stage of several species of Lepidoptera. Adults are commonly seen flying in jerky, short flights as you walk through the grass. The caterpillars feed on the grass blades at night. Sod webworms prefer well-managed lawns. Damage appears as small brown areas in the grass.

White grubs are the larval or grub stage of several species of beetles and chafers. Typically, white grubs have a cream-colored body with a dark-colored area at the posterior end, a brown head, and front legs but no back legs. White grubs feed on roots, causing brown areas in the lawn. Usually turf damaged by grubs can be rolled back like a rug to reveal the large white grubs.

Billbug and weevil larvae look much like white grubs, except that they are much

smaller and do not have legs. Larvae feed on roots, and adult beetles feed on grass blades and stems. Damage is similar to that caused by white grubs.

2. Turf problem diagnosis—Proper diagnosis of turfgrass problems is essential if an effective solution is to be found. Fact and observation must be correlated to determine the causes of turf problems. Some turf problems have their “roots” in maintenance practices from previous years, which makes diagnosis difficult. Seldom does the homeowner recognize that there is a problem until considerable damage has occurred. It is virtually impossible to accurately diagnose the initial cause of some problems because the damage occurred so long ago that there is no identifiable symptom or causal agent present. Diagnosis of turfgrass problems requires a pocket knife, a good quality hand lens, and a soil probe. The following is a checklist to help diagnose problems and give you an appreciation for the complexity of diagnosing:
 - a. Observe site conditions such as the exposure and severity of slopes; the location of sidewalks, driveways, and patios; drainage patterns; traffic distribution; and locations of buildings and other structures. Note the location, size, and types of trees; how much shade they cast; and their rooting pattern. Check prevailing winds, orientation of buildings in relation to the sun, play areas, or areas that may be compacted due to use.
 - b. Determine the species and, if possible, varieties of grasses. Evaluate vigor, density, amount and type of cover. Note whether growth is sparse or dense, and whether the color indicates chlorosis. Note the types of weeds present.
 - c. Note overall color of turf, any mottled appearance, patterns of dead or damaged turf, presence of weeds, conditions of adjoining turf areas, and general vigor and density of overall growth.
 - d. Examine overall pattern of damage. How did damage appear to spread? Note if it’s most prominent on well-drained or poorly drained areas, where thatch is heavy or minimal, or whether it appears to follow mower or foot traffic patterns.
 - e. Examine plant leaves. Note lesions, fungus fruiting structures, and symptom appearance.
 - f. Examine plant roots. In particular, note their color; healthy roots are white.
 - g. Check the thatch layer. Ask about the mowing program. Determine height of cut, frequency of mowing, sharpness and adjustment of equipment, and whether a rotary or reel mower is used.
 - h. Check the soil. Measure the depth and determine the type if possible. Also note drainage, compaction, evidence of hardpan or claypan, or presence of buried materials. Note whether a soil test has been made in the past 3 years.
 - i. Ask questions about the chemicals applied. Determine the fertilizer analysis, type of nitrogen, herbicides, insecticides, fungicides, and other products used.
 - j. The final step is to correlate all known facts, observations, and weather conditions; then, make a judgment on possible causes of damage and corrective measures to be taken.
3. Common lawn problems to watch for:
 - a. Improper watering (too much or too little) is the single most important cause of poor turf. Use 1 to 2 inches of water per week, except when rain supplements irrigations. Weather will determine if a low (1 inch) or high (2 inches) rate of water is necessary.
 - b. Poor soil drainage, especially on clay soils, may show up as standing water or as constant wetness with moss growing. This may require amending the soil or adding drainage tiles.
 - c. Summer dry spots are a common occurrence especially in southern Idaho. Use a wetting agent, aerate and top-

dress, or amend the soil and reseed. On severe slopes, terrace the area or use ground cover or turf that will not be mowed.

- d. Mowing too low (scalping) can stress turf and cause it to scorch. Mow at the height recommended for your variety (Table 5).
- e. A dull, tan cast on the surface of the grass may indicate a dull mower blade. Pick a blade of grass and look at it up close. If the tip or cut end looks torn or shredded instead of flat across, it's time to sharpen the blade.
- f. If the turf seems to be growing too fast to keep up with the mowing, consider fertilizing less. If you dislike mowing, use a dwarf tall fescue such as Bonsai, which only grows 3 to 4 inches tall.
- g. Thatch buildup is evident on turf that feels especially spongy when walked on. Check the thatch layer by cutting a wedge out of the turf. If the thatch is more than 1/2 inch thick, dethatch with a power rake in the fall.
- h. If weeds or crabgrass are a constant problem next to a driveway or sidewalk, it usually indicates that the turf is stressed due to reflected heat from the paved areas. Consider removing the turf to make a planting bed of shrubs, bulbs, perennials, or annuals along these hard-to-grow turf areas.
- i. Thin turf may be a result of shading or improper fertilizing and watering. If shade is the problem, use a shade-tolerant grass-like red fescue or use a ground cover instead. Fertilizing cool season grasses during the heat of summer can disrupt their natural physiological cycle as they tend to slow down or go semidormant during hot weather. Fertilizing forces them to grow. Over time, this practice will stress a turf and cause it to thin. Fertilize in the fall, whenever possible. Additional applications may be applied from spring to early summer.
- j. Turf diseases and insects occasionally occur on even the best of lawns. Bill-

bug on bluegrass and fairy ring fungus are two very common culprits in southern Idaho. In high elevations, snow mold may be a problem.

Refer to UI Extension publication EXP 676, *Fairy Ring in Turf*, and CIS 374, *Bluegrass Billbug Control in Idaho Lawns and Turf*. Consult with your local county Extension educator for additional information.

Further Reading

Books

- Vengris, Jonas. 1973. *Lawns: Basic Factors, Construction and Maintenance of Fine Turf Areas*. Thomson Publications, Indianapolis, IN.
- Turgeon, J. J. 1985. *Turfgrass Management*. Prentice-Hall, Inc., New York, NY.

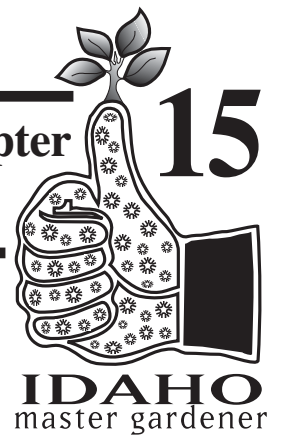
Booklets and Pamphlets

University of Idaho

- CIS 1041 Conduct Your Own Garden Research (\$2.00)
- CIS 1016 Don't Bag It! Recycle Your Grass Clippings (50¢)
- EXP 676 Fairy Rings in Turf (50¢)
- EXT 723 Herbicides for Lawn Weed Control (50¢)
- CIS 340 Lawn Pest Control (50¢)
- CIS 911 Northern Idaho Fertilizer Guide: Northern Idaho Lawns (\$1.00)
- CIS 583 Selecting Turfgrasses for Idaho Lawns (35¢)
- CIS 846 Southern Idaho Fertilizer Guide: Southern Idaho Lawns (\$1.00)
- CIS 1062 Starting a Home Lawn (\$1.50)
- CIS 1063 Thatch Prevention and Control in Home Lawns (\$1.00)
- PNW 299 Turfgrass Seedings: Recommendations for the Pacific Northwest (75¢)
- CIS 888 Weed Control in Lawns (50¢)

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Landscaping



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Landscaping



T. Finnerty

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I. Introduction

Horticulture is an art and a science—especially when it comes to landscaping. Imagine the landscape as the canvas with the greenscape (plants) and hardscape (sidewalks, edging, and patios) providing the colors, shapes, and patterns of the living portrait. Landscape architects even use the term “plant palette” when referring to plant lists.

The skill to match the proper plant to the proper environment and to provide the proper cultural inputs to guarantee the survival of plants on the landscape is the science of landscaping. In addition to being more attractive and easier to maintain, the benefits of a well-planned, well-designed landscape include economic savings (reduced inputs of water, fertilizer, and pesticides), enhanced real estate values, and personal satisfaction and peace of mind.

To help you create an attractive and functional landscape, we will discuss some basic principles of landscaping including planning and design, plant selection, and installation and maintenance. Although the following principles are primarily for homeowners, you also can apply them to larger properties or landscapes.

II. Definitions

- A. Landscape—An arrangement of outdoor space for a specific purpose or goal. Goals may be as general as increasing the attractiveness of a landscape to more specific things such as reducing the amount of water, maintenance, and chemical inputs into the landscape.
- B. Landscape Design—A blueprint or drawing of the landscape that the designer creates to fulfill the property owner’s goals and objectives for the landscape.

- C. Landscape Architect—A professional who creates landscape designs.
- D. Landscape Plan—Describes how you are going to meet the goals and expectations of the landscape design.
- E. Landscape Maintenance—The specific activities (weeding, spraying, watering, fertilizing, etc.) needed to meet the goals and objectives of the landscape plan.
- F. Landscape Management—Coordinating the maintenance procedures to meet the landscape plan’s objectives .
- G. Landscape Contractor—Someone who installs and sometimes maintains landscapes. This individual also may be the landscape manager who is responsible for meeting the landscape plan’s objectives.
- H. Landscaping—Includes all of the concepts from design to maintenance.

III. Creating a Plan

Have a plan before you plant! Whether you are developing a landscape plan for a new home or renovating an older landscape, it is important to have a plan before you do anything. In the long run, not having a plan may create maintenance problems and reduce the overall appearance of the landscape. The following steps will help you develop a plan for a landscape that is both functional and aesthetically pleasing.

A. Define Your Goals and Objectives

This is the most important step of the landscape process. Establishing clear goals and objectives at the beginning will help you achieve the benefits you hope to receive from your landscape plan.

Decide what type of plan best fits the needs of your household, while working within the

economic, social, environmental, and physical constraints that will affect your final landscape plan. Specific goals and constraints might include the following:

1. Goals
 - a. Low maintenance, low input (includes reduced watering, pesticide and fertilizer applications, and less mowing).
 - b. More privacy.
 - c. More recreation area.
 - d. More color.
 - e. More wildlife habitat (includes forage and cover for birds and desirable insects).
2. Constraints
 - a. Environmental conditions (includes climate, soil, and precipitation).

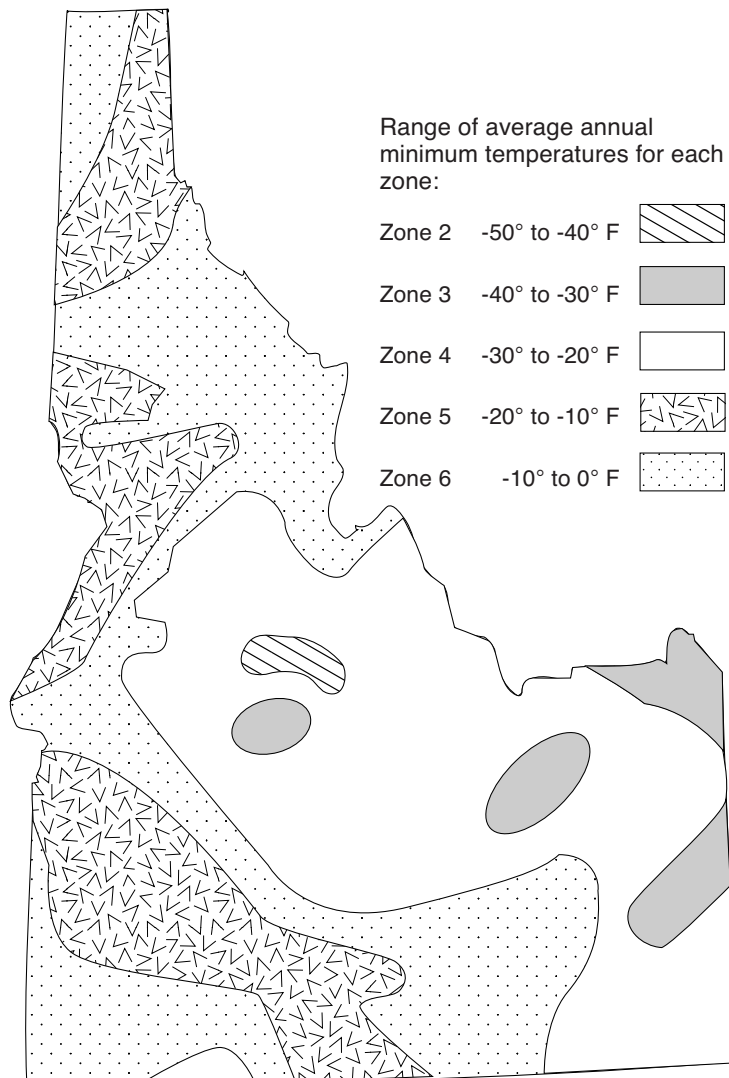
- b. Physical barriers or obstacles on the landscape.
- c. Social (includes public ordinances restricting water use or plant selection).
- d. Economic.
- e. Physical handicaps.

B. Do a Thorough Site Analysis

Gather as much information as possible about your site and the area where you live. Make a preliminary map of your property, drawn to scale, that includes the locations of your house, buildings, sidewalks, and driveway. Indicate on the map, or on a separate sheet of paper, the following information:

1. Macroclimate—This refers to major weather patterns (temperature and precipitation) that affect large areas. In Idaho, cold hardiness is a critical factor for determining plant survival. Idaho covers five USDA hardiness zones, 2 to 6, (-50° to -10°F), with temperatures being affected by elevation and latitude (Fig. 1). Temperature and precipitation can vary considerably within a hardiness zone. Always consult local or regional weather services or extension publications for specific weather information for your area.
2. Microclimates—These are the weather patterns that the landscape in your immediate area affects. When conducting a site analysis, look for potential problem areas such as hot spots, frost pockets, wet spots, or shaded areas. Mark these microclimates on your preliminary map for future reference.
3. Soils—See Chapter 4 for more information about soils. In regard to urban or residential landscapes, consider the following:
 - a. Most urban or residential soils are disturbed soils and probably won't resemble the less disturbed, native soils of the surrounding region.
 - b. Proper soil conditions are as important to plant growth and survival as ideal climate conditions. Drainage, pH, structure, organic matter, and mineral composition are factors to consider in relation to plant growth.

Fig. 1. USDA plant hardiness zones for Idaho.



- c. Because you are working with a small area, it is easier to improve the soil using various soil amendments.

Note: If your site has a lot of variability in the soil, you should indicate the different areas on your preliminary map and plan accordingly. See the UI Extension Bulletin 704, “Soil Sampling,” for information about taking soil samples on your site.

4. Topography—Besides altering the microclimate, topography can affect drainage and make some areas difficult to plant and maintain.
5. Aspect—Note the exposure of the site relative to the sun. This is more critical in mountainous areas or areas with steep hills. Generally, plants growing on the warmer, south-facing side of a slope will break dormancy faster than plants growing on the north-facing side. This provides a longer growing season, but it also can make plants more susceptible to late frosts and other freezing-related injuries.
6. Existing plant materials and structures—Show existing plant materials, sidewalks, driveways, patios, and other structures on your preliminary plan.
7. Access—Besides driveways and sidewalks, plot “traffic” areas around the landscape. Consider ways to improve access to your home or other parts of the landscape.
8. Easements—Draw these on your map to prevent planting any permanent plant materials in these areas.
9. Overhead utility lines, sewer lines, underground cables, and transformers—Note these on your preliminary site plan and plan accordingly. Some basic rules for planting in these areas include:
 - a. Plant trees and shrubs away from utilities;
 - b. Plant taller or broad spreading trees away from overhead lines, and use shorter, slower growing trees for closer planting if you must plant near overhead utilities;

- c. Don’t plant species near utilities that can prevent access or cause maintenance problems; and
- d. Avoid planting species such as poplars, willows, and cottonwood with dense, fibrous roots near sewer lines or septic systems.

Note: See the UI Extension CIS 991, “Landscaping and Utilities: Problems, Prevention, and Plant Selection,” for more information.

10. Views—Indicate your views looking out from your house, and approaching your house. What do you want to see? What don’t you want to see? What do you want others to see or not see?
11. Available water—Show the location of your water sources. If your property has areas that are difficult to water, you may want to modify your plan to meet the needs of these areas by using drought-tolerant plants or hardscape (nonliving) materials.
12. Local ordinances—Consult state and local authorities for specific regulations about planting trees and shrubs along streets, sidewalks, and rights of way.

C. Define Use Areas

You can divide use areas into three major categories:

1. Public areas—This usually describes the front of your landscape. The primary function of this area is aesthetics and to “welcome” visitors to your home.

Note: There are no distinct boundaries on these areas, and they will frequently overlap in terms of function and appearance. Within these major use areas, you should designate specific use areas (e.g., recreation, perennial flower beds, vegetable garden, and patio) for the various activities that you are planning for your landscape. For more information about planning your landscape see CIS 990, “Water Conservation in the Landscape.”

2. Private areas—These are the areas used for recreation, family activities, and entertaining.
3. Service areas—These areas are reserved for the vegetable garden, composting, pet and livestock areas, storage shed, wood-piles, and other utilitarian purposes. They can include areas that are difficult to maintain, have limited access to water, or have poor soil.

D. Define Planting Areas

Plot planting zones based on water needs or the plants' maintenance requirements and to meet the landscape plan's objectives.

1. Hydrozone or group plants with similar water needs in the same areas. For example, consider planting willows, dogwoods, or birches that usually thrive under moister conditions near annual flower beds (high water users). To conserve water, do not mix plants that have low water requirements with plants that have high water requirements.
2. Reduce maintenance activities by grouping plants with similar maintenance requirements together.
 - a. Perennials generally require less frequent maintenance than annuals. In Idaho, most of the maintenance of perennials occurs in the spring and fall.
 - b. Plant trees or shrubs with messy leaves, fruits, or seeds away from flower beds especially if these plants reproduce easily from seed. It is easier to rake this material up or remove the new seedlings from a lawn than from your planting beds.
 - c. Group shrubs with similar flowering periods together so it's easier to remember which plants you need to prune in early summer and which ones in the fall or early spring. Grouping also will help you focus maintenance activities on specific areas of your landscape.
3. Design planting areas to meet the objectives of your landscape plan. If your objective is privacy, design planting areas to maximize privacy. On the other hand, if you are concerned about security, you

may want to leave large areas of open space with reduced opportunities for concealment. Perhaps you would like to encourage more wildlife on your landscape? Then you will need to plan for more areas that provide both food and shelter. Plan and plot your objectives before starting to plant.

E. Principles of Design

The house is the focal point of the design. The landscape should complement, not clash, with the house. The landscape is an extension of the living space. Just like the appearance and arrangement of your house affects your personal living space, so does the appearance and arrangement of your landscape. It affects you aesthetically based upon your inward and outward views and from a functional perspective.

1. Balance—You can achieve balance on the landscape in two ways:
 - a. Symmetrically: Place equal numbers of plants, plants of equal size, or structures or planting beds of equal size opposite each other on the landscape. For example, plant two shrubs of the same size and species on opposite sides of an entryway or plant two flower beds of equal size, dimension, and species composition on opposite sides of a sidewalk.
 - b. Asymmetrically: Balance plants and structures in terms of volume of space occupied on the landscape. One example might be to plant a large red oak on one side of the yard to counterbalance a mass planting of ornamental shrubs on the opposite side. Also, you could counterbalance a deck with a perennial bed.
2. Movement—You can create a sense of vertical and horizontal movement on the landscape. For example:
 - a. Tall, columnar trees or shrubs draw your eyes upward, whereas a low, flat bed of colorful annuals pulls your eyes downward.
 - b. Lines, especially curved lines of walkways or planting beds, create a sense of motion that encourages you to move

visually and physically through the landscape.

3. Harmony—The proper use of space, color, texture, and plant materials on the landscape creates harmony.
 - a. Use plants and structures that are in scale with the house.
 - b. Enhance the overall landscape design with plants and plantings that complement each other.

F. Elements of Design

1. Space—Use space effectively by considering the following principles:
 - a. Select a mixture of plants that provide an effective transition from the vertical plane (air) to the horizontal plane (earth) to create a better sense of harmony and balance.
 - b. Plant trees that provide filtered shade (e.g., honey locusts) rather than trees that provide heavy shade (e.g., maples) for a more subtle influence on vertical space.
 - c. Select different species of plants based upon their form and structure as well as their color or flowering habits.
 - d. Use curved lines to create a more natural, informal appearance. Straight lines are less natural and more formal.
2. Color—Color affects the landscape design in various ways.
 - a. It gives the landscape movement, accent, shade, and depth. For example, bright colors such as reds and yellows are good for accent, variety, and for attracting attention to specific areas. Use blues and dark colors to create shade and depth.
 - b. Color affects moods. Reds are exciting colors that generate energy; pinks and greens are soothing colors; and light blues create a cool feeling.

Note: A color wheel will help you make effective color choices. They are available at crafts, art, paint, or office supplies stores.

3. Texture—Texture is the “visual feel” of the landscape or of landscape plants. Some plants have a coarse texture because of their foliage, branching patterns, or bark. For example, a horse chestnut tree with its large, serrated, compound leaves will have a coarser texture than a weeping willow.
4. Plant arrangement—The individual attributes of the plantings and overall effectiveness of the landscape plan is affected by plant arrangement.
 - a. Specimen plants draw attention to themselves because of their color, shape, or size. Plant them by themselves or enhance beds with mass plantings. Large shade trees (oaks, maples, and conifers) or small trees and shrubs (ornamental crabapples, hawthorns, burning bushes, and viburnums) make effective specimen plants.
 - b. Mass plantings enhance the appearance of plants that may not be as attractive or effective individually. Annuals, perennials, small shrubs, and ground covers are generally more effective as mass plantings. Also, on more naturalized landscapes, it is best to plant shrubs in odd numbered clusters for a more natural appearance.

G. Plant Selection

Select plants that meet your design objectives. These might include the following:

1. Functional.
2. Aesthetically pleasing.
3. Cold hardy—Check if the plant is adapted to the minimum temperature zone for your area.
4. Low maintenance—Select species that require a minimum amount of pruning, watering, and raking. Cut the frequency of maintenance time for woody plants by reducing the variety of early- and late-flowering species.
5. Low input—Select plants that require less water and chemical inputs.
6. Nonpoisonous and safe—This is especially important in areas that children will use. Try to reduce the number of plants

that may have poisonous fruits, flowers, or foliage or that have thorns or spines that can cause injuries.

Note: Contact your local Extension educator or the Poison Control Center if you have any questions.

7. Appropriate selections for planting near utilities.
8. Economical—What we want is not always what we can afford. Your budget will determine your choice and size of plant materials that you can purchase.
9. Native or nonnative species—Some people recommend planting native (indigenous) species over nonnative (nonindigenous) species because, theoretically, they are better adapted to an area. This is not necessarily true since most residential landscapes are disturbed sites and unnatural environments that probably will have more inputs (irrigation, fertilizing, and pest control) than the preexisting natural environment. Native plants are not always more drought tolerant than nonnative species either.

Note: The bottom line is to choose the best plant that is adapted to the area you are going to plant it in and that meets your desires for your landscape.

10. Nonnoxious—Noxious weeds are a serious problem in agricultural areas. If you plan to purchase or introduce plants from out of state, contact your local Extension educator for information or the County Weed Control supervisor about noxious weeds in Idaho.
- H. Other Considerations When Buying Plants
- Some other important things to consider when you are **buying** plants are:
1. To ensure greater adaptability to your area, purchase plants that local seed sources have produced. This is especially important for woody and herbaceous perennials.
 2. Before purchasing plants via mail order, check local nurseries. You may save

money, and you will be able to inspect the plants for pests and diseases. Also, you are more certain of getting a live plant.

IV. Installation and Renovation

Follow these steps when installing a new landscape or renovating an older one. The sequence depends upon your needs and abilities.

A. Primary Hardscape

Install sidewalks, driveways, walls, terraces, decks, patios, and ponds. These will define your use areas and will prevent future damage to your landscape if done in the beginning.

B. Install Planting Beds

Amend soils, if necessary, and install weed barriers, if desired.

C. Plant or Move Trees and Shrubs

Plant and transplant shrubs early in the spring or late fall when plants are dormant and the soil is workable. Do not transplant large trees and shrubs when they are actively growing. (See CIS 528, "Plant Your Container-Grown Seedlings Right," for information about planting and transplanting trees.)

D. Install Automatic Irrigation System

E. Plant Lawn or Ground Covers

Add soil amendments if you have poor soils—especially soils low in organic matter—or plant some type of an annual cover crop to improve the soil before planting.

V. Maintenance and Irrigation

A. Maintenance

Review the maintenance requirements of your landscape plan before actually installing the landscape. This will save you a lot of frustration and expense in the long run. Refer to other Master Gardener chapters for more information about the following maintenance activities:

1. Proper pruning—Timing and technique is important. (See UI BUL 819, "How to Prune Deciduous Landscape Trees.")
2. Staking and wrapping trees or shrubs.
3. Mulching—Includes organic, inert, and synthetic mulches. Organic mulches should not be deeper than 2 to 4 inches.

Incorporate fine mulches such as sawdust into the soil. Plastic, nonporous mulches are not recommended for landscape use. (See UI Extension CIS 858, "Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes," for more information about mulches on the landscape.)

4. Pest control—Includes disease, insect, and weed control.
5. Proper turf management—Mow grass to proper heights. Leave trimmings as a mulch to improve soil and water retention, fertilizing, and top-dressing. Proper watering is also important to maintain a healthy lawn, and to avoid waste, runoff, and water pollution. (See Chapter 14 for more information and publications about establishing and maintaining a lawn.)

B. Water Management

Match the irrigation program to the plants' moisture requirements, the time of the year, and soil types. Important components of a good water management program include:

1. Proper timing and duration of watering—Deep and infrequent waterings are better than shallow frequent waterings. Deep water evergreen trees and shrubs before the ground freezes in the winter.
2. Match sprinklers and irrigation scheduling to plants and planting areas—Trees and shrubs require less frequent watering than turf and herbaceous ornamentals.
3. Monitor and maintain the irrigation system frequently to prevent runoff, waste, and pollution.

Further Reading

Books

- Adams, E. Blain. 1992. *Homescaping*. Publication B-951, Cooperative Extension Service-USDA, University of Wyoming, P.O. Box 3313, Laramie, WY 82071-3313. (There is a nominal charge for this landscaping kit.)
- Bienz, D. R. 1980. *The Why and How of Home Horticulture*, W. H. Freeman and Co., San Francisco, CA.

Calkins, Carol C., Ed. 1981. *Reader's Digest Illustrated Guide to Gardening*. The Reader's Digest Association, Inc., New York, NY.

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Hogan, Elizabeth L., Ed. 1990. *Sunset Western Garden Book*, 5th Ed. Sunset Publishing Corp., Menlo Park, CA.

Krukeberg, Arthur R. 1982. *Gardening with Native Plants of the Pacific Northwest*. University of Washington Press, Seattle, WA.

Millard, Scott, Ed. 1977. *All About Groundcovers for Slopes, Walkways, Rock Gardens, Wide Open Spaces, and Nooks and Crannies*. Ortho Books, Chevron Chemical Co., San Francisco, CA.

Nelson, Wm. R., Jr. 1975. *Landscaping Your Home*, Revised Edition. Cooperative Extension Service, College of Agriculture, University of Illinois, Champaign, IL.

Booklets and Pamphlets

University of Idaho

- CIS 923 Choosing Nursery Stock for Landscaping, Conservation, and Reforestation (35¢)
- CIS 1068 Fertilizing Landscape Trees (\$1.00)
- PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair (\$2.50)
- BUL 819 How to Prune Deciduous Landscape Trees (\$2.00)
- BUL 644 How to Prune Coniferous Evergreen Trees (\$1.50)
- CIS 991 Landscaping and Utilities: Problems, Prevention, and Plant Selection (\$1.00)
- CIS 238 Leaf Scorch of Broadleaf Shade Trees (35¢)
- CIS 1054 Low Input Landscaping (\$1.00)
- PNW 500 Plant Materials for Landscaping—A List of Plants for the Pacific Northwest (\$2.50)
- EXT 704 Soil Sampling (\$2.00)
- CIS 735 Transplanting Native Seedlings (25¢)
- CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes (50¢)
- CIS 990 Water Conservation in the Landscape (50¢)

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Landscape Plants



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I. Why Ornamental Plants?

Landscape plants are placed as they are for various purposes: to create shade, to define space, to enhance architecture, to provide food (e.g., fruit trees), and to further general aesthetics. These plants should be installed according to a plan, so that they are correctly selected and placed to create the desired design effect. Plantings should be in tune with the environmental situation and take into account such things as exposure, amount of light, pH, water availability, and soil type.

Trees and shrubs will last in the landscape for many years. However, when a stress is imposed on a plant, that plant becomes much more susceptible to other problems, including insects and disease. A large percentage of landscape plant problems can be related directly to improper selection of plant material and improper cultural practices that lead to plant stress. In some cases, the effects of improper cultural practices may not be seen for years.

II. Soils and Water Considerations

A. Soil Composition

Soils are roughly 50 percent solid material and 50 percent pore space. (Pores are holes in the soil that are either filled with air or water.)

1. Pore space, ideally, should be 50 percent air and 50 percent water.
 - a. Air is necessary for root respiration and normal metabolism, including the uptake of water.
 - b. Water is used in transpiration within the plant and for the transport of dissolved mineral nutrients from the soil to roots and on up the plant through the xylem.

2. The solid material is composed of organic matter, decomposed rock, and various biological life.

B. Water Status Definitions

1. Hygroscopic water—Tightly bound to the soil particles; not available for plant growth.
2. Capillary or available water—Held less tightly to soil particles; available for plant usage.
3. Gravitational water—Moves with the force of gravity; drains away. This water is not available to the plant.
4. Saturated conditions—Tend to exclude air; detrimental to most plants (with the exception of aquatic species).

C. Water Movement

1. The thicker the film of water, the greater the ease of movement in the soil. The thinner the film of water, the harder it is to move through the soil, therefore, becoming less readily available to plants.
2. Water movement is always from wetter areas in the soil mass to drier areas.
 - a. When water is lost from the soil surface (through evaporation), more water is drawn up from lower levels.
 - b. When a plant draws water in through the roots, more water moves into the area.
 - c. Roots **do not** seek water; roots grow where water is.

D. Soil Structure (Aggregate Size)

1. Soil particles may be made up of many small particles clumped together.
 - a. Spaces (macropores) between large particles contain air for root respiration.

- b. Spaces between smaller particles and within very large particles contain capillary (available) water. Water also is found on the surface of larger particles.
2. Increase aggregate size by:
 - a. Adding of calcium (usually gypsum): Only works with clay soils.
 - b. Adding organic matter: Water and air are found **in** and **between** the organic matter particles. Organic matter loosens a clay soil for better air and water movement. In sandy soils, organic matter helps hold water and nutrients.

E. Drainage Problems

1. Hard, compacted soil—Air space squeezed out; low infiltration, little air space, and slow drainage.
2. Impenetrable layers—Clay layers, hardpan, and plowpans, etc.; may not allow water or roots through.
3. Fine-textured soil—Preferable over a coarse-textured soil or gravel.
 - a. At the interface, water cannot move rapidly into coarse soil; consequently, moisture is limited or not continuous.

Note: The interface is where one soil type stops and another begins.

- b. Water movement downward is impeded across the interface, and much of the finer soil's pore space may fill with water.
4. Coarse-textured soils over or contained within a fine-textured soil.
 - a. Drainage through coarse soils is rapid.
 - b. Infiltration into fine soils is slow, causing macropores in the coarse soil to fill with water.
 - c. Roots lack oxygen and root rots may ensue.
 - d. Add organic matter to the coarse soil to slow water penetration.

F. Overcoming Drainage Problems

1. Till by adding 3 to 4 inches of organic matter.
2. Raise plant slightly above grade and create a bed with good soil, or a raised bed.

3. Add tile to create good drainage.
4. Contour slope away from plants so that water runs off.
5. Break through hardpan layers.

III. Planting and Site Preparation

A. Types of Plant Materials

1. Bareroot (B.R.)—Dug without a ball of soil; little or no soil around the roots. Examples: dormant deciduous shrubs, roses, deciduous trees, and small evergreens.
2. Balled and burlapped (B and B)—Dug with soil that is enclosed in burlap or some sort of synthetic material. The root system has been cut for easier handling and transport.
3. Field-potted—Dug with or without soil and potted into a container.
4. Container—Plant grown for a time in a container.

B. Planting

1. Bareroot
 - a. Cut back damaged or broken roots.
 - b. Dig hole twice as large as the root system.
 - c. Put the plant in the hole at the same level it grew originally. Build a cone or mound of soil at the bottom of the hole under the plant for support and to aid in spreading the roots. Be sure the roots are spread.
 - d. Backfill with native, **not amended**, soil.
 - e. Water thoroughly.
 - f. Fertilize with a high phosphate fertilizer (5-10-10) or a balanced slow-release fertilizer (10-10-10). Fertilizers may be added to a backfill material. Fertilizer may also be added to the soil surface after watering. Always follow label directions as to amount.
2. Balled and burlapped.
 - a. Dig hole twice as wide as the ball of soil.
 - b. Remove **all** of the rope, twine, or string on the ball after setting it in position in the hole. The burlap can be sliced on the sides, and the top burlap

should be laid back so that no burlap is exposed above ground. Burlap exposed above ground will wick moisture away from the root ball. Synthetic or plastic burlaps should be removed totally. Unless B and B trees have been kept in burlap for a long time, don't worry about girdling roots or cutting damaged roots.

c. Follow steps d through f of Section B, subsection 1.

3. Container plant.

a. Dig hole twice as wide for root system spread.

b. **Remove** container, no matter what type.

c. Roots.

- If the roots are not circling (potbound), carefully spread the exterior roots outward, away from the soil ball.
- If the roots are circling, make three to four vertical cuts into the sides of the root ball (1/4 to 1/2 inch into the ball). If the roots are woody and cannot be cut with a knife, lay the ball on its side. Using a sharpened spade or shovel slice through the lower half of the root ball. This is called "butterflying." Spread out the two flaps of roots and place in planting hole so the top of the root system is level with, or slightly higher, than the surrounding soil. When butterflying, be sure not to damage the crown by splitting too close to the trunk. Make sure the split area is filled with soil so that no air spaces are left.

d. Follow steps d through f of Section B, subsection 1.

C. Pruning After Planting

1. Leave as much of the crown intact as possible, and remove only dead, injured, and diseased branches.
2. Remove interfering, rubbing, or poorly placed branches.
3. Remove a branch from narrow "V" crotches or multiple leaders.

4. Prune to shape, if necessary.

D. Staking

1. Avoid staking unless wind is a problem. Stake as low on the stem as possible and remove the stake after 1 year.

2. Reasons for staking.

- a. To anchor plant until it can root into the soil.
- b. To protect the tree from slanting with the wind.
- c. To straighten a crooked trunk.

3. Used mostly for B.R. and B and B plants.

4. One- and two-stake methods.

IV. Plant Problems

Problems associated with plant roots may show up in other plant parts, especially the leaves.

A. Circling Roots/Potbound

1. Symptoms—A general decline of plant vigor over a period of time.
2. Causes—Plant remaining in container too long at some stage of development, not necessarily the last stage of production.
3. Remedies—"Butterfly" the root ball, or cut and spread the roots before planting.

B. Girdling Roots

1. Symptoms—Girdling roots limit water and nutrient transport causing deterioration of the plant. Top growth diminishes; plant is stressed.
2. Causes—An impenetrable planting hole; twisting the plant after setting into hole; bending roots to fit into a hole that is too small; and planting potbound or rootbound container stock.
3. Remedies—Chop off girdling root; spread roots when planting; remove debris or rocks in planting area.

C. Kinked Roots/One-Sided Root System

1. Symptoms—A general decline of plant vigor over a period of time.
2. Causes—Improper production methods (such as dragging with a mechanical planter causing "J" hooked roots or jamming the plant in the pot or the planting hole).

3. Remedies—Cut off kinked roots when planting; carefully spread and straighten the roots.

D. Root Rots

1. Symptoms—Soft, brown, partially to totally decayed roots resulting in wilting or death of the plant.
2. Causes—Cause varies with susceptibility of the plant. There might not have been enough soil aeration; the water table might be high; the backfill might have been amended with fresh manures when planting; or the soil might be water-logged.
3. Remedies—Improve downward and lateral drainage; tile, if necessary; and plant in raised beds. Select a water-loving species of plant and amend the soil to improve drainage.

E. Changing Soil Grades

1. Symptoms—No buttressing or flaring roots at tree base; general decline of tree; leaves and branches die from top down; collar rots are evident. The decline may take several years to occur or to complete. Susceptibility varies with species.
2. Causes—Filling with soil or pavement on top of an established root system results in a decreased air supply to the plant changing drainage and water patterns.
3. Remedies—Cover roots with a thick layer of gravel, then with soil. Provide drainage, and in some cases, welling the trunk will help.

Note: Welling is the building of a “well” or wall around the tree several feet out to keep soil away from the trunk.

F. Trenching/Cutting Roots

1. Symptoms—Cutting roots reduces water and nutrient uptake. The decline may take several years to occur or complete. Cuts can become infected with root rot leading to the decline of plant growth. The result is often the death of a tree from the top downward. Sometimes the decline is limited to that half of the tree with the cut or damaged roots.

2. Causes—Removing top layers of soil to change a grade or damaging roots by cutting.
3. Remedies—Avoid cutting large roots; fertilize and water the rest of the root system; use a high phosphorus fertilizer to encourage new root development.

G. Compaction

1. Symptoms—Decline of the tree from the top down.
2. Cause—Soil compaction after the plant is in the ground.
3. Remedies—Direct foot traffic and machinery away from the dripline of trees. Aerate soil using a core aerator or cushion the soil with a thick mulch.

V. Stem Problems

Stem maladies usually arise from improper cultural practices and stresses to the plant.

A. Heart Rot

1. Symptoms—Decay of heartwood.
2. Causes—Improper pruning, topping, breakage, or wounding of the stem or the large branches.
3. Remedies—Prune properly and avoid wounding. Remove decayed branch wood; if rot is in an advanced stage, remove the tree.

B. Stem Wounds

1. Symptoms—Cankers, girdling, holes, splits, and oozing.
2. Causes—Various, including hitting the tree with lawn mowers and string weeders; leaving support wires or B and B string around stem; diseases, borers, and sunscald.
3. Remedies—Stay away from plant stems and trunks with equipment. Remove all lawn grass to at least 1 foot from the trunk. Keep all mulch 2 to 3 inches from plant stems. Identify and treat insects or disease. Remove labels and ties when planting. Painting or spraying with tree wound compound does **not** improve healing, but it may prevent insect entry.

C. Sunscald or Southwest Disease

1. Symptoms—Bark tends to be blistered, burnt, dead, or split on the southern or

southwestern sides of the trunk. Young and newly transplanted trees are the most susceptible.

2. Causes—Alternating freezing and thawing of bark on sunny side of tree during winter. Intense heat during summer.
3. Remedies—Shade south and southwest sides of trunk; wrap the trunk with tree wrap or paint with white, water-based (latex) paint. If there is an advanced stage of damage, carefully remove any dead bark, apply tree wound dressing, and wrap to keep insects out of heartwood.

D. Branch Rots and Infections

1. Symptoms—Oozing, cankers, holes, and splits.
2. Causes—Improper pruning. Branch stubs or flush cuts leave a tree open to disease and insects.
3. Remedies—Prune correctly; cut back only to the branch collar; do not top trees. Treat insects and diseases when first noticed.

E. Damage to Crotch Areas

1. Symptoms—Splits, oozing at crotch.
2. Causes—Narrow “V” crotches, borers, water gathering in crotch.
3. Remedies—Prune out all but one of the leaders if the tree is young and has multiple leaders. Narrow branch angles can be spread when the tree is young; cable or brace narrow crotches if the tree is older to prevent breakage.

F. Freeze Damage

1. Symptoms—Blackened tissue; dead twigs or buds; death of plant. Stem die-back. Usually younger stems die, but older wood also can be damaged during severe winters. There is generally a partial to total necrosis of the young leaves. Older leaves may become distorted later. New growth might have been frozen by late spring frost when plant was in the soft-growth stage.
2. Causes—Lethal winter temperatures and early or late frosts.
3. Remedies—Use frost prevention methods; select trees and shrubs specified for

your zone; do not fertilize trees and shrubs after July 1.

G. Graft Incompatibility

1. Symptoms—Large overgrowths above and below union; earlier than normal fall coloration; a stem that breaks off at graft.
2. Cause—Incompatibility between scion and stock.
3. Remedy—Purchase plants rooted from cuttings or use a reliable source of grafted stock.

VI. Leaf Problems

Problems with stems and roots often will show up in the leaves. If a plant is wilted, the leaves are either not getting enough water or are losing water faster than it is being supplied by the roots. Determine the cause of wilting. There also are many insects and diseases that affect leaves.

A. Drought

1. Symptoms—Wilting, drying of soft growth, and blotchy necrosis.
2. Causes—Extended periods of dryness. High heat/bright sunlight on shade-loving plants could cause leaf scorch, early leaf drop, or marginal and interveinal chlorosis or necrosis.
3. Remedies—Water plant; provide better soil preparation by adding organic matter to increase water-holding capacity; mulch to reduce surface evaporation. Select drought-tolerant plants. Shade plant; mist periodically for temporary cooling.

B. Frost Damage

1. Symptoms—Partial to total necrosis of young leaves or buds. Older leaves may become distorted if buds were injured.
2. Causes—New growth frozen by late spring frost when the plant is in the soft growth stage.

C. Root Injury

1. Symptoms—Wilting, early leaf drop, leaf chlorosis, root damage, necrosis, and plant death.
2. Causes—Root damage due to trenching, insects (such as root weevils), or disease. Overwatering limits oxygen uptake by roots and encourages root rot.

3. Remedies—Determine the cause, then take appropriate action. If the cause is not a root rot, then proper watering of the remaining root system will help. Fertilization with a high phosphorus fertilizer may help rejuvenate the root system. If overwatering is the problem, increase drainage and cut back on water. If a high water table or poor drainage exists, choose water-loving plants (such as a willow).

D. Vascular System Injury

1. Symptoms—Wilting or drying of a portion of the plant.
2. Causes—Disease, such as *Verticillium* wilt, can plug the xylem vessels.
3. Remedies—Determine the cause and take appropriate action. Remove the infected portion; treat for *Verticillium*.

E. Salt Damage

1. Symptoms—Marginal to interveinal chlorosis/necrosis; rootlets are brown instead of white.
2. Causes—Salts from excessive use of commercial fertilizers, manures, and de-icing salts. The latter may be more prevalent next to sidewalks and driveways.
3. Remedies—Leach with water, if possible; limit the use of offending materials. Alternate organic fertilizers with commercial fertilizers to reduce salt buildup.

F. Leaf Chlorosis and Nutrient Deficiencies

1. Nitrogen deficiency.
 - a. Symptoms: Overall yellowing of **older** leaves first. Stunted growth of plant. Pale green color on rest of plant.
 - b. Cause: Nitrogen deficiency.
 - c. Remedy: Fertilize with a nitrogen fertilizer.
2. High pH (over 7.5).
 - a. Symptoms: Interveinal chlorosis, light green to white in color (with zinc, older leaves affected; with iron, new leaves affected first). The margins of leaves may become necrotic, but the veins remain green. With zinc deficiency, leaves may be small, narrow, and thickened. Foliage loss may be

early, and leaves at tips of branches may be bushy with few or none along the branch. Manganese deficiency is similar to iron deficiency, but chlorosis is not so dominant on young leaves. Also there is severe browning and dropping of leaves with maturity.

- b. Cause: Iron, zinc, or manganese deficiencies because of the soil pH.
- c. Remedies: A long-term solution is to decrease soil pH. A temporary solution is to apply the deficient nutrient. You may need to make annual spring or fall applications.

3. Other causes of leaf chlorosis.

- a. Wrong soil pH for acid-loving plants. Example: azaleas.
- b. Herbicides (see Subsection G of this section and Table 1).
- c. Drought (see Section VI, subsection A).
- d. Natural leaf maturity and abscission in autumn.
- e. Natural variegation.

G. Herbicide Damage

Herbicides are formulated to be toxic to specific weeds, but they also may cause damage to desirable plants.

1. Symptoms—Some herbicides act hormonally and produce a twisted, cupped, puckered, or distorted growth. Other herbicides inhibit photosynthesis and chlorophyll formation, causing a peculiar coloration or characteristic chlorosis depending on the material used (see Table 1 on next page). In general, if many plants in one area are affected with unusual twisting, puckering, or with strange colorations and drying leaves, chemical or herbicide misuse may be the culprits. If only part of the conifer root system is affected by a herbicide, the damage may create a spiral pattern on the stem of the plant.
2. Causes—Most people do not know where the root zones of desirable plants are; consequently, they overspray, and translocation of the herbicide into a desirable plant occurs.

3. Remedies—Almost all problems arise from misapplication and misuse. Few problems arise when label directions are followed closely and the broadcasted material is kept 5 to 10 feet away from the dripline of desirable plants. Spot treat weeds rather than broadcast when possible.

H. Insecticide Injury

1. Symptoms—Dormant oil will remove the waxy bloom that gives the blue cast to Colorado Blue Spruce Oils used on deciduous plants that have started to show green will burn exposed green tissue. Some insecticides, such as malathion, will burn leaves when applied during high temperatures.

Table 1. Common herbicides.

| Herbicide | Damage symptoms |
|---------------------------------------|---|
| Dichlobenil (Casoron) | Broadleaf plants: Tip, marginal to interveinal chlorosis/necrosis. Sometimes more severe on leaves oriented toward the afternoon sun. Conifers: Needle tip chlorosis to necrosis. |
| Phenoxy compounds (2,4-D, MCPP, MCPA) | Broadleaf plants: Twisted, distorted leaves and stems. Blistering of bark on London Plane trees. Conifers: Misshapen, hooked needles. |
| Dicamba (Banvel) | Broadleaf plants: Twisted, cupped, distorted new growth, chlorosis, necrosis, death of stem tissue. Conifers: Distorted, twisted needles, needle necrosis from the base to the tip; club-shaped growth, needle distortion on pines. |
| Glyphosate (Roundup) | Broadleaf plants: Yellowing and necrosis of part or entire plant. New leaves do not develop correctly; they are skinny, strap-shaped, yellow. |
| Triazines (Atrazine) | Broadleaf plants: Marginal chlorosis. |
| Simazine (Princep) | Conifers: Tip chlorosis. |
| Chemical sterilants (many kinds) | Severe chlorosis, and necrosis, death if applied near the root system of desirable plants. |

2. Causes—When used for insect and mite control on needled evergreens, dormant oil may cause burns, especially if the concentration is too high, if the oil is applied during freezing weather, or if the plant has started to grow.

Further Reading

Books

- Partyka, R. E. 1980. *Woody Ornamentals: Plants and Problems*. ChemLawn Corp.
- Harris, R. W. 1983. *Arboriculture: Care of Trees, Shrubs and Vines in the Landscape*. Prentice-Hall, Inc.

Booklets and Pamphlets

University of Idaho

- CIS 867 Cold Hardiness in Woody Landscape Plants: Its Role in Winter Survival and How to Maximize It (25¢)
- CIS 869 Controlling Sunscald on Trees and Shrubs (25¢)
- CIS 735 Transplanting Native Seedlings (25¢)

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Woody Ornamentals



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I. Introduction

Woody ornamental plants are perennials with stiff woody stems. They are loosely classified as trees, shrubs, or vines.

A. **Trees** usually have a single trunk and can grow to impressive heights. The tallest trees are the California redwoods (*Sequoia sempervirens*), which grow to 350 feet or more. Trees can develop—or be pruned to grow—several trunks. If a mature single- or multi-trunk woody plant is less than about 20 feet tall, it is not considered to be a tree.

B. **Shrubs** are less than 20 feet tall at maturity and have multiple trunks. Standards, which are shrubs trained to grow with a single trunk, may serve as small trees in the landscape, but because they had to be trained this way, they are still considered to be shrubs. Woody shrubs may spread by underground roots or rhizomes. Very short woody shrubs make good ground covers.

C. **Vines** may climb, trail, creep, or even remain erect with some support to their stems. Woody vines may root at various places along their stems, wherever they come in good contact with the ground and have the proper growing conditions. Climbing vines such as ivy may attach to supports with small aerial roots. Grapes can climb by winding slender stems called tendrils around objects.

Some plants will perplex the expert horticulturist and the Master Gardener by defying classification with the above system. Crabapples are a good example. Some insist on growing with multiple stems, yet are greater than 15 feet tall at maturity. Others

are natural, single-stemmed beauties, reaching only 5 feet at maturity. Some weeping forms, if grown on their own rootstocks, would creep across the ground. So, crabapples can be large shrubs, tiny trees, or even vines! Thus, use the tree, shrub, or vine classification only in a general sense.

II. The Art of Designing with Woody Ornamentals

Woody ornamentals form much of the structure in landscape design and contribute to a pleasing composition. They define the skyline and become the structural element dividing space. Landscapers must carefully consider choices and initial placement. Established trees and shrubs cannot be moved simply. Within the principles of design (see Chapter 15), woody ornamentals serve the following purposes:

A. **Balance**—Tree and shrub placement, whether symmetrical or asymmetrical, creates equilibrium in the landscape. Trees and shrubs provide the coordinating composition for other elements contributed by annuals, perennials, and garden features such as fences and decks.

B. **Movement**—The repetition or alternation of shrubs and trees can carry the eye throughout the landscape. The rhythm created is an underlying theme of the landscape. Increasing heights of shrubs and trees draws the eye skyward.

C. **Harmony**—Trees and shrubs serve as a dominant feature or accent in a landscape, thus contributing to the harmony of the design. Repetition of structural elements such as woody ornamentals helps to tie the land-

scape together. The interconnectedness of a low woody ground cover under trees or of a line of shrubs or trees provides a continuity that creates harmony in the landscape.

III. Which Woody Ornamentals to Plant and Where

- A. Plant Selection—Of the many factors to consider in choosing plants, two are most important.
1. Size: During most of its life span, will the plant be of a size suitable for the location?
 2. Site suitability: Is the plant adapted to grow where it will be planted?
- B. Plant function, color, texture, shape, bloom date, rate of growth, and how well the plants relate to other elements of the design are additional important considerations. In recent years, special uses (theme gardens or patios) or adaptations (natives, Xeriscape) have played an increasingly important role in landscape planning and plant selection. See Table 1 for a summary of plant characteristics and uses and site considerations. See Chapter 15 for planning guidelines.
- C. The following considerations apply specifically to woody ornamentals.
1. Function—Woody ornamentals should be chosen with a specific function in mind, which may be as simple as providing shade. Some functions are:
 - a. Firescapes: Landscaping for fire prevention, or “firescaping,” is particularly important for suburban and rural locations in dry areas near hillsides and in narrow canyons surrounded by thick stands of trees and brushy open spaces. Homeowners should clear brush from within 30 to 400 feet of dwellings and outbuildings. Select woody plants that resist fire or that do not have high levels of oil or resin. Plants should have foliage with high moisture content or low brush and litter potential. Avoid designs that place plants of different heights in the form of a “fire ladder.” Fire ladders provide a continuous fuel supply from the ground up to the plant canopy.

- b. Screening and barriers: Windbreaks, shelterbelts, woody plant borders, and screens are all made up of rows of woody plants of various shapes and sizes. They reduce wind velocity, capture snow, stop erosion, and shelter wildlife. Besides providing beauty, they provide protection from unsightly views, disturbing sounds, dust, and, to some extent, they modify atmospheric pollutants. The right sequence of

Table 1. Plant uses and characteristics and site characteristics to consider when selecting woody ornamentals.

Plant uses:

Attract birds or other wildlife
 Attract butterflies or hummingbirds
 Bonsai
 Borders
 Container or patio plants
 Edible parts or fruits
 Espalier
 Fast growth
 Foundation plantings
 Ground cover
 Native plants
 Rock gardens
 Screen or windbreak
 Shade
 Variety of specimens
 Vines for fences or trellises
 Vines to cling to stone or brick
 Understory for woodland setting
 Weeping form

Site characteristics:

Acid soil
 Alkaline soil
 Arid sites
 Dry or sandy soil
 Heavy clay soils
 Saline soil
 Shady areas
 Low maintenance areas
 Wet sites
 Windy areas

Plant characteristics:

Colored summer foliage
 Columnar, pyramidal, or globe shape
 Decorative fruits and berries
 Decorative or interesting bark
 Fragrant flowers
 Good fall color
 Multiple trunks
 Ornamental seed pods
 Showy flowers

woody ornamentals reduces heavy wind around the home, farmstead, and park or recreation area while permitting breezes to enter.

Screening and barriers consist of one to eight rows of trees and shrubs.

Where space permits, several rows of shrubs and trees of various sizes and habits, both deciduous and evergreen, can be used. To serve as a windbreak, the plantings should be at right angles to prevailing winds. Where drifting snow is a problem, the home should be at least 60 feet beyond the last row of the planting. Careful attention to the design of entries and exits of sites will prevent snow or soils drifting into access routes. Windbreaks must be carefully tended to become effective and must be kept weeded, mulched, or cultivated (see PNW 5, "Trees Against the Wind," for more information about windbreaks).

- c. Energy efficiency: Trees can reduce utility bills and improve the comfort of your home. In summer, trees on the southern and western sides of structures can block the hot sunlight, thereby reducing the need for air conditioning. In winter, these same deciduous trees, less their leaves, allow the sun's heating rays through to warm your house. Also, the blocking of cold winter winds by shelterbelts can reduce heating expenses, especially in homes with poor insulation or air leaks.
- d. Xeriscape: In a Xeriscape, plants are chosen that are drought-tolerant in order to conserve water. With this approach, all the plants in a given area must have the same water-use requirements.
- e. Natives: Native plants are becoming increasingly popular in Idaho landscapes. Native woody ornamentals often have lower water demands, fewer pest problems, and lower fertilizer needs than introduced ornamentals. Native plants should always be consid-

ered first for conservation plantings and ecosystem restoration. Natives not only make sense due to their adaptation to existing climatic conditions, but also bring a rich diversity of texture and color to home gardens. For naturalized plantings, native species are often the best selection.

Keep in mind that even though the plant may be native, it needs adequate water, especially right after being planted. After plants are established, you can reduce watering for those that thrive in the wild with little moisture. The goal is to duplicate in your yard the growing conditions of the plant's natural habitat.

When electing to use natives for your landscape, purchase them from a reputable nursery rather than collect them from the wild. Wild collection puts pressure on wild plant communities and introduces diseases and insects found in wild conditions to your yard. The one exception to this rule is rescuing or salvaging plants that are facing destruction by construction.

In order to have well-adapted native plants, start with native plants propagated from plants growing as close to your garden as possible. This will also help prevent degradation of the gene pool of existing native plant populations in your area.

2. Growth characteristics—Growth characteristics of woody ornamentals influence the ability to fulfill a specific function in the landscape.
 - a. Exposure: Select woody plants according to the exposure they'll be subjected to. Plants may be labeled (1) full sun, partial shade, or (2) partial sun, full shade, or (3) shade. Check the genus and species in several references to gain a perspective on the range of exposures a plant can be grown in. Some species can grow under many conditions, but specific cultivars may fit only into one category.

- b. Growth rate: Woody plants are designated as slow, medium, or fast growers in the nursery trade. The rate of growth refers to the vertical increase unless specified differently. Be sure to compare mature height listed on the retail tag with the height of plants actually growing in your area.
- c. Growth habit: Woody ornamentals can grow prostrate, horizontal, or upright; they can be dwarf or standard in size. Growth shapes include round, globe, vase-shaped, pyramidal, and columnar (Fig. 1). Plant propagators select these growth habits and plant shapes for artistic, space-saving, or ornamental purposes. Some cultivars are selected for weeping or contorted forms.
- d. Foliage density: Most coniferous evergreens and some deciduous trees and shrubs have very dense foliage; thus, the shadows cast by them form dense shade, affecting growing conditions. Trees with dense foliage are very effective at blocking unpleasant views. Most deciduous trees create filtered shade, and distant views can be glimpsed through their foliage.

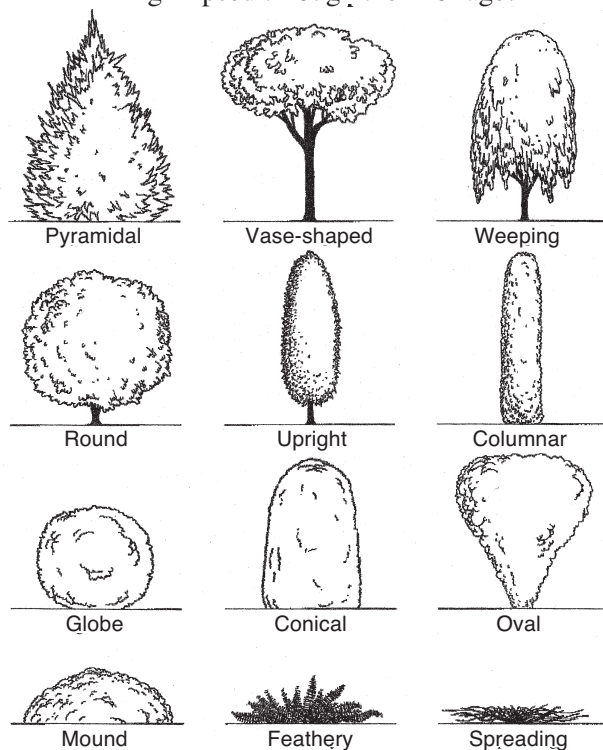


Fig. 1. Plant shapes.

- e. Crown size and height: Knowing the approximate size at maturity of trees, shrubs, and groundcovers allows the landscaper to plant them where they can develop to maturity. Plant descriptions generalize height and spread, or width of a plant, based on average growing conditions. Mature height and spread is greatly influenced by the length of the growing season, temperature, light, water, soil type, fertility, and other factors. This makes it impossible to predict the exact mature size of a plant.

Trees, shrubs, and ground covers can be categorized by height into: large trees (50 feet and over); medium trees (25 to 50 feet); small trees (under 25 feet); large shrubs (8 feet and over); medium shrubs (5 to 8 feet); small shrubs (3 to 5 feet); very small shrubs (under 3 feet); tall ground covers (under 2 feet); and short ground covers (under 1 foot).

- f. Longevity: Short-lived trees and shrubs are often quick growing and will give height and bulk in a short period of time. They may be susceptible to pests and weather-related problems. Long-lived species have strong trunks, sturdy wide-croched branches, and tend to tolerate winter storms, pests, and human damage.

- g. Hardiness zones: Select plants adapted to your climatic zone. There are several types of hardiness zone maps. The most commonly used one is that developed by the USDA (see Fig. 1, Chapter 15, page 15-3). Other maps include the Arnold Arboretum Hardiness Zones, the Sunset Western Garden Book Climate Zones, and the heat zone map of the American Horticultural Society.

Whichever map you use, the zone concept is a useful tool to give you an idea of how well adapted a particular plant is to your particular climate. When choosing woody ornamentals that will be long lasting and have dominant fea-

tures of your landscape, it is essential to choose plants that will not be damaged by an extreme climatic event. Be conservative in your choice and plant woody ornamentals adapted to one zone colder than your zone.

- h. Salt tolerance: Salt accumulation plays an important role in woody ornamental performance. In arid regions, soluble salts have accumulated at the depth to which soil moisture soaks each season. These salts can be brought to the surface with irrigation. If water sources contain high levels of salt, woody ornamentals can be injured. Salt used for winter ice removal on roads can also cause problems.

Too much salt interferes with the plant's ability to take up water, causing leaf burn and decline. Even salt-tolerant plants will not grow where salt levels are high. Plants native to a region have adapted to existing salt conditions.

- 3. Ornamental characteristics—Ornamental characteristics of the plant such as flowering, fragrance, foliage color, foliage texture, plant color, etc. must be considered by gardeners and landscapers during the selection process (Table 1).

The style of the garden needs to be considered as well. Whether the garden is cottage, Mediterranean, tropical, oriental, formal, artistic, avant-garde, rustic, naturalized, or native plays a key role in the types of woody ornamentals selected. Finally, how the garden will be used and maintained should also guide design and plant decisions.

Plants that accent, define boundaries, and/or are a special feature must be selected with specific goals in mind. Numerous landscaping books, computer programs, and publications can assist the plant selection process (see Further Reading). More on arranging the form, shape, and space of woody ornamentals is covered in Chapter 15.

- D. Site Considerations—Site analysis (climate, soil type, water availability, hardscapes,

utility location, aspect, access, etc.) is covered in Chapter 15.

In choosing plants, introduced pests (bronze birch borer, Dutch-elm disease, etc.) must also be considered. In order to minimize maintenance and the need for pest control, selecting the right plant for the existing conditions is essential. Even features such as dropped fruit, seed pods, or resulting seedlings must be considered.

IV. Getting Started with Woody Ornamentals

During the planning stage, make sure to find out what species will grow in your locality and make a scale drawing of your site to provide a basic plan that you can use and update. As trees and shrubs are essential elements of this plan, choose and buy them wisely and then plant them properly so you can have years of pleasure.

A. Purchasing Woody Ornamentals

Plants can be purchased from local nurseries, retail outlets that seasonally bring in wholesale nursery stock for resale, mail order companies, farmers' markets, nursery cooperatives, or at special plant sales sponsored by service or gardening organizations. Select only vigorously growing plants that are in good soil and are correctly labeled. They should be well-maintained and insect, weed, and disease free. Check the graft unions on plants that require this type of propagation. Beware of "good deals" at the end of the summer, for these plants may be stressed or root bound.

- 1. Local nurseries—Local nursery operators know the planting dates of your area and have experience with varieties suited to local needs and common problems. They also have selected plants that are adapted to your climatic conditions or soils. In many cases, local nursery operators are willing to special-order plants not in stock. In addition, they will generally guarantee the plants they sell.

If you personally select your plants, have your plan and plant list in hand when you visit the nursery. Be open to new ideas and plants offered by plant professionals.

If you are buying several plants, request a volume discount.

2. Local retailers with nursery stock—Plants purchased from discount, hardware, drug, convenience, grocery, or produce stores may not be appropriate for your landscape. Prices are often lower due to volume discounts, the species may not be well adapted to your area, and plant maintenance may be lacking.
3. Mail order—Check over the catalogs carefully to make sure the plants meet all the criteria in your planting plan. Mail order plants will be bare root or potted. Plant size may be small, but if shipped correctly and planted promptly, they generally perform well in your yard or garden. When ordering over the phone or by mail order, insist on the same quality as from a local nursery. If you are not satisfied, return the item and request a refund. Most mail order nurseries guarantee the plants they sell.
4. Special plant sales—Service organizations, garden clubs, schools, or public agencies occasionally hold plant sales. This is a great opportunity to obtain rare or prized woody ornamentals from local sources. You may want to quarantine the plants in a holding area before planting them into your garden to avoid introducing new pests into your landscape. If offered plants by gardening friends that don't fit your landscape plan, are not healthy, or might become invasive, have the courage to decline their offer.

B. Genetic Adaptability

The climatic zones where the plant material for propagation is collected influences the ability of plants to adapt to new locations. This genetic makeup allows plants to perform well under one set of conditions and completely fail in others. Many plants are adapted across several climatic zones or hardiness categories. This hardiness is genetically determined.

For native plants that are propagated from seeds, it is generally true that the more southern the seed source, the less hardy the plant. For example, the red maple, *Acer*

rubrum, is native from Florida to Canada. Trees grown from a southern seed source will be less hardy than those grown from a northern source. The same might be said for plants grown on the East Coast and then planted in the West. This ability is often called plasticity among professional horticulturists and should be considered in selecting woody ornamental plants.

C. Planting Woody Ornamentals

The techniques required for successful transplanting of woody plants depend upon the kind of plant; its age and size; whether it is dormant or growing; its nutritional status; whether it is nursery grown, growing around the home, or a native plant; the species adaptability to the selected site; and the site conditions and climate of the area. For more information on this topic, see Chapter 16.

V. Maintenance of Woody Ornamentals

A. The First Season

The first year in a new site is critical for a woody ornamental. Survival is determined by care and conditions, and a good start helps a landscape planting fill in more quickly.

1. Water new plants to a depth of at least 2 feet at each irrigation. Soil type and drainage will determine the frequency. Generally, irrigation will be required every 5 to 7 days. Soil should drain and dry between waterings to allow adequate oxygen in the root zone and to reduce the possibility of root rot pathogen development. New plants will wilt in saturated soil due to a lack of oxygen around the roots. Light, shallow watering does not provide enough water to develop a wide, deep, root system, and aids in the deposit of harmful salts.
2. Do not fertilize during the first season. Excess fertilizer salts in the root zone damages the limited root system of a newly planted plant. Plants need a season to establish a vigorous root system before fertilizer pushes more foliage growth.
3. Newly planted shrubs and trees may be protected from the wind by erecting a barrier of burlap or other material or

wrapping. When wrapping, don't use plastic because it gets too hot under it. Bury small or horizontal plants in leaves or loose, unfinished compost after the first frost.

The first winter in a new site for a woody plant can spell life or death. Water less frequently in the fall (see section B4 below).

B. Irrigation of Woody Plants

Proper watering of woody ornamentals is probably the most important aspect of plant growth, beauty, and health. For more information on water management, see Chapter 6.

1. Water requirement—The amount of water needed by a woody plant is determined by species, size, air temperature, air humidity, light intensity, and wind movement over the leaves. A hot, sunny, dry, windy day adds up to a lot of water for a large tree. Many sites in Idaho have just such conditions.

The water-absorbing roots of trees occur mostly in the top 12 to 18 inches of soil. Their distribution extends well beyond the dripline (Fig. 2). Apply water over the entire absorbing zone. Expand water-holding basins around the base of plants on a yearly basis to accommodate the previous year's growth.

Irrigate to wet the soil to a depth of at

least 2 feet deep. The amount of water needed depends on the soil type; sandy soil holds less water than clay soil. As with newly planted trees, avoid keeping the root zone saturated in order to allow proper root aeration. Avoid shallow, frequent irrigation because this encourages shallow and limited root development.

2. Irrigation methods—Flood irrigation is an infrequent deep soaking. Accomplish the same on a small scale by flooding the basin around trees or shrubs using a bubbler hose attachment. This is the most efficient method of irrigation for isolated plants.

The most common method of irrigation is the sprinkler. Be sure to apply enough water to soak the root zone of trees and shrubs. *Enough water for the shallow roots of a lawn will not be enough for trees and shrubs.* Sprinkling the foliage of trees and shrubs can increase the potential for some diseases. Minimize this by sprinkling early in the morning so the plant can dry off over the course of the day.

Drip irrigation systems are extremely efficient and provide a slow source of water that works better with heavy soil. Apply water away from the trunk and in the area of water-absorbing roots. Update drip systems by adding more lines or emitters as the plants grow to provide enough water for the larger plant and root system.

3. Drainage—If you have a poorly drained area, select plants adapted to wet soil conditions. In extreme cases, install drain tiles before planting to carry excess water away from the planting site. Improve surface drainage by changing the grade or trenching.

Root zone aeration can help prevent puddling and runoff. If simple aeration (poking holes at regular intervals) doesn't work, drill holes 6 to 18 inches deep and backfill them with sand or pea gravel. This is called vertical mulching.

4. Winter water management—In climates where winters are cold and the ground is

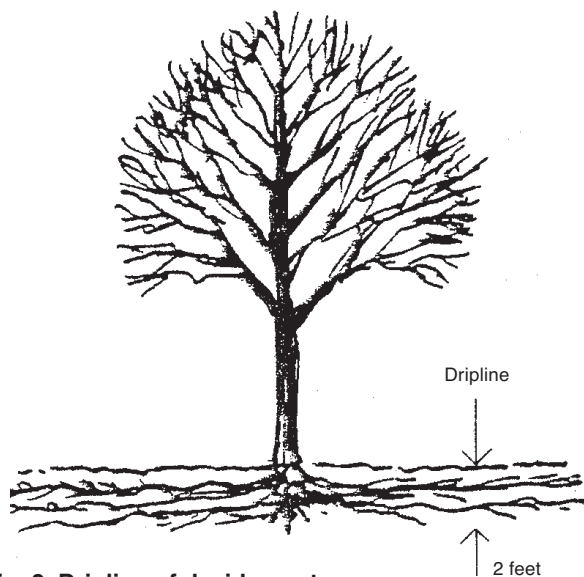


Fig. 2. Dripline of deciduous tree.

frozen, special care must be taken to make sure woody ornamentals enter the winter completely dormant and yet have an ample supply of sub-surface water to get through the winter. To accomplish this, gradually withhold water in late fall (after mid-September). This decelerates growth and helps the plant enter a dormant state. Continue this drying for 4 to 6 weeks.

Sometime just before the first hard freeze (October 15 to November 1), irrigate thoroughly. Add enough water to fill the entire root zone, and more, to capacity. This stored moisture will be available to the plant roots beneath the frozen layer of soil during the winter. Fall watering is particularly important for evergreens due to the amount of water that needles and leaves can lose on a sunny winter day.

C. Mulching Woody Ornamentals

The benefits of a mulched area around trees and shrubs are five-fold: (1) elimination of competition from weeds and grasses, (2) conservation of soil moisture, (3) moderation of the soil temperature, (4) protection of trees from lawn mower and weed eater damage, and (5) growth of a more extensive root system.

1. How to mulch—The mulch layer should be 2 to 3 inches in depth at least to the dripline of the tree. Don't place mulch against the plant trunk or stems because of the possibility of crown rot. Permeable landscaping fabric beneath the mulch will help control weeds. Do not use plastic as it will reduce water and air infiltration in the root zone.

Use of very fine or less permeable mulches, such as sawdust, encourages shallow rooting. Good mulches include coarse compost, bark chips, rocks, or gravel.

D. Symbiotic Relationships

Roots of many trees and shrubs form symbiotic relationships with fungi or bacteria.

1. Mycorrhizae—Mycorrhizal fungi live around and sometimes in the plant roots, obtaining carbohydrates, vitamins, and other organic compounds from the plant.

The zone of soil around the root inhabited by the fungi, known as the rhizosphere, is more hospitable to nutrient absorption by plant roots because of the association. Mycorrhizal fungi enhance the plant's tolerance of environmental extremes and its resistance to or tolerance of pathogens. Many of the "mushrooms" seen in the landscape at some distance from trees are fruiting bodies of mycorrhizal fungi.

Commercial products are available that contain a mixture of fungus types to mix with the soil when planting trees and shrubs. These are new products and more research is needed to prove their value. Although mycorrhizal spores are found in most soil, preliminary studies suggest these commercial products may speed the establishment of a symbiotic relationship.

2. Nitrogen-fixing—On some woody plants, specific bacteria induce nitrogen-fixing root nodules. Black locust, alder, ceanothus, and Russian olive, for example, are able to fix nitrogen to use in their own growth and for that of other plants in the same area. This makes them able to grow on nitrogen-poor sites.

E. Fertilizing Trees and Shrubs

Woody ornamentals require the essential elements to function. Too much nitrogen can promote excess growth that will only require more pruning and water and increase pests. On coniferous evergreens a "spurt" of growth in reaction to fertilizer can create whorls of branches further apart at the top of the tree and tips of the branches, detracting from the symmetry of the tree. If a woody plant is healthy, showing no nutrient deficiencies, and making satisfactory growth, it probably does not need to be fertilized. (see CIS 1068, "Fertilizing Landscape Trees," for more information, including rate recommendations).

VI. Pruning

A. The Basics

In the home landscape, trees and shrubs usually have ample light and space, and they produce a lot of branches and grow to a

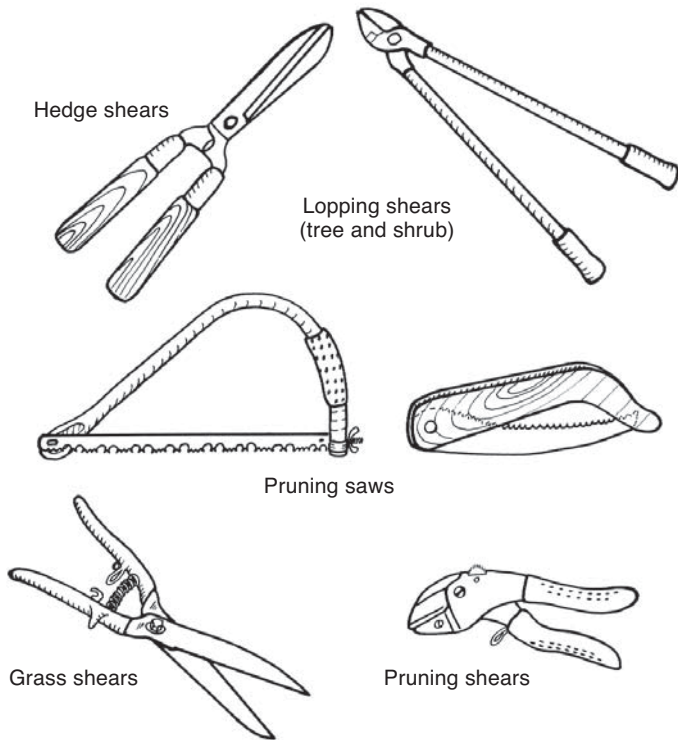


Fig. 3. Various types of pruning tools.

maximum size. Proper pruning shapes or trains these plants into appropriate and beautiful forms, while maintaining and augmenting their health and function.

Proper tools are essential for satisfactory pruning (Fig. 3). The choice of which tool to use depends largely on the size of branches to be pruned and the amount of pruning to be done. If possible, test a tool before you buy it to ensure it suits your specific needs. As with most tools, higher quality often equates to higher cost.

1. Reasons for pruning—Training young trees and shrubs to create attractive shapes and a strong structure is always a good reason. Prune older plants to remove dead, diseased, hazardous, or unsightly branches. Pruning to maintain a central leader is sometimes necessary, as is removal of branches that interfere with activities and structures. Pruning can enhance flowering and fruiting. It can also open up a tree for less wind resistance and better light penetration. Shrubs may need pruning to create a fuller look or to maintain a special shape or form such as in hedges.

Probably the worst reason to prune is to control the size of the plant. You cannot make a large woody plant small! Such pruning is a temporary, expensive, and damaging “fix.” The best solution is to remove the too-large woody plant and replace it with one whose mature size is more suited to the growing space.

2. Timing—Do light pruning or removal of dead wood at any time. On coniferous evergreens, make heading cuts (see A3, below) back to buds or light thinning cuts at any time. The most common pruning time is during winter, when the plants are dormant. This results in vigorous spring growth. Pruning coniferous evergreens during the dormant season will maximize regrowth, and cuts will be covered, making the plant look more natural.

Prune plants that bloom on the current season’s growth (new wood), such as *Potentilla* sp., during the dormant period. Wait until the coldest part of the winter has passed but before buds swell. Some plants such as maples, walnuts, birches, and grapes may bleed when pruned just before or during sap flow. Though unsightly, this does no harm to the plant and will stop as the season progresses.

Prune plants that bloom on wood from the previous year, such as lilac and forsythia, in the spring right after the flowers fade. Winter pruning will decrease the number of flowers the following spring. Pruning coniferous evergreens after the annual flush of spring growth will maintain size and preserve atypical, or clipped, forms. Pruning off part of the new growth while it is still growing will reduce the length of new growth and encourage branching.

Summer pruning, done after spring growth has stopped, slows the development of a plant or branch. This is because of reduced photosynthetic capacity from fewer leaves, which reduces the amount of food manufactured and sent to the roots for their development and next year’s growth of the crown. Prune in the summer cautiously, as it can weaken the

tree or shrub to the point of death.

Late summer or fall is not a good time to prune. Any new growth stimulated by late summer pruning will be susceptible to frost damage and the threat of introducing diseases is greater.

3. Pruning cuts—There are two basic pruning cuts: thinning and heading (Fig. 4).
 - a. A thinning cut removes a branch back to a lateral branch big enough to assume the terminal role. The lateral branch should be at least half the size of the branch being removed. In other words, if a branch 6 inches in diameter is being removed, thin it back to one no less than 3 inches in diameter. Branches thinned can be smaller, the same size as, or at the most, twice the size of the branch being thinned to. This type of cut opens up a tree, reduces the weight of limbs, can reduce the overall height, evenly distributes the invigorated new growth, and helps retain the natural growth. Thinning cuts are made at a point in the wood where wounds can heal. This is the preferred cut for ornamental trees. Thinning cuts are also those on small branchlets made to a bud that will break and assume the terminal role.
 - b. A heading cut removes a branch to a stub, to a small bud, or to a lateral

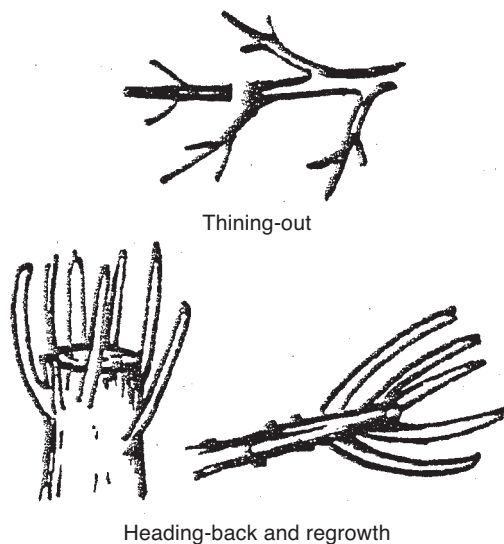


Fig. 4. Thinning and heading are two types of pruning cuts.

branch not large enough to assume the terminal role. This type of cut induces branching and bushiness below the cut. Heading cuts, which are commonly used for fruit trees, are usually not appropriate for ornamentals especially trees. Numerous vigorous upright shoots arise below the cut, especially on larger branches, altering the tree's natural form.

- c. "Topping" a tree is cutting all its major branches back with heading cuts deep into the center of the tree. Cutting the top off a tree is NOT an acceptable pruning practice. Topping results in an ugly, deformed tree with weak branches. These trees often become infected with decay organisms and are more susceptible to insects and diseases. Within a few years, they are back to their original height because of bushy growth, but are ugly as well as hazardous due to the weakly attached numerous branches.
 - d. Cutting off the top of a coniferous tree will result in multiple leaders or a flat top—in any case, the natural shape of the tree is destroyed. The older the evergreen tree is at topping, the less likely a lateral will become a new leader. Although the tree may appear to be healthy, research has shown that serious decay often develops at the wound site. This decay moves down the trunk, creating weakly attached lateral branches and a hazardous tree.
4. Where to make the pruning cut—At the base of branches there is a layer of cells that is very important to plant health. If the branch is broken off or dies, this layer of cells fills with decay-blocking chemicals such as terpenes and phenols and forms a protective area that not only keeps out decay, but facilitates healing. The challenge for the person pruning off the branch is to leave this layer of cells intact so that it can do its work for the tree.

The branch collar indicates the location of this layer of cells. This is a slightly

swollen area where the branch attaches to the trunk. Sometimes plants have a branch bark ridge where the bark grows upward because of the internal branch tissue that separates the branch from the trunk. Make pruning cuts just outside the branch bark ridge and/or collar.

5. How to make the pruning cut—Cut branches larger than about 2 inches with an undercut three-step method to prevent limb breakage and bark stripping (Fig. 5). Cut part way through the branch at A. Then cut completely through the branch at B. The final cut is made at C to D, just outside of the branch collar. Cut to preserve the branch collar and the bark ridge. Do not cut at C to X. Avoid removing branches over 6 inches in diameter, as bigger wounds do not heal quickly and decay is more likely. Remember, the branch you thin back to must not be smaller than half the size of the one you remove.
6. Wound dressings—Wound dressings and tree paints are cosmetic only. Research has shown that pruning paint or wound dressing does not protect cuts from insects or diseases or promote healing. In fact, some research suggests wound dressings may actually inhibit the healing process.

B. Early Training of Deciduous and Broadleaf Evergreens

By establishing early a good framework (or scaffolding) of branches, deciduous plants

such as ash and broadleaf evergreens such as holly will grow to fill their allotted space. They will have few structural problems and require minimal to no further pruning.

1. Establishing the framework of trees—
 - Training should begin the tree's second year. When cutting out branches, maintain at least two-thirds of the plant as a live crown, as overpruning can damage and even kill a tree.
 - Train to develop a central leader, strong branches, a straight strong trunk, and a good form.
 - a. Central leader: The central leader reaches higher than any other branch. A single leader is obvious, so it is easy to thin the tree to maintain the dominance of this branch. Sometimes, however, trees have many laterals that are of similar length. In this case it is up to you, the tree trainer, to choose the one with the best placement to be the leader, shortening the others into a pleasing and appropriate form.
 - b. Branch strength: The object is to promote strong branches that will not require expensive corrections later in the tree's life. The ideal branch angle is the 10 or 2 o'clock angle (Fig. 6). When crotch angles are very narrow, bark can become "trapped" between the two branches as they grow. Where the bark is trapped, there is no structural attachment; thus, the attachment is weak.

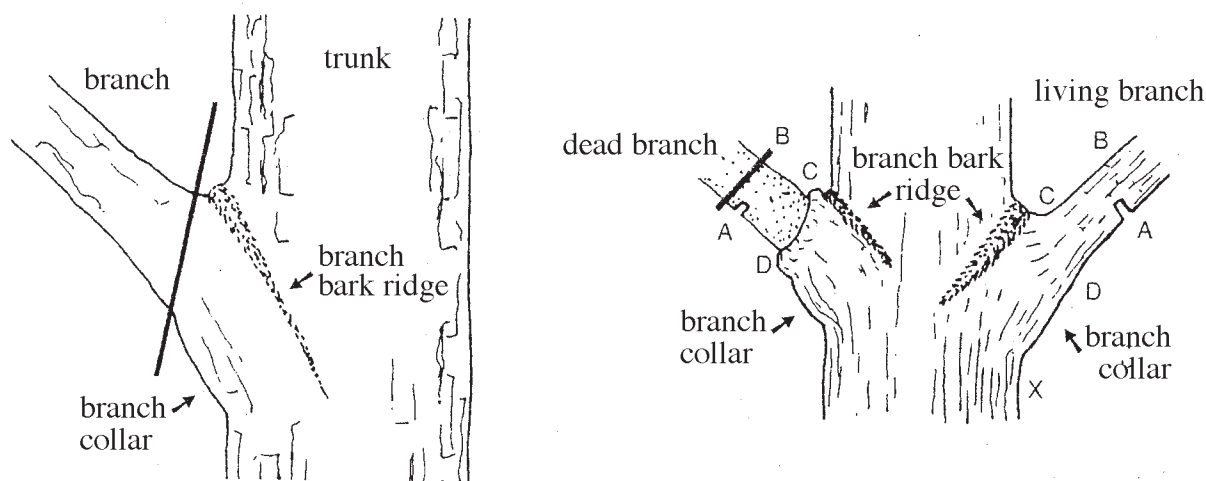


Fig. 5. Proper methods of pruning cuts.

Encourage a critically placed small branch with a narrow crotch angle to grow to a better angle by bracing it open with a stick placed between the branch and the trunk. Leave this brace in place until, when removed, the branch stays at the wider angle (Fig. 7). Deciduous trees have narrow crotch angles and develop bark inclusions more often than coniferous trees. Remove rubbing branches, as they result in wounds, decay, and notches.

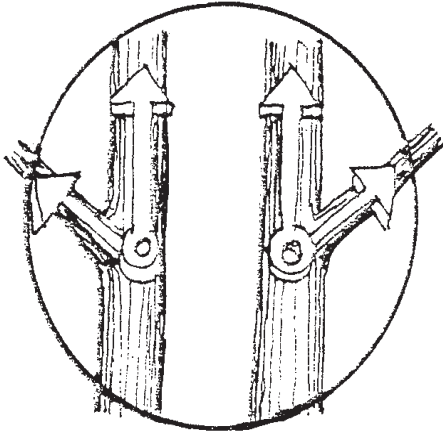


Fig. 6. Ideal branch pruning angle is 10 or 2 o'clock.

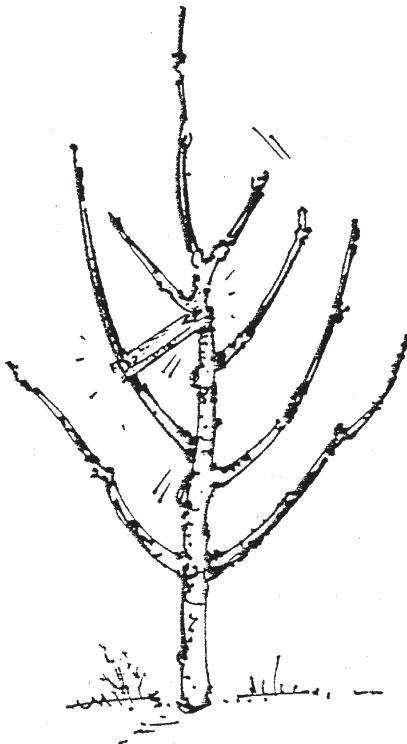


Fig. 7. Brace a narrow-angle branch until trained to grow at a wider angle.

When choosing between rubbing branches, remove the most damaged branch with the narrowest crotch angle.

Water sprouts and suckers can occur at the base or inside the crown. They are rapid growing, weakly attached shoots that should be removed as soon as possible. Rubbing them off (rather than cutting) is possible when they are very young and helps to keep them from resprouting.

If a young tree is deformed by the wind, it leans in the direction the wind blows. To correct this lean and to promote a stronger tree, prune the leader and laterals on the downwind side to more upright branches. If done during the summer, this will slow growth on these branches.

- c. Trunk strength: Develop a strong, well-tapered trunk by keeping some branches below the lowest permanent branch on your young tree. Leave these for 3 to 4 years in a shortened form. Don't let them become large and vigorous. Remember, they are only protecting the young bark from sun injury, and their wood adds taper and strength to the trunk. They will not be an ultimate part of the crown of the tree. After 3 or 4 years, remove them a few at a time over the next 2 to 3 years, beginning with the largest ones. Staking of young trees may become necessary if they have a small trunk diameter in relation to the tree height. Trunks grow strengthening "reaction wood" when they move back and forth in the wind; thus, be sure your tree is free to move in the wind. Secure the tree to stakes some distance from the trunk with bands that will not damage the trunk. Tie as low as possible to still hold the tree upright on a calm day. Remove this staking as soon as possible within one year (Fig. 8).
- d. Good form: Train to create a tree that has a pleasing shape with branches growing in the right direction for the

space it is to occupy. Respect the natural growth habit of the tree when establishing an initial framework of branches. The mature shape (round, columnar, pyramidal, etc.) should be evident, even in a tree with only five or six branches.

Thin the laterals that compete for space and light. They should be 12 to 18 inches apart on the main trunk on deciduous trees. Choose branches that come off in different directions around the tree to create a balanced form and decrease competition for space and light. Be sure to remove any crossing

and inward-growing branches first. Eliminate any branches that grow in opposition to the natural form of the tree. Thin any co-dominant branches (those that grow out from a single point like a Y) to a single branch, keeping the one with the best crotch angle (Fig. 9).

Keep in mind what the tree will look like when all these branches get longer and bigger in diameter. Direct them to an area where they can develop to maturity without pruning. Remember that branches do not move upward as the tree grows in height. If you are hitting your head on a 1-inch branch, in a few years you will still be hitting your head, but the branch will be 6 inches in diameter! Prune out problem limbs early.

2. Establishing the framework of shrubs and vines—Some deciduous and broadleaf evergreen shrubs grow large and have permanent scaffolds. Examples are viburnums and magnolias. Most coniferous shrubs such as junipers have permanent trunks and branches. Essentially, they are small trees with multiple trunks, so establish their framework as described earlier.

C. Early Training of Coniferous Trees and Shrubs

Training conifers such as spruce, pine, and juniper takes special consideration. Many coniferous trees have pyramidal forms, regular whorls of growth, and tall, straight trunks. Conifers often develop multiple leaders, so maintaining a single central leader is important in order to have a properly shaped mature tree. Remove all but one leader on coniferous evergreens with thinning cuts. Other than this, coniferous plants need little training—unless the goal is to make a hedge or clipped shape. Train random branching conifers early so they will develop attractively to fill their allotted space.

1. Buds and pruning effects—Some plants have buds on older wood that, under normal conditions, do not grow, but if part of the plant dies or is pruned off, these la-

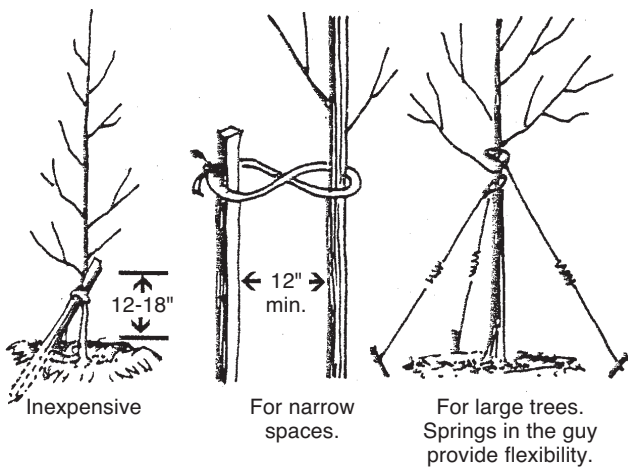


Fig. 8. Three ways to stake a young tree.

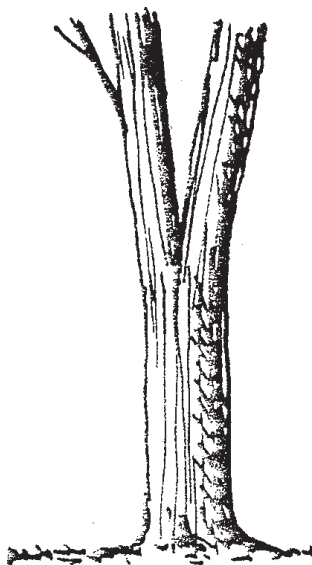


Fig. 9. Trim co-dominant “Y” branches to a single branch.

tent buds will grow. Conifers with latent buds on older wood, such as yew, can be pruned more severely because these buds will grow. But conifers without latent buds, such as pines and junipers, should not be cut down to old wood. Severe and heading cuts will result in dead zones and stumps. Conifers with and without latent buds are in Table 2.

2. Pruning cuts—Use thinning cuts when pruning conifers. Thinning cuts are less noticeable and create an open, natural-looking plant. Coniferous plants with good latent buds, such as yews and hemlocks, will respond to heading cuts. Strong, new foliage growth will result. Shearing, which is when all the small branches are cut off to produce an even shape, produces a lot of heading cuts. Shearing shapes plants and increases branch density. Shearing without some thinning can cause the center of the plant to die from lack of light, increasing dead zones.
3. Pruning related to branching patterns—Random-branching conifers such as yew or hemlock can grow both from tips (like

the whorled types) and from lateral points. They can be pruned more than once during the growing season and will produce a flush a growth each time. Use either shearing or thinning cuts for pruning random branched conifers. But remember, don't cut into the dead zone if the plant has no latent buds on old wood. Nothing will grow in the dead tangle of branches and the beauty of the plant will be ruined.

4. Conifers with whorled branching patterns, such as fur and spruce, make a single flush of spring growth, so they will not tolerate frequent or severe pruning. Shorten or shear the new growth of these plants in the early spring as the plant is expanding. This will make the growth more dense and also restrict the size of the plant (Fig. 10). You can also prune these trees back to dormant buds after new growth is finished or before growth begins in the spring (Fig. 11). Thin unwanted branches to another branch at any time of the year. Table 2 lists conifers with whorled and random-branching patterns.

Table 2 Branching patterns and latent buds on coniferous plants.

Whorled branching pattern

Latent buds in old wood?

| Yes | No |
|--|---------------------------|
| Spruce (<i>Picea</i> spp.) | Pine (<i>Pinus</i> spp.) |
| True fir (<i>Abies</i> spp.) | |
| Douglas-fir (<i>Pseudotsuga menziesii</i>) | |

Random branching pattern

Latent buds in old wood?

| Yes | Some | No |
|------------------------------|--|--|
| Hemlock (<i>Tsuga</i> spp.) | True cedar (<i>Cedrus</i> spp.) | Juniper (<i>Juniperus</i> spp.) |
| Yew (<i>Taxus</i> spp.) | Larch (<i>Larix</i> spp.) | False cypress (<i>Chamaecyparis</i> spp.) |
| | Dawn redwood (<i>Metasequoia glyptostroboides</i>) | Arborvitae (<i>Thuja</i> spp., <i>Platycladus</i> spp.) |
| | Cryptomeria japonica | Incense cedar (<i>Calocedrus</i> spp.) |
| | Giant sequoia (<i>Sequoiadendron giganteum</i>) | Staghorn cypress (<i>Thuja occidentalis</i>) |
| | | True cypress (<i>Cupressus</i> spp.) |
| | | Western red cedar (<i>Thuja plicata</i>) |

*May be some on spur-like shoots or a few in older wood.

D. Pruning Mature Trees and Shrubs

As woody ornamentals grow, age, and mature they will require maintenance training and pruning.

1. Damage and disease—Physical damage often requires corrective pruning. Broken or dead branches should be removed with a thinning cut, observing all the pruning techniques outlined earlier. Sometimes, to maintain a good center of gravity, you can thin or remove limbs opposite the broken ones. After removing the broken branch, carefully smooth any torn or stripped bark and remove ragged edges of dead or dying bark (Fig. 12). Take the bark back to where it attaches to the tree. Keep the wound as narrow as you can to hasten wound closing.

If a pyramidal conifer loses its tip, help a branch in the top whorl become the new leader. Select the best and/or the longest, and bend and tie this branch upward to a pole securely fastened to the trunk. Check ties frequently to make sure they are not cutting the bark and remove the pole in 2 or 3 years (Fig. 13).

A plant struck by lightning may not be damaged; except for removal of broken branches, do nothing for 6 to 12 months. It may take this long for damage to become visible. If damaged, the tree will decline due to an injured root system or cambium.

2. Hazard trees and shrubs—A hazard plant has a structural defect that may cause the plant, or a portion of the plant, to fall on someone or something. Careful inspection and a rational assessment of problems determines what corrective measure to take.

If the entire tree is dead or dying, remove it. All dead branches are accidents waiting to happen. Remove them. Prune off weak spots on branches caused by rubbing. Forked (or co-dominant) trunks may signal a weak tree. A sudden lean in the entire tree is cause for action. Sudden dieback of top limbs may indicate root problems. Check for signs of internal decay by examining the plant for fruiting

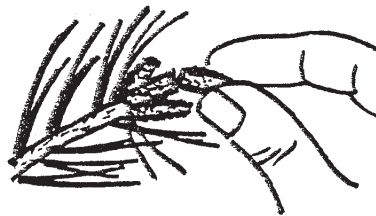


Fig. 10. By shearing in the spring, new growth will be dense and have restricted size.



Fig. 11. Trim conifers before or after new growth in spring.

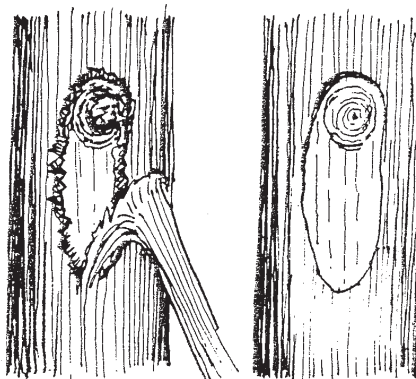


Fig. 12. Carefully remove ragged edges of dead or dying bark.

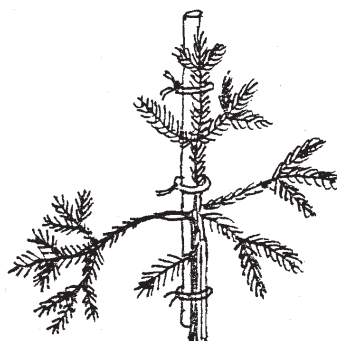


Fig. 13. Select a new leader on a top-damaged conifer and tie it to a vertically secure pole.

bodies of fungi (conks) or disfiguration (cankers). Conks at the base of the tree can indicate root and trunk decay.

A tree that has been topped has an increased risk of internal decay due to the large, unhealed wounds created by this type of massive cutting. Examine these carefully, possibly using an increment borer or an electric drill equipped with a 1/8-inch bit to test for soundness of branches and trunks.

Be sure to call a certified, professional arborist if you suspect you are dealing with a hazard tree. Hazardous conditions on plants need immediate care in order to protect lives and property.

3. Pruning mature trees—Mature trees require little to no pruning if they have been trained by proper pruning at planting and during the first few years of growth. If you have inherited an older tree with a poor shape or one previously topped, do remedial pruning following the guidelines in the next section.
4. Pruning mature deciduous and broadleaf evergreen shrubs—The unique characteristics of each type of shrub determines the pruning technique. When growing shrubs for flowers or fruit, it is important to prune to encourage this feature.
Shrubs that have a permanent scaffold, such as large viburnums and magnolias, and those that do not produce any new growth from the base are pruned like trees. These shrubs (like trees) produce flowers and fruit at the tips of branches.
With any shrub, as with trees, keep the natural form in mind and prune to develop this form by removing stems and branches that do not contribute to the desired shape.
 - a. Growth patterns and pruning: Observe *where* the flowers are produced on a shrub in order to know *how* to prune it. See Table 3 for a partial list of shrubs that produce wood from at or near the ground level throughout their lives (continuous basal growth). Prune these as follows:

- Prune plants that flower on the mid-portions of their stems to maximize production of 2- to 5-year-old wood. Do this by removing 1/4 to 1/6 of the oldest stems at or near the ground each year. Make thinning and heading cuts on the remaining stems as necessary.
- Prune plants that flower at the terminal tips of their stems to maximize production of terminal tips. Do this by removing a few older canes and spindly new canes at or near ground level. Head back vigorous canes to force branching and new tips where desired, and thin others as needed.
- Thinning cuts on deciduous and broadleaf evergreen shrubs preserve the shrub's natural form. Direct growth by thinning back to a vigorous side branch that points in the desired direction. Remove inner growth to open up a dense shrub.

Table 3 Shrubs with continuous basal growth.

Plants flowering on mid portions of stems:

Barberry (*Berberis* spp.)
Beauty bush (*Kolkwitzia amabilis*)
Brooms (*Cytisus*, *Genista* spp.)
Cotoneaster spp.
Flowering quince (*Chaenomeles* spp.)
Forsythia spp.
Holly (*Ilex* spp.)
Honeysuckle (*Lonicera* spp.)
Kerria japonica
Mock orange (*Philadelphus* spp.)
Spiraea spp.

Plants flowering on terminal tips:

Azaleas, evergreen (*Rhododendron* spp.)
Dogwoods, shrubby (*Cornus* spp.)
Hydrangea spp.
Lilac (*Syringa* spp.)
Magnolia spp., shrubby
Oregon grape (*Mahonia* spp.)
Photinia spp.
Potentilla fruticosa
Privet (*Ligustrum* spp.)
Rhododendron spp. (and deciduous azaleas)
Serviceberry (*Amelanchier* spp.)
Viburnum spp.

Carefully observe where flowers are produced on species not listed.

Use thinning cuts to maintain the size of a shrub.

- Heading cuts on deciduous and broadleaf evergreen shrubs stimulate the development of shoots right below the cut, resulting in denser growth. Make cuts where you want branching. Use heading cuts sparingly unless you are shearing a formal hedge, topiary or other atypical shape. Heading cuts result in an undesirable bushy or topped look.
- b. Flowering period and pruning: Observe *when* the flowers are produced on a shrub to know *when* to prune it. See Table 4 for a partial list of spring and summer flowering shrubs. Prune shrubs that bloom in the spring right after flowering to maximize bloom the next year. Prune shrubs that bloom in the summer in late winter or very early spring to maximize bloom and fruit.
5. Pruning mature coniferous shrubs— It is very important to train coniferous shrubs when they are young. Pruning needs to begin as the plant approaches the desired size, not after they are oversized. See section C for information on growth pattern, bud distribution, and methods and timing of pruning for the various types of coniferous plants.
6. Hedges— A hedge is a row of closely spaced shrubs or trees, usually of one kind, grown informally as a row of natural-looking shrubs or formally with a lot of training and shearing. Pruning cuts are thinning and/or heading cuts to relatively small limbs. Train hedges to be wider at the base than at the top to prevent die-

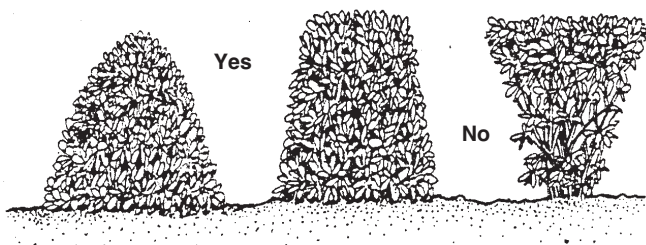


Fig. 14. Trim hedges to be wider at the bottom to prevent dieback.

back of lower foliage due to inadequate light (Fig. 14). Do not prune hedge plants at planting or during the first year of growth. To renovate an old hedge see section E.

- a. Informal hedge: To have an informal hedge, train and prune as with indi-

Table 4 Flowering shrubs.

Examples of spring flowering shrubs:

- Azaleas, deciduous and evergreen (*Rhododendron* spp.)
- Barberry, deciduous and evergreen (*Berberis* spp.)
- Beauty bush (*Kolkwitzia amabilis*)
- Brooms (*Cytisus*, *Genista* spp.)
- Daphne* spp.
- Dogwood, shrubby (*Cornus* spp.)
- Flowering almond (*Prunus triloba*)
- Flowering plum (*Prunus cistena*)
- Flowering quince (*Chaenomeles* spp.)
- Forsythia* spp.
- Heather (*Erica* spp.)
- Honeysuckle (*Lonicera* spp.)
- Kerria* sp.
- Lilac (*Syringa* spp.)
- Mongolia (*Magnolia* spp.)
- Mountain laurel (*Kalmia latifolia*)
- Oregon grape (*Mahonia aquifolium*)
- Pieris* spp.
- Pussy willow (*Salix* spp.)
- Serviceberry (*Amelanchier* spp.)
- Siberian pea shrub (*Caragana arborescens*)
- Spiraea* spp. (white flowering types)
- Viburnum* spp.
- Weigela* spp.
- Witch hazel (*Hamamelis* spp.)

Examples of summer flowering shrubs:

- Butterfly bush (*Buddleia davidii*)
- Cherry laurel (*Prunus laurocerasus*)
- Chokeberry (*Aronia arbutifolia*)
- Cotoneaster* spp.
- Euonymus* spp.
- Heather (*Calluna* spp.)
- Heavenly bamboo (*Nandina domestica*)
- Holly (*Ilex* spp.)
- Hydrangea* spp.
- Mock orange (*Philadelphus* spp.)
- Potentilla fruticosa*
- Privet (*Ligustrum* spp.)
- Pyracantha* spp.
- Roses, shrubby (*Rosa* spp.)
- Rose of sharon (*Hibiscus syriacus*)
- Spiraea* spp. (pink flowering types)
- St. John's wort (*Hypericum* spp.)
- Tamarix* spp.

Carefully observe when blooming occurs on species not listed.

vidual plants, striving to keep them similar in shape, density, and height. You will need to pay special attention to keeping the foliage dense from the ground up.

With new deciduous and broadleaf evergreen hedges, induce low, dense branching by heading back the entire plant as much as halfway down its growth the second year after planting in late winter or early spring. With new conifer hedges, in the second year, prune the tips of the new growth as, or just after, it elongates to increase branching. (Head yew and hemlock the same as deciduous and broadleaf evergreen plants.)

After the second year, and in established hedges, make judicious heading cuts interspersed with conservative thinning cuts to create the desired shape and size. Do maintenance pruning in late winter to early spring for maximum growth. For dwarfing, prune in midsummer. Remove an occasional branch at any time.

- b. Formal hedge: To establish a formal hedge do not prune at planting or during the first year of growth. During the second year prune the same as for informal hedges (see above).

In the third year, shear new shoots one-half to two-thirds of their length every time they grow 6 to 12 inches. Shear conifers whenever growth elongates (will probably be less than 6 inches long). Do not prune after midsummer. Continue this in successive years until the hedge reaches the desired width. Then allow the hedge to grow more in height than width until it reaches the desired height. Do this by shearing new growth on the sides shorter (and less frequently) than the shoots on the top.

Prune all established, full-grown formal hedges once after the season's growth ends. If you want a very formal effect, you will need to shear more than once during the growing season.

For a looser, less formal effect, shear only once in midsummer. At each shearing, remove new growth to within 1/2 inch of the previous shearing, leaving only one to three new leaves and buds.

- 7. Vines—Prune and train vines according to their growth habit. Vines that are natural climbers support themselves by aerial roots (English ivy) or sucker pads (Boston ivy). These vines grow on walls and other supports. The twining vines, such as honeysuckle, Virginia creeper, clematis, and wisteria, climb by curling or twining their leaf tendrils, leaf stalks, or stems on some kind of support system. The scramblers and floppers, such as roses, need to be tied to a support system.
 - a. Training: Any required support should be in place when planting the vine. Direct or train the branches of the vine in the directions desired.
 - b. Pruning: Treat vines the same as shrubs. Determine how to prune by where the flowers are produced and when to prune by when flowering occurs (see sections D4a and b). Besides encouraging flowering, fruiting, and new growth, reasons to prune vines include removal of weak or diseased wood. Prune any vine with a permanent framework like you would a tree.
- 8. Woody groundcovers—Low-growing woody shrubs and vines often serve as ground covers. Prune these plants as though they were flowering or non-flowering deciduous, broadleaf evergreen, or evergreen shrubs.

E. Renovation and Rejuvenation Pruning

Removal of large amounts of wood may be needed on older woody plants because they have become too large or grown into obstructions, were pruned wrong at an earlier time, have little flowering wood, lack vigor, or are unattractive. Renovation may also be necessary on plants that have died back from winterkill or other damage.

Because of the danger of electrocution, if a tree needing pruning is growing near a power line, be sure to contact your power

company or hire a professional arborist. Remember to remove any plant that is too large for its growing space when correctly trained. Replace it with a plant of a more appropriate mature size.

1. Deciduous and broadleaf evergreen trees.

a. Pruning untrained older trees: If you have a tree that has never been pruned and is seriously tangled and perhaps damaged, approach pruning from the standpoint of “better late than never.” Follow the guidelines for pruning deciduous and broadleaf evergreen trees in section VI-B. Often removing all the dead and damaged wood, rubbing branches, branches growing inward on the tree, and those branches growing outside of the natural shape of the tree are all that is necessary. That fact that a tree is older eliminates some pruning possibilities; for example, establishing a central leader or eliminating co-dominant branches may not be possible.

b. Drop crotching: This pruning technique allows the pruner to reduce the size of the tree without weakening the structure or creating an eyesore by thinning out the crown of a tree and reducing its height and spread. Limbs forming the perimeter of the tree are pruned at their junction with shorter, large-diameter side branches. This way a leader always remains, and its presence reduces latent bud sprouting and the bushy growth typical of heading cuts. This method is often used by utility companies when trees grow into power lines (Fig. 15).

c. Topped trees: Trees that have been topped or otherwise incorrectly pruned to a new height can sometimes be reshaped using thinning cuts and recommended training techniques. This requires removal of competing branches to lessen the bushiness at the ends of

the stubbed branches. It is best to remove the tree if substantial amounts of wood rot are found, or the tree is found to be in poor health, or if it is impossible to reconstruct a decent shape. Replace it with a recommended species for the site and space.

d. Directional pruning: If your tree was poorly placed initially and is now growing into an obstruction, such as overhead powerlines, consider removing it and replacing it with a properly placed or smaller tree. Trees properly pruned under or beside obstructions can continue to grow. This is directional pruning. It can result in V-shaped or one-sided trees (Fig. 16). Directional pruning is a better alternative than topping trees, since topped trees will eventually grow back into the obstruction.

2. Coniferous trees—Thinning cuts on coniferous trees can be made from the top down and the inside out in order to reduce wind resistance, if necessary. Remember to remove no more than one-third of the crown at one time. Mature conifers need little to no other pruning.

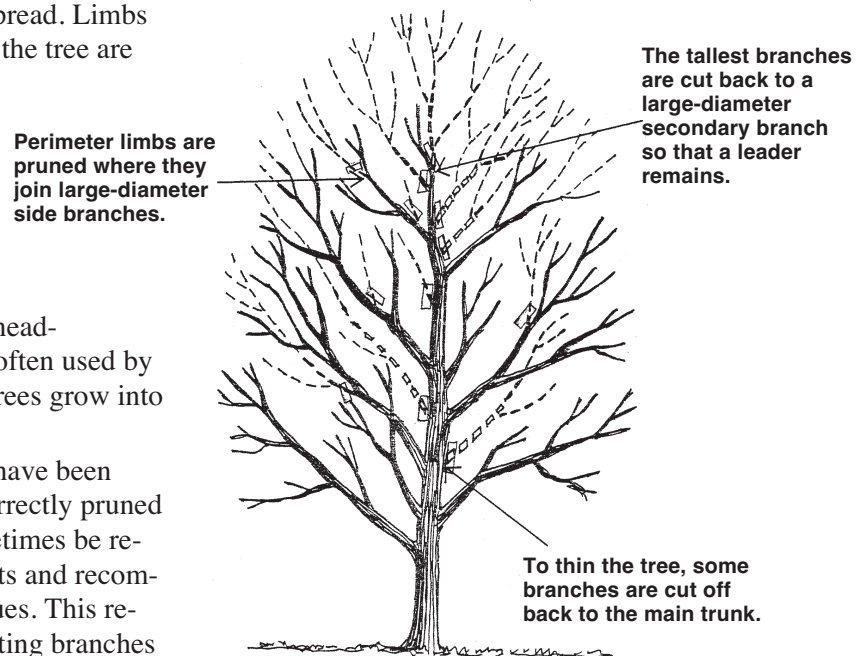


Fig. 15. Drop crotching reduces the size of a tree without weakening it.

3. Deciduous and broadleaf evergreen shrubs—Rejuvenate shrubs that exhibit continuous basal growth by heading back all stems to 3- to 5-inch stubs.

In shrubs with a permanent scaffold, rejuvenate by thinning and heading back to the basic limb framework. Boxwood, American holly, and almost all rhododendrons have good buds back to 3- to 5-year-old wood. Prune these severely. Cut back to 2- to 3-year-old wood on other species. Do this type of pruning in late winter to early spring before the new growth begins.

Once you have new vigorous growth that is about a foot long, be sure to selectively thin to remove weak, poorly placed, and excessive growth. This is very important to producing an attractive, healthy shrub.

4. Coniferous shrubs—Rejuvenating misshapen, broken or diseased coniferous shrubs is possible if the plant has good latent buds on older wood. See Table 2, which describes branching patterns and latent buds. Severe heading cuts into old wood will produce vigorous growth and much smaller shrubs. Later, be sure to thin new growth to create a desirable open form (unless the plant is a sheared hedge or topiary). Do this type of pruning in late winter to early spring before the new growth begins.

Rejuvenation is not really possible on coniferous shrubs without latent buds ex-

cept on younger twigs. To correct damage or remove dead branches, make the necessary corrective thinning cuts. Then prune new and young growth to increase new foliage density (see section VI-C).

VII. Protecting Trees and Shrubs During Construction

A. Construction Damage

Older trees contribute to the diversity of the landscape and should be preserved during construction if at all possible. Trees that should be removed include those in poor health, those that cannot withstand the necessary changes in their environment (such as shade-lovers suddenly exposed to full sun), those leaning over an existing or proposed structure, and those that will be 5 feet or closer to a constructed building or utility line.

Good pre-construction planning can often ensure that desirable trees can be left in the landscape. For instance, a flagstone walk rather than solid concrete or asphalt over a root system will allow aeration and water penetration to the tree roots. Work with contractors to designate areas for driving, parking, and materials storage. Stake out exact locations of trenches. If plants cannot remain where they are currently growing, consider transplanting any that are small enough or that can be dug with a tree spade.

1. Plant care during construction—Surround trees with a barrier that extends beyond the dripline during construction. This will keep heavy equipment from driving over the roots and from running into the trees. It will also keep chemical spills away from the root system.
2. Soil compaction—Compaction seriously limits the aeration and water penetration to root systems. The best solution is to keep all heavy traffic off of rooting zones. When this is not possible, spread several inches of wood chips or cover root areas with steel bridges, mesh matting, exterior plywood, or planks. This will help reduce compaction by spreading out the weight of heavy equipment.

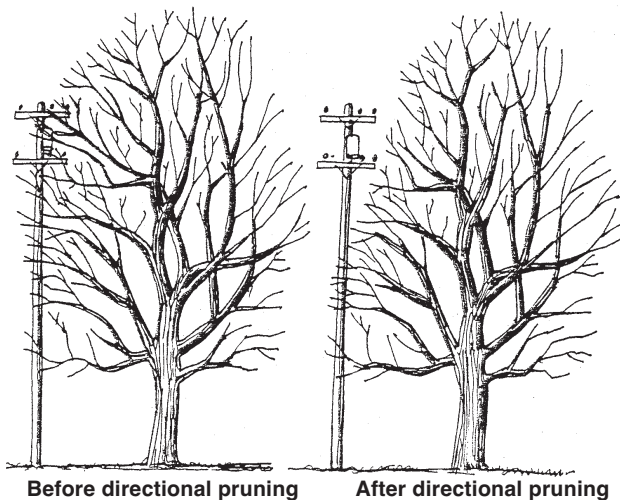


Fig. 16. Pruning can change the direction of a tree.

3. Cut roots—Severed roots can be very damaging to trees, reducing their water- and nutrient-absorbing capacity and sometimes affecting their stability in the soil. Careful selection of routes for underground utilities—detouring around root systems when possible—can reduce damage to roots. When that is impossible, tunneling, rather than trenching, is a good solution. To reduce damage on trees close to structures, substitute posts and pillars for footers and walls that require a trench.
4. Change in grade—Changes in grade can be avoided by using retaining walls to maintain the original soil level over the majority of the root zone. Also, tree wells or tree islands made as large as possible can help maintain the original grade over the root system and minimize cutting of roots. When a grade is changed more than 6 inches, vertical mulching can help modify the effect of extra soil.

VIII. Woody Ornamentals for Idaho

Given the hundreds of plant species, botanical varieties, and cultivars that can be grown in the Intermountain West, it is a challenging task to select the right trees, shrubs, vines, and groundcovers for your landscape.

A. Choices

A limited selection of woody ornamental plants suitable for Idaho is provided in this chapter; however, there are many other plant species and cultivars that may serve your needs. Table 5 suggests categories that can be used in selecting plants for different purposes and growing conditions. Consult the Internet, CD-ROM disks, resource books, local nurseries, landscape architects, your extension educator, and Further Reading in this chapter.

Use plant descriptions and photos to visualize what will best meet your own and your site's needs and preferences. Then, make a list and seek quality plants from the best sources. Be open to alternatives.

B. Idaho Conditions

In southern Idaho, summer temperatures and light intensity are high and humidity is

low. Northern Idaho has higher humidity and frequent cloud cover. Summer temperatures in southern Idaho are into the 100s during the summer, while northern Idaho experiences cooler temperatures (70° to 80°F). During the winter, dormant conditions, elevation, local microclimates, and temperature determine plant survival. Plants listed in garden publications from the eastern United States and lower coastal elevations often do poorly in Idaho.

C. Woody Ornamentals for Idaho

Table 5 lists some of the top woody ornamentals for Idaho. These plants have performed well or are deemed worthwhile for trial in Idaho. Selections were made based on Idaho research and recommendations from Idaho horticultural professionals, arborist associations, tree committees, urban foresters, and the Idaho nursery industry. This list is not all inclusive and does not list many other woody ornamentals that will grow in Idaho.

The following attributes are listed for the plants:

- Common name: The most widely accepted common name is given.
- Scientific name: Since several plants may share the same common name, the scientific name is included for precise identification.
- Desirable cultivars (cultivated varieties) are listed.
- Height: Mature height varies with your region in Idaho, microclimate, fertilizer practices, light source and intensity, and soil conditions. A range of heights is given for most woody ornamentals listed.
- Bloom time: Approximate time of flowering.
- Color: Refers to foliage color. Color for listed cultivars may vary.
- Light: Categorizes the plant into one or more light regimes: full sun is uninterrupted sunlight through the full day; partial shade is filtered sunlight through tree leaves or a minimum of 6 to 8 hours per day; full shade indicates filtered sunlight through a dense foliage canopy or less

- than 6 hours of sunlight each day.
- Use in landscape: Suggests planting locations as well as functions; for example, street tree, Xeriscape®, windbreak, or native. It also indicates if irrigation is critical.
 - USDA zone: These ratings are based upon the USDA plant hardiness zones for Idaho (see Fig. 1, Chapter 15, page 15-3) and upon reported preferences by region by Idaho plant professionals. Keep in mind that factors other than low temperatures affect plant survival in a specific area, and USDA zones should be used only as a guideline.
 - Idaho zone: Indicates in which part of Idaho this plant will perform best.
 - Growth habit: Provides a mental picture of mature form or outline of the plant.
 - Rate of growth: Refers to the vertical increase in growth unless specified differently. Rate is influenced by numerous variables such as soil, drainage, water light, and exposure. The designation “slow” means the plant grows 12 inches or less per year; “medium” indicates 13 to 24 inches of growth per year; and “fast” is 25 inches of new growth or greater.
 - Wildlife rating: Provides a guideline of reported attraction that wildlife have for many of the woody ornamentals and damage they do.
 - Utility rating: When available, this rating indicates whether this plant may be planted under power lines.
 - Source: Reference that lists this plant.

Table 5. Woody ornamentals for Idaho.

The following is a list of woody ornamental trees, shrubs, groundcovers, and vines for Idaho Master Gardeners. By learning the cultural, aesthetic, and climatic needs of these plants, best management practices in their growth and selection can be implemented. Most communities and regions in Idaho have plant lists. In addition to this list please seek out these resources in building a woody plant inventory. Several of the references at the end of this section have excellent additional information for plant selection.

The following key is used in this table:

- Height: At maturity with a range for most plants (spread for vines)
- Bloom: Season of flowering (Sp = spring; Su = summer; F = fall)
- Color: Predominant foliage color (Grn = green; Pur = purple; Yell = yellow; Gry = gray; Blu = blue; Wht = white)
- Light: F = full sun; P = part sun; S = shade
- Use in landscape: B = border; S = specimen; W = windbreak; St = street tree; X = Xeriscape; I = irrigation; N = native
- USDA zone: Idaho has USDA plant hardiness zones 3 through 6.

Idaho zone: 1 = northern Idaho; 2 = southwestern Idaho; 3 = eastern Idaho; All = whole state

Growth habit: P = pyramidal; V = vase shaped; W = weeping; R = round; U = upright; C = columnar; G = globe; O = oval; M = mound; F = feathery; S = spreading

Rate: F = fast growth; M = medium growth; S = slow growth

Wildlife rating:

- 1 = Protective—Rare damage
- 2 = Protective—Slight damage
- 3 = Beneficial—Some damage
- 4 = Attractive—Severe damage

UR (utility rating):

- _ = Recommended for planting under powerlines
- ? = Questionable for planting under powerlines
- Ø = Not recommended under powerlines
- \$ = Extreme expense; NOT recommended under powerlines.
- * = Not a concern under powerlines

Source: The referenced sources that list these plants as growing in our region.

Table 5. (cont'd) Woody ornamentals for Idaho.

| Common name | Scientific name | Height | Bloom | Color | Light | Use | USDA | Idaho zone | Habit | Rate | Wilf-life | UR | Source |
|---|--|--------|-------|----------|-------|--------|------|------------|-------|------|-----------|----|--------|
| <i>Large deciduous trees—Over 50 feet</i> | | | | | | | | | | | | | |
| Ash, Green | 'Fraxinus pennsylvanica' 'Bergeson' 'Marshall' 'Patmore' 'Urbanite' | 50-60' | - | Grn | F | S,W,X | 3-6 | All | U, S | M | 1 | Ø | 1,2,6 |
| Ash, Raymond | 'Fraxinus oxycarpa' 'Raymond' | 40-50' | - | Grn | F | S | 5-6 | 1,2 | O,U | M | 1 | Ø | 2 |
| Ash, White | 'Fraxinus americana' Autumn Applause® Autumn Purple® 'Rosehill' Skyline® | 50-60' | - | Grn | F | St | 4-6 | 1,2,3 | O,U | M | 1 | Ø | 1,2 |
| Aspen, Quaking | 'Populus tremuloides' | 30-50' | - | Grn.Gry | F,P | S,I | 3 | All | S,U | F | 2 | Ø | 1 |
| Beech, European | 'Fagus sylvatica' 'Asplenifolia' 'Riversii' 'Roseo-Marginata' 'Pendula' | 50-70' | Sp | Grn/Pur | F,P | S, | 5-6 | 1,2 | O,U | S | 2 | Ø | 2,6 |
| Birch, River | 'Betula nigra' Heritage® | 40-60' | - | Grn | P,S | S,N | 4-6 | 1,2,3 | O,U | M | 2 | Ø | 2 |
| Coffeetree, Kentucky | 'Gymnocladus dioicus' 'Espresso' | 50-75' | Sp | Grn | F | S | 4-6 | 1,2,3 | U,O | S | 4 | Ø | 2 |
| Corktree, Amur | 'Phellodendron amurense' Macho® | 35-45' | - | Grn | F | S | 4-6 | 1,2,3 | U,V | M | 2 | Ø | 2 |
| Catalpa, Northern | 'Catalpa speciosa' | 50-70' | Su | Grn | F,P | S,X, | 5-6 | All | I, U, | F | 3 | Ø | 1 |
| Filbert, Turkish | 'Corylus colurna' | 40-50' | - | Grn | F | S,X, | 5-6 | 1,2 | P | M | 2 | Ø | 2 |
| Hackberry | 'Celtis occidentalis' | 40-60' | - | Grn | F | S, W,X | 4-6 | All | U,O | S | 3 | Ø | 1,2 |
| Honeylocust | 'Gleditsia triacanthos' Imperial® 'Moraine' Shademaster® Skyline® | 30-60' | Sp | Yell/Grn | F | S,W,X | 5-6 | All | S, U | M | 3 | Ø | 1,2,5 |
| Hornbeam, European | 'Carpinus betulus' 'Fastigiata' | 40-50' | - | Grn | F,P | S,St, | 5-6 | 1,2 | P,O | S | 2 | Ø | 2 |
| Horsechestnut | 'Aesculus hippocastanum' 'Baumannii' | 40-60' | Sp | Grn | F,P | S | 4 | All | U,O | M | 3 | Ø | 1,2 |
| Larch, European | 'Larix decidua' | 50-70' | - | Grn | F | S, W,B | 3-6 | All | P | M | 2 | \$ | 2,4 |
| Linden, American | 'Tilia americana' 'Redmond' Legend® | 40-60' | Su | Grn | F,P | S,I | 3-6 | All | P,O | M | 1 | Ø | 2 |
| Linden, Littleleaf | 'Tilia cordata' Chancellor® 'Glenleven' 'Greenspire' Corinthian® | 40-60' | Su | Grn | F | S | 4-6 | All | P,O | S | 2 | Ø | 1 |
| Linden, Silver | 'Tilia tomentosa' Green Mountain® 'Sterling' | 40-60' | Su | Grn/Wht | F | S | 5-6 | 1,2 | O,P | M | 3 | Ø | 2 |
| Locust, Black | 'Robinia pseudoacacia' | 40-50' | Su | Grn | F | B,W,X | 3 | All | I,U | F | 4 | \$ | 1 |
| Maidenhair Tree | 'Ginkgo biloba' Princeton Sentry® 'Magyar' 'Autumn Gold' | 40-60' | - | Grn | F | S | 4-6 | 1,2 | P, I | S | 3 | Ø | 1,2 |
| Magnolia, Cucumbertree | 'Magnolia acuminata' | 40-60' | Sp | Grn | F,P | S,I | 4-6 | 1,2 | O | M | 1 | Ø | 2 |
| Maple, Red | 'Acer X fremanii' Autumn Blaze® | 50-60' | Sp | Grn | F,P | S | 4-8 | All | O | M | 2 | Ø | |
| Maple, Norway | 'Acer platanoides' 'Columnare' 'Deborah' Emerald Queen™ | 40-50' | Sp | Grn | F,P | S, | 4-6 | All | U,O | M | 2 | Ø | 1,2 |

Table 5. (cont'd) Woody ornamentals for Idaho.

| Common name | Scientific name | Height | Bloom | Color | Light | Use | USDA | Idaho zone | Habit | Rate | Wilf-life | UR | Source |
|--|---|----------|-------|---------|-------|-------------|------|------------|--------|------|-----------|----|---------|
| <i>(cont'd) Large deciduous trees—Over 50 feet</i> | | | | | | | | | | | | | |
| Maple, Norway (cont'd) | 'Royal Red' 'Crimson King' 'Schwedler' | | | | | | | | | | | | |
| Maple, Sugar | 'Acer saccharum' Green Mountain® 'Legacy' | 50-70' | - | Grn | P,S | S | 4-6 | 1,2 | O,U | S | 3 | Ø | 2,4 |
| Oak, Bur | 'Quercus macrocarpa' | 70-80' | - | Grn | F | S,W,X | 3-6 | All | O,U | S | 4 | Ø | 2 |
| Oak, English | 'Quercus robur' 'Fastigiata' | 50-70' | - | Grn | F | S, | 5-6 | All | U,O,C, | M | 4 | Ø | 1,2,4 |
| Oak, Northern Red | 'Quercus rubra' | 50 -75' | - | Grn | F,P | S | 5-6 | 1,2 | U,O,C | S | 4 | Ø | 1 |
| Oak, White | 'Quercus alba' | 50'- 80' | - | Grn/Gry | F,P | S, | 4-6 | All | U,O | S | 4 | Ø | 1 |
| Oak, Swamp White | 'Quercus bicolor' | 50-70' | - | Grn | F,P | S, | 4-6 | 1,2,3 | O,U | M | 4 | \$ | 2 |
| Pagodatree, Japanese | 'Sophora japonica' | 40-60' | Su | Grn | F | S | 5-6 | 1,2 | O,U | M | 1 | Ø | 2 |
| Persimmon, Common | 'Diospyros virginiana' | 30-50' | Sp | Grn | F | S | 5-6 | 1,2 | O | S | 3 | Ø | 2 |
| Poplars | 'Populus' spp. | 50'-80' | - | Grn/Gry | F,P | W,N,I | 3 | All | O,U,S | F | 1 | \$ | 1 |
| Poplar, White | 'Populus alba' 'Bolleana' | 45' -90' | - | Grn/Wht | F,P | S,B | 3-6 | All | U,S | .,F | 1 | \$ | 1 |
| Poplar, Black | 'Populus trichocarpa' | 75-100' | - | Grn | F | S,N,I | 4-6 | All | V | F | 1 | \$ | 2 |
| Sweetgum | 'Liquidamber styraciflua' | 50-60' | - | Grn | F | S,I | 5-6 | 1,2 | P,O | M | 2 | Ø | 1,2 |
| Sycamore | 'Platanus x hybrida' 'London Planetree' 'Bloodgood' | 50-100' | - | Grn | F,P | S, | 4-6 | 1,2 | O | M | 3 | \$ | 1 |
| Tree-of-Heaven | 'Ailanthus altissima' | 30-45' | - | Grn | F | S, | 4 | All | U,I | F | 4 | Ø | 1 |
| Tuliptree | 'Liriodendron tulipifera' | 65-90' | Sp | Grn | F | S,I | 5-6 | 1,2 | U,O | M | 3 | \$ | 1 |
| Walnut, Black | 'Juglans nigra' | 40-50' | - | Grn/Yel | F | S,W | 4 | All | U,D | M | 3 | \$ | 1 |
| Willow | 'Salix' spp. 'Tristis' golden weeping' 'Tortusa' corkscrew' | 40'-80' | - | Grn.Yel | F,P | S,I,N | 3 | All | U,S,O, | F | 4 | \$ | 1 |
| Yellowwood | 'Cladrastis kentukea' | 30-50' | Sp | Grn | F,P | S,I | 5-6 | 1,2 | O | M | 1 | Ø | 2 |
| <i>Large evergreen trees—Over 50 feet</i> | | | | | | | | | | | | | |
| Arborvitae, Eastern | 'Thuja occidentalis' 'Pyramidalis' | 30-50' | - | Grn | F | B,S | 3-6 | All | P | M | 2 | \$ | 2,4 |
| Bald cypress | 'Taxodium distichum' | 50-80' | - | Grn | F | S,I | 5-6 | 1,2 | P | M | 1 | \$ | 2,4 |
| Douglas-Fir | 'Pseudotsuga menziesii' | 40-60' | - | Grn | F,P | S,N | 4-6 | All | P | M | 1 | \$ | 2,4 |
| Fir, Subalpine | 'Abies lasiocarpa' | 40-50' | - | Blu/Grn | P | S,I,N | 3-6 | All | U,C,P | S | 2 | \$ | 1, |
| Fir, White | 'Abies concolor' | 50-70' | - | Gry/Grn | F,P | S,N | 4-6 | All | P,U | M | 2 | \$ | 2,4 |
| Pine, Austrian | 'Pinus nigra var. nigra' | 50-60' | - | Grn | F | S,W | 4-6 | All | U,P | M | 3 | \$ | 1,2 |
| Pine, Swiss Stone | 'Pinus cembra' | 30-40' | - | Grn | F | S | 4-6 | All | P,C | S | 2 | Ø | 3,4 |
| Pine Ponderosa | 'Pinus ponderosa' | 50-100' | - | Grn | F | S,W, N,B | 4-6 | All | U,P | M | 2 | \$ | 1,2,4,5 |
| Pine, Scots | 'Pinus sylvestris' | 50-80' | - | Grn | F | S,W,B St | 3-6 | All | U,P | M | 1 | \$ | 1,2,4 |
| Spruce, Colorado | 'Picea pungens' | 45-80' | - | Grn/Gry | F | S,W | 3-6 | All | U,P | S | 2 | \$ | 1,2,4 |
| Spruce, Engelmann | 'Picea engelmannii' | 80-100' | - | Grn | F | S,B | 3 | All | U.,P | S | 1 | \$ | 1,2,4 |
| Spruce, Norway | 'Picea abies' | 50-70' | - | Grn | F | S,B | 4-6 | All | U,P | M/F | 2 | \$ | 1,2,4 |
| Spruce, Serbian | 'Picea omorika' | 50-60' | - | Grn.Gry | F,P | S,B | 4-6 | All | P,C | S | 2 | \$ | 2,4 |
| Spruce, White | 'Picea glauca' | 40-50' | - | Grn | F,P | S,W | 3-6 | All | P | M | 2 | \$ | 2,4 |
| <i>Medium deciduous trees—25 to 50 feet</i> | | | | | | | | | | | | | |
| Alder, Mountain | 'Alnus tenuifolia' | 20-40' | Sp | Grn | F,P | S,N,I | 3-6 | All | O | M | 2 | Ø | 2 |
| Apricot | 'Prunus armeniaca' | 15-25' | Sp | Grn | F | B, | 4 | All | S,O | M | 4 | ? | 1 |
| Cherry Plum | 'Prunus cerasifera' 'Newport' | 15-25' | Sp | Pur | F | S,B,St | 4-6 | 1,2 | U,O | M | 3 | - | 1 |

Table 5. (cont'd) Woody ornamentals for Idaho.

| Common name | Scientific name | Height | Bloom | Color | Light | Use | USDA | Idaho zone | Habit | Rate | Wilf-life | UR | Source |
|--|--|--------|-------|---------|-------|---------|------|------------|----------|------|-----------|----|---------|
| <i>(cont'd) Medium deciduous trees—25 to 50 feet</i> | | | | | | | | | | | | | |
| Cherry Plum (cont'd) | 'Thundercloud' 'Atropurpurea' | | | | | | | | | | | | |
| Cherry, Japanese Flowering | 'Prunus serrulata' | 20-25' | Sp | Grn | F | S, St,I | 5-6 | 1,2 | I,C,V | F | 3 | _ | 2,3 |
| Chokecherry | 'Prunus virginiana' 'Shubert' | 15-30' | Sp | Grn | F | B,W | 2-6 | All | S,O | M | 3 | _ | |
| Crabapple | 'Malus' spp. 'Prairifire' 'Donald Wyman' 'Indian Summer' 'Spring Snow' 'Strawberry Parfait' 'Red Jewel' 'Purple Prince' 'Adirondack' | 15-40' | Sp | Grn/Red | F,P | St | 3-6 | All | S,U,C,OF | | 4 | ? | 1,2,3,4 |
| Dogwood | 'Cornus florida' | 20-25' | Sp | Grn | P | B,S, | 5-6 | 1,2 | I,U | S | 2 | ? | 2,3 |
| Dogwood,Kousa | 'Cornus kousa' | 15-25' | Sp | Grn | P | B,S | 5-6 | 1,2 | I,U | S | 2 | ? | 2 |
| Dogwood, Corneliancherry | 'Cornus mas' | 20-25' | Sp | Grn | F | B,S,St | 4-6 | All | O | M | 3 | ? | 3 |
| Eastern Redbud | 'Cercis canadensis' | 20-30' | Sp | Red/Grn | F,P | S,I | 5-6 | 1,2 | O | M | 2 | ? | 2,3 |
| Filbert, Purple Giant | 'Corylus maxima var. purpurea' | 15-20' | Sp | Pur | P | B | 5-6 | 1,2 | R,P | S | 3 | ? | 3,4 |
| Goldenraintree | 'Koelreuteria paniculata' | 30-40' | Su | Grn | F | S,X | 5-6 | 1, 2 | O | F | 1 | Ø | 2 |
| Hawthorn, English | 'Crataegus laevigata' | 15-24' | Sp | Grn | F,P | St | 3-6 | All | S,U,C,OM | | 3 | ? | 1,2 |
| Hawthorn, Green | 'Crataegus viridis' | 25-35' | Sp | Grn | F | St,S,B | 5-6 | 1,2 | O, | M | 3 | ? | 2,3, |
| Hawthorn, Lavalley | 'Crataegus x lavalleyi' | 15-30' | Sp | Grn | F | B | 4-6 | 1,2 | O | M | 2 | ? | 1,2,4 |
| Hawthorn, Washington | 'Crataegus phaenopyrum' | 20-30' | Sp | Grn | F | St,S,B | 3-6 | All | O, | M | 3 | ? | 1,2,3 |
| Hornbeam, Columnar | 'Carpinus betulus' 'Columnaris' | 20-40' | - | Grn | F | B,S,St | 4-6 | All | U,P | M | 2 | Ø | 3 |
| Lilac, Japanese Tree | 'Syringa reticulata' | 20-30' | Sp | Grn | F | S,St | 4-6 | 1,2 | O | M | 1 | ? | 2 |
| Magnolia, Saucer | 'Magnolia x soulangiana' | 20-30' | Sp | Grn | F,P | S, I | 5-6 | 1,2 | P,O | M | 1 | ? | 2 |
| Maple, Amur | 'Acer ginnala' | 15-20' | Sp | Grn | F,P | B,WB,S | 3-6 | All | U,S, | M | 2 | _ | 1,2,3 |
| Maple, Hedge | 'Acer campestre' | 25-35' | - | Grn | F,P | St,S, | 5-6 | 1,2 | O | S | 2 | ? | 2 |
| Mountain Ash, American | 'Sorbus americana' | 10-30' | Sp | Grn | F | B,S | 3-6 | All | R,U,S | F | 3 | Ø | 4 |
| Mountain Ash, European | 'Sorbus aucuparia' | 25-50' | Sp | Grn | P | S | 4-6 | All | R,U,S | M | 3 | Ø | 1 |
| Olive, Russian | 'Elaeagnus angustifolia' | 20-45' | Sp | Gry | F | S, W,X | 4 | All | U,S,O | M | 4 | \$ | 1,5 |
| Pear, Callery | 'Pyrus calleryana' 'Redspire' Aristocrat® | 25-35' | Sp | Grn | F | St,S | 5-6 | 1,2 | O,P | M | 1 | ? | 2 |
| Plum, Bliereiana | 'Prunus x bliereiana' | 15-25' | Sp | Red/Pur | F | S, | 5-6 | 1,2 | O | M | 3 | ? | 2 |
| Serviceberry | 'Amelanchier x grandiflora' | 20-25' | Sp | Grn | F | B | 4-6 | All | I,O | M | 4 | _ | 3 |
| Walnut, Persian | 'Juglans regia' | 40-50' | Sp | Grn | F | S | 5-6 | 1,2,3 | U,O | S | 4 | Ø | 1 |
| <i>Medium evergreen trees—25 to 50 feet</i> | | | | | | | | | | | | | |
| Juniper, Rocky Mountain | 'Juniperus scopulorum' | 20-40' | - | Gry/Grn | F | B,WB,N3 | 3-6 | All | P,O,I | S | 2 | ? | 1,2,3 |
| Juniper, Utah | 'Juniperus osteosperma' | 20-40' | - | Gry/Grn | F | B,WB,N3 | | 2,3,4 | I,U, | S | 2 | ? | 1 |
| Pine, Limber | 'Pinus flexilis' | 20-50' | - | Grn | P | S,N | 3-6 | All | P,I | S | 1 | Ø | 1,2,4 |
| Redcedar, Eastern | 'Juniperus virginiana' | 20-40' | - | Grn/Red | F | B, | 4 | 1,2 | G,U,I | S | 2 | ? | 1,2,3 |

Table 5. (cont'd) Woody ornamentals for Idaho.

| Common name | Scientific name | Height | Bloom | Color | Light | Use | USDA | Idaho zone | Habit | Rate | Wilf-life | UR | Source |
|--|---|--------|-------|---------|-------|----------|------|------------|--------|------|-----------|----|---------|
| <i>Small deciduous trees—Under 25 feet</i> | | | | | | | | | | | | | |
| Chinese Fringe Tree | 'Chionanthus retusus' | 8-20' | Sp | Grn | F,P | S,B,St. | 5-6 | 1,2 | O | M | 2 | — | 3,4 |
| Gamble Oak | 'Quercus gambelii' | 5-15' | - | Grn | F,P | S, | 4-6 | All | S,U | S | 4 | — | 5 |
| Goldenchain Tree | 'Laburnum x watereri' | 12-15' | Sp | Grn | F,P | B,S,St | 5-7 | 1,2 | O,R | M | 2 | ? | 3,4 |
| Magnolia, Star | 'Magnolia stellata' | 15-20' | Sp | Grn | F,P | S,I | 4-6 | 1,2 | S,O | M | 1 | ? | 2,3 |
| Sumac, Smooth | 'Rhus glabra' | 10-15' | | Grn | F | B,S, N,X | 3 | All | S,I,W, | F | 3 | — | 1 |
| Sumac, Staghorn | 'Rhus typhina' | 15-25' | Su | Grn | F | B,S,X, | 3-6 | All | S,I, | F | 3 | — | 2,3,5 |
| <i>Small evergreen trees—Under 25 feet</i> | | | | | | | | | | | | | |
| Arborvitae | 'Thuja occidentalis' 'Globosa' 'Little Gem' | 15-25' | - | Grn | F,P | B | 4 | All | C,G,U | M | 2 | ? | 1 |
| Hicks Yew | Taxus x media 'Hicksii' | 10-15' | - | Grn | N | B,I | 4-6 | 1,2 | CO, | F | 2 | ? | 3,4 |
| Pine, Bristlecone | 'Pinus aristata' | 8-20' | - | Grn | F | S,B,I | 4-6 | All | P | S | 1 | ? | 1,2,3,4 |
| Pine, Mugo | Pinus mugo 'Mugo' | 15-25' | - | Grn | F | B,I | 3-6 | All | P | S | 2 | ? | 2,4,5 |
| <i>Large shrubs—Over 8 feet</i> | | | | | | | | | | | | | |
| Cherry, Nanking | 'Prunus tomentosa' | 6-8' | Sp | Grn | F,P | B,W | 3-6 | All | P,M | F | 3 | ? | 5 |
| Chokeberry, Black | 'Aronia melanocarpa' | 10-15' | Sp | Grn | F | B,S | 4-6 | All | G,M | M | 4 | ? | 4 |
| Chokeberry, Purple Fruited | 'Aronia prunifolia' | 10-15' | Sp | Grn | F | B,S | 4-6 | All | G,P | M | 3 | ? | 4 |
| Cranberrybush, American | 'Viburnum trilobum' | 10-15' | Sp | Grn | F | B | 2-7 | All | G | F | 4 | ? | 3,4 |
| Firethorn | 'Pyracantha coccinea' | 10-15' | Sp | Grn | F,P | B,S | 5-6 | All | I,P | F | 3 | ? | 5 |
| Juniper, Common | 'Juniperus communis' | 5-10' | - | Gry/Grn | F,P | B,N | 3-6 | All | I,M | M | 2 | ? | 5 |
| Lilac, Common | 'Syringa vulgaris' | 8-15' | Sp | Grn | F | B,W | 3-7 | All | P,G | M | 2 | ? | 4,5 |
| Lilac, Villosa | 'Syringa villosa' | 8-15' | Sp | Grn | F,P | B,W | 3-7 | All | P,G | M | 2 | ? | |
| Mock Orange | 'Philadelphus lewisii' | 5-10' | Su | Grn | F,P,I | S,B,N | 4-6 | All | I,O | F | 2 | * | 5 |
| Peashrub, Siberian | 'Cargana arborescens' | 15-20' | Sp | Grn | F | B,W | 2-7 | All | P | F | 2 | ? | 3 |
| Serviceberry, Saskatoon | 'Amelanchier alnifolia' | 8-15' | Sp | Grn | F | B,S | 4-6 | All | P,O | F | 4 | ? | 4 |
| Serviceberry, Shadblow | 'Amelanchier canadensis' | 8-15' | Sp | Grn | F,P | B,S | 4-6 | All | P,O | F | 4 | ? | 4 |
| Smoke Tree | Cotinus coggyria 'Purpureus' | 10-15' | Sp | Pur/Grn | F | B, | 5-6 | All | O,P | F | 2 | ? | 2,3,4 |
| Snowball, Common | Viburnum opulus 'Roseum' | 10-15' | Sp | Grn | F,P | S,B | 4-6 | All | P | F | 2 | ? | 5 |
| Snowball, Fragrant | 'Viburnum x carlcephalum' | 8-10' | Sp | Grn | F,P | S,B | 4-6 | All | P | F | 2 | ? | 5 |
| Spiraea, Bridalwreath | 'Spiraea prunifolia' | 5-10' | Sp | Grn | F | B,S | 5-6 | All | V | F | 2 | * | 8 |
| Spiraea, Vanhoutte | 'Spiraea x vanhouttei' | 5-10' | Sp | Grn | F | B,S | 4-6 | All | V | F | 2 | * | 8 |
| Viburnum, Arrowood | 'Viburnum dentatum' | 6-8' | Sp/Su | Grn | F,P | S,B | 2-7 | All | P,G | M | 2 | ? | 4 |
| Viburnum, Siebold | 'Viburnum sieboldii' | 15-20' | Sp | Grn | F,P | B,S | 4-6 | 1,2 | I,O | F | 4 | ? | 3 |
| Yew, Hybrid | 'Taxus x media' | 4-15' | Sp | Grn | P,S,I | B | 4-6 | All | C | M | 2 | ? | 5 |
| Yucca | 'Yucca flaccida' | 4-7' | Su | Gry/Gre | F | S | 4-6 | All | O | M | 2 | * | 5 |
| <i>Small shrubs—3 to 5 feet</i> | | | | | | | | | | | | | |
| Almond, Dwarf Flowering | 'Prunus glandulosa' | 4-6' | Sp | Grn | F,P | B | 4-6 | All | M,S | M | 4 | * | 5 |
| Almond, Dwarf Russian | 'Prunus tenella' | 4-5' | Sp | Grn | F,P | B | 2-6 | All | M,S | M | 4 | * | 4 |
| Barberry, Japanese | 'Berberis thunbergii' | 3-6' | Sp | Red/Gry | F,P | S,B | 4-6 | | P,S | M | 3 | * | 5 |
| Ceanothus, Fender | 'Ceanothus fendleri' | 1-2' | Sp | Gry/Gry | F,P | S,B,N,X | 4-6 | All | S,P | F | 2 | * | 5 |
| Cinquefoil, Shrubby | 'Potentilla fruitcosa' | 1-4' | Su | Grn | F | B | 2-6 | All | M | M | 1 | * | 4 |
| Cotoneaster, Rock | 'Cotoneaster horizontalis' | 3-4' | Sp | Grn | F,P | B | 4-6 | 1,2 | M | F | 3 | * | 5 |

Table 5. (cont'd) Woody ornamentals for Idaho.

| Common name | Scientific name | Height | Bloom | Color | Light | Use | USDA | Idaho zone | Habit | Rate | Wilf-life | UR | Source |
|--|---|--------|------------|---------|-------|-------|------|------------|---------|------|-----------|----|--------|
| <i>(cont'd) Small shrubs—3 to 5 feet</i> | | | | | | | | | | | | | |
| Cotoneaster, Cranberry | 'Cotoneaster apiculatus' | 3-4' | Sp | Grn | F,P | B | 5-6 | 1,2 | M | F | 3 | * | 4,5 |
| Current, Alpine | 'Ribes alpinum' | 3-5' | Sp | Grn | F,P | S,B,N | 3-6 | All | G,M | F | 3 | * | 5 |
| Dogwood, Red Twig | 'Cornus sericea' | 7-9' | Sp | Grn | F,P | B,W,N | 2-6 | All | S,U | F | 3 | | |
| Dogwood, Tatarian | 'Cornus alba' | 8-10' | Sp | Grn/Red | F,P | B,W | 2-6 | All | S,U | M | | * | 4 |
| Dwarf Burning Bush | 'Euonymus alatus Compactus' | 3-6' | Sp | Grn | F,P | B,S | 3-6 | 1,2 | G,P | F | 3 | * | 4,5 |
| Juniper, Chinese | 'Juniperus chinensis' 'Gold Coast' 'Mint Julep' | 2-10' | | Grn/Yel | F | B,S | 4-6 | All | Various | M,F | 1 | * | 4 |
| Oregon grape | 'Mahonia aquifolium' 'Compactum' | 3-6' | Sp | Red/Grn | F | S, | 4-6 | All | S | M | 3 | * | 4,5 |
| Rhododendron, Azalea | 'Rhododendron' spp. | 0.5-5' | Sp | Grn/Gry | P | B,S | 4-6 | 1,2 | U,M | M,S | 2 | * | 4 |
| Sandcherry, Western | 'Prunus besseyi' | 7-10' | | Grn/Gry | F | B,N | 2-6 | All | M | M | 3 | * | 4 |
| Snowberry | 'Symphoricarpos alba' | 3-6' | Sp | Grn | F,P | N | 3-6 | All | U,M | M | 4 | * | 4 |
| Spruce, Dwarf Norway | 'Picea abies' 'Nidiformis' 'Procumbens' | 2-4' | - | Grn/Gry | F | B,S | 2-6 | All | Various | S | 1 | * | 4 |
| Sumac, Scented | 'Rhus trilobata' 'Lemonade Sumac' 'Skunkbush Sumac' | 3-5' | Sp | Grn | F | N,X | 3-6 | All | P,S | M | 3 | * | 8 |
| <i>Ground Covers</i> | | | | | | | | | | | | | |
| Bunchberry | 'Cornus canadensis' | 6-9" | Sp | Grn | P,S | I,N | 5-6 | 1,2 | S | M | 3 | * | 8 |
| Cotoneaster, Creeping | 'Cotoneaster adpressus' | 8-12" | Sp | Grn | F,P | S, | 4-6 | All | S | M | 2 | * | 5 |
| Crowberry | 'Vaccinium vitis-idaea' | 12" | Sp | Grn | P | I | 3-6 | 1,2 | S | S | 3 | * | 8 |
| Firethorn | 'Pyracantha' 'Gnome' | 12-15" | Su | Grn | F | I | 5-6 | 1,2,3 | S | M | 3 | * | 8 |
| Germander | 'Teucrium chamaedrys' var. Prostratum | 4-12" | Su | Grn | F | I | 3-6 | All | S | M | 1 | * | 8 |
| Honeysuckle, Halls | 'Lonicera japonica' 'Halliana' | 6-12" | Sp | Grn | S | I, | 3-6 | All | S | F | 2 | * | 5 |
| Juniper, Creeping | 'Juniperus squamata' | 4-6" | - | Grn | F | N,X | 5-6 | 1,2 | S | M | 1 | * | 4 |
| Juniper, Horizontal | 'Juniperus horizontalis' | 12-16" | - | Grn/Blu | F,P | S,N | 3-6 | All | S | M | 2 | * | 4,5 |
| Kinnickinnick | 'Arctostaphylos uva-ursi' | 4-6" | Sp | Grn | S,P | N,X | 3-6 | 1,3 | S | M | 4 | * | 5 |
| Mahonia | 'Mahonia repens' | 6-12" | Sp | Red/Grn | S,P | N,X | 4-6 | All | S | M | 4 | * | 5 |
| Paxistima, Canby | 'Paxistima canbyi' | 1-2' | Sp | Grn | F,P | B,N,I | 4-6 | All | M | M | 1 | * | 4 |
| Periwinkle | 'Vinca minor' | 4-6" | Sp | Grn | S | I | 3-6 | All | S | F | 2 | * | 5 |
| Silverwood | 'Genista pilosa' | 12-15" | Su | Grn | F | N | 5-6 | 1,2 | S | F | 1 | * | 8 |
| Sun Rose | 'Helianthemum nummularium' | 6-8" | Su | Grn/Gry | F | X | 3-6 | All | S | M | 1 | * | 8 |
| St. Johnswort | 'Hypericum calycinum' | 12-18" | Su | Grn | F,S | X | 5-6 | All | S | F | 1 | * | 8 |
| Spurge, Japanese | 'Pachysandra terminalis' 'Green Carpet' | 6-10" | Su | Grn | P,S | I | 4-6 | All | S | F | 1 | * | 8 |
| Wintergreen | 'Gaultheria procumbens' 'Gaultheria ovalifolia' | 6" | Su | Grn | P | I | 3-6 | 1,2 | S | M | 4 | * | 8 |
| | | 8" | Su | Grn | P,S | N | 5-6 | All | S | M | 4 | * | 8 |
| <i>Vines</i> | | | | | | | | | | | | | |
| Akebia, Fiveleaf | 'Akebia quinata' | 15-20' | Sp | Grn | All | I | 4-6 | All | S | M | 2 | ? | 8 |
| Bittersweet | 'Celastrus' spp. | 10-40' | Sp | Grn | F | I | 3-6 | All | S | M | 2 | ? | 8 |
| Clematis | 'Clematis' spp. x Jackmanii 'Henryi' 'Nelly Moser' | 8-20' | Sp,Su F | Grn | P | I | 4-6 | All | Sp | F | 1 | * | 8 |

Table 5. (cont'd) Woody ornamentals for Idaho.

| Common name | Scientific name | Height | Bloom | Color | Light | Use | USDA | Idaho zone | Habit | Rate | Wilf-life | UR | Source |
|-----------------------|--|--------|------------|-------|-------|-----|------|------------|-------|------|-----------|----|--------|
| <i>(cont'd) Vines</i> | | | | | | | | | | | | | |
| Clematis, Evergreen | 'Clematis armandii' | 15-20' | Sp | Grn | P | I | 5-6 | 1,2 | Sp | F | 1 | * | 8 |
| Grape | 'Vitis riparia' | 10-15' | Su | Grn | P | I | 3-6 | All | S | F | 4 | * | 9 |
| Honeysuckle, Japanese | 'Lonicera japonica 'Halliana' 'Aureo-reticulata' 'Purpurea' | 10-15' | Sp | Grn | P | I | 4-6 | All | S | F | 1 | ? | 8 |
| Honeysuckle Trumpet | 'Lonicera sempervirens' | 10-15' | Sp | Grn | P | I | 4-6 | 1,2 | S | F | | * | 8 |
| Hop | 'Humulus lupulus' | 15-30' | Su | Grn | F | I | 3-6 | All | S | F | 1 | ? | 8 |
| Hydrangea, Climbing | 'Hydrangea anomala petiolaris' | 8-15' | Sp | Grn | P | I | 3-6 | All | S | S | 2 | * | 8 |
| Ivy, Boston | 'Parthenocissus tricuspidata' | 20-50" | Grn | All | | I | 4-6 | All | S | F | 2 | ? | 8 |
| Ivy, English | 'Hedera helix' 'Baltica' 'Bulgarica' 'Arborescens' | 10-30' | - | Grn | P,S | I | 4-6 | All | S | F | 1 | ? | 8 |
| Kiwi, Hardy | 'Actinidia arguta' 'Issai' 'Ananasnaja' 'Hood River' | 20-50' | Sp | Grn | F | I | 4-6 | All | S | F | 3 | * | 8 |
| Rose | 'Rosa' spp. 'Blaze' 'Royal Sunset' 'White Dawn' | 6-15' | Sp,Su, Grn | | F,P | I | 3-6 | All | S | M | 3 | * | 8 |
| Trumpetvine | 'Campsis radicans' | 10-40' | Sp | Grn | F,P | I | 4-6 | All | S | F | 1 | ? | 8 |
| Virginia Creeper | 'Parthenocissus quinquefolia' | 10-50' | Grn | All | I | 3-6 | All | S | F | 2 | ? | 8 | |
| Winter Creeper | 'Euonymus fortunei' 'Canadale Gold' 'Coloratus' | 20-30' | Sp | Grn | F,P | X | 3-6 | All | S | F | 2 | * | 8 |
| Wisteria | 'Emerald Gaiety' 'Wisteria' spp. | 10-40' | Sp | Grn | F,P | I | 5-6 | All | S | F | 1 | ? | 8 |

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- Pruning Standards for Woody Plants, 1993*. A Guide: Compiled and edited by Harriet Husemann for the City of Lewiston, ID.
- Tree City USA Bulletins, 1988-92*. The National Arbor Day Foundation, Nebraska City, NB.

University of Idaho

- CIS 867 Cold Hardiness in Woody Landscape Plants: Its Role in Winter Survival and How to Maximize It (25¢)
- CIS 1068 Fertilizing Landscape Trees (\$1.00)
- PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair (\$2.50)
- BUL 644 How to Prune Coniferous Evergreen Trees (\$1.50)
- BUL 819 How to Prune Deciduous Landscape Trees (\$2.00)
- CIS 1054 Low Input Landscaping (\$1.00)
- PNW 500 Plant Materials for Landscaping (\$2.50)
- CIS 795 Roses: Buying and Planting (35¢)
- CIS 796 Roses: Care After Planting (\$1.00)
- CIS 794 Roses: Types, Selection, and Environmental Requirements (35¢)
- PNW 5 Trees Against the Wind (\$8.00)

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Web Sites

- Pacific Northwest Chapter, International Society of Arboriculture. Available:
<<http://www.teleport.com/~pm.wisa/>>
- National Arbor Day Foundation. Available:
<<http://www.arborday.org>>
- Arnold Arboretum. Available:
<<http://www.arboretum.harvard.edu/main.htm>>

Map: *American Horticultural Society Plant Heat Zone Map* by Marc Cathey. To order telephone 800-777-7931 (\$14.95)

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Chapter 18

Herbaceous Ornamentals



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Herbaceous Ornamentals



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I. Introduction

Herbaceous ornamentals comprise the nonwoody portion of the garden landscape. These plants generally add color and interest to a basic landscape design and landscape structure. Whether that structure is a backdrop or basic design of trees and shrubs, or a purposeful laying out of beds and other types of planting areas, the addition of herbaceous ornamentals can enhance a landscape significantly. These plants are also forgiving because they are easier to dig and rearrange than most landscape trees and shrubs. Learning to use herbaceous ornamentals to the best advantage is easy; simply follow the guidelines outlined in this chapter.

II. The Art of Design

A. Color

Herbaceous ornamentals are generally grown for their addition of color, through their flowers and foliage, to the landscape. Understanding the impact of colors and how to combine them can form a basis for use of these versatile landscape plants (Fig. 1).

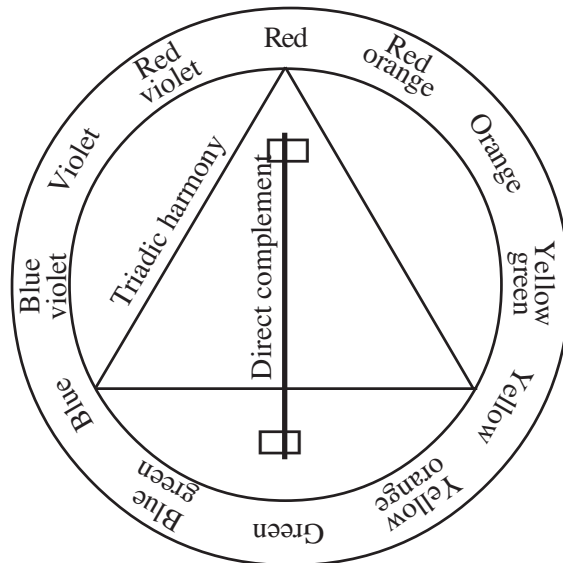
Several color schemes can be created in a single garden by planting early season blooming plants in one color scheme and late-blooming plants in a different scheme. An interesting overlap can occur in plans of this type.

The primary colors are red, yellow, and blue. Other colors are combinations of these primary colors. A pure color is a hue. A lighter version of a hue is a tint, which is accomplished by combining a hue with

white. A darker version of a hue is a shade, a color made by combining a hue with black. A tone is made by combining various amounts of black and white, or gray, with a hue. The value of any color is the brightness of that color compared to another. Pure yellow has a greater value than pure blue.

The warm colors of yellow, red, and orange will brighten cool, shady areas. These colors are attention getting and can be used to the advantage at the back of a long bed to shorten the perspective. The cool colors of violet and blue, by contrast, recede and are good for close-up viewing. Cool colors are used to the advantage in lending a cooling illusion to any overheated area such as a concrete patio.

Fig. 1. The color wheel.



Color schemes effectively used with herbaceous ornamentals are:

1. *Polychromatic*—Uses all the colors and their tints, shades, and tones. This can produce a carnival effect, and often results in some very pleasing color combinations.
2. *Monochromatic*—Uses the various tints, shades, and hues of only one color. Gardens using this color scheme are particularly dramatic.
3. *Analogous*—Uses adjacent colors on the color wheel such as blue, violet, and red. Such a color scheme can be expanded by using the various tints and shades of each of the colors.
4. *Complementary*—Uses opposite colors on the color wheel such as red and green, orange and blue, and yellow and violet. This type of color scheme is most effectively used with pure hues (not tints or shades) and creates a very bold effect. This color scheme is not recommended for the small garden.
5. *Split Complementary*—Uses a pure color and a color from either side of its complementary counterpart. An example of this is starting with blue and combining it with red or yellow, the colors bordering orange on the color wheel.
6. *Triadic*—Uses three colors that are equal distance from each other on the color wheel. This unusual idea is striking.
7. *White*—This color deserves a special comment. There have been many famous gardens planted in white flowers alone. There is a special appeal in the contrast of white against the green foliage of plants. White will give your garden a well-planned and orderly look. It is the last color to fade from sight as darkness falls, so it is a good choice for “evening” gardens. Cream and ivory flowers blend well with all colors except yellow.

B. Texture

This is dictated by the density and size of individual leaves and flowers. Plants with large leaves and large bold flowers have a coarse texture, tend to be dominant in a garden, and appear to advance to your field of

vision. Plants with tiny leaves and small flowers lend a fine texture to the landscape, and tend to recede in your field of vision. Choose herbaceous ornamentals according to the textural “feel” you wish to attain. Often a mix of all textures is most visually pleasing.

C. Shape and Size

Herbaceous ornamentals come in all sizes and shapes. Size is comprised of height, or tallness, and spread, or the extent to which the herbaceous ornamental covers the ground at maturity. A shape is the same as the habit or form of a plant. Some herbaceous ornamentals hug the ground, while others tower to 6 feet or more; others are vines. Some are compact ball-shaped plants while others are open and upright. There are herbaceous ornamentals perfect for any location. Be sure to space plants far enough apart to allow room for each to develop to maturity.

III. What to Plant

A. Exposure

Herbaceous ornamentals can be adapted to all types of sites from full sun to pure shade. Choosing a plant according to the exposure of the site ensures success with these plants.

B. Season of Flowering

Some herbaceous ornamentals are tolerant of cool temperatures and bloom in early spring. Others need warmer weather and bloom in the summer. Still others bloom in the fall. Choose the proper herbaceous ornamental based on when color in a particular area is most desirable.

C. Cut and Dried Flowers

Some kinds of herbaceous ornamentals hold up better as cut flowers while others dry beautifully. Choose herbaceous ornamentals that are adapted to fresh or dry display.

Special cutting gardens can be completely harvested for flowers without concern for how the garden looks. However, plants valuable for cut flowers can usually be incorporated into the main garden.

When cutting for air drying, choose flowers just reaching maturity. Strip off the foliage, and hang upside down in small bunches in a

dry, shady spot. Some flowers will dry well standing upright in a container.

D. Herbaceous Ornamentals That Naturalize

Some herbaceous ornamentals, such as native plants or wildflowers, reseed themselves prolifically and eventually will naturalize an area. Know which plants have this tendency, and choose the proper annuals for naturalizing. Remember, any hybrid ornamentals that reseed will not come true-to-type, and usually will produce an offspring of inferior plant quality. Seedlings of this type are not desirable.

E. Special-Use Gardens

Herbaceous ornamentals are used to create gardens with special qualities such as rock gardens, bog gardens, prairie and meadow gardens, cottage gardens, cutting gardens, fragrance gardens, herb gardens, or traditional herbaceous perennial gardens.

IV. How to Plant (Design)

A. Formal and Informal

Once you have decided where to plant herbaceous ornamentals, decide on a design. Formal designs are composed mostly of straight lines and symmetry. What appears on the right side of the garden is matched on the left. A formal design is easy to lay out and, because of its visual simplicity, is the best choice for a small lot.

Informal gardens are composed of curved flowing lines and a disregard for symmetry.

B. Beds and Borders

Beds are large blocks of planted areas. The bed requires a relatively large area around it to look its best. If you have a large yard you may have the perfect spot for a bed.

Borders run along the edges of shrub beds, buildings, fences, walkways, and lawns. They conserve space and soften the edges of whatever they border.

As a general rule, the sum of the widths of the beds and borders should not exceed one-third of the width of the yard. Also, individual beds should be no more than five-eighths to two-thirds as long as the long axis of the yard.

Herbaceous ornamentals can also be tucked here and there in a shrub or perennial bed or border to provide a spot of seasonal color.

Avoid spots, however, where water-greedy roots of trees and shrubs will interfere with growth. In these spots, a container of herbaceous ornamentals will provide better results.

C. Plant Choice

Materials will depend on the desired effect and will be influenced by color scheme, season of flowering, texture, diversity, type of background plants, and available space.

When designing the bed or border, remember to place the lower growing plants to the front so that they will be visible and not shaded out by taller types.

Since it is easier to place the tallest plants first, design the border from the back to the front; the bed from the middle to the edge. Design from fall to spring rather than spring to fall. This ties in with the suggestion to design from the back to the front of the border and from the middle to the edge of the bed, since fall plants are often taller and would logically be placed in the back of the border or the middle of the bed. Finally, because you read from left to right, design from left to right.

Plant in clumps or drifts of plants using groups of the same species or cultivar.

When planting in groups of less than 10, plant odd rather than even numbers of the same plant. These design suggestions help avoid the “zoo” effect (a collection of one of everything) and will lead the eye through the planting.

V. Gardening in Containers

Almost any annual can be grown in a container. Plants that spread or cascade are suitable for the outer rim of regular containers and for hanging baskets. If plants are mixed in a container, all should have similar sun and water requirements. Containers and hanging baskets allow the gardener to provide spots of color almost anywhere around the home grounds.

A. Containers

Choose a container with holes in the bottom to drain the water. A tray underneath will catch any drainage. Avoid letting pots rest in standing water, as roots may begin to rot. Glazed clay pots and plastic containers do not breathe and will not need watering as often as clay. Darker colors absorb more heat, which will warm the soil but cause more water loss. Therefore, light-colored containers may be the best choice for most gardeners.

B. Soil

For containerized plants, purchase a commercial potting mix that is a blend of peat, perlite, and other components and contains no soil. Mixes are blended to hold water and nutrients and to drain well. Mix some slow release fertilizer with the mix, or liquid feed about every 2 weeks. Water containers well before applying liquid fertilizer.

C. Planting

Containers look best when packed with plants. A planted container should look attractive immediately after or within a few weeks of planting.

D. Watering

Plants in containers require regular watering. Always water until the water runs out of the drain holes. Water can run right through very dry soil without actually wetting it. If you have doubts, tip the container up to test that it has become much heavier with water.

E. Maintenance

Herbaceous annuals make excellent long-flowering container plants. However, perennial container plants can be placed in the garden after their limelight. If containerized perennials are not planted out in the garden, place them in a cold frame or garage to protect their roots from freezing during the winter.

VI. Getting Started with Annuals

An annual plant completes its life cycle in a single year. Unless the plants reseed themselves, new annuals need to be planted every season. Some hardy annuals have seeds that

will germinate and grow in cooler soil. The plants will stand some freezing and thawing. Half-hardy annuals will take some cool, damp weather but will be killed by a frost. Tender annuals can take no cool weather at all. Some annuals will reseed depending on variety and climatic conditions.

Annuals serve many functions in the garden, but their primary use is for providing color. They grow quickly and easily, are great for cutting, and are generally inexpensive. Annuals generally bloom for most of the season. An added bonus is the fragrance that some annuals bring to the garden. Annuals come in a variety of sizes, shapes, and colors.

A. Propagation

1. Seeds—Come in mixtures and single cultivars. Hybrid seeds are usually more expensive but often produce spectacular flowers. If you save your own seed, be aware that most flowers, and especially hybrids, will not breed true-to-type.

Seeds will lose their viability if stored for many years, so starting with fresh seed packaged for the growing year will get you off to the best start.

Seeds that are started indoors or in a greenhouse should be growing 4 to 6 weeks before you place them in the garden. The warm weather annuals should be transplanted outdoors after the danger of frost.

The easiest way to begin annual plants is to plant the seeds directly where you wish the plants to grow. The seedlings can be thinned to achieve the desired density. Follow the seed package instructions for time and depth of planting.

2. Transplants—Plants from the garden center save you time and effort. They are, however, more expensive than growing your own. Some flowers such as petunias, impatiens, and geraniums have very small seeds, are slow to germinate, and seedlings take longer to reach transplant size. They can be started indoors, but they demand precise growing conditions and vigilant care. It is easier to buy transplants for these types of plants.

Pick good plants. Make sure plants are healthy and growing vigorously. Plants that have obviously dried out, have overgrown their containers, or are yellow or leggy should be avoided because they will bloom poorly and require constant watering.

Slip plants out of their containers to check the roots. Look for a fine network of healthy roots supported by visible soil. Avoid plants with a mass of dense, white, tangled roots.

B. Growing, Culture, and Maintenance

1. Soil preparation—A soil test is always a good idea if there is any doubt about the fertility or pH of the soil. Amend the soil appropriately before planting to adjust the acidity and provide the proper nutrients for growth.

Amendments, such as compost, peat moss, and manure added to the soil will increase organic matter, and thereby increase water-holding capacity and soil fertility. Covering the soil surface with a 3-inch layer of amendment and digging it into a 12-inch depth provides a good planting area.

2. Planting—Seeds will germinate when the soil is warmed to the proper temperature. The exact temperature will depend on the annual species being planted.

After the soil is prepared, sprinkle the seed either randomly or in rows with indentations in the soil. Cover the seed with loose, organically amended soil, so the soil will not crust over the seeds. Water in with a light misting of water, and keep the soil evenly moist until germination occurs. Be sure not to plant the seed any deeper than suggested on the seed package label.

Acclimate transplants before placing them in the soil. Place them in a protected space outdoors for several days, and make sure the plant does not dry out. At planting time, tap or tip the plants out of their pots, and set them in a prepared hole large enough for the root ball to fit comfortably. Set the plant in the hole, making sure the top of the root ball is

even with the surrounding soil surface. Recent research has shown that breaking up the root ball of even the most pot-bound of annuals only slows down their development. Plant the roots as they come out of the container. Do not let the root ball dry out. Firm the soil around the roots and water well. Protect plants against excessive sun, wind, or cold while they are getting started. Inverted pots or milk cartons, or row covers can be used.

3. Fertilizing—Dry or liquid fertilizers will work for annuals. Nitrogen stimulates leafy growth, while phosphorus and potash promotes flowering, fruiting, and root growth. Fertilizers with a *ratio* of 1-1-1, 1-2-1, or 1-2-2 are best for annuals. Remember that the numbers on the package indicate both the ratio and the percentage of active ingredients per pound of nitrogen-phosphorus-potassium.

Dry fertilizer amendments added at planting will last for about 6 weeks. Application of dry fertilizers, followed by a watering, or liquid fertilizer applied to damp soil will maintain the quality of the plants and blooms.

4. Watering—Young plants need more frequent watering until their roots get established. Sown seeds may need multiple daytime watering. As plants become established, gradually water less frequently. Watering established plants will depend on plant size, soil characteristics, and weather. During hot weather, large plants in sandy soil require frequent watering. Strive to keep the plants evenly moist. If plants are allowed to dry out, they may be permanently stunted.

Overhead watering with sprinklers is a common technique. However, some flowers are more susceptible to disease if their leaves and flowers are constantly wet. Overhead watering can also cause taller plants to tip over.

Furrow watering is a common technique if planting is done in rows. Furrows must be tended so the water flows properly, and there must be a gentle slope from one

end to the other. Once plants get large, the furrow system can be difficult to maintain.

Drip irrigation is the most efficient way to deliver water. Use drip emitters or perforated tubing to deliver water directly where you want it.

Infrequent deep watering is better than frequent light applications.

5. **Mulching**—This helps annual plants conserve moisture and keeps the soil cooler. Be sure to apply the mulch after the soil has warmed in the spring, otherwise warming will be delayed. Mulches also help in weed control and provide an attractive appearance. Organic materials, such as bark or sawdust, can be incorporated into the soil at the end of the season as an organic amendment.

Mulch materials must allow water to move through. Organic materials must be loose and coarse. Remember that many organic materials will draw nitrogen to the soil to aid in breakdown. These materials, when used as mulch, must be augmented with nitrogen fertilizer. Wood byproducts, such as bark chips and sawdust, as well as compost make good mulch for annuals. Pine needles and grass clippings can also be used. Spread grass clippings in one thin layer and allow them to dry before adding another layer. Landscape fabric can be spread over the soil surface and covered with bark chips or other organic materials. The fabric stops weed growth, but allows air and water to penetrate the soil.

6. **Thinning**—Seedlings grown from directly planted seeds need to be thinned. This process is little more than pulling out the excess seedlings to establish the proper spacing for the type of annual grown.

If pulling will disrupt the roots of the remaining plants in the garden, clip off the extras at the soil line with shears. Leaving more plants than necessary at this first thinning will provide some plants to be transplanted elsewhere and also allow a margin of safety in case of disease or

frost problems. After plants are well established, a second thinning will leave plants with plenty of room to attain a mature growth. Properly spaced plants are healthier and produce more blossoms.

7. **Pinching**—Removing the terminal growth on young annual plants will help make them bushier and more compact. Many annuals are now bred to be compact and well branched. However, any plant that has become too leggy or too tall will be improved by pinching. Examples are petunias, geraniums, and many chrysanthemums.

Pinching out the first blossoms that form on some plants will cause more overall bloom. Examples are marigolds and zinnias.

8. **Weeding**—These rob annual plants of nutrients and water and make them look unkempt. Weed problems can be reduced by proper soil preparation and mulching immediately after transplanting. In direct-seeded areas, apply mulch to retard weed growth after plants have been thinned.

If weeds grow among annuals, hoe only deep enough to sever the weeds just below the surface. This will avoid any damage to the shallow feeder roots common to annuals. If weeds are large, pull them by hand.

9. **Deadheading and grooming**—Removing the faded flowers, or deadheading, will help keep the garden looking neat and will prolong bloom on most garden annuals. A plant that is ripening seeds produces less blossoms. Pinch off or cut spent flowers back to the next branch. Shearing the flower heads with pruning shears works well for smaller-flowered plants. Be careful not to cut back too far. Remove less than one-third of the plant. Grooming annuals involves removing dead leaves and thinning extra branches. Grooming keeps plants looking good and, by removing dead foliage before it can mold on the plant, keeps diseases from gaining a foothold.

Thinning the foliage keeps the air circulating through the plants, keeps the plants

dry, and cuts down on diseases. Thinning also allows light penetration to the interior of the plant. Often insect pests, which otherwise might be overlooked, are discovered during the grooming.

10. Staking—Tall growing annuals such as larkspur and tall marigolds need protection from wind and rain or overhead sprinklers. Stakes help them grow straight and keep them from being knocked over.

Stakes can be made of wood, bamboo, or any similar material. To be less conspicuous, stakes should be small in diameter and about 6 inches shorter than the mature plant to avoid being visible above the plant. Secure the stems to the stakes with paper-covered wire, plastic ribbon, or other material that will not cut into the stem. You also can support the plants with a framework of stakes and strings in crisscrossing patterns. Commercial support frameworks are available for herbaceous annuals.

Stake plants before they have a chance to fall over or begin to grow crooked. When plants are about one-third of their mature size, begin staking. Place stakes or frames close to the plant, but take care not to damage the root system. Secure the plant stems to the stake or frame as it grows taller.

11. Insects—Although ornamental annuals are generally pest-free, the following insects can sometimes cause problems: aphids, beetles, caterpillars, thrips, white flies, earwigs, and mites.

Annuals that are well maintained can withstand most attacks by insects. Plants under water stress or those lacking plant nutrients become more susceptible to insect attack. Keeping annuals healthy and growing is the first line of defense. Many insect pests are naturally controlled by predator insects. Chemical sprays will destroy these predators and should be avoided.

Insects, such as aphids, mites, thrips, and white flies, can be controlled with insecticidal soaps.

Caterpillars can be controlled with Bt spray. Earwigs can be trapped in rolled newspapers and then destroyed.

If chemical treatment becomes necessary, make sure your pest is positively identified and use a chemical appropriate for its control. Always follow label directions.

12. Diseases—Since annuals are only in the garden for one season, diseases are not as serious a problem as they are for perennials. The following diseases, however, can sometimes cause problems: the fungus diseases botrytis blight (gray mold), damping-off fungus, powdery mildew and rust, and the virus diseases mosaic and aster yellows.

Moist conditions and splashing water favor and spread the fungus diseases rust, powdery mildew, damping-off fungus, and botrytis blight. Spacing and grooming plants correctly to maintain a good airflow will help to prevent these diseases. Sprinkler watering in the morning so the foliage will dry during the day or drip irrigating so the foliage stays completely dry will also help. Damping-off can be prevented by planting seeds after the weather warms and not keeping the seeds and seedlings too wet.

Botrytis gains a foothold in dead plant parts. Deadheading and grooming can help to keep this disease out of annuals. Insects such as aphids and leafhoppers spread the virus diseases mosaic and aster yellows. Starting with virus-free plants and then excluding insect pests will detour these diseases. No control is available for the virus diseases. Plants must be pulled and destroyed. The fungus diseases are controlled with fungicides. Check the label of each chemical for the organisms controlled and proper application methods.

13. Other pests—Slugs and snails are very common and can chew small annuals down to nothing. Handpick, trap, and destroy the pests, or use commercial baits.

C. Description of Selected Annuals

1. *Antirrhinum majus* (Snapdragon)— Available in many colors. Grows in full sun. Height varies from 12 inches for dwarf plants to 36 inches for the tall varieties. Plants can be directly seeded or transplanted in early spring. These plants often reseed themselves under Idaho conditions.
2. *Begonia semperflorens* (Bedding begonia)— Colors in shades of red and pink, and white. Leaves are bright green or bronze-red and waxy looking. Grows in partial sun to shade. Height is 6 to 12 inches at maturity. Seeds are slow to start and are best used as bedding plants or houseplants.
3. *Calendula officinalis* (Pot marigold)— Flowers are white, cream, orange, yellow, and apricot. Grows in full sun. Mature height is 12 to 30 inches. Sow seeds directly in early spring. Flower petals are edible, and the flowers make long-lasting cut flowers. These plants are very easy to grow and will reseed profusely.
4. *Callistephus chinensis* (China aster)— Asters come in white, light yellow, pink, red, blue, and lavender or purple. Grows in full sun. Height varies from 6 to 30 inches. Sow seeds directly into garden in spring. These plants dislike being transplanted. Many flower forms are available, and they all make excellent cut flowers.
5. *Centaurea* sp. (Bachelor's button)— Colors vary from blue, pink, rose, purple, yellow, and white. Grows in full sun. Height is 12 to 36 inches tall. The different species have differing planting and growth requirements.
6. *Cosmos* sp. (Cosmos)— Colors are yellow, orange, red, white, pink, and bicolors. Grows in full sun to partial shade. Height is 2 to 7 feet. Easy-to-grow plants make good backgrounds for other annuals. Several different species have differing planting and growth requirements. These plants will reseed.
7. *Dahlia* sp. (Dahlia)— Comes in all colors except blue. Requires full sun for at least half the day. Height is 12 to 20 inches.
8. *Ipomoea tricolor* (Morning glory)— Colors include blue, white, pink, red, chocolate, crimson, lavender, and violet. Grows in full sun. This climbing plant will grow to 10 feet, but some dwarf forms are available that grow to 5 inches. This fast-growing vine is attractive on trellises and fences. Flowers on old varieties are open only at night, but the newer varieties stay open most of the day. Several different species are available. Some will reseed.
9. *Lathyrus odoratus* (Sweet pea)— Comes in pink, red, purple, lavender, white, cream, apricot, salmon, maroon, and bicolors. Prefers full sun. Climbing types will grow to 5 feet while bush types grow to 12 to 36 inches. Can be planted very early. Keeping seed pods off plants will keep it blooming.
10. *Limonium sinuatum* (Statice)— Colors include blue, lavender, white, rose, yellow, apricot, and peach. Prefers full sun. Grows 10 to 48 inches tall. This plant is easily dried and is decorative in bouquets. Various forms yield plants of differing heights. *L. sinuatum* has flowers in flat-topped clusters while *L. suworowii* has curved spikes of bright rose or lilac flowers.
11. *Lobelia erinus* (Lobelia)— Colors include white, cream, rose, pink, purple, violet, and lavender. Grows in full sun to light shade. Height is 4 to 6 inches. Lobelias are easy to establish as transplants. Flowers best when nights are cool. Attractive in front of other annuals and in containers and hanging baskets.
12. *Pelargonium* sp. (Geranium)— Comes in shades of red, pink, orange, violet, white, and bicolors. Grows in full sun to partial shade, depending on variety. Height is 8 to 36 inches. These popular annuals can be planted as rooted cuttings or as transplants in spring. Several different species

These seed-grown plants will form tubers that can be dug and stored over the winter. To assure vigorous bloom, however, replant each spring from seed. These showy plants will bloom profusely in the first year.

have differing growth habits. All make good houseplants. They can also be overwintered in a cool, unheated cellar.

13. *Petunia hybrida* (Garden petunia)—Colors available include shades of pink, red, salmon, coral, yellow, cream, blue, purple, white, and bicolors. Plants prefer full sun. Height is 8 to 27 inches. They are best started as transplants. The long blooming period of petunias make them a popular annual. Flowers are single or double. The plants are adapted to a wide range of soil and water conditions. They also make good cut flowers.
14. *Portulaca grandiflora* (Moss rose)—Colors include white, cream, yellow, orange, red, and pink. Grows in full sun. Height is 6 inches. Sow seeds directly or set out transplants. This favorite grows in sunny, dry areas where many other plant will not grow. Plants have a trailing habit, and the leaves are succulent. Flowers are single or double and open in the sun and close in late afternoon. These plants look good in rock gardens, containers, and hanging baskets.
15. *Tagetes* sp. (Marigold)—Colors available include white, off-white, yellow, orange, and orange-red. Plants grow in full sun. Height is 4 inches to 4 feet. They are easily established from seed or as transplants. Marigolds bloom continuously from early summer until frost. All are good as cut flowers. The many different species have various flower forms and plant growth habits.
16. *Tropaeolum majus* (Nasturtium)—Colors include cream, yellow, orange, red, and pink. Plants grow in full sun. Height varies from 15 inches in the dwarf varieties to 10 feet in the climbing types. They are easily established from seed, but plants do not transplant well. Young leaves and blossoms have a peppery flavor and are edible. Blooms profusely throughout the summer until frost.
17. *Viola* sp. (Pansy)—Colors available include white, yellow, orange, red, purple, blue, and bicolors. Plants grow in full sun or partial shade. Height of plants is 8

inches. Violas are easy to establish as transplants are popular for containers, hanging baskets, and rock gardens. These plants grow best in early spring through early summer. Some varieties are more heat tolerant than others. The various species have various flower and growth characteristics. They will bloom all summer in cool regions if plants are dead-headed but will need to be replaced in hot summer climates.

18. *Zinnia elegans* (Garden zinnia)—Comes in shades of white, yellow, orange, red, pink, purple, and bicolors. Plants grow in full sun. Height is 6 to 36 inches. Zinnias are easily started from seed. These plants grow easily and bloom through the heat of summer and into late summer when most other annuals have finished. Available in dwarf and tall growing varieties.

VII. Getting Started with Biennials

Biennial plants complete their life cycle in 2 years. During the first year plants produce leaves that are often close to the ground and arranged circular in nature. This rosette of leaves overwinters, and the winter cold period stimulates flowering during the second year. The plants bloom and then die.

Biennial seeds can be planted in midsummer to produce plants that develop in the fall. The plant will then bloom the next year. Popular biennials are stock, foxglove, silver dollar, and hollyhock.

Culture of biennials is the same as for annuals except the plants remain for 2 years.

VIII. Getting Started with Perennials

Historically, herbaceous perennials have always been an important component of the ornamental garden, and recently there has been an upsurge of interest across the United States in the culture of herbaceous perennials. Despite this renaissance, many gardeners are reluctant to try growing herbaceous perennials because they still lack appreciation and knowledge about them.

Herbaceous perennials take the name *herbaceous* from the word *herb*, a seed-producing annual, biennial, or perennial that does not

produce woody stems. Herbaceous perennials are termed *perennial* in that they take one or more seasons to go from seed to seed, and then generally, but not necessarily, live for three or more seasons. Some, such as columbine, may be short-lived, while others such as peony will outlast several generations of the same family in the same site without being divided or moved.

The tops of the plants, the flowers, the leaves, and the stems of herbaceous perennials usually die back to the ground with the first fall frost. The hard, fleshy subterranean portions of the plant, the crown and roots, survive the winter and resume growth in spring. Those herbaceous perennials that survive the winter with little or no protection are termed *hardy*. Those herbaceous perennials that need some protection to survive the winter outdoors are said to be *half-hardy*. Some herbaceous perennials must be lifted as tubers, rhizomes, or bulbs, stored overwinter or placed in a greenhouse, and then be replanted in spring. These plants are termed *tender* herbaceous perennials.

Herbaceous perennials are available in an unlimited variety of flowers, foliage colors, textures, forms, spreads, and height. As a group, herbaceous perennials are the first plants to bloom in the spring and the last to fail with the fall frosts. They seldom bloom more than a few days to several weeks as individuals, but afford a continuity of bloom as a bed or border.

Being herbaceous rather than woody, herbaceous perennials have the capacity to bend in the breeze and lend interest and movement to a static landscape. They have the advantage, unlike trees and shrubs, of obtaining a definite size each season, somewhere between a few inches to 10 feet tall. Generally, herbaceous perennials need division and no pruning.

Herbaceous perennials vary in their environmental preferences from wet to dry, fertile to infertile, low to high pH, sandy to loam to clay soils, as well as shady to sunny sites. They also vary widely in the amount of care they need. While there are no maintenance-free herbaceous perennials, there are many that require low maintenance.

A. The Purpose of a Perennial Garden

A perennial garden may have different purposes and fill many needs. The great English gardener, Gertrude Jekyll (1848-1933), perhaps said it best when she penned:

“The first purpose of a garden is to give happiness and repose of mind, which is more often enjoyed in the contemplation of the homely border...than in any of those great gardens where the flowers lose their identity, and with it their hold of the human heart, and have to take a lower rank as mere masses of color filling so many square yards of space.”

Among the uses of a perennial garden might be to:

- Enhance those outdoor areas where you will spend much of your time from spring to fall.
- Create an attractive privacy screen.
- Soften and make attractive a steep slope by terracing it and planting herbaceous perennials.
- Create a bog garden where it is too wet for a lawn.
- Create an inviting entrance to your house.
- Grow flowers for indoor or outdoor fragrance.
- Integrate the other features of the landscape into a whole.
- Create a special place to exhibit your skill at raising specimen plants.
- Mask unattractive aspects of the yard such as tool sheds, garbage cans, compost bins, etc.
- Use a rocky outcropping as a rock garden rather than trying to remove the rocks.
- Create a stunning view from inside the house.
- Add color, shape, and dimension to the small yard patches next to entrances, which will soften the hard features of the existing backdrop.

B. Sexual Propagation by Seed

This method is advantageous because disease is not as easily carried over on the seed as it may be through vegetative propagation.

To start herbaceous perennials from seed, harvest the seed when it is ripe but before the spent flower heads self-sow. Keep in mind that seeds of many horticultural cultivars will not come true-to-type owing to its hybrid parentage. To start perennials from seed indoors, start them in midwinter to early spring so some of them will bloom the first growing season. Seeds may be started in a greenhouse or a sunny window but most commonly are started under lights.

C. Vegetative Propagation by Division, Stem Cuttings, Root Cuttings, Layering, Grafting, or Tissue Culture

Vegetative propagation guarantees that the offspring will be identical to the parent. Usually it takes far less time to have a fully mature blooming herbaceous perennial when it is vegetatively propagated.

1. Division—This is the simplest and most certain way to propagate, control the size of, and rejuvenate herbaceous perennials. Generally, perennials become larger each year and eventually begin to choke out other plants. Their outer edge thrives while the center of the clump suffers from competition for water, nutrients, root run, and sunlight. Often an advanced-age clump looks like a doughnut with a thriving outer ring and a dead center. Such a clump is a prime candidate for division. Shasta daisies, chrysanthemums, and phlox are good examples of plants where this condition exists after 2 to 3 years.

The time to divide a perennial clump depends upon the particular perennial, the time of year that the perennial blooms, and the climate. In Zone 5 or colder, most division is done in the spring while the perennials are still slightly dormant. Division is usually necessary only every 2 to 4 years for most perennials. Some perennials such as the chrysanthemum benefit from being divided every year while others, such as the oriental poppy, are best left undisturbed for as long as possible, or never divided.

Different types of perennials are handled differently depending upon their growth

habit when they are dug and divided. For example, compact shallow-rooted plants are divided by digging the entire clump and pulling it carefully apart into smaller plants. Solid clumps of plants such as daylilies, hosta, phlox, and Siberian iris are divided by digging up the entire clump and using two spading forks back-to-back to pull the clump into sections. If the center of the clump is deteriorated, it must be discarded. If you wish to have a small section of an existing clump for use elsewhere, use a sharp spade to dig a healthy section away from the parent clump without disturbing the parent clump. Shallow-rooted ground covers such as vinca and creeping phlox are divided anytime during the growing season by digging them up and cutting them apart. Fibrous- to woody-rooted perennials such as lupine must be dug carefully, the soil rinsed from the roots, and then the crown carefully divided with a sharp knife, making sure that each segment contains two to four strong tap root segments and two to four eyes or shoots.

2. Tip or stem cuttings—These are rootless sections of plants that are placed in a rooting medium where they are induced to develop adventitious roots. Cuttings may also be taken from actively growing roots.

Tip or stem cuttings are propagated by taking a terminal, 3- to 6-inch long firm portion of a vigorous nonblooming shoot that includes several nodes. Spring is the best time to take cuttings from herbaceous perennials that bloom in summer. Early summer is the best time to take cuttings from those that bloom in spring or fall.

Most perennials cuttings should begin to develop roots in 1 to 2 weeks. Bottom heat will speed the rooting process but is not necessary.

Sometimes young, virtually rootless tufts of shoots develop at the base of the perennials. These may be pulled away from the parent plant and treated the same as any cutting.

3. Root cuttings—These cuttings are best made in early spring. While it is easiest to take cuttings from perennials when they are being lifted from the bed or border, cuttings can also be taken from the parent plant by digging around the periphery of the parent plant with a shovel. Fine-rooted plants, such as achillea, are propagated from root cuttings by scattering 1- to 2-inch long sections of root horizontally on the surface of a 2- to 3-inch deep layer of moist soilless medium in a flat. Cover the pieces of root with 1/2 inch of moist sifted, soilless mix. Fleshy-rooted perennials such as baby's breath, bleeding heart, peonies, and oriental poppies are propagated by taking 1 1/2- to 2-inch long sections of roots, dusting the bottom end with a rooting compound, and sticking the root cutting bottom end down in a 50-50 mixture of peat moss and sand in pots or deep flats, with 1/4 inch of the cutting sticking above the rooting medium. For peonies, take 3-inch long root cuttings and keep the medium moist but not wet. When the cuttings begin to grow, treat them the same as any other seedlings.
4. Layering—This is an easy way to propagate vine-type plants and ground covers. Bend the supple stems, without severing the stem from the parent plant, down to the soil into a shallow trench and cover several nodes with soil, or bend the stems into pots of soil. Notching or wounding the area just below a soil-covered node will encourage rooting. Many upright plants can also be rooted with this technique by carefully bending their younger, more flexible stems downward to the ground.
5. Grafting—This is the joining of the top of one plant, the scion, to the bottom of another plant, the stock. This technique is possible but rarely used in propagating perennials.
6. Tissue culture—Millions of disease-free plants from a single small clump of apical cells in a single season can be generated from a tissue culture. This method is

beyond the facilities and capabilities of the ordinary homeowner.

D. Vegetative Propagation by Specialized Stems and Roots

These function primarily as food storage organs and can also function in vegetative reproduction.

1. Bulbs—Tunicate bulbs have outer-bulb scales that are dry and membranous and are typical of the tulip, hyacinth, bulbous iris, and daffodil. Nontunicate, or scaly bulbs, are represented by the lily. These bulbs do not have the dry covering, and the scales are separate and attached to a basal plate. Propagation is accomplished by periodically removing the small bulbs or offsets that grow off of the main bulb. This is usually done whenever the plants are dug. Digging of these perennials is necessary when the clumps become too crowded and is done after the foliage has died down naturally in the late summer or fall. Bulbs should be planted or replanted at that time. The small bulbs may need to grow for several seasons before they are large enough to flower. Lilies are propagated by removing some of the outer scales of the mother bulb, planting them, and allowing them to develop small bulbs.
2. Corms—Gladiolus and crocus are typical plants with corms. Gladiolus are semihardy to tender in Idaho and must be stored overwinter in areas with severe winters. The corm is a swollen base of the stem that is enclosed by dry, scaly leaves. Propagation is accomplished by separating the small corms or cormels from the mother corms. Plant these small corms shallowly and expect no flowers until they grow large enough, usually 1 or 2 years.
3. Tubers—These are a modified stem that serves as a storage organ. Caladium is an example of a tuberous plant. Tubers can be propagated by planting the whole structure or by cutting tubers into sections, each containing one or more buds or "eyes." This division is done shortly before planting.

4. Tuberous roots and stems—These thickened structures are botanically different from true tubers but are often called simply “tubers.” Tuberous roots are typical of several types of perennials, including the dahlia. Propagation is done by separating the tuberous roots, making sure that each root has a section of the crown with a shoot bud. Divide in late winter or spring, shortly before planting. Tuberous roots are biennial, meaning the old root disintegrates in the second year after new tuberous roots are produced.

Tuberous stems include the tuberous begonia and cyclamen. These structures are usually vertical in orientation and have vegetative buds on the upper end. These tuberous stems continue to grow larger and larger from year to year. Divide these structures early in the spring, making sure each has a bud.

5. Rhizomes—These specialized stem structures grow horizontally on top of or just below the soil surface. Rhizomatous iris and lily of the valley are two perennials that can be propagated by their rhizomes. Remove sections of shoots and roots early in the spring or in late summer or fall.

D. Growing, Culture, and Maintenance

1. Site selection—Because herbaceous perennials can be left in a given place for a long period of time, proper site selection is critical. Most plants prefer a site that has a fertile, well-drained, organically rich soil with a pH of 5.5 to 6.5. Good drainage is important, especially during the winter, and most soils will have to be improved. The site should receive full sun or shade all day. Be sure to consider not only the present shade, but also the future shade. Take into account the growth of your trees and shrubs as well as your neighbor’s. The site should be flat to only slightly sloped. It should be out of the drying, stem-snapping wind but have enough breeze to provide the air circulation essential to minimize the slow foliage-drying conditions conducive to disease.

2. Soil preparation—The best opportunity to tailor the soil needs of the perennial is the first time it is prepared. Try to start soil preparation long before planting the bed or border. Start in spring for a fall planting and in fall for a spring planting. This will allow plenty of time for any organic soil amendments and/or pH modifications to take effect. To prepare the site for planting perennials:

a. Clear all large debris from the site.

Kill and remove all existing vegetation from the site for composting. It may be necessary to re-treat the site to kill persistent perennial weeds such as quackgrass.

b. Spread 2 to 3 inches of organic matter such as well-decomposed compost, aged manure, or peat moss over the surface of the soil before beginning to work it. Rototill or spade the organic matter into the soil to a depth of 8 to 12 inches. Add no more organic matter than one-third of the final amended soil volume. Do not work the soil when it is wet. Organic matter incorporation improves soil structure by providing the lignin that glues together the soil particles. Improved soil structure encourages water percolation and retention, aeration, and root penetration. Spread an organic mulch over the prepared bed or border. It is easier and tidier to spread the mulch before planting.

c. Edge the bed or border in some fashion. An edging will be attractive and will help reduce the encroachment of the lawn.

3. Planting and transplanting—While bare-rooted perennials are best planted either spring or fall, container-grown perennials may be planted at any time during the growing season, though it is more difficult during the drought months of July and August. Freshly dug plants are best transplanted in spring or fall but may be moved all summer if you are careful. Perennials such as bearded iris, bleeding heart, peonies, and oriental poppies are

best transplanted immediately after their brief dormant period after bloom. When planting herbaceous perennials:

- a. Dig a hole two times the size of the root spread of bare root perennials and one and one-half times the size of the root ball of container-grown perennials.
- b. Soak the roots of bare root plants for several minutes in a starter solution of 1 tablespoon of 16-12-10 or 20-20-20 water soluble fertilizer dissolved in 1 gallon of water.
- c. Water the potted herbaceous perennials with a starter solution before knocking them out of the container. Place your hand over the top of the pot with your fingers grasping the main stems, turn the pot upside down, and tap the pot rim on the edge of a hard surface or tap the bottom of the pot sharply with a planting trowel. Remove fiber pots from perennials because often pots do not decompose. Be sure to at least peel back the rim of peat pots below soil level or the rim will act as a wick, drying out the pot and the contained soil.
- d. Some pot-bound plants may have to have the container cut away with snips. Score the soil ball, making three to five vertical cuts into the soil ball, top to bottom, with a sharp knife. The depth of the cuts will vary from 1/2 to 1 1/2 inches deep depending upon the size of the soil ball. Tease some of the soil away from the top, sides, and bottom of the soil ball.
- e. Place the plant in the planting hole, making sure that the crown of plant is at the same depth as it was previously growing.
- f. Work some organic matter one-fourth to one-third by volume into the soil. Place this mixture around the roots until the hole is half full. Settle the soil around the root system by mucking it in with the starter solution. Finish filling the hole with the soil-organic matter mixture.

- g. Tamp the soil firmly around the root system. Leave a berm to facilitate watering. Water the newly planted perennials with the starter solution. Label the plants or make a map of the garden for future reference.

4. Fertilizing—Perennials need steady, but light fertilizing first in late March to early April, right after the last of the mulch is removed and growth starts. Use a 5-10-5 fertilizer at the rate of 2 pounds per 100 square feet of bed space. Fertilize two more times at the same rate about 6 weeks apart. Fertilize a final time in very late summer for fall-blooming perennials. If the perennial bed or border begins to lag a bit in midsummer, use a water soluble foliar fertilizer as a boost. Foliar feeding should always be thought of as supplemental to, rather than as a substitute for, granular fertilizers.

Note: Overfertilizing, especially with nitrogen, promotes vegetative growth at the expense of flowering and increases the need of staking for support.

5. Watering—Frequency is dictated by climate and the presence of a mulch. Water early in the day to avoid going into the evening with wet, disease-susceptible foliage. Water thoroughly, to a depth of 8 to 10 inches, to encourage deep root penetration. Soil should dry out a bit between watering. Waterlogged soil will encourage root disease and excludes oxygen, resulting in shallow-rooted, drought-prone, unstable plants.
6. Mulching—Helps control weeds, reduces water loss, moderates soil temperature changes, prevents mud splattering of foliage and flowers, helps preserve surface soil structure, and adds nutrients to the soil as the mulch biodegrades.
Winter mulch can protect perennials from excessive cold temperatures and harmful thawing on freezing cycles. Apply after the first cold weather has occurred and after the soil has frozen. Cover crowns with 2 to 6 inches of light, porous mulch.

Remove mulch in the spring or before plant growth begins.

Summer mulch can be applied after the soil warms up, about 4 to 6 weeks after the last of the winter mulch is removed. Try to coordinate the placement of the summer mulch so that it follows one of the fertilizations and weed-destroying cultivations. Apply between 1 to 2 inches of mulch. Be sure to keep the mulch away from the crown of the herbaceous perennial.

The best mulches to use are those that biodegrade to the point that they can be worked into the soil in late fall or early spring. Mulches in this category include compost, peat moss, or smaller-sized bark.

7. Thinning—Removing out some of the stems increases the potential size of the individual blooms produced by the plant. For the most part, thinning is not necessary as it decreases the mass of the plant and may reduce the overall bloom impact of the plant.
8. Pinchin —Inhibits the natural legginess of many perennials such as chrysanthemums. Pinching the growing tips or shoots of the individual stems once in May or June removes the inhibition of the shoot tip, producing multibranched shoots. This produces a whole bouquet of smaller-than-usual individual blooms. The combined branched shoots give the entire plant a much greater overall blooming mass despite the smaller individual blooms. Chrysanthemums are pinched every 3 to 4 weeks with the last pinch occurring about July 15.
Pinching also delays blooming. A soft pinch, just the tip of the stem, does not delay flowering as long as a hard pinch, which removes several inches and several nodes from the stems. Pinching also decreases the need to stake herbaceous perennials as the plants are more compact.
9. Weeding—This is important because weeds compete for nutrients and water. Weeds may be grassy or broad leafed and annual, biennial, or perennial. The un-

wanted offspring of existing perennials may also be considered weeds since many of them, especially those from hybrid parents, will not come true-to-type. Your first chore is to be able to distinguish weeds, even at the seedling stage, from desirable perennials. Once so distinguished, weeding can be done by hand, with shallow cultivation, with herbicides, or largely avoided by using mulches.

10. Deadheading—Removal of spent blooms or inflorescence improves the appearance of the herbaceous perennials and prevents the investment of energy in seed production. It also encourages the plant to continue blooming, and stimulates a second flush of weaker bloom in those plants such as delphinium and foxglove.
A few perennials such as sedum ‘Autumn Joy’, Black-eyed-Susan, and ornamental grasses should be allowed to retain their seed heads for their winter interest.
11. Disbudding—The removal of all except the tip-most bud on each individual stem or branch of a multibranched stem produces large flowers on each stem or branch of that stem. Peonies are often disbudded in this fashion. The most spectacularly sized blooms can be achieved by taking a rooted cutting and limiting it to a single terminal bud on a single stem. One shortcoming of disbudding is that the second flush of bloom, which occurs after the terminal bud blooms and the axillary buds develop, is lost. Some gardeners remove the terminal bud to obtain a host of relatively large axillary blooms.
12. Staking—Giving a physical support to the individual stems or to the plant as a whole is often necessary for those perennials with a natural tendency to fall over because of their height, habit, or weight of blooms and foliage.
Tall, single stems of perennials such as delphiniums, gladiolus, and hollyhocks may require individual stakes for support. Select bamboo, plastic, or metal stakes that will be at least three-quarters as tall as the individual stems they are to support when firmly anchored in the soil.

Tie the stems to the stakes with a figure eight loop with one loop around the stake and the other around the stem. This double loop acts as a spring giving the stem a chance to sway in the breeze. The loops can be made with paper-covered wire, floral tape, or other soft material. Stake bushy, multistemmed, floppy perennials such as asters, chrysanthemums, and coreopsis by pushing a ring of stakes into the soil at a point slightly to the interior of the perennial. Select stakes that are 6 to 12 inches shorter than the ultimate height of the plant. Weave a cats' cradle of support between the stakes with green yarn or floral tape. Start 1 foot above the soil level and continue upward at 1-foot intervals until the last cats' cradle is 8 to 12 inches below the top of the stems.

Alternatively, push appropriate lengths of multibranched tree or scrub prunings or branched bamboo canes into the soil at the fringes of the perennial. Let the interweaving branches supply most of the support. Some twine or floral tape may still be needed to contain the stems of the perennials.

Place very strong, multi-legged 18- to 20-inch tall wire hoops around perennials such as peonies and oriental poppies that have very heavy blooms on supple stems.

13. Insects and diseases—Practices to prevent or reduce the chance of insect and disease problems include:
 - a. Select insect and disease-resistant perennials.
 - b. Give your perennials the very best growing conditions possible from the standpoint of soil, nutrition, watering, spacing, sunlight, and air circulation.
 - c. Grow a variety of plants. A monoculture of a cultivar or of a few cultivars will be far more susceptible to insect and disease problems.
 - d. Remove spent flowers, dead leaves, and other plant litter during the growing season when it can be a source of infestation. Clean up the bed or border thoroughly before winter to avoid any

refuse harboring insects and disease over winter.

- e. Keep weeds out of the bed or border and the immediate area because they are a source of both insect and disease problems.
 - f. Know what the most likely common pests of your perennials are and then monitor for them.
 - g. Do not compost any diseased plants. If your compost pile reaches the 140°F to 160°F, most disease organisms and insect eggs will be killed. However, most piles never get this warm, especially in the outside portion. Fungus organisms will spread along with compost.
 - h. When a problem is encountered, act immediately without using pesticides if possible. Cut off diseased portions of the herbaceous perennial, or remove seriously damaged plants entirely. Handpick large insects.
14. Pesticide control—Consult with your county Extension educator for the most bio-rational pesticide to use for your particular problem.

Spot treat if possible. Use non-chemical, non-biological pesticides such as horticultural oils and insecticidal soaps. Use biological pesticides such as *Bacillus thuringiensis* for caterpillars, or those pesticides derived from natural sources such as pyrethrum, rotenone, ryana, or sabadilla. When using any pesticide, follow the label instructions for pest controlled and for plants for which the chemical is labeled. Always apply at the labeled rate as instructed. Buy small quantities of the pesticide to avoid disposal problems.

IX. A Selection of Perennials for Idaho

Idaho growing conditions are difficult on plants. During the summer, temperatures and light intensity are high and humidity is low. This combination causes some plants listed for the eastern United States and lower coastal elevations to perform poorly in Idaho. On the following pages, Table 1 lists perennials avail-

able through the Idaho nursery trade or by mail-order that have performed well or are deemed worthwhile for trial in Idaho.

- A. Common Name—Lists several names that the perennial might be called. Cross-referencing is done through the text for convenience. For example, hollyhock is listed under *alcea*. Hollyhock is also found under the common name, which refers back to *alcea* for more information.
- B. Scientific Name—Since the common name leaves a lot of guesswork, the scientific name is included for clarity. Under the scientific name is a listing of cultivars (cultivated varieties) that may be available in your local nursery. The cultivar name (e.g. ‘Pink Star’) many times indicates flower color.
- C. Height—Varies with fertilizer practices, placement with respect to light, soil conditions, and plant vigor. A range of heights is given for most plants. Determining exact heights will be the part of the joy of gardening. Keep records of your discoveries

so that plants can be moved into more correct locations in the future. A perennial garden can be arranged and rearranged like furniture in your home.

- D. Bloom Time —Gives you the chance to “orchestrate” and synchronize the blooming sequence. Use a sheet of paper to list and “orchestrate” your flower display.
- E. Flower Color—Refers to flower colors available in the nursery trade. It does not necessarily refer back to the specific cultivars in the scientific name column.
- F. Light Needed—Categorizes the plant into one or more light regimes: full sun is uninterrupted sunlight through the full day; partial shade is filtered sunlight through tree leaves or a minimum of 6 to 8 hours of sunlight per day; full shade indicates filtered sunlight through a dense foliage canopy or less than 6 hours of sunlight each day.
- G. Landscape Use—Suggests planting locations as well as indoor uses such as cut flowers or dried flower arrangements.

Table 1. Perennials for Idaho.

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|--|--|-----------|--------------|--|---|--|
| Achillea, dwarf (Woolly Yarrow) | <i>A. tomentosa</i> German hybrids, e.g., paprika | 8"-10" | June-Aug | Yellow | Full sun | Borders, ground cover |
| Achillea, tall (Fernleaf Yarrow) | <i>Achillea</i> spp. | 2 1/2'-3' | June-Aug | Yellow | Full sun Partial shade Full shade | Borders, cut flowers dry flowers |
| Aegopodium (Bishops Goutweed) | <i>A. podigrarua</i> <i>variegatum</i> | 8"-14" | June-Aug | White | Full sun Partial shade Full shade | Ground cover, will grow in poor soil |
| Ajuga | <i>Ajuga</i> spp. ‘Alba’ ‘Bronze Beauty’ ‘Gaiety’ | 6"-9" | April-May | Blue White | Full sun Partial shade Full shade | Ground cover, edging rock gardens, beneath trees |
| Alcea (Hollyhock) | <i>Alcea rosea</i> (also <i>Althea rosea</i>) ‘Majorette’ ‘Silver Puffs’ ‘Summer Carnival’ ‘Chater’s Double Mixture’ | 2'-9' | June-Aug | White Yellow Pink Lavender Red | Full sun | Background borders, against fence or wall |
| Allium (Stars-of-Persia or Persian Onion) | <i>A. christophii</i> | 15"-24" | Early summer | Silvery-violet | Full sun | Herb gardens, edging vegetable plots, containers, edible foliage, rockeries |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|--|---|---------------|-------------------|--|---|--|
| Allium (Giant Onion) | <i>A. giganteum</i> | 3'-4' | Early summer | Pink-purple | Full sun | Herb gardens, edging vegetable plots |
| Allium (Turkestan Onion) | <i>A. karataviense</i> | 8"-10" | Late spring | Lilac-pink | Full sun | Herb gardens, edging vegetable plots |
| Allium (Golden Garlic or Lily Leek) | <i>A. moly</i> | 10"-14" | Late spring | Bright yellow | Full sun- partial shade | Herb gardens, edging vegetable plots |
| Allium (Chinese Chive or Garlic Chive) | <i>A. tuberosum</i> | 20" | Late summer | White | Full sun- partial shade | Herb gardens, edging vegetable plots |
| Allysum (Basket of Gold) (Gold Dust) | <i>A. saxatile</i> 'Compacta' | 9"-10" | April-June | Golden yellow | Full sun | Rock gardens, dry walls, banks, fronts of borders |
| Anchusa (Forget-Me-Not) | <i>A. myosotis</i> | 6"-8" | May-June | Blue | Full sun Partial shade | Borders, groupings |
| Anemone (Greek Anemone) (Greek Windflower) | <i>A. blanda</i> 'Blue Star' 'Bridesmaid' 'White Splendor' 'Pink Star' | 3"-6" | April-May | Blue Pink Purple White | Full sun Partial shade | Rock gardens, perennial borders, naturalized |
| Anthemis (Golden Chamomile) (Golden Carguerite) | <i>A. tinctoria</i> 'E.C. Buxton' 'Kelwayi' 'Moonlight' | 2'-3' | June-Sept | Yellow | Full sun | Perennial borders, cut flowers |
| Aquilegia (Columbine) | <i>A. hybrida</i> 'Mckana Giant' 'Mrs. Scott Elliot' 'Rose queen' 'Spring Song' | 2'-3' | May-June | Blue Pink Purple Red Yellow White | Full sun Partial shade | Borders, naturalized settings |
| Arabis (Rock Cress) | <i>A. caucasica</i> 'Snow Cap' 'Spring Charm' | 12" | Late March May | White Rose-tinted | Full sun | Rock gardens, dry stone walls, border, small area ground cover |
| Arenaria (Irish Moss) (Sandwort) | <i>Arenaria</i> spp. | 2"-6" | May-June | White | Full sun Partial shade Full shade | Evergreen, ground cover, rock gardens, around stepping stones |
| Armeria (Sea Pink) (Sea Thrift) | <i>A. maritima</i> 'Brilliant' 'Lauchiana' 'Royal Rose' | 6"-15" | May-June | Pink White | Full sun | Edging, rock gardens, cut flowers |
| Artemisia (Wormwood) (Angels Hair) | <i>A. schmidtiana</i> 'Silver Mound' 'Pours Castle' 'Silver Brocade' | 8"-12" | Foliage plant | | Full sun Partial shade | Perennial borders |
| Asclepias (Butterfly Weed) (Pleurisy Root) | <i>A. tuberosa</i> | 2'-3' | June-Aug | Orange | Full sun | Borders, dry flowers |
| Asperula (Sweet Woodruff) | <i>A. odorata</i> | 8" | May-July | Pink Blue White | Partial shade | Ground cover, rock gardens |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|---|---|-----------|--------------------------|--------------------------------|---------------------------|---|
| Aster, short/dwarf (China Aster) (Annual Aster) | <i>Callistephus chinensis</i> 'Pinocchio' 'Dwarf Queen' 'Color Carpet' | 4"-10" | Spring Summer or fall | Many | Full sun | Cut flowers, bedding plants |
| Aster, tall (New England Aster) (Stokes Aster) | <i>Aster</i> spp. or <i>Callistephus</i> spp. or <i>Stokesia</i> spp. | 11/2'-3' | Spring Summer or fall | Many | Full sun | Cut flowers, borders |
| Astilbe (False Spirea) | <i>Astilbe x arendsii</i> 'Deutschland' 'Fanal' 'Red Sentinel' | 2'-3' | June-July | Red Pink White | Full sun Partial shade | Border plant |
| Aubretia (False Rock Cress) | <i>A. deltoidea</i> 'Bengale' 'Purple Cascade' 'Red Cascade' | 6' | April-May | Rose-lilac Purple Red | Full sun Partial shade | Rock gardens, dry stone walls, edge of perennial borders |
| Baby's breath (see <i>Gypsophila</i>) | | | | | | |
| Basket of gold (see <i>Allysum</i>) | | | | | | |
| Bellflower, Chinese or Japanese (see <i>Platycodon</i>) | | | | | | |
| Bellis (English Daisy) | <i>Bellis perennis</i> | 4"-6" | April-June | White Pink | Full sun Partial shade | Edging, borders |
| Bergenia (Heartleaf Berfenia) (Pig Squeak) | <i>B. cordifolia</i> | 12"-15" | April-May | Pink White | Full sun Partial shade | Evergreen, rock gardens, stream banks, pools, perennial borders |
| Betonica (Lamb's Ear) (Woolly Betony) | <i>Stachys byzantina</i> | 6"-12" | July-Oct | | Full sun Partial shade | Front of borders, ground cover, rock gardens |
| Bleeding Heart (see <i>Dicentra</i>) | | | | | | |
| Campanula (Carpathian Harebell) | <i>C. carpatica</i> 'Blue Carpet' 'China Doll' | 6"-12" | June-Aug | Blue-lilac White Purple | Full sun Partial shade | Borders or rock gardens |
| Campanula (Danesblood) (Clustered Bellflower) | <i>C. glomerata</i> | 1'-1 1/2' | June-Aug | White Blue Purple | Full sun Partial shade | Borders, bedding between shrubs, cut flowers |
| Campanula (Canterbury Bells) | <i>C. medium</i> 'Cup and Saucer' | 2'-4' | June-Aug | White Pink Blue Mauve | Full sun Partial shade | Borders, isolated clumps, balconies |
| Campanula (Peach Bells) | <i>C. persicifolia</i> | 2'-3' | June-Aug | White Blue | Full sun Partial shade | Borders |
| Canterbury Bells (see <i>Campanula medium</i>) | | | | | | |
| Carnation (see <i>Dianthus caryophyllus</i>) | | | | | | |
| Cerastium (Snow-in-Summer) | <i>C. tomentosum</i> 'Columnae' 'Yoyo' | 6" | May-June | White | Full sun | Evergreen, ground cover, dry stone walls, edging |
| Ceratostigma (Plumbago) | <i>C. plumbaginoides</i> | 8"-10" | July-Sept | Dark blue | Full sun Partial shade | Rock gardens, ground cover |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|--|---|---------------|-------------------|--|------------------------------|--|
| Cheiranthus (Wallflower) | <i>C. cheiri</i> | 9"-30" | March-May | White Yellow Brown Red Pink Purple | Full sun | Balconies, terraces, mixed borders, flower beds, banks rockeries, slopes |
| Chive (see Allium) | | | | | | |
| Chrysanthemum (Shasta Daisy) | <i>Chrysanthemum x supermum</i> 'Alaska' 'Esther Read' 'Little Miss muffet' 'Marconi' 'Snowcap' | 2'-4' | June-Oct. | White | Full sun Partial shade | Cut flowers, borders |
| Columbine (see Aquilegia) | | | | | | |
| Convallaria (Lily-of-the-Valley) | <i>C. majalis</i> | 6"-12" | May | White | Full sun Partial shade | Ground cover, cut flowers |
| Coral Bells (See Heuchera) | | | | | | |
| Crocus & hybrids | <i>Crocus</i> spp. | 2"-6" | Early spring | Golden yellow Blue Lavender Purple White Purple striped | Full sun to partial shade | Excellent for early color; Large-flowered "Dutch hybrids" bloom later than most spring-flowering types |
| Crocus (Autumn) | <i>Colchicum autumnale</i> | 4"-6" | Early spring | Lavender-pink Rose White | Full sun to partial shade | Foliage grows in spring, then dies, flowers appear in fall without foliage |
| Coreopsis (Tickseed) | <i>C. lanceolata</i> 'Baby Sun' 'Brown Eyes' 'Goldfink' 'Mayfield Giant' 'Sunburst' <i>C. rosea</i> <i>C. verticillata</i> 'Moonbeam' 'Zagreb' | 2'-3' | June-July | Yellow Yellow chestnut | Full sun | Borders, cut flowers |
| Creepin Jennie (see Lysimachia) | | | | | | |
| Daffodil (see Narcissus) | | | | | | |
| Daisy, English (see Bellis) | | | | | | |
| Daisy, Gloriosa (see Rudbeckia) | | | | | | |
| Daisy, Painted (see Pyrethrum) | | | | | | |
| Daisy, Shasta (see Chrysanthemum) | | | | | | |
| Daylily (see Hemeracallis) | | | | | | |
| Delphinium (Larkspur) | <i>D. elatum</i> | 3'-6' | June-July | Many | Full sun | Background accent, cut flowers |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|---|---|---------------|-------------------|---|---------------------------|---|
| Dianthus | <i>D. barbatus</i> | 4"-6" | May-Aug | White Pink Scarlet | Full sun | Cut flowers, balconies, terraces, borders, rockeries, flower beds |
| Dianthus (Carnation) (Clove Pink) (Divine Flower) | <i>D. caryophyllus</i> 'Chabaud's Giant Improved' 'Dwarf Fragrance Mixed' 'Enfant de Nice Mixed' 'Juliet' 'Oriental Hybric Mixed' 'Spotti' 'Tiny Rubies' | 1'-2' | June-Aug | White Pink Red Purple Yellow Apricot Orange | Full sun | Cut flowers, flower beds, pot plants, borders |
| Dianthus (Pinks) | <i>D. chinensis</i> | 6"-12" | Summer-fall | Red White Pink | Full sun Partial shade | Edging, cut flowers bedding |
| Dianthus (Maiden Pink) (Meadow Pink) (Spink) | <i>D. deltooides</i> 'Brilliant' | 4"-12" | May-Aug | White Pink Red | Full sun | Rock gardens, border plants |
| Dicentra (Bleeding Heart) | <i>Dicentra</i> spp. | 2'-3' | May-June | Red and white | Partial shade | Cut flowers, shaded borders |
| Digitalis (Common Foxglove) (Fairy Glove) (Fingerflower) (Purple Foxglove) | <i>D. purpurea</i> 'Leopard Foxglove' | 2'-5' | May-July | Purple and White | Full sun Partial shade | Borders, cut flowers |
| Doronicum | <i>D. cordatum</i> 'Finesse' 'Madam Mason' | 2' | April-May | Yellow | Full sun Partial shade | Front or middle perennial borders, cut flowers |
| Echinops (Glove Thistle) | <i>E. exaltatus</i> 'Tapglow Blue' | 3'-5' | July-Sept | Blue | Full sun | Cut and dried flowers back of borders |
| Erigeron (Gleabane) | <i>E. speciosus</i> | 1'-2' | June-July | Blue | Full sun | Cut flowers, rock gardens, borders |
| Euphorbia | <i>E. myrsinites</i> | 8"-10" | March-May | Yellow | Full sun | Border plants, cut flowers, rock gardens |
| Euphorbia (Cushion Spurge) | <i>E. polychroma</i> (epithymoides) | 11/2' | March-May | Yellow | Full sun | Border plants, cut flowers |
| Festuca (Blue Fescue) | <i>F. ovina glauca</i> | 6"-10" | | | Full sun Partial shade | Edging, banks, ground cover |
| Flax (Golden Flax) | <i>Linum flavum</i> | 1'-2' | June-Aug | Golden yellow | Full sun | Rock gardens |
| Forget-Me-Not (see Anchusa) | | | | | | |
| Foxglove, Common (see Digitalis) | | | | | | |
| Fritillaria (Crown Imperial) | <i>F. imperialis</i> | 2'-3' | Spring | Red Yellow Orange | Sun or light shade | A very showy old-fashioned plant, but odor may be offensive |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|---|--|---------------|--------------------------|--|---|--|
| Fritillaria (Checked Lily or Guinea-Hen Flower) | <i>F. meleagris</i> | 8"-12" | Spring | Checked purple | Sun or light shade White | Fragile appearance; makes an interesting rock garden plant |
| Fritillaria (Persian Fritillary) | <i>F. persica</i> | 10"-30" | Spring | Maroon Purple White | Full sun | Flowers have a slight skunk odor |
| Gaillardia (Indian Blanket) | <i>G. pulchella</i> 'Baby Cole' | 1'-2' | Summer Fall | Yellow Orange Scarlet | Full sun | Cut flowers, window boxes, planters |
| Geranium (Cranesbill) | <i>Geranium</i> spp. 'Biokova' 'Johnson's Blue' | 1'-2' | May-Sept | Blue Purple | Full sun Partial shade | Rock gardens, perennial gardens |
| Geum | <i>Geum</i> spp. | 2'-2 1/2' | May-Aug | Scarlet Orange | Full sun | Groupings in perennial borders, cut flowers |
| Glory-of-the-Snow | <i>Chinonodoxa luciliae</i> | 3"-6" | Early spring | Blue Pale pink White Yellow | Full sun | Rock gardens, borders and edgings |
| Gypsophila (Baby's Breath) | <i>Gypsophila</i> spp. | 1'-3' | June-July | Rose Purple White Pink | Full sun | Borders, dry flowers, rock gardens |
| Helianthemum (RockRose) (Sun Rose) | <i>H. nummularium</i> | 1' | June-July | Yellow Rose Red and crimson White | Full sun | Rock gardens, slopes and pockets, crazy paving |
| Hemerocallis (Daylily) | <i>Hemerocallis</i> spp. | 2'-4' | Spring Summer Fall | Many | Full sun Partial shade | Foundation plants, borders |
| Hen-and-Chickens (see <i>Sempervivum</i>) | | | | | | |
| Heuchera (Coral Bells) (Alum Root) | <i>H. sanguinea</i> 'Bressingham hybrids' 'Charteuse' 'Chatterbox' 'June Bride' 'Matin Bells' 'Pluie de Feu' (Rain of fire) 'White Cloud' | 1'-2 1/2' | May-July | Red Pink White | Full sun Partial shade | Rockerries, borders |
| Hollyhock (see <i>Alcea</i>) | | | | | | |
| Hosta (Plantain Lily) | <i>Hosta</i> spp. | 1'-2' | July-Sept | White Lavender Lilac | Full sun Partial shade Full shade | Borders, rock gardens, masses |
| Hyacinth (Armenian Grape) | <i>Muscari armeniacum</i> | 6"-8" | Early spring | Blue | Full sun to partial shade | Multiplies rapidly, excellent for edging or indoor forcing, fragrant |
| Hyacinth (Grape Hyacinth) | <i>Muscari botryoides</i> | 6"-8" | Early spring | Blue White | Full sun or partial shade | Produces clusters of tiny flowers, double flowers hold color longer |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|--|--|---------------|--|--------------------------------|------------------------------|---|
| Hypericum (Aaron's Beard) (Rose of Sharon) (St. John's Wort) | <i>H. calycinum</i> | 1'-1 1/2' | June-Sept | Yellow | Full sun Partial shade | Shady slopes, banks, flowerbeds, borders, ground cover |
| Iberis (Evergreen Candytuft) (Edging Candytuft) | <i>I. sempervirens</i> 'Autumn Snow' 'Little Gem' 'Purity' 'Snowflake' 'Snowmantle' | 6"-1' | April-May | White | Full sun | Rock gardens, edging |
| Incarvillea (Hardy Gloxinia) | <i>Incarvillea</i> spp. | 1' | June-July | Red Pink | Full sun | Perennial gardens, rock gardens |
| Iris (True-Bearded) (Siberian) (Japanese) | 200+ species and many cultivars | 4"-48" | Spring to fall, most May to June, some rebloom | Wide range | Full sun | Beyond flowers, leaves provide texture, contrast of colors and combinations |
| Kniphofia (Red-Hot Poker) (TorchLily) (Tritoma) (Poker Plant) | <i>K. uvaria</i> | 2'-4' | May-Sept | Red Yellow | Full sun | Borders, cut flowers |
| Lamb's ear (see <i>Betonica</i>) | | | | | | |
| Lamium (Spotted Dead Nettle) | <i>L. maculatum</i> 'White Nancy' | 1' | April-Sept | Purple-red White | Partial shade Full shade | Shaded perennial borders, rock gardens, summer filler |
| Lavandula (Sweet Lavender) | <i>Lavandula</i> spp. 'Hidcote' 'Munstead' | 1'-3' | June-Sept | Purple | Full sun | Borders, rockeries, cut flowers, evergreen |
| Liatris (Gayfeather) (Blazing Star) | <i>Liatris</i> spp. 'Kobold' | 1 1/2'-5' | July-Oct | White Purple Pink | Full sun Partial sun | Cutting, drying, borders |
| Lily (Asiatic Hybrids) | Genus <i>Lilium</i> has 100+ species and many cultivars | 2'-7' | June to July | Wide range | Full sun to partial shade | Accent plants |
| Lily (Trumpets) | Genus <i>Lilium</i> has 100+ species and many cultivars | 2'-7' | July | Wide range | Full sun to partial shade | Accent plants |
| Lily (Surelians) | Genus <i>Lilium</i> has 100+ species and many cultivars | 2'-7' | July | Wide range | Full sun to partial shade | Accent plants |
| Lily (Oriental Hybrids) | Genus <i>Lilium</i> has 100+ species and many cultivars | 2'-7' | July to Aug | Wide range | Full sun to partial shade | Accent plants |
| Lily-of-the-Valley (see <i>Convallaria</i>) | | | | | | |
| Limonium (Sea Lavender) (Statice) | <i>L. sinatum</i> | 1 1/2'-2' | June-Aug | White Yellow Blue Red | Full sun | Flowerbeds, borders, small clumps, rockeries, cut and dried flowers |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|---|--|---------------|-----------------------|--|---|--|
| Liriope | <i>Liriope</i> spp. | 10"-15" | Aug-Sept | Purple | Full sun Partial shade Full shade | Evergreen, borders, perennial gardens, rock gardens |
| Lupine (Lupin) | <i>L. polyphyllus</i> George Russell hybrids | 2 1/2'-5' | May-July | Blue Purple Reddish purple Yellow | Full sun Partial shade | Cut flowers, borders |
| Lychnis (Maltese Cross) (Jerusalem Cross) | <i>L. chalcedonica</i> | 2'-3' | June-July | Scarlet | Full sun | Small groupings in borders |
| Lysimachia (Creeping Jennie) (Moneywort) (Creeping Charlie) | <i>L. nummularia</i> | 6"-8" | June-Nov | Yellow | Full sun Partial shade Full shade | Shaded slopes and banks, walls, hanging baskets, bag gardens, submerged aquarium plant |
| Maltese Cross (see Lychnis) | | | | | | |
| Monarda (Wild Bergamot) | <i>M. fistulosa</i> 'Gardenview Scarlet' | to 3' | June-Aug | Lilac Purple White | Full sun Partial shade | Borders |
| Narcissus (Daffodil) (Jonquil) | spp. & hybrids | 3"-14" | Early to midspring | Yellow White Pink (Cups: yellow, white, pink, orange, or nearly red) | Full sun or light shade | Borders, shrub beds, or naturalized, good for cut flowers |
| Ostrich Fern (see Pteretis) | | | | | | |
| Pachysandra (Japanese Pachysandra) | <i>P. terminalis</i> 'Variegata' (Silver edge) | 6"-8" | May | White | Partial shade Full shade | Ground cover, slopes, level ground, beneath trees |
| Paeonia (Peony) | <i>P. lactiflora</i> | 3' | May-June | Many | Full sun Partial shade | Accent, cut flowers |
| Papaver (Iceland Poppy) | <i>P. nudicaule</i> | 2'-4' | May-June | Many | Full sun Partial shade | Borders, cut flowers |
| Papaver (Oriental Poppy) | <i>P. orientale</i> | 2'-4' | May-June | Many | Full sun | Borders, cut flowers |
| Peony (see Paeonia) | | | | | | |
| Phlox, Creeping | <i>P. subulata</i> | 6"-10" | April-June | White Pink Salmon Purple | Full sun Partial shade | Edging, bedding, rock gardens |
| Phlox, Tall (Summer Phlox) (Garden Phlox) | <i>P. paniculata</i> 'Symons-Jeune' | 2'-3' | July-Sept | White Pink Red Blue Purple | Full sun Partial shade | Borders |
| Physostegia | <i>P. virginiana</i> 'Bouquet Rose' 'Vivid' 'Summer Snow' | 2'-3' | July-Sept | Rose- purple White | Full sun Partial shade | Cut flowers, back of wild flower gardens borders, informal wildflower gardens |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|--|--|---------------|-------------------|--|-----------------------------|---|
| Platycodon (Chinese Bellflower) (Balloon Flower) (Japanese Bellflower) | <i>P. grandiflorum</i> 'Apoyama' 'Shell Pink' | 2' | July-Sept | Blue Pink White | Full sun Partial shade | Cutting, rock gardens, borders |
| Plumbago (see <i>Ceratostigma</i>) | | | | | | |
| Polemonium (Jacob's Ladder) | <i>P. caeruleum</i> 'Blue Pearl' | 1 1/2' | May-June | Blue | Full sun Partial shade | Rock gardens, foreground of perennial borders |
| Poppy, Iceland (see <i>Papaver nudicaule</i>) | | | | | | |
| Poppy, Oriental (see <i>Papaver orientale</i>) | | | | | | |
| Potentilla | <i>P. verna</i> | 4"-6" | May-Oct | Yellow | Full sun Partial shade | Ground cover |
| Primrose, Polyanthus | <i>Primula x polyantha</i> 'Colossea Hybrids' 'Pacific Giants' | 6"-12" | April-June | Many | Partial shade | Shaded areas in perennial borders, shaded streams |
| Pleretis (Ostrich Fern) | <i>P. modulosa</i> | 3'-4' | Foliage | | Partial shade Full shade | North exposures, under trees or any place where light is not abundant |
| Pyrethrum (Painted Daisy) | <i>Pyrethrum</i> spp. | 1 1/2'-2' | June-July | Pink Red White | Full sun Partial shade | Rock gardens, borders, naturalizing, cut flowers |
| Red-hot poker (see <i>Knipofia</i>) | | | | | | |
| Rudbeckia (Gloriosa Daisy) | <i>R. hirta pulcherrima</i> 'Gloriosa Daisy' (<i>Rudbeckia x hybrida</i>) 'Gloriosa Double Daisy' 'Gloriosa Irish Eyes' 'Goldstrum' 'Marmalade' 'Rustic Colors' | 2-3" | July-Sept | Golden yellow Brown | Full sun Partial shade | Cutting, background |
| Santolina (Lavender Cotton) | <i>S. chamaecyparissus</i> | 1' | June | Yellow | Full sun | Evergreen, rock gardens, low hedge, carpet bedding |
| Sapanaria (Bouncing Bet) (Soapwort) | <i>S. officinalis</i> | 1' | July-Sept | Pink White | Full sun Partial shade | Wild gardens, rough corners |
| Saxifraga | <i>Saxifraga</i> spp. | 3"-18" | June-Aug | Yellow White Red Pink Purple | Partial shade | Rock gardens, borders, edging, potted plants |
| Scabiosa (Caucasian Scabious) (Pincushion Flower) | <i>S. caucasian</i> 'Butterfly Blue' 'Pink Mist' | 2' | June-Sept | Blue White Maue | Full sun | Borders, flowerbeds, cut flowers |
| Sea lavender (see <i>Limonium</i>) | | | | | | |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|--|--|---------------|-------------------|--------------------------------|-----------------------------|---|
| Sedum (Showy Stonecrop) (Live Forever) | <i>S. spectabile</i> 'Autumn Joy' 'Brilliant' 'Indian Chief' 'Meteor' 'Star Dust' 'Variegatum' | 1 1/2'-2' | Aug-Oct | Pink Red White | Full shade Partial shade | Rock gardens, borders |
| Sedum | <i>Sedum</i> spp. 'Dragon's Blood' | 6" | Aug-Oct | Red | Full sun Partial shade | Rock gardens, borders |
| Sempervivum (Hen-and-Chickens) (Old-Man-and-Woman) (Houseleeks) (St. Patrick's Cabbage) | <i>S. tectorum</i> | 6"-30" | July | Purple-red | Full sun | Rock gardens, dry walls, edging, front of perennial borders, carpet bedding, containers |
| Snowdrop (Giant snowdrop) | <i>Galanthus nivalis</i> | 6"-9" | Spring | White | Full sun | Good for borders and rock gardens |
| Snowdrop (Common Snowdrop) | <i>Galanthus nivalis</i> | 4"-6" | Early spring | White | Partial shade | One of the earliest spring bulbs for rock gardens, borders, naturalizing, easy to grow, increases rapidly |
| Snow-in-Summer (see <i>Cerastium</i>) | | | | | | |
| Stachys (see <i>Betonica</i>) | | | | | | |
| Statice (see <i>Armeria</i> or <i>Limonium</i>) | | | | | | |
| Sweet Lavender (see <i>Lavandula</i>) | | | | | | |
| Sweet William (see <i>Dianthus barbatus</i>) | | | | | | |
| Teucrium (American Germander) | <i>T. canadense</i> | 6" | June-July | Rose | Full sun | Edging, rock gardens |
| Teucrium (Germander) | <i>T. chamaedrys</i> | 4"-12" | June-July | Purple | Full sun | Edging, rock gardens, hedges |
| Thymus (Thyme) | <i>T. serpyllum</i> | 3"-6" | June-July | Purple White Red | Full sun | Rock gardens, herb gardens, stone walls |
| Tradescantia (Virginia Spiderwort) (Widow's Tears) | <i>T. virginiana</i> 'Purple Dome' | 1 1/2'-2' | June-Sept | White | Full sun Pink Red | Borders, foundations Partial shade |
| Tritoma (see <i>Kniphofia</i>) | | | | | | |
| Trollius (Globe Flower) | <i>T. europaeus</i> | 1'-2' | May-July | Lemon Orange | Shade | Borders |
| Tulip | <i>Tulipa</i> spp. & hybrids | 3"-30" | Spring | All colors except true blue | Full sun | Variety of colors, shapes, blooming times for all uses, may use annuals to cover ground above bulbs in summer |

Table 1. (cont'd)

| Common name | Scientific name | Height | Bloom time | Flower color | Light needed | Landscape use |
|---|--|--------|------------|--------------------------------|-----------------------------|---|
| Valeriana | <i>V. officinalis</i> 'Rubra' | 3'-5' | June-July | Pink White Red Purple | Full sun Partial shade | Perennial gardens, background |
| Veronica | <i>Veronica</i> spp. 'Red Fox' 'Sunny Border Blue' | 1 1/2' | June-Aug. | Blue Pink Red White | Full sun | Borders, cut flowers, rock gardens |
| Vinca (Lesser Periwinkle) (Myrtle) | <i>Vinca minor</i> | 6"-8" | March-May | Blue-purple | Partial shade Full shade | Ground cover in flower beds or rockeries, shrubberies |
| Wall Flower (see Cheiranthus) | | | | | | |
| Yarrow (see Achillea) | | | | | | |

Further Reading

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For More Information

Hardy Plant Society of Oregon, P.O. Box 5090,
Oregon City, OR 97045

Northwest Perennial Alliance, P.O. Box 45574,
University Station, Seattle, WA 98145-0574.

Perennial Plant Association, Attn: Dr. Steven M.
Still, 3383 Schirtzinger Road, Hilliard, OH
43026.

Perennial Study Group, Arboretum Foundation,
Washington Park Arboretum, University of
Washington, Box 358010, Seattle, WA 98195-
8010.

Booklets and Pamphlets

University of Idaho

PNW 550 Encouraging Beneficial Insects in Your
Garden (\$1.00)

PNW 500 Plant Materials for Landscaping (\$2.50)

PNW 164 Propagating from Bulbs, Corms, Tubers,
Rhizomes, and Tuberous Roots and
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PNW 151 Propagating Herbaceous Plants
from Cuttings (50¢)

PNW 170 Propagating Plants from Seed (\$2.50)

CIS 841 Seed Germination Test Methods
for Home Use (25¢)

CIS 858 Using Bark and Sawdust for Mulches,
Soil Amendments, and Potting Mixes
(35¢)

CIS 1062 Starting a Home Lawn (\$1.50)

CIS 1063 Thatch Prevention and Control in Home
Lawns (\$1.00)

PNW 299 Turfgrass Seedings: Recommendations
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CIS 888 Weed Control in Lawns (50¢)

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Vegetable Culture



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Chapter 19

Vegetable Culture



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I. The Vegetable Garden

When planning your garden, ask some basic questions. Who will be doing the work? Will the garden be a group project with family members or friends? Will they work willingly through the season to a fall harvest, or will you be handling the hoe alone? Remember, a small, weed-free garden will produce more vegetables than a large, weedy mess.

What do you and your family like to eat? Although the pictures in the garden catalog look delicious, there is no value in taking up gardening space with vegetables that no one eats. Make a list of your family's favorite vegetables, ranked in order of preference. This will serve as a useful guide in deciding how much of each vegetable to plant. Successive planting of certain crops, such as beans, will give a longer harvest period and increase your yield. List recommended varieties and planting dates.

How do you plan to use the produce from your garden? If you plan to can, freeze, dry, or store part of the produce, this will be a factor not only in planning the size of the garden but also in selecting the varieties to be grown. Some varieties have better storage quality than others. Take care in choosing the seeds, to make sure the varieties you select are adapted to your area and intended use. A few dollars spent on buying adapted, quality seed will pay off in high quality yielding vegetables. How much space is available? That is, how much

area can be converted into usable garden space? Empty ground may not mean available ground.

II. Planning Hints

Plan the garden on paper first. Draw a map showing the arrangement and spacing of crops. In your plan, place tall and trellised crops on the north side of the garden so they won't shade the shorter vegetables. Group plants by length of growing period. Plant spring crops together so that later crops can be planted in these areas when the early crops mature. Consider the length of harvest as well as time to maturity. Place perennial crops to the side of the garden where they will not be disturbed by annual tillage. If you wish to keep the garden growing all season, you may need a spring and summer garden plan.

Order seeds by January or February. Some plants may be started indoors as early as mid-February.

III. Locating the Garden

Vegetables grow best in a level area with loose, well-drained soil and need at least 6 hours of sun (8 to 10 hours is ideal). These are some valuable tips:

1. Avoid placing the garden in low spots, at the base of a hill, or at the foot of a slope bordered by a solid fence. These areas are slow to warm up in the spring; frost settles in these places, because cold air naturally drains to low areas. South-facing slopes are warmer and less subject to damaging frosts.
2. Avoid windy locations. If you must plant in a windy spot, build or grow a windbreak.
3. Avoid planting near trees and shrubs; they compete for sunlight, nutrients, and water.

Acknowledgment

The author compiled information for Chapters 19 and 20 from the Virginia, Utah, Oregon, and Washington Master Gardener handbooks and adapted it to Idaho conditions.

4. Choose a spot near your home so it is convenient to work in the garden when you have a few minutes. Locate the garden near a good and easily accessible supply of water.
5. Sites too near buildings may result in plants that do not receive enough sunlight. Observe shading patterns throughout the growing season. If you have a shaded area you wish to use anyway, plant shade-tolerant crops. Increase effective light by providing reflective surfaces around plants.
6. Avoid contaminated areas. Locations near busy roads are subject to airborne lead from automobile exhaust that can contaminate vegetables, especially leafy types. If you must plant in a lead-prone area, try planting a hedge to trap lead in the air. Locations where lead-painted buildings once stood may have soil lead in toxic amounts. If you are unsure about your chosen location, check the lead content by having the soil tested or having leafy vegetable tissue analyzed. Locations where water runoff from roads, sidewalks, and driveways enter the garden may contaminate the soil with salt, herbicides, and soil sterilant.
7. Use contour rows or terraces on sloped or hillside sites to avoid erosion.
8. Orient plants and rows for maximum sunlight. Garden sites too near buildings may result in plants that do not receive enough sunlight. Observe shading patterns throughout the growing season. If you have a shaded area you wish to use anyway, plant shade-tolerant crops. Increase effective light by providing reflective surfaces around plants.
9. Try not to plant related vegetables in exactly the same location in the garden more than once in 3 years. Rotation prevents the buildup of insects and disease. Use old plans as guides for rotating crops.

IV. Preparing the Soil

The ideal vegetable garden soil is deep, friable (easy to cultivate), well-drained, and has a high organic matter content. Proper soil preparation provides the basis for good seed germination and growth of garden crops. Careful use

of various soil amendments can improve garden soil and provide the best possible starting ground for your crops.

Make basic nutrient and pH adjustments to the soil by adding fertilizers. In new garden spots, remove sod with a spade and use it to patch your lawn or put it in a compost pile to decay. Round Up can be used to kill the soil before its tillage.

A. Soil Testing

Check soil fertility and pH by having your soil analyzed at least once every 3 years. Soil pH measures the degree of acidity or alkalinity of the soil. Vegetables differ to some extent in their requirements, but most garden crops will do well with a soil pH of 6.2 to 7.5. If soil pH is too high or low, poor crop growth will result, largely because of the effects of pH on the availability of nutrients to plants. A soil test will also provide a relative idea of the nutrient level in the soil.

Soil test kits are available for checking soil at home, but their quality and reliability differ greatly. Soil samples may also be sent to your local Extension office for testing. The Extension educator will mail results to you with recommendations for correcting any deficiencies. Private companies also do soil testing and, in many cases, give detailed reports and recommendations. In either case, tests cost approximately \$30 each. For best results, carefully follow soil sample instructions.

B. Soil Moisture

The addition of organic matter is the first step in improving moisture conditions in the garden. A relatively high level of humus in the soil, brought about by the addition and breakdown of organic matter, can improve this proportion. Humus helps clay particles to form aggregates, or large clumps or groups of particles. This increases the size of the soil pore space, allowing moisture to drain to lower levels as a reserve, instead of puddling and running off the top of the soil. The moisture-holding capacity of sandy soils is also improved by the addition of organic matter. Though most soil water in sandy soil is available, it drains so quickly

that plants are unable to reach water after a rain. Humus in sandy soil give the water something to cling to until it is needed by plants.

1. Mulching is a cultural practice that can significantly decrease the amount of water that must be added to the soil. A 3- to 4-inch organic mulch can reduce water needs by as much as one-half by smothering weeds (which take up and transpire moisture) and by reducing evaporation of moisture directly from the soil surface. Organic mulches themselves hold some water and increase the humidity level around the plant that may stimulate disease development. It may be necessary to move the mulch a few inches away from the plant stem.
2. During the summer, clear or black plastic mulch also conserves moisture and increases soil temperatures dramatically (clear plastic by 8°F and black plastic by 6°F) to the detriment of some plants and the benefit of others.
3. Shading and the use of windbreaks are other moisture-conserving techniques. Plants that wilt in very sunny areas can benefit from partial shade during the afternoon in summer. Small plants, in particular, should be protected. Air moving across a plant carries away the moisture on the leaf surfaces, causing the plant to need more water. In very windy areas, the roots often cannot keep up with transpiration demands, and plants wilt. In these areas, temporary or permanent windbreaks can help tremendously.

C. Fertilizing

The amount of fertilizer to apply to a garden depends on the natural fertility of the soil, the amount of organic matter present, the type of fertilizer used, and the crop being grown. The best way to determine fertilizer needs is to have the soil tested.

V. Seed for the Garden

A. Choosing Vegetable Seed

This is one of the most enjoyable gardening pastimes. Thumbing through colorful catalogs and dreaming of the season's harvest is

one way to make winter seem a little warmer.

Choose seed from a dependable seed company. Keep notes about the seeds you purchase: germination qualities, vigor of plants, and tendencies toward insects and disease. From this information, you can determine whether a seed company is meeting your needs, and whether the varieties you have chosen are suitable for your area and gardening style. For example, if powdery mildew is a big problem for the squash family, look for mildew-resistant varieties the next year.

B. Saving Your Own Vegetable Seed

This pleasurable activity offers a sense of self-sufficiency and it saves money. You can maintain a vegetable variety that is not available commercially. This helps perpetuate a broad genetic base of plant materials. Breeders often search for old-time varieties when attempting to improve commercial plants, since the "heirloom vegetables" often have inbred disease and pest resistance or cold hardiness.

Participation in a seed-saver's exchange can be rewarding. Your extra seeds can be traded for unusual types not available through other sources.

Some considerations to keep in mind when saving seed include:

1. Hybrid varieties do not produce seed that is true to parents. Only open-pollinated varieties should be used for home seed production. Some seed dealers have responded to the increasing interest in seed saving by clearly marking open-pollinated varieties in their catalogs.
2. There is the possibility of carrying seed-borne diseases into the next year's crop. Many commercially grown seeds are produced in dry areas to reduce fungal, viral, and bacterial diseases that may be present in your region. Recognize and control diseases that can be carried in seed.
3. Consider the amount of time it takes to dry seeds. Drying can be adversely affected by frequent rains, humidity, and maturity.

- If you've ever saved squash seed during a season in which you have more than one type of squash planted, you have probably seen the abnormal results that may be obtained from cross-pollination!

Note: Some common self-pollinated annual plants from which seed may be saved include lettuce, beans and peas, herbs, and tomatoes.

C. Special Case Seeds

When saving seed, be sure to mark the storage containers clearly with permanent (preferably waterproof) ink, indicating the variety and date saved. Seeds will remain viable for some time if properly stored (Table 1). To test for germination, sprout seeds between moist paper towels. If germination is low, either discard the seed or plant enough extra to give the desired number of plants.

- Beans and peas—Allow seed pods to turn brown on the plant. Harvest the pods, dry for 1 to 2 weeks, shell, and then store the seeds in a cool (below 50°F), dry environment in a paper bag.
- Lettuce seed—Cut off seed stalks when they are fluffy in appearance, just before all the seeds are completely dried. Seeds will fall off the stalk and be lost if allowed to mature on the plant. Dry the

harvested seed stalk further, shake off the seeds, and store them in a cool, dry environment in an envelope or small glass jar.

- Herb seeds—Herbs vary in the way their seeds are produced. In general, allow herb seeds to stay on the plants until they are almost completely dry. Some seed heads, such as dill, will shatter and drop their seeds as soon as they are dry. Watch the early-ripening seeds. If they tend to fall off, harvest the other seed heads before they get to that point, leaving several inches of stem attached. Hang several stems upside down; cover them with a paper bag to catch falling seed. Place them in a warm, dry place until the drying is complete. Remove seeds from the seed heads and store in envelopes or small glass jars. Some herb seeds, such as dill, celery, anise, cumin, coriander, and others, are used for flavoring and are ready to use once dry.
- Tomato seeds—Pick fruit from desirable plants when ripe. Cut the fruit and squeeze the pulp into a container. Add a little water, then let the pulp ferment 2 to 4 days at room temperature, stirring occasionally. When the seeds settle out, pour off the pulp and spread the seeds thinly, and dry thoroughly. Store in an envelope or glass jar in a cool, dry place.

Table 1. Viability of vegetable seeds.

| Vegetable | Average years seeds can be saved | Vegetable | Average years seeds can be saved | Vegetable | Average years seeds can be saved |
|------------------|----------------------------------|--------------|----------------------------------|------------|----------------------------------|
| Asparagus | 3 | Cress, water | 5 | Parsnip | 1 |
| Bean | 3 | Cucumber | 5 | Pea | 3 |
| Beet | 4 | Eggplant | 5 | Pepper | 4 |
| Broccoli | 5 | Endive | 5 | Pumpkin | 4 |
| Brussels sprouts | 5 | Kale | 5 | Radish | 5 |
| Cabbage | 5 | Kohlrabi | 5 | Rutabaga | 5 |
| Carrot | 3 | Leek | 1 | Spinach | 5 |
| Cauliflower | 5 | Lettuce | 5 | Squash | 5 |
| Celery | 5 | Muskmelon | 5 | Sweet corn | 1 |
| Chinese cabbage | 5 | Mustard | 4 | Tomato | 4 |
| Cabbage | 5 | Okra | 2 | Turnip | 5 |
| Collard | 5 | Onion | 1 | Watermelon | 5 |
| Corn | 5 | Parsley | 2 | | |

D. Planting Vegetable Seeds

The depth to cover seeds when you plant them depends on factors such as the size of the seed, the type of soil you have, and the season of the year.

As a general rule, vegetable and flower seeds should be covered about three times their lateral diameter or width (not their length). However, there are exceptions. You should read the packet directions.

Some seeds require light for germination and should not be covered at all. These instructions apply to seeds planted both inside and outside.

VI. Starting Seed Indoors

Starting seeds indoors for transplanting is an important aspect of intensive gardening. To get the most from the garden plot, a new crop should be ready to take the place of the crop being removed. Several weeks may be gained by having 6-inch transplants ready to go into vacated areas. Don't forget to recondition the soil for the new plants.

A. Light

To start seeds indoors, it is important to have enough light. More homegrown seedlings are probably lost to this one factor than to any other.

Vegetable seedlings grown under low light conditions are likely to be leggy and weak. They fall over under their own weight after they are 3 to 4 inches tall.

If you do not have a sunny room or back porch with a southern exposure, you will need supplemental lights. A simple fluorescent shop light with one warm-white and one cool-white bulb (or grow lights) will suffice.

B. Media

It is easiest to use a mix containing peat to start seedlings, since garden soil contains disease organisms that can be highly destructive to small plants.

Garden soil high in clay should be conditioned with compost or perlite to prevent excess moisture and/or shrinkage. Mix your own soilless media if you prefer; 50 percent vermiculite or perlite and 50 percent

fine sphagnum peat is excellent for starting seeds. Fertilizer, at half the normal strength, can be added to the mixture. Mix well before using.

Soil can be sterilized in the oven by baking it at 220°F until the internal soil temperature is 180°F. It should be held at that temperature for 30 minutes. This may be an odorous process, but it works.

C. Containers

Many types of containers can be used to start seeds.

1. Flats or other large containers can be used. Plant in rows and grow seedlings until they have one or two sets of true leaves, then transplant into other containers for growing to the size to transplant outdoors.
2. Seedlings may also be started in pots, old cans, cut-off milk cartons, margarine tubs, egg cartons, or other throwaways. The pop-out trays found at garden centers are easy to use and are reusable.
3. Peat pots are nice, especially for large seeds. Sow one or two large seeds directly into each peat pot. Thin to one seedling per pot. Peat pots can be planted directly in the garden, but do not allow the edges of the pot to stick out above the soil. The edges will act as a wick and moisture will evaporate from this exposed surface.

D. Starting the Seeds

Regardless of the type of container chosen, fill it three-fourths full with seed-starting mixture and sow the seeds. Cover to the specified depth and water the mix.

If your home is dry, it may help to cover the containers with plastic wrap to maintain a uniform moisture level since seeds and seedlings are extremely sensitive to drying out. However, seeds should not be kept soaking wet since this condition is conducive to damping-off, a fungus disease deadly to seedlings. Damping-off can be prevented or diminished by sprinkling milled sphagnum moss, which contains a natural fungicide, on top of the soil.

Another option for seedling production is to use peat pellets or cubes. These are pre-

formed and require no added soil mix. Many home gardeners make their own soil cubes using low cost, homemade molds. The pellets or cubes are soaked until thoroughly wet. Then seeds are planted in the holes provided. The whole pellet or cube may be planted without disturbing the roots. The only disadvantage to this method is the expense.

VII. Starting Seed Outdoors

☐☐☐ Many seeds may be sown directly in the garden. If garden soil is quite sandy, or is easy to work because of the high content of organic matter, seeds may be planted deeper. Young seedlings will emerge easily from a sandy or organic soil. Fast emergence can reduce the chance of seedling disease.

If garden soil texture has a high silt and clay content, the seeds should be covered with only two to three times their diameter. In such soils, it may be helpful to apply a band of sand, fine compost, or vermiculite 4 inches wide and 1/4 inch deep along the row after seeds are planted. This will help retain soil moisture and reduce crusting, then seedlings can easily push through the soil surface.

A thin, clear plastic film may be used to cover the planted seeds. It will raise the soil temperatures and hold the moisture, speeding up the germination process. The plastic should be removed after germination starts to prevent burning of the new plants.

Soil temperature has an effect on the rate of seed germination. In the spring, soil is often cold, and seeds of some plants will rot before they have a chance to sprout. Table 2 lists optimum soil temperatures.

VIII. Planting the Fall Garden

When planting the fall garden in midsummer, the soil will be warm and dry. Therefore, cover the seeds six to eight times their diameter. A light organic mulch can keep soil cool and moist. It can be removed after emergence. Deep planting can produce stress on emerging seedlings.

Seedlings may need to be watered each day with a sprinkler or a sprinkling can to promote germination.

Moisture can also be retained with a shallow mulch or by covering the row with a board until the seeds are up.

Shading the area may be helpful to keep the soil cooler for seed germination, especially when planting cool weather crops such as onions, peas, radishes, and lettuce in summer. Seed that requires a lower germination temperature may benefit from being kept in the refrigerator for 2 weeks before planting. These seeds may also benefit from presprouting indoors. Presprouting is a useful technique for planting in cold soils as well.

Handle seed carefully once sprouted to prevent damaging new root tissue.

Table 2. Plant production data chart.

| Crop | Days to emergence from seeding | Optimal germination soil temperature range | Weeks to grow transplant size |
|-------------------------|--------------------------------|--|-------------------------------|
| | | (°F) | |
| Beans | 5 to 10 | 65° to 85° | * |
| Beets | 7 to 10 | 50° to 85° | * |
| Broccoli | 3 to 10 | 50° to 85° | 5 to 7 |
| Cabbage | 4 to 10 | 50° to 85° | 5 to 7 |
| Carrots | 12 to 18 | 50° to 85° | * |
| Cauliflower | 4 to 10 | 50° to 85° | 5 to 7 |
| Celery | 9 to 21 | 50° to 65° | 10 to 12 |
| Chard, Swiss | 7 to 10 | 65° to 85° | * |
| Corn, sweet | 5 to 10 | 65° to 85° | * |
| Cucumber | 6 to 10 | 65° to 85° | 4 |
| Eggplant | 6 to 10 | 65° to 85° | 6 to 9 |
| Lettuce | 6 to 10 | 50° to 65° | 3 to 5 |
| Melons | 6 to 8 | 65° to 85° | 3 to 4 |
| Okra | 7 to 10 | 65° to 85° | * |
| Onion | 7 to 10 | 65° to 85° | 8 |
| Parsley | 15 to 21 | 50° to 85° | 8 |
| Peas | 6 to 10 | 50° to 65° | * |
| Peppers | 9 to 14 | 65° to 85° | 6 to 8 |
| Potatoes, sweet (slips) | | 50° to 65° | * |
| Radish | 3 to 6 | 50° to 65° | * |
| Spinach | 7 to 12 | 50° to 65° | * |
| Squash | 4 to 6 | 65° to 85° | 3 to |
| Tomato | 6 to 12 | 65° to 85° | 5 to 7 |
| Turnip | 4 to 8 | 50° to 65° | * |

* Transplants not recommended

IX. Planting Methods

A. Row Planting

A string stretched between stakes or home-made row markers can provide a guide for straight rows. Use a hoe handle, a special furrow hoe, or a grub hoe to make a furrow of the appropriate depth for the seed being planted. Sow seed thinly; it may help to mix very small seed with coarse sand to distribute the seeds more evenly. Draw soil over the seed, removing stones and large clods. Firming soil over seeds improves the uptake of soil moisture and hastens germination. Water the seeds in to improve soil-to-seed contact. When plants have grown 4 to 6 inches tall, thin according to seed packet instructions.

B. Broadcast Planting

Many crops can be sown in wide rows or beds instead of in long, single rows. Crops such as spinach, beans, peas, beets, lettuce, and carrots are especially suited to this type of culture.

Sow seed evenly over the area, then rake it in. Firm soil over the seeds. Thin young plants to allow room for growth.

C. Hill Planting

Larger vegetables, such as melons, squash, corn, and cucumbers, may be planted in hills. Soil is mounded to a foot or so in diameter, at the recommended spacing. Plant 4 to 6 seeds per hill, firming the soil well. Thin the seedlings to 3 to 5 plants per hill.

X. Intensive Gardening Methods

The purpose of an intensively grown garden is to harvest the most produce possible from a given space. More traditional gardens consist of long, single rows of vegetables spaced widely apart. Much of the garden area is taken by the space between the rows. An intensive garden reduces wasted space to a minimum. The intensive ideal is to have something growing in every part of the garden at all times during the growing season.

A good intensive garden requires early, thorough planning to make the best use of time and space in the garden. Interrelationships of plants must be considered before planting. Evaluate nutrient needs, shade tolerance, above- and be-

low-ground growth patterns, and preferred growing season.

Using such techniques as raised beds, vertical gardening, interplanting, spacing and relay planting you can develop a high-yielding intensive garden.

A. Raised Bed

This type of bed, also called the growing bed is the basic unit of an intensive garden. The raised bed allows the gardener to concentrate soil preparation in small areas, resulting in effective use of soil amendments and creating an ideal environment for vegetable growth. Beds are generally 3 to 4 feet wide and as long as desired. The gardener works from either side of the bed, reducing the incidence of compaction caused when walking on the soil to work it.

Soil preparation is the key to successful intensive gardening. If your soil is not deep, double-dig the beds for best results. Remove the top 12 inches of soil from the bed. Insert a spade or spading fork into the next 10 to 12 inches of soil and wiggle the handle back and forth to break up compacted layers. Do this every 6 to 8 inches in the bed.

Mix the topsoil with a generous amount of compost or manure, and return the mixture to the bed. It should be somewhat fluffy and may be raised slightly. To create a true raised bed, take topsoil from the neighboring pathways and mix it in as well.

To grow so closely together, plants must have adequate nutrients and water. Providing extra synthetic fertilizers and irrigation will help, but there is no substitute for deep, fertile soil high in organic matter. Humus-rich soil holds extra nutrients; and existing elements locked in the soil are released by the actions of earthworms, microorganisms, and acids present in a life-filled soil, making them available for plant use.

By nature, raised beds are a form of wide-bed gardening, a technique by which seeds and transplants are planted in wide bands of several rows or broadcast in a wide strip. The goal of this technique is to space plants at equidistant from each other on all sides, so that, at maturity, plant leaves touch. The close planting saves space and reduces moisture loss from surrounding soil.

B. Vertical Gardening

The use of trellises, nets, strings, cages, or poles to support growing plants constitutes vertical gardening. This technique is especially suited, but not limited, to gardeners with a small garden space.

Vining and sprawling plants, such as cucumbers, tomatoes, melons, and pole beans, are obvious candidates for this type of gardening. Some plants entwine themselves onto the support, while others need to be tied. Some varieties of squash, cucumbers, and watermelons are bush type and are more suitable for intensive gardening.

A vertical planting will cast a shadow, so beware of shading sun-loving crops. Take advantage of the shade by planting shade-tolerant crops near the vertical ones.

Plants grown vertically take up much less space on the ground, and though the yield per plant may be less, the yield per square foot of garden space is much greater.

Because vertically growing plants are more exposed, they dry out faster and may need to be watered more frequently than if they were allowed to spread over the ground.

This fast drying is also an advantage to those plants susceptible to fungus diseases.

A higher rate of fertilization may be needed for vertically growing plants, and soil should be deep and well drained to allow roots to extend vertically rather than complete with others at a shallow level.

C. Interplanting

Growing two or more types of vegetables in the same place at the same time is known as interplanting. Proper planning is essential to obtain high production and increased quality of the crops planted. Interplanting has been practiced for thousands of years in Europe and Japan but is just now gaining widespread support in this country.

1. To successfully plan an interplanted garden, consider these factors for each plant:
 - a. Length of the plant's growth period, its growth pattern (tall, short, below or above ground).
 - b. Its possible negative effects on other plants (e.g., allelopathic effects of sun-

flowers and Jerusalem artichokes on nearby plants).

- c. Its preferred season.
 - d. Its light, nutrient, and moisture requirements.
2. Interplanting can be accomplished by alternating rows within a bed (plant a row of peppers next to a row of onion), by mixing plants within a row, or by distributing various species throughout the bed. For the beginner, alternating rows may be the easiest to manage.
 3. Long season (slow to mature) and short season (quick to mature) plants such as carrots and radishes, respectively, can be planted at the same time. The radishes are harvested before they begin to crowd the carrots. Smaller plants can be planted close to larger plants (e.g., radishes at the base of beans or broccoli). Shade-tolerant species such as lettuce, spinach, and celery can be planted in the shadow of taller crops. Heavy feeders, such as cabbage family crops, can be interplanted with less gluttonous plants.
 4. Interplanting can help keep insect and disease problems under control. Pests are usually fairly crop specific, that is, they prefer vegetables of one type or family. Mixing families of plants helps break up large expanses of the pest-preferred crop, helping to contain early pest damage within a small area, and giving you a little more time to deal with the problem.

Note: Spraying for pests becomes more difficult with the interplanting method.

D. Spacing

In this technique, individual plants are closely spaced in a raised bed or interplanted garden.

An equidistant spacing pattern calls for plants to be the same distance from each other within the bed. Plant so that the center of one plant is the same distance from the plants on all sides of it. In beds of more than two rows, this means that the rows should be staggered so that plants in every other row are between the plants in adjacent rows.

The distance recommended on the seed packet for plants within the row is the distance from the center of one plant to the center of the next (Table 3). However, plants should not be crowded to the point that disease causes problems or competition causes stunting.

This technique results in an efficient use of space. The close spacing creates a nearly solid leaf canopy, acts as a living mulch, decreases water loss from bare ground, and minimizes weed problems.

E. Succession or Relay Planting

To obtain a succession of crops, plant something new in spots vacated by spent plants (such as planting corn after peas).

Planting a spring, summer, and fall garden is another form of succession planting. Cool season crops (broccoli, lettuce, peas) are followed by warm season crops (beans, tomatoes, peppers). Where possible, these

may be followed by more cool season plants, or even a winter crop.

The new planting can be made before the old one is removed. For instance, sweet corn may be planted in 2-week intervals for a continuous harvest. This requires some care. Crops planted early are likely to get a slower start because of low temperatures. In the case of corn, it can be disastrous to have two varieties pollinating at the same time, because the quality of the kernels may be affected. For best results, give early planted corn extra time to get started.

Another way to achieve a lengthy harvest is to plant different varieties of the same vegetable at the same time (e.g., plant early season, midseason, and late-season corn).

XI. Transplants for the Garden

Most gardeners use transplants in the garden to give long season plants a chance to grow to maturity or just to lengthen the harvest season. In short season areas, crops such as head lettuce, broccoli, and celery may not reach their prime harvest stage if not given those extra weeks indoors to get a head start. Tomatoes would have a short harvest period if started from seed in the ground, and peppers and eggplants might not produce at all unless they are grown from transplants. See Table 4 for a rating of many vegetables and their tolerance for transplanting.

Table 3. Intensive spacing guide for vegetables.

| Plant | Spacing | Plant | Spacing |
|------------------|----------|-----------------|----------|
| | (inches) | | (inches) |
| Asparagus | 15 to 18 | Leeks | 3 to 6 |
| Beans, bush | 4 to 6 | Lettuce, head | 10 to 12 |
| Beans, lima | 4 to 6 | Lettuce, leaf | 4 to 6 |
| Beans, pole | 6 to 12 | Melons | 18 to 24 |
| Beets | 2 to 4 | Mustard | 6 to 9 |
| Broccoli | 12 to 18 | Okra | 12 to 18 |
| Brussels sprouts | 15 to 18 | Onion | 2 to 4 |
| Cabbage | 15 to 18 | Peas | 2 to 4 |
| Cabbage, Chinese | 10 to 12 | Peppers | 12 to 15 |
| Carrots | 2 to 3 | Potatoes | 10 to 12 |
| Cauliflower | 15 to 18 | Pumpkins* | 12 to 36 |
| Cucumber | 12 to 18 | Radishes | 2 to 3 |
| Chard, Swiss | 6 to 9 | Rutabaga | 4 to 6 |
| Collards* | 12 to 15 | Spinach | 4 to 6 |
| Endive | 15 to 18 | Squash, summer* | 18 to 24 |
| Eggplant | 18 to 24 | Squash, winter* | 24 to 36 |
| Kale | 15 to 18 | Tomatoes | 18 to 24 |
| Kohlrabi | 6 to 9 | Turnips | 4 to 6 |

Note: To determine spacing for interplanting, add the inches for the two crops to be planted together, and divide the sum by two. For example, if radishes are planted next to beans, add 2 inches + 4 inches = 6 inches, then divide 6 inches by 2 = 3 inches. The radishes should be planted 3 inches from the beans.

*Miniature varieties or trellising may increase value per square foot.

Table 4. Ease of transplanting vegetables.

| Easily survive transplanting | Require care in the operation | Cannot be successfully transplanted by usual methods |
|------------------------------|-------------------------------|--|
| Broccoli | Beets | Beans |
| Cabbage | Carrots | Peas |
| Cauliflower | Celery | Okra |
| Eggplant | Chard | |
| Lettuce | Corn | |
| Chinese cabbage | Cucumbers | |
| Sweet potato slips | Melon | |
| Onion (tends to bolt) | Squash | |
| Tomatoes | | |
| Pepper | | |

Because of the amount of time, attention, and need for controlled growing conditions, many gardeners prefer to purchase plants for their gardens. However, for a larger choice in varieties and the control of plant production from seed to harvest, others choose to start their own.

A. Annual Plants

Transplants of annual vegetables and flowers should be stocky, healthy, free from disease and insects, and should have good roots. Plants should not be too small or too mature.

1. Be sure plants have been hardened-off so that they will easily adapt to environmental change. Avoid hardened plants that are woody and yellow.
2. Successful transplanting is achieved by interrupting plant growth as little as possible, an advantage provided by peat pots and peat pellets, neither of which have to be removed when transplanting.
3. Have garden soil prepared before transplanting. All additives that require time to break down, such as manures, sulfur, limestone, rock fertilizers, and green manures, should be incorporated several weeks before planting. Quick-acting (hydrated) lime for low pH soils, fertilizers, and well-decayed compost may be added just before planting.
4. Transplant on a shady day, in late afternoon, or in early evening to prevent or reduce wilting. Water the plants several hours before transplanting. When using bare root plants, such as sweet potato slips, soak the roots thoroughly an hour or two before setting them out in the garden. They should not be allowed to dry out completely at any time.
5. Handle plants carefully. Avoid disturbing the roots or bruising the stems.
6. Dig a hole large enough to hold the roots of the plants. Set vegetable plants slightly deeper than previously planted and at recommended intervals. Tomatoes are an exception. They will develop roots all along the stems, and you can plant deeply enough to leave only two or three sets of leaves exposed. Press soil firmly around

the roots of transplants. Pour about a cup of starter fertilizer solution in the hole around the plant. Use a half-strength solution for that type of plant during the normal growing season. Fish emulsion or diluted manure tea can also be used.

7. For a few days after transplanting, protect the plants from wind and sun by placing newspaper or cardboard on the south side of the plant, or by covering them with jugs, baskets, or flower pots.
8. Water the plants once or twice during the next week. Overwatering can cause damping-off.

B. Perennial Plants

When buying small fruit plants and perennial crowns (asparagus and rhubarb), order early or buy from reliable local outlets.

It pays to do some research about perennial plants. Determine the major diseases and insect pests and then buy resistant varieties. Investigate whether any plants are restricted. The Idaho Department of Agriculture in Boise may quarantine plants from some areas of the country.

1. Select varieties that will do well in your growing conditions. Check crowns for signs of viable buds. Avoid plants with roots and stems that are brown or soggy black, which indicates poor storage or diseased stock. Inspect plants for signs of insects. If you receive plants by mail that are not satisfactory, do not hesitate to send them back.
2. Once you have the plants, keep the roots moist (but not soaking wet) by misting occasionally, and do not allow them to freeze or be exposed to high temperatures. If it is necessary to keep the crowns for more than a few days, place them in cold storage (not freezing) or else heel into a trench of moist soil in a shaded location, then pack soil firmly against the roots to eliminate any air pockets.
3. Transplant crowns according to directions, digging holes large enough to give the roots plenty of room to spread. Remove any roots that are discolored or dried out. Do not mix compost at the bottom of the hole as it may prevent water

from moving across a boundary of dissimilar materials. It can also inhibit root elongation out of the planting hole, increasing the likelihood of drought and heat stress.

4. Once transplanted, shade the plants, and water when needed. Extra care at the beginning of their growth will result in productive, healthy plants.

XII. Irrigating the Home Garden

During times when cultural practices simply aren't enough, that is when rainfall is sparse and the sun is hot, watering may benefit the garden with higher yields. Watering may save the garden by aiding in seedling emergence; reducing or increasing soil crusting; improving germination and plant stand; reducing wilting and stimulating growth in transplants; increasing fruit size of tomato, cucumber, and melon; and maintaining uniform plant growth.

A. Plant Water Requirements

These may be lower in the early spring and late fall when temperatures are low. Check specifications for your soil temperature and type to be sure of the necessary water amount. Keep a rain gauge near the garden or check with the local weather bureau for rainfall amounts, then supplement rainfall with irrigation water if needed.

1. A healthy plant is composed of 75 to 90 percent water, which is used for the plant's vital functions, including photosynthesis, support (rigidity), and transportation of nutrients and sugars to various parts of the plant. During the first 2 weeks of growth, plants are becoming established and must have water to build their root systems. From April to September, vegetable crops need about 1 inch of water per week in the form of rainwater, irrigation water, or both.
2. During dry periods, one thorough watering each week of 1 to 2 inches of moisture (65 to 130 gallons per 100 square feet) is usually enough for most soils. Soil should be wetted to a depth of 5 to 6 inches each watering and not watered again until the top few inches begin to dry out. Average garden soil will store

about 2 to 2 1/2 inches of water available to plants per foot of depth.

3. All water in the soil may not be available to plants, particularly if the soil is fine textured. Clay particles hold soil moisture tightly. If, for example, there are 4 1/2 inches of water per foot of fine-textured soil, there may be as little as 1 1/2 inches available water for plants.

B. Irrigating Equipment

The home gardener has several options for applying water to plants: a sprinkler watering can, a garden hose with a fan nozzle or spray attachment, a portable lawn sprinkler, a perforated plastic soaker hose, a drip or trickle irrigation system, or a semiautomatic drip system. Quality equipment will last for many years when properly cared for.

C. Irrigating Techniques

When deciding on which type of watering equipment to use, consider the following basic techniques for watering:

1. Adjust the flow or rate of water application to about 1/2 inch per hour. A faster rate will cause runoff, unless the soil has exceptionally good drainage. To determine the rate for a sprinkler, place small tin cans at various places within the sprinkler's reach, and check the level of water in the cans at 15-minute intervals.
2. When using the oscillating type of lawn sprinklers, place the sprinkler on a platform higher than the crop to prevent water from being diverted by plant leaves. Try to keep the watering pattern even by frequently moving the sprinkler, overlapping about one-half of each pattern.
3. Avoid getting foliage wet in the evening, as you can encourage diseases. Morning watering is preferred.
4. Place perforated plastic hoses or soaker hoses with holes down along one side of the crop row or underneath mulch, so that water is allowed to soak or seep into the soil slowly.
5. It is best to add enough water to soak the soil to a depth of 5 to 6 inches. It takes approximately 2/3 gallon of water for each square foot or 65 to 130 gallons for

100 square feet of garden area. This varies with the nature of the soil. Frequent, light waterings encourages shallow rooting that causes plants to suffer more quickly during drought periods, especially if mulches are not used. On the other hand, too much water, especially in poorly drained soils, can be as damaging to plant growth as too little water.

6. Know the critical watering periods for selected vegetables. You can reduce the amount of supplemental water you add, which can be important where water supplies are limited. Water is most needed during the first few weeks of development, immediately after transplanting, and during development of edible storage organs.
7. In areas prone to repeated drought, look for drought-resistant varieties when buying seed or plants.

D. Irrigating with Grey Water

If water supplies are short in your area, consider using grey water (water from household uses) on your vegetable garden. However, a few rules should be observed:

1. Do not use "black water" (any water run through the toilet) because of the possibility of contamination from fecal organisms.
2. It is preferable not to use kitchen waste water that contains grease or harsh cleaners, ammonia, bleach, softeners, or nonbiodegradable detergents.
3. If using water from the bathtub or washing machine, use only mild, biodegradable soaps. Omit softeners and bleaches. Allow wash and rinse water to mix, if possible, to dilute the soap content. Never use a borax-containing product (such as washing soda) in water to be used on a garden because of the danger of applying plant-toxic levels of boron.
4. Apply grey water to the soil, but not to plant leaves.

XIII. Controlling Weeds in the Garden

The old saying, "One year's weed, seven years' seed," contains more truth than myth, as

most gardeners soon learn. Weeds (some native and some introduced) are remarkably adapted to conditions in the area where they grow, usually much more so than the imported cultured vegetables we prize so highly for food. Many weeds that would otherwise not be growing in a lawn or natural area spring up as if by magic when the soil is cultivated.

There are several ways to rid the garden of most problem plants. Since mature weeds extract large quantities of moisture and nutrients from the soil, it is more beneficial (and easier) to remove weeds when they are young and tender.

A. Cultivation

Hand pulling and digging weeds in small gardens and raised beds works well. Hoeing is preferred in larger spaces. Manual powered rotary cultivators do a good job on long rows and pathways if the soil is not too wet or dry and if the weeds are not too big.

1. A rotary tiller of appropriate size makes the work easy and fast, but it is not the most pleasant chore to get behind a smoky, noisy engine on a hot summer day. Manual and powered rotary cultivators are usually a poor choice of tool to use to control weeds near vegetable plants since use may inspire vegetables. Hand pulling or hoeing with a light touch are best for removing weeds near vegetable plants. Deep cultivation with any instrument is likely to damage roots or stems of crop plants.
2. Turning under weeds, especially before they flower, provides organic matter to the soil. Hand pulled weeds, except for rhizomatous grasses, may be laid on top of the soil to dry out and will eventually have the same effect. If rain is predicted in the area within a day or two, it is best to collect the weeds and add them to the compost pile. Rain will wash soil around the roots and some weeds will survive. If weeds have started to go to seed, leaving them in the garden is not a good idea.
3. Composting may not destroy weed seeds if the pile doesn't heat up enough after the weeds are added. Grasses that spread by rhizomes or stolons also present a

problem if not completely dried up. In these cases, despite their potential value as organic material, it is better to let the trash collectors take these weeds.

4. Reducing weed growth around the garden by mowing or other means will also help prevent the spread of weeds and seeds to the garden area.
5. Cultivation is best done when the soil is somewhat moist, but not wet. A day or two after a rain or irrigation is the best time to cultivate. Working wet soil will damage the structure, especially of fine-textured soils. When it is too dry, weeds are difficult to pull and hoeing is also hard.
6. If you have a choice, remember that the work will be much more pleasant in the cool temperatures of early morning or late evening.

B. Mulching

If you have a reliable source of mulching materials you can reduce the need for weeding. Thick layers of organic mulch will prevent most annual seeds to poke through, and those that do are usually easily pulled.

1. Mulching with black plastic is a good choice for controlling weeds with runners.
2. Use newspaper, old carpeting, or other such materials, or sawdust or bark, as mulch materials for paths. These provide excellent weed suppression.
3. Uncomposted sawdust is not recommended for use next to plants. It has a tendency to crust, and soil microbes reduce the amount of nitrogen available to the vegetables.

C. Close Spacing

When spaced close to each other, established vegetable plants will shade the soil and prevent the growth of many weed seedlings. This is the effect achieved by a well-planned raised bed. The plants are spaced so that the foliage of adjacent plants touches and forms a closed canopy at a mature growth stage.

D. Other Practices

Some gardeners are experimenting with various types of no-till gardening. The fol-

lowing techniques are still in the experimental stage for home gardeners. Try them in small sections of the garden to determine their effectiveness.

1. One method is to plant a cover crop in the fall, kill it with a herbicide in the spring, then plant vegetables in the dead sod after a recommended waiting period. However, there are no herbicides recommended for use in established home vegetable gardens to kill emerged weeds at the present time. Use of weed killers normally recommended for lawns or other areas is not advised, and until a safe herbicide is available for growing weeds, this type of no-till practice is unsafe for growing vegetables in the home garden.
2. Another method is the use of a living sod that is mowed regularly. This has many of the benefits of no-till gardening and does not necessitate the use of herbicides. The living sod method is a good choice for raised beds, so that only the paths need to be mowed.
3. The use of cover crops over several seasons or years in a particularly weedy section can also reduce weed problems. This method requires leaving the cover crop section uncultivated, which reduces gardening space. Cover crops must also be cut or harvested regularly, which can be time-consuming and difficult without appropriate tools.
4. Investigate crop rotations thoroughly before using them to control weeds.

E. Herbicides

As mentioned before, herbicides may be used in and around the home garden, but it can be risky business, if knowledgeable applications are not made. They should always be used according to label instructions and only for crops listed on the label. The wrong herbicide can destroy garden productivity for many years.

1. Even when used properly, drift from herbicide sprays used on lawns or in areas surrounding the garden can cause damage to vegetable plants. Spray on windless days and erect barriers to protect plants if necessary. Drift from preemergence her-

bicides does not damage growing plants but may prevent seeds from germinating.

2. Be aware that treatment with an herbicide for one type of weed may result in the area being colonized by other weeds that are tolerant to the chemical.
3. Finally, never use an herbicide in the same sprayer used for insect and disease control. Keep a separate sprayer for herbicides.

XIV. Container Gardening

If you don't have space for a vegetable garden, or if your present site is too small, consider raising fresh, nutritious homegrown vegetables in containers. A window sill, patio, balcony, or doorstep can provide sufficient space for a productive container garden. Problems with soil-borne diseases, nematodes, or poor soil can be overcome by switching to container gardening. Grow vegetables that take up little space. Carrots, radishes and lettuce, or crops that bear

fruits over a period of time, such as tomatoes and peppers, make the best use of space and containers. Dwarf or miniature varieties often mature and bear fruit early, but most do not produce as well overall as standard varieties. With increasing interest in container gardening, plant breeders and seed companies are working on vegetables specifically bred for container culture. These varieties are not necessarily miniature or dwarf and may produce as well as standard types if properly cared for (Table 5).

The amount of sunlight your container garden spot receives may determine which crops can be grown. Generally, root crops and leaf crops can tolerate partial shade, but vegetables grown for their fruits generally need at least 5 hours of full, direct sunlight each day, and perform better with 8 to 10 hours. Available light can be increased somewhat by providing reflective materials around the plants (e.g., aluminum foil, white-painted surfaces, marble chips).

Table 5. Growing vegetables in containers.

| Vegetable | Light requirements ¹ | Distance (inches) | | Days from seed to harvest | Comments |
|-----------------|---------------------------------|------------------------|------------------------------|---------------------------|---|
| | | Minimum container size | Between plants in containers | | |
| Beans, bush | FS | 2 gallon | 2 to 3 | 45 to 60 | Several plantings at 2 to week intervals |
| Beets | FS/PS | 1/2 gallon | 2 to 3 | 50 to 60 | Thin plants when 1 to 2 inches tall |
| Carrots | FS/PS | 1 quart | 2 to 3 | 65 to 80 | Several plantings; 2 week intervals |
| Cabbage | FS/PS | 5 gallon | 12 to 18 | 65 to 120 | Requires fertile soil |
| Chard, Swiss | FS/PS | 1/2 gallon | 4 to 6 | 30 to 40 | Harvest leaves |
| Cucumbers | FS | 5 gallon | 14 to 18 | 70 to 80 | Requires hot weather; vining types need support |
| Eggplant | FS | 5 gallon | 1 plant per | 75 to 100 | Requires fertile soil |
| Kale | FS/PS | 5 gallon | 10 to 15 | 55 to 65 | Harvest leaves |
| Lettuce, leaf | PS | 1/2 gallon | 4 to 6 | 30 to 35 | Harvest leaves |
| Mustard, greens | PS | 1/2 gallon | 4 to 5 | 35 to 40 | Several plantings; 2 to week intervals |
| Onion, green | FS/PS | 1/2 gallon | 2 to 3 | 70 to 100 | Requires lots of moisture |
| Peppers, bell | FS | 2 gallon | 1 plant per container | 110 to 120 | Requires lots of moisture |
| Squash, summer | FS | 5 gallon | 1 plant per container | 50 to 60 | Plant only bush types |
| Tomatoes | FS | 5 gallon | 1 plant per | 55 to 100 | Stake and prune or cage |
| Turnips | FS/PS | 3 gallon | 2 to 3 | 30 to 60 | Harvest leaves and roots |

Note: Consult seed catalogs for varieties adapted to container culture.

¹FS = full sun; FS/PS = full sun, tolerates partial shade; PS = partial shade.

A. Containers

Possible containers for gardening are clay, wood, plastic, and metal. Containers for vegetable plants must be big enough to support plants when they are fully grown, must hold soil without spilling, must have adequate drainage, and must be free from contamination (e.g., herbicide residue).

1. Consider using barrels, cutoff milk jugs, window boxes, and baskets lined with plastic (with drainage holes punched in them), or even pieces of drainage pipe or cement blocks.
2. If you are building a planting box out of wood, you will find redwood and cedar to be the most rot resistant, but bear in mind that cedar trees are much more available than redwoods. Wood for use around plants should never be treated with creosote or pentachlorophenol (penta) wood preservatives. These may be toxic to plants and harmful to people as well.
3. Some gardeners have built vertical planters out of wood lattice lined with black plastic and then filled with a lightweight medium. Others build planters out of welded wire shaped into cylinders, lined with sphagnum moss, and filled with soil mix. Depending on the size of your vertical planter, 2-inch diameter perforated plastic pipes may be needed inside to aid watering.
4. Whatever type of container you use, be sure that there are holes in the bottom for drainage so that plant roots do not stand in water. Most plants need containers at least 6 to 8 inches deep for adequate rooting.
5. For ease of care, dollies or platforms with wheels or casters can be used to move the containers from place to place. This is especially useful for apartment or balcony gardening so that plants can be moved to get maximum use of available space and sunlight and to avoid destruction from particularly nasty weather.

B. Media

Unless your garden has sandy loam or sandy soil, a lightweight potting mix is needed for container vegetable gardening.

Soil straight from the garden usually cannot be used in a container because it may be too light textured. Container medium must be porous in order to support plants, because roots require both air and water.

Packaged potting soil available at local garden centers is relatively lightweight and makes a good container medium. Mixes such as peat-like mix are generally too light for container vegetable gardening. They do not offer enough support to plant roots.

Soiless mixes are sterile and contain few nutrients, so even though major fertilizers are added, no trace elements are available for good plant growth. Add soil or compost if you wish to use a soiless mix as a base. For a large container garden, the expense of prepackaged or soiless mixes may be quite high.

C. Planting

Plant container crops at the same time as you would in planting a regular garden.

Fill a clean container to within 1/2 inch of the top with a slightly damp soil mixture. Peat moss in the mix will absorb water and mix much more readily if soaked with warm water before putting the mix in the container.

1. Sow the seeds or set transplants according to instructions on the seed package. Put a label with the name, variety, and date of planting on or in each container.
2. After planting, gently soak the soil with water, being careful not to wash out or displace seeds.
3. Thin seedlings to obtain proper spacing when the plants have two or three leaves.
4. If cages, stakes, or other supports are needed, provide them when the plants are very small to avoid root damage later.

D. Watering

Pay particular attention to watering container plants. Because the volume of soil is relatively small, containers can dry out quickly, especially on a concrete patio in full sun. Daily or twice daily watering may be necessary.

1. One sign of dry soil is wilting plants. Check containers at least once a day, and

twice on hot, or windy days. Feel the soil to determine whether it is damp.

2. Mulching and windbreaks can help reduce water requirements for containers. If you must be away from the garden for long periods of time, consider an automatic drip emitter irrigation system.
3. Apply water until it runs out the drainage holes. On an upstairs balcony, this may mean neighbor problems, so make provisions for drainage of water. Large trays filled with coarse marble chips work nicely. The soil should never be soggy or have water standing on top of it.
4. Clay pots and other porous containers allow additional evaporation from the sides of the pots and watering must be done more often. If the soil appears to be getting excessively dry, group the containers together so that the foliage creates structures that will allow air movement beneath the pots and prevent direct contact with the cement.

E. Fertilizing

If you use a soil mix with fertilizer added, then your plants will have enough nutrients for 8 to 10 weeks. If plants are grown longer than this, add a water-soluble fertilizer, dry fertilizer (slow release), manure, or compost at the recommended rate. Repeat every 2 to 3 weeks. An occasional dose of fish emulsion or compost will add trace elements to the soil.

Do not add more than the recommended rate of any fertilizer, since this may cause fertilizer burn and kill the plants. Container plants do not have the buffering capacity of large volumes of soil and humus to protect them from overfertilizing or overliming. Just because a little is good for the plants does not guarantee that a lot will be better.

F. General Care

Vegetables grown in containers can be attacked by the various types of insects and diseases that are common to any vegetable garden.

1. Plants should be periodically inspected for the presence of foliage-feeding and fruit-feeding insects as well as the occurrence of diseases.

2. Protect plants from very high heat caused by light reflecting from pavement. Move them to a cool spot or shade them during severe rain, hail, or wind storms, and for protection from early fall frosts.

G. Indoor Container Gardening

If you want fresh, homegrown vegetables over the winter, or if you don't have an outdoor space in which you can place containers, it is worth trying some indoor container gardening. Of course, you cannot have a full garden in the house, but a bright, sunny window can be the site for growing fresh food all year.

1. Some small-fruited tomatoes and peppers, several types of lettuce, radishes, Swiss chard, and many herbs are among the plants you can include in the indoor garden.
2. Plants dry out less quickly indoors than outdoors and also grow more slowly. They need less fertilizer and less water. To make watering easy, set the pots in large trays with an inch or two of decorative stones in them. Not only will this prevent your having to move the plants in order to water them, which may discourage you from watering when you should, but it will also provide humidity. Humidity is a major requirement, especially during winter when houses are warm and dry.
3. A sunny window, preferably south-facing, is essential for successful indoor vegetable growing. Fruiting vegetables such as tomatoes and peppers may also need supplemental light, such as a combination warm-white/cool-white florescent fixture, during winter months. Insufficient light results in tall, spindly plants that often fail to flower and set fruit.

XV. Preparing Perennial Vegetables for the Winter

Late fall is the time to prepare perennial vegetables for winter.

A. Basic Preparations

Most will benefit from a top-dressing of manure or compost and a layer of mulch, which reduces damage from freezing and

thawing. Dead leaf stalks of perennial vegetables (asparagus and rhubarb) should be cut to the ground after their tops are killed by frost, though some people prefer to leave asparagus stalks until late winter to hold snow over the bed.

1. Don't forget strawberry beds. Remove weeds that you let grow when you were too busy last summer. You can transplant some of the runner plants if you carefully dig a good-sized ball of soil with the roots. Mulch the bed well with a light material.
2. Raspberry plant's expended floricanes should be removed immediately after harvest. Top the primocanes when dormant, and thin in the spring.

B. Stakes and Trellises

When tender crops have been harvested and overwintering crops cared for, pull up all stakes and trellises except those stakes that clearly mark the sites of overwintering plants.

Clean stakes and trellises of plant and soil remnants. Hose them down and allow to dry. Tie stakes in bundles and stack for storage over the winter. If possible, roll up wire trellises and tie them securely. Store these items inside your attic, barn, or shed where they are out of the way, and where rodents and other animals cannot use them as winter nests.

C. Preparing Soil for Winter

Pull up all dead and unproductive plants and place the residue on top of the soil to be tilled under or placed into the compost heap.

1. Remove any diseased or insect-infested plant material from the garden. This also removes diseases and insects that may reproduce next spring and add to your pest problems.
2. Another option is to burn infested plant material. Check laws in your area before burning anything; you may need a permit. If you live near a wooded area, burning may be too risky. In this case, haul the diseased material away.
3. Cleaning up the garden also gives you the chance to add compost to the garden. Compost contains highly nutritious, de-

composed plant material and beneficial organisms, and is an excellent soil-builder.

4. Don't overlook other sources of organic material available during the fall. Leaves are abundant. Put some on the garden, store some for next year's mulch, and compost some. Leaves will mat if put on in too thick a layer, and will not decompose quickly. You can help leaves break down more easily by running a lawn mower back and forth over the pile. Add one cup of ammonium nitrate per bushel of leaves.
5. Sawdust and wood chips are easy to obtain from sawmills, and many farms and stables want to get rid of manure piles before winter sets in. By adding these materials in the fall, you give them plenty of time to decompose and blend into the soil before planting time. If you don't have enough organic material for the entire garden, try to cover those areas you want to be especially rich for next summer's crop.

D. Preparing the Cold Frame

Unless you are lucky enough to live in a warm area where a cold frame will protect vegetables all winter, you will need to clean up the frame when all vegetables have been harvested. Remove all remaining plant material and spread it on the cold frame soil. Thoroughly spade the plant refuse and any other organic material into the soil in the cold frame.

Do not leave the top on the cold frame over the winter as the weight of snow may crack or break the glass. Remove the top, wash it thoroughly, and store it on its side in a protected indoor area.

Further Reading

Many University of Idaho publications about gardening are available from your county's UI Extension office. Also, you may write to Publications, University of Idaho, Moscow, ID 83844-2240, or call (208) 885-7982. You could also check, and in some cases download, the online publication and video catalog on the UI Educational Communications web site (<http://info.ag.uidaho.edu>).

Chapter
Vegetables

20



IDAHO
master gardener

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Chapter 20

Vegetables



G. F. Gardner

George F. Gardner, Former Extension Educator, Bannock County, Pocatello

I. Beans, Snap

A. Food Value

A pound of raw green bean pods broken into 1- or 2-inch lengths yields about 3 2/3 cups of cooked beans. They are composed of 90.1 percent water, 145 calories, 8.6 grams of protein, 0.9 gram of fat, and 32.2 grams of carbohydrates.

B. Description

Snap beans grown from the immature pod originated in Central America and were widely distributed by the Indians, basically as bush and pole beans. Bush beans ripen earlier, but pole bean yields are higher.

C. Yield Per Person

It is estimated that each person will consume 6 to 12 pounds of garden fresh beans and 12 to 14 pounds of canned or frozen beans per year. Each foot of row space planted to beans produces an average of 0.35 to 0.5 pound of snap beans. A 20- to 30-foot row of beans produces enough beans for one person.

D. Seedbed

Beans do best on sandy loam soil that warms up early in the spring and has a soil pH from 7.0 to 7.5 but can tolerate a soil pH near 8.0. Cultivate the soil for planting when the moisture in the soil allows the formation of a soil ball that crumbles into pieces under finger pressure. Cultivate to mix crop residues and organic matter into

the top 7 to 8 inches of soil, destroy current weed growth, and provide a granular soil bed for seeding. Overcultivation causes the soil to become powdery or to crust.

E. Seed Time

The best time to seed beans is after the last killing frost in the spring, when day temperature is 65°F and the night is expected to average above 55°F. Select early maturing varieties that ripen in 55 to 70 days.

F. Planting Specifications:

| | |
|-----------------------|--------------------------|
| <i>Seed per foot</i> | <i>6 to 8</i> |
| <i>Row width</i> | <i>18 to 30 inches</i> |
| <i>Germination</i> | <i>6 to 14 days</i> |
| <i>Seed depth</i> | <i>1 1/2 to 2 inches</i> |
| <i>Ounce per foot</i> | <i>0.13</i> |
| <i>Plant spacing</i> | <i>2 to 4 inches</i> |

G. Planting Suggestions

Beans need a warm soil to grow and good spacing for sunlight. Some gardeners are tempted to soak their seeds before planting. This practice injures many of the bean varieties, and could result in poor germination and diseased, weak plants.

H. Fertilizer

Beans are a legume and can produce some of their own nitrogen (N) because of their N fixation ability. The seed may be inoculated with rhizobium to stimulate additional fixation. To supplement this, add a preplant fertilizer of 0.2 pound of N for each 100 square feet. After the first heavy bloom and set of pods, sidedress with 1 1/2 ounces of ammonium sulfate.

The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants are easily over- or under-fertilized.

Acknowledgment

The author compiled information for Chapters 19 and 20 from the Virginia, Utah, Oregon, and Washington Master Gardener handbooks and adapted it to Idaho conditions.

I. Cultivation

Cultivate (shallow) when necessary to remove other plant competition. Deep cultivation close to the plants destroys much of the root system and reduces yield and quality.

J. Watering

Beans have a water stress point of 60 percent. When the percentage of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. To estimate water percentage, take a handful of soil at the 6-inch depth and squeeze it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or higher. If the soil moisture is below 60 percent, you will not feel the film of water on your hand, and it is time to water again. Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases.

K. Insects

Lygus bugs, nitidulid beetles, aphids including the bean aphid, army worms and cutworms, grasshoppers, pea leaf weevil, corn maggot, slug, spider mites, cucumber beetles, and wireworms create problems in beans.

L. Diseases

Common diseases include brown spot, curly top, halo blight, mosaics, necrosis, root rot, rust, sclerotinia disease, white mold, seed rot, and seedling blight.

M. Harvesting

Beans can be harvested when pods are 3 inches long but before the seed is much larger than the diameter of a pencil lead. Harvest every 3 to 4 days to prevent over maturity. Frequent picking stimulates the plants to produce new pods and helps to ensure a heavy harvest. Disturbing wet vines spreads rust and other diseases.

II. Beets

A. Food Value

A pound of raw, peeled, common red beets consists of 90.9 percent water, 5.0 grams of

protein, 0.5 gram of fat, 23.7 grams of carbohydrates, and 145 calories.

B. Description

Beets are native to the Mediterranean area of north Africa, Europe, and west Asia. They are cool weather biennials that are grown as annuals for their leaves and roots. The roots may be round, flat, or elongated. They are usually red in color, but there are several golden varieties.

C. Yield Per Person

On the average, each person consumes 7 to 12 pounds of fresh beets during a growing season, and an additional 12.5 to 30 pounds of canned and frozen beets. Each foot of row space should produce approximately 1.25 pounds of beets.

D. Seedbed

Beets grow best in sandy loam and peat soils. Heavy clay soils can be improved by the addition of organic matter. Seedbed preparation should start when the soil has sufficient moisture to form a ball that crumbles into medium-sized fragments. Cultivate to mix crop residues and organic matter into the top 7 to 8 inches of soil, destroy current weeds, and provide a small granular-type bed for planting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for beets is from 6.0 to 7.5, although a pH value near 8.0 is acceptable.

E. Seed Time

The best time to seed beets is 2 to 4 weeks before the last killing frost in the spring when soil temperature is 50°F or above. Select early maturing varieties that ripen in 55 to 65 days.

F. Planting Specifications:

| | |
|-----------------------|-----------------------|
| <i>Ounce per foot</i> | <i>0.01</i> |
| <i>Seed per foot</i> | <i>15 to 20</i> |
| <i>Row width</i> | <i>2 to 18 inches</i> |
| <i>Germination</i> | <i>10 to 15 days</i> |
| <i>Seed depth</i> | <i>1/2 to 1 inch</i> |
| <i>Plant spacing</i> | <i>2 to 3 inches</i> |
| <i>Row spacing</i> | <i>12 inches</i> |

G. Planting Suggestions

Beets need a cool soil to grow and good spacing for sunlight. Their frost tolerance is

moderate. They are not harmed by spring and fall frosts, but their roots may become tough during hot weather. The seed of beets is actually a dried fruit or seed ball containing several tiny true seeds. Heat, drought, or crusting of the soil surface interferes with seed germination and emergence. Make successive plantings 3 weeks apart to ensure a continuous supply of young beets.

H. Fertilizer

Preplant fertilizer is a recommended 0.2 pound of N for each 100 square feet. No sidedressing is required. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Use shallow cultivation when necessary to remove other plant competition. Deep cultivation close to the plants destroys much of the root system and reduces yield and quality.

J. Watering

Beets have a water stress point of 50 percent. When the percentage of water in soil drops below this level, the plants will start to dehydrate, and growth will be slowed down or stopped. To estimate the water percentage take a handful of soil at the 6-inch depth and squeeze it into a ball in your hand. If it forms a ball but feels dry, the soil moisture will be 50 percent or higher. If the soil moisture is below 50 percent, the ball will be fragile and break apart with slight pressure, and it is time to water again. Plant growth can suffer from too much or too little water. The symptoms will be the same. Plants need water, oxygen, and nutrients to grow.

K. Insects

Alfalfa looper, army worm, cutworms, flea beetles, two-spotted mite, variegated cutworm, zebra caterpillar, and nematodes are common beet pests.

L. Diseases

Disease problems include boron deficiency, curly top, damping-off, downy mildew, and leaf spot.

M. Harvesting

Beets can be harvested as soon as the roots are large enough to use. Early thinning is critical for beets to develop large, tender roots. Leave 2 inches between plants. The tops of beets removed during thinning can be used for "greens." Beets are ready to be pulled up for their roots 8 to 9 weeks after seeds are sown. Roots are most tender when less than 2 inches across. Harvest for storage before roots become woody. Pull the beet and cut off the tops, but leave 1 to 1 1/2 inches of top above the crown. To see if roots are ready for use, push the soil away from the top of the beet and check its size.

III. Broccoli

A. Food Value

A pound of broccoli stalks (head or bud clusters, stem, and leaves) consists of 89.1 percent water, 16.3 grams of protein, 1.4 grams of fat, 26.8 grams of carbohydrates, and 145 calories.

B. Description

Broccoli is a member of the cabbage family with similar requirements and problems. It was developed in southern Europe and brought to America by immigrants. The plant has a loose flower head on a tall, green, branching stalk. The flower heads are formed both terminally and laterally. The plant may grow to 3 to 5 feet tall.

C. Yield Per Person

It is estimated that each person consumes 3 to 5 pounds of fresh broccoli during a growing season and an additional 5 to 6 pounds of frozen broccoli each year. Each foot of row space produces about 0.75 pound of broccoli.

D. Seedbed

Broccoli will grow in most soils from sand to clay. Seedbed preparation should start when the soil has sufficient moisture to form a ball that crumbles into medium-sized fragments. Cultivate mix crop residues and organic matter into the top 7 to 8 inches of soil, destroy weed growth, and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and

has a tendency to crust. The ideal pH for broccoli is from 6.0 to 7.0, but values near 8.0 are acceptable.

E. Seed Time

The best time to seed broccoli is 6 to 8 weeks before transplanting when soil temperature is 50°F or above. The variety should have an early maturity date and be suitable for weather conditions in the area planted. The maturity date should be 60 to 80 days after transplanting. Plant in containers inside for early crops and transplant after last frost.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>3 to 4</i> |
| <i>Row width</i> | <i>24 to 30 inches</i> |
| <i>Germination</i> | <i>3 to 10 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |
| <i>Plant spacing</i> | <i>20 to 24 inches</i> |

G. Planting Suggestions

Broccoli needs a cool soil to grow and good spacing for sunlight. If transplants are purchased, they should be stocky and from 4 to 6 inches tall.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. Three weeks after transplanting, sidedress with 1 1/2 ounces of ammonium sulfate (southern Idaho) or ammonium nitrate (northern Idaho) per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Use shallow cultivation when necessary to remove other plant competition. Deep cultivation close to the plants destroys much of the root system and reduces yield and quality.

J. Watering

Broccoli has a water stress point of 60 percent. When the percentage of water in soil drops below this level, the plant will start to dehydrate and growth will be slowed down or stopped. The percentage of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into

a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or higher. If the soil moisture is below 60 percent, you will not feel the film of water on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

Aphids, cabbage maggots, cabbage worm, cabbage looper, diamond back moth, flea beetles, spider mites, and wireworms are common broccoli pests.

L. Diseases

Diseases include bacterial soft rot, club root, and downy mildew.

M. Harvesting

Broccoli should be harvested when the center head is 4 to 6 inches across, but before the buds separate or open. Lateral buds will develop into smaller heads after the terminal head is removed. When a head is ready for use, cut the stem 3 inches below the flower buds.

IV. Brussels Sprouts

A. Food Value

A pound of Brussels sprouts consists of 85.2 percent water, 22.2 grams of protein, 1.8 grams of fat, 37.6 grams of carbohydrates, and 204 calories.

B. Description

Brussels sprouts originated in Europe, the principal location being Brussels, Belgium. They resemble small cabbages but require a longer growing season. Each plant grows to about 2 1/2 feet tall, bearing small cabbage like buds along its stem. Each stem may bear as many as 100 1- to 2-inch ball-like sprouts.

C. Yield Per Person

On the average, each person eats from 1.5 to 3.75 pounds of fresh Brussels sprouts during a growing season and uses an additional 3.75 to 6 pounds of canned or frozen sprouts

during the year. Each foot of row space produces about 0.5 pound of Brussels sprouts. From 3.5 to 8.5 feet of row space per person should be planted for fresh use during the growing season and an additional 3.5 to 14 feet for canning or freezing.

D. Seedbed

Brussels sprouts are adaptable to different soils as long as the soils are fertile, have good texture, and are moist. Brussels sprouts mature less rapidly than cabbage. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that you can crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil, destroy current weed growth, and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for Brussels sprouts is from 6.0 to 7.5; they do well in Idaho's soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to plant Brussels sprouts seed in containers is 4 to 6 weeks before transplanting in the garden, when soil temperature is 40°F or above. Seed planted in the garden for later maturing plants should be inserted into the soil as soon as the soil can be cultivated, 6 to 8 weeks before the last killing frost. The variety of Brussels sprouts planted should have an early maturity date and be suited for weather conditions in the area planted. The maturity date should be 80 to 90 days after transplanting.

F. Planting specifications—

| | |
|-----------------------|------------------------|
| <i>Seed per foot</i> | <i>3 to 4</i> |
| <i>Row width</i> | <i>24 to 30 inches</i> |
| <i>Germination</i> | <i>3 to 10 days</i> |
| <i>Seed depth</i> | <i>1/4 to 1/2 inch</i> |
| <i>Planting space</i> | <i>18 to 24 inches</i> |

G. Fertilizer

Brussels sprouts require good fertility and moisture. A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plants are one-third grown, sidedress with 1 1/2 ounces of ammonium sulfate in high pH soils or ammonium nitrate in low pH soils per 10 feet of

row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

H. Cultivation

When necessary, cultivation should be shallow to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. Hilling soil up around the main stem of the cabbage may stimulate early heading.

I. Watering

Brussels sprouts have a stress point of 55 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it is moist but does not leave a film of water on it, the soil moisture will be 55 percent or above. If the soil moisture is below 55 percent, the moisture will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

J. Insects

Aphids, flea beetles, cabbage looper, garden symphylans, slugs, thrips, and cauliflower head maggot are common pests.

K. Diseases

Brussels sprouts diseases are minimal in Idaho but may include bacterial soft rot, blackleg, club rot, and sprout rot.

L. Harvesting

Remove lower leaves as sprouts start to enlarge. Harvest sprouts as they become solid at about 1 to 2 inches in diameter. The lowest sprouts will mature first. To speed up sprout maturity pinch off the tip of each plant in late August or early September,

however, this may reduce the total yield of the plant by as much as one third. Break the sprouts from the stalk. The tastiest sprouts will be those that mature after the first fall frost.

M. Storage

When night temperatures drop to 20°F on a regular basis, dig up the plants with a little soil remaining around the roots. Put them into a deep cold frame or in an unheated dark garage. They will continue to grow until all the sprouts mature.

V. Cabbage

A. Food Value

A pound of cabbage consists of 92.4 percent water, 5.9 grams of protein, 0.9 gram of fat, 24.5 grams of carbohydrates, and an average of 109 calories.

B. Description

Cabbage ranks as one of the most important homegrown crops. It may be globular, flat, or flowery and green, red, or purple. It was developed from wild leafy nonheading plants native to Europe.

C. Yield Per Person

On the average each person eats 4 to 5 pounds of fresh cabbage during a growing season, and an additional 6 to 12 pounds of canned or frozen cabbage during the year. Each foot of row space produces about 1.5 pounds of cabbage. Plant 5 to 6 feet of row space per person for fresh use during the growing season and an additional 7.5 to 15 feet for canning.

D. Seedbed

Cabbage is adaptable to different soils as long as they are fertile, have good texture, and are moist. Start seedbed preparation when the soil has enough moisture to form a mud ball that will crumble into medium-sized fragments. Mix crop residues and organic matter into the top 7 to 8 inches of soil, destroy current weed growth, and provide a small granular-type bed for transplanting. Overcultivated soil is powdery and has a tendency to crust. The ideal pH for cabbage growth is 6.0 to 7.5, and they do well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to plant cabbage seed is 5 to 7 weeks before transplanting in containers. Large cabbage transplants may produce seed stalks if subjected to 3 to 4 weeks of 40° to 50°F weather. To help prevent this problem, plant out transplants when the stem is about the size of a pencil lead when soil temperature is 50°F or higher. Seeds planted in the garden for later maturing plants should be inserted into the soil as soon as the soil can be cultivated, 6 to 8 weeks before the last killing frost. Select cabbage varieties suited to weather conditions in the area planted. Maturity dates should be 65 to 95 days after transplanting.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>8 to 10</i> |
| <i>Row width</i> | <i>24 to 30 inches</i> |
| <i>Germination</i> | <i>4 to 10 days</i> |
| <i>Seed depth</i> | <i>1/4 to 1/2 inch</i> |
| <i>Plant spacing</i> | <i>4 to 6 inches</i> |

G. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plants are one-third grown, sidedress with 1 1/2 ounces of ammonium sulfate in alkaline soils and ammonium nitrate in acid soils per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

H. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. Hilling soil up around the main stem of the cabbage may stimulate early heading.

I. Watering

Cabbages have a water stress point of 55 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. To estimate water percentage, take a handful of soil at the 6-inch depth and

squeeze it into a ball in your hand. If it forms a ball and your hand feels like it is damp but does not have a film of water on it, the soil moisture will be 55 percent or above. If the soil moisture is below 55 percent, the dampness of water will not be felt on your hand, and it is time to water again. Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

J. Insects

Aphids, flea beetles, cabbage looper, blister beetles, diamond back moth, wireworms, and the imported cabbage worm are common cabbage pests.

K. Diseases

Cabbage diseases, minimal in Idaho, may include bacterial soft rot, blackleg, club rot, damping off and wire stem, downy mildew, drop or watery soft rot, leaf spot, and oedema.

L. Harvesting

Cabbage is ready to harvest 50 to 65 days after transplanting. The heads should be solid but must be picked before they crack. Soft heads have poor quality. Heads may split during hot weather if there is an over supply of water. Reducing irrigation or twisting the mature heads part of the way around to sever half the roots will allow mature cabbage to stay in the garden longer without losing quality. Plants harvested early in the summer and left with as many leaves as possible will often develop small heads on the stem next to the base of the leaves. These heads are edible and should be picked when firm.

M. Storage

Cabbage freeze at about 30°F. For storage, place mature cabbages in a pit, trench, or outdoor cellar. The temperature should be as near 32°F as possible but at least 40°F or below. Humidity should be high. Stored cabbages will last into early winter.

VI. Cantaloupes

A. Food Value

A pound of raw cantaloupe consists of 91.2 percent water, 3.2 grams of protein, 0.5

gram of fat, 34.0 grams of carbohydrates, and an average of 136 calories.

B. Description

Cantaloupes are native to India. The plants have separate male and female flowers on the same vine and are cross-pollinated. They do not cross-pollinate with cucumbers, gourds, watermelons, squash, or pumpkins. Cantaloupes may develop a bitter flavor because of cloudy weather, excessively high temperatures, or too much or too little water during the ripening period. They need a lot of heat and a long growing season to mature.

C. Yield Per Person

Each person eats about 8 to 10 cantaloupes during the growing season. Each foot of row space produces about 1 pound of cantaloupe, and 8 to 10 feet of row will supply one person.

D. Seedbed

Cantaloupes are adapted to most soils but grow best in a fertile mellow soil with large amounts of compost. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Mix crop residues and organic matter into the top 7 to 8 inches of soil, destroy current weed growth, and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for cantaloupe growth is from 6.0 to 7.5, but the fruit does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to transplant cantaloupes in Idaho is 3 weeks after the last killing frost. When transplanting, soil temperature should be 65°F or above, and night temperature should average above 55°F. Select varieties that ripen in 75 to 85 days after transplanting.

F. Planting Specifications:

| | |
|-----------------------|------------------------|
| <i>Seed per foot</i> | <i>1</i> |
| <i>Ounce per foot</i> | <i>0.05</i> |
| <i>Row width</i> | <i>60 to 72 inches</i> |
| <i>Germination</i> | <i>3 to 5 days</i> |
| <i>Seed depth</i> | <i>1 inch</i> |
| <i>Plant spacing</i> | <i>36 to 72 inches</i> |

G. Planting Suggestions

Cantaloupes need warm soil to grow and good spacing for sunlight to ensure high sugar content and flavor. If transplants are used, they should be stocky. Soils should be well drained and contain large amounts of compost or well-rotted manure. Clear plastic mulch can be used around the plants to warm the soil.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. One week after blossoming begins, sidedress with 1 1/2 ounces of ammonium sulfate per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivate no more than 1 inch deep to control weeds.

J. Watering

Cantaloupes have a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

Aphids, cucumber beetle, and squash bug are common pests.

L. Diseases

Diseases include Fusarium wilt, leaf blight, and powdery mildew.

M. Harvesting

Cantaloupes must ripen on the vine for maximum quality. Ripe fruit forms an abscission layer, and the stem loosens from the fruit. When the stem is nearly loose, the cantaloupe is said to be at the full slip stage. Softening of the blossom end, a change in color of the base of the pedicel from green to waxy, and a strong cantaloupe smell are indications of ripeness. Cantaloupe harvested before the full slip stage do not increase in sugar after picking.

VII. Carrots

A. Food Value

Carrots are a good source of vitamins A, B, B₂, and C, sugar, and iron. A pound of carrots consists of 88.2 percent water, 5.0 grams of protein, 0.9 gram of fat, 44.0 grams of carbohydrates, and an average of 191 calories.

B. Description

Carrots are related to the wild flower Queen Anne's Lace. They have bright green feathery foliage 10 to 12 inches tall and develop an orange yellow root.

C. Yield Per Person

Each person eats about 5 to 10 pounds of fresh carrots and an additional 10 to 15 pounds of canned or frozen carrots per year. Each foot of row space should produce about 1 pound of carrots.

D. Seedbed

Carrots grow best in sandy loam and peat soils. Heavy clay soils can be improved by the addition of organic matter. If you apply manure, do so sparingly and use only well-rotted manure to avoid rough, branching carrots. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Over-cultivated soil becomes powdery and has a tendency to crust. The ideal pH for carrot growth is from 6.0 to 7.0, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

Plant carrots after the last killing frost in the spring when soil temperature is 40°F or above. Their frost tolerance is moderate. Low temperature carrots grow long and have pointed tips. High temperature carrots have blunt tips. For an extended harvest, you can continue planting throughout the summer until about 70 days before the last expected frost. Most varieties mature in 60 to 70 days.

F. Planting Specifications:

| | |
|-----------------------|------------------------|
| <i>Ounce per foot</i> | <i>0.02</i> |
| <i>Seed per foot</i> | <i>15 to 20</i> |
| <i>Row width</i> | <i>14 to 24 inches</i> |
| <i>Germination</i> | <i>10 to 17 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |
| <i>Plant spacing</i> | <i>1 to 2 inches</i> |

G. Planting Suggestions

Carrots prefer warm soil and need good spacing for proper root development. A salt or pepper shaker can be used to scatter seeds in the row. For small gardens, try growing carrots in raised beds at least 12 inches deep. A mixture of one-fifth garden soil, two-fifths sand, and two-fifths compost or peat moss works well. Carrot seedlings are tiny. Some gardeners mix a few radish seeds with the carrot seeds so they can see the row.

To prevent the soil from forming a crust that would inhibit the seedling's growth, cover the seeds with a light layer of compost, (sifted) grass clippings, and sawdust of vermiculite. A film of clear plastic over the seedbed will speed up germination by warming the soil, prevent crusting, and keep the soil moist. Remove the plastic as soon as the seedlings emerge. Thin seedlings to 2 inches apart.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. No sidedressing is required. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Excessive N causes carrots to split into forks in the top half.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Carrots have a water stress point of 55 percent. When the percent of water in soil drops below this level, the plants will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball, and your hand feels damp, but does not have a film of water on it, the soil moisture will be 55 percent or above. If the soil moisture is below 55 percent, the dampness will not be felt on your hand, and it is time to water. Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: aphids, carrot rust fly, garden symphylan, wireworm, six-spotted leafhopper, and slug.

L. Diseases

Diseases include aster yellows, cottony soft rot, damping-off, leaf spot, leaf blight, motley dwarf virus, phytophthora root rot, and nematode soft rot.

M. Harvesting

Carrots can be harvested as soon as the roots are the size of your little finger. Harvest carrots before they become woody.

N. Storage

Carrots can be stored throughout the fall and winter in a pit, storage cellar, or covered row. Storage temperature should be as near 32°F as possible. Humidity should be high.

VIII. Cauliflower

A. Food Value

A pound of cauliflower with head and 4 to 6 inches of stem consists of 91 percent water,

23.2 grams of protein, 1.7 grams of fat, 44.7 grams of carbohydrates, and an average of 232 calories.

B. Description

The most delicate member of the cabbage family, cauliflower has similar requirements and problems. It was developed in southern Europe and is grown for its flower buds, which are clustered together in a head or curd. It may be difficult to grow because it requires cool temperatures, constant moisture, and frequent fertilizing. Cauliflower does not head up well in hot weather and is less tolerant of cold temperatures than cabbage. It grows about 2 feet high and has blue green leaves.

C. Yield Per Person

It is estimated that each person eats from 3 to 5 pounds of fresh cauliflower and 8 to 12 pounds of canned or frozen cauliflower each year. Each foot of row space produces about 1 pound of cauliflower.

D. Seedbed

Cauliflower grows in most soils from sand to clay. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for cauliflower is from 6.0 to 7.5. It is a plant that does well in Idaho's soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed cauliflower is 6 to 8 weeks before transplanting when soil temperature is 50°F or above. The variety of cauliflower planted should have an early maturity date and should be developed for weather conditions in the area planted. Maturity date should be 60 to 80 days after transplanting. For transplants, start seeds indoors 5 to 7 weeks before the last expected frost. Seed directly into the garden as early as 4 weeks before the last expected frost. Allow 50 to 85 days for maturity, depending upon variety.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>3 to 4 per hill</i> |
| <i>Row width</i> | <i>30 to 36 inches</i> |
| <i>Germination</i> | <i>4 to 10 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |
| <i>Plant spacing</i> | <i>18 to 20 inches</i> |

G. Planting Suggestions

Cauliflower needs cool soil and good spacing. If transplants are used they should be stocky and from 4 to 6 inches tall. Transplant about the same time as the last killing frost.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plants are grown, sidedress with 1 1/2 ounces of ammonium sulfate in high pH areas or ammonium nitrate in low pH areas per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. Hill the soil up around each plant.

J. Watering

Cauliflower has a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent inches of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball, and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, a film of water will not be felt on your hand, and it will be time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases.

K. Insects

Aphids, cabbage maggot, cauliflower head maggot, diamond back moth, flea beetles, spider mites, and wireworms are common pests.

L. Diseases

Diseases include bacterial soft rot, club root, downy mildew, blackleg, black rot, damping-off, wirestem drop or watery soft rot, leaf spot, and oedema.

M. Harvesting

To prevent discolored heads, tie the plant leaves above the head to shade it when the head reaches golf ball size. Cut the head 4 to 6 days later. Make your decision based on the temperature, but be sure to cut it before the curd starts to separate. Leave 4 to 6 inches of stem with the head.

N. Storage

Cauliflower freezes at 30°F. Store in a cellar with a temperature as near 32°F as possible. Humidity should be moderately high. Stored under ideal conditions, cauliflower may last up to 6 to 8 weeks.

IX. Cucumber

A. Food Value

A pound of raw, whole cucumbers with skins consist of 95.7 percent water, 2.7 grams of protein, 0.5 gram of fat, 14.5 grams of carbohydrates, and provide an average of 64 calories.

B. Description

Native to Asia and Africa, cucumbers do not cross-pollinate with muskmelons or water melons, and the flavor of cucumbers is not affected by the pollen from these plants.

C. Yield Per Person

It is estimated that each person eats from 2.5 to 4 pounds of cucumbers per year, requiring a row of cucumbers 2 to 3 feet long. Each foot of row space should produce about 0.8 pound of cucumbers.

D. Seedbed

Cucumbers grow in most soils, but they grow best in a fertile soil with 5 percent or more organic matter content. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that

will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for cucumber growth is from 5.5 to 7.0, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed cucumbers in Idaho is 3 weeks before transplanting when soil temperature is 65°F or above and night temperature is expected to average above 55°F. The variety of cucumbers planted should have an early maturity date and should be developed for weather conditions in the area planted. Maturity date should be 55 to 65 days after transplanting. Cucumbers may be seeded directly into the soil. They are killed by very light frosts. Cucumbers love warm soil, and the use of plastic mulches is common.

F. Planting Specifications:

| | |
|-------------------------|------------------------|
| <i>Seed per foot</i> | <i>6 to 8</i> |
| <i>Ounce per foot</i> | <i>0.05</i> |
| <i>Row width</i> | <i>75 to 72 inches</i> |
| <i>Germination</i> | <i>6 to 10 days</i> |
| <i>Seed depth</i> | <i>1 inch</i> |
| <i>Planting spacing</i> | <i>12 to 24 inches</i> |

G. Planting Suggestions

Cucumbers need a warm soil to grow and good spacing for sunlight. If transplants are purchased, they should be stocky.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. One week after blossoming begins, sidedress with 1 1/2 ounces of ammonium sulfate in high pH soils or ammonium nitrate in low pH soils. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

When necessary, cultivation should be shallow to remove other plant competition. Deep cultivation close to the plants will de-

stroy much of the root system and reduce yield and quality. If it becomes necessary to cultivate, penetrate the soil no deeper than 1 inch.

J. Watering

Cucumbers have a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: aphids, cucumber beetle, cabbage looper, thrips, slugs, spider mites, garden symphylans, and wireworms.

L. Diseases

Diseases include *Alternaria* leaf spot, angular leaf spot, bacterial wilt, curly top mosaic, powdery mildew, root knot, nematode root rot, scab, and white mold.

M. Harvesting

Cucumbers may be harvested any time after they have reached the desired size, but be sure to do so before the cucumbers turn yellow and the seeds become hard. For slicing, the fruits should be 6 to 10 inches long.

Harvest when 2 1/2 to 6 inches in length for pickles. Cucumbers are of the highest quality when they are dark green in color, firm, and crisp.

X. Eggplant

A. Food Value

A pound of cooked (boiled) drained eggplant contains 94.3 percent water, 4.5 grams

of protein, 0.9 gram of fat, 18.6 grams of carbohydrates, and an average of 86 calories.

B. Description

Native to India, eggplants grow from 2 to 3 feet tall. The fruit is generally large and purple or white in color, with smooth, shiny skin. The seeds are embedded in the flesh.

C. Yield Per Person

Each person eats about 3 to 5 pounds during a growing season and will use 2 to 3 pounds for canning, storage, or freezing. This will require a row of eggplants 6 to 10 feet long. Each foot of row space should produce about 1 pound of fruit.

D. Seedbed

Eggplants grow in fertile, sandy loam soil. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for eggplant growth is from 5.5 to 6.4, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

Plant seeds in containers 10 weeks before transplanting in soil with a 65°F temperature or above. The variety should have an early maturity date and should be developed for weather conditions in the area planted. The maturity date should be 75 to 95 days after transplanting.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>6 to 8</i> |
| <i>Row width</i> | <i>24 to 36 inches</i> |
| <i>Germination</i> | <i>8 to 12 days</i> |
| <i>Seed depth</i> | <i>1/4 to 1/2 inch</i> |
| <i>Plant spacing</i> | <i>18 to 24 inches</i> |

G. Planting Suggestions

Eggplants need a warm soil to grow and good spacing for sunlight. If transplants are purchased, they should be stocky and from 4 to 6 inches tall. A plastic mulch can be used to increase soil temperatures.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the first fruits set, sidedress with 1 1/2 ounces of ammonium sulfate in high pH areas or ammonium nitrate in low pH areas. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Eggplants have a water stress point of 65 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent inches of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 65 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. Symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects—The following insects may cause problems: aphids, Colorado potato beetle, spider mites, western potato flea beetle, and wireworms.

L. Diseases—Common diseases include anthracnose, cercospora leaf spot, root rot fungus, and verticillium wilt.

M. Harvesting

Eggplant can be harvested any time after the fruits reach egg size, but be sure to do so before the fruit reaches full maturity and the seeds harden. The quality of young fruit is better than older fruit. Leave a short stem on the fruit when harvesting. The stems are woody, so harvest with pruning shears.

XI. Kohlrabi

A. Food Value

A pound of kohlrabi contains of 92.2 percent water, 7.7 grams of protein, 0.5 gram of fat, 24.0 grams of carbohydrates, and will provide an average of 109 calories.

B. Description

Developed in northern Europe, kohlrabi is a member of the cabbage family with similar requirements and problems. The edible portion is an above-ground enlargement resembling a mild turnip in shape and flavor. An excellent raw addition to relish dishes, it also may be boiled, stuffed, or baked.

C. Yield Per Person

Each person will eat from 2 to 4 pounds of fresh kohlrabi a season, and 4 to 8 pounds for canning or freezing. A foot of row space produces about 0.75 pound of kohlrabi.

D. Seedbed

Kohlrabi grows in most soils from sand to clay. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for kohlrabi is from 6.0 to 7.5, and the plants do well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

Seed kohlrabi in container 6 weeks before transplanting in soil with 65°F or above. The variety should have an early maturity date and should be developed for weather conditions in the area planted. The maturity date should be 60 to 70 days after transplanting.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>8 to 12</i> |
| <i>Row width</i> | <i>18 to 24 inches</i> |
| <i>Germination</i> | <i>3 to 10 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |
| <i>Plant spacing</i> | <i>18 to 24 inches</i> |

G. Planting Suggestions

Kohlrabi needs a cool soil to grow and good spacing for sunlight. If transplants are pur-

chased, they should be stocky, from 4 to 6 inches tall.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plants are one-third grown, sidedress with 1 1/2 ounces of ammonium sulfate in high pH areas or ammonium nitrate in low pH areas per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Kohlrabi has a water stress point of 50 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and feels damp, but fails to leave a film of water on your hand, the soil moisture will be 50 percent or above. If the soil moisture is below 50 percent, the film of water will not feel damp, and it is time to water again.

Plant growth can suffer from too much or too little water. Symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: aphids, flea beetles, cabbage looper, and wireworms.

L. Harvesting

Kohlrabi is ready to harvest 50 to 60 days after transplanting. It has the best flavor when it is 2 to 4 inches in size, and the flesh is still tender. The leaves of the young plant may be used like spinach.

XII. Lettuce

A. Food Value

A pound of lettuce contains 95.1 percent water, 5.4 grams of protein, 0.9 gram of fat, 11.3 grams of carbohydrates, and will provide an average of 64 calories.

B. Description

Lettuce is the most extensively grown and important of all salad crops. Common lettuce comes in three types: head, leaf, and butterhead. It is native to Mediterranean and Near East. It grows best at low temperatures and is sensitive to high temperatures.

C. Yield Per Person

Each person will eat about 4 to 5 pounds of fresh lettuce during a growing season. Each foot of row space should produce about 0.5 pound of lettuce. About 10 feet of row space per person should be planted for fresh use during the growing season.

D. Seedbed

Lettuce is adaptable to different soils as long as they are fertile, of good texture, and moist. The plants grow quickly. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for lettuce growth is from 6.0 to 7.0, but lettuce does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed lettuce is 4 to 6 weeks before transplanting when soil temperature is 50°F or above. Transplant lettuce into the garden when it is 2 to 3 inches tall and night temperature is 25°F or above. For garden-planted lettuce, plant as soon as the ground can be worked and 6 to 8 weeks before the last killing frost. To spread out the lettuce season, make subsequent plantings every 2 weeks. Early plantings should be placed where they get full sunlight, and later plantings in partial shade for hot summer

growth. The variety should have an early maturity date and should be developed for weather conditions in the area planted. The maturity date should be 55 to 80 days after transplanting.

F. Planting Specifications:

| | |
|--------------------------|------------------------|
| <i>Seed per foot</i> | <i>4 to 8</i> |
| <i>Row width</i> | <i>18 to 24 inches</i> |
| <i>Germination</i> | <i>4 to 8 days</i> |
| <i>Seed depth</i> | <i>1/4 to 1/2 inch</i> |
| <i>Plant space, leaf</i> | <i>6 to 12 inches</i> |
| <i>Plant space, head</i> | <i>8 to 15 inches</i> |

G. Planting Suggestions

Lettuce needs light to germinate and may not germinate at temperatures of 80°F or above. During hot weather, lettuce bolts, produces seed stalks, and develops internal tip scorching and a bitter taste.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plants are 4 weeks old, sidedress with 1 1/2 ounces of ammonium sulfate per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Lettuce must be thinned to produce good plants. For head lettuce, thin to 12 to 15 inches between plants. For leaf lettuce, thin to 4 to 6 inches between plants in the first thinning and 6 to 12 inches in the final thinning. Cultivation should be shallow to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. Lettuce has a shallow, meager root system.

J. Watering

Lettuce has a shallow root system, and the plant requires frequent watering to support rapid leaf development. Too much water on heavy soils may lead to leaf scorch and disease. Don't wet the foliage any more than necessary when watering.

K. Insects

The following insects may create problems: aphids, flea beetles, looper, cucumber

beetles, wireworms, cutworms, army worms, and slugs.

L. Diseases

Lettuce diseases include anthracnose, aster yellows, big vein virus, bottom rot fungus, downy mildew, drop or watery soft rot, mosaic, and red rib.

M. Harvesting

Lettuce thinnings can be used for early salads. The lettuce heads should be solid but not overly mature when harvested. Butter-head lettuce can be harvested as soon as the heads form. Leaf lettuce can be harvested any time before it sends up seed stalks.

XIII. Onions

A. Food Value

A pound of onions contains 89.4 percent water, 7.8 grams of protein, 0.9 gram of fat, 37.2 grams of carbohydrates, and an average of 16.3 calories.

B. Description

Onions are native to North America. They are cold hardy and adaptable to Idaho. There are more than 300 species of onions in the world. In Idaho, onions are grown as green onions for table use and bulbs for storage. The bulbs for harvest come in yellow, white, and red. They may be round, flat, or long.

C. Yield Per Person

Each person will eat about 3 to 5 pounds of onions during a growing season and another 30 to 50 pounds per person may be desired for storage. Each foot of row space should produce about 0.74 pound of onions. Plant from 3 to 5 feet of row per person for use during the growing season and an additional 30 to 50 feet for storage.

D. Seedbed

Onions grow well in a wide range of soils and climates, but they develop best in a loose, crumbly soil with high fertility. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed

growth and provide a small, granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for onion growth is from 5.5 to 7.0, but onions do well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed onions is 6 to 8 weeks before the last killing frost in the spring when soil temperature is 50°F or above. The variety of onion planted should have an early maturity date and should be developed for weather conditions in the area planted.

The maturity dates should be 95 to 120 days for sets, and 95 to 120 days for plants (transplant to maturity and seed, 100 to 165 days).

F. Planting Specifications:

| | |
|-----------------------|------------------------|
| <i>Ounce per foot</i> | <i>0.02</i> |
| <i>Seed per foot</i> | <i>10 to 15</i> |
| <i>Row width</i> | <i>12 to 14 inches</i> |
| <i>Germination</i> | <i>7 to 12 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |
| <i>Sets depth</i> | <i>2 to 3 inches</i> |
| <i>Plant space</i> | <i>3 to 4 inches</i> |

G. Planting Suggestions

Onion sets should be separated into two sizes: sets smaller than 3/4-inch and 3/4- inch and above. The large sets are used for green onions, as they frequently form seed stalks instead of a bulb. The smaller sets are used for mature dry bulbs. Seeds for mature dry bulbs should be sown indoors and transplanted into your garden.

H. Fertilizer

Preplant fertilizer of 0.2 pound of N for each 100 square feet worked into the top 2 inches of soil is recommended. Fertilizers should be applied to the soil before seeding. Sidedress with 1 1/2 ounces of ammonium sulfate in high pH areas and ammonium nitrate in low pH areas per 10 feet of row. Do so when onions are 12 inches tall or the bulbs begin to form. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition.

Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. Onions have a shallow root system and cannot compete with weeds.

J. Watering

Onions have a water stress point of 70 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a hard ball and your hand feels like it has a film of water on it, and the soil is sticky, the soil moisture will be 70 percent or above. If the soil moisture is below 70 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may create problems: brown wheat mite, onion thrips, onion maggot, pea leaf miner, and wireworms.

L. Diseases

Disease problems include basal rot, downy mildew, neck rot, pink rot, purple blotch, smut, and white rot.

M. Harvesting

Green bunch onions can be harvested as soon as desired. Thinnings from bulb onions can be used as green onions. Bulb onion maturity is determined by softening of the neck tissues, falling over of the tops, and dying of the roots. At maturity bulbs enlarge rapidly and are ready for harvest when two-thirds of the top has fallen over or after a light frost in Idaho's short growing season. If the onions are slow to mature, it may be necessary to bend the tops over to speed up the maturity process before heavy frosts. Onions should then be pulled and, if the weather permits, left in the garden until tops and outer scales are completely dry. The

tops can be spread over the bulbs to prevent sunburn. After the bulbs are cured they should be topped.

N. Storage

With a freezing point of 30°F, you should store onions as near 32°F as possible in any cool dry (humidity, 70 percent) place. They keep well through the fall and winter in a cool dry cellar or attic.

XIV. Peas

A. Food Value

A pound of English peas contains 78.0 percent water, 381 calories, 28.6 grams of protein, 1.8 grams of fat, and 65.3 grams of carbohydrates. A pound of edible podded peas contains 84.8 percent water, 259 calories, 15.4 grams of protein, 1.4 grams of fat, and 47.2 grams of carbohydrates.

B. Description

Garden peas originated in eastern Europe and western Asia. They are one of the earliest vegetables picked in the spring. Peas are classified smooth or wrinkled according to how the seed looks when dry. The wrinkled seed is normally the sweetest.

C. Yield Per Person

It is recommended that 15 to 20 feet of row space be planted per person for fresh use during the garden season and an additional 40 to 60 feet for storage and canning. About 0.28 pound of English peas is produced per foot of row space. Each person consumes about 4 pounds of fresh and about 10 pounds of frozen and canned peas.

D. Seedbed

Soil types for pea production range from a light sandy loam for early pea harvest to a heavy clay soil for later or main harvest crop. The ideal pH for pea production is 6.0 to 7.5. The soil should be well drained and moderately fertile. Cultivate the soil when the soil moisture will allow formation of a mud ball that will crumble into pieces under finger pressure. It should mix crop residue and organic matter in the top 7 to 8 inches of soil, destroy current weed growth, and provide a granular-type bed for seeding. Overcultivated soil becomes powdery and has a tendency to crust.

E. Seed Time

Plant peas as soon as the ground can be worked in the spring, about 6 to 8 weeks before the last killing frost. Soil temperature for planting should be 50°F or above. Peas are a cool climate crop, and their quality is greatly influenced by cool soil and air temperature. It is suggested that planting successions should be arranged at 10-day intervals to spread harvest over a longer period of time.

F. Planting Specifications:

| | |
|-----------------------|------------------------|
| <i>Seed per foot</i> | <i>6 or 7</i> |
| <i>Row width</i> | <i>18 to 30 inches</i> |
| <i>Germination</i> | <i>6 to 15 days</i> |
| <i>Ounce per foot</i> | <i>0.16</i> |
| <i>Seed depth</i> | <i>2 inches</i> |
| <i>Plant spacing</i> | <i>3 inches</i> |

G. Planting Suggestions

Some gardeners make a double planting of peas in each row with approximately a 6-inch space between the plantings.

H. Fertilizer

This plant is a legume and is able to draw N from the air. Excessive N can cause the plants to produce large vines, but fewer peas are produced. It is suggested that 0.2 pound of N be broadcasted over a 100 square foot area. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private soil testing laboratory.

I. Cultivation

Cultivation should be conducted only when necessary to remove other plant competition. Pea roots are easily damaged by hoeing and shallow cultivation.

J. Watering

Peas have a water stress point of 50 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels moist without a film of water on it, the soil moisture will be 50 percent or above. If the soil moisture is below 50 percent, the moist condition will not be felt on

your hand, and it will be time to water again. Plant growth can suffer from too much or too little water. The symptoms will be the same.

K. Insects

The following insects may cause problems: looper, cutworms, army worms, grasshoppers, pea aphids, pea leaf weevil, pea moth, pea weevil, and wireworms.

L. Diseases

Diseases that may be a problem include bacterial blight, basal stem rot, downy mildew, enation mosaic virus, leaf and pod blight, root rots, seed rot, damping off, seed borne mosaic virus, viruses, and wilt.

M. Harvesting

English peas can be harvested when pods are nearly full but before pods begin to wrinkle. Edible podded peas should be harvested while the pods are still flat and the peas are hardly discernible. These peas need to be picked every other day to prevent over maturity. If they do become over mature the pea seed inside can be eaten. Pick peas from the vine during the cool part of the day.

N. Storage

Edible podded peas can be stored 10 days in plastic bags in the refrigerator without a loss of quality.

XV. Peppers

A. Food Value

A pound of immature, sweet, green, raw peppers contain 93.4 percent water, 5.4 grams of protein, 0.9 gram of fat, 21.8 grams of carbohydrates, and provides an average of 100 calories.

B. Description

Peppers are native to the warmer parts of America and were cultivated more than 2,000 years ago. They are classified as sweet, mild, or hot, and are excellent for salads, seasoning in other foods and for baking.

D. Seedbed

Peppers grow best in a sandy loam soil. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop resi-

dues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for pepper growth is from 5.5 to 7.0, but the pepper does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed peppers is 6 to 8 weeks before transplanting when soil temperature is 65°F or above. The variety of peppers planted should have an early maturity date and should be developed for weather conditions in the area planted. The maturity date should be 60 to 80 days after transplanting.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>6 to 8</i> |
| <i>Row width</i> | <i>24 to 36 inches</i> |
| <i>Germination</i> | <i>10 to 20 days</i> |
| <i>Seed depth</i> | <i>1/4 inch</i> |
| <i>Plant spacing</i> | <i>14 to 18 inches</i> |

G. Planting Suggestions

Peppers need a warm soil to grow and good spacing for sunlight. If transplants are purchased, they should be stocky, from 4 to 6 inches tall.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the first fruits set, sidedress with 1 1/2 ounces of ammonium sulfate for high pH soils and ammonium nitrate for low pH soils. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Peppers have a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to

dehydrate and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: green peach aphid, garden symphylan, flea beetles, spider mites, and wireworms.

L. Diseases

Pepper diseases include alfalfa mosaic virus, tomato ring spot virus, anthracnose, cercospora leaf spot, common mosaic, root rot, and verticillium wilt.

M. Harvesting

Peppers can be harvested at any time after they are large enough to use. Bell types usually are harvested when they are 3 to 4 inches long. When picking peppers, cut them from the plant rather than pulling them off. The branches are extremely brittle and will break easily if pulled.

N. Storage

The freezing point of peppers is 30°F. Store in unheated basement or room at 45° to 50°F. Humidity should be moderately high. Storage may be 2 to 3 weeks.

XVI. Pumpkin

A. Food Value

A pound of pumpkin contains 90.2 percent water, 4.5 grams of protein, 1.4 grams of fat, 35.8 grams of protein, 35.8 grams of carbohydrates, and an average of 150 calories.

B. Description

Pumpkins are native to America. They are sensitive to frost but tolerant of cool moist environments. They need a warm but not a

hot, growing season. They do not cross with cucumbers, or watermelon, but will cross with plants of the same species. Their flesh is coarse but can be baked, pureed, or used to thicken soups.

C. Yield Per Person

Each person will eat about 3 to 6 pounds of pumpkin during a growing season and use 3 to 6 pounds for canning, freezing, or storage. This will require a row of pumpkins 2 to 3 feet long for garden use and 2 to 3 feet for storage, canning, or freezing. Each foot of row space should produce about 1 pound of pumpkin.

D. Seedbed

Pumpkins are adapted to most soils, but they grow best in a fertile soil rich in humus. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for pumpkin growth is from 5.5 to 7.0, but the pumpkin does well in Idaho soil. Pumpkins grow best in full sunlight, but they will do equally well in light shade. For huge exhibition pumpkins, allow one fruit to develop per vine and water heavily.

E. Seed Time

Seed pumpkins in Idaho 3 weeks before transplanting when soil temperature is 65°F or above. They also may be seeded directly into the garden soil when the soil temperature is 65°F or above. The pumpkin variety planted should have an early maturity date and be developed for weather conditions in the area planted. The maturity date should be 70 to 110 days after transplanting. Pumpkins are killed by very light frosts. Pumpkins love warm soil. The use of plastic mulches is common.

F. Planting Specifications:

| | |
|-----------------------|------------------|
| <i>Seed per foot</i> | 2 |
| <i>Ounce per foot</i> | 0.5 |
| <i>Row width</i> | 72 to 120 inches |

| | |
|----------------------|--------------------------|
| <i>Germination</i> | <i>6 to 10 days</i> |
| <i>Seed depth</i> | <i>1 to 1 1/2 inches</i> |
| <i>Plant spacing</i> | <i>40 to 60 inches</i> |

G. Planting Suggestions

Pumpkins need a warm soil to grow but not extremely hot days. They are sensitive to frost.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. One week after blossoming begins, sidedress with 1 1/2 ounces of ammonium sulfate if the soil pH is high or ammonium nitrate if it is low. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. If it becomes necessary to cultivate, penetrate the soil no deeper than 1 inch.

J. Watering

Pumpkin roots are shallow. Their water stress point is 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it the soil moisture will be 60 percent or above. If soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again. Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may create problems: aphids, cucumber beetle, slugs, spider mites, and squash bugs.

L. Diseases

Disease problems include aster yellows, root rot, and storage rot.

M. Harvesting

Pumpkins can be harvested any time after their rinds are hard and their skins turn gold in color. Harvest before they are injured by hard frost. Some types have the best quality if they are harvested after their vines are killed by frost. When pumpkins are cut from the vine, leave 3 or 4 inches of stem attached to the fruit. Pumpkins without stems do not store well.

N. Storage

Cure pumpkins after a light frost kills the vines or by cutting the stems and allowing them to lie in the garden for a week to 10 days. Pumpkins can cure inside a house for the same period at 75°F. They may then be stored in a home cellar or basement at an average temperature of 55°F with a moderately high humidity. High quality cured pumpkins will store in good condition through the fall and early winter months.

XVII. Radish

A. Food Value

A pound of radishes contains 94.5 percent water, 4.5 grams of protein, 0.5 gram of fat, 15.3 grams of carbohydrates, and 77 calories.

B. Description

Radishes are native to Europe and Asia. They are cold hardy but will not withstand high heat. During hot weather the roots become pungent, and the plants produce seed stalks.

C. Yield Per Person

It is estimated that each person will eat from 2 to 3 pounds of radishes during a growing season. Each foot of row space should produce approximately 0.67 pound of radishes. Plant about 3 to 5 feet of row per person.

D. Seedbed

Radishes grow best in sandy loam and peat soils. Heavy clay soils can be improved by the addition of organic matter. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments.

Cultivation should mix crop residues and organic matter in the top 7 to 8 inches soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for radish growth is from 6.0 to 7.0, but radishes do well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed radishes is 6 to 8 weeks before the last killing frost in the spring when soil temperature is 50°F or above. The variety planted should have an early maturity date and be developed for weather conditions in the area planted. Maturity date should be 20 to 50 days.

F. Planting Specifications:

| | |
|-----------------------|-----------------------|
| <i>Ounce per foot</i> | <i>0.02</i> |
| <i>Seed per foot</i> | <i>14 to 16</i> |
| <i>Row width</i> | <i>6 to 12 inches</i> |
| <i>Germination</i> | <i>3 to 10 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |

G. Planting Suggestions

Radishes need a cool soil to grow in and good spacing for sunlight. Their frost tolerance is good. Make successive plantings every 10 to 14 days, beginning in the spring as soon as the soil can be worked and a month before frost in the fall. Radishes can be mixed with carrot, beet, and parsnips to mark the row of these vegetables that grow slower.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. Fertilizers should be applied to the soil before seeding to ensure its availability to plants during the short growing season. Over-fertilization can result in excessive top growth with no root enlargement. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition.

Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Radishes have a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. Symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: cabbage aphid, turnip aphid, cabbage maggot, cutworms, army worms, black cutworms, diamond back moth, flea beetles, and wireworms.

L. Diseases

Radish disease problems include black rot.

M. Harvesting

Radishes can be harvested as soon as the roots reach edible size (1 to 2 inch) and before becoming tough and pithy. They normally mature in 20 to 30 days.

N. Storage

Storage life of radishes is limited to 5 to 6 days in the refrigerator if stored in plastic bags with holes punched for air circulation space. Remove tops at 1/2 inch from radish and clean root before storage.

XVIII. Summer Squash

A. Food Value

A pound of immature raw summer squash contains 94.0 percent water, 5 grams of protein, 0.05 gram of fat, 19.1 grams of carbohydrates, and 81 calories.

B. Description

Summer squash are native to Central American and were used extensively by Indians for food. Summer squash have whitish or yellow flesh and are picked in the summer while immature. They may be vining, semivining, or bush types. Squash will cross-pollinate with other squash, pumpkin, or gourds within the same species, but don't cross-pollinate with cucumbers or watermelon. They grow well in Idaho.

C. Yield Per Person

It is estimated that each person will eat from 6 to 9 pounds of squash during a growing season and need an additional 6 to 9 pounds for storage, canning, or freezing. This will require a row of squash 4 to 6 feet long. Each foot of row space should produce about 1.5 pounds of summer squash.

D. Seedbed

Summer squash grow best on fertile, well-drained soil, well supplied with organic matter. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for summer squash growth is 6.0 to 7.5, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed summer squash in a container is 3 to 4 weeks before transplanting. Seed direct into soil or transplant when temperature is 65°F or above. The variety of squash planted should have an early maturity date and be developed for weather conditions in the area planted. Maturity date should be 50 to 60 days after transplanting. Sow squash outdoors when night temperature no longer falls below 55°F.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>4 to 6</i> |
| <i>Row width</i> | <i>26 to 60 inches</i> |
| <i>Germination</i> | <i>3 to 12 days</i> |

| | |
|----------------------|-----------------------|
| <i>Seed depth</i> | <i>1 inch</i> |
| <i>Plant spacing</i> | <i>6 to 24 inches</i> |

G. Planting Suggestions

Summer squash needs a warm soil to grow and good spacing for sunlight. If transplants are purchased, they should be stocky. Bees are needed for pollination.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plant begins to spread out, sidedress with 1 1/2 ounces of ammonium sulfate for high pH soils and ammonium nitrate for low pH soils. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Summer squashes have a water stress point of 65 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a heavy film of water on it, the soil moisture will be 65 percent or above. If the soil moisture is below 65 percent, the film of water will not be felt on your hand, and it will be time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may create problems: bean aphid, melon aphid, potato aphid, nitidulid beetles, squash bug, and wireworms.

L. Diseases

Diseases include aster yellows, black rot, curly top, and root rot.

M. Harvesting

Summer squash can be harvested any time the fruits reach a desired size but before the squash forms hard seed or rinds. Break fruit from the vine, leaving a piece of stem with the fruit.

XIX. Sweet Corn

A. Food Value

A pound of raw, white, or yellow sweet corn consists of about 45 percent cob and 55 percent edible. The kernels contain about 72.7 percent water and provide an average of 240 calories, 8.7 grams of protein, 2.5 grams of fat, and 55.1 grams of carbohydrates.

B. Description

Corn is an annual grass, native to the Americas and differing from other types of corn by the retention of large amounts of sugar in the kernels during the milk stage of maturity. Its skin is slightly thinner than other types. Kernel color ranges from white to yellow. There are about 2,000 sweet corn varieties in existence.

C. Yield Per Person

It is estimated that each person will require from 10 to 15 feet of plants in a row for fresh use and an additional 30 to 50 feet for storage, canning, or freezing. Each foot of row space should produce about 0.3 pound of corn.

D. Seedbed

Soil texture can vary for sweet corn production. A sandy loam is best, but corn can be grown in clay or loam soils also. The soil cultivation should be conducted when the moisture in the soil will allow formation of a mud ball that will crumble into pieces under finger pressure. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil, destroy current weed growth, and provide a granular-type bed for seeding. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for corn growth is from 6.0 to 7.0, but it

does well in Idaho soils, which have a pH of 7.0 to 8.0.

E. Seed Time

The best time to seed corn is in May when soil temperature is 50°F or above and air temperature averages 65°F or above. Corn is a tender crop and should be planted after the last frost. The warmer the temperature, the faster the corn grows and matures. The variety planted should have an early maturity date and be developed for weather conditions in the area planted.

F. Planting Specifications:

| | |
|-----------------------|------------------------------|
| <i>Seed per foot</i> | <i>4 to 6 inches</i> |
| <i>Row width</i> | <i>30 to 36 inches</i> |
| <i>Germination</i> | <i>6 to 10 days</i> |
| <i>Ounce per foot</i> | <i>0.16</i> |
| <i>Seed depth</i> | <i>1 1/2 to 2 1/2 inches</i> |
| <i>Plant space</i> | <i>10 to 12 inches</i> |

G. Planting Suggestions

Sweet corn needs a warm soil and good spacing for sunlight. It is wind-pollinated so plants should be in 3 or more short rows, rather than one long row. Varieties should be separated because cross-pollination between low-sugar plants and high-sugar plants reduces the sweetness of the high-sugar corn.

H. Fertilizer

Corn has a high N requirement. The principal application of N and other fertilizers should be broadcast before planting with, if necessary, a sidedressing 3 inches from the plant at the corn four-leaf stage. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private soil testing laboratory. Plants stunted by a lack of nutrients seldom recover or produce up to their potential.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation will destroy much of the root system and reduce yield and quality. The number of suckers a sweet corn plant produces depends on the variety of the corn. Suckers should not be removed. Their removal does not increase yields but may reduce them.

J. Watering

Corn has a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again. Plant growth can suffer from too much or too little water. Symptoms will be the same.

K. Insects

The following insects may be a problem in sweet corn: corn ear worm, cutworm, army worm, wireworm, root worm, slug, aphids, spider mites, earwigs, and cucumber beetles.

L. Diseases

Root stock, ear rot, maize dwarf mosaic, seed rot, seedling blight, and smut are common diseases of corn.

M. Harvesting

Depending on temperatures, sweet corn generally ripens in 22 to 24 days after silking. For eating, the silks are brown, and the ear fills the husk. The liquid squeezed from a ripe kernel is milky; from an immature kernel it is watery; and from an overmature kernel, solid or creamy. Prime eating quality lasts about 4 to 5 days before the sugar starts to turn to starch. Pick corn when the sugar is at its maximum. Canning corn can be picked when it is in the cream stage. Sweet corn loses quality quickly after picking, especially at high temperatures. Process as soon as possible after harvesting. Pull cobs from the stocks with a downward motion and a twist to the side.

N. Storage

Refrigerate at 35° to 40°F for 2 to 3 days.

XX. Swiss Chard

A. Food Value

A pound of chard contains about 3.7 percent water, 8.2 grams of protein, 0.9 gram of fat, 15.0 grams of carbohydrates, and 82 calories.

B. Description

Chard is native of the Mediterranean area. It is a relative of the beet and is grown for its tender vitamin rich leaves. The leaves and petioles are cooked to provide a pot herb similar to spinach.

C. Yield Per Person

It is estimated that each person will eat from 1.5 to 3 pounds of fresh chard during a growing season and will use an additional 3 to 4.5 pounds for canning or freezing. Each foot of row space should produce about 0.85 pound of chard. From 2 to 4 feet of row space per person should be planted for fresh use during the growing season and an additional 4 to 6 feet for canning or freezing.

D. Seedbed

Chard is widely adapted to different soils as long as they are rich, of good texture, and well drained. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil, destroy current weed growth, and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for chard growth is from 6.0 to 7.5, and it does well in Idaho soil, which is 7.0 to 8.0.

E. Seed Time

The best time to seed chard is as soon as the soil can be cultivated in the spring, 2 to 4 weeks before the last killing frost. Minimum soil temperature for planting is 50°F or above. The variety of chard planted should have an early maturity date and be developed for weather conditions in the area planted. Maturity date should be 55 to 65 days after planting.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>6 to 10</i> |
| <i>Row width</i> | <i>18 to 24 inches</i> |
| <i>Germination</i> | <i>7 to 10 days</i> |
| <i>Seed depth</i> | <i>1 inch</i> |
| <i>Plant spacing</i> | <i>4 to 8 inches</i> |

G. Planting Suggestions

Chard can be planted in the garden or in a greenhouse for later transplanting.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the plants are one-third grown, sidedress with 1 1/2 ounces of ammonium sulfate per 10 feet of row. Amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Chard has a water stress point of 55 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball, and your hand feels like it has a film of water on it, the soil moisture will be 55 percent or above. If the soil moisture is below 55 percent, the soil will not feel moist on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. Symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: aphids, blister beetles, looper, lygus bugs, cutworms, serpentine leaf miner, western spotted cucumber beetles, and wireworms.

L. Diseases

Top virus is the main chard disease.

M. Harvesting

Chard can be harvested throughout an entire 3-month growing season. Plants removed at thinning time can be used in salads. Cut outer leaves first about 1 inch from the soil surface with a sharp knife. Care should be taken to ensure the new inner stems and growing point are not damaged.

N. Storage

Before the first hard freeze, plants can be transplanted into containers. Store the containerized plants in a cool place, and water lightly to prevent wilting. Leaves can be harvested into the winter months.

XXI. Tomatoes

A. Food Value

A pound of tomatoes contains about 93.5 percent water, 4.5 grams of protein, 0.8 gram of fat, and 19.4 grams of carbohydrates. The fruits are high in vitamin A, B₁, B₂, and C, and provide an average of 91 calories per pound.

B. Description

Tomatoes are native to the Andes Mountains in South America. They are a warm season crop and rank second in popularity among the vegetable crops grown in the United States. They are classified according to their growth patterns into three groups: Determinant, semideterminant, and indeterminate. Determinant plant vines grow 12 to 18 inches long, and stop fruiting when the vines stop growing. Semideterminant plants are similar but grow 18 to 24 inches. The vines of indeterminate plants continue to grow and fruit is set indefinitely.

C. Yield Per Person

Tomatoes grow best in a fertile, sandy, well-drained, loam soil. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The pH for tomato growth is from 5.5 to 7.5, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed tomatoes is 6 to 8 weeks before transplanting when soil temperature is 65°F or above. The variety of tomatoes planted should have an early maturity date and be developed for weather

conditions in the area planted. Maturity date should be 60 to 80 days after transplanting. Two or three different varieties can be planted to obtain ripening at different times. One series of plants could be early bearers and another series that mature later could be used for the main crop.

F. Planting Specifications:

| | |
|----------------------|------------------------|
| <i>Seed per foot</i> | <i>Use transplants</i> |
| <i>Row width</i> | <i>36 to 60 inches</i> |
| <i>Germination</i> | <i>6 to 14 days</i> |
| <i>Seed depth</i> | <i>1/4 to 1/2 inch</i> |
| <i>Plant spacing</i> | <i>18 to 36 inches</i> |

G. Planting Suggestions

Tomatoes need a warm soil to grow and good spacing for sunlight. If transplants are purchased, they should be stocky and from 4 to 6 inches tall. If you plan to grow your own transplants, seed in your greenhouse or house 5 to 7 weeks before transplanting. Put plants in the garden 10 days after the last expected killing frost. Hot caps or other protection devices may allow earlier transplanting. Tomatoes normally do not set fruit below 58°F or above 85°F and must have 6 or more hours each day of direct sunlight. Transplants should not have fruit on them when planted out as the fruit will stunt the plants' growth and development.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. When the first fruits set, sidedress with 1 1/2 ounces of ammonium sulfate for high pH soils and ammonium nitrate for low pH soils. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality.

J. Watering

Tomatoes have a water stress point of 65 percent. When the percent of water in soil drops below this level, the plant will start to

dehydrate and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 65 percent or above. If the soil moisture is below 65 percent, the film of water will not be felt on your hand, and it will be time to water again. Plant growth can suffer from too much or too little water. Symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: green peach aphid, garden symphytan, flea beetles, spider mites, wireworms, and tomato horn worm.

L. Diseases

Tomato diseases include anthracnose, yellow aster, bacterial canker, blossom end rot, curly top, early blight, fruit rot, late blight, leaf mold mosaic, root-rot nematode, spotted wilt virus (tip blight), streak, and wilt.

M. Harvesting

For best flavor tomato fruits should be harvested when they are fully ripe and firm. The best ripening temperature is 65°F. Tomatoes will ripen to high quality indoors if picked as the red color first shows. Remove stems from harvested tomatoes.

N. Storage

The freezing point of tomatoes is 30°F. Store in unheated basement or room temperature of from 55° to 70°F. Humidity should be moderately low. Tomatoes may be stored for 4 to 6 weeks. For fall storage, pick all green fruit that is nearly full size and wrap individually in newspaper and store at 50° to 60°F. They will ripen slowly providing a longer eating season. Green fruit will ripen more quickly when enclosed in a bag or box with an apple or banana.

XXII. Turnips

A. Food Value

A pound of turnips contains about 93.6 percent water, 3.6 grams of protein, 0.9 gram

of fat, 22.2 grams of carbohydrates, and 104 calories.

B. Description

Turnips are native to western Asia. They are cold hardy but will not withstand heat, and during hot weather roots become bitter and pithy. Turnips are grown for their tender, crisp roots, but the leaves or greens of turnips are also good cooked.

C. Yield Per Person

It is estimated that each person will eat from 3 to 6 pounds of turnips during a growing season. Each foot of row space should produce approximately 0.5 to 1 pound of turnips. Plant from 5 to 10 feet of row per person.

D. Seedbed

Turnips grow best in sandy loam and peat soils. Heavy clay soils can be improved by the addition of organic matter. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for turnip growth is 5.5 to 7.0, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed turnips is 6 to 8 weeks before the last killing frost in the spring when soil temperature is 50°F or above. The variety planted should have an early maturity date and be developed for weather conditions in the area planted. Maturity date should be 45 to 60 days.

F. Planting Specifications:

| | |
|-----------------------|------------------------|
| <i>Ounce per foot</i> | <i>0.01</i> |
| <i>Seed per foot</i> | <i>10 to 15</i> |
| <i>Row width</i> | <i>15 to 18 inches</i> |
| <i>Germination</i> | <i>3 to 10 days</i> |
| <i>Seed depth</i> | <i>1/2 inch</i> |
| <i>Plant space</i> | <i>4 to 6 inches</i> |

G. Planting Suggestions

Turnips need a cool soil to grow in. They have excellent frost tolerance. It is sug-

gested that successive plantings be made every 10 to 14 days beginning in spring as soon as the soil can be worked and before the daytime temperature is expected to average 80°F or above. Turnips can be mixed with seed for carrots, beets, and parsnips to mark the row of these vegetables that grow slower.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. Sidedress the plants with 1.5 ounces of ammonium sulfate for high pH soils or ammonium nitrate for low pH soils per 10 feet of row when plants are about one-third grown. Over fertilization can result in excessive top growth with no root enlargement. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. Thin by leaving 1 to 2 inches between plants. Plants removed during thinning can be eaten.

J. Watering

Turnips have a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball, and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again. Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases.

K. Insects

The following insects may cause problems: cabbage aphid, turnip aphid, cabbage root

maggot, cutworms, army worms, black cutworms, diamond back moth, flea beetles, and wireworms.

L. Diseases

Turnip disease problems include black root rot, club root, and powdery mildew.

M. Harvesting

Turnips can be harvested as soon as the roots reach edible size (2 to 3 inches) and before becoming bitter and pithy. They normally mature in 45 to 60 days. Pull or cut off tops above the crown.

N. Storage

Storage life of turnips can be extended into the fall and winter by leaving them in the ground and covering them with a mulch to prevent them from freezing in the ground. For pit storage the temperature should be as near 32°F as possible under moist air conditions.

XXIII. Watermelon

A. Food Value

A pound of raw watermelon contains 92.6 percent water, 2.3 grams of protein, 0.9 gram of fat, 29.0 grams of carbohydrates, and 118 calories.

B. Description

Watermelons are a native of Africa. The plants have separate male and female flowers on the same vine and are cross-pollinated. They do not cross-pollinate with cucumbers, squash, or pumpkins. Watermelon are difficult to grow in many parts of Idaho. They need high temperatures and a long growing season.

C. Yield Per Person

It is estimated that each person will eat from 3 to 6 pounds of watermelon during a growing season. This will require a row of melons 6 to 12 feet long. Each foot of row space should produce about 0.5 pound of watermelons.

D. Seedbed

Watermelons are adapted to most soils but grow best in a fertile, light, sandy soil with large amounts of compost. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will

crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular-type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for watermelon growth is from 6.0 to 7.5, but it does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The best time to seed watermelons in Idaho is 3 weeks after the last killing frost. When transplanting, the soil temperature should be 65°F or above. The variety of watermelons planted should have an early maturity date and be developed for weather conditions in the area planted. The maturity date should be 80 to 100 days after transplanting.

F. Planting Specifications:

| | |
|-----------------------|------------------------|
| <i>Seed per foot</i> | <i>2 to 3</i> |
| <i>Ounce per foot</i> | <i>0.05</i> |
| <i>Row width</i> | <i>72 to 84 inches</i> |
| <i>Germination</i> | <i>3 to 12 days</i> |
| <i>Seed depth</i> | <i>1 inch</i> |
| <i>Plant spacing</i> | <i>12 to 24 inches</i> |

G. Planting Suggestions

Watermelons need a warm soil to grow and good spacing for sunlight for high sugar content and flavor. If transplants are purchased, they should be stocky.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. One week after blossoming begins, sidedress with 1 1/2 ounces of ammonium sulfate for pH soils or ammonium nitrate for low pH soils per 10 feet of row. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. If it becomes necessary to cultivate, penetrate the soil no deeper than 1 inch.

J. Watering

Watermelons have a water stress point of 65 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball, and your hand feels like it has a film of water on it, the soil moisture will be 65 percent or above. If the soil moisture is below 65 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much or too little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: aphids, cucumber beetle, cabbage looper, spider mites, and wireworms.

L. Diseases

Diseases include curly top, leaf spot, and wilt.

M. Harvesting

Watermelon is ripe when the vine tendril next to the fruit yellows and dries, when the underside of the melon next to the ground takes on a yellow tinge, and when thumping with a finger causes a dull rather than a sharp sound. Cut the melon off the vine, leaving a short stem on the fruit. Pulling the stem from the fruit may damage the fruit. Most melon cultivars form an abscission layer at maturity, and the stem loosens from the fruit. When the stem is nearly loose the melon is said to be at the full slip stage.

XXIV. Winter Squash

A. Food Value

A pound of cooked winter squash contains about 81.4 percent water, 8.2 grams of protein, 1.8 grams of fat, 69.9 grams of carbohydrates, and 286 calories.

B. Description

Winter squash is native to America and was grown by the Indians. There are three main

types: vining, semivining, and bush. Squash will cross-pollinate with other squash, pumpkins, and gourds within the same species. They have separate male and female flowers on the same plant. The fruits, which vary widely in shape and color, may be baked, boiled, or used for pie filling.

C. Yield Per Person

Each person will eat about 6 to 9 pounds of squash during a growing season and need 6 to 9 pounds for canning or freezing. This will require a row of squash 12 to 18 feet long. Each foot of row space produces about 1 pound of squash.

D. Seedbed

Squash is adapted to most soils but grows best in a fertile soil rich in humus. Seedbed preparation should start when the soil has sufficient moisture to form a mud ball that will crumble into medium-sized fragments. Cultivation should mix crop residues and organic matter in the top 7 to 8 inches of soil. It should destroy current weed growth and provide a small, granular type bed for transplanting. Overcultivated soil becomes powdery and has a tendency to crust. The ideal pH for squash growth is 6.0 to 7.5. Squash does well in Idaho soil, which ranges from 7.0 to 8.0.

E. Seed Time

The time to seed squash in Idaho is 3 weeks before transplanting when soil temperature is 65°F. The variety of squash planted should have an early maturity date and be developed for weather conditions in the area planted. Maturity date should be 85 to 120 days after transplanting. Squash may also be seeded directly into the soil 2 to 3 weeks after the last killing frost. Squash thrives in warm soil, and the use of plastic mulches is common.

F. Planting Specifications:

| | |
|-----------------------|-------------------------|
| <i>Seed per foot</i> | <i>1 to 2</i> |
| <i>Ounce per foot</i> | <i>0.05</i> |
| <i>Row width</i> | <i>72 to 120 inches</i> |
| <i>Germination</i> | <i>6 to 10 days</i> |
| <i>Seed depth</i> | <i>1 inch</i> |
| <i>Plant spacing</i> | <i>12 to 24 inches</i> |

G. Planting Suggestions

Squash needs a warm soil to grow in, but not an extremely hot growing season.

Squash tolerates partial shade and is sometimes interplanted with corn.

H. Fertilizer

A preplant fertilizer of 0.2 pound of N for each 100 square feet is recommended. One week after blossoming begins, sidedress with 1 1/2 ounces of ammonium sulfate for high pH soils or ammonium nitrate for low pH soils. The amount of fertilizer applied should be based on a soil test report from the University of Idaho Analytical Laboratory or a private testing laboratory. Plants may be over- or under-fertilized.

I. Cultivation

Cultivation should be shallow, when necessary, to remove other plant competition. Deep cultivation close to the plants will destroy much of the root system and reduce yield and quality. If it becomes necessary to cultivate, penetrate the soil no deeper than 1 inch. Squash plants provide good ground cover and will shade out most weeds as they mature.

J. Watering

Winter squash has a water stress point of 60 percent. When the percent of water in soil drops below this level, the plant will start to dehydrate, and growth will be slowed down or stopped. The percent of water in the soil can be estimated by taking a handful of soil at the 6-inch depth and squeezing it into a ball in your hand. If it forms a ball and your hand feels like it has a film of water on it, the soil moisture will be 60 percent or above. If the soil moisture is below 60 percent, the film of water will not be felt on your hand, and it is time to water again.

Plant growth can suffer from too much to little water. The symptoms will be the same. As the percentage of soil moisture drops, the oxygen level in the soil increases. Plants need water, oxygen, and nutrients to grow.

K. Insects

The following insects may cause problems: aphids, cucumber beetle, slugs, spider mites, wireworms, and squash bugs.

L. Diseases

Squash diseases include aster yellows, black rot, curly top virus, root rot, and storage rots.

M. Harvesting

Harvest winter squash when fully mature. Indications of maturity are a hard rind and a solid exterior coloring. The acorn types are harvested when a yellow, orange color has developed on the fruit where it is in contact with the soil. In Idaho, the growing season is short at best, and most winter squash are harvested when the vine has been killed by frost but before a hard frost. To harvest, cut the stem with a knife 2 inches from the fruit. Let the squash cure in the sun for 1 or more weeks or cure inside house at a temperature of 75°F for 1 week or more before storage.

N. Storage

When cured, store in a home cellar or basement at 55°F. The humidity should be moderately low. Properly cured and stored squash should remain in good condition throughout the winter.

Further Reading

Booklets and Pamphlets

- CIS 292 Blossom-End Rot of Tomatoes (25¢)
- CIS 1041 Conduct Your Own Garden Research (\$2.00)
- CIS 803 Growing Asparagus (35¢)
- CIS 660 Growing Beets, Carrots, Radishes and Other Root Crops (50¢)
- CIS 661 Growing Cole Crops (25¢)
- CIS 756 Growing Cucumbers (35¢)
- CIS 686 Growing Garlic (25¢)
- CIS 691 Growing Lettuce, Spinach, and Swiss Chard (35¢)
- CIS 1077 Growing Mushrooms Commercially—Risks and Opportunities (\$1.50)
- CIS 723 Growing Squash and Pumpkin (35¢)
- CIS 800 Growing Vegetable Seedlings for Transplanting (35¢)
- PNW 495 Grow Your Own: Beans and Peas (\$1.00)
- CIS 993 Management of Vegetable Diseases in Home Gardens (50¢)
- BUL 775 Planning an Idaho Vegetable Garden (\$4.00)
- CIS 1000 Potato Production in the Home Garden (\$1.00)
- PNW 497 Short-Season Vegetable Gardening (\$2.00)
- CIS 1079 Small Farm Herb Production—Is It for You? (\$1.50)

CIS 910 Sweet Corn Production for the Small-Market
Grower and Home Gardener (50¢)

CIS 667 Tomatoes for the Home Garden (\$1.00)

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Chapter **21**
Fruit Trees



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Fruit Trees



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I. Introduction

Growing fruit can be an important part of home gardening, but it demands a year-round and year-to-year commitment by the gardener. In addition to the personal satisfaction and enjoyment of tree ripened fruits, fruit trees have considerable landscape value. Properly cared for, they are attractive in form and display beautiful flowers in the spring. If judiciously placed, they can enhance a well-designed landscape.

II. Site Selection

An ideal location for fruit trees:

A. Is Without Frost Pockets—A gentle slope with good air drainage will work well. Plant the trees three-quarters of the way down the hill. Cold air will drain down the hill and will help limit frost damage in the spring (Fig. 1). Frost damage can occur any time from bloom to late spring.

Frost damage to blossoms is a likely problem, particularly with early blooming fruit trees (Table 1). For example, apricots may

Fig. 1. Frost damage is best prevented by proper site selection. Choose a gentle slope with good air drainage.

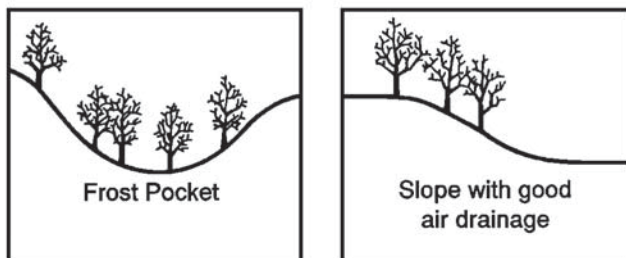


Table 1. Usual order of bloom in fruit trees.

| | |
|-----------------|----------------|
| Earliest | Apricots |
| | Japanese plums |
| | Peaches |
| | Oriental pears |
| | Italian plums |
| | Cherries |
| | Pears |
| Latest | Apples |

produce a crop only once every 5 years because of early spring frosts. Small fruit may fall off soon after a killing frost. Stone fruit, such as peaches, may stay on the tree until mid to late June, and then drop. Diagnose for frost damage by cutting open the small fruit. If the ovules (the portion that becomes the seed) are brown, the fruit is dead.

B. Is in Full Sun—Fruit trees should be planted well away from areas of shade such as large trees and buildings. Not only must the tree itself receive full sun, but it must also be properly pruned so that light can penetrate to the inner leaves. This is necessary in order to maintain good flower production and fruit set throughout the tree.

C. Has Well-Drained But Not Droughty Soil—A site with deep, fertile, sandy loam soil increases the probability of successful tree growth and fruit production. A site with poor drainage increases the probability of winter injury to fruit trees. A drainage problem, such as a perched water table, can be lessened by breaking through the hard pan layer in the soil. Stone fruits, particularly peaches, do not tolerate “wet feet.”

III. Fruit and Nut Cultivars for Idaho

Once the decision is made to start a home orchard, a lot of thought must go into cultivar selection. Cultivars must be adapted to the climate and soils of your specific area, must provide fruit at the desired time, and must be suited to uses such as freezing, canning, and preserving. Select cultivars that will extend the harvest season from July through October. Since some cultivars are easier to grow than others, choose only the ones you, your family, and friends really appreciate so your horticultural efforts will be justified. In addition to local expertise, “Western Fruit Berries & Nuts—How to Select, Grow, and Enjoy,” is a good reference. Some cultivars can be ordered if you give your local nursery enough notice.

Note: Fruit and nut trees are propagated either by grafting or budding to obtain true-to-name trees. A seedling fruit tree cannot produce the same kind or quality fruit as its parent and it comes into production much later.

IV. Types of Tree Fruits

The complexity of tree fruits can be simplified for study by grouping tree fruits into two categories: pome fruits and stone fruits. Both pome fruits—apples (*Malus*) and pears (*Pyrus*)—share many cultural similarities and pest problems. The stone fruits (*Prunus*)—apricots, cherries, nectarines, peaches, and plums—share cultural similarities.

A. Pome Fruits (Apples and Pears)

1. Apple trees are among the most cold tolerant fruit trees, but climate adaptability varies according to cultivar. In colder areas of Idaho, it is best to plant mid-season cultivars that will escape spring frosts and ripen before extreme cold in the fall. The best vegetative growth and optimal fruit production are obtained in well-drained, deep soil□.

Many apple cultivars require a second cultivar for cross-pollination by bees to ensure adequate crops. Crab apples can also cross-pollinate apple cultivars. Bloom times of the cultivars need to overlap to ensure pollination.

Choose cultivars to grow at home that are not readily available in your local grocery store, that you especially enjoy, and that are best for your purpose.

Less commonly grown cultivar suggestions are:

- a. *King*: Large, waxy yellow with red striping. Crisp and sweet. Good for eating and baking.
 - b. *Northern Spy*: Large, red apple with tender, fine-grained flesh. One of the finest for flavor. Stores well. The tree is slow to reach bearing age, and tends to bear alternate years.
 - c. *Spitzenberg*: Medium, red with yellow dots. Crisp, fine-grained flesh with a tangy, spicy flavor.
 - d. *Wealthy*: Red-tinted white flesh and a deserved reputation for quality. Good cooking apple; satisfactory for fresh use. It is a particularly good tree for colder areas. Tends to bear alternate years. Good pollinizer for other apples.
 - e. *Winesap*: Large, round, and with a lively flavor, these apples make good desserts. An old-timer that remains a favorite. The trees are vigorous, and are early, reliable bearers.
2. Pears will tolerate poor drainage and neglect better than other fruit trees. For best vegetative growth and optimal fruit production, pears should be planted in a well-drained, deep soil and spaced about 16 to 18 feet apart.

The major problem with pears is fire blight, which primarily attacks young, vigorous wood. Treatment is to cut out and destroy the blackened diseased wood. Train and prune trees only to shape them, limiting cuts to smaller branches as much as possible. Excessive pruning can stimulate vigorous, susceptible growth. Heavy rain during bloom as well as hail-inflicted wounds will increase the chances of fire blight infections. To lessen the incidence of the disease, application of copper can be made during the delayed dormant stage. This will reduce the bacterial inoculum levels on the surface of the tree.

Avoid the use of nitrogen fertilizer unless trees show obvious signs of a deficiency. Excess nitrogen application promotes vigorous growth that will then be vulnerable to fire blight.

Cultivar suggestions include:

- a. *Bartlett*: A standard commercial variety, matures toward the end of summer and has excellent fresh eating as well as canning quality.
- b. *Bosc*: A fine-flavored dessert variety ripening after Bartlett.
- c. *Clapps Favorite*: Matures before Bartlett and is the earliest pear of good quality.
- d. *Seckel*: A small gourmet pear with a russet skin; a pickling as well as a dessert pear.

B. Stone Fruits

1. Apricots—Flower very early in spring; consequently, the occurrence of spring frost will affect fruit production. It may help to plant apricots on a northern exposure (but not in shade) to delay bloom, but a safer course of action is to choose later-blooming cultivars. Bloom and maturity dates vary, depending on area, cultural practices, tree age, and season.
2. Cherries—Do best in deep, well-drained soil. Space sweet cherries about 30 feet apart. The trees may not fill that much space, but the cherry fruits need sunlight to ripen.

Most sweet cherry cultivars need an aid in pollinating in order to produce fruit, so choose the second tree carefully.

Black Tartarian, Corum, Republican, Sam, and Van will pollinate any other cherry tree. Stella, Compact Stella, and Garden Bing are self-fertilizing and require no second tree for pollination. Bing, Lambert, and Royal Ann will not produce fruit in any combination.

The most dependable cherries for colder areas of Idaho are the sour type that are self-fertilizing. Montmorency is the most popular cultivar for the home garden as well as being a leader in commercial sour cherry production. Sour cherry trees may be planted 20 feet apart.

3. Peaches and nectarines—Differ in their tolerance of cold or mild winters. Be sure to select cultivars that are adapted to your climate.

Generally, there is a risk of damage where winter temperatures fall below -10° to -15°F. Trees planted on a hillside where the coldest air drains to low-lying areas or trees planted near large bodies of water may tolerate areas otherwise too cold for them.

Reliance and Polly (Haven Polly) are considered some of the hardiest peach cultivars. Nectarines are more tender than peaches.

Peaches and nectarines are generally self-fruitful, or self-pollinating.

4. Plums and prunes—The most popular cultivars are derived from either European or Japanese species. These cultivars can grow 15 to 20 feet high and about as wide. European varieties bloom late and are better adapted to areas with late frost or cool, rainy spring weather than are the early-blooming Japanese varieties. Many plum and prune cultivars need another cultivar growing nearby for pollination. The European-type plum, called the Italian prune, is a high yielder, requires no thinning, hangs on the tree, and ripens to a taste treat that more than justifies its place in the home garden.

C. Nuts

1. Filberts or hazelnuts—These make an attractive, small tree for the garden. Spring to fall, the roundish, ruffled-edged leaves cast a pleasant spot of shade. Showy male catkins hang long and full on bare branches in winter. Female flowers are small and red in color. A crop of round or oblong nuts comes as a bonus in the fall. Plant trees in early spring in well-drained, soil and plant at least two compatible cultivars for cross-pollination. Filberts tend to sucker. If you wish to maintain a single trunk, remove these shoots three to four times a year. Filberts can also be grown as a bush.
2. The Persian (English) walnut—Should not be planted as a landscape tree except

on a large lot with deep soil. Established trees take some drought, but deep, regular watering is required. Older trees need pruning only to remove dead wood. Plant walnut trees 40 to 60 feet apart. Walnut flowers are susceptible to spring frosts.

3. Almonds—Will survive in southwestern Idaho, but don't produce annual crops because they bloom early in the spring and are usually killed by frost.

V. Rootstock

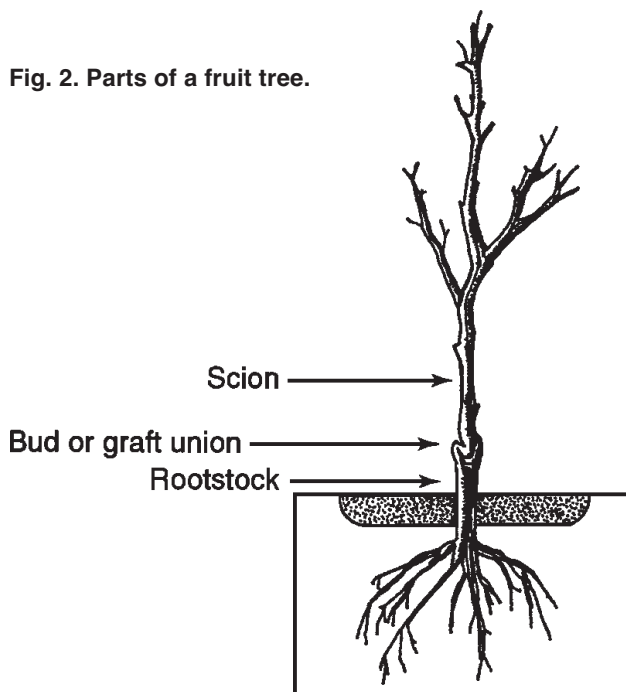
Fruit trees consist of two parts: a scion and a rootstock. The scion, or fruiting cultivar, is the most above-ground part of the tree. It is grafted or budded onto a rootstock to form a new tree (Fig. 2). This tree is the same cultivar as the scion and will produce fruit of that cultivar. A wide range of rootstock, varying in size as well as other attributes, are available for apples. However, rootstock selections for other tree fruit are more limited.

Dwarfing rootstock is preferred since it produces a more compact fruit tree. It bears fruit earlier in its life, is easier to prune and spray, and is easier to harvest.

A. Apples

Apple tree growth may be manipulated to three basic sizes: standard, semi-dwarf, and dwarf.

Fig. 2. Parts of a fruit tree.



1. The standard (seedling) rootstock is adaptable to most conditions. It has an extensive root system and should be planted about 20 feet apart.
2. The semidwarf rootstock (MM-111, MM-106, and EM-7) make a tree one-half to two-thirds the size of a standard tree.
3. The dwarf rootstock (M-26 and EM-9) make a tree one-third to one-half the size of a standard tree. The more dwarfing the apple rootstock, the more support the tree will require. When the tree is bearing a crop, dwarfing rootstock (M-9 and M-26) will need a stake to hold the tree up in the wind. In general, the more dwarfing the rootstock, the faster the tree will bear. It is important to allow sufficient vegetative growth to fill the space before allowing the crop to slow vegetative growth.

B. Pears

Pear cultivars are available on semidwarf or seedling rootstock. The seedling rootstock are hardier than other rootstock, making larger but more manageable trees.

C. Stone Fruits

Nectarines, peaches, and apricots are grown on seedling rootstock and form fruit on 1-year-old wood. It is easy to keep them the desired size by pruning and still have fruit production on seedling stock. Cherry trees produce large canopies. There is no such thing as a true dwarf cherry. Semidwarf trees on Mahaleb rootstock reduce tree size a maximum of only 10 percent. Work is being done to develop a rootstock that will reduce size, but the end results are a few years away.

VI. Cultural Practices and Problems

A. Planting

Fruit trees may be planted in the fall or spring. Bare root trees are usually available only in the spring. Planting early in the season before the roots dry out will ensure the best success. With containerized trees, the time of planting is less critical. Follow these steps to plant a fruit tree:

1. Dig a planting pit with vertical sides and make it large enough to accommodate the

root system without crowding. The pit should be a minimum of 2 to 3 feet deep and should allow at least a 6-inch clearance from the end of the roots.

2. After removing all broken or damaged roots, place the tree in the planting pit. Spread the planting soil around the tree and tamp to firm. Use planting soil that is as good or better than the soil in which the tree originally grew. Avoid using planting soil around the tree that is so different from the native soil that water and roots either do not penetrate the native soil, or that water runs around the planting soil in the pit and into the native soil.
3. Pour water into the planting pit until the consistency of thick liquid is attained. Gently raise and lower the tree to allow the soil to fill between the fibrous roots and to eliminate air pockets. Add water and planting soil alternately until the pit is filled to grade.
4. The tree should rest at the depth at which it grew in the nursery, and the bud union (the place where the tree was budded in the nursery) should be about 6 inches above the soil level after planting. A collar at the base of the tree, lighter in color than the rest of the trunk, indicates the original growing depth.

B. Training and Pruning

Both can influence apical dominance, or the tendency for the apex (uppermost bud) to grow more rapidly than the lower buds. Apical dominance is thought to be caused by a hormonal stimulus produced by the growing apex that suppresses the development of lateral bud growth. Cuts on higher or lower parts of the tree will have differing results in vegetative growth depending on the distance from the apex.

1. Training—This is the process of giving desirable structure to fruit trees from 1 to 4 years after planting. The objective of training young trees is to establish the essential structure of the tree and to bring the tree into bearing.
2. Pruning—This is used to maintain the shape of trees 3 or 4 years after planting as well as after trees are bearing fruit.

The objective of pruning older trees is either to open the trees to sunlight or to maintain fruiting by pruning back the overhanging limbs in the upper part of the tree, so that sunlight reaches the lower and inner portions of the tree.

There are two types of pruning cuts:

- a. *Heading-back cut*: This is an invigorating cut that causes an increase in vegetative growth in the immediate area of the cut. Because the hormonal gradient is destroyed, the growth of the lateral buds is no longer suppressed.
- b. *Thinning-out cut*: This type of cut removes shoots but does not stimulate vigorous regrowth. Because the hormonal gradient is not interrupted, vegetative growth continues. A thinning-out cut can also be used on upright and overhanging growth. This type of cut will result in an increased flower bud production over the whole tree.

Note: Excessive pruning, especially heading-back cuts, will delay fruiting in the early years and reduce fruiting on older trees.

3. Seasons of pruning—Trees can be pruned any time after the leaves fall in autumn and before bud break in the spring. Avoid making large saw cuts (over 3 inches in diameter) until hazardous winter temperatures are over. If you have only a few trees, resist the temptation to prune your trees on the first non-subzero day that seems warm enough to be doing something outside. Some commercial peach growers wait until bloom time to see what blossoms exist before they prune.
 - a. *Winter (dormant) pruning*: The dormant period is the most desirable time to prune out broken, damaged, diseased, and weak wood; to remove limbs crossing over other limbs; or to eliminate narrow angled crotches. (Wide angled branch crotches of 45 to 90 degrees are the strongest.)
 - b. *Summer pruning*: Trees can be pruned any time during the growing season.

Pruning during this period decreases the shoot growth and, therefore, is a common practice where better control of shoot growth is desired. Rub off or pull off water sprouts and suckers that shade the inner parts of the tree, fruits, and spurs. This should be done when shoots are 3 to 4 inches long and before they become woody. Shoot removal by pulling at this stage damages adventitious buds at the base of the shoot, which limits regrowth.

Note: Pruning after the first of September or before trees become dormant stimulates growth, making the trees more susceptible to winter injury during early fall freezes.

4. Pruning tips

- Don't leave stubs! Cut close to the trunk at the branch collar. Cut back to a live branch or bud.
- Don't paint wounds. Paint traps moisture and encourages rot. Slant cuts so rain runs off.
- Remember, the art of pruning comes from knowing how and where to cut.

C. Water Management (Irrigation)

Soil moisture (e.g., not too much and not too little) is important in maintaining tree vigor, productivity, and fruit size.

1. Drought or moisture stress alone rarely kills healthy, well-established fruit trees. However, newly set trees with limited root systems or plants damaged by cold injury, diseases, or insects are more susceptible to moisture stress. Occasionally, a prolonged drought results in extensive feeder-root death, which destroys large trees. This is most severe in sandy soils with poor moisture-holding capacity.
2. Good soil drainage is important, especially in the spring. During the summer and early fall, the trees deplete the available soil moisture. Irrigation is usually required! Poor drainage is common in soils with a high clay content and dense, impervious subsoil, or in lowlands with a high water table.

3. Although fruit trees have deep root systems, most of the roots are concentrated in the upper 2 feet of soil and extend outward slightly beyond the spread of the limbs.
4. Oftentimes trees in lawns and under grass sod are irrigated to maintain a good grass cover, but insufficient water is applied to the root zone of the tree. Tree roots do not compete well with grass roots. To remedy this problem, clean out all grass growing under the dripline of any fruit tree.

Note: High soil moisture levels or frequent watering around the base of the trunk, particularly in heavy soils, can result in the development of crown rot, a fungal disease that attacks the roots and kills the tree. Overwatering by itself can also kill roots. Because oxygen is only partially soluble in water and becomes depleted under waterlogged conditions, the roots are asphyxiated. Root or crown damage from excess moisture turns inner-bark tissue brown. Often, damage is not apparent for several months, especially if the excess moisture occurs in late fall or early spring. Crown rot causes earlier leaf color change in the fall.

Note: Prunus species, including cherries, peaches, and nectarines, are most susceptible to death of feeder roots in poorly drained soils. Pears, apples, plums, and most small fruits are more tolerant to temporary excess soil moisture, but they can be severely injured or weakened by extended periods of very wet soil conditions.

D. Fertilization

Nutritional deficiencies are not a direct cause of tree death unless excessive or improper fertilizing results in tree damage. Normally, it is not advisable to fertilize at planting. Young tree roots are easily burned, and the tree may die back or die completely. After growth has begun, however, use a complete fertilizer having essential nitrogen

Table 2. Recommended annual terminal growth of fruit trees.

| Nonbearing trees | |
|------------------------------|-----------------|
| Apple | 24 to 36 inches |
| Pear | 12 to 26 inches |
| Peach and other stone fruits | 16 to 24 inches |
| Bearing trees | |
| Apple | 12 to 14 inches |
| Pear | 6 to 12 inches |
| Peach and other stone fruits | 10 to 15 inches |

(N), phosphorus (P), and potassium (K) or (N-P-K) with 10 percent N (such as 10-6-4 or 10-10-10), particularly in the sandy soils. The amount of N to apply in late fall or early spring (preferably before bud break) depends upon the type of tree fruit and its productive status (Table 2). Much less than these recommended growth rates will result in reduced fruiting wood and a smaller crop the following year.

If you are just starting a fertilizer program, 1/8 pound of actual nitrogen should be soil applied to stone fruits for every inch of trunk diameter (measured 1 foot above ground level). In the case of pome fruits (apples and pears), 1/10 pound of actual nitrogen should be used for each inch of trunk diameter.

The actual amount of N differs among products, and this difference must be taken into account when computing the amount of fertilizer needed. For example, a 5-inch diameter peach tree will need 5/8 pound of actual nitrogen (A.N.):

$$\text{diameter} \times \text{pounds A.N. required} = 5 \times 1/8 = 5/8 \text{ lb (.625 lb) A.N. needed}$$

If ammonium sulfate 20-0-0 (20% N) is used, 3 1/8 pound of fertilizer will be required to provide the N needed for a 5-inch peach tree:

$$\frac{\text{lb AN needed}}{\% \text{ N}} = \frac{5/8 \text{ lb}}{20\%} = \frac{0.625}{0.20} = 3.125 \text{ lb}$$

In the case of ammonium nitrate at 33 percent N (33-0-0), a little over 1 7/8 pounds of ammonium nitrate is needed for the same 5-inch diameter peach tree:

$$\frac{\text{lb AN needed}}{\% \text{ N}} = \frac{5/8 \text{ lb}}{33\%} = \frac{0.625}{0.33} = 1.89 \text{ lb}$$

The amount of nitrogen to be applied is determined by the amount of growth in the previous year. If too little growth is occurred, increase the nitrogen application. If too much growth occurred, reduce the nitrogen application. Knowing how much nitrogen to apply requires accurate record keeping.

Where organic mulches are used, the amount of N fertilizer may be decreased as the mulch begins to decay, releasing N. Fertilizing with manure is tricky because N and salt levels vary depending on the age and source of the manure.

Other nutrients need to be applied according to the results of a leaf analysis. Zinc, iron, and boron are micronutrients that are often deficient.

E. Insect and Disease Control

Success in growing fruit depends on effective control of insects and diseases, recognition of the common diseases and insects, selection of effective pesticides, proper timing of pesticide sprays, and thorough coverage of fruit and foliage with the spray mixture.

1. Organic control measures are available for some pests but, in general, their results are mixed.
2. Commercial fruit growers, because of the size of their operations, can afford to buy large equipment to effectively apply pesticides.
3. Home orchardists with a few fruit trees are at a disadvantage when it comes to obtaining equipment that will do a satisfactory job of spraying fruit trees. In most cases, they are restricted largely by the cost of hand-operated sprayers or those operated by small electric or gasoline motors. The capacity of these machines is small, the pressure is low, and the energy expended to do an effective job is considerable. Yet the homeowner fights the same pests, often on the same size trees, as the commercial grower.

4. It has been shown repeatedly that failure of homeowners to adequately control pests on their fruit trees can generally be attributed to not knowing what is causing the damage or what could cause the damage, not applying enough material to cover the trees completely, not making applications on time, and not continuing the spray program late enough into the summer.

Note: Dormant sprays are an important step in controlling insects and diseases. However, there are different dormant sprays; some control only diseases, while others control only insects. Consult the *Pacific Northwest Insect Control Handbook* and the *Pacific Northwest Plant Disease Control Handbook* for specific recommendations.

F. Rodent and Deer Damage

Fruit trees are susceptible to mouse, gopher, and deer damage.

1. Mice—Eat the bark of the trunk and roots near the soil surface. Damage is easily detected by removing soil from around the base of the tree and the larger roots near the surface. Bark completely removed by gnawing rodents will girdle, weaken, and finally kill the tree. As with other types of mechanical injury, plants weakened but not killed by rodents are more susceptible to drought, cold injury, disease infections, and insect infestations. To reduce the hazard of mouse damage, clean out all grass and weeds in a 3- to 4-foot diameter circle around the trunk of the tree. This rids the area of ground cover that might protect mice from predators. Wire guards, constructed from fine wire mesh and placed 1-inch deep in the soil, are effective around young trees.
2. Gophers—Are best controlled in the home garden by trapping. Poisoned baits are available for mouse and gopher control.
3. Deer—May damage fruit trees planted near woods or other areas with adequate deer cover. Deer feeding on young grow-

ing shoots and buds of fruit trees can severely stunt and weaken the plants. In the late summer and fall, buck deer often break and kill young trees while rubbing the velvet from their antlers. Tall fences or repeated use of approved repellents may be required for adequate deer damage control.

4. Moles can sometimes present problems by burrowing directly under trees. In this case, roots dry out and tunnels are used by mice who feed on the roots. Moles do not feed on tree roots.

G. Vegetation Management Due to Weed and Herbicide Injury

Weeds weaken fruit trees by competing for soil moisture and nutrients. The wise combination of cultivation and approved herbicides helps reduce weed competition.

Improper or excessive herbicide use frequently causes fruit tree death. Contact-action herbicides, when misused and allowed to drift onto foliage or tender green bark, can severely injure and ultimately kill the plant. Similarly, systemically absorbed herbicides for weeds can be lethal to fruit plants when improperly sprayed.

Long term use of the same soil-residual herbicide may eventually result in excessive soil accumulation, causing root injury, plant weakening, or death.

Do not plant fruit trees on sites immediately after corn or grain crops where a persistent herbicide, such as atrazine, was used for weed control. Fallow the soil for one or two growing seasons before planting fruit trees. This allows herbicide degradation and prevents tree injury or death.

Herbicides are safe, effective tools for reducing weeds in fruit crop planting. To prevent herbicide damage or plant death, pay careful attention to label guidelines for application, apply the correct rates, and use only herbicides approved for specific fruit crops.

H. Preventing Winter Injury

Normally, vegetative growth stops about early August, and a terminal bud is set. Unusually warm fall temperatures and exces-

sive amounts of nitrogen may cause continued or renewed growth in the fall. These conditions may predispose trees to cold injury; keep trees in moderately vigorous condition before winter arrives.

1. Lethal winter injury occurs most frequently in the lower trunk, in the crown region, or in the roots near the soil surface. The tree will generally die shortly after growth begins in the spring, if the damage has been severe enough to destroy the inner bark tissue.

Damaged inner bark is brown, while healthy bark and cambium tissue are a greenish yellow. Severe cold injury may result in split bark, however, the splits may later heal.

2. Sunscald, another type of injury, normally occurs in late winter on the south to southwest side of the main trunk and large branches. Bark, whether brown or gray, absorbs the sun's rays in midafternoon and often warms up as much as 20°F above the surrounding air temperature. As a result, bright sunny days in late winter may activate the cambium and

bark tissues on southwestern trunk exposures. This reduces cold resistance and may result in injury because of extremely cold night temperatures. The bark dries, then splits, and finally wood-rotting fungi enter. This may seriously weaken or even kill the tree. The problem is most severe for young trees and smooth-bark trees such as cherry and plum.

To protect a tree from sunscald, wrap the trunk with strips of burlap or a tree wrap material; or paint the trunk with a white indoor latex paint, which will lower bark temperature by reflecting light.

I. Cropping Problems

Biennial bearing (crop overproduction in one year and a need to rest the next year) confuses many home orchardists. This condition will alternate until finally the tree will produce fruit only every other year. To correct or reduce this problem, annual thinning done when fruit is still small will allow the tree to handle the crop and produce higher quality fruit. Thinning is done by hand when the fruit is about 1/2 inch in diameter. After thinning, the fruit should be spaced

Table 3. Why fruit trees don't bear.

| Symptoms | Prevention strategy | Possible causes |
|--|---|--|
| Trees 4 to 8 years old have never set fruit buds or bloomed | Trees growing too vegetatively pruning especially heading cuts | Spread or tie down branches; reduce nitrogen; reduce dormant |
| Few fruit buds form | Trees under stress (shade, "wet feet," drought, lack of nutrients) | Choose sunny, well-drained site; fertilize and irrigate properly; |
| (same as above) | Trees too vegetative pruning; increase summer pruning | Reduce nitrogen; reduce dormant |
| Fruit buds form only at tips | Fruit buds were killed by low temperatures during bud swell | Choose site with good air drainage |
| Tree blooms, but all flower parts fall off when petals fall, so few or no fruit sets | Frost killed open blossoms | Choose site with good air drainage; choose late-blooming or frost-resistant cultivars |
| (same as above) | Flowers were not adequately cross-pollinated | When choosing cultivars, be sure to include pollenizers; during spring bloom, place flowering branches of another cultivar in buckets of water in the tree |
| Tree bears only every other year (e.g., biennial bearing) | Heavy crop one year weakens tree, so few fruit buds form for next year's crop | Thin fruit 4 to 6 weeks after year, bloom when crop is heavy |

approximately 6 inches between fruits. Do not delay thinning. The later the thinning occurs, the smaller the fruit will be.

Additional cropping problems, their possible causes, and prevention strategies are found on Table 3.

Further Reading

Books

- A Catalog of New & Noteworthy Fruits* (annual). 1992. New York State Fruit Testing Cooperative Assn. Inc., Geneva, NY.
- All About Growing Fruits & Berries*. 1982. Chevron Chemical Corporation (Ortho Books), San Francisco, CA.
- Fitzgerald, T. J. 1984. *Gardening in the Inland Northwest, A Guide to Growing Vegetables, Berries, Grapes & Fruit Trees*. Ye Galleon Press, Fairfield, WA.
- Walheim, L., and R. L. Stebbins. 1981. *Western Fruit, Berries & Nuts—How to Select, Grow and Enjoy*. HP Books, Tucson, AZ.
- Westwood, M. N. 1978. *Temperature-Zone Pomology*. Timber Press, San Francisco, CA.

Booklets and Pamphlets

University of Idaho

- CIS 729 Apple-and-thorn Skeletonizer (25¢)
- PNW 341 Choosing Pear Rootstocks for the Pacific Northwest (50¢)
- PNW 221 Cold Resistance of Stone Fruit Flower Buds (50¢)
- CIS 726 Cytospora Canker Disease in Idaho Orchards (25¢)
- CIS 812 Fusarium Root-rot of Orchard Trees (50¢)

- PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair (\$2.50)
- BUL 820 Growing Apples for Local Markets in Cold Climates (\$2.50)
- PNW 235 Growing Walnuts in the Pacific Northwest (\$1.00)
- CIS 866 Homeowner's Guide to Fruit Tree Fertilization (35¢)
- PNW 121 Nutrient Disorders in Tree Fruits (web only)
- CIS 229 Peach Leaf Curl (25¢)
- CIS 898 Pears in the Home Garden (35¢)
- CIS 752 Phytophthora Collar-Rot of Orchard Trees (50¢)
- PNW 400 Training and Pruning Your Home Orchard (\$1.00)
- CIS 692 Weed Control in Tree Fruits (25¢)
- CIS 776 Why Home Fruit Trees Die (25¢)

To order University of Idaho publications, contact your county's UI Extension office or write to: Publications, University of Idaho, Moscow, ID 83844-2240, call (208) 885-7982, or email: calspubs@uidaho.edu. Make checks payable to *Publications*. Idaho residents add 6 percent sales tax. Also check, and in some cases download, the online publication catalog on the UI Educational Communications web site: (<http://info.ag.uidaho.edu>).

Washington State University

- EB1436 Apple Cultivars for Puget Sound (\$8.00)
- EB 665 Fruitfulness in Pome and Stone Fruits (50¢)

To order Washington State University publications, contact your county's Cooperative Extension office or write to Bulletin Office, Cooperative Extension, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

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Small Fruits



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Small Fruits



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I. Strawberries

Strawberries are grown all over the United States and perform well throughout the Pacific Northwest.

- A. Botanically, the strawberry is a member of the rose family (Rosaceae). The fruit is the swollen receptacle of the flower that bears seeds (achenes) on its surface. A high percentage of these seeds must be fertile for the berry to form properly. Plants produce for 3 to 5 years before production declines, and then they should be replaced.
1. Strawberry varieties, except for everbearing, are affected by daylength. Varieties are regionally adapted by latitude. Buy plants locally if possible, and base your purchases on regional recommendations.
 2. The two main types of strawberries are June bearing and everbearing. June bearing varieties set flower buds in the fall and ripen fruit in June. Everbearing varieties have a spring and fall crop.
 - a. The older cultivars of everbearers are daylength sensitive and have a break in production between the spring and fall crops.
 - b. The newer day neutral varieties set the flower buds throughout the season for a very long harvest period with no production break.
 - c. Total season berry production from the everbearing cultivars tends to be lower than the June bearing and day neutral types. The June bearing types produce the highest quality berries.

B. Cultivars in Idaho (in order of ripening)

1. Cultivars are June bearing in northern Idaho. Be sure to select cultivars that are adapted to northern growing conditions. For southern Idaho, select cultivars that are also adapted to high summer temperatures.
 - a. *Earliglow*: Earliglow bears early in the season and is resistant to many diseases.
 - b. *Crimson King*: The plants of this variety are very hardy and produce large fruit.
 - c. *Honeoye*: Another very hardy variety with large, firm fruit.
 - d. *Sumas*: Sumas have a high yield, but they are susceptible to fruit rot. They grow large fruit.
 - e. *Totem*: These fruits are good fresh and frozen. Totems are disease resistant.
 - f. *Benton*: This variety grows a medium-sized fruit with a light inside color.
 - g. *Shuksan*: Shuksans are susceptible to virus. The fruit is excellent fresh and frozen.
 - h. *Sparkle*: This variety produces a soft fruit with an excellent flavor.
2. Everbearing—Day neutral
 - a. *Fort Laramie*: An everbearing plant, the Fort Laramie is very hardy and productive.
 - b. *Quinault*: Another everbearing plant, the Quinault produces small berries, which are soft and have a good flavor.

- c. *Tristar*: The Tristar is day neutral and productive; it bears relatively large fruit with a good flavor.
- d. *Tribute*: A variety that is superior to Quinault, day neutral, and later in the season than Tristar, the Tribute has a firm fruit.

C. Culture

1. Planting

- a. Well-drained soil is required. Heavier soils should be molded to raised beds for improved drainage. Strawberry pyramids and containers work well and give good yields in small spaces. Incorporation of organic matter benefits both light (sandy) and heavy clay soils. Adjust pH to 5.5 to 6.5.
- b. Established weeds: Gardeners must eradicate all perennial weeds before planting. Use repeated fallow cultivation or heavy mulches.
- c. Matted row culture: Most popular in home gardens. Set plants 1 1/2 to 2 feet apart in rows 3 to 4 feet apart. Runners from initial planting are allowed to fill in to form a solid planting, until it reaches approximately one plant every 5 to 8 inches. Remove excess plants or runners. Plants at a higher density will produce fewer and lower quality berries.
- d. Hill culture: Plants remain as individual plants in the garden; remove all runners. Space individual plants 15 to 18 inches apart, and place them in rows 2 1/2 to 3 feet apart.

2. Setting plants

- a. Plant in early spring or early fall. In areas where frost heaving is a problem, plant only in spring, or mulch fall plantings to reduce heaving. If you plant at any time other than early spring, irrigation is important. Plants are mostly available in stores in the spring.
- b. Use certified virus, disease, and insect-free stock when establishing a new planting to ensure that pests are not introduced into the garden with planting stock.

3. Fertilization

a. Timing

- i. It is important to fertilize and water June bearers in late summer to promote maximum fall growth and flower bud formation.
- ii. Spring fertilization results in excessive formation of leaves and runners and in less fruit growth.
- iii. Fertilize everbearers and day neutrals with small amounts several times during the growing season.

b. Amount

- i. Apply a total of 30 to 60 pounds of actual nitrogen per acre for all types of strawberries.
- ii. June bearing types should be fertilized in early August, if irrigation is available; otherwise, fertilize in mid-September without irrigation.
- iii. A balanced fertilizer such as 10-10-10 will supply ample phosphorus and potassium. Any deficiencies should be diagnosed with a soil or plant tissue test.

4. Irrigation—Consistent watering is essential when plants are first set and during dry periods in spring and summer. Irrigate in the morning to reduce rot.

- a. Critical irrigation periods: These occur during harvest or in late August and fall, when plant growth resumes and the flower buds form for the following year's crop.
- b. Efficient irrigation methods: Black plastic or straw mulch and plastic-tube drip irrigation systems (soakers) are highly adaptable to strawberry culture and water conservation. Strawberries absorb 90 percent of their water from the top foot of soil.

5. Renewal (June bearers only)—After the harvest early in July, June bearers will benefit from removal of the foliage, which will allow you to rid the plants of disease-infested foliage and will act as a stimulant to the plant for new, vigorous foliage.

- a. Cut the foliage with a lawnmower set high or use hand tools. Be careful not to damage the crowns.
 - b. Rake leaves from the plot.
6. Cold protection
- a. Winter protection: In colder areas, strawberries will benefit from a mulch. Coarse hay or straw may be placed over the entire planting when the ground begins to freeze. The mulch should be removed from the plants in the spring. Weed-free mulch materials should be used.
 - b. Spring frosts: These often kill the early flowers. Sprinkle plants with water during the coldest frosts (when temperature at ground level reaches 34°F). Leave the water running until the temperature is above 32°F, or cover plants with a light mulch or a floating row protective fabric.
- D. Common Plant Problems—Diagnosis and Control
1. Diseases
- a. Verticillium wilt
 - i. Symptoms: A soilborne fungi, verticillium wilt causes wilting and death of older leaves in individual plants or groups of plants. Black lesions develop on petioles. New roots may be short with blackened tips. Plants may outgrow these symptoms.
 - ii. Control: Avoid planting strawberries in ground where potatoes, tomatoes, strawberries, or other susceptible crops have been planted. Eliminate infected plants and do not replant in spots. Rotate crops.
 - b. Red Stele: Soilborne fungi
 - i. Symptoms: Often there are no symptoms the year of planting. During the first year of fruiting, there may be dwarfing, reddening of leaves, and wilting of older leaves. Root tips may decay, causing “rat-tailed” appearance. The central core or vascular system of root (stele), may be clogged by fungi and show a red discoloration of the stele. Symptoms are most readily apparent early in the season. They may be difficult to see later in the season. Not all the roots of an infected plant will show symptoms.
 - ii. Control: Use certified plants. Plant in disease-free soil. The soil needs to have good drainage. Earliglow, Sparkle, Tribute, Tristar, and Totem are resistant to this disease.
- c. Viral diseases
- i. Symptoms: Viral diseases can cause stunting, an unevenness in field or planting, as well as some foliar symptoms, such as streaking, cupping, and yellowing.
 - ii. Control: Use certified planting stock. Control the aphid infestation, as aphids are the primary vector of disease.
- d. Fruit rot/botrytis
- i. Symptoms: Botrytis is evident in a gray, fuzzy mold on fruit during moist weather. Infections start at bloom. Fruit from the infected blossom rots as it ripens.
 - ii. Control: Ensure good air circulation, remove infected fruit, and clean straw mulch so that fruit rests on clean, dry surface. Use fungicide during wet springs. Apply fungicide at 10 percent bloom. Repeat according to label directions.
- e. Common leaf spot
- i. Symptoms: Leaf spot causes foliage with dark red or purple spots, that gradually becomes gray-white with age. Fully developed spots are 1/8 inch in diameter and have a whitish center with red margin. Infection occurs during moist weather and is most severe during spring and fall. Crimson King is resistant.
 - ii. Control: Fruit rot fungicide sprays will keep this disease under control. Removing foliage from June

bearers after harvest reduces inoculum.

- f. Powdery mildew
 - i. Symptoms: Disease causes upward curling of leaflet edges. Leaf undersides become reddened and coated with a grayish white fungus. Leaves later turn purplish red. To-tem and Benton strains are very tolerant. Shuksan has moderate susceptibility. Fort Laramie is very susceptible.
 - ii. Control: Destroy old infected leaves.

2. Insects

- a. Root weevils
 - i. Damage: Larvae feed on root systems. Adults notch edges of leaves.
 - ii. Control: Don't use chemical control in the home garden. Collect adults at night on leaves and destroy.
- b. Aphids
 - i. Damage: Can spread viruses.
 - ii. Control: Hose off and use insecticidal soap sprays.
- c. Spider mites
 - i. Damage: There is a stippled appearance to top part of leaves, which leads to bleaching. Webbing and mites will be found on the undersides of leaves.
 - ii. Control: See aphid control.
- d. Spittle bugs are small, yellow-green insects similar to the leaf hopper in appearance.
 - i. Damage: Nymphs develop "spittle" on plants.
 - ii. Control: Since this pest is not a major one, there is no need to control.
- e. Slugs (mostly nocturnal): Many sizes feed on foliage and fruit.
 - i. Damage: Slugs cause leaf damage, often in the leaf center.
 - ii. Control: Manually remove or use slug bait around the perimeter of the garden. Bury containers of beer

with the lip of the container at soil level to attract and drown slugs. Check containers often.

II. Red Raspberries

Red raspberries are grown as a commercial crop in the Pacific Northwest. More than 10,000 acres are planted in Washington, Oregon, and British Columbia. Raspberries can be expected to do well in most Idaho locations, although severe freeze injury to canes will occur in many winters in southeastern Idaho.

- A. Botanically, raspberries are members of the Rose family (Rosaceae) and belong to the genus *Rubus*, as do blackberries and other caneberries. The plants are perennial, with roots that live 40 years or more. Red raspberries have stiff erect canes, which are usually covered with thorns. Canes are produced freely from adventitious buds on the roots, and they generally live two seasons.
 1. Fruit is borne on lateral fruit spurs produced on 1-year-old canes. Fruiting canes die after harvest; meanwhile, new canes (primocanes) have been growing from the root system to be next year's fruiting wood.
 2. The raspberry is an aggregate composed of 75 to 125 drupelets that separate from the receptacle when ripe, producing a hollow "berry."
 3. Optimum production for red raspberries is in areas with relatively cool summers, a rain-free harvest season, and a mild winter with sufficient cold to satisfy chilling requirements. However, care in cultivar selection will sustain fruit in areas lacking in one or more of these conditions. Raspberries are one of the hardiest of cane fruits. Some cultivars will tolerate temperatures to -20°F without damage.
 4. Red raspberries come in two types: Summer bearing and fall bearing.
 - a. Summer bearing raspberry canes are biennial, growing one year and producing the next.
 - b. The fall bearing raspberry produces canes that bear on the upper part of the

primocanes in the same growing season. These canes, if left the second year, will bear fruit on the lower portions.

- i. Alternatively, the canes can be totally removed by mowing to the ground after the fall crop is harvested. When managed in this way, fall bearing raspberries will bear only the single crop in the fall.
- ii. In Idaho locations with short growing seasons, fall bearing raspberries may not ripen their crop. Trial plantings of these cultivars are recommended to ascertain their ripening characteristics.

B. Cultivars in Idaho

1. Summer bearing

- a. *Boyne*: Hardy in cold conditions, Boynes are good fresh and frozen. This variety is productive.
- b. *Canby*: Canbys produce a thornless plant. They are virus resistant and aphid immune, but sensitive to root rot. This variety is very productive, and it is cold hardy through Zone 4.
- c. *Haida*: Though this variety is hardy and has large, sweet, firm berries, it has short canes and is low in vigor.
- d. *Latham*: A popular variety, Lathams are hardy and have a nice flavor.
- e. *Newburgh*: Newburghs are cold hardy, as well as resistant to root rot and mosaic virus.
- f. *Nootka*: This variety is a firm, flavorful, vigorous plant.
- g. *Nordic*: Nordics are cold hardy, productive, and resistant to fungal diseases and aphid feeding.
- h. *Skeena*: A large, bright fruit, the Skeena is hardy and root rot susceptible.
- i. *Taylor*: A long conic fruit, the Taylor has an excellent flavor and is productive.
- j. *Titan*: The Titan produces a hardy, large fruit with a mild flavor. It is very productive and root rot susceptible.

2. Fall bearing

- a. *Amity*: This variety harvests about a week earlier than Heritage. It has a good size, flavor, and firmness.
- b. *Autumn Bliss*: A early crop variety, Autumn Bliss creates berries that have a large size and good flavor.
- c. *Heritage*: The Heritage ripens late in fall and produces heavy yields.
- d. *Redwing*: A soft fruit, resistant to high temperatures, this strain ripens earlier than Heritage.
- e. *Ruby*: Ruby bears a productive, large fruit, which can produce when planted with Amity.
- f. *Summit*: While this plant has a better flavor than Heritage and is root rot resistant, it produces a small fruit.

C. Culture

1. Planting—Plant in raised mounds or beds in heavier soil to improve drainage away from the crown of the plant.
 - a. Use certified stock, plants, or root cuttings.
 - b. Spacing is generally 1 1/2 to 3 feet apart in rows 6 to 8 feet apart. You must ensure a recommended 4 foot minimum depth to winter water table to create optimum conditions for high fertility and freedom from erosion.
 - c. Soil: Good drainage, high water-holding capacity, and adequate depth are essential. Plants are highly susceptible to root rot. Heavy, poorly drained soil severely limits life expectancy of plants. Irrigation is required on sandy or gravelly soils.
2. Established weeds—Gardeners must eradicate all perennial weeds before planting. Use fallow cultivation or heavy mulch.
3. Training—Place top wires at 4 1/2 to 5 1/2 feet to support canes. You may also have another wire at 2 to 3 feet. Use one-, two-, or four-wire systems. Plants will be shorter in some climates (Fig. 1).
4. Hill culture—Maintain plants as individual hills (weeding is easier), or allow to fill in as a solid row. Light distribution

is better when each individual cane is spaced along the wire separately. Canes are bundled commercially for labor savings. Tie canes to top wire in fall or winter as in Fig. 1. Tie in clumps or individually along the wire.

5. Pruning—Top dormant canes 6 to 10 inches above the wire in early spring to stimulate lateral branching. Canes are subject to dieback in a cold winter if they are pruned in the fall.

a. Remove all fruiting canes after harvest, as that reduces insect and disease problems, helps in hardening off process, and simplifies weed control. Remove weak new canes or those with small diameter.

b. Cut off canes close to soil line. Leave all canes over 6 feet and the diameter of your index finger (about 12 healthy canes per hill, or in solid rows spaced 4 to 5 inches between canes). Keep rows no more than about 12 inches wide.

6. Fertilization—Test the soil to determine plant needs. Broadcast apply in spring over rows or split application with one-half applied at first growth in spring and the remaining one-half at the beginning

of or at fruit set. Apply a total of about 30 pounds actual nitrogen per acre.

7. Weed control—Hand hoe weeds between hills. Cultivate very shallowly.

a. Remove suckers between rows as they emerge.

b. Cover crops between rows are effective.

c. Herbicides can be used to control weeds. Make sure they are registered for use in raspberries.

8. Irrigation—Watering frequency will vary with conditions. As a general rule, irrigate every 2 to 3 weeks before and after harvest; then supplement with a weekly irrigation during harvest.

9. Cold protection

a. Winter protection: Good snow cover or mulch will protect crowns. In severe areas, or with less hardy cultivars, pin canes to the ground and mulch over them.

b. Spring frosts: See strawberries.

D. Common Plant Problems—Diagnosis and Control

1. Diseases

a. Phytophthora root rots: A fungus disease caused by *Phytophthora erythroseptica*.

i. Symptoms: The disease kills the fine feeder roots, while the interior of any larger roots becomes brown. Suckering is reduced. New primocanes wilt and leaves die. Floricane leaves turn bright yellow and brown and then die out. Favored by wet, heavy soils.

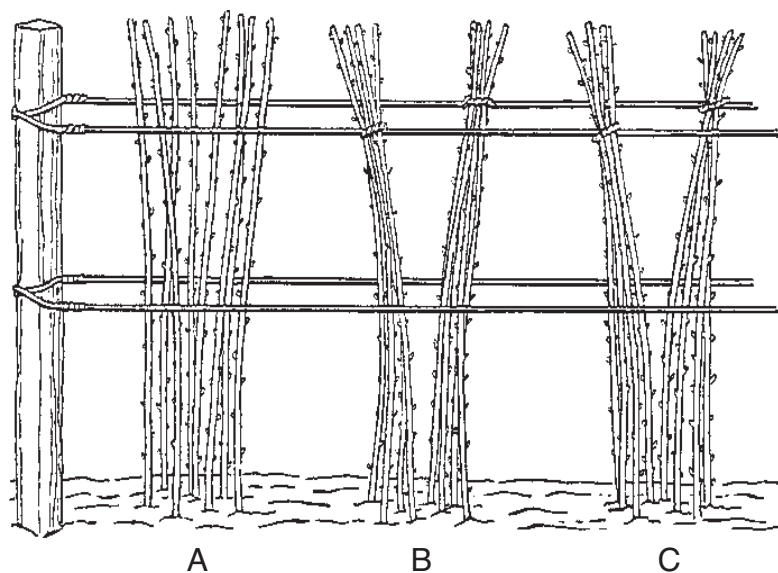
ii. Control: Use certified plants free of disease. Plant on well-drained soils. Increase drainage by using raised beds.

b. Virus diseases

i. Symptoms: Viruses create stunting, or delayed growth in the spring; crumbly berries; ring spotting; and a bright yellow mosaic on the leaves.

ii. Control: Plant certified stock; remove infected plants.

Fig. 1. Mature raspberry canes after spring pruning and tying to four-wire trellis.



A Hill after spring heading.

B Hills with canes spread and tied.

- c. Crown gall: Bacterial disease.
 - i. Symptoms: Dark “knobs or tumors” of growth appear at or below soil line. Crown gall spreads primarily by pruning, when it enters new wounds on pruning shears. It also can come in on infected planting stock.
 - ii. Control: Remove plants.
 - d. Fruit rot/botrytis (see strawberries)
 - e. Spur blight: A common fungal disease (*Didymella applanata*) in damper areas, spur blight causes little damage in this area. Buds on infected canes are more susceptible to winter injury.
 - i. Symptoms: Spur blight creates wedge-shaped necrotic lesions on leaves, especially near base of cane. Infected leaves drop, leaving petiole attached to cane. Brown or reddish-brown lesions appear around buds at base of petiole; these lesions are usually limited to one or two buds. Minute black fruiting bodies appear on lesion by fall.
 - ii. Control: Avoid overhead watering if possible. Remove and destroy infected canes. Thin canes appropriately to allow for air movement. Avoid excessive nitrogen fertilizer.
 - f. Verticillium wilt (see strawberries)
 - g. Anthracnose (see blackberries)
 - h. Yellow rust: Caused by a fungus, particularly following late spring rains.
 - i. Symptoms: Plants develop leaves with yellow spotting, and later become dusty from the yellow spores. Lower leaves yellow and drop, and the crop is reduced. The fruit dies before maturing. In the winter, infected leaves produce black spores at sites of infection.
 - ii. Control: Good sanitation. Remove sources of infection; cut old fruiting canes immediately after harvest and destroy.
2. Insects
- a. Crown borer
 - i. Damage: These insects bore tunnels in lower portions of canes, which cause the death of the cane.
 - ii. Control: Dig out infected plants by hand. Replant any new plantings in different area.
 - b. Spider mites
 - i. Damage: Their feeding reduces plant vigor and causes leaves to brown and drop prematurely. When pesticide use kills natural predators, the mites are often a problem.
 - c. Cane borer
 - i. Damage: These insects bore tunnels in the upper portions of the cane (Shepherd’s Crook).
 - ii. Control: Prune out any affected cane and destroy. Use no chemical control.
 - d. Yellow jackets
 - i. Damage: Yellow jackets hide in ripe fruit and feed on sugars. They are a hazard to those working in the plants.
 - ii. Control: Keep overripe fruit harvested. Yellow jacket traps can be effective.
3. Other
- a. Crumbly berry
 - i. Damage: Crumbly berries may reveal a plant with a Boron deficiency. Soil testing is recommended. A virus disease may interfere with flower functions, causing crumbly fruit. Poor pollination occurring from lack of bees or from poor weather during flowering also causes crumbly fruits.
 - ii. Control: Add boron, if necessary; add bees to the field; and replace plants with virus free stock.
 - b. Sunburn/high temperatures
 - i. Damage: The fruit forms, but it doesn’t ripen, or it ripens slowly. This problem is caused by excess ultraviolet rays or elevated temperatures.
 - ii. Control: Shade the plants, especially during high noon hours. Use shadecloth or plant in the shade of other foliage or structures.

III. Black and Purple Raspberries

A. Purple raspberries are hybrids of red and black. The fruits resemble the red more than the black. Both have canes that will root at the tips and are propagated by tip layers.

1. Black raspberries are less cold hardy than red or purple types. Freeze injury will begin at temperatures around -5°F.
2. They are susceptible to virus diseases and anthracnose.
3. Except for Royalty, the following cultivars sucker poorly, so hill culture rather than hedgerow is recommended.

B. Cultivars in Idaho

1. Black raspberries

- a. *Allen*: An early fruit with a concentrated ripening, this strain is hardy.
- b. *Black Hawk*: A late variety, Black Hawk produces large, flavorful berries. A productive variety, it is very hardy, to Zone 5 (-20° to -10°F).
- c. *Lowden*: The Lowden is a cross between a purple and a black raspberry with an excellent flavor. The plant has good disease resistance and is hardy.
- d. *Munger*: The fruit of the Munger has an excellent flavor. Mungers ripen in midseason and are also hardy.

2. Purple raspberries

- a. *Brandywine*: A variety that produces large fruit with a tart flavor, the Brandywine is very winter hardy, to Zone 4 (-30° to -20°F).
- b. *Royalty*: Royalty produces large fruit, which is sweet when fully ripe. It is a very productive variety and hardy to Zone 4 (-30° to -20°F). This variety ripens late.

C. Culture (see Red Raspberries)

D. Common Plant Problems—Diagnosis and Control (see Red Raspberries)

IV. Trailing Berries (Blackberries)

Trailing berries are in the same genus as raspberries (*Rubus*). Their fruit is similar to raspberries, but a white core or receptacle remains part of the fruit when picked.

A. Blackberries are the least hardy of the berries grown in Idaho. These plants can be injured by temperatures between +5° and -10°F. Boysenberries, Loganberries, Tayberries, Nectarberries, and Marionberries are all trailing berries.

B. Cultivars In Idaho

1. *Cherokee*—The plant has an upright, thorny, strong vigorous growth; it is hardy to Zone 5 (-20° to -10°F).
2. *Chester*—This variety has a semi-erect plant that is productive and hardy to Zone 5 (-20° to -10°F). In fact, the Chester is the most hardy of the thornless type. It produces large fruit late in the season.
3. *Darrow*—A tall, semi-erect, variety, the Darrow is the most cold hardy cultivated blackberry.
4. *Hull*—Another semi-erect variety, the Hull produces large fruit. The plant is thornless, and its growth is vigorous.
5. *Roseborough*—An upright plant, the Roseborough holds up under extreme heat and dryness. It produces heavy crops and is hardy to Zone 5 (-20° to -10°F).

C. Culture

1. The planting, fertilization, and soil requirements are similar to those for red raspberries.
2. Trellising systems—Long canes of trailing and semi-erect varieties are generally “woven” on a two-wire trellis system as in Fig. 2. Wires are 18 inches apart with the top wire 5 feet from ground level. Upright cultivars will not require trellising, or at most a single wire at 5 feet.
3. Pruning—Remove fruiting canes after harvest. Weave new canes around top wire in fall or spring.

D. Common Plant Problems—Diagnosis and Control

1. Diseases (see red raspberries)
 - a. Leaf and cane spot (*Septoria* leaf spot): Fungal disease.
 - i. Symptoms: Leaf spots vary from light to dark brown. They begin as an 1/8 inch purple spot later turning brown. Cane spots are larger and may contain fruiting bodies

(spores). Spots girdle and kill cane. The disease is promoted by canes overwintering on or near ground.

- ii. Control: Remove fruiting canes after harvest. Provide good air circulation.
- b. Anthracnose: Overwinters on infected canes.
- i. Symptoms: Purple spots appear on canes, then increase in size, and develop light gray centers with brown-purple edges. Spots converge to form large irregular lesions. Canes may dry and crack. On leaves purple spots enlarge to form gray to white areas that drop out. Berries ripen prematurely and are small and dry.
 - ii. Control: Remove canes after harvest. Leave no old stubs. Thin to allow air circulation.
2. Insects (see red raspberries)

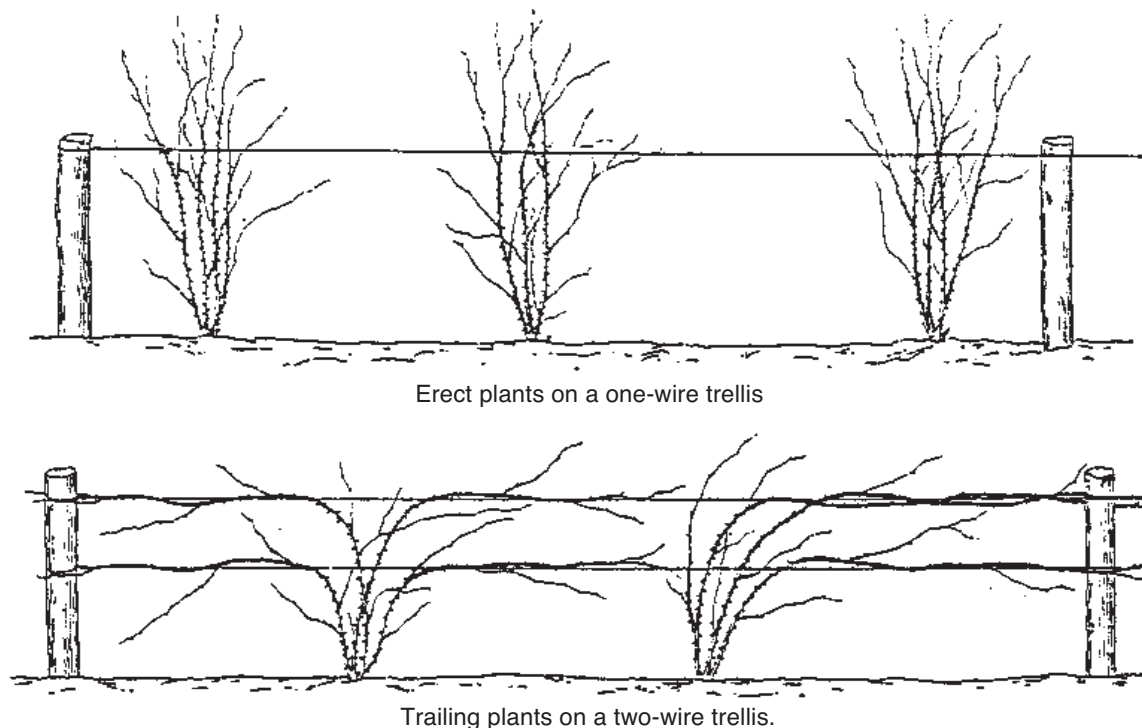
V. Blueberries

Blueberries, members of the Ericaceae or heath family, prefer a culture similar to rhododendrons or azaleas. Wild blueberries are

often called “huckleberries,” but are just different species of the cultivated blueberry.

- A. Blueberry production in Idaho will be limited to those sites with acidic soil (pH of 4.5 to 5.5).
1. In areas with alkaline soil, grow blueberries in raised beds or large containers with peat. The addition of ground sulfur, 1 pound per 100 square feet in sandy soil and 2 pounds per 100 square feet in clay soil, will lower the pH approximately one point.
 2. Blueberry plants are attractive and can serve as ornamentals and fruit producers, as they tolerate partial shading better than other berry crops.
 3. Blueberries are self fertile but will have higher yields with cross-pollination. The plants are hardy.
- B. Cultivars in Idaho (listed in order of ripening dates).
1. *Earliblue*—This short plant variety flowers very early.
 2. *Patriot*—The Patriot is a very hardy plant with large, firm fruit.
 3. *Northland*—A hardy, spreading plant, the Northland has a good flavor.

Fig. 2. Trellises for blackberries.



4. *Bluecrop*—A fruit with an excellent sweet flavor, this variety has a vigorous plant.
5. *Blueray*—Large, firm fruit.
6. *Jersey*—Fair flavor; late, vigorous plant.

C. Culture

1. Established weeds—Eradicate all perennial weeds before planting. Use fallow cultivation or mulches.
2. Planting
 - a. Setting: Blueberries are set out as dormant plants in late winter or potted plants in spring or fall.
 - b. Soil: The root system is shallow, fibrous, and prefers soil with high organic matter and good water holding capacity. Add organic matter to soil when planting; mix well with soil in and around planting hole. Mulch to protect the shallow root system from temperature extremes and drying.
3. Pruning—Prune hard after planting to stimulate new growth. For mature plants, remove older canes to ground or to strong lateral, retaining 1- to 3-year-old wood.
4. Fertilization—The amount of fertilizer used depends on the rate of previous growth. Apply light amounts three times in the growing season for optimal growth. Ammonium sulfate is a good nitrogen source to help acidify soil.
5. Irrigation—Keep soil evenly moist. Plants need adequate drainage. Drip irrigation systems work well. Mulch up to 6 inches deep to conserve water.

D. Common Plant Problems—Diagnosis and Control

1. Diseases

- a. Mummy berry: Fungus disease (*Monilinia vaccinicorymbosi*).
 - i. Symptoms: Infected berries are reddish-buff or tan “mummies.” They fall to the ground, gray, shriveled, and hard to overwinter. In spring as blueberry buds break, fruiting cups grow from mummies on the soil and release infecting spores. Blossoms become infected and turn brown and wither. New

vegetative shoot is blackened in the center and wilts and dies. The remaining fruit becomes infected.

- ii. Control: Remove and destroy all infected parts including fruit. Mulch thickly to bury any dropped mummies. In early spring destroy developing fruiting cups by cultivation. Apply fungicide during bloom according to label instructions.

b. Botrytis

- i. Symptoms: Twig dieback in wet weather, invading blossoms, and moving down shoots.
- ii. Control: Apply fungicide early in spring when growth begins. Repeat, but do not make more than four applications before harvest. Follow label instructions. Prune out and destroy dead twigs.

2. Insects

a. Aphids

- i. Damage: Deform leaves, devitalize plants, secrete honeydew.
- ii. Control: Light infestations may be controlled by natural insect predators; use insecticidal soap.

b. Cherry fruitworm

- i. Damage: Larvae approximately 3/8 inch in size will bore into the berries.
- ii. Control: Insecticidal sprays before bloom or after, according to label directions, for cherry fruitworm on blueberries.

c. Leafrollers

- i. Damage: Create webs and feed on foliage and fruit.
- ii. Control: *Bacillus thuringensis* at any time.

d. Scale

- i. Damage: Weaken plant.
- ii. Control: Prune off infested areas as soon as observed.

3. Birds—Can be a persistent problem. Net plants as the fruit colors. Secure the perimeter of the net carefully. Use mylar strips or balloons to scare away birds.

VI. Hardy Kiwi

A. The botanical name of the hardy kiwi fruit, also known as Siberian Gooseberry, is *Actinidia arguta*. It is a member of the Actinidiaceae family (not related to the common garden gooseberries). Kiwi fruit is native to eastern Asia. Chinese gooseberry (*A. chinensis*) is not hardy anywhere in Idaho, as fruit buds are damaged by temperatures of 10° to 15°F.

1. The fruit is fuzzy and brown skinned, approximately the size of a large cherry. The flesh is green with edible black seeds and has a unique “fruity” flavor. Fruit is high in vitamin C and stores well.
2. Kiwi is dioecious (Latin for two houses), which means there are separate male and female plants. One male will pollinate six to eight female plants within 50 feet. Bloom periods between male and female must match. Some varieties are self-fertile.

B. Cultivars in Idaho

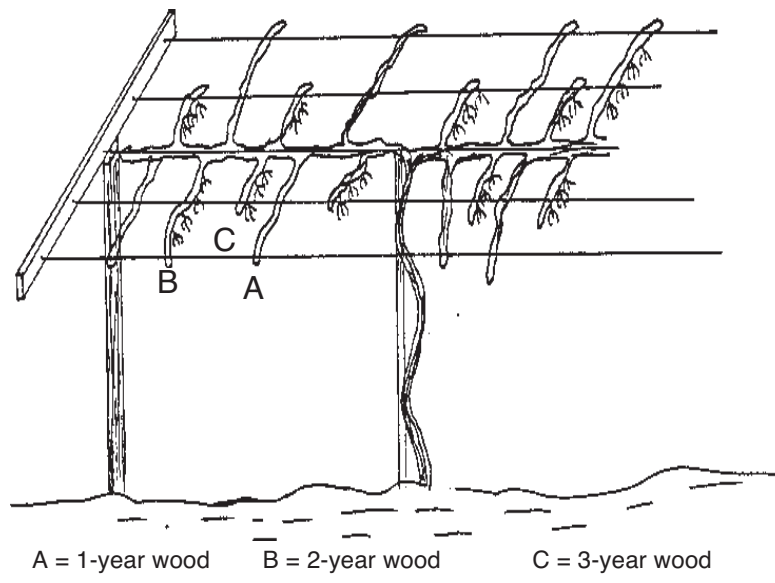
1. Seedlings—Many varieties are just listed as *A. arguta*, available in male or female plants.
2. *Ananasnaja*—A variety with a fuzzless skin, the *Ananasnaja* is very sweet and spicy. The Russian name means “pine-apple-like.”
3. *Issai*—Self-fertile, the *Issai* has fruit with sweet flesh, often used as a fruit-producing pollinator. This variety is very productive.
4. *Meadar*—A good pollinator for *Ananasnaja*, the *Meadar* produces sweet fruit and ripens in late August.

C. Culture

1. Site

- a. Hardiness: Dormant vines are hardy to -25° to -30°F and sensitive to late spring frosts. Avoid frost pockets.
- b. Soil: Kiwi need well-drained soil, even soil moisture, and a sunny location **free from wind** to protect fruit and laterals from damage and drying.

Fig. 3. Kiwi on trellis.



2. Training and trellising—The vines are large and heavy so the Kiwi needs a strong trellis system as in Fig. 3. The Kiwi is a perennial with a lifespan of 50 to 60 years. Pressure-treated posts should be 5 to 6 feet tall with another 3 feet below ground. Use high tensile 12 or 10 gauge wire. A T-bar trellis with three to five horizontal wires is recommended. Space the plants 10 to 15 feet apart in row and 10 to 15 feet between rows.
3. Pruning
 - a. Summer pruning: A must for Kiwis. Avoid shading of fruiting wood. Prune new growth several times to 6 to 8 inches during the growing period.
 - b. Winter pruning: Prune during the dormant period. Start by developing well defined leaders or cordons which will be permanent. Set up an evenly spaced system of fruiting arms or laterals.
 - i. Remove fruiting wood that is losing vigor. Start with one-third removal each year.
 - ii. Remove fruiting lateral after third year.
 - iii. Shorten 1-year wood to two to four buds. Allow second-year wood to fruit freely.

4. Fertilization
 - a. Young plants: Add balanced fertilizer split into two applications.
 - b. Mature plants: Apply one-half to two-thirds of the balanced fertilizer at bud break; then apply the rest after the fruit is set.
5. Harvesting—Plants take 3 to 4 years to bear; they reach full production in 7 to 8 years. Pick the fruit in late August to November when it is **firm-ripe** (for best storage ability). Keep refrigerated.

D. Common Plant Problems—Diagnosis and Control

1. Diseases—None.
2. Insects—None.

VII. Black Currants

A. The black currant, or *Ribes nigrum*, is a native of central and eastern Europe.

1. The native plant grows in damp, woody places. A fully grown bush may reach 5 to 6 feet in height and spread, and have an average yield of 10 to 12 pounds per plant.
2. There are many cultivars, mostly of European origin. Most are extremely hardy. Black currants are partially self-fruitful, but set a larger drop with another cultivar nearby. Plant nonblister rust resistant cultivars at least 1,000 feet and preferably 3/4 mile from the nearest five-needle pine.

B. Cultivars in Idaho

1. *Black September*—This variety produces a large, firm fruit with a strong black currant flavor that is hardy to -30°F. The plant is mildew resistant.
2. *Consort*—The fruit of the Consort has a sweet, musky flavor, while the plant is self-fruitful, resistant to white-pine blister rust, and hardy to -30°F.
3. *Crusader*—The Crusader needs a pollinator; it is rust resistant.
4. *Jostaberry*—This variety is a cross between a black currant and a gooseberry. It produces large fruit that is good fresh. The vigorous plant is resistant to mildew and white-pine blister rust and is cold hardy.

C. Culture

1. Soil—The currant will grow on a wide variety of soils. The ideal pH is 6.5 with good water holding capacity. Currants will tolerate poorly drained soils. Add organic matter to light soils.
2. Site—Plants bloom early so avoid frost pockets. Though the currant prefers a sunny location, it will tolerate partial shade. Control all perennial weeds before planting.
3. Planting—Plant in late winter or early spring. Space the plants 5 feet apart in rows, with 6 feet between rows. Plants grow by stooling; plant 2 inches deeper than in nursery. Cut all shoots to 2-inch stubs at planting. Plants root easily; use prunings as cuttings.
4. Pruning—Prune annually, as black currants bear best on 1-year wood. Remove all 3-year-old wood annually, as well as any older growth. Cut to strong young shoot, or near base, or off completely. Keep five or six canes each of 1- and 2-year-old wood.
5. Irrigation and fertilization—The currant likes even soil moisture. It will require frequent irrigation in arid parts of the state. Currants are fairly heavy feeders, so apply balanced fertilizer in March and more nitrogen in April.
6. Weed control—These plants are shallow rooted, so avoid deep cultivation. Sawdust mulch 4 inches thick is effective in controlling weeds.

D. Common Plant Problems—Diagnosis and Control (see Gooseberries)

VIII. Red and White Currants

- A. Red currants, or *Ribes rubrum* and *Ribes spicatum*, are native to Europe. A full-grown bush may be 5 to 6 feet in height and spread. The fruit is smooth skinned and glistening. Red currants are used for jelly, pies, juice, and wine.
1. The white currant is a sport of the red currant, and the culture is the same.
 2. The plants are self-pollinating; the average yield of the mature plant is 8 to 10 pounds of fruit per plant.

B. Cultivars in Idaho

1. Red currants

- a. *Cherry*: This variety has a high fruit quality, is hardy in Zone 3 (-40° to -30°F), and is productive.
- b. *Minnesota 71*: A vigorous plant, the Minnesota 71 produces large fruit of good quality.
- c. *Red Lake*: The Red Lake is productive with a long growing season. It produces early fruit. The dark red berries are widely grown.

2. White currants

- a. *White Imperial*: An old, but vigorous variety, the White Imperial produces very sweet medium to large fruit.
- b. *White Pearl*: The White Pearl has a pale yellow skin and large fruit.

C. Culture

1. Soil—Both white and red currants are less tolerant of poorly-drained soils than black currants. Ideal pH is 6.5. The plants need good water holding capacity; add organic matter to light soils.
2. Site—These plants bloom early, so avoid frost pockets. The flowers are hardier than black currants; you'll find them useful for north-facing walls. If you want full flavor in the fruit, then these plants require a sunny location. Control all perennial weeds before planting.
3. Planting—Plant in late winter or early spring. Space plants 5 feet apart in rows, with 5 feet between rows. Plant at the same depth as in nursery.
4. Pruning—Your objective is to create a goblet-shaped bush with 8 to 10 main branches. Prune leaders to outward facing-buds. Prune drooping branches to upward-facing buds. Fruit buds produced in clusters at base of 1-year wood or on short spurs on old wood. Maintain about three canes each of 1-, 2-, and 3-year-old wood.
5. Irrigation and fertilization—These currants like even soil moisture. Use mulch on light soils. The plants are fairly heavy feeders, so apply balanced fertilizer in March at bud break.

6. Weed control—As the plants are shallow rooted, avoid deep cultivation.

7. Harvesting—Pick as soon as the berries are clear in color. Pick whole clusters to avoid injury to delicate fruit.

D. Common Plant Problems—Diagnosis and Control (see Gooseberries)

IX. Gooseberries

A. Botanically, gooseberries are known as *Ribes usa-crispa*.

1. They are self-pollinating and are a deciduous, thorny shrub.
2. The mature plant has a height and spread of 5 feet, and produces 5 to 6 pounds of fruit. It bears fruit like red currant at the base of 1-year wood and on spurs of older wood.
3. Gooseberries are more tolerant of hot weather than currants.

B. Cultivars in Idaho

1. *Captivators*—This variety is winter hardy and disease resistant. It produces a large 1-inch fruit that is pink to red when it is ripe and has an average flavor.
2. *Pixwell*—A hardy, thornless plant, the Pixwell produces fruit with sweet, pink flesh.
3. *Poorman*—A vigorous productive variety, the Poorman has a highly flavored, wine-red fruit. The plants are hardy.
4. *Welcome*—Welcomes are extremely productive plants with medium to large, light-green fruits that have a sweet-tart flavor.

C. Culture

1. Soil—The top 18 inches of soil needs to be well drained. An ideal pH is 6.5. Gooseberries need good water holding capacity; add organic matter to light soils.
2. Site—Avoid frost pockets, as the plants bloom early and blossoms can be damaged by spring frost. Gooseberries are tolerant of partial shade, though they do best in sunny site. Control all perennial weeds before planting; the thorny plant is hard to weed around.

3. Planting—Plant in late winter or early spring. Gooseberries are one of the first berry plants to leaf out. Space plants 5 feet apart in rows, with 5 feet between rows. Plant at same depth as nursery.
 4. Pruning—See red currants.
 5. Irrigation and fertilization—The gooseberry likes even soil moisture. Uneven or heavy watering may cause fruit to split as it ripens. Use mulch on light soils. The plants are fairly heavy feeders so apply balanced fertilizer in March at bud break.
 6. Weed control—As the plants are shallow rooted, avoid deep cultivation.
 7. Harvesting—Protect the plants from birds with netting. Pick as soon as the berries are good size, but while they are still green (June or July). For dessert fruit thin every other one. Use thinnings for cooking.
- D. Common Plant Problems—Diagnosis and Control
1. Diseases
 - a. Anthracnose or leaf fungal disease: Overwinters on dead leaves.
 - i. Symptoms: The disease creates small leaf and fruit spots. By mid-season there is a yellowing and dropping of leaves.
 - ii. Control: Remove and destroy affected leaves. Prune to open center to allow air circulation.
 - b. Powdery mildew: A fungal disease that overwinters on twigs.
 - i. Symptoms: The mildew can be seen as a white, powdery growth on the surface of leaves, green shoots, and fruits. Infected plants are stunted.
 - ii. Control: Prune to maintain an open plant with good air circulation.
 - c. White pine blister rust (fungal disease): It is no longer illegal to cultivate *Ribes* in Idaho. (Too many wild *Ribes* combined with rust resistant pine cultivars). Alternate the host to five-needle pines. Black currant is most susceptible.
 - i. Symptoms: Small cuplike spots appear on the underside of leaves and produce orange yellow spores.
 - ii. Control: Remove and destroy infected plants. Do not plant *Ribes* near five-needle pines.
 2. Insects
 - a. Currant fruit fly (gooseberry maggot).
 - i. Damage: The larvae enter the soil in late June. They overwinter as pupae in brown cases the size of wheat grains. Flies emerge in April and lay eggs on the developing berries of either currants or gooseberries.
 - ii. Control: Use shallow cultivation under bushes during July and August, as this method helps expose and kill pupae.
 - b. Currant aphid
 - i. Damage: A small, yellow aphid appears on new growth in the spring. The aphid overwinters as eggs on bark. It causes cupping and red color on new leaves. Honeydew accumulates.
 - ii. Control: Use water washes or insecticidal soap.
 - c. Currant borer
 - i. Damage: The adults are clear winged with blue-black coloring and yellow markings. The larvae tunnel in the canes. Canes wilt in summer and autumn.
 - ii. Control: Prune out and destroy infected canes.
 - d. Imported currantworm
 - i. Damage: The larvae are 1/2 inch long, greenish in color, while the immature have dark spots. They feed along leaf margin and may defoliate the plant when they become numerous. Sawfly adults are black with yellow markings.
 - ii. Control: Use insecticide according to label recommendations for currantworm on gooseberries.

- e. Two-spotted spider mite
 - i. Damage: Adults are 1/5 inch long, tan or greenish in color with two spots on each side of the back. They overwinter as adults on weeds and debris near host plant. Feeding reduces plant vigor and causes stippling on leaves. Webbing, when severe, may cause leaf drop.
 - ii. Control: Insecticidal soap.

X. Elderberries

- A. Elderberries belong to the genus *Sambucus* and grow wild over much of the United States and Canada. The blue or black varieties are edible. The fruit, born in flat clusters, makes excellent jelly, jams, pies, and wine. Most elderberries require cross-pollination, and all are hardy to Zone 4 (-30° to -20°F).
- B. Cultivars in Idaho
 - 1. *Adams*—A strong plant with huge clusters, this variety produces sweet fruit.
 - 2. *Johns*—This variety bears later than the Adams and produces best when it has been cross-pollinated. It also has huge clusters of large, sweet fruit.
 - 3. *Nova*—Pollinate the Nova with the York. The plant produces large, sweet fruit.
 - 4. *York*—This hardy, late plant produces the juicy, sweet fruit that is the largest fruit of any elderberry. Pollinate the York with the Nova.
- C. Culture
 - 1. Soil—The elderberry grows on about any soil type, but prefers moist, well-drained, siltloam soils, neutral to slightly acidic.
 - 2. Irrigation and fertilization—The plants need to stay evenly moist. Fertilize lightly, as the root system is shallow.
 - 3. Weed control—Elderberries can be grown in sod. Mulch with 4 to 6 inches of sawdust to control weeds and conserve moisture.
 - 4. Propagation—Plants are spread by stolons. Propagate with hardwood, greenwood, or root-cuttings.
 - 5. Pruning—This vigorous plant requires pruning to control size and maintain productivity. Cut a few main shoots to the

ground each year. Prune out all wood more than 4 years old.

D. Common Plant Problems—Diagnosis and Control

- 1. Diseases—None.
- 2. Insects—None.

XI. Grapes

- A. Grapes account for one-fourth of all fruit production in the world. They are used for wine and juice, preserves, and are eaten as raisins or table fruit.
 - 1. Grape production in Idaho is limited by cold winter temperatures and, in many locations, short growing seasons.
 - 2. All grapes in the Genus *Vitis* have vines that are generally vigorous and deep rooted. Grape varieties are self-pollinated. Fruit is borne on current season's growth.
- B. Cultivars in Idaho
 - 1. Types of grapes
 - a. European (*Vitis vinifera*): European varieties produce a tight-skinned wine, raisin or table grape. Quality wine types are made from them. Most viniferas require a mild winter such as those in California or Arizona (hardy only to about 10°F). Thompson seedless falls in this group and will not be hardy in Idaho.
 - b. American (*Vitis labrusca*): American varieties have a slip skin and a musty or "foxy" flavor. The Concord is a typical example. Some are quite winter hardy.
 - c. French and American hybrids: These are crosses intended to combine the quality of European grapes with the hardiness and disease resistance of American grapes.
 - 2. Cultivars
 - a. *Betas*: This plant is a productive American blue-black variety with a tangy, wild grape flavor. It is good for jelly and juice and is hardy to -40°F.
 - b. *Black Monukkas*: While this grape is one of the hardiest of the European plants, it still requires winter protec-

tion in many parts of Idaho. The fruit is large, reddish-black, and mostly seedless. It is sweet and good fresh.

- c. *Campbell's Early* (Island Belle): A Concord type with early fruit, this variety is good for juice.
- d. *Concord*: An American, blue-black plant with a vigorous, hardy vine, this variety is cold-resistant to -15°F. The fruit has a distinctive flavor.
- e. *Fredonia* (Early Concord): Another American variety similar to the Concord, though it bears fruit earlier, this plant is hardy to -40°F.
- f. *Himrod*: An American variety with a golden yellow, seedless fruit, this grape makes a good table grape. The Himrod is hardy to -15°F.
- g. *Interlakan Seedless*: A sister of Himrod, the plant is similar, but more productive. It is hardy to -15°F, vigorous, and disease resistant.
- h. *Reliance*: The Reliance produces a fine quality, seedless grape that is pinkish-red in color and has an excellent sweet, fruity flavor. This variety is disease resistant and hardy to -34°F.
- i. *Van Buren*: An American Concord, this sweet table grape is hardy to -20°F.
- j. *Worden*: Another American Concord, except larger and darker, this variety is good for juice and jelly and good served fresh. Worden is disease resistant and hardy to -50°F.

C. Culture

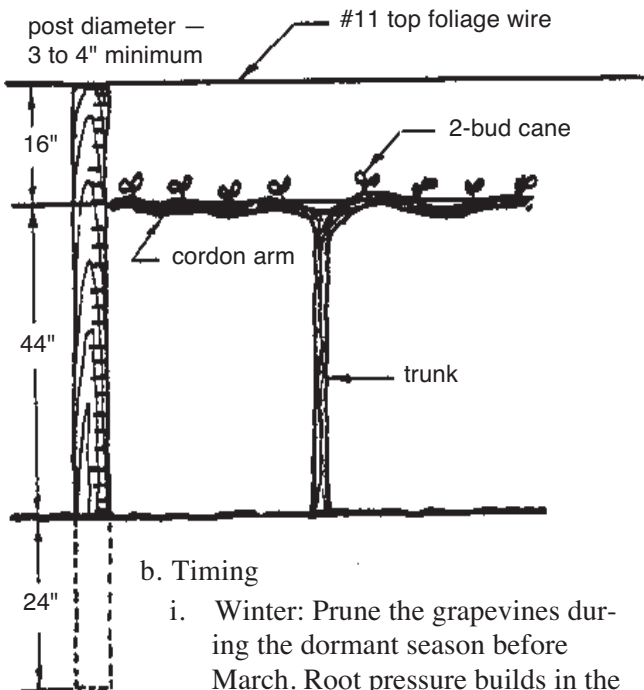
1. Planting

- a. Plants: Many plants are produced from dormant cuttings. Some cultivars are budded or grafted onto disease, insect, and nematode resistant rootstocks. Rootstocks can modify vigor (increase or decrease) and provide tolerance to a wide range of soil conditions.
- b. Soil: Grapes require a deep, well-drained soil for their extensive root system. Highest yields are on sandy loams. Grapes worldwide are planted on an extreme range of soil types.

Rootstock may be necessary to tolerate some soils.

- c. Spacing: Depends on the vigor of cultivar, soil, and training system used: 8 feet for American grapes and 6 feet on poor soils (sandy or gravelly) and 9 feet plus for vigorous European grapes.
 - d. Orientation: Maximize sunlight; plant on a south-facing slope; place rows north to south.
2. Irrigation—Required for most sites in Idaho.
 3. Fertilization
 - a. General: Nitrogen fertilizers are detrimental to a fruit set. Most vines have over-vigor problems. Only very old or stressed vines may require nitrogen boost.
 - b. Potassium and phosphorus: Needs are low. See Subsection D, “Common Plant Problems: Diagnosis and Control.”
 - c. Micronutrient: Boron deficiencies are common. See Subsection D on common plant problems.
 4. Training and pruning
 - a. Types
 - i. Cordon or spur pruned (Fig. 4): Permanent canes or cordons are trained on a wire 40 to 45 inches from ground. Spurs are established along a cordon which bear fruiting canes each year. A second wire, placed at a height of 5 feet, is used to tie up fruiting canes in midseason.
 - ii. Cane-renewal system or Kniffen training (Fig. 5): Probably the best system for the homeowner in Idaho. A strong trunk is developed up to the second wire with spurs established at the trunk near the wires. Two canes with 10 to 12 buds are left as fruiting wood on wires; two to four spurs are left on the base of the cane to grow renewal wood.

Fig. 4. Bilateral cordon training on vertical trellis.



b. Timing

- i. Winter: Prune the grapevines during the dormant season before March. Root pressure builds in the spring and that leads to “bleeding” of water from plants. This has little harmful effect on plants, but it is best to avoid this period.
- ii. Summer: Vigorous vines require summer maintenance. Yearly removal of suckers from the base of the plant or on the trunk below the first wire is needed.
- iii. Pinching or heading back: The current season’s canes will top the wire and flop into the row. Head back to keep plant upright and to prevent shading of clusters.
- iv. Leaf removal: On late season grapes, remove leaves near clusters to provide air circulation and to lessen the chances for the development of bunch rot. Normally detrimental to overall vine vigor due to low sunlight.

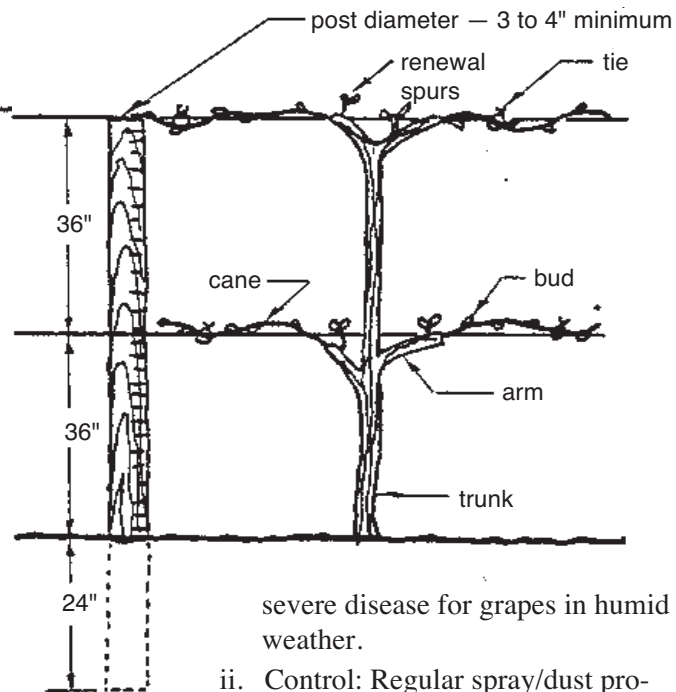
D. Common Plant Problems—Diagnosis and Control

1. Diseases

a. Powdery mildew

- i. Symptoms: This disease is the big limiting factor to home production of European grapes. It is the most

Fig. 5. Two-wire vertical trellis Kniffin trained.



severe disease for grapes in humid weather.

- ii. Control: Regular spray/dust programs of sulfur are essential. Use according to the label. Many recommended American grape varieties are resistant.
- b. Botrytis mold: “Noble rot” for producing a late harvest, sweet wine on many white wine varieties. Not desirable most of the time.
- i. Symptoms: Early infections cause spotting on leaves, or infection sites on cluster stems. Bunch rot also occurs during the late season on ripening grapes.
 - ii. Control: Fungicide sprays according to the label for botrytis on grapes.
2. Insects
- a. Caterpillars: Includes cutworms.
 - i. Symptoms: Feed on buds and shoots.
 - ii. Control: Pick off at night or use *Bacillus thuringiensis* (B.T.).
 - b. Scale
 - i. Symptoms: The scale may be round to oblong depending on species and may also have waxy excretions.

- ii. Control: Apply insecticide according to the label instructions for scale on grapes.
- c. Leafhoppers
 - i. Symptoms: These torpedo-shaped insects hold their wings in a rooflike position when at rest. They cause leaf injury and secrete honeydew.
 - ii. Control: Insecticidal soap sprays.
- 3. Other
 - a. 2,4-D injury: Grapes are very susceptible to damage by 2,4-D. It has been known to drift for miles and to affect plants.
 - i. Symptoms: Terminal growth can be misshapen; venation becomes parallel and fan-shaped; young leaves are thickened and distorted.
 - ii. Control: Avoid 2,4-D use around grapes. Wait for plants to grow out of problem.
 - b. Boron deficiency
 - i. Symptoms: There will be a light set of fruit, while the flower clusters will be affected with a “burning off.” Terminal shoots may die in early summer, or show leaf chlorosis. Some European grapes are particularly affected.
 - ii. Control: Soil or leaf analysis is recommended and foliar sprays of soluble boron should be applied to correct the deficiency.
 - c. Potassium deficiency
 - i. Symptoms: Chlorosis of outer margins of leaves will leave a dark green area (Christmas tree effect) in the center of leaf and brown spots on the margins.
 - ii. Control: Apply potassium.

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- Jennings, D. L. *Raspberries and Blackberries: Their Breeding, Diseases and Growth*. Academic Press, Inc., San Diego, CA.
- Galletta, G., and D. Himelrick. *Small Fruit Crop Management*. West Nyack, Prentice Hall, New York, NY.
- Shoemaker, James S. *Small Fruit Culture*. AVI Publishing Co., Westport, CT.
- Stebbins, Robert L., and Lance Walheim. *Western Fruit Berries and Nuts*. HP Books, Inc., Tucson, AZ.
- Westwood, Melvin N. *Temperate Zone Pomology*. W. H. Freeman and Co., San Francisco, CA.

Booklets and Pamphlets

USDA

- Farmers Bulletin No. 2165: Growing Raspberries.
Farmers Bulletin No. 2236: Commercial Strawberry Growing in the Pacific Coast States.

University of Idaho

Small Fruits

- EXT 739 Berry Varieties for Idaho (\$2.00)
CIS 932 Blueberry Production: 1992 (50¢)
BUL 815 Growing Blueberries in the Inland Northwest & Intermountain West (\$3.00)
BUL 821 Growing Western Huckleberries (\$2.50)
PNW 215 Highbush Blueberry Production (\$16.50)
CIS 628 Insects and Mites Destructive to Berries (50¢)
CIS 815 Northern Idaho Fertilizer Guide: Blueberries, Raspberries, Strawberries (web only)
CIS 979 Publications and Organizations for Small Fruit Producers (50¢)

Strawberries

- BUL 810 Growing Strawberries in the Inland Northwest & Intermountain West (\$2.50)
CIS 931 Strawberry Production: Overview (50¢)

Raspberries

- CIS 341 Crumbly Fruit in Raspberries (25¢)

Further Reading

Books

Childers, Norman F. *Modern Fruit Science*. Horticultural Publications, Gainesville, FL.

CIS 789 Diseases of Raspberries in Idaho (35¢)

Raspberries (cont'd)

BUL 812 Growing Raspberries and Blackberries in the Inland Northwest & Intermountain West (\$2.50)

CIS 960 Raspberry Production: Overview (50¢)

CIS 847 Virus and Nematode Diseases of Raspberries (35¢)

Grapes

CIS 790 Backyard Grapes (\$1.00)

RES 162 Contribution of the Grape and Wine Industry to Idaho's Economy (\$2.00)

BUL 828 Economic Feasibility of Growing Wine Grapes in Idaho (\$5.00)

CIS 1043 Selecting Grape Cultivars and Planting Sites in Idaho (\$1.00)

Kiwifruit

PNW 507 Growing Kiwifruit (\$3.50)

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Washington State University

Small Fruits

EB 0708 Small Fruits for Home Gardens (50¢).

EB 1015 Small Fruits and Berries: Insect Disease Control for Home gardens (50¢).

EB 1082 Raspberry and Strawberry Root Rots in Home Gardens (50¢).

EB 1388 Small Fruit Pests: Biology, Diagnosis and Management (50¢).

Grapes

EB 0637 Trellising and Training Grapes for Production in Washington (50¢).

EB 0775 Growing Grapes for Wine and Table in the Puget Sound Region (50¢).

EB 1615 Critical Temperatures for Concord Grapes (50¢).

Blueberries

PNW 0215 Highbush Blueberry Production (\$1.00).

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Slides

Small Fruits, 117 slides, Eugene Memmler, P.O. Box 94475, Pasadena, CA 91109

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Houseplants and Home Greenhouses



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Houseplants and Home Greenhouses

J. A. Robbins

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Houseplant—Any plant grown indoors, typically in a container. There are three groups of houseplants: foliage, flowering, and cactus and succulents.

I. Environmental Conditions and Requirements

A. Plant Needs

Understanding plant needs and existing conditions helps you to be successful with houseplants. All plants don't have the same needs, and average home conditions are basically inhospitable for plants. Normally, conditions are minimally appropriate for a few species. For success you have to be selective and manipulate the environment.

B. Light

1. Lack of light is the major constraint to indoor plant growth.
2. Light intensity refers to the amount of light available at a particular site. It is measured in foot-candles or lux (1 foot-candle = 10.7 lux).
 - a. 50 to 75 foot-candles (fc) are the minimum necessary for plant growth.
 - b. Light is reduced by the reciprocal of the square of the distance from the measured source. In other words, light levels diminish rapidly as you move away from the window or the lighting fixture. For instance, if you measure the intensity of light 1 foot from a window at 100 fc the following applies:
 - i. 1 foot from window = 100 fc.
 - ii. 2 feet from window = $100/2^2 = 25$ fc.
 - iii. 3 feet from window = $100/3^2 = 11$ fc.

- c. An easy way to measure light is with a 35mm camera with a built-in light meter. Set ASA = 100, aperture to f4. Take reading of a white paper or board filling the camera's viewfinder. Light intensity is reciprocal of appropriate shutter speed (e.g., $1/100 = 100$ fc). Hand held light meters designed for photography will accomplish the same task.

3. At low light levels, most common houseplants are classified as long term perishable and should be replaced every 2 years or so.

4. Increasing light

- a. Move your plants to a sunnier window with less overhang, less shading from trees, and a southern exposure.
- b. Move your plants closer to the window.
- c. Provide reflected light to plants by using white walls and mirrors.
- d. Provide artificial light (see section "VIII-h" on greenhouse lighting).
 - i. Fluorescent bulbs provide low intensity light. For example a 40 watt bulb at a distance of 2 feet only provides 50 fc of light.
 - ii. Incandescent lights are also low intensity. A 60 watt bulb at a distance of 2 feet provides 17 fc of light.
 - iii. High intensity lights such as mercury vapor, sodium, and metallic halide provide significantly higher levels of light intensity.

- iv. Most non-flowering foliage houseplants benefit from receiving light 12 to 16 hours/day.
5. Symptoms of light anomalies.
 - a. Low light: Plants not receiving enough light become weak, spindly, and have long distances between nodes. Leaves turn yellow and drop, usually beginning from the bottom of the plant. Growth ceases. Variegated plants revert to solid green.
 - b. High light: Plants receiving too much light have leaves that are light colored. The old leaves curl under and develop brown scorched spots or margins. New leaves are thickened.
- C. Temperature
1. Most indoor plants are of tropical origin and do not do well in cold temperatures.
 - a. Most plants will tolerate a fairly broad range (55° to 85°F).
 - b. Plants prefer 75°F days and 65°F nights (in general, 10 degrees cooler at night than in day).
 2. The direction the window faces affects temperature. South and west facing windows receive more sun, so tend to be warmer than east and north facing windows.
 3. Plants lose heat, or radiate, to anything colder. Place sheets of newspaper between plants and windowpanes on frosty nights to avoid cold damage to houseplants.
 4. Symptoms of temperature anomalies.
 - a. High temperatures: If a houseplant is receiving too much heat the leaves will turn yellow, wilt, drop, or scorch.
 - b. Low temperatures: If temperatures are too low, leaves will curl up, turn brown, and drop off.
- D. Humidity
1. Most houseplants prefer a high relative humidity. However, many will adapt to low levels of humidity.
 2. Heating systems differ in drying air. Normal humidity inside buildings (especially in winter) is much lower than the lowest range tolerable for good plant growth.
3. Methods to raise humidity.
 - a. Group your houseplants together to use the water vapor created by transpiration of other plants to increase the humidity level.
 - b. A gravel tray beneath the houseplant pot filled with water will provide extra humidity as the water evaporates. Be sure that the base of the pot sits on the top of the gravel and does not touch the water.
 - c. Humidity can be increased around a houseplant by misting. However, the effect is very short in duration and must be repeated frequently for any beneficial effect.
 - d. Place plants in areas of high humidity, such as the kitchen or bathroom.
 - e. Provide a double pot for your houseplants. Place moist sphagnum moss between the inner and outer pots to provide extra humidity.
 - f. Increase the humidity level in the entire room with a humidifier.
 4. Methods to lower humidity.
 - a. Ventilate the area around the houseplant by opening doors and windows and by using fans and air conditioners.
 - b. Be sure not to over water plants or have water standing in trays beneath pots for any length of time.
 5. Symptoms of humidity anomalies.
 - a. Low humidity: Plants growing under low humidity may develop brown leaf tips and yellow leaf margins. The plant may have stunted growth, or none at all, and will display signs of bud and leaf drop, shriveling, and wilting.
 - b. Excessive humidity: Too much humidity will cause the plant to decay and rot. Its leaves and stems will darken, be susceptible to bacterial and fungal invasions, and show soft wilt.

E. Irrigation

Irrigation is the most important and most abused cultural practice with houseplants. Water relations are much more critical for potted plants because of their limited root space and the necessity for soil aeration.

1. Water requirements vary by plant species from constantly moist to mostly dry. You need to know individual plant requirements, which can be learned by consulting a reliable reference.
2. Water use is dependent upon a number of factors.
 - a. Ratio of foliage to pot size: A large plant in a small pot may need to be watered daily due to the large amount of water lost and the small soil reservoir.
 - b. Potting media: Sandy potting soil will hold less water than soil with peat or other organic matter. Plants in a sandy mix will need to be watered more often.
 - c. Temperature: If temperatures are high, houseplants transpire freely, and water will evaporate rapidly from the soil surface. Plants in warm conditions will need to be watered more often.
 - d. Humidity: Plants in dry air will transpire more and will need watering more often than those in moist air.
 - e. Air movements: Plants located in a breeze will transpire more and will require more water.
 - f. Light: Plants that are photosynthesizing will be exchanging gasses through open stomates and will allow transpiration to occur. Plants in brighter light areas, therefore, will require more water than those in dimly lit areas.
 - g. Plant species: Some plants simply need more water to grow and be healthy than others.
 - h. Container porosity: Clay and unglazed ceramic pots “breathe” and will lose water more quickly than glass, glazed ceramic, or plastic pots, so plants in clay and unglazed ceramic pots will need more water.
3. Water quality varies, particularly in the amount of soluble salts present. Well wa-

ter in Idaho is often “hard.” Many softening processes replace the calcium in the water with sodium that is damaging to houseplants; thus, be sure to water houseplants with water that has not been softened by this method. The amount of chlorine found in city water systems generally is not sufficient to cause problems with houseplants. Alkaline water makes growing acid-loving plants such as azaleas and gardenias difficult. Generous use of acidic peat moss and acid-reacting fertilizers will help offset the alkaline content in the water.

4. All containers should have drainage. Lack of drainage saturates the soil and excludes air from the roots. This condition leads to root rot.
5. Water temperature is important. Many houseplants are tropical, and adding cold water to their roots can harm them. African violet and other gesneriad leaves will be bleached by cold water. To avoid problems, water your houseplants with barely warm or tepid water.
6. Methods to determine the relative amount of water in a pot include checking with a finger one inch or so below soil surface for moistness, comparing the “heft” or weight of the pot, or tapping the side of the pot and listening for a hollow sound. The main thing is to check plants regularly.

Note: Inexpensive moisture meters actually measure conductivity (salinity) of the soil and are not reliable.

7. The amount of water held and available is dependent upon media ingredients. Peat moss, field soil, and vermiculite hold the most. Sand, perlite, and pumice hold the least.
8. Symptoms of water-related anomalies.
 - a. Not enough water: Foliage of broad-leaved plants darkens and turns crisp; the lower leaves will drop, and plants gradually wilt. The leaves and stems of succulent plants turn pale and shrivel.
 - b. Too much water (or insufficient drainage): Leaves curl, wilt, blacken, and

drop. Corky scabs or protrusions form on the undersides of leaves or on branches. The leaves and stems become soft and the roots rot.

F. Fertilization

1. Nutrients needed for plant growth are generally obtained from “real soil” that your potting mix does not usually contain.
2. There is a limited supply available to houseplants because of the finite size of the pot. Also, the potting soil is usually “artificial” mix that contains little to no nutrients.
3. The best method is to provide a constant supply of nutrients at relatively low levels.
 - a. Nutrients will be particularly important during periods of growth.
 - b. Don’t over fertilize. You will get lanky growth, fertilizer burn, and the possibility of root damage.
 - c. During the winter months, when home temperatures are apt to be cooler and days are short, decrease or eliminate fertilization to give plants a short rest of 2 to 3 months.
4. There are many types of fertilizers. It is best to use a complete fertilizer that provides nitrogen, phosphorus, potassium, and micronutrients such as iron.
 - a. No one type of fertilizer is better than the others. Slow-release granules let out a little fertilizer at each watering. Dry fertilizers or fertilizers that dissolve in water can be applied.
 - b. Organic forms such as fish emulsion will provide micronutrients and low amounts of nitrogen. Fertilizer burn is less likely with an organic source.
5. It is best to fertilize with soluble inorganic fertilizers when the soil is already wet. This way there is less of an uptake shock and, subsequently, less possibility of root damage and/or fertilizer burn.
6. Fertilizer is not a cure-all; it will not make a sick plant healthy. In fact, fertilizing a plant with disease or other stress and, hence, forcing growth may be the final stress that kills it.

7. Nutritional deficiencies

a. Macronutrients

- i. Nitrogen (N): Lack of N results in a stunted plant with yellow leaves; older leaves fade first, then turn brown and die.
- ii. Phosphorus (P): Lack of P results in retarded growth. The plant remains a deep green leaf color until it turns purple or bronze (or mottled in light and dark tones). The symptoms are apparent in older leaves. Another symptom is retarded flowering.
- iii. Potassium (K): Lack of K creates tip and marginal burn on lower leaves. These burns advance up the plant. The leaves crinkle and turn inward, and the plant stops growing.

b. Micronutrients

- i. Deficiencies in anything more than N, P, K, or iron are unusual. If the addition of a balanced fertilizer doesn’t cure deficient symptoms, repot plant in new soil and resume a regular fertilizer schedule.
- ii. Iron (Fe): Leaves turn yellow, while veins remain green. The plant will have stunted growth and curled leaves.
- iii. Excess chlorine (Cl): Too much chlorine causes thickened leaf tissue, which becomes brittle. Great excesses of Cl burn and destroy plant roots.

G. Salt Damage

Salt damage is a common problem in house plants, and steps must be taken to avoid it in order to have healthy plants.

1. Salt build up is indicated by a crusty white substance coating the top of the soil or the rim of the pot.
2. Salt build up is caused by repeated fertilizing, giving plants too little water at a time, high salt concentrations in tap water, and poor drainage in pots.
3. The symptoms of salt damage are easy to spot.

- a. Plants will not grow well.
- b. Leaf tip and marginal leaf burn are evident. Roots are burned and deteriorated. You may also see thick, dwarfed leaves with sunken breathing pores on leaf undersides.
- 4. To avoid salt build up in pots:
 - a. Do not water houseplants with water softened by sodium salts
 - b. Water plants with distilled water; it contains no salts or minerals.
 - c. Flush excess salts out of pots periodically (monthly) by watering heavily and repeatedly until water pours out of the drainage holes.
 - d. Repot plant in new soil and new pot.
 - e. Wash old pots well before reusing for houseplants. Soak clay pots in several changes of clean water to flush out salts absorbed by the clay.

H. Overall Environmental Factors Affecting Plant Growth

- 1. Plants are living things. The keys to healthy houseplants are to minimize stress and provide a favorable environment with minimal variation.
- 2. Don't overcorrect. Don't make up for underwatering with overwatering. Don't make up for lack of light by placing plant in direct sun. Shocks like this will not benefit growth.

II. Media, Containers, and Potting

A. Root Media

- 1. Because of the physical limitations of the container, houseplants need specialized media. Do not use straight field soil. It lacks correct physical properties. It is best to buy a potting mix from a garden center.
- 2. There are some important properties to consider when choosing a container media.
 - a. Roots need air to grow, so the percentage of air-filled space for houseplant soil needs to be 10 percent or more.
 - b. Container media needs to hold enough water to supply what the plant needs. Pure sand makes a poor container media, as the soil must hold water equal to 40 percent of volume or more.

- c. Container media needs to be able to hold nutrients (have a high cation exchange capacity). Organic matter will help increase nutrient-holding capacity.
- d. The pH (acid balance) of the soil needs to be favorable for houseplant growth. A pH range of 5.5 to 6.5 is best.
- e. Container media must be free of diseases and toxic substances.

B. Container Choice

- 1. No one container material is better than another, but each container type requires different management. All containers require drainage holes at the bottom.
- 2. Basic container materials.
 - a. Clay pots are attractive, and plants grow well in them because they breathe and allow air exchange through their walls. As a result, they will dry out faster than other types of pots, and plants will require more frequent watering. They also tend to accumulate salts in their walls because of the evaporation. These can be flushed out of empty pots by soaking them in several changes of clean water.
 - b. Plastic pots are readily available and come in colors to complement your decor. They are impervious to water, and their walls do not breathe. Because of this, soil aeration of the media is particularly important. The soil will also hold the water longer, so less frequent watering will be necessary.
 - c. Fiber pots are inexpensive and rustic looking. They are porous and allow a limited amount of air and water exchange. The bottoms of these pots tend to break down and fall apart over time.
 - d. Wooden pots are attractive but they tend to leak out of the cracks if not lined with a plastic interior. When lined, they essentially become a plastic container.
- 3. When using saucers, it's best to lift the pot above the saucer so that after irrigation the pot doesn't sit in drained water. If it does sit in water, be sure the water is all taken up within an hour or two. Sitting

in water for days at a time will cause the soil to be saturated, which will eventually kill a plant. Decorative containers that hold the entire pot (jardinieres) can be used and should be treated just like saucers.

4. When reusing containers, be sure to clean them well to reduce any carryover of insects or diseases found in plant parts or old soil clinging to the plants. Soaking clay pots in fresh water for several days will leach out any accumulated salts. Scrub other pots with a stiff brush and detergent, and rinse in a solution of bleach.

C. Repotting Houseplants

1. There should be a balance between top growth and container size. Too small a container will cause rapid water loss, and too large a container will keep the soil saturated and lead to root problems.
2. When potting, cover the drainage hole with old nylon stocking or pottery shard to minimize soil loss when irrigating. Do not use gravel in the bottom as it only reduces the effective pot size and does not help drainage.
 - a. Do not press or tamp soil firmly in pots as this reduces aeration. Rather, tap the filled pot on a table to settle soil and remove air pockets.
 - b. Leave a 1-inch head space at the top of pots for irrigation.
 - c. Media containing peat moss that has gotten bone dry may need to have the moisture kneaded in before using it for potting. If this isn't done, penetration of the water in the repotted plant will be extremely slow until the peat absorbs the water. In the meantime the roots are completely dry.
 - d. Water immediately after potting. It's best to irrigate two times to be sure soil is settled well around the roots and that the media is completely wetted.
3. Repot if compacted or salt-filled soil, poor drainage, soilborne insects, inadequate nutrition, and crowded roots.
 - a. Move up only one pot size at a time. A general rule is to make the internal size of the container about 1 inch larger all around than the old pot.

- b. Replant the plant at the same level on the stem as in an old container.
- c. How often to repot depends upon the plant's rate of growth, root condition, and media characteristics.

4. Terrariums typically have no drainage, so use activated charcoal at the bottom of the container and water less.

III. Controlling Size and Shape

A. Phototropism

Houseplants orient their leaves toward a fixed light source. To keep a balanced shape, rotate plants frequently.

B. Pinch

Frequently remove terminal growth such as vines and branching plants to keep them bushy and within bounds.

IV. Diagnosis of Problems

A. Be Observant

1. In diagnosis the most difficult task is not to jump to conclusions. Don't be absolute, even though the problem seems obvious. This is particularly true if you are being guided by a description of a problem without actually seeing the plant.
2. Ninety-five percent of all problems with houseplants have to do with light, water, humidity, and fertilization. Frequently, the problem is a combination of these factors. Diseases are usually a result of some environmental stress.
3. Be methodical in your questioning. Ask step-by-step questions about plant care and conditions.
4. Learn to ask questions the right way. Not, "Are you watering correctly?" Rather, "How often do you water?" Get a quantitative answer that will help you decide if the watering is correct.
5. Look at the roots of the plant. Roots should be healthy and growing.
6. Symptoms overlap so brown tips on the ends or edges of leaves are symptomatic of several problems. It is up to you to ferret out what is causing them.

V. Insect Pests

Watch for insects when you introduce new plants to a home. Most insects are brought in with new plants and plants that have been outside in the summer. They also hitchhike in on pots, equipment, and your clothes, shoes, and person.

Pests have preferences for certain plant species. Thus, some plants are more prone to insect problems.

A. Major Insect Pests

1. Aphids—These are soft bodied, small round insects that mass around growing tips and tender tissue. Aphids suck plant juices. Their invasion causes deformed and curled new leaves, buds, and flowers. Some carry virus diseases and some species cause galls. They all secrete honeydew, and this is sometimes the first symptom noticed. The honeydew attracts ants who feed on it.
2. White fly—This small white winged fly congregates on undersides of leaves. Small immature crawlers, or larvae, suck sap and secrete honeydew. Adults fly up in a random pattern when disturbed and resettle to the plant surface quickly.
3. Scale—These are small, hard, immobile, disk-like insects. Scales suck plant juices. Their presence causes leaves to develop yellow spots, turn yellow, and drop off. They also have a crawler stage that moves about until it matures. This crawler becomes the disk-like immobile adult that is obvious.
4. Mealy bugs—Mealy bugs are scale insects that are covered with layers of white waxy substance. Mealy bugs look like little cotton pieces. They suck sap, resulting in stunted growth, wilting, defoliation, and eventual plant death. They also secrete honeydew.
5. Spider mites—Spider mites are tiny, eight-legged arachnids that proliferate rapidly in hot dry growing environments. They suck sap, causing pale blotches, loss of color, and dry, rusty leaf textures. The leaves tend to turn gray, yellow, or to be smothered in fine, mealy cobwebs be-

fore dropping off. They can be seen, although they look like moving dust unless viewed with a magnifying lens. They most often congregate on the undersides of leaves.

6. Cyclamen mites—These microscopic voracious feeders cause distorted, blotchy bloom; stunted, twisted, or shriveled stems; and leaves with stunted and compact plant centers. Their presence is often followed by the dropping off of flower buds and streaky, purplish foliage. These mites are difficult to eradicate. As their name implies they are a particular problem in cyclamen, but also affect other houseplants.
7. Leafminers—The larvae of fly, moth, sawfly, or beetle leafminers eat leaf tissue between the upper and lower leaf surfaces causing slender, winding trails, tunnels, and blisters on leaves.
8. Fungus gnats—Light attracts these tiny black flies. The flies zig and zag in irregular flight when disturbed before settling back down on the soil surface. The eggs of fungus gnats hatch into threadlike white maggots that burrow through the soil, embed themselves in root tissue, and eat small feeding roots, root hairs, and crowns of plants. The plants suffer from root rot, slow weak top growth, and yellowing leaves. Root feeding produces wounds that can permit entry of disease organisms.

B. Insect Control

1. It is essential to quarantine all new plants introduced into your home until you are sure they are pest free.
2. Several effective nonchemical insect control methods are available.
 - a. Water: Keep all plant leaves clean by washing or spraying with water. This is especially good for control of aphids. Putting the plant in the bathtub to give its leaves this shower works well.
 - b. Soapy water (use specially formulated insecticidal soaps): Sponge or spray onto leaves. This works well on spider mites and aphids.

- c. Rubbing or denatured ethyl alcohol: Use alcohol on a cotton ball, tissue, or swab to remove insects such as scale and mealy bugs. This works well on large, stiff leaves. Be sure to test first to make sure the alcohol will not damage the leaves, especially on soft, thin, and fragile leaves. This is not practical on something with tiny leaves, and you must be sure to repeat often for complete control.
 - d. Yellow sticky boards: Insects are attracted to the yellow surface and become tangled in the sticky goo on the surface. These are best used early when infestations of flying insects are low. This is a good technique for white fly control.
 - e. Predators: These can be insects, nematodes, or mites. Some of these are very specific. They are effective in reducing pests, but may be difficult to keep on the plant and to maintain.
 - f. Replacement: If pest population is too high or complete control seems impossible, discard the plant and buy a new one.
3. Chemical controls for insects are available.
- a. Use caution when using chemical insecticides. Read the label thoroughly and follow instructions carefully. Not only are excessive rates or unlabeled applications unhealthy for you, but they may cause plant damage or phytotoxicity.
 - b. Use different chemicals for different problems or when one type stops working.
 - c. Be sure to use the chemical that will control the pest you have.
 - d. Understand the life cycles of pests and susceptible stages. If you must repeat applications, follow the timing precisely.
 - e. Some pests have developed a resistance to certain pesticides. If one is not effective, try another from a different chemical group. Do not increase dosage.

VI. Plant Diseases

Diseases usually occur in plants that are stressed by unfavorable environmental conditions. The most common stresses are high or low temperatures, overwatering, low light, overfertilizing, open wounds, air pollution, and excessive humidity.

Parasitic organisms, bacteria, or fungi can cause disease in houseplants.

A. Common Diseases

1. Anthracnose—This fungus is characterized by depressed leafy spots with dry centers. The entire end of the leaf may turn dark tan with darker bars crisscrossing the leaf.
2. Crown and stem rot—These fungal diseases cause stems and bases of affected plants to turn soft and mushy to the touch.
3. Damping-off—This disease is caused by a soilborne fungus that attacks the lower portion of the seedling stems, which then collapses. The leaves turn inward and look pinched. The seedling wilts and dies.
4. Leaf spot—This disease creates yellow-margined spots with dark brown or black damp or blistered centers. Bacterial or fungal invasions cause leaf spot.
5. Mildews and molds—Black sooty mold on leaves appears as black coating and can be associated with honeydew secreted by aphids, mealybugs, and scale. A white or grayish felt-like coating on foliage is mildew. It causes leaves to curl and shrivel. A gray or white mold on the soil surface can be fungus caused.
6. Root rot—Root rot invades roots and diminishes roots' ability to absorb water. This rot is fungus-caused. It damages new growth, which dies back. The entire plant eventually wilts and dies.

B. Disease Control

1. Correct the environmental conditions that are allowing the disease to thrive. For instance many rots thrive in excess water. Treatment is to lower the humidity and cut down on watering.

2. Pick off and destroy infected leaves and plant parts. Repot or replant in new media.
3. Apply fungicidal dusts or drenches as recommended, following label instructions for the specific disease.

VII. Propagation

A. Clone

Vegetative or asexual propagation produces a clone of the plant that you propagate from.

1. This is the most common commercial technique. It is fast and ensures genetic consistency. It is also easy to do.
2. Propagate by using cuttings from the stem, leaf, offsets, or stolons.
3. Air layering can be done with many plants by scoring the stem, wrapping with damp sphagnum moss, and enclosing in a plastic covering secured above and below by a loose tie.
4. Factors to consider when propagating houseplants:
 - a. Be sure to start with vigorous, healthy plants.
 - b. Use sterile, well-aerated rooting media. Most packaged mixes are sterilized before packaging. Peat mixed with either perlite or vermiculite makes a good rooting media.
 - c. Pieces of plants cannot be under water stress while roots are forming. To maintain a good water balance, remove part of leaves on large-leafed plants, and raise humidity with enclosure or mist.
 - d. Cuttings and newly rooted plants need light for photosynthesis. However, cuttings should not be in direct light unless they are under an automatic mist system. Newly rooted plants should be eased into high light situations gradually.
 - e. Bottom heat (heat at root zone) helps plants to root. A temperature of 70° to 75°F with an air temperature of 60° to 65°F is ideal. Use a heating cable or mat to provide bottom heat.
 - f. Use rooting hormones to stimulate root initiation and growth. These are ap-

plied as a dry powder or a solution in which the cutting is dipped.

- g. When placing cuttings in media, be careful not to wipe off the hormone.
- h. When roots have grown on cuttings to where they are large enough to support the cutting, transplant quickly since there is less transplant shock for small root systems.

B. Uniqueness

Seed or sexual propagation may produce an individual similar to the mother plant. With cross pollination, however, variation will occur, and the resulting seedlings will all be unique individuals.

1. With seed propagation you can produce more plants. Plant breeders use this method to produce new varieties using the variation produced by seedling variation.
2. Some seeds need a presowing treatment to break dormancy.
 - a. Stratification, or a moist cold treatment, is needed for some.
 - b. Scarification, or scratching or breaking down the seed coat, is needed for some.
3. Seeds from different species of plants have different light and temperature requirements.
4. Be sure to use sterile media to avoid seed rot and damping-off of seedlings.
5. Transplant seedlings when they become crowded. Be sure to lift plants by a leaf, not by the tender stem or growing tip.

VIII. Greenhouses

A home greenhouse is a satisfying addition for the home gardener. Many plants will grow in greenhouses including annual bedding plants, forced bulbs, cacti and succulents, geraniums, gloxinia, orchids, and tropical foliage plants. You can grow vegetables and fruits such as cucumbers, eggplant, lettuce, onions, peppers, radishes, strawberries, and tomatoes in a greenhouse.

The various plants require different temperatures and light conditions, so the size of the greenhouse and its cooling and heating equip-

ment may restrict the greenhouse grower to certain plants. Providing proper growing conditions is essential for successful greenhouse gardening.

A. Types of Greenhouses

1. Attached lean-to—Built against a building, this greenhouse uses the building's walls for one or more of its sides. Usually, the width is limited to a total of 7 to 12 feet.
2. Attached even-span—Similar to a free-standing structure, this greenhouse is attached at one gable end to a house or other structure. They are larger and more flexible than the lean-to type.
3. Attached window-mounted—This reach-in unit replaces a window and is ideal for growing a few plants at low cost for heating and cooling.
4. Free-standing—Set apart to get the most sun, this type of greenhouse can be as large or small as desired. With many shapes or frame types available, this type of greenhouse is the most costly to build and maintain.

B. Location and Orientation

1. Light—Get the most light by placing the attached greenhouse on the south or southeast side of the structure. The east side is the second best location followed by southwest and west. A north exposure is the least desirable. Locate free-standing greenhouses where large trees, other buildings, and obstructions will not shade them.
2. Shelter—Locate small greenhouses in a sheltered area to reduce wind-related heat losses. A windbreak or building located far enough away so as to not shade the greenhouse will provide shelter. Choose a site that has access to electricity, water, and an energy source for heat.
3. Orientation—Once you have selected a site, orient the greenhouse to make the most of the available light. An east-west orientation (with the ridge of the house running east and west) is preferable, especially during the winter when light is most critical.

C. Design and Construction

1. Shapes—Many styles of greenhouses are possible, such as Quonset, dome, gothic arch, A-frame, slant-leg, gable roof, and tripartita. Plans, kits, or finished houses are available from a variety of sources.
2. Frames
 - a. Wood: Wood contributes to uniform greenhouse temperature because it does not cool down quickly. Use a wood resistant to decay, pressure treated, or treated with non-toxic water-borne, salt-type preservative.
 - b. Steel: Provides a more solid structure than wood and lets more light into the greenhouse. You must paint steel frames to prevent rust.
 - c. Aluminum alloy: Lightweight and strong, aluminum frames offer a high degree of light reflectiveness and require little maintenance. They transmit heat readily, resulting in greater heat loss.
 - d. Plastic: Light, strong, and readily available, plastic (especially PVC pipe) is good for hoop-house construction.
3. Covering materials
 - a. Glass: Use extra strength or tempered glass. Attractive, permanent, and expensive, it requires periodic recaulking. Leave construction to a manufacturer because glass is difficult to fabricate. A single layer has 90 percent light transmission.
 - b. Plastics
 - i. Rigid plastic: Resists breakage, is lightweight, and easy to install. Most degrade under sunlight.
 - ii. Polyvinylchloride (PVC): Available in UV-treated form, PVC allows 88 to 90 percent light transmission. It is flexible, comes corrugated or flat, and lasts 2 to 7 years.
 - iii. Clear acrylic (Plexiglas, Perspex, Transpex, and Lucite): Half as heavy as glass, acrylic plastics resist impact and are flexible but expensive. All but Lucite scratches.

Most types are available in double-walled panels that will last 20 years and allow 90 to 95 percent light transmission.

- iv. Polycarbonate: More flexible and less expensive than acrylic, polycarbonate plastic yellows and loses transparency with age.
 - v. Film plastic: Inexpensive, but temporary, film plastic requires more maintenance. Ultraviolet (UV) radiation will destroy it if not treated with a UV inhibitor. Use double layer to reduce heat loss.
- c. Polyethylene
- i. Regular polyethylene: Not recommended because of its short life span (9 to 12 months). Stronger with increasing thickness, it usually splits on the fold. Allows 85 to 88 percent light transmission.
 - ii. UV-treated polyethylene: Lasts 1 to 2 years. Use 4 to 6 mil thickness. Keep clean to increase winter light; 85 to 88 percent light transmission.
 - iii. Co-polymer films (Monsanto 602): An ethylene and vinyl acetate, co-polymer films are stronger with a life of 2 years. Keep clean for an 85 to 88 percent light transmission.
 - iv. Reinforced polyethylene: Contains glass or acrylic fiber for additional strength and a 2-year life span. Keep clean for an 85 percent transmission.
 - v. Reinforced UV-treated polyethylene: Has similar characteristics to reinforced polyethylene.
 - vi. Vinyl films: Thicker (8 mil) types are hazy. Keep clean because they attract smog and dirt. This tears easily when punctured and will last for about 2 to 5 years. Allows 89 to 91 percent light transmission.
 - vii. Polyvinyl fluoride films (Tedlar PVF and Teflon FEP): An expensive type of film plastic that lasts 7 to 8 years with 92 percent light transmission.
- d. Polyester
- i. Polyester films (Molar, Melinex, and Llumar): This stiff plastic film tears easily when punctured and degrades rapidly in the sun.
 - ii. Acrylic laminated to polyester (Flexigard): Reduced UV radiation breakdown and tearing gives this type of plastic a moderately long life.
- e. Fiberglass
- i. Durable, attractive, and moderately priced, fiberglass is more resistant to impact than glass and much lighter.
 - ii. Use UV-treated fiberglass because the untreated types will yellow with age. If not treated with UV-resistant materials, the fibers become exposed or “fray.” Low maintenance, fiberglass lasts for a year untreated and 15 to 20 years if UV treated.
 - iii. With a 75 to 90 percent light transmission, fiberglass is not recommended for plants with high light requirements in areas with less than 40 percent sunny days in the winter.
 - iv. Fiberglass comes corrugated or flat. It is flammable. Buy only clear (not colored) types of high grade fiberglass.
4. Benches
- a. Side benches: Because you access side benches from only one side, they should be no wider than what you can reach across (generally 2 to 3 feet). Leave about 6 inches between the benches and the side walls for air-circulation.
 - b. Center benches: Because you access center benches from both sides, they can be as wide as 6 feet. Small greenhouses may have room only for side benches.
 - c. Other types: Beds, shelves, and imaginative types of benches are all possible in a greenhouse. Tailor them to your needs and plant requirements.

5. Walkways and flooring

- a. Walkways should be easy on the feet, well drained, and non-slippery.
- b. Use pea gravel, ready-mix concrete, porous concrete, treated wood, brick on a sand bed, porous aggregate, or stepping stones in any combination for walkways and flooring.

6. Heating

- a. Heating capacity will depend on size of greenhouse, the type of covering, and the coldness of the external temperature and wind relative to the desired inside temperature. Attached greenhouses often can use the home heat source for warmth.
 - i. Conventional: You can use coal, electricity, gas, or oil heat sources. You can use these sources to heat the air directly in a forced air system or to heat water for a hot water or steam system. Use an approved flue to vent gas, oil, and coal. Electricity is often too expensive to use.
 - ii. Solar: By capturing the sun's heat in water, stone, concrete, or similar heat-absorbing material, you can heat your greenhouse via radiation during non-sunny periods. You should combine solar heat with other methods such as double walls, covers, and blankets to minimize heat loss from the greenhouse.
 - iii. Blankets and shutters: Movable blankets and shutters can serve as nighttime insulation. They are only as effective as the operator who must faithfully open and close them. You can make these interior insulating systems from black or clear polyethylene film, aluminized fabric, PVC laminate, spun-bonded polyester, foam-backed fiberglass drapery material, woven and lofted polyester, or clear plastic bubble wrap. Fit them on tracks, rollers, or slides or secure with hooks.
Shutters are foam insulation boards that you cut to fit between wall studs and ceiling rafters. Foam with

aluminum foil facing is even more effective. Wood turn knobs or magnetic clips will hold the panels in place. They are more effective than thin blanket materials but are labor intensive to install and require a larger storage space.

- iv. An alternative is external blankets or insulation. They are more expensive to build, however, because they must be weather resistant. Sleet and snow are difficult to remove, and the operator must go outside to install them.

7. Ventilation and cooling

- i. Ventilation: Ventilation equipment will help control temperatures in all seasons. Hand-operated side or roof vents require constant supervision. Automatic ventilation is simple to install and requires only an electric motor, thermostat, and a pulley or gear system.
- ii. Fans provide good ventilation. You can use them alone or in combination with other vents. Vent fans to draw in the outside air or to recirculate internal air. Fans in combination with a polyethylene duct will help to distribute the air evenly throughout the greenhouse.
- iii. Exhaust fans will draw out the heated air. Usually, you install them near the roof line to prevent drafts. Use in conjunction with a second vent such as a louvered shutter that opens when the exhaust fan starts. Place the vent at a lower level so cool air moves across the greenhouse, mixing with warmer air.

Note: Wire all fans to a thermostat set at the temperature desired before beginning ventilation.

- iv. Cooling: When the external air is not cool enough to provide internal cooling for the greenhouse, you should use evaporative coolers or mist blowers to cool the air. Evapo-

rative cooling draws outside air through wet fiber pads that cool the air and add some moisture to it.

- v. Mist blowers use fans that blow mist from a fine jet of water into the greenhouse. The mist cools the air and provides needed humidity. Control all cooling systems automatically with thermostats.
- vi. Shading: Shading can reduce the need to ventilate and cool a greenhouse because it curtails the amount of radiation entering. Shading also protects plants from the direct rays of the hot summer sun and reduces light intensity. Often needed from June to August, you can provide shading by whitewashing the greenhouse, attaching blinds or panels, or by covering the house with shade or saran cloth.

8. Lighting

In the greenhouse, you may need to supplement natural light, especially during the long winter nights. Light controls most plant functions, so it is important to understand the needs of your plants.

- a. Light quality: Plants use red and blue portions of white light for various plant functions. It is important to have red/orange light for germination, maturation, and flower and seed production. Plants use blue/violet light for growth and leaf development. Artificial lights must supply the proper light spectra.
- b. Light intensity: Some plants require bright light to grow, while others prefer shady (less intense light) areas. Light is measured in foot-candles or lux (see section "I.B" on Light).
- c. Light duration: A photoperiodic effect is the response of a plant to the length of the light and dark periods. Flowering is the most dramatic effect associated with the length of exposure to light.
 - i. Short-day plants respond to a day-length of less than 12 hours.
 - ii. Long-day plants respond to a day-length of longer than 12 hours.

- iii. Day-neutral plants do not respond to the variations in the light-dark cycle.
- iv. If you want flowering in certain plants, you need to provide the proper daylength. You do this by extending the days with artificial light, or if the days are too long, by shading the plants with an opaque black cloth supported on a frame.
- v. Do not ever peek into the shaded area, however, as just a "flash" of light will destroy the long-night effect!
- vi. To provide a longer day-length, the light intensity does not need to be as high as it would be for proper growing conditions.
- d. Artificial lights: You can use various types of lamps in the greenhouse. A simple timer is ideal for turning the lights on and off.
 - i. Incandescent: These lamps give off red light and infrared radiation that becomes heat. They are not intense enough to supply light to plants with a high light requirement. Light distribution is restricted.
 - ii. Fluorescent: Fluorescent lamps produce less heat, and different types vary in their output in the red-blue areas. One cool-white and one warm-white bulb provide a good spectrum for plant growth.
 - iii. Mercury vapor, sodium, and metallic halide: These lamps provide high intensity lighting. They are expensive and more suitable to large-scale production.
- e. Watering: In the home greenhouse, the traditional watering method is a mist or spray nozzle on a garden hose. The greenhouse gardener who is gone a lot can install automatic systems, such as mist nozzles, spaghetti tubes, or capillary mats.
 - i. In some areas, water quality is a concern. Water high in salts or high in alkalinity may need special treatment for greenhouse use.

IX. Small Beds for Growing Plants

A. Cold Frames

A cold frame is a bottomless box with a removable lid that you can prop open at various degrees. The lid consists of glass or other greenhouse covering material on a frame.

1. Cold frames do not require artificial heat or manure. They use the sun's heat to warm the soil during the day, and the heat's radiation in the closed cold frame keeps the plants warm at night.
2. During the day, control ventilation and heating by propping open the lid.
3. Use cold frames to plant seeds and produce transplants for main season gardens and for root cuttings.

B. Hotbeds

You can convert cold frames to hotbeds simply by adding a heat source such as manure, electricity, steam, or hot-water pipes. Start seeds or force plants in hotbeds.

1. The amount of extra heat needed depends on available sun and the external temperatures. Soil-heating cable that provides 10 to 15 watts of electric heat per square foot is ideal for most hotbeds. If the bed is in a sunny, well-sheltered location and the climate is not too severe; 10 watts per square foot should be adequate.
2. Attach your heat source to a thermostat or buy a heat cable with one to provide accurate temperature control in the 50° to 79°F range. On very cold nights, cover the beds with extra insulating materials.
3. Adding manure that heats as it decomposes is an effective practice that has worked for centuries. Modern gardeners, however, rarely use manure as a heat source.

C. Cloches

Protecting plants by providing a cloche, or miniature greenhouse, is standard practice for gardeners. The cloche offers only temporary protection until the outside temperature is favorable enough to produce good growth. Hot caps, commercial "Walls of Water," and 1-gallon plastic milk cartons with the bottom cut out are temporary structures that help moderate the temperature around plants.

1. Producing an entire crop under cover of a cloche is practical wherever the weather is unreliable or predominantly cool. Growing a crop in a cloche allows the gardener to produce plants that otherwise may not grow in the area. Cloches are suited to intensively managed gardens and severe climates. The cloche provides a constant warm temperature and prevents wind, rain, frost, and pest damage. They may be only the size of a single plant or large enough to cover several.
2. Cloches can have a frame of some type to support the covering material (use any greenhouse material or floating row cover). It may be necessary to use some type of venting system to reduce the heat that solar radiation produces. Construction and anchoring needs to be strong enough to withstand the wind conditions of the area. Often cloches are designed to last only 1 year.

Further Reading

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University of Idaho

PNW 171 Building Hobby Greenhouses (50¢)

PNW 151 Propagating Herbaceous Plants from Cuttings (50¢)

PNW 170 Propagating Plants from Seed (\$2.50)

CIS 841 Seed Germination Test Methods for Home Use (25¢)

CIS 881 Success with Very Small Seeds (35¢)

CIS 858 Using Bark and sawdust for Mulches, Soil Amendments, and Potting Mixes (35¢)

To order University of Idaho publications, contact your county's UI Extension office or write to: Publications, University of Idaho, Moscow, ID 83844-2240, call (208) 885-7982, or email: calspubs@uidaho.edu. Make checks payable to *Publications*. Idaho residents add 6 percent sales tax. Also check, and in some cases download, the online publication catalog on the UI Educational Communications web site: (<http://info.ag.uidaho.edu>).

Washington State University

EB 0695 House Plant Pests (\$1.00)

EB 1070 Potting Soil Mixtures

EB 1354 Houseplants (50¢)

To order Washington State University publications, contact your county's Cooperative Extension office or write to Bulletin Office, Cooperative Extension, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

Alberta Agriculture

Agdex 731-5 Hobby Greenhouses in Alberta (\$14.00)

To order, contact Alberta Agriculture, 7000 - 113 Street, Edmonton, Alberta T6H5T6

Videos

How to Grow Healthy Houseplants, VHS 457, District III Extension Office, Twin Falls, ID.

Foliage Plants for Interiors, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Indoor Plants, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Plant Propagation: From Seed to Tissue, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Slide Sets

Care and Culture of House Plants, ASHS 10, 80 sl., F. Gouin, Eugene Memmler, P.O. Box 94475, Pasadena, CA 91109.

Indoor Landscaping (House Plants), ASHS 1, 92 sl., Cochran, Eugene Memmler, P.O. Box 94475, Pasadena, CA 91109.

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