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by: Ernest Mortensen and Ervin T. Bullard

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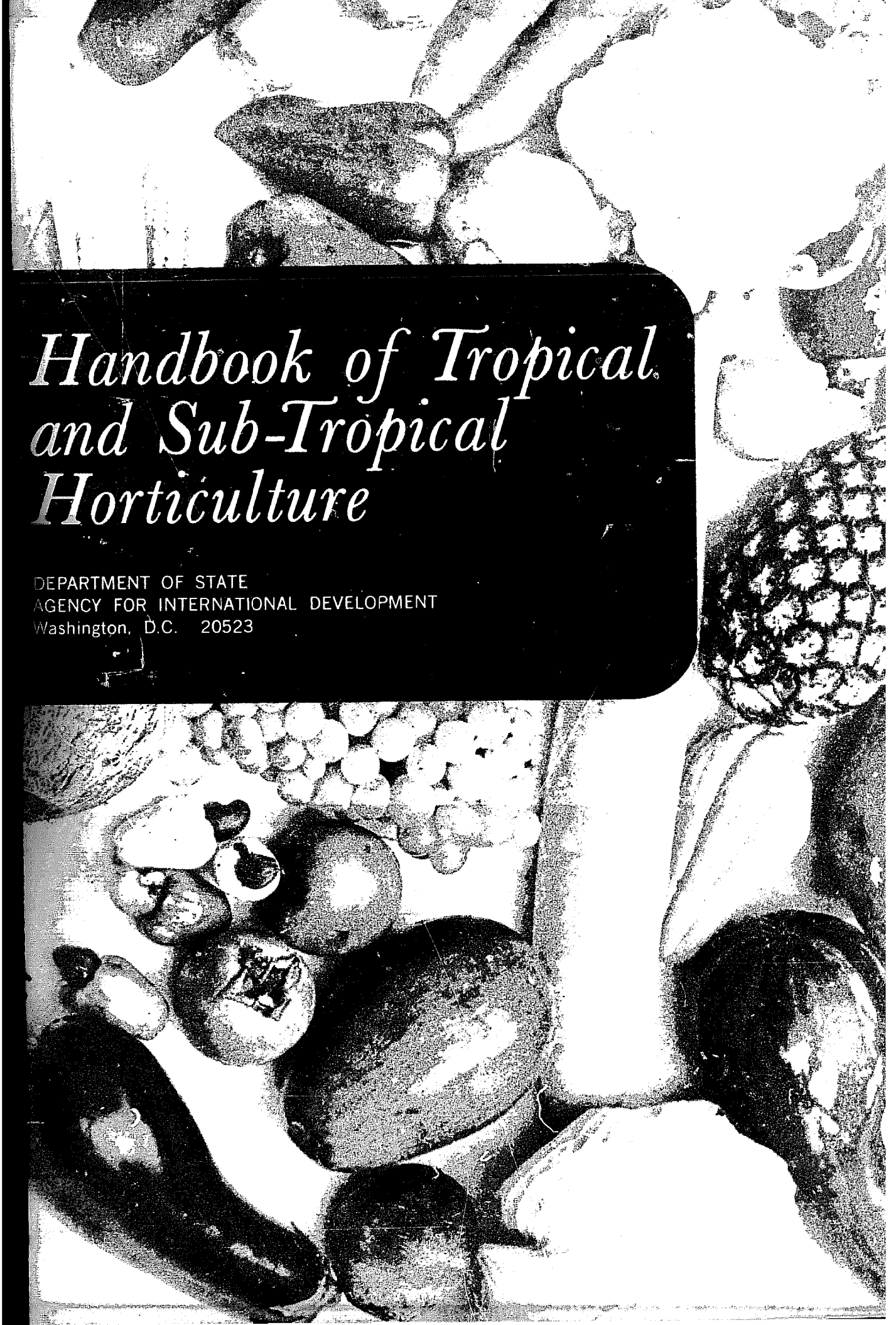

Handbook of Tropical and Sub-Tropical Horticulture

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

HANDBOOK OF TROPICAL AND SUBTROPICAL HORTICULTURE

By

Ernest Mortensen and Ervin T. Bullard

Department of State
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PREFACE

U.S. agencies having responsibility in foreign assistance programs long have recognized the need for a handbook on horticultural crops in the Tropics. Information on the subject may be found in various scientific textbooks, treatises and papers. It is to fill the need for consolidated information in ready reference form that this "Handbook on Tropical and Subtropical Horticulture" is issued by the Agency for International Development in consultation with the U. S. Department of Agriculture.

Based upon an extensive survey of available literature, this manual is designed for the use of U.S. A.I.D. technicians and contract personnel, and for Peace Corps volunteers engaged in rural development. It is written in layman's language so that it may be understood by the non-specialist who yet is called upon to work with farm families in solving their agricultural problems. Nevertheless, research workers and students also will find it of value because of its up to date and extensive bibliography. It also serves as reference and guide for teaching courses.

In addition to U.S. A.I.D. and Peace Corps personnel, there are two other groups to whom this Handbook can be of great help. The one group is composed of missionaries living with rural people and concerned with agricultural education in the Tropics. Often lacking an agricultural background, they must search for practical information on tropical crops to help local farmers increase agricultural productivity. In the other group are employees of large agricultural companies. Some of these are foreign, others are local technicians. Perhaps their first aim is to promote the use of a specific agricultural chemical, for example, but since they have close contact with farmers, they are called upon often to answer questions pertaining to other phases of agriculture.

There has been a dearth of agricultural research people in the Tropics and a shortage of funds for basic and applied research. In general the quality of research work has been good, but quantity and coverage are limited. The Handbook indicates in the first chapter those fields of endeavor where work is needed immediately. Major fruit, nut and tree crops are discussed in the second chapter with emphasis on such important points as spacing, pruning, fertilizing, budding, and disease and insect control. A few Temperate Zone fruits are included to stress that they can be grown only at higher elevations in the Tropics, due to chilling requirements. Crops are listed alphabetically and scientific names are given for reference purposes.

The Handbook continues with a description of all major vegetable crops. Information is presented on seed storage, vegetable varieties, fertilizer recommendations, plant spacings, temperature requirements, soil and cultivation. Major diseases with their control are presented in a table for easy reference.

Herbicides are being used extensively in temperate regions for weed control. They will come into more use in the Tropics in the future, especially if labor costs continue to increase. Accordingly, a table lists recommended herbicides for each crop. Likewise, a table is presented to indicate major insects and how they can be controlled. Pictures are included for identification purposes.

Source of plant material is provided, as well as sources of equipment and materials used in the production of horticultural crops. Conversion factors are included for converting the imperial system of weights and measurements to the metric system, which is used in most of the tropical countries. A conversion table is presented for converting temperature from Fahrenheit to centigrade. Included also is a table to determine the number of plants or trees per hectare at the most common spacings.

In summary, the main function of the Handbook is to give A.I.D. agricultural technicians, Peace Corps personnel, and other workers concise methods of economically producing horticultural crops in the Tropics. It is to assist them in helping the farmer produce food crops more efficiently and improve his standard of living. As this Handbook is translated into different languages, it is used directly by local extension personnel, village-level

workers, and the better-trained farmers who are natural leaders in their communities. This publication has been translated into French by A.I.D.'s Centre Regional d'Editions Techniques (C.R.E.T) in Paris, France. It also has been translated into Spanish by A.I.D.'s Regional Technical Aids Center (R.T.A.C.) in Mexico City, Mexico. Finally, the references on the different crops lead the student's way to the more detailed information which is beyond the scope of the Handbook.

ACKNOWLEDGMENTS

The authors acknowledge the help received from members of the U.S. Agency for International Development Mission to Haiti. Thanks, in particular, are expressed to David Keogh, Acting Mission Director, to Albertano C'de Baca, Acting Food and Agriculture Officer, and to the Agriculture Staff. Their interest, encouragement and cooperation made possible the production of the original field notes from which the original Handbook and this revision evolved.

Appreciation also is expressed to the staff of the Haitian Division of Research for research assistance, and in particular to Jacques Jolicoeur, Director of Research at the Damien Experiment Station, Haiti. Donald Penner, Research Assistant at the Grand Pré Experiment Station, reviewed the literature and wrote information on several tropical crops included in the Handbook. Hassan Azzam, University of Puerto Rico, supplied information on conversion factors used in Latin America. The picture for the cover was contributed by Donna Bullard.

The authors also wish to express appreciation to James E. Knott and to his publishers for permission to use information on vegetable yields and spacing found in his book "Handbook for Vegetable Growers," published in 1960 by John Wiley and Sons, Inc., New York City.

The following specialists were consulted in the preparation of this revision:

Agricultural Research Service, U.S. Department of Agriculture: W. H. Anderson, J. H. Gilmore, and Judson McGuire for insects; C. R. Benjamin for plant pathogens; J. M. Good for nematodes; B. S. Crandall and J. R. McGrew for plant diseases; L. L. Danielson for weed control.

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Harold F. Winters and other specialists in the Crops Research Division, Agricultural Research Service, provided general review, editing and proofreading.

In no case are the consultants responsible for the facts as presented or the method of presentation.

ABOUT THE AUTHORS

Ernest Mortensen worked for eight years for the Australian Government on prickly pear control in Brazil, Mexico, Honduras and El Salvador. He was associated for 23 years with the Agricultural and Mechanical College of Texas, and served in the following countries under the United States Agency for International Development: Greece, Jordan, Lebanon, El Salvador, Haiti and Afghanistan.

Ervin T. Bullard was with the University of Rhode Island, Purdue University and the University of Idaho before starting work with the United States Agency for International Development. He was associated with the Ministry of Agriculture and the University of Cairo as a Research Scholar under a Fulbright Grant in 1951–52. He also made trips to Israel and Turkey under the UNESCO program in 1952. During his time with U.S.A.I.D. he has worked in Liberia, Ecuador, Haiti, Dominican Republic and Brazil.

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Figure 22. REMOVING A WITCHES BROOM ON A YOUNG CACAO TREE.

Figure 24. POD DAMAGE CAUSED BY A SQUIRREL.

Figure 23. DISTORTED CACAO POD CAUSED BY WITCHES BROOM.

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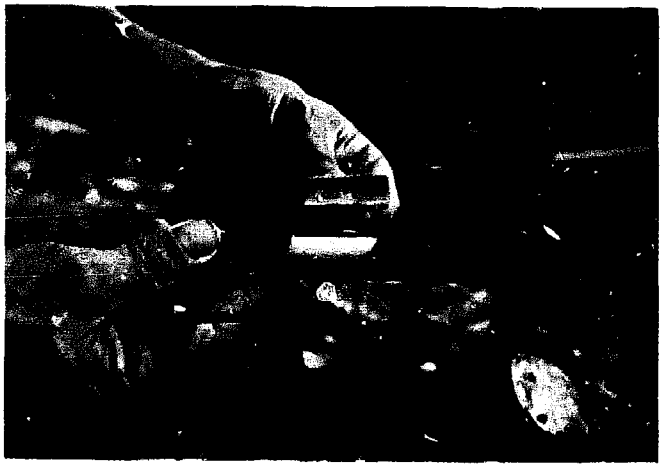
Figure 26. PREPARING A YOUNG CACAO TREE TO RECEIVE BUD.



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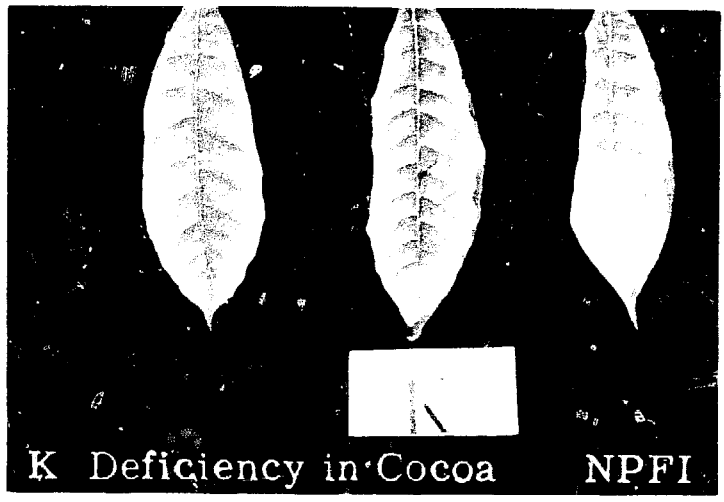


Figure 32. POTASSIUM DEFICIENCY.

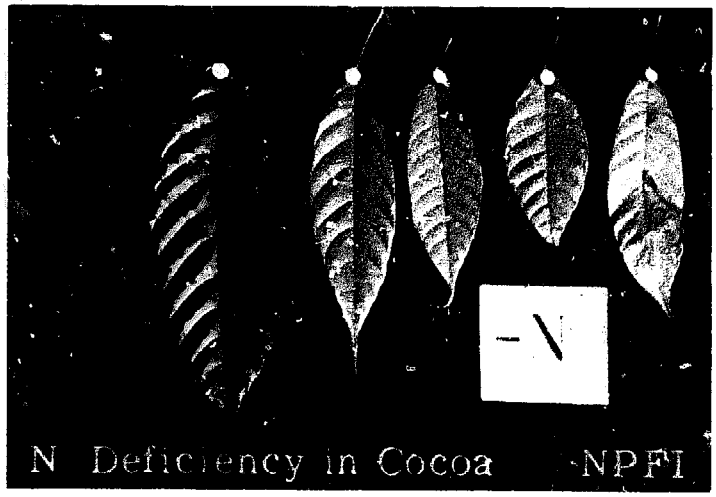


Figure 30. NITROGEN DEFICIENCY.

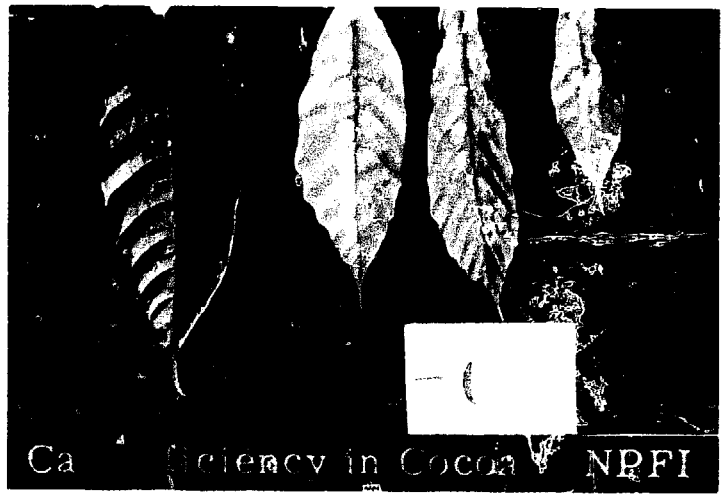


Figure 33. CALCIUM DEFICIENCY.

Figure 31. PHOSPHORUS DEFICIENCY.

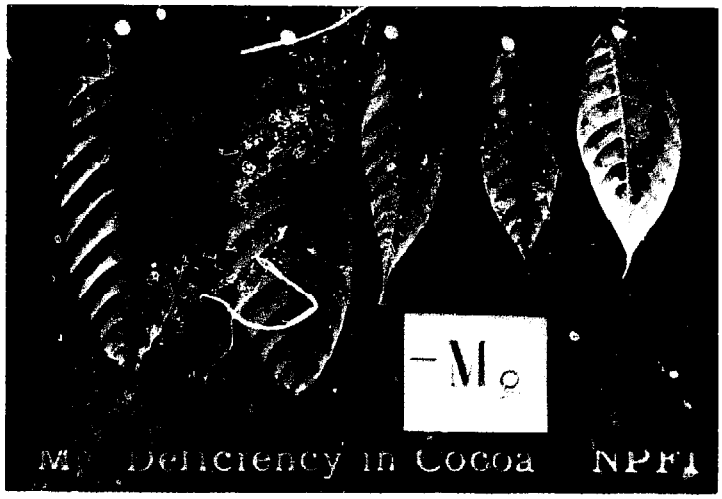


Figure 34. MAGNESIUM DEFICIENCY.

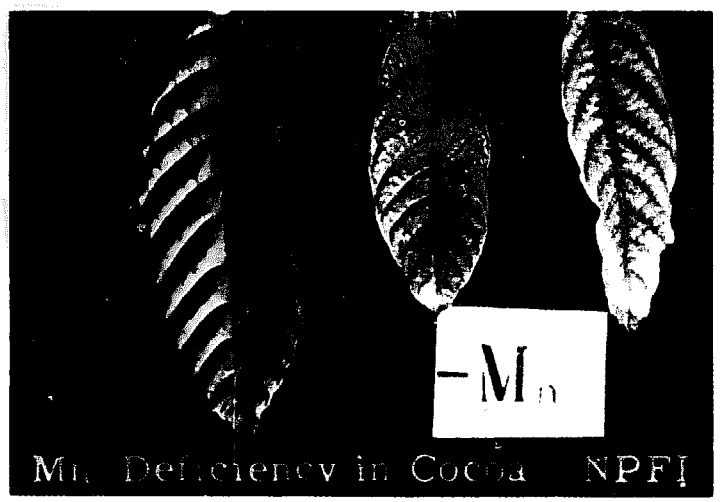


Figure 35. MANGANESE DEFICIENCY.

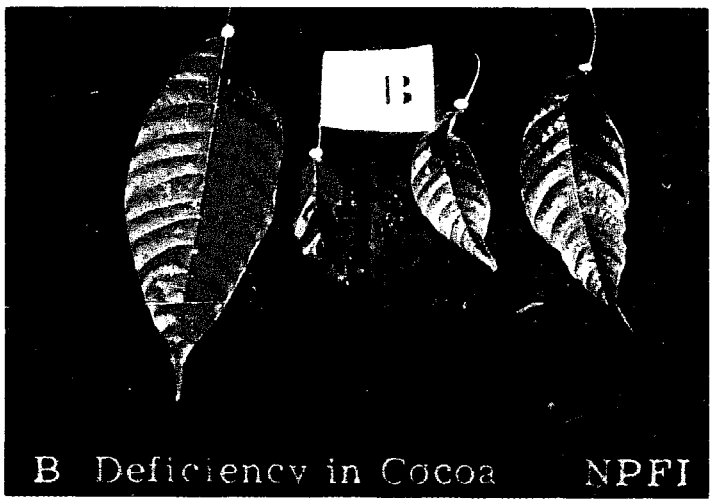
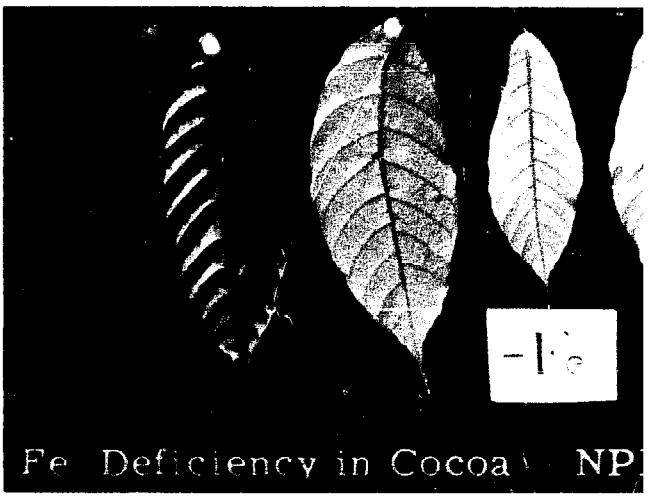


Figure 36. BORON DEFICIENCY.

Figure 37. COPPER DEFICIENCY.



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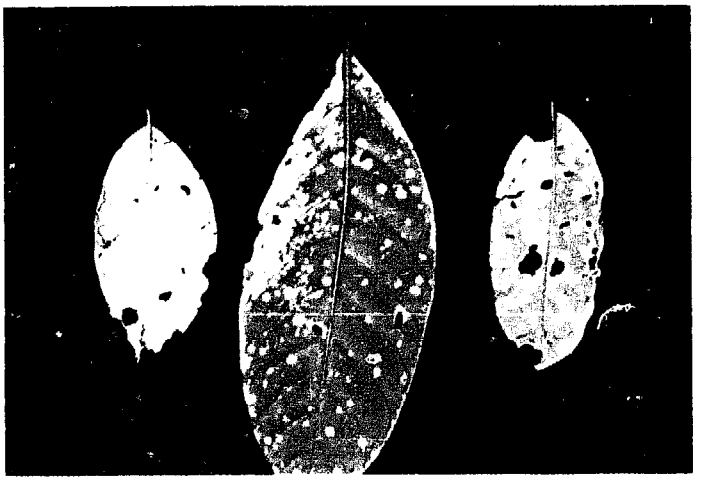

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Figure 44. ROBUSTA COFFEE.

Figure 47. COFFEE CHERRIES READY FOR HARVEST. GREEN CHERRIES SHOULD NEVER BE HARVESTED.

PLANT DEFICIENCY SYMPTOMS IN COFFEE

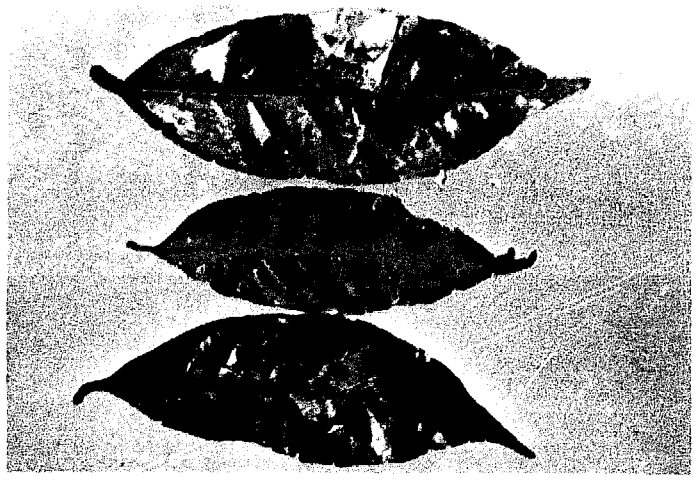

Figure 51. PHOSPHORUS DEFICIENCY.

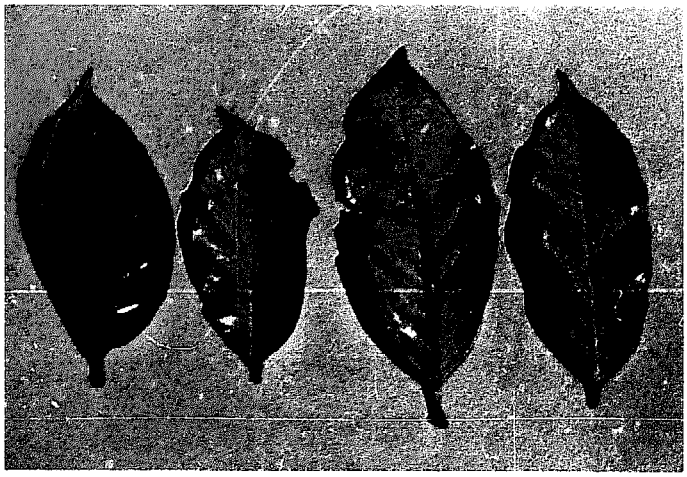

Figure 49. NITROGEN DEFICIENCY.

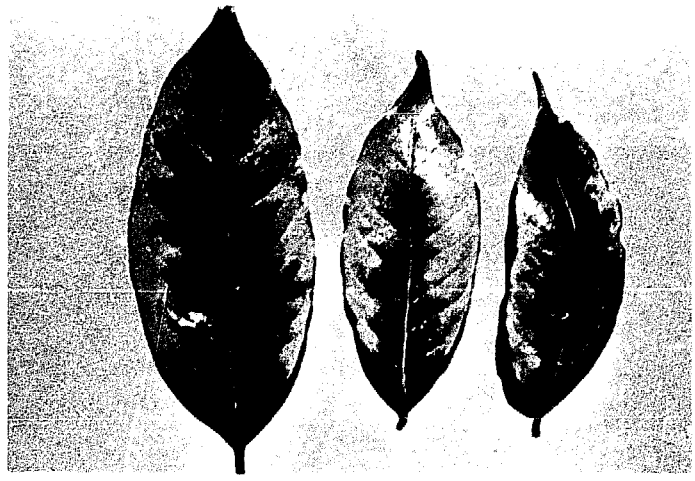

Figure 52. CALCIUM DEFICIENCY.

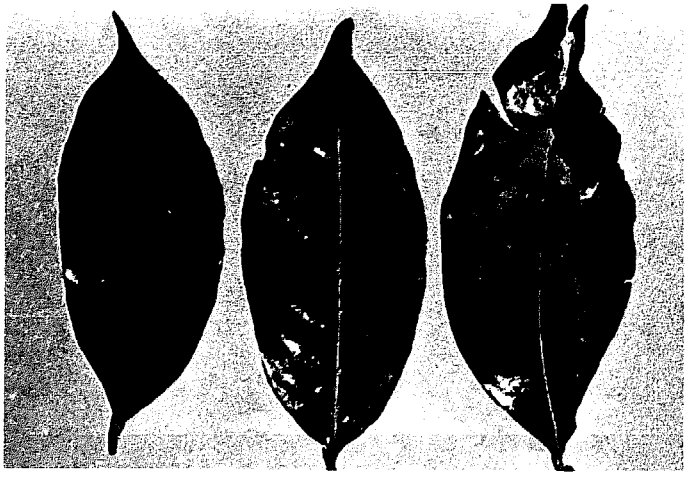

Figure 50. POTASSIUM DEFICIENCY.

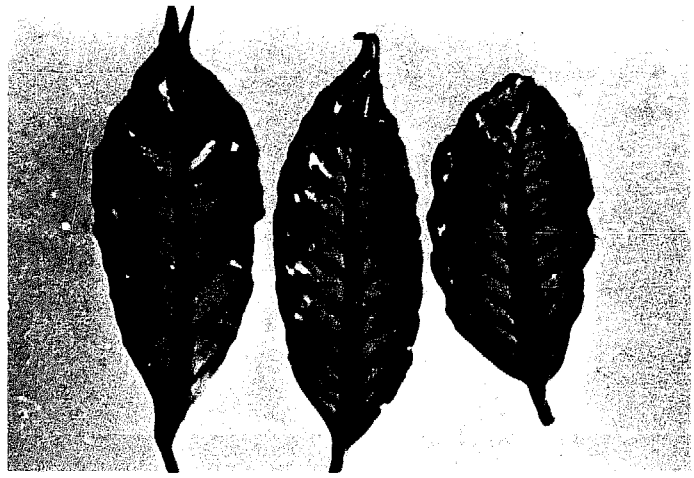

Figure 53. MAGNESIUM DEFICIENCY.

PLANT DEFICIENCY SYMPTOMS IN COFFEE (Continued)

Figure 54. MANGANESE DEFICIENCY.

Figure 55. BORON DEFICIENCY.

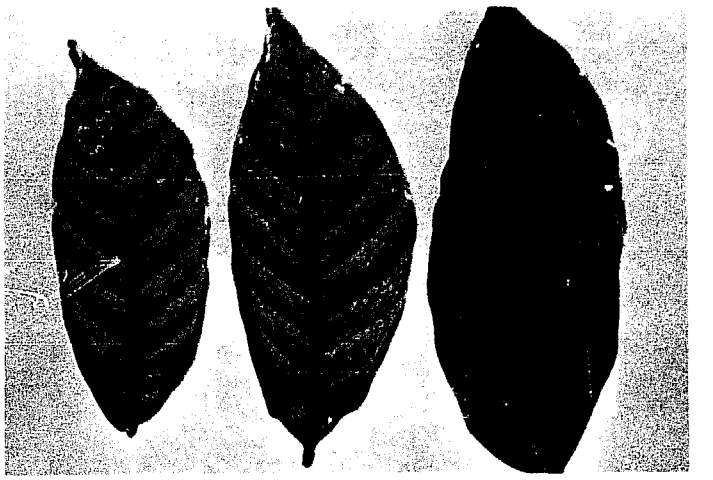

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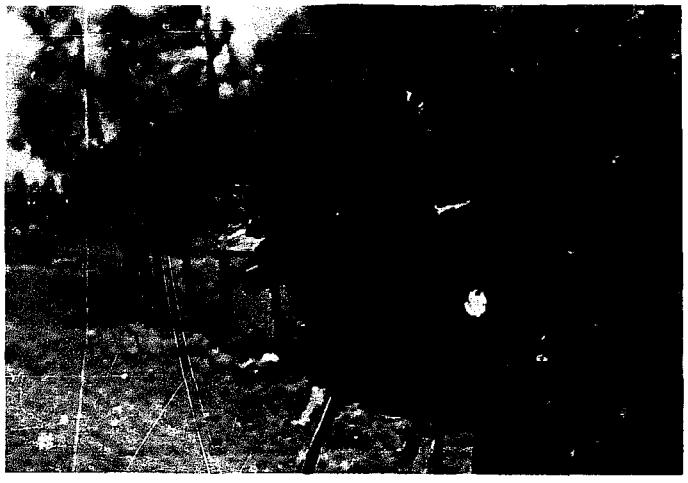
Figure 59. FEMALE PAPAYA TREE WITH FRUIT.

Figure 65. BROAD BEAN PLANT AND PODS. SOMETIMES CALLED HORSE BEAN.



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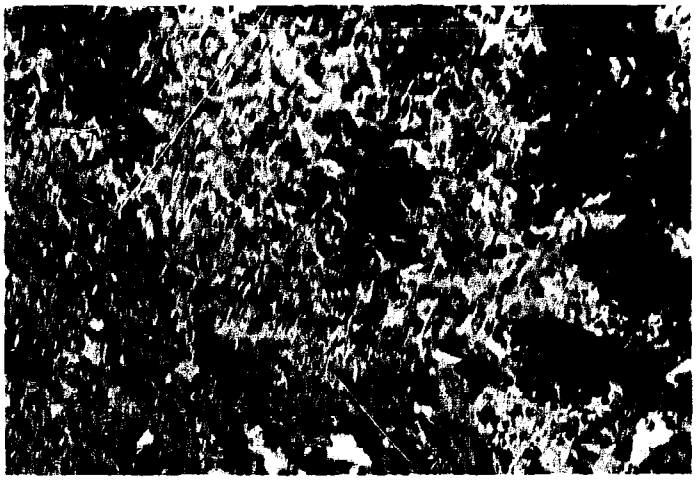

Figure 77. CUCUMBER MOSAIC CAUSED BY A VIRUS ON A TOMATO PLANT.

Chapter 1

AGRICULTURAL RESEARCH

Low agricultural productivity prevailed generally throughout all parts of the world until research began making substantial improvements in the field of agriculture. A relationship exists between the level of agricultural productivity and the level of economic development and nutrition. Countries of the highest productivity are among the most highly developed of the world. Increased food production and improved human nutrition are major objectives of national development and international assistance programs.

Average crop yields in the United States increased 50 per cent from 1940 to 1961. Agricultural production in the United Kingdom, France, Netherlands and Japan was 54, 52, 68 and 45 per cent greater, respectively, in 1960 than during the prewar era. Most of the increases resulted from increased yields per unit area of crops or per livestock unit rather than from an increase in the area of crops or number of livestock. George H. Schull, who first developed hybrid corn, is partly responsible for the fact the U.S. farmers are now producing 20 per cent more corn on 25 per cent less area than in 1930. Agricultural research is directly or indirectly responsible for a large percentage of the increase in production.

The farm picture in the United States has changed considerably as a result of agricultural research in the past century. One hundred years ago 67 per cent of the working people were working on farms but in 1962 only 8 per cent of the U. S. population was on farms. However, the efficiency of farming is mechanized to a point where one farmer can produce enough to feed 27 people. The average American spent only 20 per cent of his income for food in 1962 as compared with 67 per cent one hundred years before (1).

Modern agricultural research began during the period of 1830 to 1850 in France, England and Germany. The United States Department of Agriculture and the land grant colleges and experiment stations were started in the 1860–1890 period. Senator Justin S. Morrill from Vermont sponsored a bill in 1862 to establish land grant colleges to encourage the development of agriculture.

The information obtained through research resulted in increased crop yield and livestock production. This was due in part to the extensive use of a wide range of improved methods and technology, including improved crop varieties, fertilizers, pesticides, herbicides, water conservation and mechanization that made possible more economic and better seeding, cultivating, harvesting and marketing. The extensive use of modern scientific methods could treble or quadruple agricultural production in most of the less extensively developed tropical countries. Such methods will continue to provide for higher levels of productivity in the economically advanced countries. It is estimated that the U. S. population could live a year on the food destroyed annually by the world's rats, insects and plant diseases. Americans eat enough fruits and vegetables in a year to fill 1,500,000 freight cars (1).

The scientific methods used in the more advanced countries must be adapted for use in the other countries, most of which are in the tropical areas. Technical assistance is needed to accelerate change and increase productivity. It is necessary to promote the introduction and adaptation of modern scientific methods of agricultural production, assist in the establishment of agricultural institutions and services, the training of staff members and the analysis of the country's agricultural problems and methods of solving them.

The foundation for technological advance has been laid in most regions. The introduction, adaptation and breeding of improved varieties of major crops has been intensified in the last ten years in the Near East, Far East, and Latin America and to a lesser degree in Africa. Many superior varieties of numerous food crops are being grown now and more will be used within a few years. Some countries are developing improved facilities for the

production, storage and distribution of improved seed, but much remains to be done.

Fertilizer is closely correlated with productivity and serves as an index of the degree to which more modern agricultural practices are used by a nation (2). It has been established that the Near East, Far East, Latin America and Africa will require an additional 26 million tons of nitrogen, phosphate and potash by 1980 if food production and nutrition goals are to be met (2).

The development of well trained personnel and agricultural institutions requires a long time. In some countries a good start has been made in recent years. The number of competent agricultural personnel and institutions in 1962 is much greater than in 1950.

A great deal of research is needed on tropical crops in the future. The areas which need immediate attention are as follows:

1. Variety Trials: to determine the best varieties for a given environment.
2. Plant Breeding: to develop new high yielding varieties resistant to plant pests.
3. Fertilizer Trials: to determine the kind, amount and placement of fertilizers for each crop for a given environment.
4. Machinery: to develop machinery that will work under tropical conditions on small farms, or develop cooperative machinery pools.
5. Disease Control: to determine the most economical means of disease control under tropical conditions.
6. Insect and Rodent Control: to determine the most economical means of insect, rodent and nematode control.
7. Herbicide Trials: to determine the most economical means of weed control.
8. Irrigation Trials: to determine water requirements and methods of irrigation for tropical crops.
9. Farm Management: to determine the most economical cultural practices for tropical crops.
10. Marketing: to determine the most economical means of transportation and marketing.
11. Processing: to explore the possibility of processing tropical crops for export.
12. Distribution: to determine the most economical means of distribution to prevent spoilage and inefficient handling.
13. Health: to improve the quality of the diet and change the nutritional level where needed in tropical countries.
14. Credit: to establish a good credit system so that farmers can take advantage of new scientific methods.
15. Extension: to develop an efficient means of distributing research results to the farmers.

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Chapter 2

FRUIT AND TREE CROPS

Tropical fruit crops are numerous and only those considered most important are included in this book. Many of the temperate zone fruit crops can be grown in the Tropics at high altitudes provided the chilling requirements are met. Each fruit crop is considered separately and listed alphabetically so that each can be located readily.

There is a shortage of reliable research data on many of the crops in the Tropics. Experimentation is much needed on most of the important tropical fruits. Most of the work in past years has been conducted by the French, Dutch, Germans, English, Belgians, Hawaiians, Costa Ricans, Puerto Ricans, Portuguese and Brazilians.

A classification of the most important fruit crops follows:

CLASS I. Of wide commercial importance.
CLASS II. Of limited commercial importance.
CLASS III. Usually grown for local markets only.
CLASS IV. Minor crops not often marketed.

CLASS I.

Ananas comosus.	Pineapple.
Citrus paradisi.	Grapefruit.
Citrus reticulata.	Mandarines and Tangerines.
Citrus sinensis.	Orange.
Cocos nucifera.	Coconut.
Coffea arabica.	Coffee.
Hevea brasiliensis.	Rubber tree.
Mangifera indica.	Mango.
Musa spp.	Banana.
Musa paradisiaca.	Plantain.
Persea americana.	Avocado.
Thea sinensis.	Tea.
Theobroma cacao.	Cocoa.

CLASS II.

Aleurites fordii.	Tung nut for industrial oil.
Anacardium occidentale.	Cashew, nuts and fruits.
Annona cherimola.	Cherimoya.
Annona diversifolia.	Ilama.
Areca catheeu.	Betel nut for chewing.
Artocarpus communis.	Breadfruit.
Bertholletia excelsa.	Brazil nut.
Canarium ovatum.	Pili nut.
Citrus aurantium.	Sour orange.
Citrus aurantifolia.	Lime.
Citrus limon.	Lemon.
Citrus nobilis.	King and Satsuma orange.
Cola acuminata.	Kola nut for drinks.
Diospyros kaki.	Persimmon.
Dipteryx odorata.	Tonka bean.
Elaeis guineensis.	African oil palm.
Eriobotrya japonica.	Loquat.
Ficus carica.	Fig.
Fragaria spp.	Strawberry.
Ilex paraguariensis.	Mate tea.
Litchi chinensis.	Lychee.
Macadamia ternifolia.	Macadamia nut.
Malus sylvestris.	Apple.
Myristica fragrans.	Nutmeg.
Olea europaea.	Olive.
Passiflora edulis.	Passion fruit.
Phoenix dactylifera.	Dates.
Pinus pinea.	Pine nuts.
Piper nigrum.	Black pepper.
Pistacia vera.	Pistachio nut.
Prunus armeniaca.	Apricot.
Prunus persica.	Peach.
Prunus salicina.	Plum.
Psidium guajava.	Guava.
Punica granatum.	Pomegranate.
Vanilla planifolia.	Vanilla vine.
Vitis spp.	Grapes.

CLASS III.

Achras zapota.	Sapodilla, Chicle.

CLASS III. (Cont'd)

Annona muricata.	Guanabana, Soursop.
Annona reticulata.	Custard apple.
Annona squamosa.	Sweetsop.
Artocarpus integra.	Jackfruit.
Artocarpus odoratissima.	Marang (dessert fruit).
Byrsonima crassifolia.	Nanche, Golden Spoon.
Calocarpum sapota.	Sapote.
Calocarpum viride.	Green sapote.
Carica papaya.	Papaya.
Canarium commune.	Java almond.
Casimiroa edulis.	White sapote.
Ceratonia siliqua.	Carob.
Chrysophyllum cainito.	Cainito, Star-apple.
Citrus grandis.	Shaddock.
Cubilia blancoi.	Cubili nut.
Cyphomandra betacea.	Tree tomato.
Dovyalis hebecarpa.	Ketembilla, Ceylon gooseberry.
Durio zibethinus.	Durian.
Euphoria longan.	Longan.
Fortunella spp.	Kumquat.
Garcinia mangostana.	Mangosteen.
Lansium domesticum.	Lanson.
Lecythis spp.	Sapucaia nut, Paradise nut.
Malpighia glabra.	Acerola, Barbados cherry.
Mammea americana.	Mamey.
Mangifera verticillata.	Bauno.
Melicocca bijuga.	Mamoncillo, Genip.
Monstera deliciosa.	Ceriman.
Myrciaria cauliflora.	Jaboticaba.
Nephelium lappaceum.	Rambutan.
Passiflora ligularis.	Sweet Granadilla.
Passiflora quadrangularis.	Giant granadilla.
Psidium cattleianum.	Yellow Strawberry guava.
Pyrus prunifolia.	Chinese pear.
Rollinia deliciosa.	Biriba.
Rubus spp.	Blackberry.
Rubus albescens.	Mysore raspberry.
Solanum quitoense.	Naranjilla.
Spondias cytherea.	Otaheite apple.
Spondias mombin.	Yellow mombin.
Spondias purpurea.	Red mombin, "Ciruela del Pais."
Spondias tuberosa.	Imbu.
Tamarindus indica.	Tamarind.

CLASS IV.

Anacolosa luzoniensis.	Galo (filbert).
Annona purpurea.	Soncoya.
Antidesma bunius.	Bignay.
Averrhoa bilimbi.	Bilimbi.
Averrhoa carambola.	Carambola.
Carissa grandiflora.	Natal plum.
Carissa carandas.	Karanda.
Caryocar nuciferum.	Souari nut.
Chrysobalanus icaco.	Icaco, Cocoplum.
Citrus mitis.	Calamondin Orange.
Coccoloba uvifera.	Seagrape.
Cydonia oblonga.	Quince.
Eugenia brasiliensis.	Grumixameira.
Eugenia dombeyi.	Grumichama.
Eugenia malaccensis.	Malay apple.
Eugenia uniflora.	Pitanga, Surinam cherry.
Feijoa sellowiana.	Feijoa.
Flacourtia indica.	Governor's plum.

CLASS IV. (Cont'd)

Licania platypus.	Sansapote.
Morus nigra.	Black mulberry.
Nephelium mutabile.	Pulasan, Bulala like lychee.
Syzygium cumini.	Java plum.
Syzygium jambos.	Rose apple.
Terminalia edulis.	Beach almond, Calompit.
Zizyphus mauritiana.	Indian Jujube.

ACEROLA

WEST INDIAN CHERRY, BARBADOS CHERRY

(Malpighia glabra)

Acerola is a shrub which may grow to a height of 15 feet. Some acerola trees have been found to have the highest known content of ascorbic acid of any fruit, 1,000 to 3,300 mg. of ascorbic acid per 100 grams of edible fruit or about 100 times that of oranges and 10 times that of guava or cashew (2). It is also an excellent source of vitamin A and iron (4).

Since there is a great variation in seedlings, it is best to propagate superior clones asexually either by cuttings with leaves untrimmed or by shield budding. Because acerola is highly susceptible to

nematodes, side-grafting or budding on *Malpighia suberosa* or another resistant species might be advisable.

The Florida Sweet variety selected at Homestead, Florida, is superior in vigor, yield, ease of propagation and has a pleasant flavor similar to that of cherry. It may yield 25 tons of fruit per acre at 8 years of age (3).

Poor pollination has become a factor in Hawaii, perhaps because of lack of wind or specific pollinating insects; the use of indole butyric acid at 100 p.p.m. gave a good set without serious toxic effect (5).

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APPLES

(Malus sylvestris)

Apples normally are temperate zone plants since they require varying amounts of chilling and dormancy for good crops; however, some varieties are able to produce fruit with relatively short chilling. In any case apples can be grown at higher elevations in the Tropics if the cold requirements can be met. Quality is never as good in hot regions as in the temperate zone, but at 7,000 feet in Guatemala good quality has been obtained. Apples are grown near Ambato, Ecuador, which is one degree south of the equator, at an altitude of 9,000 feet.

It has been calculated that most apple varieties require 1,000 hours below 45°F and 1,500 to 2,000 day degrees for maturing the fruit. This may be modified by cloudy weather, pruning or dwarfing rootstocks. There should be a mean minimum of 45°F or less and a mean maximum of 65°F or below for 4 months together with low rainfall. Warm months should have a mean minimum of 50°F or higher and a mean maximum of 70°F or higher (2). Sprays may be used but are not very satisfactory for breaking dormancy in apples. (2).

Mild winter varieties that have been recommended are White Pearmain, Winter Banana, Beverly Hills (1), Emilia (2), Transcendant, Yellow Siberian (3), Early Harvest, Hyslop, Delicious, Wolf River (4), and Hume (5).

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APRICOTS

(Prunus armeniaca)

Temperatures between 40° and 45°F are needed for breaking the rest period of apricots. Some varieties with low chilling requirements can be used in places like southern California but apricots generally are poorly adapted to the Tropics. Earligold, Reeves, Trevatt, Royal and Newcastle (1) (2), seem to withstand mild winter temperatures better than others.

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AVOCADO

(Persea americana)

Avocados are native to tropical America but are cultivated in nearly all tropical countries. In food value the avocado compares with banana. Fat con-

Figure 1. APPLE DEFORMED AND RUSSETED BY PEAR LEAF BLISTER MITES. *U.S.D.A. Photograph.*

tent varies from 7 to 23 per cent in different varieties and is highly digestible. Pound for pound, the avocado has more energy value than meat. The iron content is higher and it contains vitamins A, B, C, D, E, and K (8).

Three races are recognized: the West Indian, which is larger in size and lower in percentage of oil than the Guatemalan, which has a thick rind and is intermediate in oil percentage and is of medium to small size; the Mexican race has anise-scented leaves while the other races do not.

Pollination is a problem that has had much study in the United States because of the poor crops in some cases; however, none of the leading commercial varieties have been found to be self-incompatible (4). There are other causes for poor fruit set, such as a heavy crop the preceding year and weather conditions at the time of flowering.

Varieties have been classified as to time of opening of flowers into: (A) those which shed their pollen in the morning but are not receptive except in the afternoon, and (B) those which shed their pollen in the afternoon and are not receptive except in the morning. In some cases it has been considered best to interplant varieties of each class to insure good crops (6).

Seeds should not be permitted to dry out and it is best to plant them directly from the fruit. They should be planted with the broadest part downward and usually the tip left uncovered or only

lightly covered. Since the trees usually become large and need more space than citrus, it is best to allow about 100 m² per tree. Avocado trees usually are balled when being moved from nursery to orchard. Balls 10 inches in diameter and 14 to 16 inches deep are used (7). Pruning is mainly for convenience in cultivating or harvesting.

Shield budding has been successful in California but in wrapping, the bud should be left uncovered. The veneer side-graft is generally preferred in Florida.

Varieties (10) more commonly propagated are:

West Indian race:	Simmonds, Pollock, Catalina.
Guatemalan race:	Hass, Nabal, Itzamna, Taylor.
Mexican race:	Puebla.
Hybrids:	Fuerte, Lula, Choquette, Booth 8, Hall, Collinred.

Edranol, Fuerte, Hass, Huzzard and Sherwil were the best of many varieties tested in Queensland. Kampong has very large fruits and ripens in the spring at Homestead, Florida.

Nitrogen is the most important fertilizer; however, requirements appear to be less than in citrus. Too much nitrogen apparently reduces fruit set in California (1). No evidence of need for phosphates or potash has been reported, to the knowledge of the authors. Magnesium requirements are higher than in citrus but toxicity results from excessive amounts (2). Approximately 2 lbs. N per tree per year appears to be the maximum in California (5) and 0.5 to 1.0 lb. per tree is an average application.

Avocado trees are sensitive to poor drainage and water logging, factors which may predispose the trees to the avocado root rot, *Phytophthora cinnamomi* Rands (11). This soil-borne fungus is difficult to control and practically impossible to eradicate at present.

Fruits do not tolerate storage at temperatures below 50°F (3).

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BANANAS

(*Musa* spp.)

Bananas are unusual in that all are parthenocarpic clones of uncertain origin. This is one of the oldest known cultivated crops. The cooking banana or plantain has been classified as *Musa paradisiaca* but taxonomy of other bananas is not entirely clear (4).

Among dessert varieties, Gros Michel is adapted to shipping but is susceptible to *Fusarium oxysporum* (Schlecht.) which causes Panama disease. Other names for Gros Michel are Pisang Embon, Bluefields and Johnson. Cavendish, which is resistant to *Fusarium* sp., is small and well flavored but more easily bruised when handled as stems. It is the principal variety in the Canary Islands, the Mediterranean region and Australia where hands are cut from stems and packed in crates. Lacatan is larger than Cavendish but otherwise similar. The

Figure 2. BANANAS SHOULD BE PLANTED ONLY ON SOIL FREE OF THE PANAMA DISEASE.

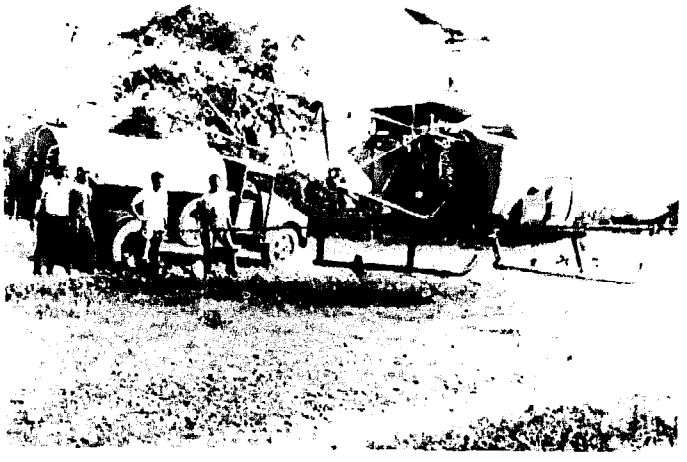

Figure 3. THE SIGATOKA DISEASE ON BANANAS IS CONTROLLED WITH DITHANE M 22 IN AGRICULTURAL SPRAY OIL.

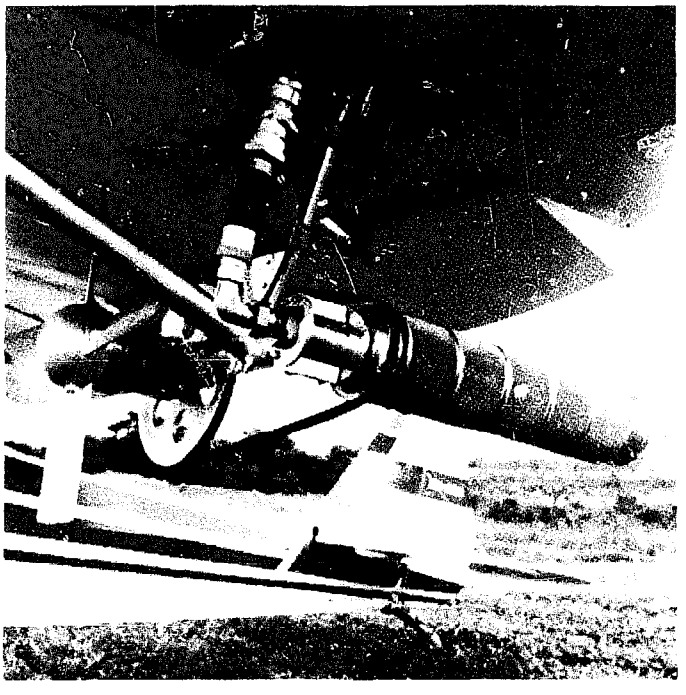

Figure 4. MICRO-AIR SPRAYER USED FOR THE CONTROL OF SIGATOKA ON BANANAS.

varieties Apple and Lady Finger or Date are small, richly-flavored bananas, useful mainly for home use or local market (4). Williams Hybrid is especially valuable where high winds occur and may have resistance to bunchy top, to which Cavendish is susceptible.

Bananas produce the same tonnage of edible materials per acre as potatoes (9).

Fruit matures in 75 to 115 days, depending on the temperature. At lower temperatures fruits require a longer time. Temperatures below 53° F are harmful to the fruit. "An ideal banana district would have no temperatures below 60° F or above 95° F and for high yields, temperatures above 75° during a considerable part of the time" (4). Constant moisture is needed; soil should be a deep, well drained loam.

Limiting the number of suckers that are allowed to grow per plant is necessary to obtain marketable fruit. Cavendish bananas planted 3 x 3 meters do best with 2 to 3 stems. Gros Michel at 16 x 16 feet will do well with 4 suckers or stems. Choosing and spacing these to provide continuous production requires skill and good judgment. The banana plants should be close enough to shade out grasses while other weeds are kept low by periodic machete cuttings.

Blossoming occurs 9 to 10 months after planting and the first harvest 13 to 15 months after planting. Cutting the bud below the stem after it has been formed is a common practice in Central America and is thought to add about 2 pounds to the weight of the stem. Stems are cut before the fruit is fully ripe or when the ribs begin to round out. Bananas tend to split if allowed to ripen on the tree (1).

Sprinkling for 24 hours may cause loss of 8 per cent N and 14 per cent Mg from Cavendish leaves by leaching (2). Frequent light irrigations under the trees gives better results than overhead sprinkling or less frequent heavier irrigations.

Nitrogen is the only fertilizer which has shown response in 13 years of experience in Jamaica (3).

Insects, diseases and nematode control are important factors in production (8). Consult Chapters 4 and 6 for further information.

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BETEL NUT

ARECANUT

(Areca cathecu Linn.)

The betel nut palm or arecanut palm is the chief source of chewing nuts of India and other far eastern nations such as Malaya and Indonesia (1). The betel nut is tropical in its requirements and is confined to Southeast Asia for the most part. The betel nut is believed to have originated in the Sunda Islands (1).

The betel nut can grow in very moist soils; however, the soil should have the capacity for thorough drainage and the ability to retain optimum moisture for the palms. An overabundance of lime may limit production (1). The betel nut is a shade loving plant that prefers low altitudes with temperatures of 60° to 100°F. If grown in areas of 30 to 60 inches of rainfall per year the betel nut may require supplementary irrigation.

The betel nut is propagated exclusively by seed. It is preferable to shade the nursery and bananas spaced 3 m. x 3 m. provide adequate shade. The seedlings are usually transplanted 3 months to 4 years after seeding in the nursery. The seedlings should be transplanted during the rainy season. The number of trees planted per acre varies from 400 to 600 trees per acre in some areas to as high as 800 to 1200 trees per acre (1).

The betel nut palm will attain the height of 12 to 30 meters, 30 to 45 cm. in diameter. It flowers in its seventh year and reaches full bearing potential in about 10 to 15 years. The flowers are cross-pollinated. The fruits take 6 to 8 months to ripen and are harvested when they are bright red in color. Trees may yield 300 to 600 fruits per year. In Malaya trained monkeys often are used to aid in harvesting the nuts from the tall palms (1).

The most prevalent diseases of the betel nut are the "Koleroga" fruit rot caused by *Phytophthora arecae* (Col.) Pethy, and a foot rot caused by *Ganoderma lucidum* (Leys.) Karst. The fruit rot attacks the fruits while they are still green which results in premature fruit fall. If the disease goes unchecked it may be fatal to the tree. Control procedures call for Bordeaux applications and the removal of infected trees. The symptoms of the foot rot are similar to those of drought. The most common procedure for at least partial control of this disease is the eradication of infected material (1).

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BLACKBERRIES

(Rubus spp.)

Berries grow only at higher altitudes in tropical areas or at cool locations. One variety known locally as "Mora" is *Rubus glaucus* and grows successfully at 5,000 ft. in Central America. This is a vigorous vine that requires trellising and bears large fruits, very firm and richly flavored. Production is practically continuous with sufficient moisture.

Other varieties of possible value are Bigness, Regal Ness, Oklawaha and Flordagrand (3). Flordagrand requires a pollinator if no wild berries are growing near by.

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BRAZIL NUT

(Bertholletia excelsa)

Brazil nuts generally are not planted as a commercial crop but are gathered from wild trees in the Amazon valley. The nuts are in large pods with up to 25 or more triangular nuts packed inside. Nuts have a high oil content, 65 to 70 per cent fat, 8 per cent carbohydrates and 13 to 17 per cent protein. Seeds lose their viability rapidly when stored (1).

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BREADFRUIT

(Artocarpus communis)

This is an East Indian and Polynesian fruit which has been introduced to the West Indies. It is not generally liked in Central America where many other fruits are more tasty, but is used widely in the West Indies. The breadfruit is an attractive, ornamental tree with large leaves. The fruit is high in starch, rich in calcium and is a fair source of vitamins A and B.

Breadfruit is limited by some horticulturists to the seedless clones which are propagated by root suckers or root cuttings. Branch cuttings 3/8 inch in diameter and 12 to 15 inches long, treated by dipping the bases in 1% indolebutyric acid (IBA) solution, have resulted in rooting.

The common forms which produce seeds are sometimes called breadnuts. These seeds are commonly sold in the markets in Haiti and are roasted and eaten like chestnuts.

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CACAO

(Theobroma cacao)

Cacao belongs to the family Sterculiaceae. It can be grown in areas between 20 degrees north and south of the equator. All the main production centers are located within a belt extending 10 degrees north and south of the equator. Cacao is grown in altitudes from sea level up to 500 meters but it thrives best in the lowlands, below 300 meters. Cacao performs best at 1,500 to 2,000 mm. (60 to 80 inches) of rainfall annually, well distributed throughout the year. A deep, well drained top soil, rich in organic matter is desirable for cacao. Cacao will tolerate a pH range of 4.0 to 7.4 in the top soil and pH 4.0 to 8.3 in the subsoil. A soil survey should be made before planting so that only the best areas will be selected for cacao (2).

Most of the world's supply of cacao is produced in Nigeria and Ghana. Brazil also accounts for a large part of the world production.

Most of the research work has been conducted in Nigeria, Ghana, Trinidad, Brazil, Costa Rica, Indonesia and Ecuador. Information can be obtained on the latest cacao research from these countries. The American Cocoa Research Institute is financing research in some of these countries.

It is desirable to start with the highest-producing plant material available. Clonal or hybrid cacao should be used. There is a tendency in the western hemisphere to concentrate on hybrid cacao since certain hybrids are resistant to witches' broom caused by *Marasmius perniciosus* (Stathel).

In order to produce interclonal cacao hybrids it is necessary to have cacao clones available. The highest yielding clones in Trinidad are ICS 1, ICS 95, ICS 6 and IMC 67; the best clones in Ecuador are EET 400 and EET 19, and the best clones in Costa Rica are UF 221 and CC–10; however, these clones are not resistant to witches' broom. If hybrids are to be made in the future with resistance to witches' broom the SCA 6, SCA 12 and SIL 1 clones, all of which have resistance, should be used. These can be imported from the United States Department of Agriculture Plant Introduction Station at Miami, Florida, or Mayaguez, Puerto Rico, as these are quarantine stations and the plant material is free from serious cacao diseases.

Figure 5. ROOTING CACAO CUTTINGS IN A CORE OF SAWDUST WHICH IS IN THE CENTER OF A BAG OF GOOD SOIL

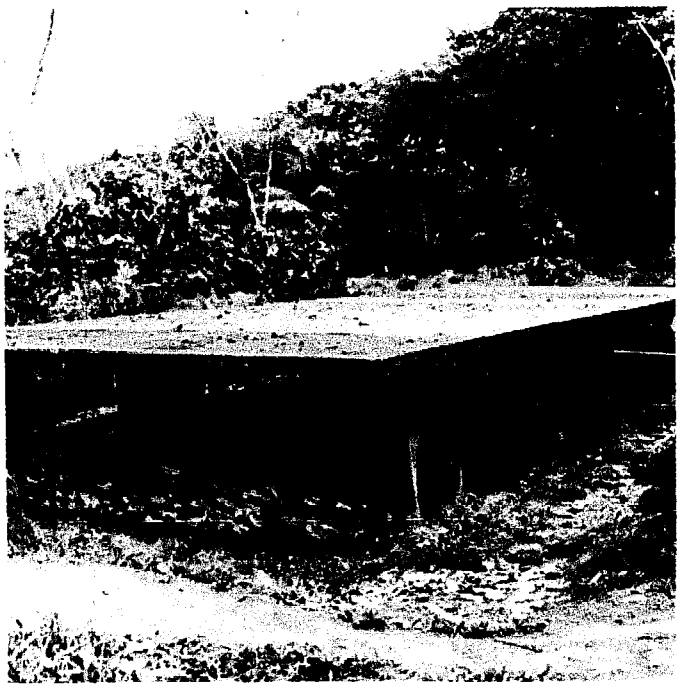

Figure 6. A MIST TYPE CACAO PROPAGATOR WITH 50 PER CENT SHADE

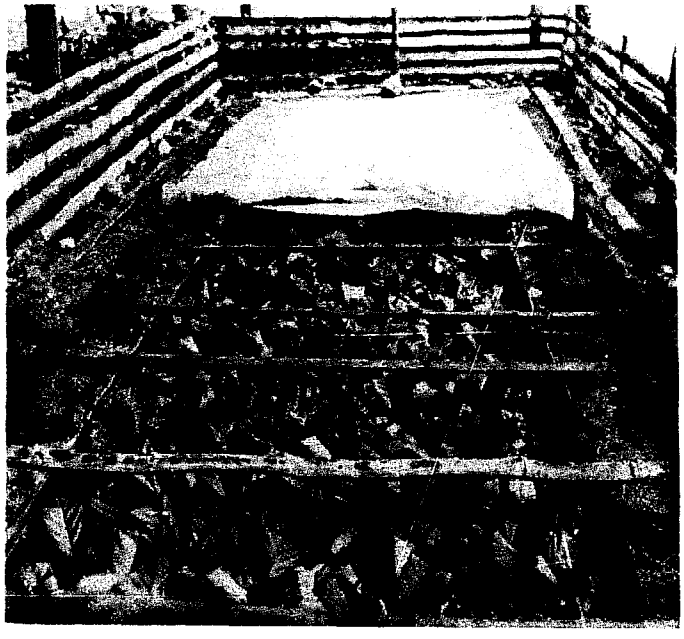

Figure 7. A POLYETHYLENE TYPE CACAO PROPAGATOR

The highest yielding hybrids in Trinidad, resistant to witches' broom, are ICS 60 x SCA–12, ICS 6 x SCA 6, ICS 1 x SCA 12 and ICS 6 x SCA 12. The best yielding hybrids in Ecuador resistant to witches' broom are ICS–6 x SIL–1, ICS–1 x SIL–1, and ICS–6 x SCA 12. Most of the hybrids tested in the western hemisphere have one parent resistant to witches' broom so that the hybrid progeny will be resistant to witches' broom since resistance seems to be governed by dominant genes. The clones SCA 6 and SCA 12 are resistant to witches' broom but they have no commercial value as clones because of their small seed size. When these clones are crossed to clones having large seeds the hybrid progency produces seed acceptable to the market since the seed size of the hybrid tends to equal the mean of the two parents. In countries where witches' broom is not a problem it would not be necessary to use resistant clones and many different crosses could be tried. It would be desirable to try crossing high yielding clones of diverse origins. The use of self-incompatible clones should be considered since isolated seed gardens could be used in the future for producing hybrid seed.

There has not been a great deal of work done on spacing cacao trees. A spacing trial at the Tropical Experiment Station in Pichilingue, Ecuador, showed that clonal cacao trees spaced 2 x 5 meters gave a higher yield than trees spaced 3 x 5 or 4 x 5 meters. At the present time, many growers are spacing clonal and hybrid cacao 4 x 4 meters. Experiments are needed to determine the most economical spacing for hybrid and clonal cacao. The results in Trinidad indicate that closely spaced cacao trees give high yields per acre in the earlier years of production. The spacing recommended for clonal cacao in Trinidad is 3.6 x 3.6 meters.

An experiment on pruning clonal cacao was started in 1954 at the Tropical Experiment Station in Ecuador. The results at the present time indicate that the unpruned trees give the highest yield. Experiments need to be conducted on hybrid cacao. At the present time the information available would indicate that cacao trees should be pruned as little as possible. Light pruning can be done to remove diseased wood and to make harvesting and spraying easier.

It has been a common practice nearly everywhere to grow cacao trees under shade trees. In a few areas cacao trees grown without shade are producing high yields; however, where cacao is grown without shade, the young seedlings receive temporary shade while being established. Experiments need to be carried out in all new areas to determine which method is best. Fertilizer trials need to be incorporated into the experiments as the unshaded cacao may require more fertilizer since the level of phytosynthesis would be higher.

The fertilizer practices must be worked out for each cacao area since the environmental conditions

Figure 8. AN INTERCLONAL HYBRID CACAO THAT IS RESISTANT TO WITCHES' BROOM CAN BE MADE BY CROSSING SCA-12 WITH ICS-6.

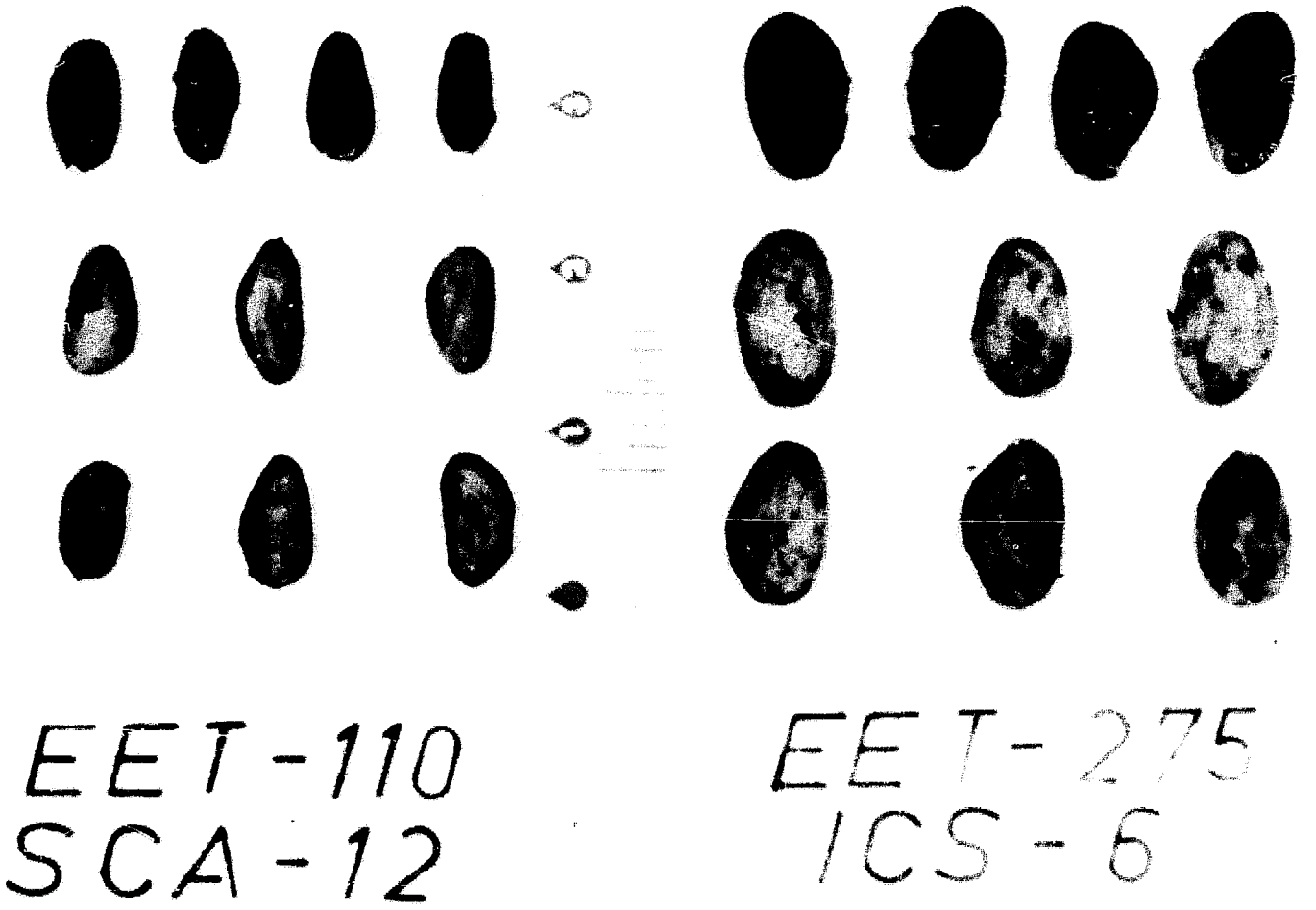

Figure 9. THE SEEDS OF SCA-12 ARE TOO SMALL TO BE SOLD COMMERCIALLY BUT WHEN IT IS CROSSED WITH ICS-6 THE SEEDS OF THE PROGENY ARE ACCEPTED COMMERCIALLY.

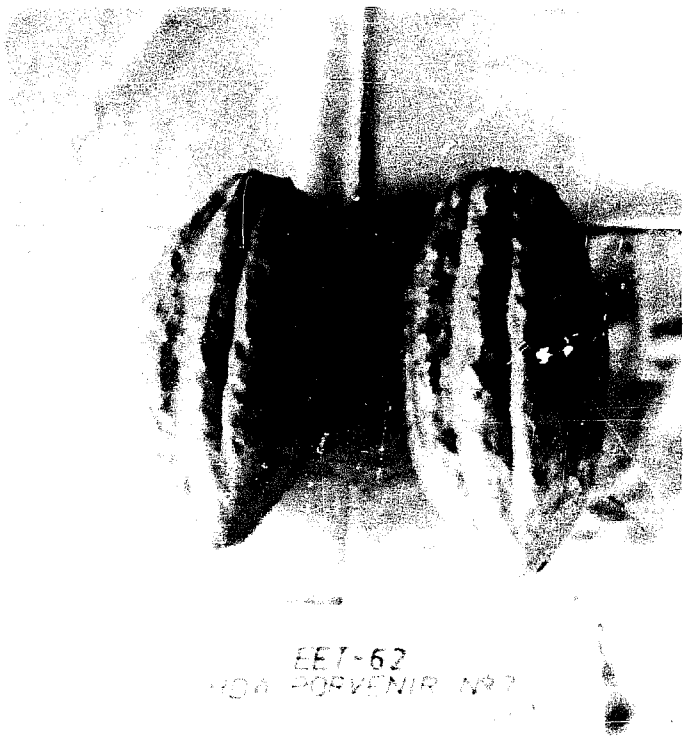

Figure 10. CLONE EET–62 WAS LOCATED AT HACIENDA PORVENIR IN ECUADOR AND IS A VERY HIGH YIELDING CLONE.

vary in different places. Where nothing is known about fertilizers in an area a complete factorial experiment should be started. It is possible that responses from fertilizers will be apparent earlier on unshaded cacao than on shaded cacao. In some countries no fertilizer response to nitrogen has been obtained in areas on unshaded cacao.

The most serious disease in the western hemisphere are witches' broom caused by *Marasmius perniciosus* (Stathel.), Monilia pod rot caused by *Monilia* sp. and black pod rot caused by *Phytophthora palmivora* Butl. In order to prevent witches' broom, resistant interclonal hybrid cacao should be grown. Experiments are being conducted on Monilia pod rot at the Tropical Experiment Station, Pichilingue, Ecuador. Kocide or zineb is the best control at the present time. Bordeaux or kocide has been used to control black pod rot and at the present time experiments are being conducted with new fungicides by the Instituto de Ciencias Agricolas at Turrialba, Costa Rica.

The most important disease in West Africa is swollen shoot caused by viruses. The branches of the trees swell and small yellow elongated spots appear all over the mature leaves. Later the leaves drop and death of the branches follows. There is no good control of this disease. Infected trees are removed and burned and insecticides are used against mealybugs, *Planococcoides njalensis* (Laing) which disseminate the virus (3). Dieldrin is used to control the ants which move the mealybugs.

The cacao pods should be harvested only when they are fully ripe. Some types of cacao produce red pods while others produce yellow pods. The red-podded types turn vermilion-orange color when they are ripe and the green-podded types turn yellow. The trees should be harvested weekly during the harvest season. The diseased and insect-infected pods should be destroyed (3).

The cacao beans should be fermented in wooden boxes for 3 to 8 days, depending on the type of cacao and climatic conditions. Some types of cacao can be fermented in baskets or by placing them in piles on a drying patio. The Rohan system of fermentation has given excellent results for small lots of beans. This system consists of stacking small boxes together in piles. The time of fermentation needs to be worked out for different types of cacao since some types require less time than others. After the beans are fermented they are dried in the sun on a patio. This will require 3 or 4 days depending on the temperature. Some of the large plantations use artificial driers. The dry beans are graded for size and insect injury. (Color photographs, pages 1–4.)

Figure 11. A CACAO FERMENTATION BOX IS NEEDED TO PRODUCE HIGH QUALITY CACAO.

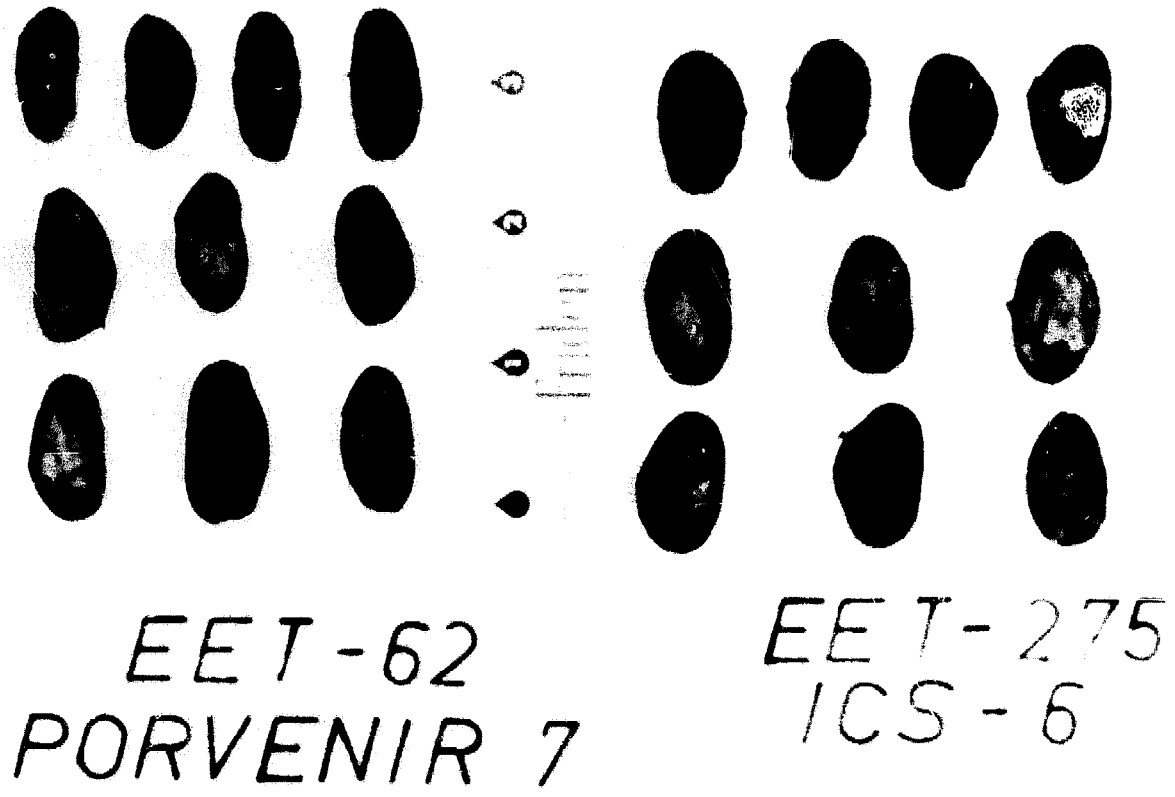

Figure 12. THE SEEDS OF EET-62 AND ICS-6 ARE LARGE AND MAKE GOOD PARENTS FOR CROSSING WITH WITCHES' BROOM-RESISTANT CLONES SUCH AS SCA-6 AND SCA-12.

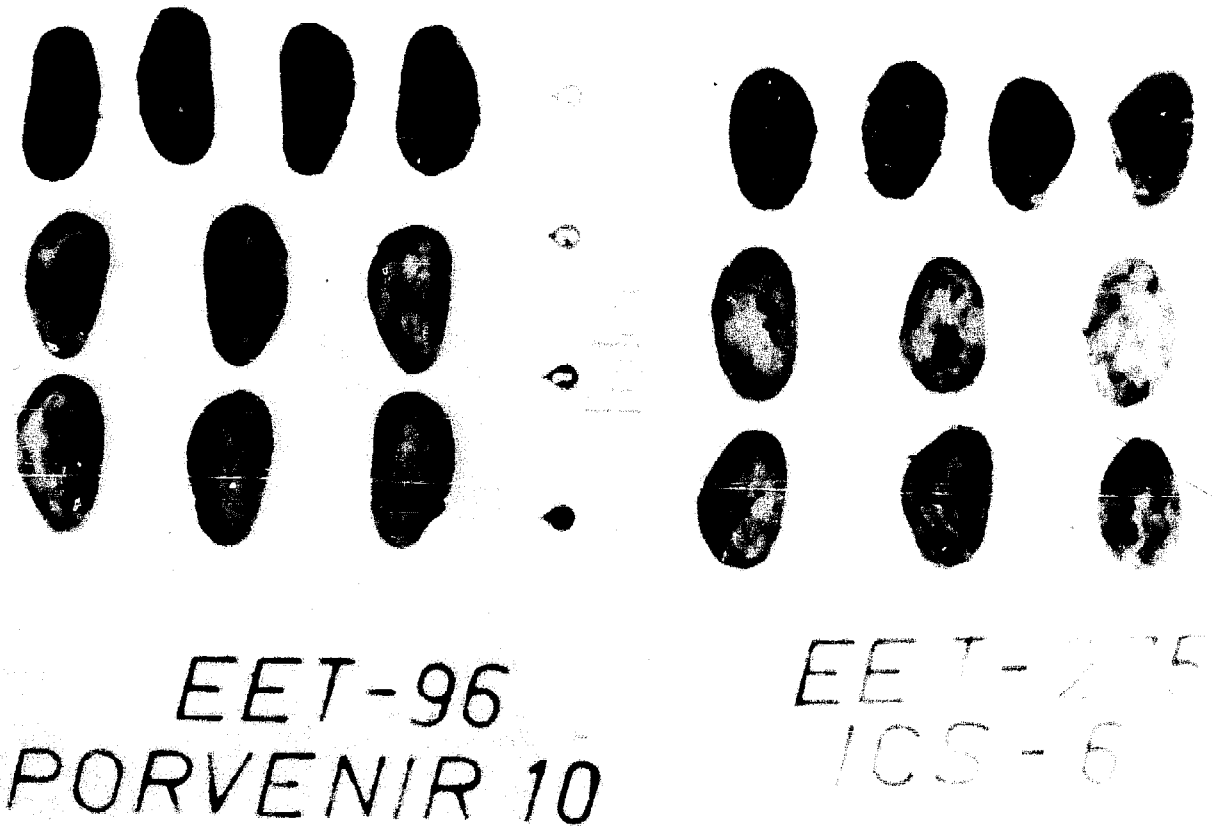

Figure 13. CLONES EET-96 AND ICS-6 HAVE LARGE SEEDS AND ARE HIGH YIELDING CLONES. THESE CLONES CAN BE CROSSED WITH SCA-12 OR SCA-6 TO OBTAIN HYBRIDS RESISTANT TO WITCHES' BROOM.

Figure 14. THE VIALS ARE REPLACED AFTER POLLINATION, TO PREVENT INSECTS FROM VISITING THE FLOWERS.

Figure 15. THE VIALS ARE HELD ON THE TRUNK OF THE TREE WITH MOLDING CLAY AND WIRE.

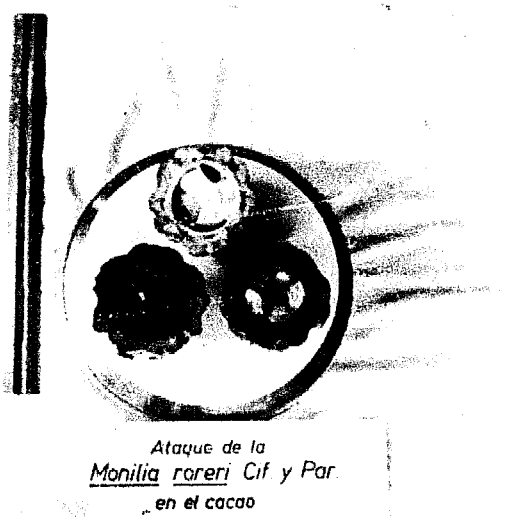

Figure 16. A HEALTHY POD AT TOP COMPARED WITH TWO PODS INFECTED WITH MONILIA.

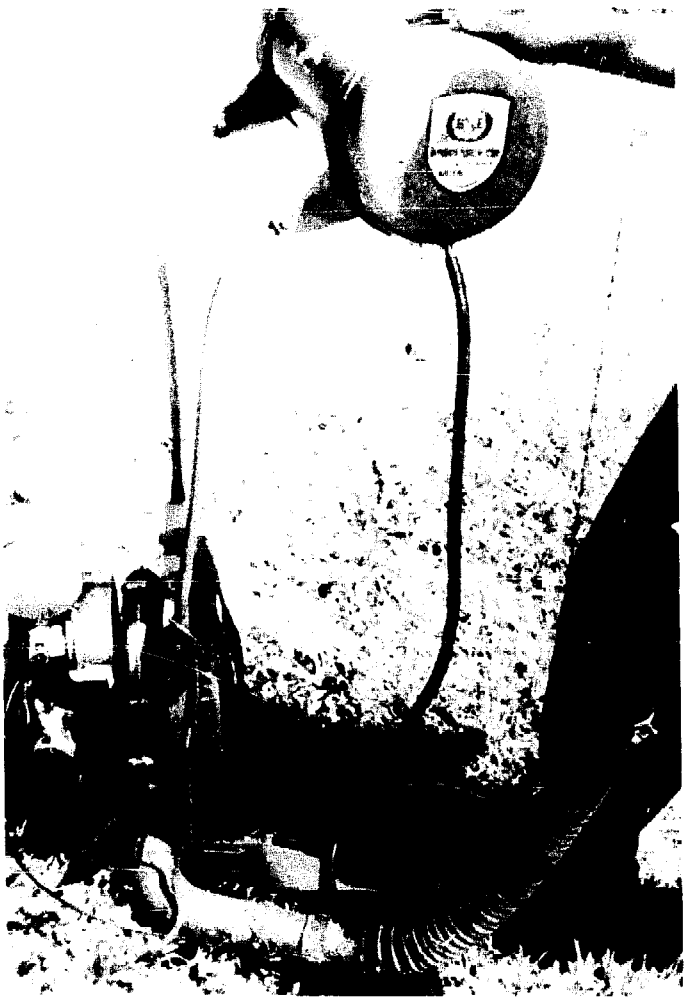

Figure 17. SIDE VIEW OF LOW VOLUME KNAPSACK SPRAYER.

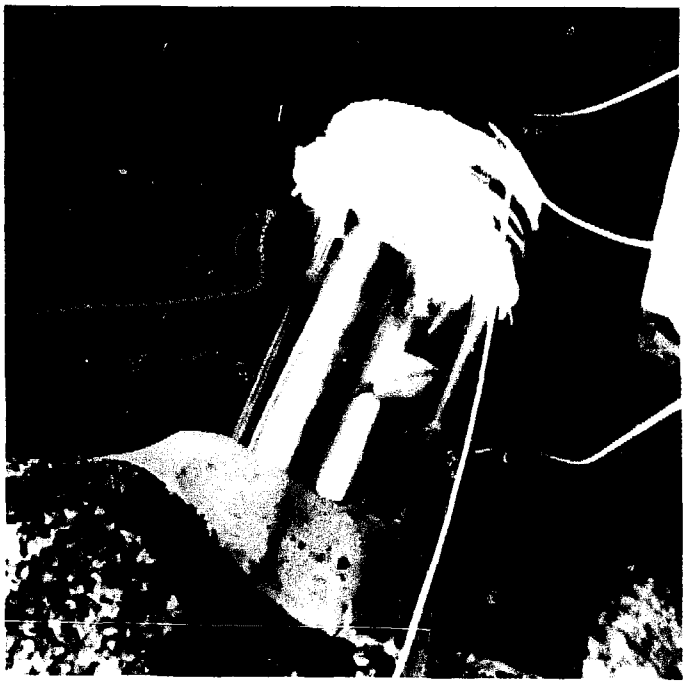

Figure 18. VIALS ARE PLACED OVER CACAO BUDS BEFORE THEY OPEN.

Figure 19. FRONT VIEW OF LOW VOLUME KNAPSACK SPRAYER USED ON SMALL BANANA, CACAO AND COFFEE PLANTATIONS.

Figure 20. THE FLOWERS ARE EMASCULATED BEFORE BEING POLLINATED WITH A DIFFERENT CLONE.

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CALAMONDIN

(Citrus mitis)

Calamondin also is called Philippine lime and is especially useful for limeades. Flavor is different and appeals to many people. It has the advantages of year-round production and decorative value. Fruits are bright orange color, mostly an inch in diameter and the peel is thin and loose resembling the tangerine. It is considered by some as a mandarin hybrid but since it breeds true from seed it does not have to be vegetatively propagated. It has shown some promise as a rootstock since it has re-

sistance to gummosis (2) and has been found suitable for satsumas but questionable for oranges in south Texas (4). It is a good stock for citrus at Homestead, Florida (3). It is not resistant to nematodes. It is highly tolerant of calcareous soils (1).

Culture, fertilizers and pests would be similar to that of oranges. Calamondins are considered excellent for marmalade.

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CASHEW

(Anacardium occidentale)

Cashews are related to mangoes. They will grow in stony, sandy or hilly land not suitable for other crops. They rarely are grown above 5,000 feet and are found mostly below 2,000 feet elevation (7).

The fleshy portion or apple is used for fresh eating and when fully ripe can be made into a delicious beverage. It also makes a good wine or may be used in preserves (9). It is rated as a rich source of vitamin C and has 7 to 9 per cent sugar and 0.5 per cent tannin (3).

There is a wide variation in the weight, size and juice content of the apples as well as the size of the nuts. Larger apples usually have larger nuts and higher juice content while yellow apples are less astringent, heavier and softer than red apples (1).

Cashew nuts of high density usually give better germination, more vigorous seedlings and produce a higher yield than those from nuts of low density (2)(12).

The kernel is an important commercial item growing extensively in India and East Africa. It has 40 per cent oil of high quality and 15 per cent protein (6).

In spite of the great variation in seedlings there are few named varieties (5). Seeds were found to germinate best when planted 2 to 3 inches deep with the stalk upward (10). Maturity and time of harvest had no effect on germination. Seeds germinate in 3 to 4 weeks.

Seedlings were found to transplant readily at 1 month old or at 10 months old. At 3 to 8 months of age, they were difficult to transplant (4).

Spacing of 20 to 40 feet is used in South India. Plantings 15 ft. each way usually are too close.

Air layers from the more productive trees come into bearing in 20 months as compared with 4 years for seedlings. Grafted trees are taller and more robust and bear fruit sooner than seedlings (8). Budded trees come into bearing in the second year after budding in El Salvador. Trees may be budded in the Philippines by using mature budwood that is turning grayish; the bud is cut 1½ to 1¾ inches long; the bud is inserted at a point of approximately the same age and appearance as the scion.

Harvesting the nuts may be done as soon as the shells become ash-colored, before the fruit is ripe. The usual method is to shake the tree. Nuts are allowed to dry in the sun until they rattle in the hull, then they are roasted in rotary cylinders at 150 to 160°F. Shelling is done by hand after roasting and kernels are dried either in the sun or in hot air chambers. Mechanical shelling is used in Tanganyika experimentally (5). Afterwards the brownish thin skin is removed and the peeled kernels are placed in "sweating chambers" to absorb some moisture (7). The shell contains an oil that is highly irritating to the skin. It is expelled during roasting so the smoke should not come in contact with the eyes or skin.

Since only 5 per cent of the trees in South India are heavy bearers and the nut characters show a wide variation there should be a great improvement by propagating superior clones (10).

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CASIMIROA

(Casimiroa edulis)

This is called white sapote in the United States and actually is not a sapote but a relative of citrus. In Central America it is called "matasano". Two species are recognized, *C. edulis* and *C. tetrameria,* of which only *C. edulis* has fruits that are free of unpleasant turpentine flavors (1). Fruits of *C. tetrameria* are larger and more attractive but have a lingering, disagreeable aftertaste.

The trees are ornamental, vigorous, rapid growing, and easily propagated. They tend to grow tall and, like most citrus, severe pruning causes them to reduce flowering and fruiting. They normally are found in deep, well drained soils at medium elevations in Central America but probably with irrigation would grow at lower elevations.

Selections have been made in California and Florida of which Dade and Pike probably are best. The skin of Pike is smooth and bright green when ripe but is yellow on Dade. The flesh is yellow, tender and sweet, without acidity. Fruits tend to fall when ripe but may be harvested before ripe and still develop almost full flavor. The fruit is fairly rich in vitamin C and nearly as rich in carbohydrates and protein as banana (1).

Dade requires another variety for pollination as it does not have normal pollen (2).

As in citrus, seeds should be planted at once after removing from the fruit. Nitrogen requirements are lower than for citrus. Spacing probably should be 8 to 10 meters each way in the orchard.

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CEYLON GOOSEBERRY (Kitembilla)

(Dovyalis hebecarpa)

This is a shrub native to Ceylon, bearing round velvety berries along the branches about the size of marbles and brownish-purple when ripe. The juice from these berries is an intense red color and makes excellent jelly or beverage. Fruits ripen in August and September north of the equator and thrive in well-drained soil (1). Plants normally are dioecious when grown from seed. Perfect flowered plants are found occasionally and selections should be made from these for propagation by cuttings which are easily rooted. Seeds germinate in 10 to 15 days. The plants may be budded or grafted (2).

Because of its high ascorbic acid content it is well worth growing for home use and might have some commercial value for processing as jelly. Spacing should be at least 6 to 8 meters each way because plants are widely spreading and occupy as much ground as citrus. Enormous crops of fruit are normally produced (3).

Other species that have larger fruits with yellow or apricot-colored flesh are *Dovyalis abyssinica* and *D. caffra,* the keiapple. Each of these may be made into jelly, sauces or preserves but *D. abyssinica* is especially pleasant for fresh eating. Both of these species also are deciduous (2).

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CHERIMOYA

(Annona cherimola)

Cherimoya, *Annona cherimola,* is found in the highlands of Central America and South America and does not thrive in hot areas. A temperature range of 70° to 85°F seems ideal, which means that it would not do well in the Tropics below 3,000 ft. elevation. Only in southern California have named varieties been reported to the authors' knowledge. Fruits from some clones may average 1 to 2 lbs. Hand pollination seems to be necessary for a good crop (1) since cherimoya flowers do not pollinate themselves. In Peru, pollen from *Annona senegalensis* is reported to give a better set and larger fruit (2).

Cherimoya does not tolerate heavy pruning and usually light pruning is sufficient.

It grafts well on seedlings of *Annona reticulata,* cherimoya or *Annona squamosa.*

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CHINESE GOOSEBERRY

(Actinidia chinensis)

The Chinese gooseberry is a climbing shrub with fruits about the size of a small hen's egg. These are tart until fully ripe when they are sweet and may be eaten fresh. The Chinese gooseberry is native to China and thrives in citrus growing areas of New Zealand. They have not been seen in the American Tropics by the authors. It is readily propagated from cuttings. Abundant moisture is required. A good market for the fruits is available in Australia (1).

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COCONUT

(Cocos nucifera)

The coconut is grown throughout the tropical world and has become important as the source of copra and coconut oil. Coconuts can withstand brackish water and commonly are seen growing along the sandy tropical coasts.

The coconut requires a well-drained soil for proper root development. The trees do well in low areas where the water table is relatively high, provided the water table fluctuates to allow sufficient aeration for proper root development (1) (3) (4).

The most important centers of coconut production lie within 15° latitude of the equator and at elevations of 300 meters or lower (4); however, coconuts have been grown successfully as far as 26° latitude north and at elevations as high as 600 meters (1). Coconuts will withstand a small amount of frost but do best in a climate having a mean temperature ranging from 77° to 86°F (1) (4). A minimum of 60 inches of rainfall is required. Even distribution of the rainfall and high atmospheric humidity are preferable (1) (4).

Cross-pollination has resulted in a great number of varieties. These are distinguished on the basis of color, size and shape (4). Because coconuts are propagated only by seed, careful selection of seed for reproduction is necessary. Coconuts from known parentage should be selected (2) (3). Dwarf coconuts bear early and give high yields in Jamaica.

Coconuts for propagation should be planted in a nursery and then transplanted to the field from one-half to 4 years after placement in the nursery (4). It is preferable to transplant them when they have attained a height of at least 18 inches (2).

Spacing of trees in the plantation varies from 8 m^2 to 10 m^2 which results in a tree density ranging from 100 to 156 trees per hectare (2) (4).

The coconut requires 6 to 10 years before production begins and does not reach full production until 15 to 20 years of age (3). In many areas the average annual production is about 50 fruits per tree, however, yields in superior plantations may go as high as 100 fruits per tree (2) (4). Fruits usually require 1 year to develop (3).

The plantation should be well cultivated for weed control or a cover crop may be grown between the coconuts for the first 4 to 6 years (2) (3). Corn, tomatoes, bananas, or plantain may be grown between the rows; however, it is preferable to grow leguminous green manure crops to increase the level of soil fertility and enchance coconut production (2) (3). Legumes recommended are *Vigna sinensis, Vigna hosei, Pueraria phaseoloides, Crotalaria* spp., *Tephrosia* sp., *Stizolobium* sp. etc. (2) (4). Pasturing of the plantation usually is inadvisable because the packing of the soil at the base of the tree reduces the soil aeration, thus impeding root development.

Coconuts will respond to NPK applications depending upon the nutrient level of the soil. Increased coconut production may be obtained by soil application of 5 pounds of 10-10-10 fertilizer per mature tree per year (4). Gattoni (2) recommends 1 pound of nitrogen per plant for one year old plants. By the time the trees reach the age of 5 years this amount could be increased to 4 or 5 pounds of nitrogen per tree per year.

The most damaging diseases attacking coconuts are as follows:

1. Bud rot caused by *Phytophthora palmivora* Butl. which attacks and kills the terminal bud (2).
2. Leaf spot or leaf blight caused by *Pestalotia palmarum* Cke. (2).
3. Red ring caused by *Aphelenchoides cocophilus,* a nematode hitherto confined to the western hemispheric tropics, results in a rapid wilting of the leaves and a red ring in the trunk (4).
4. Bronze leaf wilt, which is believed to be physiological in nature (4).
5. Bleeding stem disease caused by *Thielaviopsis paradoxa* (De Segn.) Hoehn. (4).
6. Dieback caused by *Botryodiplodia theobromae* Pat. (4).

The height of the coconut often makes chemical control difficult in older plantations. However, in many areas, aerial spray equipment is available and fungicides may be applied.

The most common insect pests of coconuts are as follows:

1. Rhinoceros beetle, *Oryctes rhinoceros* L. which attacks the heart of the tree (4).
2. The coconut weevil, *Rhynchophorus palmarum* (L.) is a Coleoptera which attacks the bud. (Dieldrin gives an effective control) (2).
3. The beetles, *Strategus* spp., the larvae of which attack the soft wood and the heart of the tree (4).
4. Katydids or long-horn grasshoppers, *Sexava coriacea* (L.), *S. nubila* Stal, *S. karnyi* Leefmans, and *S. novaeguineae* Brancs. attack coconuts in almost all the coconut growing areas (4).
5. The larvae of the moths, *Artona catoxantha* (Hampson) and *Hidari irava* (Moore) eat the young coconut leaves (4).

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COFFEE

(Coffea arabica)

Coffee belongs to the family Rubiaceae and will grow under a wide range of climatic conditions. High quality coffee is obtained at altitudes of 1,200 to 1,700 meters where the temperature is 16° to 22° centigrade. About 50 per cent of the world's coffee comes from Brazil at elevations of 800 to 1,200 meters (4). Very high yields of sun-grown coffee are obtained at sea level in Hawaii. The milder coffees come from the higher elevations of El Salvador, Guatemala, Colombia and Costa Rica.

Coffee thrives best in a deep, well-drained soil that is not too light or too heavy. Volcanic loams seem to be ideal for coffee. A pH range of 4.2 to

5.1 is best for arabica coffee in Brazil and Robusta coffee in East Africa (4).

It is very important to select the right variety for any given area. In order to decide which variety yields the highest, it is necessary to conduct variety trials. The following varieties have performed well in some Latin American countries: Caturra, Pacas, Mundo Novo and Bourbon. The Caturra variety has short internodes, is easy to harvest and adapts itself well to close spacing. The INEAC variety of Robusta coffee is a good yielder.

Coffee is grown under shade in many countries but at the present time there is a trend away from this type of coffee culture. Several experiments in different parts of the world have shown that sun-grown coffee, when fertilized, yields several times more coffee than shade grown coffee.

Spacing trials in Puerto Rico and Ecuador have shown that close spacing of coffee trees yields higher than wide spacing of the trees. At the present time the best spacing seems to be 1 x 2 meters for Caturra coffee. Close spacing reduces the labor costs for weeding the coffee.

Since fertilizer requirements for coffee vary with different environmental conditions, trials correlated with tissue analysis are necessary for determining the correct fertilizer practices for a specific environment.

Sun coffee requires more fertilizer than shade-grown coffee. Nitrogen usually is deficient in most tropical soils and a nitrogen response frequently is found in sun-grown coffee. The leaves of coffee trees should have about 2.8 per cent total nitrogen for good production. A potash response has been obtained in some countries on sun-grown coffee. Generally coffee does not respond to phosphate. In some areas coffee responds to magnesium, iron, zinc, manganese and boron. Leaf symptoms of

Figure 40. GROWING COFFEE SEEDLINGS IN POLYETHYLENE BAGS.

Figure 41. A FOUR-YEAR-OLD ROBUSTA COFFEE TREE GROWN WITHOUT SHADE.

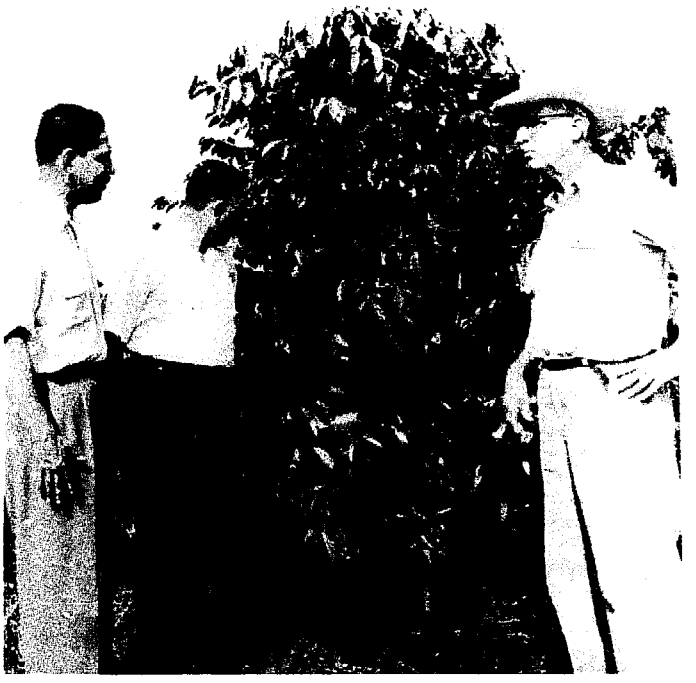

Figure 42. A THREE-YEAR-OLD CATURRA COFFEE TREE GROWN WITHOUT SHADE.

nutrient deficiencies are shown in color on pages 22 through 25.

Many different types of pruning systems are used for coffee. The main reason for pruning is to reduce the effect of biennial bearing and to make harvesting easier. Biennial bearing is a characteristic of coffee since the cherries develop on one year old wood. When coffee is not pruned there is a tendency for coffee to bear heavily one year and produce new wood the next year when production is light, then to produce another heavy crop the following year on the one year old wood. A good pruning system will tend to lower the yield on the peak years and raise the yield on the lower years of coffee production. Some pruning systems require skilled laborers. The best system that does not require skilled labor is called the BF pruning system and was named after Dr. J. H. Beaumont and Mr. Edward Fukunaga of the Department of Horticulture, University of Hawaii. The main advantages of this system are that it can be applied to a high population of trees and the pruning system is simple enough so that it can be taught to the farm workers. Several modifications of the BF system can be used for different coffee tree spacings. The BF 1 - 3 - 2 - 4 system will be used as an example. The pruning system should start after the second harvest year. The system consists of cutting off the trees about 12 to 18 inches above the ground with a pruning saw. On large plantations a mechanical saw can be used. New shoots will appear and the three best ones should be selected for the next crop while the others are removed with pruning shears. The pruning should be done after the harvest is completed each year. The BF 1 - 3 - 2 - 4 system usually is used on coffee spaced 1 x 2 meters. An example of two cycles of pruning is shown in Table 1.

The rows are numbered consecutively throughout the field from one to four and all the number one rows are cut the first year. These trees will be out of production for one year so that only 75 per cent of the total tree population will be harvested each year. This might appear as a disadvantage of the system but since the system is set up for close spacing such as 1 x 2 meters there will be 5,000 trees in each hectare and 3,750 trees would be harvested each year. In a normal planting of coffee spaced 3 x 3 meters, there are only 1,111 trees per hectare, all of which are harvested each year. The second year all the trees in row number three are pruned in like manner. The reason for alternate

TABLE 1. PRUNING COFFEE BY THE BF 1 - 3 - 2 - 4 SYSTEM

Trees planted in 1964 with two meters between rows and one meter between trees

Row No. 1 pruned in 1967	1st cycle
Row No. 3 pruned in 1968	
Row No. 2 pruned in 1969	
Row No. 4 pruned in 1970	
Row No. 1 pruned in 1971	2nd cycle
Row No. 3 pruned in 1972	
Row No. 2 pruned in 1973	
Row No. 4 pruned in 1974	

row pruning is to take advantage of the shade of the trees which have not been pruned recently. More information on the BF system of pruning can be obtained from the Department of Horticulture of the University of Hawaii.

The most serious coffee disease is Hemileia rust caused by *Hemileia vastatrix* Berk. & Br. as shown on page 23. This disease prevents the growth of arabica coffee in several countries of the world. Robusta and Liberica coffee are more tolerant to the disease and will grow in areas like western Africa where Arabica coffee cannot produce. A few Arabica varieties have resistance to this disease.

Rootrot caused by *Rosellinia bunodes* (Berk. & Br.) (Sacc.) can be serious under certain environmental conditions as well as berry spot caused by *Cercospora coffeicola* (Berk. & Cke.)

Scales and leaf miners can be serious on coffee in many Latin American countries. Scale damage is more serious in the dry season since a fungus is present in the wet season that kills the scale. Overhead irrigation is the best control for scale when it is feasible. When it is not possible, the trees can be sprayed with a mixture of agricultural spray oil and parathion. Leaf miners can be controlled with malathion or diazinon but the timing of the spray is very important and must be worked out for each environment. These insecticides should be applied only by experienced personnel since they are very toxic to human beings.

Coffee pickers tend to strip the berries from the trees in many parts of the world. The reason for this is that the pickers are paid a certain amount per box and they wish to harvest the highest amount possible in a given period of time in order to make as much money as possible. When the berries are stripped off the limbs, the green berries

are harvested with the red cherries as the cherries near the central axis of the tree mature before the berries on the other part of the limb. The green cherries are difficult to pulp and give a lower quality coffee. When the limbs are stripped the buds on the limbs also are injured and this affects production next year.

This problem can be solved by the use of a grading board. This can be made of wood or plastic and should contain one hundred holes slightly smaller than a coffee cherry. A random sample of cherries is graded on the board by counting the number of green cherries. When pickers are penalized for the number of green cherries, this system has a tendency to reduce the number of green cherries picked.

All coffee should be processed by the wet method in order to produce a high quality coffee. The red cherries are pulped as soon as possible after harvest. In some countries a siphon tank is used before pulping to separate the light beans from the heavy beans. After the cherries are pulped they are fermented for 12 to 24 hours, then washed to remove the mucilage from the beans. The beans are then sun-dried or artificially dried. After the beans have been dried they are hulled, polished and graded. Large processing plants are more efficient for handling coffee and should be used whenever possible. In areas where processing plants are not available small pulpers and washers can be used. The technique or skill of processing coffee is acquired with experience and cannot be obtained strictly from books.

The dry method of processing is used in Brazil in areas where there is a shortage of water. The cherries are dried for 15 to 30 days and hulled mechanically. This type of coffee usually is sold for less money due to lower quality.

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Figure 48. SUN-DRYING COFFEE.

CUSTARD APPLE, BULLOCKS HEART

(Annona reticulata)

The custard apple is native to Central America and the West Indies and grows in more difficult situations than other Annonas. Fruits are as large as those of cherimoya but not generally liked except in India (2). It grows in areas subject to long dry periods and does not tolerate high soil moisture (1).

Its main value is as a vigorous, resistant stock for other Annonas.

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CYPHOMANDRA

(Cyphomandra betacea)

The "palo de tomate" or tree tomato of the family Solanaceae is native to Peru and grows in warmer regions only at higher elevations. The plant is found in the Andean areas of Latin America and in Brazil. It begins bearing at 2 years from seed and usually is finished at 5 or 6 years (2). It

has been developed as a commercial crop in New Zealand.

It grows 8 to 10 feet high with large cordate ovate leaves, small pinkish flowers and fruits oval in shape about 2 inches long, at first greenish purple changing to reddish purple when ripe. It has a subacid agreeable flavor but usually is used in stews or for preserves (3). Other varieties may be orange or red when mature. It requires abundant soil moisture and cool temperatures. Because it has a hard rind, it withstands the rough ride to market and is a useful fruit for tropical mountain areas. It is easily propagated from seed but also may be propagated from cuttings which come into bearing earlier (2). A spacing of 4 meters should be sufficient. The plants do well in the poultry yard where they can serve as shade.

It is fairly free from insects and diseases but has been reported to be a host to potato virus Y (1).

When cooking the fruit the skin is removed by scalding and the seeds are strained out (2).

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DATES

(Phoenix dactylifera)

Date palms will grow throughout the Tropics but only in favorable areas will they bloom and ripen fruit. North East Brazil has promise as a date area (14). Over one third of the dates of the world are grown in Iraq (12).

It probably is one of the earliest cultivated crops. The plants are dioecious and are not pollinated by insects but fruit production is dependent on man for pollination. Although the male flowers produce abundant pollen wind does not carry pollen very far.

In orchard culture, one male palm produces enough pollen for 40 or 50 female palms. The female flower has to be pollinated within 2 to 3 days from opening. Pollen can be stored for as long as 12 months in an ordinary household refrigerator if kept dry. Pollen from different males can affect size of fruit, size of seed or time of ripening. Pollen from the Fard male ripens Deglet Noor several weeks earlier than from other male varieties. Pollen from *Phoenix canariensis* delays ripening by 3 weeks and reduces seed size (12).

Propagation is from offshoots which are produced in the first 8 to 10 years of growth. Planting seeds will give half males and half females and sex cannot be determined until flowers are produced, after 5 to 8 years or more. Seedlings are highly variable. Offshoots should grow to about 15 to 20 pounds in weight and preferably have roots before removing for transplanting. Special sharp chisels are used to sever the connection with the mother palm to prevent damage to either one. Mulching about the base of the plant after transplanting and wrapping the leaves in burlap are helpful in the hot summer. Medjhool is a large fruit of high quality that resists rain (5). To avoid rain and insect damage some varieties are eaten in the khalal (hard ripe) stage. Barhi, Jozee and Braim are sweet in this stage. Braim may be ripened by boiling and drying (7).

It is important that the time of ripening be free of rain to prevent spoilage; however, some varieties such as Amir Hajj, Kustawy, Thoory, Khadrawy, Dayri and Halawy are less susceptible to rain spoilage.

The number of heat units from the time of blossoming to ripening ranges from 4,000 to 5,500 for various varieties (1). Growth of palms stops below 48°F (10).

Pruning or thinning 50 to 60 per cent of the fruit set has been shown to give good results (13).

Dates are especially salt tolerant but are twice as productive on salt free soils (8).

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DURIAN

(Durio zibethinus)

The durian is not well known outside of southeast Asia and the Malay archipelago where it is native. The large fruits weighing up to 10 lbs. are covered with numerous spines. When mature, the fruits have a very offensive odor but an excellent flavor and they are highly appreciated in the area where they are native (3). The seeds may be roasted and eaten like nuts (2).

Apparently there is a great variation in seedlings and some occur that are free of the objectionable odor (1). Seeds are quickly perishable but germinate readily in 8 days when planted soon after removing from the fruit. They can be budded by using buds prepared by removing the leaves from the twigs about 2 weeks before they are to be used.

No horticultural varieties have been located by the authors.

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FIGS

(Ficus carica)

A native of the Near East, the fig is more properly subtropical. It is deciduous and grows where temperatures drop considerably below freezing; however, figs also grow in the Tropics in areas free of frost. The most favorable climate appears to be that of the Mediterranean area and similar areas such as California, Chile and South Africa. To get the best quality of fruit, nights should be warm but temperatures above 100°F would not be desirable (4). Figs thrive on abundant moisture but since figs are native to desert areas they can withstand dry periods very well if the soil is deep enough. Annual rainfall should be at least 25 inches, preferably in the winter or early spring.

Figs are high in calcium, sugar, iron and copper (2). Larger and better quality figs are grown along the coast rather than in the dry interior of California.

Figs are propagated readily from cuttings. Grafting or budding also may be done. Many varieties are known but only a few are adapted to the Tropics. Because of insect damage by entering the "eye" near maturity, it is necessary to choose varieties with a closed "eye."

Smyrna figs require pollination but most of the "closed eye" group are parthenocarpic. Celeste, Green Ischia, Kadota and Brown Turkey do not require pollination (3). Preston Prolific is reported to be resistant to splitting and insect damage in Australia. (6).

Large scale production will continue to be in the Mediterranean type of climate but other areas may grow them for home use or canning (1) (5). It has been shown that nitrogen gives increased growth and yields without reducing quality. There was no response from heavy applications of phosphorus and potash (6). Figs are very susceptible to nematodes and should not be grown in nematode infested soils unless the soil has been treated.

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GRAPES

(*Vitis* spp.)

Grapes are preferred fruits in all Mediterranean countries and wherever Mediterranean people have gone in the Tropics they have taken grapes with them. Except for a few instances grapes have not prospered in the Tropics. This is partly due to the lack of a dormant period but diseases have also prevented good growth and fruiting. The knowledge that some vines have borne good fruit in the Tropics and that some species of *Vitis* are tropical has encouraged plant breeders at the Florida Agricultural Experiment Station laboratory at Leesburg, Florida, to use these in developing varieties suitable for warm climates (7, 15). Other breeders are using species from warm regions to develop resistance to black rot (1, 2, 16).

Some varieties released that are of particular interest for the Tropics are Lake Emerald, Blue Lake (15), Dunstan, Phil S. Taylor (5), Red Niagara (6), Fairchild, Tropics (3), Everglades, Largo and Tamiami (4). Of the older varieties, Perle of Csaba, Perlette and Delight (11), Queen of the Vineyard (8), Barlinka (9) and Pachadraksha (13) have been recommended in different areas.

Some varieties have been observed to bear fruit in the Tropics. Black Spanish and a variety resembling Valhallah have produced fruit in El Salvador. Several vines bear fruit regularly at medium elevations in Haiti. Lake Emerald has borne fruit at sea level in Haiti. Isabella is one of the better known varieties in Guatemala and Colombia. Herbemont and Lenoir are capable of cropping twice a year in Honduras. Trials including the above varieties would be worthwhile wherever permanent planting can be made.

Grapes are commonly propagated by cuttings. Rootstocks are useful in avoiding soil diseases and nematodes. Dog Ridge, Champanel and La Pryor are good stocks for root rot resistance (12). Dog Ridge, Salt Creek and 1613 (14) are resistant to some nematodes.

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GRAPEFRUIT

(*Citrus paradisi*)

Grapefruit is of American origin, probably in the Caribbean area (6). It is characterized by generally thinner skin, smaller juice sacs, and a more pleasing pulp texture than usually found in shaddocks. It is very important in the U.S. citrus market and is generally liked in the Caribbean area but is finding slow acceptance in other parts of the Tropics. This is partly due to the very seedy fruits usually obtained from seedling trees and to the fact that they are not allowed to ripen properly before harvesting.

Grapefruit is especially adapted to the warm climates at low elevations and does not require low temperatures for proper coloring when mature as do the oranges (7). Grapefruit also requires nearly twice as many heat units for maturity as oranges. Using the summation of daily means above 55°F as an index, grapefruit needs 6300 units. Higher average temperatures give larger fruit in California. Grapefruit is not as sensitive to water

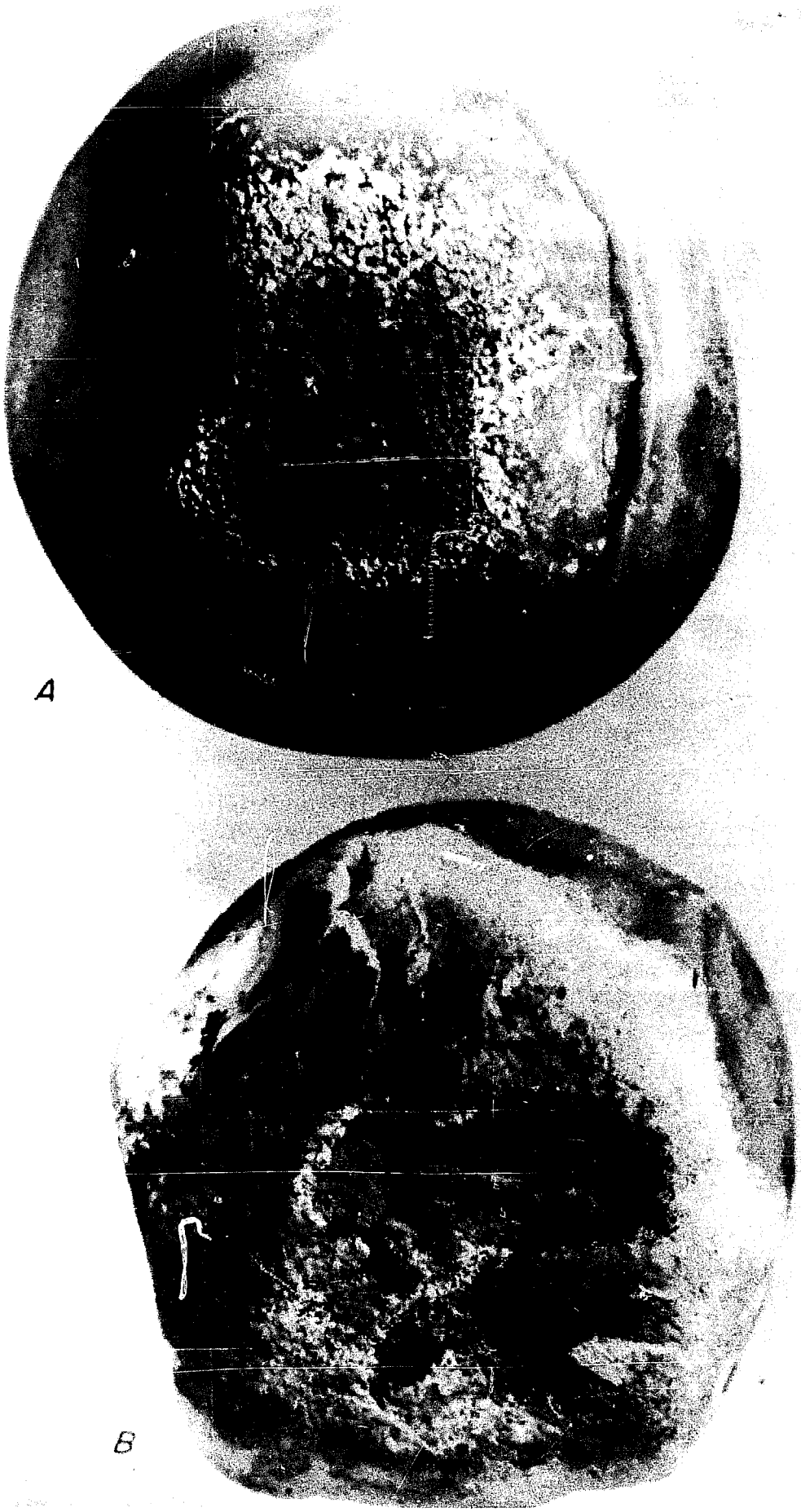

Figure 58. A—BLUE MOLD ON GRAPEFRUIT. B—BLUE AND GREEN MOLD ROTS. *U.S.D.A. Photogr*

deficits as oranges but an abundance of moisture is important for good yields (8).

Most grapefruit varieties have originated in the United States. Two popular earlier varieties were Duncan, a very seedy but high quality fruit with white flesh and Marsh, seedless with white flesh. Limb sports with pink flesh are Thompson (Marsh Pink) and Foster which is seedy. Further mutations in recent years have produced varieties with deeper red flesh and with color that shows through the peel. Ruby is the leading variety in South Texas (3). Burgundy Red has a deeper red color throughout the season than Ruby (5). John Garner originated from Duncan seed and has the Duncan quality, with only 5 seeds per fruit (2). Duncan is preferred for canning because the segments separate more easily.

Grapefruit is propagated by budding on seedlings. The best rootstock in extensive trials in Texas has been the Cleopatra mandarin (4).

Grapefruit requires a little more space than oranges and should be planted 25 x 25 or 30 x 30 feet. Pruning to remove dead wood and broken branches usually is sufficient. In very humid areas it may be necessary to prune branches near the ground.

Grapefruit requires fertilizer to produce high yields which may reach 20 tons of fruit per acre or more. About 1 to 2 lbs. of actual N per tree should be used per year. This usually is applied in the spring just before blooming. It is best to keep the nitrogen low when the fruit is ripening. Nitrogen applied at the time of ripening may delay maturity and reduce the quality.

The California red scale is the most serious of all insects. In humid areas or during the rainy season the scale is kept in check by fungi if no spraying is done; however, when humidity is low and fungi cannot develop, it sometimes becomes necessary to spray with parathion. Mites occasionally are serious and can be controlled with Kelthane or malathion. Fruit flies also can be serious in the Tropics. These are controlled by a bait spray at 2 week intervals; this consists of 1 lb. protein hydrolysate, 3 lbs. malathion (25%) with 1 gal. or more of water (1).

Gummosis is a common disease in the Tropics. This may be avoided by budding 12 to 15 inches above the ground level onto resistant stock such as sour orange or Cleopatra mandarin. In setting the nursery trees in the orchard, planting boards should be used to prevent the trees from settling as the scion may become infected if the bud union is near the ground. Infected areas may be cleaned and painted with Bordeaux paste or Cuprocide but the only satisfactory control is the use of resistant rootstocks.

An "aerial" gummosis can attack the branches in humid areas. Spraying with Captan has been found effective when applied at the beginning of the rainy season each year. Reducing pruning to a minimum also is helpful since the disease enters through wounds.

Tristeza is a serious virus that is transmitted through infected budwood. This can be controlled only by using virus-free budwood and resistant rootstock such as Cleopatra mandarin.

To prevent blue or green mold, fruits should be stored at 45°F. Fruits in tropical climates tend to show pitting if stored below 45°F.

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GUAVA

(Psidium guajava)

The common guava, *Psidium guajava,* native to tropical America, has been distributed to nearly all the tropical and subtropical areas of the world. The fruit commonly is used for making jelly, puree, paste or jam; however, it may be eaten as fresh fruit. The guava has a high vitamin C content which may be 5 times as high as the orange (6).

The guava may be grown on a wide range of soils. It will thrive on soils ranging in pH from 4.5 to 8.2 if properly fertilized (7). For optimal growth

the guava needs a constant supply of moisture (4). The guava will survive flooding and will grow on water-logged soils (2).

Guavas are sensitive to low temperatures. Mature trees may withstand 26°F for a short duration. However if mature trees are killed back to the ground they will sprout from the base and return to production in 2 or 3 years. Young trees may be killed at 28°F for a short period of time (7).

Guavas are grown commercially at elevations less than 1,000 meters in areas having an annual rainfall from 40 to 150 inches (2) (5). Excessive and prolonged rainfall at the time of fruit ripening often causes severe fruit cracking resulting in spoilage and fruit loss (7).

Guavas commonly are propagated by seed. This has resulted in a wide assortment of seedlings. At present only a few named varieties of guava exist. The variety Supreme is high-yielding and produces a white-fleshed fruit of good quality for preserving or eating fresh (7). Three of the better known red-fleshed varieties are Red Indian, Rolfs, and Ruby. A cross between Ruby and Supreme has been produced in Florida (7).

Guavas are open-pollinated and produce seedlings which are highly variable regarding fruit and tree characteristics. In order to produce high yields of desirable fruit it is advantageous to use vegetative propagation. Variability in seedlings can be decreased by hand self-pollination of individual flowers designated for seed production.

When guavas are propagated by seed the seed should be planted as soon as possible after the removal from the fruit (7). The seed should be sown in flats of a sandy loam soil and covered to the depth of ¼ inch. Damping off may be a problem but can be controlled by seed treatment with cuprous oxide or other suitable fungicides. Five to seven months are required before the seedlings are ready to be transplanted (2).

An efficient method of vegetative propagation is by bud grafting the selected variety on seedling rootstocks. Both the patch bud technique and the Forkert technique are successful. Seedling stock and budwood should be from ½ inch to 1 inch in diameter. Budwood should be conditioned by cutting off the leaves of selected branches 10 days to 2 weeks before removing the branches for budwood. During this period of time the buds become more enlarged and grow more readily after budding (2).

Other successful means of vegetative propagation are marcottage or air layering, side-grafting and cuttings. Both root and stem cuttings may be used. Hybrid guava stem cuttings treated with 0.8 per cent indolebutyric acid were 40 per cent successful in rooting after remaining under mist for one month (3).

A limited number of plants can be made by severing roots 2 to 3 feet away from the trunk of a desired parent with a spade. Plants developing from the cut off portion can be dug up and transplanted as soon as they reach a height of 12 inches.

Recommended spacings between trees vary from 18 to 30 ft. (2) (7). In fertile soils or under heavy fertilization the greater spacing would be the more desirable.

The guava requires little pruning. Suckers arising at the base of the trunk should be removed as well as low-hanging branches that touch the ground.

The type, amount, and mixture of fertilizer used will vary with the nature of the soil. One general recommendation (2) includes applications of ⅓ pound of 8–8–8 or 10–10–5 fertilizer around the base of each tree four to five times a year. The second year ½ pound and the third year 1 pound per tree per application should be used. Mature, producing guava trees should receive 150–200 pounds of nitrogen per acre per year, preferably split into at least 3 applications per year (7).

Under proper fertility guava trees usually begin bearing fruit the second or third year and reach satisfactory production after the fourth year (6) (7).

The fungus, *Clitocybe tabescens* (Scop. ex Fr.) Bres. causes a root and crown rot which often attacks and kills guava trees. The fungus attacks many species of trees as both a parasite and a saprophyte. Removal of tree roots, especially oak, in the field prior to planting is the only known method of avoiding this disease (7).

The alga, *Cephaleuros virescens* Kunze often causes a spotting of fruits and leaves in humid coastal areas. Spraying with copper and zinc reduces the infection (7).

Parasitic rootknot nematodes can cause considerable damage in sandy soils. Injury can be somewhat overcome by heavy fertilization, irrigation, and the use of nutritional sprays (7).

The oriental fruit fly, *Dacus dorsalis* Hendel, is the most serious insect pest of guava in Hawaii. In other areas the Mediterranean fruit fly, *Ceratitis capitata* (Wied.), may be the most important pest attacking guava. The larvae of the fruit flies bur-

row through ripe fruit making it unfit for human consumption. Satisfactory control may be obtained with applications of malathion combined with a protein hydrolysate bait material, applied at 2 week intervals. High pressure spraying of DDT or Methoxychlor also will give effective control (2).

Consult Chapter 4 for insect controls.

CATTLEY GUAVA

(Psidium cattleianum)

The Cattley guava *Psidium cattleianum* Sabine, often called the strawberry guava, is more frost resistant than the common guava. Mature plants may withstand 22°F. The Cattley guava is of two types, red and yellow. It is easily propagated by seed and the seedlings are less variable than in the common guava. Red-banded thrips may attack the Cattley guava but they can be controlled easily with Malathion (1) (4).

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ILAMA

(Annona diversifolia)

This fruit thrives at low elevations and is considered by most people equal to cherimoya as a dessert fruit. The flesh may be either white or pink. Superior clones have been successfully grafted on *Annona reticulata.* Because it can be grown under more diverse conditions it probably has greater value than cherimoya in the Tropics. In addition, hand-pollination is unnecessary. It is seldom found above 2,000 feet elevation.

The large sized fruit cracks when it ripens on the tree and this cracking is the usual indication of time to harvest in Central America; however, it would be better to harvest just before it splits and allow it to ripen after harvest. It should be soft before eating.

Ilama appears to be well adapted to a protracted dry season. "It is a fruit which cannot be too strongly recommended for cultivation throughout the Tropics" (1).

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IMBU

(Spondias tuberosa)

The imbu grows wild on the plains of northeastern Brazil and has been cultivated in areas where it is not indigenous. It has a low spreading crown about 25 feet in diameter. The roots are swollen, hence the specific name *tuberosa.* The leaves are 4 to 6 inches long with 5 to 9 oblong ovate leaflets, 1 to 1¾ inches in length. The fruit is similar to a Green Gage plum. It is oval, about 1½ inches long and greenish yellow in color. The skin is thicker than a plum and tough. The seed is oblong and about ¾ inch long (1).

The fruit of the imbu has the best flavor of the Spondias. The fruit is eaten fresh and is used in a jelly. It is used to make a dessert in Brazil called imbuyada.

The fruits usually are grown from seed but it is desirable to propagate high yielding trees by vegetative propagation. Cuttings can be used or imbu can be inarched on ambarella. The tree should not be planted on calcareous soil.

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KUMQUATS

(Fortunella spp.)

This citrus differs from other commercial types of citrus in that it is bushy and the fruits are small

with a sweet, mild rind. These are borne on small shoots with 1 to 5 fruits per shoot. These shoots often are harvested by cutting the twig to be used for decoration. There is considerable demand for the fruits in salads.

Three varieties usually are considered most important. The Nagami is oval or oblong, brightly colored but somewhat acid in pulp, about 1 to 2 inches long and ¾ to 1 inch in diameter. The Marumi is small, round, rather acid but pleasant to eat in small quantities. It is highly colored and decorative. The Meiwa is larger, about 1 to 1.5 inches in diameter, round, sweet and pleasant to eat. It is not as highly colored as the other two. It frequently bears fruit in the nursery row before it is one year old (1).

They grow readily on trifoliate stock but may be budded on other stocks, especially the citranges.

Kumquats do not bloom until May in the United States, thus being at their best at Christmas time.

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LEMON

(Citrus limon)

Lemons are not as well adapted as limes and calamondins to the Tropics (6) and are commercially important only in the Subtropics such as California, Chile and the Mediterranean area. This is unfortunate for tropical regions as lemons have some advantages in their tougher peels and resistance to handling in marketing. They also have higher ascorbic acid content and may be stored for considerable time.

In Florida a lemon-lime hybrid called Perrine is being grown to some extent (1). It appears to do best on rough lemon or sweet orange (4). Meyer, another variety introduced from China is doing better than Eureka or Lisbon in the warmer areas of Texas and Florida and has shown evidence of better adaptation to the Tropics. It is a large-fruited juicy lemon with thinner peel than Lisbon or Eureka.

Lemons are grown much like oranges except that sometimes more pruning is required; however, pruning is confined to interfering branches and dead wood.

Close spacing may be best in areas where the frost hazard is a problem, but in the warmer areas 25 x 25 feet is recommended. Nitrogen is the main fertilizer needed but more than 1 lb. of actual nitrogen per tree per year has not given any increased yields (5). Lemons may respond to phosphorus especially if budded on rough lemon (2).

Lemons are harvested green and "cured" before putting on the market. This is done in rooms with 80 per cent humidity at 60°F for 3 weeks (3).

Insect and disease problems are the same as for oranges.

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LIMES

(Citrus aurantifolia)

Citrus aurantifolia is considered to be the only truly tropical species of commercial citrus (6). Limes are especially well adapted to tropical areas, growing well at low elevations and even near the seacoast where other citrus does not thrive. The common lime was introduced to the American Tropics by early explorers and has been propagated generally by seeds. Various names are used depending on where they are grown such as Key lime, Mexican lime and West Indian lime. These are the main commercial limes, popular for drinks, seafood, melons, fruits, salad dressing, etc. (1). Trees of this group are small and bushy so that they may be spaced closely, about 16 x 16 or 20 x 20 feet.

Another group of limes includes Tahiti, Persian and Bearss, which are triploid, with larger trees, leaves and fruit, and are seedless. This fruit is as large as lemons and often is called lemon in the Tropics where true lemons are not well adapted. They are heavy producers and resistant to the withertip disease which attacks the West Indian lime (4).

A group of varieties developed from crosses of the Key lime with kumquat is a little more tolerant of cold. Those already released include Eustis, Lakeland and Idemor, of which Lakeland is more nearly like the lime parent.

Limes normally have been grown from seeds in the West Indies but gummosis has made it advisable to bud on resistant stocks such as sour orange or Cleopatra mandarin. The varieties Tahiti and Persian, which are seedless, can be propagated only by budding. Sour orange was found undesirable at Homestead, Florida, but Cleopatra, rough lemon and calamondin were good stocks for Tahiti limes. The stock apparently did not influence production or juice content (3). Excellent results from rooting cuttings under polyethylene covers in partial shade have been reported (5).

Cultural practices are similar as for oranges but harvesting is likely to be continuous unless there is interruption by cold or dry periods. It is important to avoid bruising in harvesting because it causes very rapid rind breakdown. With careful handling, 4 weeks is about the limit of storage at 40°F. Storing at 50°F is better but the fruits turn yellow (2).

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LOQUAT

(Eriobotrya japonica)

This fruit is more important in Japan than in any other country but is cultivated extensively in the Mediterranean region and in India. It is related to apple, pear and quince. Fruits are borne in clusters and are mostly oval to pyriform with a tough skin which separates easily from the flesh when ripe. The fruit is firm, yellowish, sweet and mildly subacid but in some clones may lack flavor. Good varieties with a higher proportion of edible flesh are available, of which Tanaka, Oliver and Early Red are consumed fresh. Smaller fruited sorts are used for cooking or for jellies (1).

The loquat needs a little cool weather to give good production and in Central America does best at 3,000 feet elevation or higher. The tree will withstand frost when not in bloom but in the northern temperate zone it flowers in early February and any frost would prevent fruiting (7). Light pruning is done after harvesting the crop. Seedling trees are extremely variable. Shield budding on one-year old seedlings with mature buds from which leaves have dropped should be done in the fall in California. Grafting is more successful than budding in Florida (7).

The best results in grafting are produced by using the side-veneer graft (4). Loquat seedlings give longlived trees but poor crops. Quince stocks give dwarf trees and early, high yields. *Crataegus oxyacantha* stocks give smaller, shorter-lived trees but bear regularly and heavily (5). Oliver is the best variety at Homestead, Florida, and Fletcher and Red Royal are promising (6). One-year-old wood is best for grafting. Hu reported that *Photinia serrulata* and persimmon stock have been used successfully in Japan (3).

Fire blight, or pear blight, is the most serious disease affecting loquat. Thinning the fruit will help to avoid alternate bearing and at the same time give better-sized fruit (2).

Cross-pollination has been found beneficial in all varieties in India. Golden Yellow is entirely self-sterile.

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LYCHEE

(Litchi chinensis)

Lychee is subtropical since it requires some cold to induce flowering and does not produce fruit except at elevations high enough to provide a cool period in the winter. South Florida and Cuba appear to be ideal for lychees. They also do well in Hawaii. Apparently most varieties have perfect flowers but pollination by bees has been reported to be necessary for fruit set (2).

Fruits are produced in clusters of 10 to 20 and are 1.0 to 1.5 inches in diameter. The peel or rind is fairly thick but separates easily from the white gelatinous flesh beneath. The flavor is appealing to most people. Fruits usually are dried and sold as "nuts" in China but freezing is a better way of preserving them and they may be stored for a year or more, especially if carefully culled for insect punctures and kept in polyethylene bags (1). They also can be canned after removing peel and seeds.

Propagation usually is made by air-layering. The best results in grafting is by the preparation of budwood by ringing 3 or 4 weeks in advance. Layered plants bear in the third year. Seeds are short-lived and must be planted directly from the fruit (4).

Varieties of lychee are numerous. Brewster is the main variety in Florida and Peerless seems promising because of larger fruit and regular bearing. Groff is a regular bearer in Hawaii (7) and Mauritius is commonly grown in South Africa. Bengal is a good variety which was selected in Florida.

Pruning is unimportant (5). Improper nutrition, lack of dormancy and drought may prevent normal flowering in Florida (10). Ammonium sulfate appears to be the best source of nitrogen (9) but an excess of nitrogen may depress growth rate (6). The plants are brittle and cannot withstand strong winds (8).

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MACADAMIA: AUSTRALIAN NUT

(Macadamia integrifolia)

A native of Australia, Macadamia is not as widely grown as cashew and only a small commercial production in Hawaii has been developed outside of Australia. Thirty-five trees are planted per acre in Hawaii and should produce 100 lbs. of nuts annually at 15 years of age (3). Nuts have a high nutritive value and are very tasty but shells are usually thick and hard. Oil content is 73 per cent at maturity and the kernels are a good source of calcium, phosphorus, iron and vitamin B_1. The kernel contains about 9 per cent each of protein and carbohydrate (2). Shelling percent is only 24 to 43 per cent.

Seeds are planted 1 inch deep in sand or vermiculite in full sun and germinate in 1 to 4 months. After 18 months the seedlings are ready to graft with side or veneer grafts. They also may be cleft-grafted or whip-grafted. Cuttings from mature branches with the leaves intact may be rooted in sand with high humidity. Wood for grafting should be girdled well in advance of time of use. The entire scion is covered with grafting tape to avoid drying. Transplanting needs to be done carefully and preferably in the cool season (5).

Heavy producing varieties in Hawaii are Ikaiki, Kakea, Keauhou and Wailua (4). The Burdick variety has a thin hull and is said to bear annually (1).

Difficulty in propagating, slowness in coming into bearing and the limited areas in which it produces well are factors in preventing any rapid expansion of production.

Macadamias have failed to produce at low elevations in Central America and possibly require more cool temperatures to induce flowering. Anthracnose caused by *Colletotrichum* can be a serious disease in many areas (4).

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MAMEY

(Mammea americana)

The mamey is native to the American Tropics. It is common as a garden plant in the Caribbean area. The flesh of the fruit is similar to a fine apricot in taste and texture.

Mature trees reach a height of 25 meters. The fruit is globose or oblate in form, 7.5 to 15 cm. in diameter, with a russet-brown, rough, thick, pliable skin and firm, pulpy, reddish, yellow or bright yellow flesh. The fruit contains one to four large seeds (1).

The mamey prefers humid areas below an elevation of 1,000 meters. Temperatures lower than 5°C may kill the trees. Deep, rich, well-drained sandy loams are best for mamey. The plants are propagated by seed but high yielding trees can be budded or grafted to obtain a high yielding orchard. The trees should be spaced 10 meters apart (2).

The fruits can be eaten fresh or stewed. They are sometimes processed into jam, preserves and a sauce. The sauce may be used over cakes or cookies. All parts of the plants have been known to contain toxic principles (1).

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MAMONCILLO

(Melicocca bijuga)

The mamoncillo is cultivated in the West Indies and South America. It is a popular fruit in Puerto Rico and Cuba. The tree is usually 30 to 40 feet high but may reach a height of 60 feet. The smooth round fruits are about the size of plums. The outer covering of these fruits is thin and leathery, and green on the surface. It encloses a large round seed surrounded by soft, yellowish, translucent, juicy pulp. The flavor is usually sweet and pleasant if the fruits are fully ripe. In some varieties it may be acid. "Melicocca" means honey-berry and refers to the flavor of the fruit. In English speaking countries it is known as the Spanish lime.

The mature plant withstands several degrees of frost without injury. The mamoncillo is generally propagated by seed but probably could be vegetatively propagated. It will grow on most soil types and does not require rich soil.

MANDARIN

(Citrus reticulata)

The more recent botanical works have classified the whole group of loose skinned oranges under mandarins, *Citrus reticulata* (3). These are then divided into horticultural classes as follows:

CLASS I. *King,* which has relatively large seedy fruits with thick, rough and bumpy rind. Varieties: King.

CLASS II. *Satsuma,* with medium-sized, mostly seedless fruits with smooth, thin, loose peel. Varieties: Owari, Silverhill, Wase, Ikeda, False-hybrid, etc.

CLASS III. *Mandarin,* which is bushy with numerous fine branches, small leaves and flowers, small to medium fruits, peels yellow to light orange. Varieties: Emperor, Onesco, Willowleaf, etc.

CLASS IV. *Tangerines,* which have deep orange to reddish fruits with small seeds. Varieties: Beauty, Dancy, Clementine, Ponkan, Cleopatra, etc.

CLASS V. *Hybrids*: Kara, Kinnow, Wilking (10).

Nagpur and Coorg mandarins are important in India. Ponkan is considered identical with Suntara of India and Swatow of China (11). Satsumas are well adapted to the Tropics. Tankan has red skin, deep orange colored, highly flavored pulp and seems a genuine tropical variety better suited to a hot humid climate than the sweet orange (11). Beauty of Glen Retreat is a high quality mandarin in good demand in Australia (4). Emperor, Ellendale Beauty and King of Siam are recommended for tropical Queensland (9). Kara has a relatively large fruit with rich flavor and high quality (2).

Although these fruits have to be handled more carefully than grapefruit or sweet oranges, they have the advantages of richer flavor, being easier to eat, and higher vitamin A content. In the case of satsumas there is the additional advantage of seedlessness and low acidity. One is not so likely to have ill effects from eating satsumas in quantity. The disadvantages are that they may be kept only a short while after maturity and must be sold quickly.

Pollination is not a problem with most mandarins but Clementine has lower yields when planted alone, particularly as the trees become older. Pollen from other mandarins increases the crop and the number of seeds (8). Girdling has improved the crop in the Mediterranean area (7). Budding on trifoliate stock and keeping bees in the orchard is recommended in Algeria (5).

Rootstocks reported suitable for mandarins are calamondin, Carrizo, Rusk and Rustic citranges, sour orange, trifoliate (6) and Rangpur (1). Since Cleopatra mandarin is a good stock for other citrus, it might be quite satisfactory for mandarins.

Mandarins are more likely to be damaged by high temperatures during intense sunlight than other oranges. A few days of very high temperature may permanently damage the fruits so that they have to be culled out when harvested; generally, however, warmer temperatures produce higher quality fruit and higher yields.

Spacing usually is 20 x 20 feet but in some of the more vigorous varieties should be 25 x 25 feet.

Except for training in the first year or two, pruning is probably unnecessary, and, except to remove dead wood, reduces production.

Fertilizers, irrigation, culture and insect and disease control are similar to oranges.

Mandarins are susceptible to damage by birds. Sapsuckers and woodpeckers are especially destructive when the fruit ripens. Erecting poles about 400 feet apart in the orchard gives these birds a place to light where they may be shot. A few days of watching and shooting will discourage them. Probably other means of protection will have to be used for other birds.

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MANGO

(Mangifera indica)

The mango probably is the most widely used tropical fruit other than bananas and citrus. It is especially well adapted to areas with a definite dry and wet seasons. It is Asiatic in origin and definitely tropical.

Varieties from India are very old and sometimes light producers. The best varieties in Florida come from Mulgoba and include Haden, Irwin, Keitt and Kent which are seedlings. Other important varieties for home use or market are Carrie, Ed-

ward, Earlygold, Fascell, Lippens, Palmer, Springfels and Zill (7) (3). Pairi and Fairchild are liked in Hawaii (14) (4). Kensington is highly recommended in Australia (11). Other good varieties are Julie, Sandersha and Manila in various areas. Local names often are given to popular varieties. The West Indian varieties are Madame Francisse and Bombay. Many seedling mangos have a strong turpentine flavor which is undesirable to many people.

Propagation is mostly by seeds but most varieties need to be budded or grafted. A few varieties are polyembryonic and can be propagated from seeds without grafting. The Manila or Mexico, Cambodiana, Saigon, Cecil and Simmonds are of this type but are not the best market varieties. Kensington comes true from seed and is highly recommended (12). It usually is necessary to graft or bud for commercial plantings. Seeds are very perishable and should be planted at once with the point upward so that straight stems and tap roots will be produced. Sowing the seeds flat may cause crooked stems and roots. Seeds germinate 12 days sooner if the hull is removed but this is an expensive operation. Growing in pots is generally too slow and direct sowing in the field is expensive in comparison with nursery propagation. About 80 per cent germination may be expected in the seedbeds within 25 days (8). Seedlings usually are transplanted to nursery rows when about 6 inches tall. When the stocks reach the stage of turning from green to brown or when they are about pencil size or larger they may be budded or grafted. The most successful type appears to be veneer graft, a type of side graft. The bud material should be prepared about two weeks ahead by cutting the leaves from the petioles and ringing which results in a higher take. Inarching is commonly done in India and some other countries but is a laborious process. Budding on young stock of pencil size with terminal buds cut 1.5 in. long from prepared budwood costs one-fourth as much as inarching (6).

Mangos are more difficult to transplant than citrus and require more watering and care in moving. Roots never should be allowed to dry out. Spacing is best at 30 feet or more except for the Julie which may be planted at 20 or 25 feet.

Pruning, except for early training and preventing excessive height, is apparently not important. Pruning to reduce alternate bearing has not proved to have value.

Fertilizing apparently is unimportant in mango culture and certainly should be used with caution. Excessive fertilization may prevent blooming. Some nitrogen is used in Florida and Australia (12) (15).

Anthracnose may be a problem, especially at fruit setting time. Three pounds of Captan per 100 gallons of water has given excellent control in Hawaii (2). Scale insects may be a problem in some areas but usually the worst pest is the fruit fly. The Mediterranean fruit fly has been controlled by a bait spray consisting of 1 lb. protein hydrolysate and 3 lbs. of malathion in water (1). Methoxyclor has been more effective for the Mexican fruit fly. Investigations on control are being intensively studied in the Fruit Fly Laboratory, Mexico, D. F.

Marketing of the mango fruit has been greatly hindered because of the fruit fly. It is necessary to be sure that the fruit fly is not introduced into free areas. Fumigation with methyl dibromide is effective.

Some canned mangos are now on the market. Processing by drying and freezing also may be developed (10). Mangos are being dehydrated in Haiti for shipping to the United States.

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MANGOSTEEN

(Garcinia mangostana)

The reputation of this fruit as the best flavored of any in the Tropics has caused many attempts to grow it in tropical regions of the Western Hemisphere but results have not always been encouraging (3). The trees are slow growing but may reach a height of 30 to 40 feet. The trees take 8 to 15 years to come into bearing depending on the growing conditions (3). Fruits must ripen on the tree and keep only a short time after harvesting. They also tend to be irregular in fruiting (5). The fruits are 1.5 to 3 inches in diameter and are reddish-violet at harvest time (3).

Mangosteen trees grow well on tropical lowlands on clay or loam soils. The trees require a humid environment with ample rainfall. Good soil drainage is necessary for high production.

Seeds are all from the mother tissue and come as true as though they were from cuttings. Seeds are very perishable and lose germination within a week (6). The seeds can be shipped if placed in moist charcoal. The seeds germinate well in peat moss. Transplanting to outdoor nurseries should be done at the 2-leaf stage (2). The outdoor nursery should be heavily shaded (3). The shade should be gradually reduced to about fifty percent shade. It is desirable to mix manure with the soil for the nursery planting.

The seedlings can be transplanted to the field when 2 to 3 years old. It is very important to move the plants to the field with a large ball of moist earth. A clay type soil holds together better for a nursery soil. Animal manure should be placed in the planting hole and mixed with soil. The young trees should be heavily shaded at planting time, and the shade should be gradually removed so the trees will adjust to full sunlight (3).

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NARANJILLA

(Solanum quitoense)

The naranjilla is a perennial plant with large leaves and a orange tomato-like fruit. Its bright green pulp yields a pleasantly flavored juice used in drinks, ice creams, sherbets, jelly and jams. Fruits also may be preserved. The crop is limited to cooler areas with high moisture but will not succeed in the open where frost occurs. It does not tolerate temperatures above 85°F (1). Since the naranjilla is highly susceptible to nematodes it is necessary to rotate the crop frequently. Plants produce when 6 to 12 months old and bear continuously for 2 to 4 years (2). The plant itself is ornamental.

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NUTMEG, MACE

(Myristica fragrans)

The nutmeg tree reaches a height of 10 to 18 meters. The flowers are unisexual (dioecious), although trees with perfect or polygamous flowers occur occasionally. The seed is 1.5 to 4.5 cm. long and 1 to 2.5 cm. thick. The kernel is whitish and much plaited and ruminate. The husk is thick, yellowish white or amber in color and encloses the single glossy dark brown seed. Each seed is partially covered by a lacy red aril, the mace of commerce.

Nutmeg is grown in Indonesia, Grenada, Penang and Banda. It prefers a tropical climate with high humidity and well distributed rainfall. Nutmeg is a surface feeder and requires a light soil.

Nutmeg usually is grown from seed; it flowers after six or seven years and starts production after eight years. Since about 40 per cent of the seedling trees are males and only 10 per cent are needed for pollination, vegetative propagation has possibilities. High yielding trees can be budded onto *M. argentea* which is resistant to root rot. The trees should

be spaced about 9 meters apart. A tree should yield about 300 nuts and 600 grams of mace annually (1).

The nuts are harvested when the fruits burst open and the nuts and mace are removed from the fruits. The mace is peeled off carefully and the mace and nuts are dried separately in the sun.

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OIL PALM

(Elaeis guineensis)

Most of the oil from oil palms is produced in West Africa, especially in Nigeria. The Belgian Congo, Sierra Leone, The Republic of Guinea and the Ivory Coast also produce a large quantity of oil. A considerable quantity of oil is produced in Indonesia and Malaya. A few oil palm plantations exist in the Western Hemisphere but the total production is low. Some plantations are in Costa Rica, Ecuador, Honduras and Mexico.

Elaeis guineensis belongs to the tribe *Ceroxyline* of the palm family. The trees reach a height of 60 feet or more. Male and female flowers are borne separately on the same tree. The trees are propagated only by seeds. The most common types are Congo, Macrocarya, Dura, Tenera, Pisifora and Diwakkawakka (1).

At the present time breeding work is being done in oil palm at several experiment stations. The seed of the best hybrids can be obtained from the West African Institute for Oil Palm Research (WAIFOR) in Tafo, Nigeria, the A.V.R.O.S. Experiment Station in Sumatra, the National Institute for the Study of Agronomy (INEAC) at the Experiment Station in Yangambi in the Belgian Congo and the Federal Experiment Station "Serdang," Malaya (1).

Most of the oil palms are grown within 10 degrees of the equator in hot humid lowlands. A rainfall of 3,000 mm. (120 inches) is preferred, with even distribution throughout the year. The trees require high temperatures throughout the year.

Oil palms are grown on red loams in West Africa and on volcanic soils in Sumatra. A porous, well drained soil is desirable with a pH of 5.5 to 7.0.

Various methods of germinating oil palms are successful. In some areas they are germinated in charcoal and in other areas sand is used. It is desirable to maintain a temperature of 37°C for the germination of the seed. Hot boxes are used in the Belgian Congo and the heat is obtained by fermentation of banana and papaya leaves mixed with foliage of creeping legumes. In Nigeria the fruits are soaked in water for a few days so that the pericarp can be removed by pounding. The seeds are then planted in flats of charcoal and placed over a water-heated germinator held at 36° to 37°C. It requires about four months for germination and the germinated seeds are planted in nursery beds. The seedlings are spaced about 10 to 15 cm. in the bed and covered with palm leaves for a few days. The plants should be watered regularly for three or four months if rain is not present. When the plants are four months old they can be planted in woven baskets or perforated polyethylene bags. The plants will be ready for field planting when they have 10 leaves. The trees can be spaced 8 x 8 or 9 x 9 meters. The dead and diseased leaves should be removed at regular intervals. If good hybrids are grown, a yield of 2,200 kilograms of oil and 600 kilograms of kernels per hectare can be expected per year (1).

During the early years the fruit clusters can be harvested from the ground but when the trees reach maturity ladders are necessary for harvesting. In large plantations tractor-mounted platforms are used which are similar to those used by electric light companies in the United States. It is important not to bruise the fruit, since enzymatic activity in ripe fruits takes place with surprising rapidity and releases unwanted free fatty acids. The bunches are heated to 55°C in vats with steam to destroy the enzymes. The fruits are then separated from the branches. Hydraulic presses are used to extract the oil from the fruits. The oil is then clarified and filtered to remove impurities. The kernels are dried to 10 per cent before they are cracked with a centrifugal or roller type machine. The wet kernels are dried to 6 to 7 per cent moisture content by the sun or in hot air ovens, then the kernels are ready to be bagged for shipment (1). Both the kernel and pericarp produce edible oil.

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OLIVE

(Olea europaea)

Olives grow anywhere in the Tropics but for some reason not yet ascertained they do not produce fruit at latitudes lower than 25° as the trees do not bloom; however, they make good ornamental trees. Whether this is due to day length or need for cool temperatures in the winter has not been determined as far as the authors know. The trees are long-lived and rarely killed by diseases. Olives need low humidity during the fruiting season for best results. This restricts their production to climates similar to the Mediterranean area (2). Up to 2,000 hours below 45°F are reported to be necessary for good crops (7).

They usually are propagated from cuttings or budded on wild seedlings. Leafy cuttings are rooted under spray or high humidity. Trees begin bearing at 6 years. Cuttings 1 to 2 in. in diameter root fairly easily but are expensive (3). Grafting on seedlings by whip and tongue method also is used (4).

Spacing averages 36 trees per acre in Spain, 45 per acre in Jordan and 60 in Greece. At least 35 ft. will be needed to get best yields and in dry regions much more (6).

Some early training is needed but any pruning retards growth. The least pruning gives the highest yields, therefore any pruning is only for training or convenience (8).

Nitrogen appears to be needed on soils of low fertility and should be applied in the spring. About 1 lb. of actual nitrogen per tree per year would be sufficient. Phosphorus has not been found to be needed but on poor soils, potassium might be needed. Boron deficiency has occurred in California (2). Good nutrition is especially important for obtaining a good crop the following year.

Alternate bearing is very common in olives. Fruit thinning has been reported to be helpful but pruning has not controlled alternate bearing. Girdling has been reported to be helpful in increasing crops (5). Irrigation also is helpful. The Minerva variety has been patented and released as an annual cropper (1).

Harvesting should be postponed until late to get the highest oil yield. For processing or pickling the fruit is hand-picked but for oil it is stripped or threshed.

Processing is necessary to reduce or remove the bitterness in the fruit. In California this is accomplished with sodium hydroxide (lye) at 2 oz. per gal. of water. In home processing this is done in earthenware crocks, leaving the fruit until the lye has penetrated to the pit. Then the fruit is kept in clear water which is changed daily for 3 days or more to remove the lye. Afterwards, they are changed to a brine solution of up to 12 oz. of salt per gallon to be kept safely (2).

Olive scale *(Parlatoria oleae)* is a problem in California. In the Mediterranean area *Dacus oleae* (Gmel.), the olive fruit fly, is the main pest. The olive scale is effectively controlled with malathion (9). *Dacus oleae* is not easily controlled. Some damage can be avoided by harvesting early. Olive knot is a bacterial disease that occurs in all olive areas. Bordeaux at 8–8–10 is reported to be helpful as a winter spray but careful sanitation in pruning is most important if pruning is done.

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ORANGE - SOUR

(Citrus aurantium)

The sour, or Seville, orange is important in most areas for its extensive use as a rootstock. It is now dropping in favor because of its susceptibility to tristeza. It is grown commercially, particularly in Spain, for use in marmalade. It also is used in drinks and as a substitute for lemon juice. In the Tropics, seedlings are common and the fruit is sold on local markets. Young seedlings may be detected by the stronger, acrid smell of the crushed

leaf as compared with sweet orange, also the leaf has a broader wing on the petiole than sweet orange leaves. Some selections have been made for rootstock purposes, all of which are propagated from seed since about 85 per cent of all seedlings are nucellar and are like the parent tree.

A subspecies, *C. aurantium* var. *myrtifolia,* called Chinotto, has clusters of smaller fruits which are candied in Italy. A variety called Paraguay is sweeter than most strains and has higher total solids (1).

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ORANGE - SWEET

(Citrus sinensis)

Sweet oranges do not tolerate temperatures below 20°F, but neither do they grow well where temperatures exceed 100°F (12). Short days do not cause dormancy (17) but low soil temperatures appear to retard growth enough to provide a partial dormancy. High daytime temperatures prevent coloring of fruit and quality is never as good at low elevations in the Tropics as at high elevations with cooler temperatures. Washington Navel requires 3,200 degree days above 55°F for maturity (4) but Navel oranges are adversely affected by high temperatures and quality is poor at elevations below 600 meters in the Tropics. Navel oranges never should be planted at low elevations in the Tropics. They produce well if properly cared for but quality is not equal to mandarins, grapefruit and tangelos. The Valencia or Joppa gives a more acceptable quality at low elevations.

Many of the older orange trees in the Tropics are seedlings but because of *Phytophthora* gummosis or foot-root that attacks sweet oranges it has become necessary to bud on resistant rootstocks such as sour orange or Cleopatra mandarin and others. Budding has to be "high" or about 12 to 15 inches above the ground level in order to avoid infestation of the sweet orange scion. Unfortunately, since a virus disease called tristeza is especially destructive to sour oranges when budded with infected scions it is wise to use tristeza-resistant stock, of which Cleopatra mandarin is the most acceptable. Other reasons for budding on rootstocks are to obtain tolerance to lime, salt and nematodes. Cleopatra is more salt tolerant than sour orange (8). It has fair resistance to high lime and will tolerate chlorine (9). However, no commercial rootstocks are completely resistant to citrus nematodes. Selections of trifoliate and Carrizo citrange have been found resistant (11). Sour oranges, rough lemon and Cleopatra resist drought better than other stocks (13).

Although budded trees are usually less vigorous and smaller than seedling trees, they come into bearing at least two years sooner. They are less thorny and fruits have fewer seeds than from the seedling trees.

The best known variety for quality is the Washington Navel, a seedless orange with an extra growth or "navel" at the blossom end. Since mutations occur, many of which have poor quality, it is important that budwood is derived from known trees. Other varieties of Navels differing in various characters and in adaptability have been found. Robertson Navel is precocious and a more regular bearer. Texas Navel is better adapted to warm climates. Dream Navel and Paradise Navel are well adapted to Florida. In California, Trovita ripens earlier than Washington, and Summernavel later. Bahianinha is a smaller fruited mutation in Brazil.

The most widely planted variety, Valencia, is found practically everywhere oranges are grown. It keeps especially well on the trees after maturity which helps in marketing. It requires more heat units for ripening than Navel.

An important variety in the Near East is Shamouti, a variety of high quality with few or no seeds; however, it does not seem to do as well in other areas. Jaffa, or Joppa, grown in the U.S. apparently is the same as Belladi in the Near East. It is a regular producer with high yields. Fruits resemble Valencia but ripen earlier and have up to 5 seeds per fruit. It is especially useful at low elevations. Other varieties are Hamlin, Pineapple, Truncana (Chile), Premier (South Africa), Marrs (Texas) and Salustiana (Spain), the latter of which is a very early ripening seedless orange. The Blood oranges are popular in the Mediterranean area but are not generally grown in the Americas.

In most areas oranges will bloom only once a year. In temperate zones this occurs in the early spring, in tropical areas blooming occurs at the beginning of the rainy season. The prolonged dry periods favor bud formation when growth begins

again. Only a small percentage of orange flowers set fruit, about 0.2 per cent of Navel and 1.0 per cent of Valencia (10). Ringing the branches during the blossoming period will increase the fruit set but may reduce the crop in the following year (6). Ringing is not recommended as a commercial practice.

A light crop of citrus is usually lower in quality than a heavy crop. Thinning has not proved economical in oranges. Alternate bearing is fairly common in some varieties but there seems to be a rootstock effect also. Washington Navel tends to bear in alternate years on sour orange stock but has annual crops on trifoliate.

Planting space varies according to soil, available moisture and whether machinery is used. In general, a spacing of 25 x 25 feet is best, but where all hand labor is used 20 x 20 feet may be used. Transplanting from commercial nurseries usually is effected with balled trees but where trees can be transplanted bare-root, quicker growth will be obtained. At the same time a larger root system with fewer weeds and soil diseases to be transferred to the orchard are other advantages (18).

Pruning always reduces yields and should be used only for convenience in harvesting or spraying or to remove broken or dead branches. Pruning to increase yields or thin the crop is a failure in oranges. Less training is required in oranges than in most fruits. Actually severe pruning will prevent blooming, encourage sucker growth and in the Tropics there is the further possibility of spreading *Diplodia* gummosis.

High application of fertilizers may cause trees to fail to flower. In most cases fertilizers are not needed before trees begin bearing and often may be harmful.

Fertilizers on oranges should be used with care. Generally, an application of 2 lbs. of actual nitrogen at blooming time or just before will be sufficient. In some poorer soils other elements might be needed. Soil temperatures may affect nutrition. The best root development occurs at 80° to 90°F soil temperature. There is poor development below 60°F and the roots die at 105°F (16). Non-tillage reduces the nitrogen requirements and the need for organic materials (7). The use of herbicides to avoid cultivation spares the roots serious damage from disking or cultivating as well as loss of organic matter from the soil.

Citrus needs a constant supply of moisture and irrigation about every two weeks will be needed during the dry season. Insufficient irrigation can reduce yields as much as 30 to 40 per cent even when trees appear to be in good condition (14). Allowing Bermuda grass to grow requires 79 per cent more moisture than with clean culture (1).

Fruits usually color poorly in high temperatures, and at sea level in the Tropics may remain green even when the pulp is ready to eat. Good color occurs only at higher elevations where temperatures go below 60°F.

Generally the best storage is on the tree except for some varieties like Hamlin which dry out rapidly after they reach maturity; however, tree storage may encourage bird problems. Sapsuckers and related birds drill holes in the fruit which cause it to rot. Sapsuckers have been controlled by erecting a tall pole in each acre of fruit. When they are disturbed they almost always land at the top of the pole where they may be shot.

The most common disease in the Tropics is foot-rot gummosis which, as mentioned previously, is best controlled by high budding on resistant rootstocks. A copper paint of either Cuprocide or Bordeaux is helpful on seedling trees.

The most dangerous disease is tristeza which is a virus occurring now in almost all citrus areas. It is transmitted by budding or by aphids after feeding 60 minutes or longer on diseased trees (5). The best control is the use of certified budwood placed on immune rootstocks such as Cleopatra mandarin. Symptoms are either gradual or rapid die-back of the branches.

A gummosis caused by *Diplodia natalensis* (P. Evans) is fairly common in tropical orchards that are being pruned so that the fungus has a place to enter. A single spray with Captan at the beginning of the rainy season gave good control in El Salvador.

Nematodes may cause symptoms closely resembling tristeza. Treatment of bare root trees in hot water at 113°F for 25 to 30 minutes eradicates both nematodes and fungi (3); however, in Florida it is not always effective and resistant stocks are best (15).

Consult Chapter 4 for insect control notes.

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PAPAYA

(Carica papaya)

This fruit is widely distributed in tropical regions, and is commonly eaten as a fresh fruit. It appears to have the highest quality in Mexico and Central America where it is thought to have originated. The fruit is an excellent source of vitamin C and contains some vitamins A and B. Papayas can be cooked when green like summer squash or used as preserves, sauces or in pies (3). Acceptable products have been made by dehydration, canning, pickling and preserving (6). Some interest has been shown in producing papain for use as a meat-tenderizer. So far this has not become an important industry, probably because it requires special skills in collecting and drying the latex (2).

Papayas usually have male and female flowers on separate plants and the sex cannot be determined until the plants flower, about 6 months after germination. Pure male crossed with pure female produces a progency of about half of each sex (12). Any variety may be converted to hermaphroditic (or perfect-flowered) by using only hermaphroditic pollen and selecting. Apparently environment can influence sex expression and it is important to provide good growing conditions to avoid sterility in hermaphroditic plants (1).

Some of the named hermaphroditic varieties are Solo, Bluestem, Graham, Betty, Fairchild, Kissimmee and Hortus Gold (3). It is well to use varieties developed locally since papayas are sensitive to climatic changes (4). None of these are stable and sibbing is necessary to maintain them.

Seeds can be sown in seed beds or directly in place. The best system would be to sow in seed beds at 15 gms. per square meter. These germinate in 3 to 4 weeks. Sunshine until noon and shade in the afternoon increases germination (10). Afterwards they may be transplanted in paper pots or polyethylene bags, 3 to 4 plants per pot. When they are 6 to 8 inches tall they are set 3 x 3 meters apart in the orchard. Plants should be set at the same level as in the seedbed (5).

Flowering will begin in the first year and males or pure females can be removed from each hill leaving only one plant to bear fruit. If pure females are kept, one male for each 15 to 20 females should be left. (Illus. page 8.)

Virus is reported from all papaya areas. It has been found to be related to cucurbit mosaic and is transmitted by the green peach aphid *(Myzus persicae)*. It can be very destructive if not controlled. It is very important that plants be grown in clean seedbeds and transplanted to well drained land. Consult the chapter on diseases for further details.

Papayas respond well to high nitrogen fertilization and require a plentiful supply of good moisture. Mulching helps conserve moisture and assist in weed control. Polyethylene mulching has given best results (9).

Nematodes can be serious and DD (a nematocide) at 35 to 70 lbs. per acre may be needed to obtain good production (8). DBCP is effective also. Consult Chapter 6 on nematodes for further information.

Some ripe fruit will be obtained about 9 to 10 months after transplanting. Papaya fruit should

be stored at 48°F. Handling and bruising should be kept at a minimum.

Plantations need to be renewed every few years and should be rotated with other crops.

In regions with especially high labor costs the crop has become uneconomical.

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PASSION FRUIT

(Passiflora edulis var. *flavicarpa)*

Passion fruit produces vigorous vines which come into bearing in about two years. The purple granadilla is common in tropical markets and is eaten fresh or as juice. The yellow granadilla, or passion fruit, is too acid to be consumed fresh but makes a pleasantly flavored juice which is used in blending with other fruit juices (e.g., Hawaiian punch) and in sherbets and jellies. Passion fruit will withstand a light frost and does best at 1,000 to 3,000 feet in the Tropics; however, it grows at sea level too. The purple granadilla requires high elevations in tropical regions. A deep, light soil with plenty of organic matter is preferred (5).

The passion fruit needs insect pollinators, mostly carpenter bees, in Hawaii (1). The honey bee is also helpful (6).

Seed selected from vines producing good yields of high quality fruit is planted at once from ripe fruit and germinates in 2 weeks. Washed seeds may be stored at room temperature for 3 months or more. They also may be propagated from newly mature wood which roots in one month (1).

The vines are set in rows at a minimum of 3 meters apart to permit cultivation. Since they are vigorous, a distance of 5 meters is probably better between plants in the row (1). They are trained on trellises about 7 feet high. The trellis may be a straight fence type with 2 or more wires. Others prefer the T-type with crossbars but they are more difficult to construct. Trellises require good bracing at the ends to support the heavy growth and crop. Windstorms also may cause breakage because of the resistance due to dense vine growth. Sturdy posts will be needed and the portion in the ground should be treated to prevent decay.

Pruning excess vine growth should be done after the main crop is harvested. While it is necessary to prune excess growth that tends to trail on the ground, it probably is advisable to avoid severe pruning.

Fertilizing is apparently necessary. In Hawaii, heavy applications of 10–5–20 are needed at 3 lbs. per vine applied 4 times during the year (7).

Harvesting is done by allowing the fruit to drop to the ground. Fruits are collected once or twice a week. Fruits should be processed soon after harvesting. Yellow passion fruit yields 12 to 25 tons per acre and purple, from 2 to 5 tons in Hawaii. It is considered that a yield of 15 tons is needed to be profitable.

For information on insects and diseases consult Chapters 4 and 6.

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PEACHES

(Prunus persica)

Peaches grow primarily in the temperate zones, most varieties thriving best at 30 to 40 degrees latitude or where winter temperatures are sufficiently low to satisfy the chilling requirements to permit normal leafing and flowering in the spring Some varieties of the Peento or Honey race, however, are able to produce with very low chilling requirements. Extensive breeding programs in California, Florida and Texas have originated varieties more suited to mild winters. Peaches grow well at 5,000 to 7,000 feet in Guatemala, but will produce at an altitude of 3,500 feet.

The dormancy of peaches is complex and a definite standard cannot be set that would be valid under all conditions (23). Cloudy and foggy weather doubles the effectiveness of chilling (21). Sunlight and high temperature combined with low humidity increase the chilling requirement (14). The growth inhibitor has been identified as naringenin. It decreases at the end of winter (11). Applications of aqueous solutions of naringenin to peach branches in New York, however, failed to delay flowering (7). Sprays to break dormancy have been only partially successful and breeding new varieties with low chilling requirements is the most reliable remedy (13).

Varieties with very low chilling requirements are Red Ceylon, Okinawa, Peento (Saucer), St. Helena, Transvaal, Sharbati, Pallas, Florida Gem, Estella, Jewell, Dorothy N., Lejon, Rochon, Luken's, Dwarf, Shalil, C. O. Smith, Angel, Smith, Waldo and Kakamas. Others with more or less resistance to mild winters are Early Dawn, Boland, Babcock, Bokhara, Bonita, Chadon, Curlew, Donwel, Flamingo, Fontana, Frank, Frankie, Lucas, Meadow Lark, Melba, Redwing, Rosy, Rubidoux, Socala, Weldon, Flordawon and Flordahome.

In general, peaches are considered satisfactory stocks for peaches. Apricots are difficult to use for rootstocks and plums are usually unsuitable and short-lived, but *Prunus besseyi* is said to be a good dwarfing stock.

Nematode resistance would be an important factor in the Tropics too, thus eliminating almonds which are susceptible. Extensive trials have found no peaches completely immune but satisfactory resistance has been found in Dwarf, Shalil, Bokhara, Yunnan, Okinawa, S-37, P.I. 61302, Quetta and Traveller nectarines. In choosing a variety for rootstock purposes, the availability of seed, percentage of germination, ease of budding and disease resistance are important factors. Nemaguard is a new rootstock with resistance to two root knot nematode species.

Seeds need to be stratified before they are ready to germinate. Seeds should be removed from tree ripe fruits, washed, dried at room temperature, then stored at 35 to 40°F in damp sawdust. After 12 weeks the pits are cracked and kernels removed and planted 1 inch deep in sandy soil. Soaking 20 hours in 3 per cent fermate before stratifying gives better germination (3). Germination at 77°F or above during the first 9 days causes severe dwarfing (15). Budding is usually possible 5 to 6 months after germination. The best success is with buds from new growth. Peaches prefer a deep, well-drained soil, free from alkali. A minimum of 20 inches of well distributed rainfall is necessary for good growth. Peaches are easily transplanted bare root when dormant. Spacing is usually 20 x 20 or 25 x 25 feet.

Nitrogen has been the chief element needed. A need for phosphate never has been shown in field planting, to the knowledge of the authors. Occasionally there may be a need for potash when leaf scorch occurs (20). If a readily available nitrogen is used the best time to apply is 3 weeks after full bloom (18). About 0.9 lb. per tree gives good returns (19).

Organic carbon is quickly destroyed by cultivation. The best yields under irrigation are obtained from non-cultivation with chemical weed control or from clean cultivation with winter crops (17). Sod cover crops are not generally satisfactory (10).

Maintaining readily available moisture gives best results (12). Cover crops compete for moisture as well as plant nutrients (6).

Light pruning is recommended but severe pruning is harmful (22). Summer pruning in July has given good results in California (2).

The important insects in the United States are San José scale, peach tree borer, peach twig borer, and oriental fruit moth. The recommended control for the peach tree borer is DDT spray on the trunks at three consecutive times in the summer

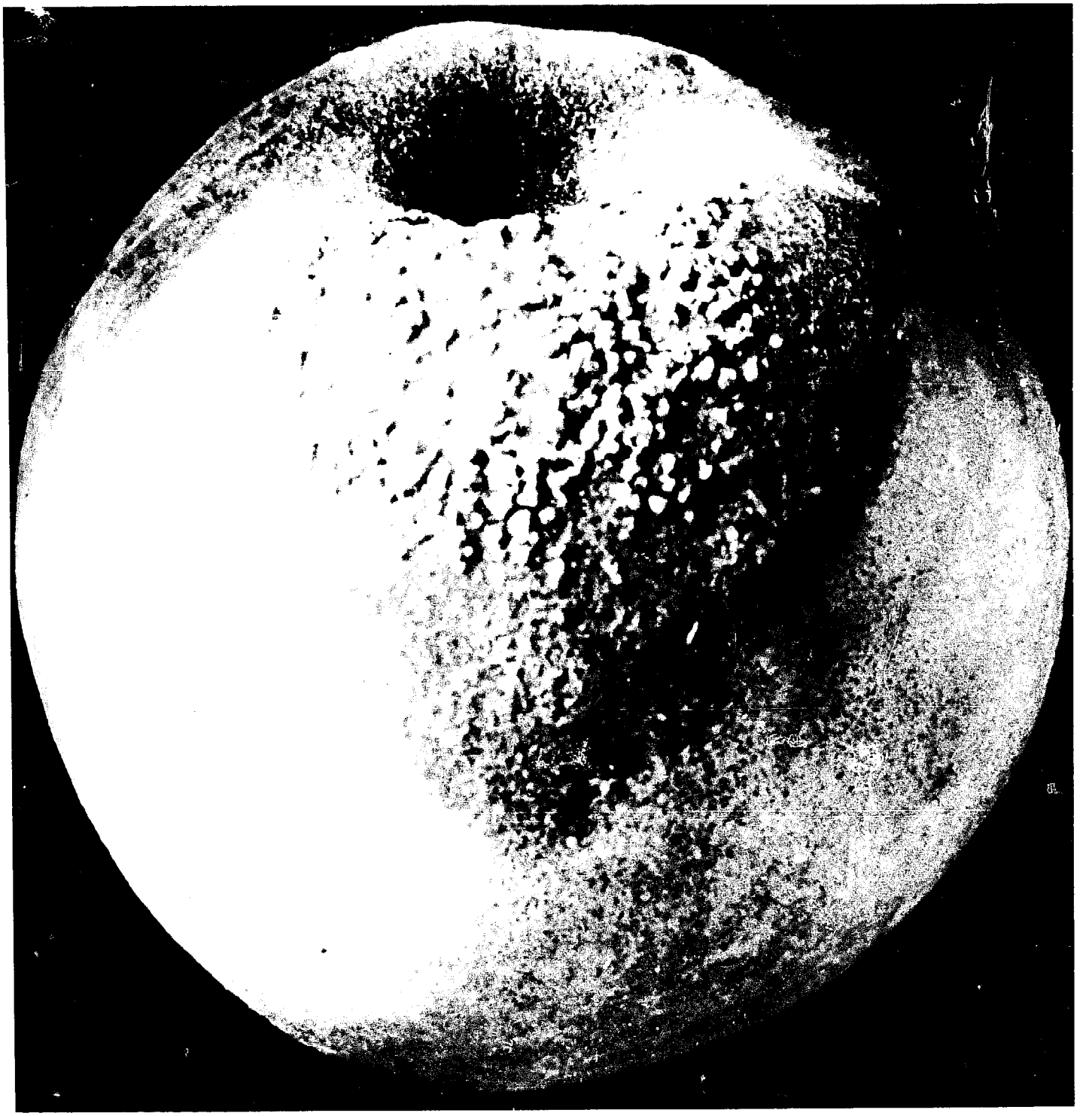

Figure 60. BROWN ROT ON PEACH SHOWING MASSES OF SPORES. *U.S.D.A. Photograph.*

(5). Three early season sprays with carbaryl or D.D.T. have given good control of oriental fruit moth (1).

The chief diseases of peach are brown rot, root knot, scab and mosaic. The brown rot can be controlled by successive sprays with wettable sulfur (8). Root knot can be controlled by applying 8 gal. per acre of Nemagon which remains effective for 2 years after fumigation (9). Better control, however, would be to use resistant peach stocks. Use of resistant cover crops is also helpful. Scab can be controlled by using a sulfur spray or dust 2 to 4 weeks after the petals fall. Mosaic has been controlled only by quarantine.

Peaches bear at 3 to 5 years of age and reach peak production at 9 to 12 years of age.

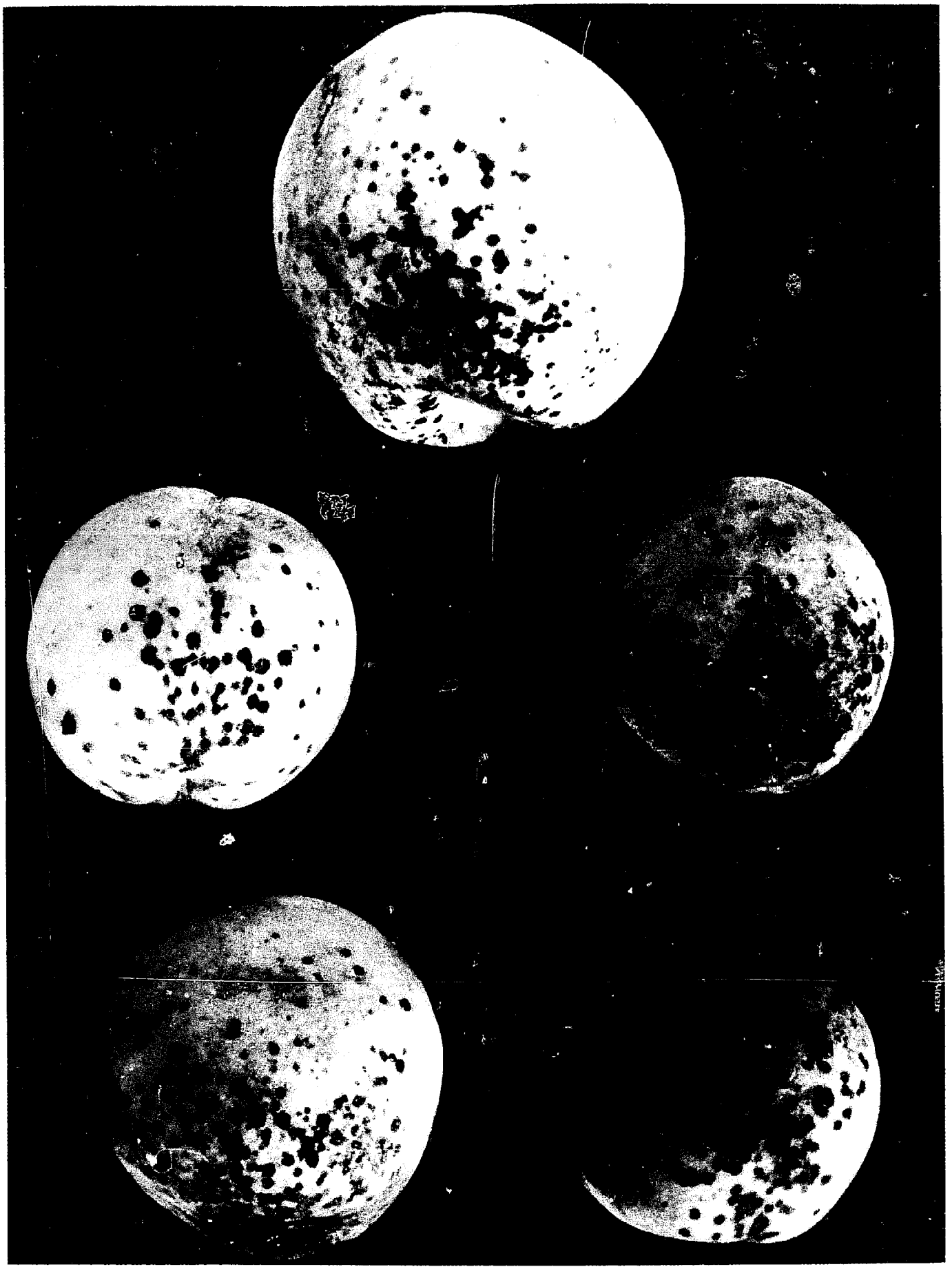

Figure 61. SCAB SPOTS ON PEACH. *U.S.D.A. Photograph.*

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PEARS

(*Pyrus* spp.)

Pear varieties of the *Pyrus communis* have a high chilling requirement for dormancy so are not suited for mild winter climates; however, varieties with *Pyrus pyrifolia* and *Pyrus serotina* relationship have lower chilling requirements. Frequently, they have low quality also but at least can be grown at the higher elevations in the Tropics.

In southern California pears grow well at elevations of 2,000 ft. or higher (5). In Guatemala pears are grown at elevations of 5,000 ft. or more, often being found at elevations of 6,500 ft. or higher (1).

Some of the varieties recommended for mild areas are: Kieffer, LeConte, Garber, Douglas, Wilder Early and Pineapple in Texas; Kieffer, Packham's Triumph and Beurre Bosc in South Africa (2); Baldwin, Orient, Hood and Richard Peters in Mississippi (7). Blight resistance is important in warm areas. The varieties Douglas, Baldwin, Richard Peters, Campas, Pontotoc, and Pineapple have considerable blight resistance (6), (8).

In the subtropical zones fire blight appears to be the most damaging disease on pears. The varieties Kieffer, Orient, Pineapple, Garber and Richard Peters have partial resistance to fire blight. Cedar-apple rust also may attack pears. The varieties Bosc and Waite are susceptible to stony pit and should not be grown where the disease is prevalent.

Many pear varieties are self-unfruitful and will need other varieties for cross-pollination. These should be not more than 3 trees away. Spacing is 25 to 30 feet apart each way. Pruning is not needed for production, but may be needed to keep the trees low enough for harvesting. Some varieties are improved by pruning but in general light to moderate pruning gives best yields.

Fertilizers are not generally needed as much as in other fruits. Too much nitrogen encourages vigorous growth and greater susceptibility to fire blight.

Irrigation to avoid moisture stress is recommended and the late season period is critical because water use is greatly increased at this time (4).

Pear thrips attack the fruit buds and small fruits

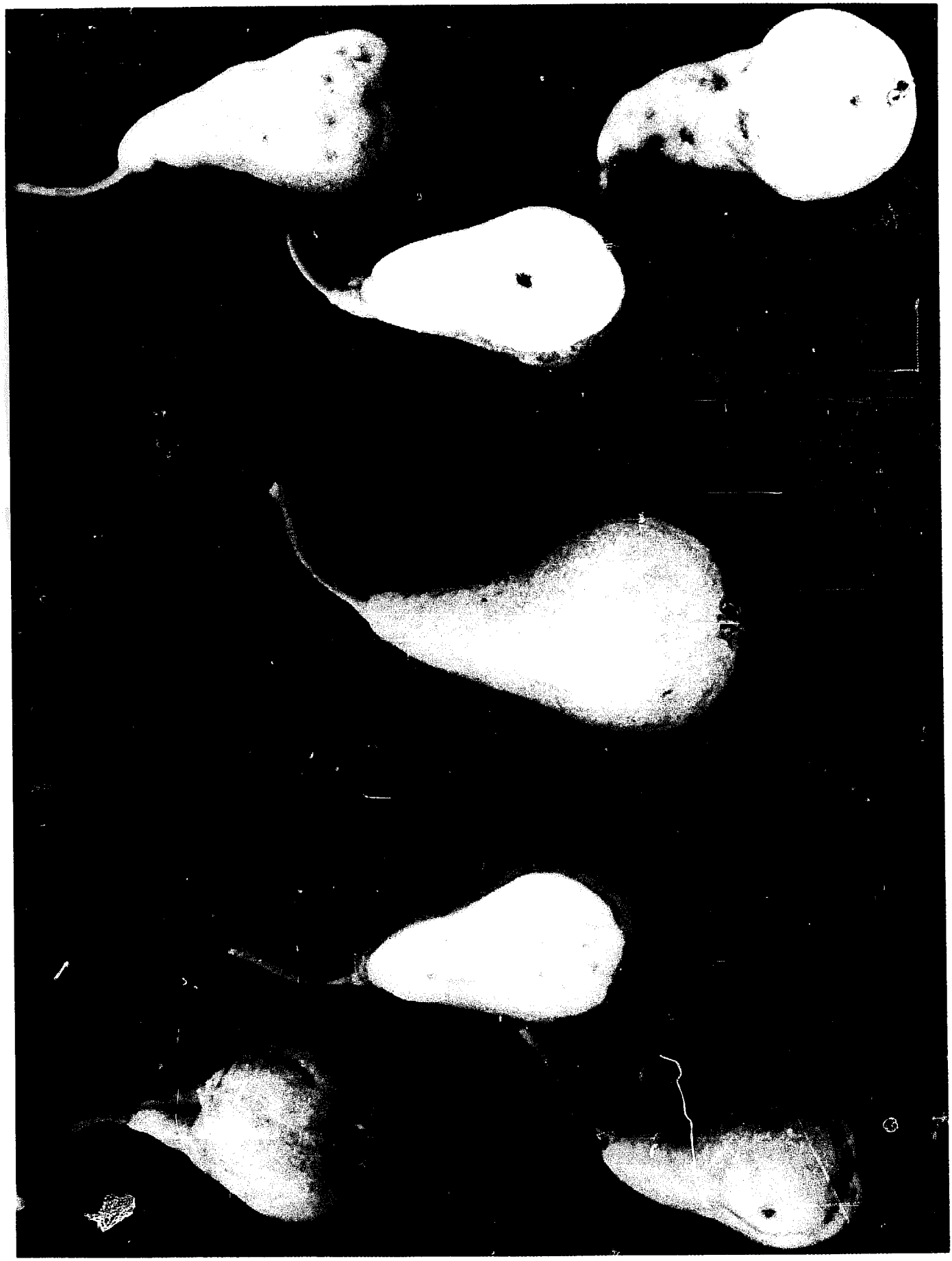

Figure 62. STONY PIT DISEASE ON THE BOSC VARIETY OF PEARS. *U.S.D.A. Photograph.*

in the spring and may ruin the pears. They can be effectively controlled with DDT sprays (5).

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PEPPER

(Piper nigrum)

Most of the pepper in the world is produced in India, Sarawak, Indonesia and Ceylon. Pepper is a climbing woody perennial vine. The flowers are small and usually unisexual (dioecious) but frequently polygamous. The fruiting spikes are 5 to 20 cm. long and the berries are red when ripe and black when dry and about 0.3 to 0.6 cm. in diameter (3).

It is necessary to conduct variety trials to determine what varieties are best in a given environment. Lada Korintji, Lada Djambi and Lada Belantung are varieties grown in Sumatra, and Lampong and Muntok are varieties grown on the islands of Bangka and Biliton (3). Balamcotta produced well in Puerto Rico but was subject to root rot. Kalluvalli and Kal-Balamcotta are varieties grown in India.

The Sumatran varieties are grown for black pepper and the Bangkan varieties for white pepper. Other varieties that should be tried are British Indian, Cambodia and Atjeh.

Pepper prefers good soil that is well drained. High rainfall, well distributed throughout the year, is necessary for good yields.

Cuttings about 2 feet long are used for planting material. They are buried for about two-thirds of their length in planting holes which are 2 x 2 x 2 ft. in size, and spaced 6 x 6 ft. apart. Tall-growing trees or posts are set near the planting holes to give the vines support. After the cuttings are 4.5 ft. tall they are laid in shallow trenches to promote stooling. The vines are later thinned to 12 to 15 shoots. Flowers should appear after 18 months and the first spikes should be removed as soon as they are formed (3).

The vines come into mature production when they are five to six years old and continue to produce for about 15 years. The average yield varies from 1 to 9 lbs. per plant per year. Since nematodes may be a problem in some areas, it is best to use plant material free of nematodes and only land known to be free of nematodes should be used for planting.

Only ripe fruits should be harvested and they should be piled in heaps for fermentation. When berries turn back, they can be separated from their spikes. The fruits are dried on mats in the sun. One hundred pounds of berries yield about 35 pounds of black pepper.

The best and ripest berries are used to produce white pepper. These are bagged and submerged in running water for one or two weeks to allow them to soften. The berries are then scarified to remove the flesh and are dried. One hundred pounds of fresh berries will produce only about 12 pounds of white pepper; however, the price of white pepper is higher than that of black pepper (3).

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PERSIMMON (JAPANESE) KAKI

(Diospyrus kaki)

The kaki is common in China and Japan where it is native. It has been introduced in cool subtropical and tropical highland regions throughout the world.

The kaki is a slow growing shrub from 10 to 50 feet high with a short trunk from 5 to 14 in. in diameter. The flowers are unisexual-dioecious and sometimes bisexual. The fruit is ovate or obtusely quadrangular-globose in shape; yellowish-green, yellow, orange or red-colored, with sweet flesh. The seeds are often abortive; or there may be two to eight, ovoid-oblong and flattened on one side. Some varieties are astringent until the fruits are fully ripe. They require pollination and fertilization for proper development of the fruits. Seedless varieties have golden yellow or orange-colored firm flesh with a flavor similar to that of apricots. These forms produce normal-sized fruits without pollination and are more commonly grown than seeded varieties. Hachiya is the important seedless variety in California where Fuyu is also grown. In Florida Tane Nashi is the important seedless variety. Persimmons should be soft ripe before eating to attain the highest quality. Fuyu and other non-astringent varieties can be eaten when firm but are best when soft-ripe. The seedless varieties when cut in half can be eaten with a spoon and are especially good when chilled. The male trees are necessary for pollen and both should flower at the same time for good pollination (4).

Kaki is planted as far north as 32°N. latitude and some varieties withstand a temperature of 0°F (1). When grown in tropical areas an elevation of 1,000 meters or higher is required. A good loose, rich, well-drained soil having ample organic matter is desirable. If rainfall is insufficient, irrigation is necessary.

Propation is by means of root suckers, budding and grafting. Root-stocks of kaki, American persimmon or date-plum can be used. The date-plum is preferred for dry areas, but *D. kaki* is preferred in California. The seedlings should be planted in polyethylene bags for budding or the budding should be done at stake. The trees should be planted 25 x 25 feet in the field. The best varieties bear in 3 or 4 years (4).

Pruning should be started early to shape the trees but later pruning should consist only of removing dead wood and crossed-over branches. It is important to clean weed the trees and fertilize them.

Fertilizer trials are needed to determine the most economical application of fertilizer.

Fruits are best when harvested at full maturity and must be stored in a refrigerator. They can be harvested a few days earlier than full maturity and soaked for 24 hours in dilute lime-water to rid them of astringency. Seedless fruits are less likely to be astringent than those with seeds if picked a bit immature.

The fruits are eaten fresh or served as a dessert fruit. They are sometimes made into a puree and used for topping ice cream or cakes. Kaki also makes excellent jam and marmalade. The Chinese make dried kaki fruits called kaki "figs." The fruits are steamed until they become soft and are then dried in the sun (4).

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PILI NUT

(Canarium ovatum)

The Pili nut tree usually grows to a height of about 65 feet. It is a tropical tree that does not tolerate even slight frost. It thrives in the Philippines only below 1,000 feet elevation. A closely related species, *Canarium commune,* is known as Java almond. Although seedlings appear to be highly variable there are no commercial varieties propagated as yet (1).

The tree may be propagated by budding and grafting but usually is grown from seed. Cracking the shell hastens germination but the viability is reduced.

The species is dioecious and flowers in terminal clusters over a long period. The ovary has 6 ovules, only one of which develops a nut. About 12 to 16 per cent of the whole fruit is kernel which is high in fats (75 per cent or more). Pili nuts seem more digestible than some other nuts. The shell is thick and hard to crack. The edible outer pulp is removed by dipping in hot water 104° to 122°F. (1).

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PINEAPPLE

(Ananas comosus)

Pineapples are widely grown in the Tropics and often on a large commercial scale. Pineapples are high in sugars and provide a good source of vitamins A, B and C. They also contain bromelin which aids in digesting meats. Plants are herbaceous and mutations are frequent. The six leading varieties are: Cayenne, with large fruits, the main variety in Mexico and Hawaii; Cabezona, the largest, grown in Puerto Rico; Queen, small (2 to 3 lbs.), and has high quality for the fresh market; Red-Spanish, white-fleshed, acid and intermediate in size; Pernambuco, mild flavored, small, with pale yellow flesh; Monte Lirio, white-fleshed and has smooth leaves (6). Other varieties are Abachi, Sugar Loaf, Andina, and Francesca (7).

Propagation is by suckers which are removed after fruiting and allowed to dry one week or more before planting to prevent rotting. Summer is the best time to plant in Puerto Rico. Aldrin is used at 2 to 6 lbs. per acre in 100 to 150 gallons of water to control white grubs. The ground should be harrowed after treatment and plants should be spaced 12 inches apart in double rows 2 ft. apart with a 3 ft. alley between (8).

A single application of fertilizer per year is better in Puerto Rico than split applications when 300 lbs. of N and 100 lbs. of K are used. More than 56 lbs. per acre of phosphate reduces yield and lowers quality (11). Australia recommends a 10–6–10 fertilizer for pineapples (3).

Pineapples are very sensitive to nematodes. Longer rooted varieties such as Natal, Pernambuco and Hilo are more tolerant (5). It is estimated that yields of both fruits and shoots would be doubled by the use of nematocides in Puerto Rico (1).

Weed control is a serious problem in pineapples because of the spines which makes hand weeding difficult. Broadleaved weeds can be controlled for 3 to 6 months by spraying with Pentachlorophenate (PCP) at 10 lbs. active ingredient per 200 gal. water per acre. Grasses can be controlled with 100 lbs. of TCA or 40 lbs. of Dalapon per acre but either of those will injure pineapple plants and are best used between crops (4).

A leaf blight is caused by a scale *Dysmicoccus brevipes* (Ckll.) which is carried by ants. The ants may be controlled by chlordane. The scale is controlled with Malathion (2). This should be applied only by experienced personnel.

Flowering can be influenced by hormones sprayed on the crown of the plant at 8 to 12 months after planting (9).

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PLUMS

(Prunus spp.)

Of the several plum species, the oriental or Japanese plum, *Prunus salicina,* has the least chilling requirement and will produce after mild winters. They do need some cold and should be grown at higher elevations in the Tropics. In Guatemala plums do very well at elevations ranging from 5,400 ft. to 7,500 ft. above sea level (2). Other species from mild climates are *Prunus cerasifera, P. occidentalis* and *P. texana* (1).

Some promising varieties for warm areas are Santa Rosa, Mariposa, Hollywood, Brilliant, Marvel, Oxheart, Redbud, Bruce, Methley, Bests Hybrid, Wickson, Kelsey, Satsuma, Beauty, Burmosa, Duarte, Redheart, Shiro and Inca (8) (4). Most of these set better if they have cross-pollination. Almost all plums require cross-pollination with another variety for good fruit production. Only Beauty, Methley and Santa Rosa are self-fertile (3). The species *P. texana* is well adapted to mild winter and may be of value in the Tropics. The fruit is small and sometimes strong-flavored but it crosses

readily with other species and should be of value in breeding varieties for subtropical regions (5).

Plums usually are budded on peach stocks, preferably nematode resistant varieties. Marianna is a good nematode resistant plum stock. Shalil, P.I. 61302, S–37, Okinawa or Yunnan peaches are good nematode resistant stocks. Plums usually are budded on root-stocks of nematode resistant varieties of peaches or on the Marianna plum.

Planting is done bare-rooted in the dormant season at a spacing of 25 x 25 feet for the larger varieties. Kelsey and smaller trees may be spaced 20 x 20 feet. Normally the oriental plum may be spaced at distances of 20 x 20 feet.

Nitrogen should be applied soon after blossoming. A rate of 3 to 4 lbs. per tree of ammonium sulfate or equivalent rate of other nitrogen fertilizers is suggested when trees begin to bear (7).

Irrigation should be moderate throughout the season. Cover crops can be used during the dormant season but would compete for moisture and nutrients during the growing season (6).

Red spiders attacking the leaves of the plum can be effectively controlled with malathion.

Plums are usually harvested in the early ripe stage. Santa Rosa and other varieties will ripen satisfactorily when harvested at the straw pink stage. This enables the fruit to be sent to distant markets before they become fully ripe.

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POMEGRANATE

(Punica granatum)

The pomegranate is a very popular sub-tropical fruit. It is grown in many subtropical countries, especially in the Mediterranean region and in South America.

The plant is a shrub which ranges in height from 1 to 5 meters. The leaves are opposite, often densely crowded on small axillary twigs. The fruit is a large globose berry, shiny red, yellowish-green or whitish when ripe, crowned by the calyx, 2 to 3 in. in diameter. The fruit is filled with angular hard seeds which are covered with a juicy, red, pink or yellowish-white, astringent acid pulp (2).

The pomegranate thrives best in the Tropics below an elevation of 3,300 feet. It will thrive in areas with long, hot, dry summers and cool winters or those which are continuously warm and dry. High temperatures should accompany the ripening season. Minimum temperatures of 15°F may not injure the plant severely.

It grows best on deep, rather heavy loams. It can grow on soils with a pH near 7. The bushes should be spaced 12 to 18 feet apart, but when planted in a hedgerow a close spacing of 6 to 8 feet can be used. When the plant is set it should be cut back to a whip at about 24 to 30 inches from the ground. As shoots are produced they should be selected and thinned out to three or five scaffold branches which should be pinched back to make them stocky. The main stem and frame limbs should be kept free from suckers at all times. Pruning after the third year should be confined to a regular removal of all sucker growth arising from the root, and interfering branches as well as dead limbs. This should be done after the leaves fall.

Propagation is effected by means of seeds, cuttings and layers. It is best to use cuttings or layers to obtain high yielding trees. The most popular varieties are Wonderful, with large fruits that have a diameter of five inches; Paper-Shell, which has a very thin rind; Spanish Ruby, which is juicy with a sweet aromatic flavor; and Purple or Purple seeded, which is not too important commercially (1).

The trees come into bearing at three or four years of age. A properly grown tree of mature size may yield 200 to 400 pounds of fruit annually if properly pruned.

The fruit of most varieties must be picked before fully matured to prevent splitting. The fruits always should be clipped with pruning shears and never pulled off. The fruits are graded for size and wrapped in tissue paper before packing (1).

The pomegranate is one of those fruits which, after reaching a certain degree of maturity, continues to ripen in cold storage, where it will keep

for six months. The quality is improved in storage with the flavor becoming richer.

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RAMBUTAN

(Nephelium lappaceum)

The rambutan is sometimes called the "hairy lychee" because of the small hair-like projections protruding from the fruit. The rambutan is a tree ranging from 50 to 80 feet in height. The flowers are dioecious with five to eight stamens in the male flowers and with five to seven staminodes in the female flowers. The fruit consists of a drupe represented by a tubercle at the base. They vary from 1 to 2 in. in diameter and are red or yellow with soft spines all over the fruit. The rambutan can be grown in lowlands where lychee will not produce (1).

The most common varieties in the Far East are Lebakbooloos, Seematjan, Seenjonja, Seetangkooweh, Seelengkeng and Seekonto. Since the trees are dioecious, propagation should be by asexual means. The seed for stock should be planted in a black polyethylene bag. Two weeks before budding the budwood should be trimmed by removing the leaflets and leaving well-healed leaf scars. The budding should be done during the rainy season and before the crop is harvested from the scion parent or a month or two after harvest (1). When the rootstock is one year old, budding should be done with nonpetioled wood.

The budded trees should be carried to the field in the polyethylene bags and planted 30 to 40 feet apart. The polyethylene bags should be removed before planting. If the plants are watered heavily two hours before planting the soil will adhere to the roots. The use of nitrogen fertilizer may be desirable but trials will be necessary to determine if it is economical.

The fresh fruits are excellent and are sometimes stewed or preserved. In flavor it compares favorably with mangosteen.

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RASPBERRIES

(Rubus albescens)

Raspberries are cool weather plants but one variety, Mysore, does well in tropical areas at medium elevations. Mysore is from India and has black fruits, small seeds and is disease resistant (1). *Rubus albescens* is reported to have 200 fruits per pint at Homestead, Florida, where it grows well (3). The Queensland raspberry does well in Puerto Rico (2). These would be useful for home use or local market.

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ROSELLE

(Hibiscus sabdariffa)

Roselle is a good home garden plant in the Tropics and serves as a substitute for cranberries. The calyx is bright red and acid, and can be used in preserves, jelly and juice. The leaves are used as greens. The fiber is used like kenaf.

Roselle is subject to nematodes. Propagation is from seed.

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RUBBER

(Hevea brasiliensis)

Rubber is a member of the Spurge family and is fairly exacting in its requirements for good growth. Before starting any rubber project it would be well to study carefully the world market for rubber. Natural rubber will have to compete with the new so-called natural synthetics. It is possible for natural rubber to compete with synthetic rubber at the

present time if it is grown at the right location with efficient plantation management and by using the highest yielding planting material available presently in the rubber world. It is important to consider that it requires seven years before the trees are ready for tapping.

Rubber trees require a minimum of 80 inches of well distributed rainfall per year for good production. The rains should come in the afternoon and at night so as not to interfere with the tapping of the trees. Rubber should be grown in areas with a temperature range of 68°F to 82°F. The land should be well drained and above flooding at all times. Flat or gently rolling land is preferred. Rubber will not grow in land which has a high water table; therefore, land with a water table less than two meters below the surface of the land should be avoided.

The soil for rubber trees should be fertile, friable, deep, well oxidized and acid in reaction (pH 4.5 to 6.5). It is best not to plant rubber in areas of high winds. Locations exposed to moderate winds can be planted if windbreaks are planted as protection around the rubber trees.

Only high yielding clones of rubber should be used as they yield much more than seedlings or hybrids. In order to determine the best yielding clone for a given area, clonal trails are necessary. Clones GU–31 and GT–711 are yielding well in Guatemala and should be tried. The following clones should be tested in all new areas: GA–308, G–26, GU–49, Harbel 1, and Harbel 2, RRI–501, RRI–502, RRI–503, RRI–504, RRI–505, RRI–506, RRI–507, RRI–508, RRI–509, RRI–513, RRI–526, RRI–527, RRI–600, RRI–605, RRI–606, RRI–607, RRI–614, and RRI–628. The clones mentioned can be obtained from the United States Plant Introduction Station at Miami, Florida. Some areas are free of the South American leaf blight, caused by *Dothidella ulei* (P. Henn.) and all precautions should be taken to see that this disease does not spread into areas free of the disease. Other outstanding clones are available in Guatemala and Brazil.

In order to establish a source of material, budwood gardens must be started in areas where the young trees are to be budded. It would be desirable to produce budded stumps in nurseries. The germinated seedlings are planted on beds in nurseries at a spacing of 6″ x 12″ with 3 feet between beds, and are allowed to grow until the bases measure ¾″ or more in diameter. The seedlings are then budded with high yielding clonal material, and one month or so after budding they are ready for topping and planting in the field.

Budwood garden spacing is 3 feet by 4 feet and the first year stumps are allowed to shoot only one tip, but after the first cut back of budding material, two or three tips can be allowed to grow.

The skill of budding is acquired only by practice and a man learning how to bud should work with an experienced budder for several weeks to learn all the tricks of the trade. A good budder can bud 100 to 150 trees per day with a usual budding success of 80 to 90 per cent.

When the budded trees are ready to be transplanted to the field, planting holes 2 x 2 feet at the surface 16″ x 16″ at the bottom and a depth of 2 feet should be dug. The holes should be filled with good topsoil when the budded stumps are planted. A tree density of 400 per hectare is usually recommended. Experiments on closer spacings may give some interesting results. For a tree density of 450 trees per hectare a spacing 11 x 22 feet should be used.

In immature stands of rubber, it is desirable to plant *Pueraria javanica* during the first rainy season after the rubber has been planted. About 20 seeds should be planted in a 3-foot ring in the center of every four trees. A pound of *Pueraria javanica* should be sufficient to plant 12 acres in this manner (2).

For rubber trees under two inches in diameter, a four-foot ring should be kept cleared around each tree. The woody growth between the trees should be slashed down low enough so that the cover crop can grow over it. In rubber trees over two inches in diameter, the maintenance work will be the same, with the exception that the ringweeding can be discontinued as the cover crop will cover the ring except for a portion at the base of the tree. It will be necessary to pull the cover crop away from this area frequently to prevent it from climbing the tree.

Generally the laborer working in a rubber plantation is put on a task basis. If this is not done the operation may become uneconomical. The environmental conditions for growing rubber vary in different parts of the world. A task example follows for conditions in Liberia (2).

1. One man can fell one acre of bush in 10 days.
2. One man can slash and ringweed 160 trees per day.
3. One man can plant 77 trees per day.
4. One man can prune 4 acres a day.
5. One man can dig 15–30 holes per day.

6. One man can budgraft 100 trees per day.
7. One man can backfill 25–50 holes per day.

On clonal trees all seedling shoots must be kept pruned off so as to force the bud to grow. The lateral shoots are kept pruned off for a height of 84 inches. During the rainy months it is necessary to increase the size of the pruning crew to a point where a stand of young rubber may be covered two or three times in a month.

In order to determine the fertilizer practice for a given area it is necessary to conduct fertilizer trials, which require a long period of time. In Guatemala four ounces of 20–15–15 are applied every six months for the first two years. Soil analysis may help in starting a fertilizer program. The fertilizer should be applied about nine inches from the base of the tree the first year and about 12 to 15 inches the second year. The fertilizer should be worked into the soil with a hoe to prevent it from washing away due to rain action.

The tapping methods are not described in detail since the only way to learn how to tap rubber is

Figure 63. THE ONE-HALF SPIRAL SYSTEM OF TAPPING RUBBER TREES.

usually start to grow in 30 days. A take of 33 per cent is considered good (6). In Central America following the method above a take of 60 to 80 per cent was secured. The sapodilla usually requires 6 to 8 years to reach bearing age (4).

The nursery trees are difficult to transplant bare-rooted and should be balled. Spacing of the trees depends upon the variety and the soil. Ordinarily 7 to 9 meters is adequate; however, for spreading varieties a spacing of 40 to 45 feet is recommended (3).

Very little information is available on the fertilization of the sapodilla. The tree responds to fertilizers and in Florida it is suggested that the sapodilla should be given 3 applications per year of twice as many pounds of a low analysis fertilizer, such as 4–7–5, as the tree is years old (5).

Little or no information is available on any serious diseases attacking the sapodilla. In Florida it is reported that a rust identified as *Scopella sapotae* (Mains ex. Cumm.) *Uredo sapotae* (Arth. and J.R. Johnston) attacks the sapodilla but can be controlled by monthly applications of ferbam at the rate of 2 pounds per 100 gallons of water (5). A leaf spot from which a species of Septoria has been isolated, has been observed causing defoliation of trees in Florida (5).

Fruit flies often attack sapodilla. The most damaging are the Mediterranean fruit fly, *Ceratitis capitata* (Wied.) and the Mexican fruit fly, *Anastrepha ludens* (Lw.) (4). The larvae of a tiny grayish colored moth, *Eucosmophora* sp. have been observed feeding between the young leaves (5). The mining scale, *Howardia biclavis* (Comst.), the green shield scale, *Pulvinaria psidii* (Mask.), the pustule scale, *Asterolecanium pustulans* (Ckll.), and others may infest the sapodilla (5). Malathion applied no less than 30 days before harvest effectively controls these insects but great caution should be observed in working with this toxic compound (5).

The grafted trees begin to bear in 4 or 5 years. Fruits are harvested when the first fruits begin to drop. It takes up to 14 days to soften so that it can be eaten.

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SAPOTE

(*Calocarpum* sp.)

The sapote, *Calocarpum sapota* (Jacq.) Merr. or *Calocarpum mammosum* (L.) Pierre, often also called the mamey sapote, is native to Central America (1) (3). The tree is tropical in its requirements and produces brown fruit 3 to 6 inches long (3). The fruit is eaten fresh or made into preserves.

The sapote does well in hot, humid lowlands, requiring a heavy soil (4). It is found at elevations from sea level up to 4,000 feet above sea level (4). Mature trees can withstand 28°F for a few hours with only a slight amount of damage; however, young trees are more susceptible to cold and would be damaged more severely (3). Flooding for several days will seriously damage or kill the sapote (3).

Propagation of the sapote is by seed; however, their heterogeneity results in variable seedlings (4). Vegetative propagation of desirable types is therefore preferable. The seeds require about one month for germination (3). The seeds are shortlived but germinate more readily if the thick husk is removed before planting (4). When the seedlings reach a height of 6 to 8 inches they should be transplanted (4). Vegetative propagation of desired types is possible by side grafting or by air layering or marcottage (3). The sapote requires 7 to 8 years to reach production (2) (4).

Young trees may be attacked by one or more species of bark-infesting scale insects, which must be controlled if the vigor of the trees is to be maintained (3). Malathion or carbaryl could be tried to control the insects.

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SAPUCAIA NUT

(Lecythis elliptica)

Trees are small and spreading, bearing fruit near the ground. They have been cultivated to a small extent in Trinidad and Central America. Because they are close to the ground and easier to handle than Brazil nuts, they have received some attention. Another factor is that Brazil nuts can be harvested from wild trees but Sapucaia is seldom gathered in the wild due to the fact that the urn-shaped fruits hang downward and the cap falls out at maturity releasing the nuts.

The Paradise Nut, *Lecythis zabucajo* Aubl. is produced by a large forest tree in Brazil and Guiana and produces edible nuts. The nuts have an excellent flavor and are similar to Brazil nuts but the shell is softer.

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SOURSOP

(Annona muricata)

Soursop, also known as guanabana, is a common tropical fruit which grows on a small tree usually less than 20 feet tall. The leaves are leathery and four to six inches long. The flowers are large and are produced on short stems on the branches. In order to assure a high yield of fruit, it is desirable to use hand pollination since the stigma of each flower is not receptive until after the pollen has been shed (2).

The dark-green fruits are usually ovoid or oblong-conical in shape and may weigh 4 to 5 pounds (1). The surface is covered with numerous, recurved fleshy spines. The trees fruit throughout the year but there is usually a heavier cropping period which depends on the environmental conditions in different areas. The flesh is white and has a pleasant taste. The fruit is commonly used to make a drink in tropical countries. It is also used to flavor sherbets and ice cream as well as for jelly and preserves (2).

Named clones are not known and most trees are seedlings. It may be grafted successfully onto *Annona reticulata* and *Annona glabra* (1).

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STAR-APPLE

(Chrysophyllum cainito)

The star-apple is native to the American Tropics and is grown both for its value as an ornamental and for its fruit (2). The tree may reach a height of 50 feet or more. The fruit is green or purplish on the outside depending upon the race, and whitish on the inside. Fruits are from 2 to 4 inches in diameter and if cut transversely the seeds appear to be arranged in a star-like pattern. The fruit usually is eaten as fresh fruit.

The star-apple is tropical in its requirements and slow to recover from damaging low temperatures. Young trees are more susceptible to frost injury and may be killed at 31°F. Mature trees may withstand temperatures as low as 29°F for several hours with only moderate damage (3).

The propagation of the star-apple is commonly by seed. This has resulted in a variety of forms. The two most common forms are a green-fruited and a reddish purple-fruited form. Due to seedling variability there is large variance in fruit yields. If the star-apple is to be grown for its fruit, high yielding trees may be propagated vegetatively.

The seeds of the star-apple require about six weeks for germination (3). Desired varieties may be propagated vegetatively by the following means: marcottage, cleft grafting, inarching, and cuttings (1) (3) (4). When grafting, conditioning of the scion by removal of the leaves a week prior to grafting enhances the success of the graft (1).

To produce the most desirable texture and taste, the fruit should be tree-ripened. Mummification of immature fruits by a fungal infection has been observed in Florida (3).

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STRAWBERRIES

(*Fragaria* spp.)

Strawberries have been grown near Ambato, Ecuador, at an altitude of 7,000 to 9,000 feet for many years. They were erroneously called frutilla and had fruits 2 to 3 times the size of the European types. These plants were used to develop the hybrids of today.

Strawberries are popular and some are grown in favorable locations in almost all countries. In tropical regions it is necessary to plant them at the higher elevations, 3,000 feet or higher, where temperatures are cooler. Varieties adapted to short days and mild winters are essential. The optimum daylight temperature average is 73°F (4). Short day varieties are Missionary, Klondike, Ettersburg 121 and Marshall (5). Additional varieties are Florida 90 and Texas Ranger. The European species, *Fragaria vesca,* which is grown from seeds, also can be grown successfully in the Tropics. Regardless of the temperature, short days favor fruit bud production and inhibit runner production (6). Therefore, in the Tropics strawberries are likely to bear fruit the year round and not produce as many runners as in regions with longer days.

By keeping the soil temperature below 95°F strawberries can be kept alive and growing through the summer months with frequent irrigations. To have a good flavor, daytime temperatures above 50°F are needed (16). Chilling strawberry plants for 6 to 7 months at 28°F before planting gives maximum fruiting and growth response (15). Sandy soils with a pH of 5.7 to 6.8 are best but strawberries will tolerate a wide range if temperatures are not high. A good water supply should be available for the dry periods. Strawberries do not tolerate drought or saline soils.

The most promising variety for tropical regions seems to be Missionary; however, it would be well to try several others which have shown promise in mild climates: Florida 90, Blakemore, Texas Ranger, Lassen, Solana, Fresno, Torrey, Armore, Daybreak, Klondike, Brightmore, Klonmore (7) (8).

Best yields are obtained by setting new plants each year at the rate of 30,000 plants per acre. Strawberry plants should be set in the field at the same level as they were grown. The crown is very short and will not tolerate deep planting. Roots should not dry out and should be carefully spread. This can be done by setting with a spade, opening the soil enough to permit the roots to extend to full length. The soil is firmed with the foot and irrigated immediately to prevent drying.

Fertilizers are not often needed. Usually phosphate shows the best response (1). Use of ammonium phosphate at 150 lbs. per acre is sometimes satisfactory and has been reported to give a better flavor but most investigators have not found that fertilizers affect quality. In Florida soils up to 2,000 lbs. of 6–8–6 fertilizer increase yields (9).

Weed control is very important. DNBP at 8 lbs. per acre was the best preplanting treatment and may control weeds for 30 to 60 days (14). Black polyethylene mulch is sometimes used to control weeds, conserve moisture and prevent berries from touching the soil.

Harvesting should be done in the mornings and fruit should be protected from the sun. Fruits, when harvested greenish white to 10 per cent pink and placed in the dark at 85°F, ripened to full color in 48 hours with total solids content comparable to field ripened fruit. Color develops more slowly at lower temperatures and good coloring is not obtained at 55°F (3). Glass jars have been found better than polyethylene or cellophane as containers for freezing. The berries are cleaned and stemmed and put up with sugar.

Leaf spot is the most common disease. Nematodes cause heavy damage and it may be necessary to use Nemagon or a similar nematocide before plantings. The use of DD before planting and followed with Nemagon side dressing at 68 gal. per acre gives good control (12). Unusual diseases may occur, particularly viruses (10) (13) (17).

Consult Chapter 6 for insect control recommendations.

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SWEETSOP—SUGAR APPLE—CUSTARD APPLE

(Annona squamosa)

This species is native to the West Indies. It seems to be more popular in India than elsewhere and is called the custard apple there. The tree may reach a height of 20 feet; the fruit is heart-shaped but smaller than cherimoya and the white flesh is sweeter than cherimoya. The fruit is eaten fresh or the pulp can be strained and mixed with wine, ice cream or milk (1). It tolerates hot weather and produces fruit even in the Nile and Jordan Valleys. It does not seem to require hand pollination to the extent that cherimoya does (2). In Cuba a seedless clone has been found which is highly desirable as a dessert fruit.

It grafts or buds easily on *Annona cherimola* or *A. reticulata*. Buds on *A. cherimola* seedlings come into bearing in one year and buds on *A. reticulata* also come into bearing much earlier than seedlings. In India, *Annona reticulata* is the best stock (3).

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TANGELOS AND OTHER CITRUS HYBRIDS

A number of hybrids between citrus species have been developed artificially and released under the names tangelo (tangerine crossed with grapefruit), tangors (tangerine crossed with orange), limequat (lime with kumquat), etc. Some also have been found that obviously arose from natural crosses.

One of the most important hybrids in the United States is the Temple which is a tangor but the exact parentage is unknown. It was introduced from Jamaica in 1894 (3). Fruits are a deep reddish-orange color, resembling a large mandarin, with the peel separating more easily than oranges. The flesh is very tender and juicy with a rich pleasant flavor different from either mandarins or oranges. It is becoming increasingly popular in Florida. So far it has not been grown much in tropical areas but should succeed as well as mandarins. Temple oranges do not keep well on the tree.

A considerable number of hybrids between tangerine and grapefruit have been introduced. These are being marketed as tangelos and are becoming better known in the larger markets. They mostly have a rich flavor, tender pulp, abundant juice with variations to suit any taste. Some are firm and ship well while others are for home use only. Three varieties with commercial promise are Minneola, Orlando and Seminole. All three have richly flavored, dark orange-colored juice and smooth orange red skin.

Minneola is comparatively large and bell-shaped with a neck at the stem end. Orlando resembles a

tangerine in shape and size. Seminole is larger and mandarin shaped. Orlando is the earliest, Minneola intermediate and Seminole late in Florida. They do best on Cleopatra rootstock (4). Minneola and Orlando do not set fruit when self-pollinated. Seminole is a good pollinator for Minneola (9). Temple and Dancy are the only recommended pollinators for Orlando (7). Pollinators should be planted every third or fourth row. Girdling at full bloom will increase set when pollinators are not available (7).

Thornton is one of the older releases and is grown commercially. It is about the size of Orlando but not as rich in flavor. It has a light colored juice. Wekiwa is a mild spicy flavored, very sweet tangelo preferred by many. A very early variety of high quality is the Webber which is the size and shape of a grapefruit. The Pearl and San Jacinto tangelos are used in California (5).

Robinson, Osceola and Lee are new varieties with rich flavor and good quality. Robinson sets well with Orlando as a pollinator. Osceola does not need a pollinator (10).

The Puerto Rican Chironja appears to be from an orange-grapefruit cross and comes true from seed (8). Murcott is probably a tangor and is an excellent fresh fruit in Florida (1).

Tangelos succeed in the Subtropics where oranges grow and probably would be well adapted to tropical areas where grapefruit thrives. Tropical horticulturists would do well to consider these in developing plantings at lower elevations.

In general a steady growth is desirable to obtain good quality fruit. Avoiding soil temperatures above 95°F is important to maintain good growth. The most favorable soil temperatures for citrus growth are 64° to 88°F (2).

Dowpon at 2 lbs. per acre will control Bermuda grass and cause little or no injury to citrus (6). Oil sprays also may be used when weeds are small.

Tangelos are not well known on world markets but popularity is certain to increase as they become more widely planted.

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TEA

(Thea sinensis)

Tea is grown in India, Ceylon, Japan, Indonesia, Pakistan, Kenya, Mozambique, Uganda, Tanganyika and the U.S.S.R. There are some tea plantings in Brazil near Santos and in the Andean region of Chile and Peru (1).

Tea is divided into two major groups: the Chinese teas, called variety *bohea,* and the Assam teas, called variety *assamica.* These two varieties cross and Chinese-Assam hybrids are grown around Darjeeling near the Nepal border in India and in Ceylon. Tea shrubs are usually less than 6 feet high when pruned but if they are unpruned they could reach a height of 50 feet. The Chinese type produces small leaves about 3 in. long and the Assam type produces large leaves up to 14 in. long. The flowers are white or pink and the fruit has 5 seeds about ½ in. in diameter. The Chinese types are noted for their highly developed aroma and the Assam types for their large leaf size. The quality of tea is based on leaf color, flexibility of the leaf, hairiness of the terminal bud, aroma, tint of the infusion and flavor. Strains having light colored foliage are preferred since they result in a deeper tint of infusion. They tend to be thinner and more flexible so that they are easier to roll in processing. The dark-leaved types tend to possess superior aroma and astringency (1).

Tea grows best in subtropical regions and can withstand temperatures below freezing in the dor-

mant stage. Tea should be planted at elevations of 3,300 feet or higher in tropical areas but in cooler climates such as China and Japan it can be grown at sea level. Tea prefers a deep, friable, well-drained soil with a pH of 5 to 6.

Tea is propagated by seeds, cuttings and buddings. Clonal tea is preferred since the planting material is genetically alike; however, the cost of producing the planting material is more costly due to the budding or rooting of the cuttings. The following clones are recommended in Indonesia: PS 1, PS 87, Mal 11, KP 4 and Pam 5. Clones PS 1, KP 3 and SA 40 have good resistance to blister blight caused by *Exobasidium vexans* Massee (1).

Tea cuttings can be rooted with a success of 60 per cent where 2 per cent indole–3–butyric acid–talc powder is used. A tea budder can make 100 to 150 buddings a day with a success of 75 per cent. The Forkert method with small leafy scion or leafless scions can be used as well as the V–method. The methods of rooting cuttings or budding can be learned only by actually working with experienced personnel in the field, therefore the methods are not described here.

Tea seed can be obtained throughout the year but it is planted only at the beginning of the rainy season unless irrigation is available in the nursery. The seeds should be stored in tightly closed cans and kept in a cool place. The poor seeds should be discarded before planting. This can be done by putting them in water so that the floaters can be eliminated. The germination time which usually is 2 to 3 months can be reduced by peeling off the seedcoats or by soaking the seeds in water for 12 hours and then placing them in the sun (1).

The seeds are planted 1.5 x 1.5 inches in germination beds. They are set 1 inch deep with the eye down in order to obtain straight taproots. The nursery beds are 2 to 3 feet wide, with a 1½ foot path between beds. The seedings are spaced 8 x 8 inches in the beds. Shade trees such as *Leucaena glauca, Albizzia falcata, Derris microphylla* and *Erythrina subumbrans* are used for shade in the nursery, as well as for field plantings.

Since tea usually is planted on hillsides, erosion control is very important. It is necessary to make contour plantings, dikes, silt pits and terraces in some areas. Cover crops such as *Vigna hosei, Indigofera endecaphylla, Centrosema pubescens, Pueraria phaseoloides* and *Calopogonium mucunoides* can be used to help prevent erosion (1).

Seedlings or stumps can be planted. The seedlings can be taken from the nursery when they are 20 inches high, with a ball of earth around them, and transplanted or if the seedlings are grown in polyethylene bags they can be taken directly to the field in the bags. Stumps are plants which have been in the nursery for a year and then cut back to 8 inches before they are planted. The planting holes should be 18 inches square and 16 inches deep. The seedling plants are cut back to 5 to 6 inches when they have a diameter of 1 to 1.5 inches at 6 inches above the ground.

The planting can be made in single rows or in a hedgerow system. For single rows a spacing of 4 x 5 or 4 x 6 or 5 x 5 feet can be used. If a hedgerow is used it will consist of 2 or 3 rows close together with a wider alley between the hedge. The plants in the hedge can be spaced 12 x 12 inches and the alley between hedges may be 7 to 10 feet wide (1).

In order to determine the fertilizer practices it is necessary to conduct fertilizer trials as the rates will depend on the environment. A production of 2,200 lbs. of tea leaves per hectare will remove about 99 lbs. of nitrogen, 20 lbs. of phosphate and 55 lbs. of potash. Leaf tissue analyses should be correlated with the fertilizer trials. Mulch should be used when available. When the shade trees are thinned out the material can be cut and used for mulch as well as the refuse from pruning the tea.

The pruning of tea can be learned only by working with experienced tea pruners. The Assam and Chinese-Assam hybrids require much more pruning than the Chinese types due to the fact that shrubby trees reach a height of 50 feet if they go unpruned and this makes harvesting very difficult. The first pruning is designated as "stem pruning" which consists of cutting back the main stem or leaders of young shrubs. "Shape pruning" involves heading back and thinning of the lateral shoots. Weak and crossed-over branches also are removed. "Production pruning" is carried on throughout the life of the shrub in order to keep the tree within a fairly low plucking height.

Plucking consists of the removal of young tender shoots which have developed one or two large stipules, three or four partially to fully grown leaves and a terminal bud. The best quality tea comes from the youngest leaves and terminals in flush growth. The usual method is to pluck the terminal bud and two or three leaves per shoot while leaving at least one leaf and the stipules. The period of time between harvests will vary with the environmental conditions under which the tea is grown. In Indo-

nesia a seven to ten day cycle has proved to be most economical. Women commonly harvest tea and they carry two or three baskets so that they can grade the tea as it is harvested. Mechanical harvesting has been done in Japan and the U.S.S.R. but where high quality teas are grown hand picking is necessary for selectivity (1).

The leaves are carried to weighing stations and then to the factory for processing. The processing consists of withering, rolling and sorting of fresh leaves, fermentation, drying and sorting of dried leaves. This process requires about 48 hours. The fresh shoots have a water content of 75 to 80 per cent. The leaves are spread out on trays to wilt. The trays are stacked under special sheds with controlled heating and ventilating facilities. The leaves are exposed to 86°F for 20 hours. The moisture content of the leaves drops to 57 to 67 per cent. The foliage is then rolled under pressure to separate the leaves from the tips and to crush them sufficiently for good distribution of the sap. Fermentation starts as soon as the leaves enter the rollers. The foliage is usually rolled three or four times in roller machines. The rolled pieces are screened after each rolling by using swinging screens or compound shakers. The pieces are separated into about five grades. The graded pieces are kept separately and are put on racks, then placed in the fermentation chamber. The fermentation rooms have a temperature between 70° and 77°F with a relative humidity of 90 per cent with forced air circulation. The period of fermentation depends on the type of plant material and the aroma, taste and color desired. The fermented leaves are dried for 20 to 25 minutes at 90° to 100°C in drying ovens and then sorted to the market requirements. The moisture content of the dried leaves is between 3 to 6 per cent. Sometimes the tea is dried a second time at 176° to 194°F for a few minutes just before it is packed.

The tea is sorted with rotating or vibrating screens and sometimes blowers are used. Hand sorting is necessary to remove trash and pieces of petioles. The main grades are divided into three large groups. The leaf teas include orange pekoe, pekoe, pekoe souchon and souchon. The broken tea group includes broken orange pekoe, broken pekoe and broken tea, the lower grades consist of fannings, dust and Bohea (1).

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TUNG

(Aleurites fordii)

Tung trees produce a high quality drying oil used in the manufacture of paint and other materials. China produces about 80 per cent of the world crop. Tung is also produced in the United States, Argentina, Brazil, Paraguay, Australia, Burma, Vietnam, Cambodia, Laos and the U.S.S.R. (1).

Tung belongs to the Spurge family and is a small deciduous tree that grows to 39 feet in height. The inflorescences are monoecious and commonly synoecious. The fruit is 1.5 to 3.0 in. in diameter and green when immature but turns brown at maturity. The seeds are 0.5 to 3 in. long and have a brown, hard, rough, thin coat and white flesh which contains toxic substances poisonous to man and warm blooded animals (1).

Tung grows well in warm temperate regions and is not a tropical crop but may produce at higher elevations. A period of complete dormancy is essential during the months that the tree is deciduous but the winter temperatures should not go below 21°F. Tung requires a few hundred hours of chilling below 41°F to flower and fruit well. The trees need at least 30 inches of rainfall annually. Tung performs best on slightly acid, sandy loams or clay loams with a pH of 6.0 to 6.5. Good drainage is important for tung trees.

It is important to use high yielding clonal material for planting. A clonal trial would be necessary to determine the best clone for a specific location. Experimental plant material can be obtained from the University of Mississippi. Dwarf, early bearing varieties can be spaced 17 x 17 feet and large, late bearing varieties can be spaced 23 x 23 feet. The budded trees can be set out when one to two years old. The trees are topped so that the main branches will arise from the trunk around 6 to 12 in. above the ground. When the trees are 6 to 7 years old, only dead and diseased wood should be pruned. Clean weeding is recommended but a cover crop can be used if erosion is a problem (1). Trees yield between 1.5 to 2.5 tons per acre.

The fertilizer practices can be determined by a fertilizer trial correlated with tissue analysis. Minor elements such as copper, zinc, manganese and iron may be deficient in some areas. In Mississippi tung responds to nitrogen and potash in a 1–0–1 ratio. Anhydrous ammonia is as good as ammonium nitrate as a source of fertilizer.

The tung nuts fall to the ground when they are

ripe and are allowed to dry there for a few weeks before they are collected. They are collected by hand or machine-drawn rakes and stored in well-ventilated bins. They are allowed to dry for two months in order to reduce the moisture content to 15 to 20 per cent.

A ball-bearing disk hulling machine is used to remove the hulls. Hulled seeds are ground to meal and then preheated to about 176°F and passed into a screw-type press. The air dried fruits contain from 15 to 20 per cent tung oil. The pressed cake can be used as fertilizer but cannot be fed to livestock since it is toxic (1).

MU OIL (MU—YU—SHU)

(Aleurites montana)

Since tung trees require a chilling temperature below 41°F they will not grow in tropical regions. In cool subtropical regions the Mu oil tree should be tried as it does not require as low temperatures for chilling as the tung trees.

Mu oil differs in chemical structure from that of tung oil, but it is equal in value and usually is sold as tung oil. About 10 per cent of the entire tung oil from China is estimated to come from Mu-oil trees. Mu oil is also produced in Vietnam, Cambodia Laos, Belgian Congo, East Africa, Malagasy Rep., South Africa, India and the U.S.S.R. (1).

The cultural practices are similar to those for tung but a wider spacing may be necessary since the tree is larger than the tung oil tree.

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VANILLA

(Vanilla planifolia)

Synthetic vanilla is made from eugenol obtained by the fractional distillation of clove oil and since this is much cheaper than natural vanilla it would be desirable to make a study of the world market on vanilla before any projects are undertaken.

Vanilla is produced in Malagasy Rep., Mexico, French Oceania, Reunion, Java and Guadaloupe at the present time. Vanilla belongs to the Orchid family and the plants produce capsules 6 to 10 inches long which are fleshy and nondehiscent or seldom dehiscent. The Bourbon and Javanese vanilla beans produce the highest percentage of vanillin (4).

Vanilla requires a rainy season of 80 inches and a dry period of at least three months to ripen the fruits. A temperature of 77°F and a relative humidity of 80 per cent are ideal for the growth of the plant. Vanilla requires a soil high in organic matter.

Vanilla is planted from stem cuttings about 20 inches long. Shade trees such as *Gliricidia, Erythrina, Leucaena* and *Albizzia* are used for support and shade for the vanilla plants. Hand-pollinations are made to insure a high fruit set. A period of nine months is required between pollination and harvest. The beans are placed on racks for twenty-four hours before they are wrapped in mats for fermentation. The beans turn brown in color after several days. After the beans are fermented they are dried for eight to twelve days, depending on the humidity. The pods are then packed in tins and sealed for shipment (4).

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Chapter 3

VEGETABLE CROPS

Many of the temperate zone vegetables can be grown in the Tropics but some of them require special climatic conditions such as cool temperatures which can be attained only during the winter months and at high altitudes.

The day length has an effect on many vegetable crops and this must be considered in selecting the right varieties to be grown under tropical conditions. Onions and soybeans are examples of crops that are affected by day length. If the proper varieties are grown in tropical areas, high yields can be obtained.

This book includes vegetable crops that will grow in tropical regions. All of the crops are described separately and listed alphabetically for easy reference.

Most of the plant breeding work on vegetables has been done in the temperate zone, but in the future more plant breeding work may be undertaken in the Tropics. Vegetable varieties are constantly being improved and the varieties suggested in this book are the ones available at the time of publication. It is important to check the seed catalogues for newer varieties that have been released since the publication of this book.

The use of local varieties never should be overlooked. Through natural selection some of the local varieties may be highly resistant to local pest problems. The local varieties always should be compared with imported varieties in replicated variety trials before the imported varieties are recommended.

Information on soil pH, temperature requirements, spacing and seed requirements are listed in Table 4 for the most important vegetable crops. In a few cases some of the information was not available and has been omitted.

Insect and disease control are considered as separate chapters for easy reference to specific control measures for each insect or disease. They are listed alphabetically by crops and by diseases or insects under each crop. Weeds also are considered separately as a chapter for easy reference.

When vegetable seeds are stored at air temperature in the Tropics, they lose their viability rapidly due to high respiration rate of the seeds. Since the temperature and humidity in tropical areas are usually higher than in temperate zone regions, the length of time the seeds are viable is greatly reduced.

Most seed companies sell seed in sealed containers and it is desirable to specify that seeds be sent in these containers for use in the Tropics. Small amounts of seeds, usually under four ounces, are not generally put up in cans and special care should be used in storing seeds. Some vegetable seeds remain viable up to five years if stored properly.

The moisture content of seeds should be low when they are stored in the Tropics. They can be forced air dried at 110° F from one to three hours depending on the size of the seed. Small lots of seeds can be dried in an airtight can with a desiccant such as calcium chloride or silica gel. The desiccant never should come in contact with the seeds.

Beans and okra sometimes develop hard seeds at a moisture content of 7 per cent or below. The white-seeded beans become hard even at 10 per cent, which results in poor germination; however, the dark seeded beans are affected at 7 per cent moisture or below (1).

All vegetable seeds in the Tropics should be stored at 40° F and 60 per cent relative humidity when the moisture content is low as shown in Table 2. If refrigeration facilities are not available the moisture content of the seeds should be reduced to 4 or 5 per cent except for okra and beans, and placed in airtight containers. They can then be stored for 1 year at 70° F.

When seeds are removed from a refrigerator they should be used soon afterwards since moisture condenses on the seeds when moved to a warmer temperature. This can be avoided if the seeds are enclosed in an airtight can in the refrigerator.

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Table 2. MAXIMUM SEED-MOISTURE CONTENT FOR STORAGE [1]

Kind of Seed	Moisture Content for Temperature of Storage		
	40°–50° F.	70° F.	80° F.
Bean	15%	11%	8%
Bean, lima	15	11	8
Beet	14	11	9
Cabbage	9	7	5
Carrot	13	9	7
Celery	13	9	7
Corn	14	10	8
Cucumber	11	9	8
Lettuce	10	7	5
Okra	14	12	10
Onion	11	8	6
Pea	15	13	9
Pepper	10	9	7
Spinach	13	11	9
Tomato	13	11	9
Turnip	10	8	6
Watermelon	10	8	7

[1] Adapted from United States Department of Agriculture Leaflet 220, *Storage of Vegetable Seeds*. 1942.

Tropical vegetable crops may be classified as follows:

CLASS I. Of wide commercial importance.
CLASS II. Of limited commercial importance.
CLASS III. Usually grown for local market only.
CLASS IV. Minor crops not often marketed.

CLASS I

Allium cepa.	Onion.
Arachis hypogaea.	Peanut.
Brassica oleracea.	Cabbage.
Capsicum annuum.	Sweet pepper.
Capsicum frutescens.	Pepper (Hot).
Citrullus vulgaris.	Watermelon.
Cucumis melo.	Cantaloupe, Muskmelon.
Cucumis sativus.	Cucumber.
Dioscorea alata.	Yam.
Ipomoea batatas.	Sweet potato.
Lycopersicon esculentum.	Tomato.
Manihot utilissima.	Cassava, Yuca, Manioc.
Phaseolus vulgaris.	Beans.
Solanum melongena.	Eggplant.

CLASS II

Allium sativum.	Garlic.
Apium graveolens.	Celery.
Brassica oleracea.	Cauliflower.
Brassica oleracea.	Broccoli.
Cajanus indicus.	Pigeon pea.
Cicer arietinum.	Chickpea.
Colocasia antiquorum.	Taro.
Colocasia esculenta.	Dasheen, Malanga.
Dolichos lablab.	Hyacinth bean.
Glycine max.	Soybean.
Helianthus annuus.	Sunflower.
Lactuca sativa.	Lettuce.
Lens esculenta.	Lentil.
Luffa spp.	Sponge gourd.
Phaseolus aureus.	Mung bean.
Phaseolus lunatus.	Lima bean.
Pisum sativum.	Peas.
Sesamum indicum.	Sesame.
Solanum tuberosum.	Potato.
Vicia faba.	Broad bean.

CLASS III

Allium ascalonicum.	Shallot.
Allium porrum.	Leeks.
Amaranthus gangeticus.	Chinese spinach.
Barbarea vulgaris.	Upland cress.
Beta vulgaris.	Beet.
Beta vulgaris.	Chard.
Brassica campestris.	Turnip.
Brassica chinensis.	Chinese cabbage.
Brassica juncea.	Mustard.
Brassica oleracea.	Kale.
Brassica oleracea.	Brussels sprouts.

CLASS III (Cont'd)

Brassica oleracea.	Kohlrabi.
Chenopodium quinoa.	Quinoa. Seeds and greens.
Cichorium endivia.	Endive.
Cichorium intybus.	Chicory.
Corchorus olitorius.	Jute for greens.
Cucurbita spp.	Squash and pumpkins.
Cynara scolymus.	Globe artichoke.
Daucus carota.	Carrot.
Foeniculum vulgare.	Sweet fennel.
Helianthus tuberosus.	Jerusalem artichoke.
Hibiscus esculentus.	Okra.
Pachyrhizus erosus.	Yam bean.
Petroselinum crispum.	Parsley.
Physalis pubescens.	Husk tomato.
Pimpinella anisum.	Anise.
Raphanus sativas.	Radish.
Roripa nasturtium-aquaticum.	Water cress.
Sechium edule.	Chayote.
Spinacia oleracea.	Spinach.
Tetragonia expansa.	New Zealand spinach.
Vigna sinensis.	Cowpeas.
Xanthosoma sagittalfolium.	Yautia.
Zea mays.	Sweet corn or field corn.

CLASS IV

Allium schoenoprasum.	Chives.
Amarantus spp.	Chinese spinach.
Anethum graveolens.	Dill.
Anthriscus cerefolium.	Chervil.
Armoracia rusticana.	Horse-radish.
Arracacia xanthorrhiza.	Arracacha.
Asparagus officinalis.	Asparagus.
Basella alba.	Malabar spinach.
Basella rubra.	Ceylon spinach.
Canavalia ensiformis.	Jack bean.
Cucurbita ficifolia.	Chilacayote.
Hibiscus sabdariffa.	Roselle.
Maranta arundinacea.	Arrowroot.
Ocimum basilicum.	Basil.
Pastinaca sativa.	Parsnip.
Plectranthus ternata.	Coleus tubers.
Portulaca oleracea.	Purslane.
Rheum rhaponticum.	Rhubarb.
Sicana odorifera.	Curuba.
Solanum commersonii.	Uruguay potato.
Tragopogon porrifolius.	Salsify.
Tropaeolum tuberosum.	Cubio.
Voandzeia subterranea.	Bambarra groundnut.
Zea mays.	Popcorn.

ARTICHOKE

(Cynara scolymus)

The globe artichoke is a perennial vegetable grown for its flower bud or head. These heads are harvested before they open and the fleshy portion at the center is eaten. The heads usually are boiled after cutting off the tough portion with a sharp knife. The base of the petals are sometimes dipped in a butter sauce before eating.

Hot weather causes the flowers to open and increases the fiber and toughness, hence the artichoke does best in cooler temperatures at 3,000 feet or above in elevation.

They are propagated originally from seed but to obtain the best production, offshoots or divisions from old crowns of high producing plants are used (1). A period of two years is required for production from seed.

Artichokes will withstand some dry weather but should be irrigated during the dry season for best results. Nitrogen fertilizer at the rate of 60 to 80 lbs. of nitrogen per acre is used just before harvesting begins (2). (Illus. page 8.)

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ASPARAGUS

(Asparagus officinalis)

Asparagus is rare in tropical regions but is popular where it is known. It is a perennial with male and female flowers on separate plants.

A neutral or slightly alkaline soil that is loose and deep enough to permit development of good shoots is preferred. The chief problem in the Tropics is the dormancy necessary to produce shoots of sufficient size for the market. It may not be a very profitable commercial crop as without a dormant period the shoots are very slender.

Seeds are planted in nursery rows where they

Table 3. ESTIMATED YIELDS PER ACRE OF VEGETABLE CROPS IN THE UNITED STATES.[1]

Crop	Average Yield in Lbs. per Acre	Good Yield in Lbs. per Acre
Artichoke	4,000	6,000
Asparagus —Market	2,700	6,000
—Processing	2,000	4,000
Bean–snap—Market	3,300	6,000
—Processing	4,000	7,000
Beets —Market	10,400	20,800
—Processing	20,000	24,000
Broccoli	5,040	8,400
Brussels sprouts	9,000	10,000
Cabbage	16,000	24,000
Carrot	27,000	33,750
Cauliflower	15,540	22,200
Celery	38,400	90,000
Chard, Swiss		10,000
Corn	5,250	15,000
Cucumbers	7,440	24,000
Eggplant	9,900	16,500
Endive	12,500	17,500
Garlic	6,000	8,000
Lettuce	12,600	21,000
Muskmelon	7,700	14,000
Okra		10,000
Onion	18,000	35,000
Peas in pods	3,150	4,500
Pepper, bell	6,125	12,500
Pepper, chili–dried	2,000	3,000
Potato	15,000	24,000
Pumpkin		20,000
Radish		20,000 bunches
Rutabaga		20,000
Shallot	3,000	3,750
Spinach	6,250	12,500
Squash, summer		18,000
Squash, winter		20,000
Sweet potato	5,225	11,000
Tomato	20,000	30,000
Turnip–bunched		10,000
Watermelon	7,000	12,500

[1] Permission to use this information has been granted by Dr. James Edward Knott. "Handbook for Vegetable Growers." 1962. John Wiley and Sons, Inc. New York, N. Y.

are grown for about a year. They are transplanted when the plants are dormant. Smaller crowns should be discarded since they have proved to be unprofitable (1). Crowns are planted about 2 inches deep in furrows which eventually may be covered 6 or 8 inches deep. Male plants produce better than female plants but it has not been found profitable to separate them.

Weeds must be controlled for good results, either with a chemical herbicide or by cultivation. Fertilizer usually is needed but in the rich soils of the Sacramento Valley they have not been shown to be necessary. In most areas a complete fertilizer with a 1–1–1 ratio would be satisfactory.

Plants usually are spaced 18 to 24 inches in rows 4 to 6 feet apart in the field. Recent spacing experiments have shown high yields from 6 inch spacings in 5 foot rows (2). In the seedbed 30 to 36 inch rows are used with plants 3 to 4 inches apart.

Harvesting usually is done once a year, beginning when the planting has had two seasons of growth (3). The shoots are cut during a period of 2 to 8 weeks depending on the strength of the plants.

Table 4. SUGGESTED PLANTING AND TEMPERATURE REQUIREMENTS FOR VEGETABLES.[1]

CROP	SOIL pH	TEMPERATURE REQUIREMENT	QUANTITY OF SEEDS TO PLANT AN ACRE IN LBS.	APPROXIMATE NO. OF SEEDS PER OUNCE	SPACING IN THE ROW IN INCHES	SPACING BETWEEN ROWS IN INCHES
1. Artichoke		60°–65° F	907–1,089 root section	700	72	96
2. Asparagus	6.0–6.8	30° F	2.5– 4	700	12–18	36–84
3. Bean–broad	5.5–6.8	60°–65° F	50–100	20–50	8–10	20–48
4. Bean–common	5.5–6.8	60°–70° F	40– 80	100	2– 4	18–36
5. Bean Lima	5.5–6.8	60°–70° F	50–100	20–70	6– 8	18–36
6. Bean–snap	5.5–6.8	60°–70° F	40– 80	100	2– 4	18–36
7. Beet	6.0–6.8	60°–65° F	8– 10	1,600	2– 4	18–36
8. Cabbage	6.0–6.8	60°–65° F	1.5– 2	8,500	16–30	24–40
9. Cantaloupe	6.0–6.8	65°–75° F	1.5– 2	1,200	12	60–96
10. Carrot	5.5–6.8	60°–65° F	2.5– 3	23,000	1– 3	16–36
11. Corn–field	5.5–6.8	60°–75° F	8– 10	100–150	12–18	36–48
12. Corn–sweet	5.5–6.8	60°–75° F	10– 15	100–200	9–15	36–48
13. Cowpea		60°–75° F	20– 40	125	5– 6	36–48
14. Cucumber	5.5–6.8	65°–75° F	2	1,000	12	36–72
15. Dasheen		70°–85° F	200–1,200 tubers		24–30	42–48
16. Eggplant	5.5–6.8	70°–85° F	2	6,000	18–36	24–54
17. Garlic	5.5–6.8	55°–75 F	800–1,000 cloves		2–3	18–24
18. Leek	6.0–6.8	55°–75 F	4	11,000	2–6	12–36
19. Lettuce–head	6.0–6.8	60°–65° F	1.5–3	25,000	10–15	18–24
20. Lettuce–leaf	6.0–6.8	60°–65° F	1.5–3	25,000	10-12	18–24
21. Okra	6.0–6.8	70°–85° F	6–8	500	12–24	24–60
22. Onion	6.0–6.8	55°–75° F	3–4	9,500	2–4	18–36
23. Pea	5.5–6.8	60°–65° F	60–100	50–230	1–3	24–48
24. Pepper–hot	5.5–6.8	70°–85° F	2–4	4,500	12–24	18–36
25. Pepper–sweet	5.5–6.8	70°–75° F	2–4	4,500	12–24	18–36
26. Potato–Irish	5.0–6.8	60°–65° F	1200–2200 tubers		9–12	30–42
27. Potato–sweet	5.0–6.8	70°–85° F	9,680 vine cuttings		10–18	36–48
28. Pumpkin	5.5–6.8	65°–75° F	2–3	110	36–60	96–144
29. Radish	5.5–6.8	60°–65° F	10–12	2,000	1	12–18
30. Spinach	6.0–6.8	60°–65° F	10–15	2,800	2–6	12–36
31. Spinach–New Zealand	6.0–6.8	60°–75° F	15	350	10–20	36–60
32. Soybean	6.0–6.8	65°–75° F	40–80	175–350	1–2	18–24
33. Squash–summer	5.5–6.8	65°–75° F	4–6	300	24–48	36–48
34. Squash–winter	5.5–6.8	65°–75° F	3–4	100	36–120	72–120
35. Tomato	5.5–6.8	70°–75° F	0.5–1.5	11,000	18–48	36–72
36. Watermelon	5.0–6.8	70°–85° F	1–2	225–300	24–36	72–96

[1] Permission to use this information has been granted by Dr. James Edward Knott: "Handbook for Vegetable Growers". 1962. John Wiley and Sons, Inc. New York, N. Y.

Shoots ordinarily are cut every day during the harvest period. Care in harvesting is essential and this is done with a special asparagus knife to avoid injuring the crown or roots. If blanched shoots are desired it is necessary to mound up earth on the shoots several inches and harvest as the shoots appear above the surface to prevent them from becoming green. Beds usually last 10 to 15 years.

References

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Table 5. PROXIMATE COMPOSITION OF VEGETABLES [1]

Amount per 100-gram fresh edible portion

No.	Vegetable	Refuse A p[a]	Approximate household equivalent (100 gm = 3½ oz)	Average food energy	Water	Protein	Fat	Total sugar	Other CHOb	Vitamins: A	Vitamins: Thiamine	Vitamins: Ribo-flavin	Vitamins: Niacin	Vitamins: C	Minerals: Ca	Minerals: Fe	Minerals: Mg	Minerals: P	Minerals: K	Minerals: Na
		per cent	*units*	*calories*			*grams*			*international units*	*milligrams*				*milligrams*					
1	**ARTICHOKE, GLOBE**	60	1 small or 1/2 large	20	83	2.7	0.2	1.8	0.5[c]	160	0.08	0.06	0.8	11	53	1.5	48	78	340	110
	Large bud, 200 gm																			
2	Bracts	60		20	82	2.6	0.1	1.8	0.6[c]	220	0.09	0.07	0.7	12	57	2.1	39	70	270	70
3	Receptacle	20		20	84	2.8	0.2	1.4	0.6[c]	100	0.08	0.04	0.8	10	44	1.4	50	80	340	110
	Small bud, 100 gm																			
4	Bracts	60		21	83	2.7	0.2	2.2	0.4[c]	220	0.07	0.09	0.8	11	37	1.5	39	75	310	56
5	Receptacle	30		22	81	2.5	0.3	1.4	0.6[c]	100	0.07	0.04	0.7	10	47	1.7	60	83	370	110
	ASPARAGUS																			
6	Green, shoots	40	6 5-inch spears 1/2- to 5/8-inch diameter	27	92	2.8	0.2	1.9	0.3	980	0.23	0.15	2.2	48	24	1.5		52		
7	White, shoots	30	6 5-inch spears 1/2- to 5/8-inch diameter	25	93	1.9	0.2	2.3	0.2	50	0.11	0.08	1.1	28	16	1.1		52		
	ASPARAGUS BEAN (*See* 15)																			
	BEANS																			
8	Blackeye pea (Cowpea)	6	3/4 cup	40	85	3.3	0.3	3.0	3.3	634	0.37	0.06	1.3	38	32	1.7	54	78	220	5
9	Fava, immature	70	2/3 cup	53	81	5.6	0.6	2.8	3.8	350	0.17	0.11	1.5	33	22	1.9	38	95	250	50
10	Lima, baby	60	2/3 cup	90	69	7.1	1.4	3.1	9.2	390	0.27	0.13	1.6	31	62	3.3		175		
11	Lima, Fordhook	60	2/3 cup	80	71	6.3	1.8	2.5	7.5	250	0.29	0.11	1.4	27	28	2.5	30	145	260	5
12	Snap, bush	6	3/4 cup	34	86	2.7	0.2	2.1	3.6	540	0.09	0.08	0.9	21	35	1.2	51	78	330	9
13	Snap, pole	5	3/4 cup	21	91	1.6	0.1	2.3	1.2	450	0.21	0.07	0.6	16	50	0.8	37	41	200	4
14	Soybean	40	5/8 cup	106	73	9.0	5.0	2.8	4.1	640	0.57	0.14	1.6	33	66	2.5		178		
15	Yard-long	3	3/4 cup	30	89	2.8	0.4	3.1	0.7	1,400	0.13	0.11	1.0	32	50	1.0	51	59	210	4
16	**BEAN SPROUTS** (Mung bean)	0	1 1/8 cups	25	92	2.7	0.1	2.1	1.4	25	0.11	0.03	0.6	12	20	0.6	16	35	130	2
17	**BEETS, TABLE**	65	3/4 cup, 2 roots 2-inch diameter	34	89	1.9	0.1	5.9	0.4	Trace	0.05	0.02	0.4	11	13	0.5	19	55	290	130
	BELL PEPPERS (*See* 82–83)																			
18	**BORAGE**	20	1 1/8 cups	17	93	1.8	0.7	0.9	0.2	4,200	0.06	0.15	0.9	35	93	3.3	52	53	470	80
	BRASCHETTE (*See* 59)																			
19	**BROCCOLI, SPROUTING**	20	3/4 cup or 2 1/2 stalks	23	90	3.6	0.3	1.6	0.4	3,800	0.11	0.10	0.6	110	78	1.0	39	74	360	40
20	**BRUSSELS SPROUTS**	5	5 to 7 sprouts	26	88	3.5	0.2	2.2	0.5	950	0.13	0.04	0.6	85	39	0.9	23	69	390	30
21	**BURDOCK ROOT**	10	1 cup	40	72	1.1	(0.1)[d]	1.9	4.8	0	0.01	0.03	0.3	3	41	0.8		51		

	CABBAGE																			
22	White	15	1 1/2 cups	21	92	1.2	0.1	3.3	0.4	200	0.05	0.03	0.3	60	38	0.4	22	34	220	20
23	Red	15	1 1/2 cups	19	92	1.4	0.1	3.3	0.2	40	0.05	0.03	0.3	57	51	0.7	17	42	190	17
24	Savoy	15	1 1/2 cups	20	91	2.0	0.1	2.9	...	1,000	0.07	0.03	0.3	31	35	0.4	28	42	230	28
	Chinese																			
25	Pak-choi	5	1 1/2 cups	13	95	1.5	0.2	1.0	0.2	3,000	0.04	0.07	0.5	45	105	0.8	27	37	180	100
26	Pe-tsai	10	1 1/2 cups	11	91	1.2	0.2	1.3	0.1	1,200	0.04	0.05	0.4	27	92	0.5	14	31	230	70
	CANTALOUPE (*See* 66)																			
27	CARDOON	55	1 1/8 cups	10	94	0.7	0.1	1.7	0.1	120	0.02	0.03	0.3	2	70	0.7	42	23	400	170
	CARROTS																			
28	Chantenay	20	1 cup	31	89	0.8	0.2	6.2	0.4	13,000	0.05	0.04	0.3	6	30	1.4	17	36	250	70
29	Danvers	25	1 cup	32	87	1.0	0.2	6.6	0.6	15,000	0.05	0.04	0.4	6	33	1.1	..	40	...	...
30	Imperator	20	1 cup	33	86	1.0	0.2	7.1	0.6	14,000	0.05	0.04	0.5	7	39	1.3	17	43	280	34
31	Nantes	15	1 cup	32	88	0.8	0.2	6.4	0.4	10,000	0.05	0.03	0.4	5	31	0.9	.	32	...	...
	CASABA (*See* 67)																			
	CAULIFLOWER																			
32	Snowball	50	2/3 cup	22	91	2.2	0.1	2.3	0.9	40	0.09	0.02	0.6	71	30	0.5	12	45	230	20
33	Winter	60	2/3 cup	22	90	2.2	0.3	2.5	0.4	0	0.08	0.06	0.6	72	35	0.6	19	60	340	20
34	C 'RIAC	55	1/2 medium, 1 cup	20	88	1.5	0.3	2.0	1.5	0	0.05	0.06	0.7	8	43	0.7	20	115	300	100
	CELERY																			
35	Self-blanching	5	3/4 cup	7	96	0.7	0.1	1.0	0.2	90	0.03	0.02	0.3	7	25	0.3	10	27	160	200
36	Green	5	3/4 cup	8	95	0.9	0.1	1.0	0.2	120	0.03	0.04	0.3	10	70	0.5	14	34	240	130
	CELTUCE																			
37	Leaves	20	1 1/4 cups	12	94	1.1	0.4	1.2	0.1	3,500	0.09	0.12	0.5	33	59	0.8	38	34	330	9
38	Stalks	70	3/4 cup	12	95	0.6	0.2	2.2	0.2	70	0.02	0.02	0.6	6	18	0.3	17	43	330	12
39	CHARD, SWISS, leaves	5	1 1/8 cups	16	92	1.8	0.2	1.3	0.2	3,300	0.04	0.09	0.4	30	51	1.8	75	46	240	250
40	CHAYOTE	0	3/4 cup	26	93	0.9	0.3	4.0	1.3	50	0.03	0.04	0.5	11	19	0.4	14	20	150	4
	CHICORY																			
41	Leaves	20	1/2 head	13	92	1.7	0.3	0.9	0.2	4,000	0.06	0.10	0.5	24	100	0.9	30	47	420	45
42	Roots	0	1 cup	23	80	1.4	0.2	2.4	2.2	0	0.04	0.03	0.4	5	41	0.8	22	61	290	50
	CHILI PEPPERS (*See* 84–85)																			
	CHINESE OKRA (*See* 73)																			
43	CHIVES	0	3/4 bunch	20	92	2.8	0.6	1.0	0.1	6,400	0.10	0.18	0.7	79	81	1.6	55	51	250	6
	COLLARDS (*See* 58)																			
44	CORN, SWEET	65	1 medium ear or 1/2 cup	116	68	4.0	1.3	5.3	19.0	650	0.20	0.06	1.7	9	11	1.4	45	125	260	10
	COWPEA (*See* 8)																			
	CRESS, WATER– (*See* 124)																			
	CUCUMBER																			
45	Marketing	15	3/4 cup	12	96	0.6	0.1	2.5	0.2	45	0.03	0.02	0.3	12	12	0.3	15	24	150	6

See footnote at end of table.

Table 5. PROXIMATE COMPOSITION OF VEGETABLES (Continued)

Amount per 100-gram fresh edible portion

No.	Vegetable	Refuse A [a]	Approximate household equivalent (100 gm = 3½ oz)	Average food energy	Water	Protein	Fat	Total sugar	Other CHO[b]	Minerals A	Vitamins Thiamine	Riboflavin	Niacin	C	Ca	Fe	Mg	P	K	Na
		per cent	*units*	*calories*			*grams*			*international units*			*milligrams*					*milligrams*			
	CUCUMBER (Continued)																			
46	Pickling	0	3/4 cup	12	96	0.7	0.1	2.0	0.2	270	0.04	0.02	0.4	19	13	0.4	14	24	190	6
	DASHEEN (*See* 115–116)																			
	DOCK (*See* 98)																			
	EDIBLE PODDED PEA (*See* 80)																			
47	EGGPLANT	10	1 slice, 3/4 x 4 inches or 1 1/2 cups	20	93	1.1	0.1	3.3	0.7	70	0.09	0.02	0.6	7	7	0.4	16	25	210	5
48	ENDIVE	20	1/2 head	11	95	1.3	0.2	1.1	0.1	2,500	0.07	0.08	0.4	8	42	2.0	20	30	280	60
49	EPOS ROOT (dry)	..	1 cup	154	60	4.6	1.8	9.3	21.5	0	0.11	0.12	3.0	13	110	6.5	32	165	340	12
50	ESCAROLE	15	1 1/4 cups or 1/4 head	12	94	1.2	0.2	1.4	0.1	1,600	0.09	0.07	0.4	5	50	0.7	14	21	240	72
	FAVA BEAN (*See* 9)																			
51	FLORENCE FENNEL (Sweet anise)	60	2 cups	15	93	1.1	0.1	2.3	0.3	100	0.04	0.02	0.4	9	44	0.8	23	38	330	90
52	GARLIC, bulbs	20	2 of 2-inch diameter	39	61	6.4	0.5	1.0	1.9[c]	0	0.20	0.11	0.7	15	24	1.7	32	195	540	10
53	GHERKIN	0	6 fruits	17	93	1.4	0.3	2.2	0.4	270	0.10	0.04	0.4	51	26	0.6	32	38	290	6
54	GINGER	30	3/4 cup	28	90	1.5	0.7	2.8	2.3	0	0.02	0.02	0.6	5	22	0.3	..	13	...	...
	GUMBO (*See* 72)																			
	HONEYDEW (*See* 68)																			
55	HORSE-RADISH	0	3/4 cup	55	77	3.1	1.7	1.8	5.2	0	0.06	0.03	0.5	95	150	2.4	81	41	420	16
56	HUSK-TOMATO	2	1 cup	25	91	1.4	0.5	3.9	0.3	380	0.15	0.03	3.5	4	8	0.3	..	34	...	...
57	ICE-PLANT	0	1 1/4 cups	5	94	0.7	0.2	0.1	0.2	2,000	0.04	0.06	0.3	23	20	0.6	..	26	...	...
58	KALE	25	1 1/2 cups	27	85	3.3	0.7	2.0	0.4	5,800	0.11	0.13	1.0	120	135	1.7	34	56	400	40
59	Kale, Scotch (Braschette)	40	1 1/2 cups	26	87	2.8	0.6	2.3	0.2	3,100	0.07	0.05	1.3	130	205	3.0	88	62	450	70
60	KOHLRABI	40	3/4 cup	23	91	1.7	0.1	4.5	0.1	30	0.05	0.02	0.4	62	24	0.4	19	46	350	20
61	LEEK	70	1 cup, 3 to 5 of 1-inch diameter	35	83	1.5	0.3	4.5	0.9	95	0.06	0.03	0.4	12	59	2.1	28	35	180	20
	LETTUCE																			
62	Butterhead	20	1/3 to 1/2 head	11	96	1.2	0.2	1.1	0.1	1,200	0.07	0.07	0.4	9	40	1.1	16	31	270	10
63	Cos (Romaine)	25	1/4 head	16	94	1.6	0.2	2.0	0.1	2,600	0.10	0.10	0.5	24	36	1.1	6	45	400	9
64	Crisphead (Great Lakes)	15	1/4 head	11	95	0.8	0.1	2.2	0.1	300	0.07	0.03	0.3	5	13	1.5	7	25	100	5

	LIMA BEAN (*See* 10–11)																		
65	LOTUS ROOT	5	1 1/4 cups	69	75	2.6	0.1	1.2	13.5	0	0.16	0.22	0.4	44	45	1.6	25	100	730	40
	MELONS																			
66	Cantaloupe (muskmelon)	45	1/8 of 6-inch melon	31	90	1.0	0.1	7.0	0.2	4,200	0.06	0.02	0.9	45	10	0.4	17	39	330	20
67	Casaba	45	1-inch wedge from 8-inch melon	26	92	0.6	0.1	6.2	0.1	Trace	0.06	0.02	0.4	19	5	0.4	8	7	210	12
68	Honeydew	45	1/2 slice, 3/4 x 10 inches	41	87	0.9	0.1	10.1	0.2	500	0.06	0.02	0.6	32	6	0.2	10	14	330	20
69	Watermelon	50	6 1-inch cubes	36	90	0.6	0.1	9.0	0.1	300	0.08	0.02	0.2	6	5	0.2	11	9	130	5
	MUNG BEAN SPROUTS (*See* 16)																			
70	MUSHROOM	0	2 cups	13	92	2.9	0.1	0.1	0.3	0	0.08	0.30	4.6	8	5	0.5	12	90	320	9
71	MUSTARD GREENS	5	2 cups	15	91	2.7	0.2	0.8	0.1	5,300	0.08	0.11	0.8	70	140	2.0	48	45	340	50
	NEW ZEALAND SPINACH (*See* 100)																			
72	OKRA (Gumbo)	10	10 to 12 pods	25	88	2.0	0.1	2.5	0.2	660	0.20	0.06	1.0	44	81	0.8	59	63	280	10
73	OKRA, CHINESE	10	2 medium fruits	20	93	1.2	0.2	3.2	0.8	410	0.05	0.06	0.4	12	20	0.4	..	32	...	...
	ONION, DRY, bulbs																			
74	Southport White Globe	5	1 medium or 1 cup	37	86	1.5	0.6	8.1	0.3*	0	0.06	0.01	0.1	9	33	0.4	17	43	180	8
75	Sweet Spanish	5	1 medium or 1 cup	26	90	0.5	0.1	6.3	0.2*	0	0.02	0.02	0.1	6	27	0.6	16	27	120	6
	ONION, GREEN																			
76	Bulb	10	1 cup	21	90	1.3	0.2	3.5	0.5*	330	0.06	0.05	0.3	32	62	0.5	25	43	120	70
77	Leaves		2 cups	19	92	2.0	0.2	3.0	0.4	5,000	0.07	0.14	0.2	45	80	1.0	24	30	220	10
78	PARSLEY	5	2 1/2 cups or 1 small bunch	16	90	2.2	0.3	1.1	0.2	5,200	0.08	0.11	0.7	90	125	2.0	79	40	270	140
79	PARSNIP	15	3/4 cup	53	81	1.2	0.3	4.8	6.8	0	0.09	0.05	0.7	17	40	0.7	29	69	330	10
	PEAR TOMATO (*See* 118)																			
	PEAS																			
80	Edible (podded)	5	3/4 cup	35	88	2.8	0.2	4.0	1.8	580	0.15	0.08	0.6	60	43	0.9	22	53	170	6
81	Garden (green)	70	3/4 cup	68	79	5.9	0.3	5.6	5.4	1,000	0.30	0.08	1.5	40	35	1.6	31	110	260	10
	PEPPERS																			
82	Bell (green)	15	1 of 4-inch fruit, 1 cup	22	93	0.9	0.3	4.0	0.4	530	0.06	0.02	0.4	160	7	0.4	13	22	150	2
83	Bell (red)	15	1 of 4-inch fruit, 1 cup	29	91	0.8	0.6	5.0	0.3	5,700	0.11	0.08	0.7	220	4	0.3	13	28	200	2
84	Chili (green)	5	1 medium	43	86	2.0	1.5	5.1	0.8	10,500	0.08	0.08	0.9	245	17	1.4	23	46	260	5

See footnote at end of table.

Table 5. PROXIMATE COMPOSITION OF VEGETABLES (Continued)

Amount per 100 g am fresh edible portion

No.	Vegetable	Refuse A pª	Approximate household equivalent (100 gm = 3½ oz)	Average food energy	Water	Protein	Fat	Total sugar	Other CHOb	Vitamins					Minerals					
										A	Thiamine	Ribo-flavin	Niacin	C	Ca	Fe	Mg	P	K	Na
		per cent	*units*	*calories*		*grams*				*international units*	*milligrams*				*milligrams*					
	PEPPERS (Continued)																			
85	Chili (red)	5	1 medium	46	84	2.0	2.0	5.5	0.3	11,000	0.10	0.10	1.0	240	18	1.0	27	45	420	9
86	Pimiento	30	1 large	35	90	1.2	0.9	5.6	0.3	2,200	0.05	0.46	0.6	165	9	0.5	4	20	250	4
	POTATO																			
87	Pontiac	5	3/4 cup	75	78	2.3	0.1	0.7	15.6	0	0.13	0.02	0.3	10	9	0.7	30	65	390	6
88	Russet Burbank	5	3/4 cup	71	80	2.1	0.1	0.7	14.9	0	0.10	0.01	0.6	6	10	0.7	26	38	340	12
89	White Rose	5	3/4 cup	72	80	2.0	0.1	1.0	15.0	0	0.09	0.02	0.6	36	19	1.3	20	51	370	9
	PUMPKIN (*See* 107–111)																			
	RADISH																			
90	Chinese winter	50	1 cup	13	94	0.6	0.1	2.5	0.2	0	0.02	0.02	0.2	22	27	0.4	22	24	190	30
91	Icicle	35	1 of 1-inch diameter	15	94	1.1	0.1	2.5	0.1	0	0.03	0.02	0.3	29	27	0.8	9	28	280	16
92	Scarlet Globe	40	4 to 6 of 1-inch diameter	14	94	0.7	0.1	2.7	0.1	0	0.02	0.03	0.4	21	20	0.8	11	27	190	30
	RAPPINI (*See* 121)																			
93	RHUBARB	20	3/4 cup, 2 9-inch stalks	12	92	0.7	0.2	2.0	0.3	100	0.02	0.03	0.3	8	130	0.7	28	20	360	10
94	RUTABAGA	40	3/4 cup	25	90	1.2	0.2	5.0	0.5	Trace	0.09	0.04	0.7	33	31	0.4	19	41	220	20
95	SALSIFY (Vegetable oyster)	25	3/4 cup or 2 medium	34	77	3.3	0.2	2.9	2.3	0	0.08	0.22	0.5	8	60	0.7	23	75	380	20
	SCOTCH KALE (*See* 59)																			
	SEA-KALE																			
96	Blanched	0	1 1/2 cups	13	94	2.0	0.3	0.7	0.1	100	0.04	0.04	0.3	26	35	0.5	..	34	...	...
97	Green	0	1 1/2 cups	22	90	3.5	0.3	1.2	0.1	4,600	0.16	0.10	0.5	87	110	0.9	64	63	360	30
	SNAP BEAN (*See* 12–13)																			
98	SORREL (Dock)	25	3/4 cup	15	93	2.0	0.7	0.3	0.2	4,000	0.04	0.10	0.5	48	44	2.4	103	63	390	4
	SOYBEAN (*See* 14)																			
99	SPINACH	5	1 1/2 cups	20	90	3.6	0.4	0.6	0.2	5,800	0.12	0.16	0.8	52	107	2.1	103	66	710	110
100	SPINACH, NEW ZEALAND	0	1 1/2 cups	10	94	1.5	0.2	0.4	0.2	4,400	0.04	0.13	0.5	30	58	0.8	39	28	130	130
	SQUASH (SUMMER)																			
101	Crookneck	3	3/4 cup	22	92	1.4	0.2	2.6	1.3	140	0.07	0.04	0.6	18	19	0.5	26	38	190	3
102	Early Prolific	2	3/4 cup	16	94	1.0	0.2	2.4	0.6	80	0.05	0.03	0.5	19	19	0.4	20	28	180	3
103	Scallop	1	3/4 cup	18	93	1.2	0.2	2.5	0.8	110	0.07	0.03	0.6	18	19	0.4	23	36	150	3
104	Zucchini	5	3/4 cup	13	95	1.2	0.1	1.8	0.2	340	0.07	0.03	0.4	9	15	0.5	21	32	220	3
105	Balsam Pear	25	3/4 cup	10	94	1.1	0.2	0.8	0.4	380	0.04	0.04	0.4	84	19	0.5	..	28	...	...
106	Chinese squash	10	3/4 cup	18	94	1.0	0.2	2.3	1.0	450	0.02	0.04	0.5	57	13	0.4	..	23	...	...

	SQUASH (WINTER) AND PUMPKIN																		
107	Acorn, Table Queen	40	3/4 cup	35	86	0.8	0.1	7.0	1.0	340	0.14	0.01	0.7	11	33	0.7	32	36	520	6
108	Pink Banana	15	3/4 cup	20	91	2.0	0.2	3.0	0.3	2,700	0.08	0.04	0.8	6	27	0.5	16	38	330	3
109	Butternut	25	3/4 cup	41	85	1.0	0.1	4.5	4.0	7,800	0.10	0.02	1.2	21	48	0.7	34	33	400	...
110	Hubbard	35	3/4 cup	34	88	2.0	0.5	5.0	1.3	5,400	0.07	0.04	0.5	11	14	0.4	19	21	320	7
111	Chinese winter-melon	25	Slice, 1 x 5 inches	9	96	0.2	0.1	1.9	0.2	Trace	0.02	0.03	0.5	14	14	0.4	16	7	200	2
	SWEET ANISE (*See* 51)																		
	SWEET POTATO																		
112	Jersey	15	3/4 cup	116	67	2.0	0.2	6.0	21.0	1,500	0.10	0.02	0.8	32	60	0.9	34	57	390	40
113	Puerto (Porto) Rico	15	3/4 cup	101	70	2.0	0.2	4.4	...	8,800	0.20	0.03	0.5	18	36	0.9	30	71	430	60
114	Velvet	15	3/4 cup	93	69	1.4	0.2	5.8	16.3	14,000	0.10	0.04	0.2	21	37	0.7	28	65	290	80
	SWISS CHARD (*See* 39)																		
	TARO (Dasheen)																		
115	Pink	15	3/4 cup	52	80	1.0	0.2	0.7	11.0	0	0.10	0.03	0.6	5	60	0.7	46	107	560	4
116	White	15	3/4 cup	54	82	2.0	0.2	1.0	10.0	0	0.09	0.02	0.6	4	26	0.4	25	60	710	7
	TOMATO																		
117	Pearson	5	1 of 3-inch diameter	19	94	0.9	0.1	3.5	0.2	1,700	0.10	0.02	0.6	21	6	0.3	10	16	220	5
118	San Marzano (Pear tomato)	5	1 medium	15	94	0.9	0.1	3.0	0.5	770	0.10	0.01	0.7	23	9	0.1	11	20	250	3
	TOMATO, HUSK- (*See* 56)																		
	TURNIP																		
119	Greens	10	2 cups	14	91	1.5	0.3	1.3	0.1	3,400	0.07	0.10	0.6	60	190	1.1	31	42	250	40
120	Roots (mature)	55	3/4 cup	18	92	0.9	0.1	3.8	0.2	0	0.04	0.03	0.4	21	30	0.3	11	27	170	40
121	Tops and roots (immature) (Rappini)	20	2 to 4 plants	18	92	1.8	0.2	1.7	0.2	2,700	0.05	0.07	0.5	70	125	1.5	45	45	250	40
	VEGETABLE OYSTER (*See* 95)																		
122	WATER-CHESTNUT	35	15 to 20 corms	56	82	1.4	0.1	4.8	8.0	0	0.14	0.20	1.0	10	11	3.5	12	63	500	20
123	WATER-CONVOLVULUS	0	1 1/2 cups	25	92	2.6	0.2	0.3	3.1	3,500	0.03	0.10	0.9	55	95	2.2	49	40	370	6
124	WATER-CRESS	0	2 1/2 cups	11	95	2.3	0.1	0.2	0.2	4,700	0.09	0.12	0.2	43	120	0.2	13	60	270	32
	WATERMELON (*See* 69)																		
125	WONDERBERRY	0	1 cup	24	89	2.0	1.0	1.0	0.1	570	0.10	0.06	0.7	12	24	0.6	40	42	510	2
126	YAM	20	3/4 cup	88	74	1.8	0.5	0.5	19.0	0	0.08	0.01	0.4	6	23	0.6	29	65	600	14
	YARD-LONG BEAN (*See* 15)																		

[a] As purchased. (Per cent refuse will vary according to quality and method of preparation.)
[b] Carbohydrates.
[c] The carbohydrate fraction of artichoke contains inulin, which is reportedly not metabolized by man and is not included in these figures.
[d] Estimated value.
[e] Fructosans not included.
[1] Reproduced from California Agricultural Experiment Station Bulletin 788. Nutrient Composition of Fresh California-Grown Vegtables by Frederick D. Howard, John H. MacGillivray and Masatoshi Yamaguchi.

BEANS

Beans provide an essential part of the diet for the people of many tropical areas. A favorite dish in several Latin American countries is that of rice and beans. In some of the Arabic countries the broad bean, which is sometimes called the horse bean, *Vicia faba,* is cooked as a breakfast food and is considered delicious.

The most important beans in the Tropics are the broad-bean, *Vicia faba;* dry or field bean, *Phaseolus vulgaris;* Hyacinth bean, *Dolichos lablab;* lima bean, *P. lunatus;* mung bean, *P. aureus;* snap bean, *P. vulgaris;* and soybean, *Glycine max.*

Figure 66. DRY BEANS WITH SYMPTOMS OF YELLOW BEAN MOSAIC.

BROAD BEAN

(Vicia faba)

The broad bean is grown in most of the tropical and subtropical areas. It is generally grown during the winter months and at a higher altitude in the tropical areas. The broad bean is more resistant than the dry bean to many of the bean diseases.

Broad beans are moderately salt tolerant. A good spacing in 3-foot rows would be about 4 inches.

A number of varieties have been developed in local areas but unless they are constantly selected they tend to become variable.

Mildew is serious in the warmer areas. Sulfur sprays have some benefit but karathane has no effect. (Illus. page 8.)

DRY BEAN

(Phaseolus vulgaris)

The dry beans consist of pea, medium, marrow and kidney types. The red kidney type of bean is preferred in some Latin American countries; however, in Central America, the black beans are preferred. Pinto beans also have a good market but many of the varieties are susceptible to rust. Where rust is a problem it might be desirable to try the resistant varieties such as Pinto 5, Pinto 14, Columbia Pinto, and Rico 23.

The red kidney beans are susceptible to several virus diseases in the Tropics which are transmitted by aphids and leaf-hoppers. Common bean mosaic and yellow bean mosaic probably are the most serious of these diseases. The U.S. No. 5 Refugee variety is resistant to the common bean mosaic and strains of *P. coccineus* are resistant to the yellow bean mosaic. A cross between the *P. coccineus and P. vulgaris* has been made at the University of Oregon and segregations of this cross have resistance to the disease under the growing conditions in Oregon. Where yellow bean mosaic is a problem it would be well to request a few seeds for trial from Dr. J. R. Baggett of the Department of Horticulture at the State University of Oregon.

Variety trials should be conducted to determine the best variety for any given location, and fertilizer trials are needed to determine the type and amount of fertilizer required to give economic yields. Local varieties often are best since day length is an important factor. Phosphorous is the element most commonly lacking in bean soils. The best returns are from 110,000 plants per acre or spacings of 2 to 3 inches in rows 20 inches apart. The seeding rate can be obtained from Table 4. Seeds should be stored at 45° to 60°F to avoid loss of germination.

HYACINTH BEAN

(Dolichos lablab)

The hyacinth bean is cultivated in southern Asia and Africa. The ripe seeds as well as the green pods are used for food. The bean is an annual outside of tropical areas but will persist for two years or more in the Tropics if it is not killed by pests. The hyacinth bean is similar to the cowpea but the stems are harder and the plant more viny. When the plant is supported it often has a vine 20 to 25 feet long.

The infloresences have a sweet scent and are 4 to 6 inches long. The compressed pods are shaped like a broad scimitar and the seeds have a white caruncle extending one-third of their circumference.

There are many varieties and they differ in earliness, color and foliage, which is green or purple; flower color, which may be white, pink or purple; size, shape and color of the pods and seeds which may be white, reddish, black or speckled. Selections should be made for yield among the local varieties in any given location.

The adaptations of the hyacinth bean are practically identical with those of the cowpea and it may be cultivated as cowpeas. Some varieties yield about the same as cowpeas.

The hyacinth bean is susceptible to root-knot nematodes and wilt. Local strains may be resistant in some areas due to survival of the fittest through natural selection.

Variety and fertilizer trials are needed in each area to determine the best variety and the right kind and amount of fertilizer to use.

LIMA BEAN

(Phaseolus lunatus)

The large seeded lima beans are classified as *Phaseolus limensis* and the small seeded types as *P. lunatus* (2). Lima beans are eaten freshly cooked, canned, frozen and dry. There are pole and bush varieties and the pole varieties require a longer period of time to mature. Some of the large seeded varieties do not set pods well in hot weather and should be grown during the winter months or at high altitudes in tropical areas. Limas are not affected by length of day. Some varieties are more tolerant to heat than others and it is important to conduct variety trials in all new areas of production. Some of the more promising varieties are Fordhook 242, Wilbur, Westan, Baby Fordhook, and Triumph.

Loam and silt loam soils are recommended in tropical and subtropical areas. Fertilizer trials must be conducted to determine the correct fertilizer program for each location. It may be found that lima beans respond to higher levels of nitrogen than snap beans.

MUNG BEAN

(Phaseolus aureus)

The mung bean is native to southern Asia and is grown in this area as well as the Malayan Islands and in Africa. It is grown mainly for the seed which is used for food. This type of bean is used for bean sprouts which are commonly used in Chinese foods. In India the straw is used as forage for livestock.

The habit of the mung bean is similar to that of the cowpeas, but the plants are less viny and some are strictly bushy-type. They grow under the same environmental conditions as the cowpeas. It is known in the United States as the Chickasaw pea and as the Oregon pea.

The seeds are attacked by the cowpea weevil and control measures may be required if the attack is severe. For control of this insect consult the table on insect control.

The culture of the mung bean is the same as that for cowpeas but weed control is very important since the young plants do not compete with weeds as well as does the cowpea. The mung beans always should be planted in rows so that they can be weeded easily. Seeding rate is 20 lbs. per acre and average yields are 300 to 500 lbs. per acre (3).

There are many varieties and the local varieties should be compared with imported varieties. The varieties differ in plant size, habit, earliness and the shape and color of the seed. The seeds are spherical in most varieties, green, brown or marbled. The Newman variety is the same as the old Chickasaw pea. This variety is late and reaches a height of 3.5 feet.

SNAP BEAN

(Phaseolus vulgaris)

Snap beans will grow on sandy loams to heavy clays. Beans do not respond readily to fertilizers but fertilizer trials should be conducted in new areas or in areas under intensive cultivation of rotation crops. Since beans set a higher percentage of fruit in cooler weather it is best to grow them at high altitudes or during the winter months in tropical areas.

Kano pole bean is a good white seeded bean in Nigeria. Goa bean (*Psophocarpus tetragonolobus*) is a climbing bean suited to poor soils in regions of high rainfall where green beans do not thrive. Pods of Goa bean should be harvested while tender (2). New varieties of interest for the Tropics include Dade pole bean, a rust resistant, high yielding variety; Alabama No. 1, Coffee Wonder, Isbell's Nematode Resistant, and Springwater are nematode resistant varieties (1).

Beans are classified according to color, such as green podded or yellow podded, and according to bush or climbing varieties. The snap bean is not as widely grown in the Tropics as the dry bean and there is not a great deal of information on variety performance. Suggested varieties are Wade, Contender, Corneli 14, Extender, Blue Lake 231, Harvester, Top Crop, Florigreen, Seminole and Kentucky Wonder. Information on herbicides, insecticides and fungicides can be found in Tables 12, 18 and 8 respectively.

SOYBEANS

(Glycine max)

Soybeans are grown in many parts of the world and at the present time the United States, China and Manchuria account for the highest production. Soybeans also are grown in Central and South America as well as the Near East, Far East and Africa. Since soybeans can be produced over such a wide range of environmental conditions it is very important to grow the right variety for any given location as soybeans are very sensitive to day length. Variety trials are necessary in order to find varieties adapted to a particular environment. The varieties selected for trial should come from areas that have similar day length and climatic conditions. Lee, Hardee, and Improved Pelican should be tried.

Soybeans grow best in a humid climate with plenty of rain during the growing season but require dry weather during the period of ripening. Soybeans do well on deep, mellow, fertile, slightly acid soils. A commercial inoculum is usually used to treat the seeds before planting and it is important to use the proper species of *Rhizobium* as the organisms are specific as to host (1).

Soybeans are considered here as a food crop but they can serve as a source of raw material for widely diversified chemical industry. As a food crop they are baked, broiled, roasted and are used to make grits, soy sauce, cooking oil, shortening, salad oils, margarine, medicinal oil and vegetable milk (1). In Hawaii, they are cooked when seeds are plump in the green pod in fairly salty water. They are then eaten by putting the pods in the mouth and eating only the seeds. They have a high protein content (40–50%). Breeding to develop more suitable varieties for the Tropics is in progress at the Hawaii Agricultural Experiment Station.

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BEETS

(Beta vulgaris)

Most beet varieties do well in the Tropics but high temperatures will prevent development of good quality roots, hence, it is essentially a cool weather crop. It develops satisfactorily at medium to high elevations. It is mainly grown for local markets. Beets are sensitive to length of day and remain in vegetative condition under medium or high temperatures.

Detroit Dark Red is considered a good quality beet but since the tops often are used for greens, varieties such as Long Season and Early Wonder Tall Top might be preferred.

Planting is done by sowing rows 18 to 24 inches apart. Thinning 1 to 4 inches is recommended but seldom is practiced. Roots are harvested when they are one to three inches in diameter.

Beets are subject to boron deficiency which is demonstrated by internal black spots in the roots. Application of about 40 pounds of borax per acre is useful for correcting this. This trouble is associated with high calcium levels in the soils (2).

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BROCCOLI

(Brassica oleracea var. *botrytis)*

Sprouting broccoli was relatively unknown in America until the advent of quick freezing. It is

now an important quick frozen vegetable. It has a high vitamin C content as indicated in Table 5 as well as other vitamins and minerals (2). It is particularly valuable for tropical areas where the diet is likely to be low in green or leafy vegetables (1). Adding some leaves to the heads increases the carotene value.

Seed can be sown in nursery beds. One pound will grow enough plants for 4 acres. Plants are set in rows 40 to 48 inches apart and 8 to 12 inches in the row. Wider spacing gives lower yields (3).

The best varieties in the Tropics have been De Cicco and Texas 107. Plantings have been harvested continuously for as long as 4 months and it is quite feasible to produce sprouting broccoli the year round at the medium elevations in the Tropics.

Nitrogen is needed for good crops, especially after the first harvest. Good results have been obtained with diammonium phosphate (18.5–50–0) at the rate of 200 lbs. per acre. This can be used as a side-dressing with irrigation. Irrigation will be needed during the dry season.

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CABBAGE

(Brassica oleracea var. *capitata)*

Cabbage is the most important member of the genus *Brassica* grown in tropical regions. Since it can withstand rough transport it often is grown at higher elevations and brought to market by donkeys. It is successful at moderately cool temperatures at any elevation but seldom makes good heads at sea level within the Tropics. Surprisingly good yields are obtained at elevations as low as 2,000 ft. in the tropical areas.

Many excellent disease-resistant varieties are available now. In the Philippines, O–S Cross, Succession, Perfection Drumhead, Wisconsin Hollander and Premium Flat Dutch have given the best yields. They matured in 90 days in the mountains and 76 days in the lowlands. Heads are smaller in the lowlands (1). In Central America, Wisconsin Allseason, Badger Market and Ditmarch gave good results. In Venezuela, Marion Market, Copenhagen Market and Early Flat Dutch have been successful (2). It has been reported that Wisconsin Copenhagen and Bonanza have resistance to tipburn while other varieties are susceptible to this non-parasitic disease (5). Premium Late Flat Dutch and Marion Market have produced well in Haiti.

Cabbage seed can be sown in open beds in the Tropics. It is possible that protection from the hot sun would be needed as the plants first emerge. During the rainy season protection from heavy rains may be necessary to prevent washing out of the seeds or small plants.

Transplanting is done in rows 3 feet apart, using a spacing of 12 inches. Larger heads can be obtained with wider spacing but there is a loss of yield per acre and a greater likelihood of splitting.

Cabbage responds well to starter solution at transplanting time. Nitrogen is the most important element but an excess may cause internal breakdown (3). It also may increase burst heads unless plants are spaced closely, 8 to 10 inches (4).

Seeds are perishable in a hot climate and should be kept in refrigeration at 45° F.

Cabbageworms are the main problem in tropical plantings and may be controlled with DDT or lindane. Cabbage loopers are not affected by malathion sprays.

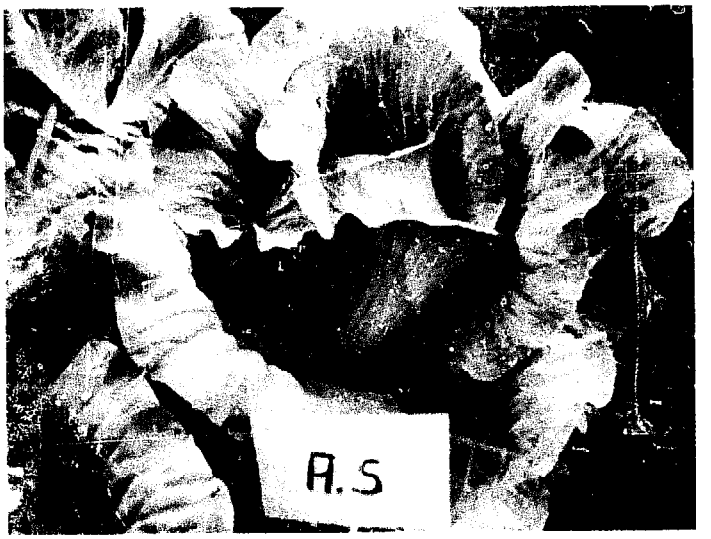

Figure 67. THE ALL SEASON CABBAGE VARIETY DOES WELL IN THE TROPICS.

[1] Out of print. Superseded by: Winters, H. F. and G. W. Miskimen. 1967. Vegetable Gardening in the Caribbean Area. U. S. Dep. Agr. Handb. 323, 114 pp., illus.

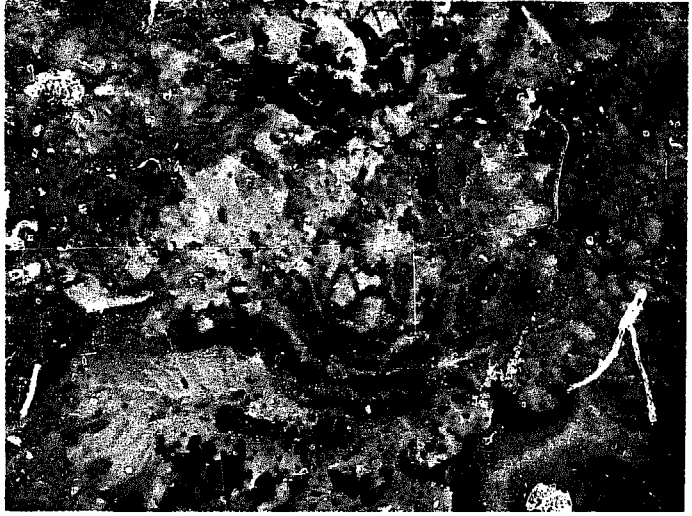

Figure 68. CABBAGE WORMS CAN DO A LOT OF DAMAGE IF NOT CONTROLLED WHEN THE PLANTS ARE YOUNG.

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CARROTS

(Daucus carota)

Carrots have been grown every month of the year at both high and low elevations in Puerto Rico but they perform best at 60° to 75° F (4). At high temperatures they become tough and low in quality. Carrots are rich in vitamins and high in sugar and are palatable to nearly all people. They also keep longer than some crops and are more easily marketed.

There are many named varieties but only a few really distinct types. The long cylindrical-rooted varieties such as Imperator, Gold Spike, and Gold Pak are most in demand but are not easily grown unless the soil can be kept loose with deep cultivation which requires tractors. For most tropical areas the Danvers Half Long or Chantenay will give best results. For home use the highest quality carrot is Nantes. There are several strains of each of these with red cores, stronger tops, etc. Farmers of heavy clay soils such as the highlands of Central America prefer the Oxheart for its ease in harvesting. Generally yields are higher from Danvers or Chantenay.

Seeding is done in 18 to 24 inch rows at a depth of ½ to ¾ inch. Spreading the seed in a band 3 to 4 inches wide will allow room for growth without thinning. A "spoon" attachment on the seeder helps to accomplish this. From 2 to 4 lbs. of seed per acre are needed depending on the seed size. About 25 seeds per foot of row is suggested. They require 75 to 85 days before harvest (2). Because carrots take up to 14 days to germinate, it is highly important to keep the soil surface moist until the seedlings emerge.

Fertilizers usually are needed for American or European varieties. About 40 lbs. of nitrogen per acre and 80 lbs. of phosphate have given best results in Arizona (6). Reports from Texas indicate that 40 lbs. of nitrogen and 40 lbs. of phosphate per acre produce the best yields (3). Urea will cause branching of the roots (7).

Irrigation should provide constant moisture to prevent cracking of the roots (8). Quick growth gives higher quality carrots (5).

Harvesting too soon will cause the roots to shrivel on the market, therefore roots should be reasonably mature. The highest quality is from the early harvests. Carrots usually are bunched for local markets but commercial shipments are now packed in cellophane bags without the tops.

Carrots store very well in the ground. Bunched carrots will keep 2 weeks at 32° F and 90 to 95 per cent humidity (9).

The worst diseases in the Tropics are *Cercospora* and *Alternaria* for which weekly sprays with Captain or Dithane M45 after emergence are recommended. Treating with 3 grams of either Semesan or Ceresan per kilogram of seeds, agitated for 10 minutes is also valuable (1). In the Subtropics carrot yellows is especially destructive.

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CAULIFLOWER

(Brassica oleracea var. *botrytis)*

Cauliflower thrives best in a cool, moist climate and will not withstand as much heat as cabbage. Since the heads do not develop well in hot weather, cauliflower does not seem to have much place in the tropics. It can be grown only during the winter months at high elevations. There is usually not much of a market for cauliflower in tropical areas since many people are not familiar with the plant. Two varieties which have been grown successfully in some areas are Sutton's Early Patna from India and Pua Kea from Hawaii, which mature in 55 days.

Sandy loams and silt loams are preferred for cauliflower. The soil should be well supplied with organic matter and well drained. Cauliflower is sensitive to highly acid soils and prefers a pH of 5.5 to 6.6. Lime must be used if the pH is below 5.5. A lime containing magnesium is preferred since this element may be lacking in the soil.

Cauliflower usually responds to fertilizer and heavy applications are used in temperate regions. Fertilizer trails will show the amount and type of fertilizer to use. In some areas 1 to 1¼ tons of 5–10–5 are used. Boron is deficient in some areas and results in hollow stem and brown spots on the head. This can be corrected by applying 5 to 10 pounds of borax per acre. Large amounts of borax can injure the plants (1).

The seed is sown in seed beds and the seedlings are later transplanted to the field. They are handled in the same way as cabbage. They should be planted so that they will be growing in the coldest part of the year in the Tropics. The plants are set 18 to 30 inches apart in the row with a row spacing of 3 feet.

The most important diseases of cauliflower are blackleg, blackrot, clubroot, whiptail and browning. All of these diseases except whiptail and browning are indicated in Table 8 under cabbage. Browning has been discussed under the section on fertilizers; whiptail appears to be due to a lack of calcium or molybdenum and is associated with low acidity. Applications of lime reduce or eliminate the disease.

The most prevalent insects are listed in Table 18 on insect control.

The market prefers a pure white head of cauliflower. To obtain a white head, it is necessary to exclude the light. When the cauliflower head still is too immature to cut, the outer leaves should be tied around the curd until it is ready to harvest. Different color rubber bands can be used so that the first heads tied can be distinguished from heads tied later for the purpose of harvesting (1).

The heads are cut when they are 5 to 8 inches in diameter, depending on the variety. The medium-sized heads are preferred. The plant is cut well below the head with a sharp knife and trimmed so that ½ to 1 inch of leaves project above the head for protection in shipping. Cauliflower can be stored for 30 days at 32° F.

Reference

Thompson, H.C. and W.C. Kelly. 1957. Vegetable Crops. McGraw-Hill Co., Inc. New York, N.Y.

CELERY

(Apium gravelens)

Celery thrives best in cool weather with a moderate, well-distributed rainfall during the growing season. Celery can be grown only in the winter season or at high elevations in tropical regions. Irrigation can be used if there is not sufficient rainfall, especially if diseases are a problem.

A sandy-loam soil, well supplied with humus, is preferred to any other type of mineral soil. A cover crop should be grown before celery and plowed under if possible. The soil should be deeply plowed in order to hold as much moisture as possible in the surface, since celery is not a deep-rooted plant (1).

The fertilizer requirements will depend on the environment and local trials can demonstrate the amount and kind of fertilizers to use. It would be desirable to conduct fertilizer trials with N, P, and K ranging up to 150 pounds per acre. Generally

celery is a heavy feeder on nitrogen and potash.

The yellow tvpe varieties such as Michigan Golden, Cornell 19, and Florida Golden Self Blanching do not perform toc well in the Tropics. It probably would be best to try the green types such as Florida Green Pascal (which is probably the same as Summer Pascal), Emerson Pascal, Utah 52–/0, Emerald Green Light and Smallage.

Soaking the seeds before planting hastens germination. The seeds are planted in seedbeds and transplanted about two months after sowing. The plants are set 6 to 8 inches apart in rows 18 to 24 inches apart. The plants can be set by machine or by hand. Clean cultivation is necessary as the celery plant grows slowly and is readily injured by weeds.

The insect and disease problems are mentioned in Tables 18 and 8. Cracked stem is caused by a deficiency of boron. The first symptom of the trouble is a brownish mottling of the leaf, appearing on the margins of the younger leaves. This mottling is associated with a brittleness of the petiole and by brown stripes in the epidermis over the vascular bundles. The tissue becomes brown in color. This can be controlled by applying 10 pounds of borax per acre to the soil near the base of the plants about two weeks after they are set in the field. The borax can be mixed with the fertilizer application.

The plants are cut below the surface of the soil, leaving a portion of the roots attached. This can be done with a sharp knife or by special machines made for this purpose. Generally, the celery is washed and hydro-cooled before shipping. A temperature of 33° F usually is used for hydro-cooling and a storage temperature of 32° F is recommended.

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CHAYOTE

(Sechium edule)

Chayote is a favorite home garden vegetable in tropical countries and is nearly always available on local markets. It is a perennial cucurbit vine usually grown on fences, trellises or arbors.

Fruits are rough or smooth with protuberances on the surface. The outside color may be white to deep green. The flesh is firm, white and the seed is large and soft. The fruit is cooked like squash but lacks the flavor of winter squash.

It does not thrive in excessively hot areas but should succeed at 1,000 feet or higher. It does not tolerate frost. It will do better with light shade in hot areas. The white form seems more heat resistant than the green.

The whole fruit is planted in place and the vines begin bearing in 3 to 4 months after planting. Production is continuous or nearly so and continues until plants are killed by diseases.

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CHICK-PEAS

(Cicer arietinum)

Chick-peas are cultivated extensively in Asia, Spain and Mexico where they are also called gram and garbanzo. The plant is a branched annual with pinnate leaves growing to a height of 1 or 2 feet. Pods are thin, inflated, short, with only 1 or 2 seeds. The crop thrives in the cooler season and is grown at the same time as wheat and in much the same way. Yields may vary from 15 to 35 bushels per acre. The seeds are free from attack by weevils (2).

Semi-aridity and mild temperatures are required for successful production (1). In areas without winter rainfall, irrigation at least once may be necessary. About 18 lbs. of seed are planted per acre but more may be used when broadcasted. Seed can be saved from the crop for sowing next season.

Many varieties are popular but the most commonly grown type has large straw-colored seeds similar to the Spanish variety. A short season variety in Mexico named Breve can be planted as late as January.

Seed is graded for size for selling, the smaller sizes bringing lower prices.

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CORN

(Zea mays)

Garden corn in the U.S.A. is nearly always sweet corn which is a sweet form of the well known field

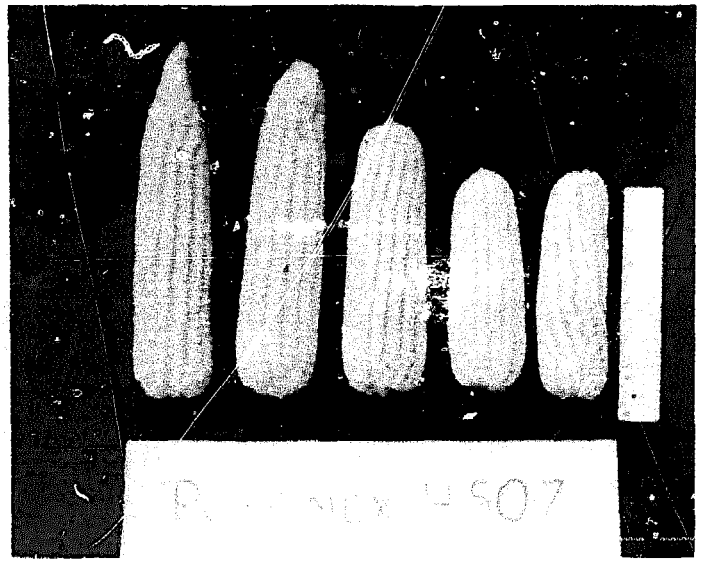

Figure 69. ROCOMEX H-507 IS A HIGH YIELDING WHITE FIELD CORN DEVELOPED IN MEXICO FOR THE TROPICS.

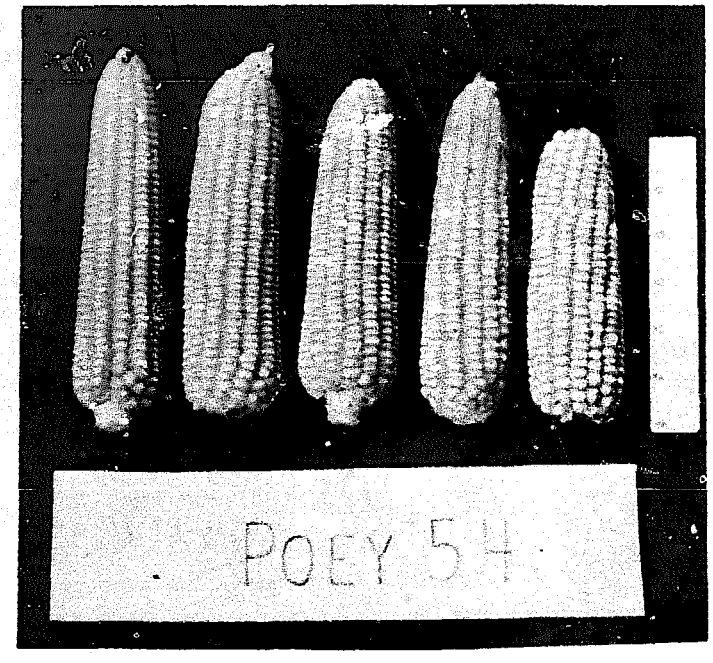

Figure 70. POEY 54 ORIGINALLY WAS CALLED CORNELI 54. IT IS A HIGH YIELDING YELLOW FIELD CORN DEVELOPED FOR THE TROPICS.

corn, or maize. Most varieties of sweet corn have been developed for northern latitudes and do not thrive in the shorter days of the Tropics; however, several hybrids now available can be grown with reasonable success.

Field corn is commonly used as roasting-ears or for making various dishes and in the milk stage is made into a drink in some localities. For eating in the fresh state the sweet corn has much higher quality and therefore would be preferable.

Some varieties have been developed for the Tropics and Subtropics, such as U. S. 34 in Puerto Rico, Honey June in Texas and field corn varieties in Mexico have been developed by the Rockefeller Foundation. Sweet corn hybrids developed for Florida and Cuba do quite well in Central America. Deep Gold, Sweetangold, Golden Security, Asgrow Golden, Calumet and Surecrop also are suggested for trial. Two corn plantings in Central America were severely attacked by a virus ("achaparramiento") which causes stunt and sterility and yellowing of the leaves which may also turn reddish. Sweet corn is very susceptible to this disease (1). Where "achaparramiento" is serious, P.R. 50 and Pajamaca should be tried. In periods of continous rainfall, known as "temporal" in Central America, the sweet corn is unable to pollinate properly; however, since these occur infrequently sweet corn may be planted the year round at low or medium elevations (2). Temperatures above 95° F and low humidity are unfavorable for pollination.

Two or three kernels are planted at intervals of one foot in rows three feet apart. Later the hills may be thinned to one stalk. Removing the tillers or suckers is of no value and reduces yields (6). Corn generally responds well to fertilizers and local trials should be initiated. Up to 100 lbs. of nitrogen per acre (500 lbs. ammonium sulfate) for 15,000 plants per acre can be tolerated (3). Phosphates reduced ear worm damage in Florida while nitrogen increased it (4). In calcareous soil, corn is especially susceptible to zinc deficiency (5). Symptoms of yellow interveinal streaks with the midrib and margin green and stunted plants may be confused with those of the corn stunt virus. This can be determined only by careful tests.

The corn earworm is the worst insect pest. It attacks the bud area and later the ear at silking time. Many of the best varieties have tight shucks and resist damage to the ear but it may be necessary to dust or spray to prevent damage to the plant. Other insects that may cause damage when corn plants newly emerge are lesser cornstalk borer and flea beetles. Dusting with toxaphene, dieldrin or chlordane is effective. The most important diseases are corn stunt virus and *Helminthosporium* leaf disease which can be especially severe in the rainy season.

Sweet corn should be harvested in the milk stage before the kernels become firm. Most varieties keep their quality only a short time after harvesting.

Field corn is more common than sweet corn in

the Tropics. The field corn seems to be more tolerant to insect attack than sweet corn and this may be due to the long tight husks which cover the end of the ear. Most of the field corn types in tropical areas are open-pollinated varieties but there is a trend toward using double cross hybrids. It is desirable to purchase the hybrid seed each time the corn is planted so as not to lose vigor; usually double cross hybrids perform well in a limited environmental area. Synthetic varieties are a combination of several inbred lines and the seed can be saved year after year for replanting without appreciable loss of vigor. They usually are adapted to a wider range of environmental conditions than double cross hybrids.

The best yielding double cross hybrids in corn trials conducted at the Damien Experiment Station in Haiti, 1961 and 1962, were Poey T–65, Poey T–66, Corneli 54 and Semi Flint White Hybrid 2088 x 2085. The Semi Flint White Hybrid 2088 x 2085 is a white kerneled field corn from the Rockefeller Foundation in Mexico. The other hybrids had yellow kernels and were from the Poey Seed Company in Louisiana. The highest yielding synthetic varieties were Tuxpeno Synthetic, White-Yellow Synthetic Tuxpeno, VS–2 and Tuxpeno Yellow Synthetic from the Rockefeller Foundation in Mexico and the Tropical Experiment Station, Pichilingue, Ecuador. It would be desirable to try these hybrids and varieties under different tropical environments as they seem to be more tolerant to virus stunt which is also called "achaparramiento".

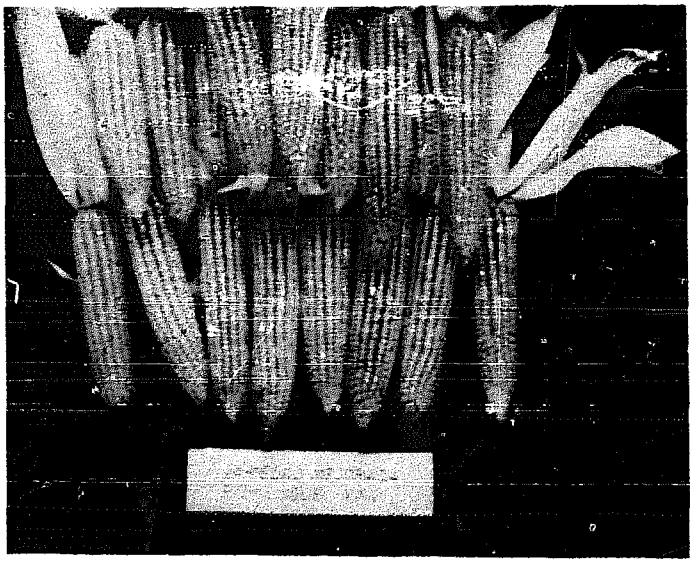

Figure 71. A SYNTHETIC CORN DEVELOPED IN PICHILINGUE, ECUADOR. THE MAIN ADVANTAGE OF A SYNTHETIC CORN IS THAT THE FARMER CAN SAVE HIS OWN CORN SEED FOR REPLANTING.

Poey T–23, T–46, T–61 and Armarillo Salvadoreno No. 1 also are tolerant or resistant. Rocomex H–503 is susceptible. Rocomex H–507 is a white corn that has yielded well in several countries.

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WATER CRESS

(Roripa nasturtium-aquaticum)

Water cress is common on markets in the Tropics but comes from plantings along running water or rivers. It is perennial and trailing in habit. It is used for making salads. It does best at higher elevations.

CUCUMBER

(Cucumis sativus)

Cucumbers are very popular in all tropical countries but until the new downy mildew resistant varieties were introduced there was considerable danger of crop failure. Introduction of high quality, disease resistant varieties is needed in most tropical areas. Cucumbers should be planted in low rainfall areas and grown under irrigation to reduce disease problems.

In recent years several disease resistant varieties have been made available. Downy mildew resistance is available in Ashe, Fletcher (4), Barclay, P. 51, Polaris, Pixie (2), Palmetto (6), Ashley, Stono and Palomar. Powdery mildew resistance is re-

[1] Out of print. Superseded by: Winters, H. F. and G. W. Miskimen. 1967. Vegetable Gardening in the Caribbean Area. U. S. Dep. Agr. Handb. 323, 114 pp., illus.

ported for Table Green (1) and Pixie (2). Mosaic resistance is available in Table Green, Jet (1), SMR 15 and SMR 18 (16). Anthracnose resistance is reported for Polaris and Pixie (2). Other good varieties but with no particular disease resistance are Smoothie, Straight 8 and Coolgreen. Many of these varieties have been tried in El Salvador and Venezuela where only the downy mildew resistant varieties are successful (4).

Seeding never should be more than 1 inch deep; spacing at 1 x 5 feet or 1 x 4 feet is recommended (13). One plant per hill is best at these spacings. Two plants per hill may be left in hills 2 ft. apart.

Phosphates are valuable for cucumbers. Ammonium phosphate gives good results. Some experiments report 20 lbs. N, 100 lbs. P_2O_5 and 80 lbs. K_2O give good results (12). About 150 to 200 lbs. of 18½–50–0 has given good yields in Central America.

Yields may be increased in some areas by placing bees in or near the field (17).

The main insect pest is the cucumber beetle. Those may be controlled with 10 per cent chlordane dust or 3 per cent DDT dust or equivalent spray (9). Pickleworms are common in the Tropics. Malathion dust at weekly intervals controls pickleworms and leaves no harmful residue after 2½ hours (14). Lindane and Sevin also are effective (11). Aphids also are likely to cause damage but are controlled with malathion if sprayed before they are too numerous. Both aphids and cucumber beetles transmit cucumber mosaic (15).

Diseases most commonly found in tropical areas are downy mildew, mosaic and anthracnose. In drier regions powdery mildew may be a problem. Resistant varieties should be used if available, otherwise a regular spray program should be followed. Weekly sprays of zineb, captan, Phygon XL or other fungicide will be needed (3). Tobacco ringspot virus is most common in South Texas while true cucumber mosaic is relatively rare (8).

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EGGPLANT

(Solanum melongena)

The eggplant is especially well adapted to warm climates and easily grown in the Tropics. It will grow year round at sea level unless temperatures much above 100° F occur. Plants may continue to bear for a year or more (4). At 3,000 feet or higher, they are not successful in Puerto Rico.

Some of the better producing varieties such as Florida Market and Fort Myers Market are susceptible to bacterial wilt. The varieties, Matale from Ceylon and Kopek from Java, are resistant to bacterial wilt (10). The Rosita variety is resistant to bacterial wilt in Puerto Rico (4). Of 25 varieties tried in Venezuela, Florida High Bush performed best (1). The Purple Thornless was the best variety tried in Netherlands Antilles (7). Since fruit average 2,500 seeds each, hybrid varieties for planting are feasible and several are available.

Natural crossing averages 6 to 7 per cent in regular plantings but at a distance of 50 meters no crossing is found (8).

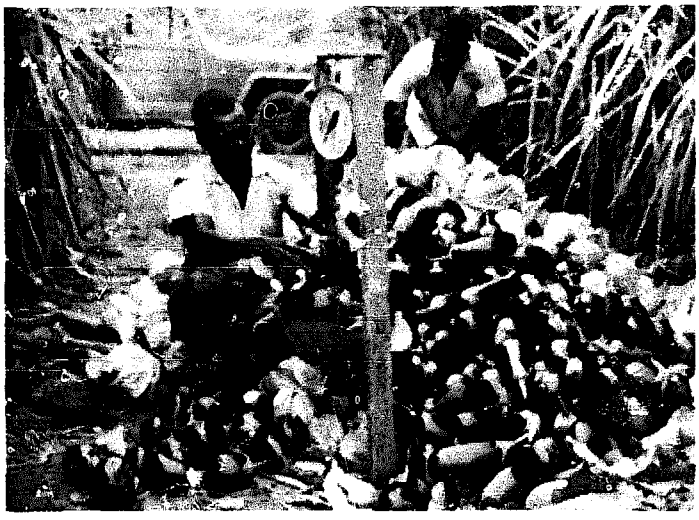

Figure 72. EGGPLANTS FROM AN EGGPLANT TRIAL AT THE DAMIEN EXPERIMENT STATION IN HAITI ARE BEING WEIGHED.

The Aushey variety was found to be highly resistant to fruit and shoot borer (*Leucinodes orbonalis*), serious insect pest in India. This insect has 10 generations a year and occurs in many parts of Europe and Asia (6).

Seeds are sown in seedbeds in the same manner as tomatoes. Transplanting is done when plants are 6 to 8 inches tall. Starter solution including 1 tablespoon of zineb per gallon should be used.

Spacing is usually 4 x 2 feet although 3 x 2½ feet also has been recommended (2). In Trinidad the most profitable spacing was 18 x 18 inches (3).

A good fertilizer is diammonium phosphate at 200 lbs. per acre. Otherwise a fertilizer providing about 40 lbs. nitrogen and 100 lbs. phosphate usually would be good. If harvesting is continued over a long period, side dressings will be needed. Fertilizer trials are necessary to determine the most economical application.

It is wise to dust the seedbed with sulfur in areas where the yellow virus occurs (5). Verticillium wilt causes stunting, mottling and defoliation (9), but is not as general as bacterial wilt.

Fruits should be harvested while they still have an attractive color. If allowed to mature fully, the yields will be reduced.

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ENDIVE OR ESCAROLE

(Cichorium endivia)

Endive is more tolerant to heat than lettuce and could be tried in areas where lettuce will not form heads. Endive should be grown in the winter months and at high altitudes. The general methods of culture of endive are the same as for lettuce. Recommended varieties for tropical areas are Florida Deep Heart and Green Curled Ruffec. Endive should be planted in rows 15 to 18 inches apart and should be thinned to 6 to 10 inches apart in the row. Any soil suitable for lettuce will produce endive. The fertilizer practices are the same as for lettuce.

Blanching is sometimes done to reduce the bitterness of the leaves and render them more tender. This requires 2 to 3 weeks. The most common method of blanching is to gather all the leaves into a bunch and tie them near the top. If rains follow it is important to examine the crowns frequently to see that they are not decaying. After the inner leaves are blanched they should be harvested quickly to prevent decay.

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GREEN VEGETABLES

of green vegetables is often serious in tropical markets and undoubtedly is a contributing factor to malnutrition. This is partly due to the fact that the commonly known greens such as spinach, collards and kale are not well adapted to hot climates. Plants like Amaranthus (Chinese spinach), Basella (Malabar spinach), jute mallow, purslane, New Zealand spinach and chard usually can be grown successfully. Mustard and Chinese cabbage will grow at moderate temperatures. Cool temperatures usually found only at the higher elevations (above 2,500 feet) in the Tropics are needed for spinach, beets, turnips and chicory.

Amaranthus - (Chinese spinach)

Amaranthus (Chinese spinach) is an old cultivated crop in Asia. It has good vitamin content but is lacking in flavor. Only the young tender plants or leaves are used. The American Indians used at least 7 species for greens, and 2 or more were used for their seeds which were ground to flour to make cakes (4). *Amaranthus gangeticus,* also called tampala, is sold in bundles when in the seedling stage 4 to 12 inches high A recipe from Hawaii says: "Wash thoroughly, remove roots; put in heated pot with 1½ teaspoon peanut oil, a little garlic, 1 teaspoon salt. Stir and add ½ cup water and cook 15 minutes. Serve hot" (2).

Amaranths are common weeds in the tropical regions but selected varieties might be found.

Chard

Chard (*Beta vulgaris)* probably is the best green vegetable in the Tropics (3). The leaves are cut and bunched and successive cuttings can be obtained if the area has sufficient moisture. There are several varieties but Lucullus is probably the best. Rhubarb is a variety with bright red petioles like the crop rhubarb which may be used in salads or for garnishing.

Chard will withstand fairly high temperatures. It is also tolerant of saline soils. In most tropical areas it will grow throughout the year. Culture is the same as for beets except that plants are thinned to 6 inches apart.

Chinese Cabbage

Chinese cabbage will tolerate moderately warm temperatures but is less tolerant to heat than chard. It is highly productive and more agreeable to most tastes than most of the other greens. It also is used as salad where lettuce is scarce. Chihli or Michihli generally are preferred but Chefoo is reported to tolerate heat better. Other varieties are Pe-tsai and Wong Bok.

Seed may be sown directly in the field and thinned to 12 inches apart. It also can be transplanted like cabbage.

Mustards

The best of the mustards for a hot climate is *Brassica juncea* (Chinese mustard). Normally they do better in the cooler season but in areas with moderate temperatures they may be grown the year-round. Seeds are sown in rows 12 to 16 inches apart or they may be planted broadcast and thinned. Leaves can be harvested in a month after planting and successive cuttings can be made. The Chinese mustard and Tendergreen are mild.

Jute Mallow

Corchorus olitorius is normally grown for fiber but during the hot summer months is commonly used as a green in the Middle East. It grows easily and rapidly. The whole stem is cut when about 4 feet long and is thus marketed. The customer removes the leaves for cooking. The greens from this are more palatable than most of the Amaranths. Seed usually is obtainable locally in South Asia.

Purslane

Portulaca oleracea is a weed in many of the tropical and subtropical regions, but in the summer months in the Mediterranean area is commonly found in the markets. It is used in salads or as a pot herb. In tropical America, purslane is called "verduga" and is used as a pot-herb. Some improved selections are found in the Mediterranean area but not generally cultivated.

Malabar Spinach

Malabar spinach *(Basella alba)* is a coarse vine that grows well at low elevations in the Tropics (1). It is grown from seed or cuttings and should be trellised and given sufficient space. A few plants will supply enough leaves and tender shoots for a family. With fertilizer and irrigation better yield and quality will be obtained. Ceylon spinach (*Basella rubra*) is similar in culture and use.

New Zealand Spinach

New Zealand spinach *(Tetragonia expansa)* is the "spinach" sometimes found in tropical American markets. Seed should be soaked for 24 hours before sowing. It is grown in 30 to 36-inch rows and thinned to 12 inches in the row. About 3 inches of the terminal tips are harvested and bunched for market. It is not as palatable as Malabar spinach but is quite drought resistant and easily grown (1).

Miscellaneous

The tops of beets and turnips often are used for greens but they form roots only at higher elevations. At these elevations kale, collards and sprouting broccoli also may be grown. In some parts of the Caribbean these are grown at 4,000 to 5,000 feet and marketed in the cities at sea level.

Some tropical areas also use tender tips and leaves of sweet potato, cassava, cowpeas, chayote and other plants for pot-herbs.

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LETTUCE

(Lactuca sativa)

Lettuce is the most popular salad crop. It thrives best in a fairly cool growing season which means it must be grown at high altitudes in the Tropics, usually above 3,000 feet. It does best during the cooler months.

Lettuce can be grown on all types of soil from clay loams to sandy loams. The soil should be well drained but retentive of moisture, as lettuce plants have a small root system. When furrow irrigation is used, the land is bedded into low flat beds about 6 inches high with an irrigation furrow between beds. The beds can be 18 to 20 inches wide with 2 rows of lettuce planted on each bed (1).

Since lettuce plants have a small root system the surface soil should be well supplied with nutrients. Soil-improving crops and manure should be used, if available, to maintain the soil in good physical condition. The only way to determine the correct fertilizer program for a given location is by fertilizer trials. Nitrogen is an important element for good growth and phosphate helps to produce solid heads. Potash should be tried to see if it gives an increase in yield; in some trials in temperate regions no response was obtained from potash. On sandy soils fertilizer trials should be tried with a range of nitrogen up to 100 pounds per acre and with phosphoric acid and potassium up to 200 pounds. On silt and clay loams, the nitrogen level could be reduced to 50 pounds and the phosphoric acid and potassium to 150 pounds. On irrigated soil the fertilizer should be placed 1½ in. toward the furrow side and 3 in. deep (1).

It is very important to select the right variety for a given environment and this can be done only by conducting variety trials. Only heat-resistant varieties should be tried, such as Great Lakes types for head lettuce and Salad Bowl for the leaf lettuce type. The following head lettuce varieties might be worth testing: Great Lakes 659, 659G, 66, 59, 118, 13, 456, Pennlake, Mesa 659, Valverde, Primaverde and Kulanui. The following leaf lettuce varieties should be tried: Salad Bowl, Ruby, Bath Cos. Suggested butterhead varieties are Artic King, Big Boston and Midas. Valverde is resistant to downy mildew. Salad Bowl, Bath Cos, Arctic King and Big Boston are resistant to powdery mildew. Mesa 659 is resistant to bolting and tipburn. Great Lakes 659, Buttercrunch 659G and Primaverde are tolerant to hot weather. Kulanui is grown in Hawaii and is resistant to hot weather.

It is important to use disease-free seed, as a virus which causes mosaic can be carried through the seed. Lettuce seed can be stored up to four years at a relative humidity of 46 to 58 per cent and at 50° F.

Information on herbicides, fungicides and insecticides is listed under the appropriate tables.

Leaf lettuce has a place in the home garden but it cannot be stored or shipped in the Tropics since it wilts soon after harvest. Head lettuce can be shipped and stored for a period of 3 or 4 weeks if it is refrigerated at a temperature of 32° F soon after harvest.

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MUSKMELON

(Cucumis melo)

Muskmelons, or cantaloupes are best adapted to a warm dry season. In the Tropics where high humidity occurs they are susceptible to mildews, particularly downy mildew (*Pseudoperonospora cubensis* (Berk. & Curt.) Rostow.). Resistance to this disease is now available in some varieties. The Smith's Perfect, a variety developed from a selection found on the Isle of Pines is practically immune to downy mildew. Other varieties with high resistance are Georgia 47 and Seminole. Selections showing high resistance in El Salvador, Central America, trials are C 105, C 434A, 58–21, C 315, all from the U.S. Vegetable Breeding Laboratory, Charleston, S. C. Moderate resistance was shown by Edisto. Varieties reported to have resistance in the United States, such as Rio Gold and Texas Resistant 1, were susceptible. Some recently released varieties are reported to have resistance to both powdery mildew and downy mildew. Perlita, Jacumba, Campo, Florigold, Florisun, Floridees, Wescan, Edisto, and Georgia 47 should be tried in the Tropics.

In areas where powdery mildew is severe, resistant varieties like PMR 45 will be needed; however, this variety is susceptible to downy mildew. The Home-garden variety was developed with resistance to both mildews as well as aphis (5). Seminole, Delta Gold and Virginia 435 are other varieties with resistance to both mildews.

Muskmelons did poorly at 1,500 ft. elevation in El Salvador, evidently because of cool temperatures since good results were obtained at low elevations where temperatures were higher.

Gummy stem blight (*Mycosphaerella citrullina*) is very serious in some parts of the Tropics. A source of resistance has been found for use in breeding. In the meantime some tolerance is shown in Edisto, Banana and Rio Gold.

Healthy green foliage is necessary for production of melons of high sugar content while melons harvested from partly defoliated vines will be lacking in sugar. Plenty of sunshine with high temperatures also is needed. An accumulated daily temperature of 2,500 degrees above 50° F is needed for ripening. Melons should be planted in low rainfall areas and grown under irrigation. They should be planted in the fall and winter for the United States spring market.

Barnyard manure is especially valuable for melons and should be applied in the furrow a month ahead of planting. A fertilizer with a 1–2–0 ratio may be best. Good results have been obtained with diammonium phosphate 18½–50–0 at the rate of 250 lbs. per acre. Application of up to 90 lbs. of nitrogen per acre increases fruit set (3).

Rows are usually 6 feet apart and hills 2 feet apart in the row. One to two plants per hill are left when thinned. One and a half pounds of seed should plant an acre. Planting at ½ inch depth is much better than deeper planting (8).

The insects most likely to be encountered are *Diabrotica* beetles which carry bacterial wilt as well as mosaic. These can be controlled with 1½ per cent dieldrin dust or 10 per cent chlordane dust. The melonworm (*Diaphania hyalinata*) also can be destructive at times. Dusting the soil with dieldrin is helpful but melonworms are not easily controlled. Aphids, or plant lice, are also common. Malathion spray is very effective on this pest but should be used when they first appear, not after the leaves are curled.

In addition to the mildews and mosaic mentioned above, some losses are likely to occur from Southern blight (*Sclerotium rolfsii* Sacc.) where melons are in contact with moist soil. Rotation with sorghums or grain is advisable. Application of 0.5 lb. maneb with 1 lb. zineb in 100 gal. water has given good control of downy mildew with weekly sprayings (1), but has no effect on powdery mildew; however, 0.5 per cent Karathane dust every 2 weeks gives good control of powdery mildew but does not control downy mildew (7).

The melon fly is a problem in some areas. The best possibility for control is poison bait using protein hydrosylates. It is best to get the latest recommendations from the U. S. Department of Agriculture for the melon fly. Attractants to trap the males before they have a chance to mate have been found (2).

Harvesting should be done in the cooler part of the day and the harvested melons should be shaded from the hot sun (6).

Harvesting is at the half or three-quarter slip for distant shipments. For local markets full slip is best. Harvesting Honey Dews is done when sugars have developed since the stems do not slip.

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OKRA

(Hibiscus esculentus)

Okra is an important crop in the tropical areas since it is heat tolerant. Okra is eaten in the green state, frozen or canned and is used dry in many countries. Dried okra powder is used for salad dressings, ice creams, soups, cheese spreads and candies. It also is used as a medicine to treat peptic ulcers.

The best varieties for the Tropics are Clemson Spineless and Perkins Spineless. Other varieties such as Emerald, Gold Coast, Louisiana Market and Pusa Sawani can be tried. Emerald is a high quality variety for canning with deep green pods. Pusa Sawani is a variety from India which is resistant to yellow vein mosaic. Seed should be kept in a sealed tin can in the refrigerator when stored in the Tropics.

Seed is drilled in rows 2½ to 4 feet apart. Later they are thinned to stand 18 to 24 inches apart in the row. Okra will grow well in most soil types but sandy loam soils may require more fertilizer. Actual fertilizer requirements can be determined only by fertilizer tests but an application of up to 1,000 pounds of a 5–10–5 mixture could be tried.

It usually requires 2 months from planting to the first harvest. The pods should be harvested every day after the first ones mature. They should be harvested before the pods get too large as they become leathery when they are harvested too large. They are graded for size and can be stored 3 days at room temperature or a week at 32° F. The quality for all purposes is highest at the four day stage from blossoming (1).

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ONIONS

(Allium cepa)

Onions are strongly influenced by length of day and most onions of northern latitudes will not bulb at all in the Tropics or even in the Subtropics. They make a good vegetative growth but require a day length of 15 hours for bulbing. Some European varieties require 16 hours or more (8). In South Texas these are called "blue whistlers" because of the bluish green color and the long tops. It is very important to consider the length of day to which they will be subjected before choosing the variety to grow.

Fortunately varieties have been developed that will bulb at a 13 hour day in South Texas and these are available commercially. Open-pollinated varieties are Texas Grano 502 (Texas Early Grano), Excel Bermuda, Eclipse, White Grano, L 36, Red Creole and White Creole. Considerably higher yields in some cases can be secured with the hybrids Granex, Bermex, Brilliance, White Granex, Texas Hybrid 28, White Alamo and Crystal Hybrid.

L 36, Excel and Texas Hybrid 28 show the highest resistance to pink root (10). Red Creole onions grown from seeds produced on the mainland of the United States tend to split and double too much; however, a selection from Hawaii called Awahia is free of splits and doubles. If direct seeding is done, about 4 to 6 lbs. per acre are sown in 14 to 16 inch rows.

Seed is sown in beds at the rate of 18 lbs. per acre in a 16 inch row, or 1 ounce in 25 meters of row. In the areas north of the equator this planting should be done in September or October (March or April south of the equator). This permits plants to grow thru the shorter days and thus make larger bulbs when the days reach 12 hours again, usually about April 1. The bulb is an enlargement of the stem and therefore the larger the plant, the larger the bulb that is formed.

Transplanting is done when plants reach pencil size. They are set 3 to 4 inches apart in rows 20 to 24 inches apart. Yields are better if the plants are not pruned. Plants are set with a stick, or dibble,

at about the level they were in the seed bed. The use of starter solutions at transplanting has produced 89 per cent increase in bulb development in Ceylon (5).

Onion sets of Granex grown in June, July and August produce faster and better than in other months in Venezuela (1). It has been shown that the percentage of bolting is decreased if sets are stored at 86° F at low humidity for at least eight weeks (7). The sets should be grown at a season when diseases would be less damaging.

Fertilizers are applied broadcast before transplanting. A ratio of 1–2–0 or 1–3–0 has been found satisfactory in most areas. Usually 40 lbs. of nitrogen and 80 to 120 lbs. of phosphate per acre are found to be sufficient.

Onions should have adequate moisture at all times and especially when bulbing begins (6). Experiments have shown that water requirements of onions greatly increase at bulbing time (4).

The chief insect problem is caused by onion thrips which tear the leaves in feeding and cause them to turn white and curl. Thrips will appear at the base of the leaves first and should be controlled before they have time to do much damage. Malathion or dieldrin dust will give the best control (11).

The main disease is usually mildew (*Peronospora destructor*) (Berk.) (Casp.). Dithane Z–78 or Parzate at weekly intervals will help in controlling the disease. Pink root (*Pyrenochaeta terrestris*) (Hans.) (Gorenz et al.) can be very serious in some sections. Resistant varieties are the best solution.

Harvesting usually is done when tops fall on about 50 per cent of the plants. They are pulled and laid in rows with tops covering the bulb to protect them from the sun. After curing about half a day they are clipped leaving about ½ inch of stem above the bulb and about the same length of roots. They are then graded into sizes and sent to market or placed in storage. Texas Grano and Red Creole have stored better than other varieties in the Tropics but storage at ordinary temperatures is not recommended beyond 2 months after harvest. Bulbs kept for seed should have at least 2 months of storage at 40° to 50° F before setting in the field for seed production. Bulbs kept at ordinary temperatures will not flower in tropical areas.

Leeks (*Allium porrum*) often are grown for local market in the Tropics. Their culture is the same as for onions but they produce best at cool temperatures. A number of varieties are recommended but there seems to be little difference between them. They are used in much the same way as onions.

Shallots (*Allium ascalonicum*) are grown from bulbs which multiply into clusters. The plants are used in the green state much like green onions. Culture is similar to onion.

Garlic (*Allium sativum*) is grown from bulbs, or cloves, and is cultivated like onions. The same insects and diseases attack garlic as onions. In harvesting, they have to be cured longer in the field than onions, often a week or more (13), then they are clipped like the onions and graded for market. Garlic stores well at moderately low humidity. Bulbs need a dormancy of 4 to 5 months at 45° F to produce well (9). Small cloves should be discarded in planting because they have poor germination (2). Garlic powder or garlic oil has strong antibiotic properties (12).

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PEANUTS

(Arachis hypogaea)

Peanuts are important throughout tropical areas as a cash crop. It is a high income crop in sandy land areas in the southern part of the United States where the crop has become almost entirely mechanized (1). Peanuts have been grown primarily as an oil crop but food uses have become very important as peanut butter, roasted peanuts, etc. Peanuts are high in vitamin B complex which is affected very little in processing (22). The hay, when properly cured, has value equal to alfalfa (16).

The large seeded varieties are commonly used for roasting and often produce the highest yields. Jumbo has a shelling per cent of 60 to 62 while Spanish has 73 to 75 per cent and Valencia 65 to 66 per cent (18). Virginia Bunch, Virginia Jumbo and Florigiant, recently released in Florida (10), yield well. Dixie Runner has less disease damage and higher yields in Florida.

The small seeded Spanish types usually are grown for oil. Various strains have been developed such as Spantex, Spanish 146 and recently a new variety, Starr, with larger seeds (2).

The best flavored variety for eating is the Valencia (Tennessee Red) and Cordoba Red (24) which have 3 to 4 seeds per pod and a red skin.

Since there apparently is little natural crossing, mass selection has little value (25); nevertheless, good seed of normal size gives better results than small seeds (1). Seeds need a dormant period of 40 days at 86° F. before planting but this is shortened to 15 days at 104 to 122° F. The nuts require about 70 days to mature after the gynophore enters the soil (23).

Seed treatment with 2 per cent Ceresan at 1.5 oz. to 100 lbs. shelled seed increases germination considerably (3). Arasan and Spergon also may be used.

Good stands are necessary for the best yields of nuts and forage. In 36-inch rows spacing should be 6 inches in Texas. Spacing of 4 inches is recommended in Georgia. In Texas 25 to 30 lbs. of seed per acre of Spanish is best (17). For close spacing 40 to 50 lbs. per acre are needed (8). In Australia 30 lbs. per acre for Virginia Bunch and 45 lbs. for Natal Common in 24 inch rows are recommended (21). Planting in hills at 40 to 60 plants per square meter increases yields and reduces weeds in Vietnam (19).

Weeds greatly reduce yields and should be controlled either by hoeing or by a pre-emergence spray of pentachlorophenate (PCP) at 10 to 20 lbs. per acre. This controls most weeds but nutgrass requires hand weeding after 10 weeks (19).

Peanuts usually show very little response to fertilizers. In poorer soils good results have been obtained with 200 lbs. of 4–12–4 per acre but nitrogen alone has increased yields in some areas. The greatest minor element requirements have been shown to be for calcium and under some conditions, sulfur, particularly for large seeded varieties. An ample supply of calcium is needed in the fruiting zone as well as the root zone (9). Applying 300 lbs. per acre of gypsum evenly at the flowering stage will prevent "pops" or unfilled pods (7).

Three year rotations have increased peanut yields by 3 times in 10 years (8). Plowing under vetch in the winter has increased yields by 40 per cent (14). In Australia, continuous cropping with peanuts did not decrease yields in 10 years, provided fertilizers were used (3). A sorghum-peanut rotation increased sorghum yields but did not affect peanut yields (20).

The worst damage to peanuts generally is from *Sclerotium rolfsii* which occurs in all parts of the Tropics. This disease is active only near the surface where oxygen is available; hence, mounding the vines at pegging time increases the disease and decreases yields. Burying crop residue and trash at least 3 inches deep aids in control (4). Terraclor at 10 lbs. per acre in three applications when cultivating, gives control of *Sclerotium* but is profitable only when the yields are high (13).

Leaf spot is another common disease. Damage is not always severe but control is possible by dusting with No. 325 mesh sulfur. In areas where nematodes are troublesome the use of Nemagon at 1 gal. per acre or Cyanamid 18133 at 16 lbs. per acre has been shown to be profitable (11).

Insects that may damage peanuts are white grubs, leafhoppers, thrips, lesser cornstalk borers, etc. These may be controlled with malathion, endrin and chlordane (15).

Harvesting is done by cutting the tap root when leaves begin to turn yellow and nuts are full grown. This is done with broad sweeps which also raise the vines out of the ground so that they can be picked up with a side delivery shaker rake which

throws them into windrows of 4 to 6 rows each. Vines usually dry in the windrows for 3 days or more before threshing. If the nuts are to be dried artificially they may be threshed soon after digging but threshing is more efficient if the vines are dry (1).

Nuts may be dried artifically in a few hours at a reasonable cost. The best quality results from drying at 96° F; higher temperatures tend to reduce quality (6). Storage is best at 60 per cent humidity and 32° F.

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PEAS

(Pisum sativum)

Peas are considered to be cool weather plants but can be grown either in the winter months or at higher elevations in tropical regions. They usually are grown for home use or local markets in tropical areas because yields are likely to be too low for canning or freezing. Day length also affects some varieties but Alaska and Surprise are fairly well adapted to short days (2). The temperature range for good production is 55 to 65° F (1).

Some of the best varieties for subtropical areas are Asgrow 40, Canner 75, Greenfeast, Melting Sugar, Ronda, Shasta, Alaska, Surprise, Wando, Thomas Laxton, World Record and Freezer 37. All of these are dwarf varieties and do not need trellising. The best variety in one test in El Salvador proved to be Burpeeana.

Manoa Sugar, a variety of the Dwarf Grey Sugar type, has immunity to powdery mildew and some resistance to warm temperatures. The variety is liked better than Melting Sugar in Hawaii. It grows 3 to 4 feet tall and needs a trellis. Caution in saving seed is advised by Dr. J. C. Gilbert of the Hawaii Experiment Station in order to avoid *Ascochyta* blight which is seed borne.

Peas are planted 2 inches apart in rows 18 to 20 inches apart.

In heavy rainfall, mildew and leaf spot may become serious and sprays of zineb or maneb may be needed.

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PEPPER

(Capsicum annum)—Bell or sweet pepper

(Capsicum fruiescens)—Hot or tabasco pepper

The bell pepper is a cool weather crop and does well at 65° to 75° F which means it should be planted only during the winter months or at higher elevation in the Tropics. If grown at temperatures above 75° F, the fruit set is poor and sunburning of the fruits is serious. The soil should be fertile and well drained with a good moisture holding capacity and should be free of nematodes, bacterial and fusarium wilts. If nematode-free land is not available the soil can be treated with 20 per cent ethylene dibromide (EDB) at 15 gallons per acre. If bacterial wilt has been a problem, pepper, tomato, eggplant or Irish potatoes should not be planted on the land for a period of five years. If Southern blight caused by *Sclerotium rolfsii* has been a problem the land should remain fallow or be planted to corn for 2 years. The variety World Beater is supposed to be resistant to this disease (2).

The only way to determine the best variety for a given location is by variety trials. The following varieties should be tried: Yolo Wonder, Liberty Bell and Keystone Resistant Giant, since they are resistant to mosaic caused by a virus. The thick-walled World Beater should be tried also.

Recently introduced varieties with mosaic resistance are Delaware Belle, Idabelle, Titan, and Florida Giant 5.

A variety and spacing trial in Haiti in 1962 showed that Yolo Wonder yielded significantly more than World Beater and Keystone Wonder Giant. The plants spaced 12 inches apart in the row yielded more than plants spaced 14 and 16 inches in the row when the distance between rows was 3 feet.

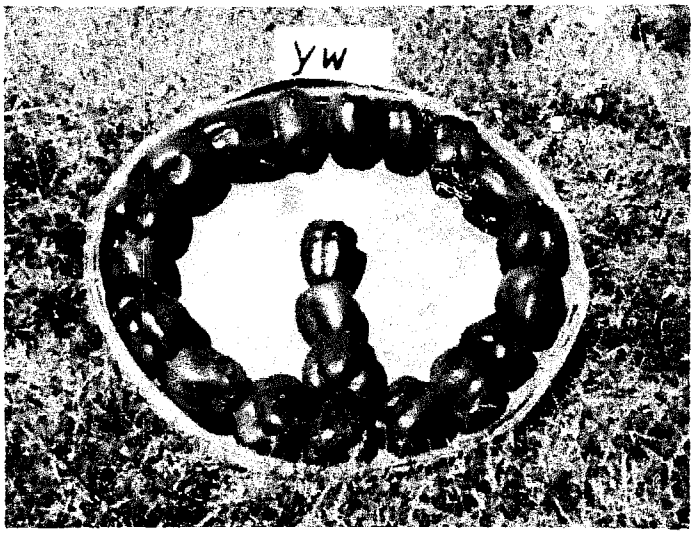

Figure 73. THE YOLO WONDER PEPPER IS AN EXCELLENT VARIETY IN THE TROPICS.

Many varieties of hot peppers are available and many of the names are local names used within certain countries. Local selections of hot peppers should be tried along with the imported varieties as they may be just as good or better. Some of the more common varieties are Tabasco, Anaheim Chili, Mexican or "native" chili, College No. 9 Chili, Long Thick Cayenne, Sport, Hungarian, Paprika and Spanish Paprika.

Determination of the correct fertilizer is by local fertilizer trials. In Hawaii a fertilizer application of 500 pounds per acre of 8–12.5–6, 10–10–5 or 8–20–5 is suggested at transplanting time. This should be applied 3 inches from the stem and 3 to 4 inches deep. At the flowering stage a second application should be made using 500 pounds per acre of 10–5–10 or 9–12–14. An additional application of 200 pounds per acre of ammonium sulfate can be applied one month after the second application to increase vigor and fruit size (1).

Information on diseases and insects can be obtained from the appropriate tables.

Peppers should be harvested when mature green. The skin of mature green peppers is shiny and waxy while that of the immature pepper is not. Peppers harvested too young will wilt and shrivel. Stems should be left on the fruits when they are harvested. Peppers should be cleaned and graded before they are sent to market.

[1] Out of print. Superseded by: Winters, H. F. and G. W. Miskimen. 1967. Vegetable Gardening in the Caribbean Area. U. S. Dep. Agr. Handb. 323. 114 pp., illus.

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PIGEON PEA

(Cajanus indicus)

The pigeon pea is a warm weather crop and thrives from sea level to about 2,000 ft. elevation. They grow from 6 to 8 feet tall, forming perennial bushes. They are popular in the Caribbean and are called "gandul" in Spanish speaking countries, congo peas in some other countries (2). They are widely grown in India. The plants bear continuously, beginning at 6 months from seed but should be cut back at intervals and fertilized (1). Pigeon peas find a useful place anywhere in the Tropics where garden peas cannot be grown.

A number of named varieties are grown in Puerto Rico, of which Kaki is an early variety with high yields. Saragateado is late maturing (3). Totiempo produces all during the year and is not affected by day length. Most varieties produce only during short days. This variety is subject to pod borers in the summer months.

Yield averages about 800 lbs. of seed per acre. The pods contain 4 to 6 seeds and 280 seeds weigh one ounce. They compare in composition with kidney beans (2).

There is interest in canning and freezing in Puerto Rico where they have developed methods of canning an acceptable product (6). Steaming the pods before shelling is essential to inactivate the enzyme system; after shelling they are cooled, sized and graded, then washed and blanched at 185° F for 35 minutes. For canning the best grade is obtained before they reach full size (5). For freezing, fully mature green peas are better than the more tender or over-ripe peas (4).

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POPCORN

(Zea mays)

Popcorn is not so well known outside of the United States but usually will grow wherever field corn grows. The chief problem is to get the proper amount of moisture for good popping (1). This is done commercially by bringing the kernels to 11 to 13 per cent moisture and then sealing in cans.

Several varieties are available. Hybrids are probably the best but seed must be purchased each year. The highest yielding varieties in Haiti in 1962 were Purdue 410 and Purdue 605 but the top yield was only 1903 pounds per acre. The cultural practices are the same as for sweet corn.

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PUMPKIN

(Cucurbita spp.)

Pumpkins are native to America and are widely adapted to various environments. They need considerable space and usually are grown on the borders in home gardens.

A Cuban variety called Cuban, Camagueyana,etc., is a good market variety of rich flavor. Seeds are available in several countries but probably will need selection to obtain a uniform variety. Northern pumpkin varieties usually are not suitable for tropical areas. Fortuna, a variety released in Puerto Rico, is resistant to downy mildew and mosaic.

Culture, insects and diseases are the same as for squash.

A dried product, pumpkin flakes, recently has been placed on the market from North Carolina.

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RADISH

(Raphanus sativus)

The radish is a favorite crop of the home garden and matures in 3 to 6 weeks. It is more common in temperate regions than it is in the Tropics. The large hot radishes are more common in tropical areas.

Radishes prefer cool temperatures and should be grown during winter months or at high altitudes in the Tropics. Earliest Scarlet Button, Red Prince, Calvalrondo, Red Boy, Champion, Cherry Bell and Buchaneer are varieties that should be tried. The varieties of hot radishes that can be tried are Black Spanish and White Chinese.

Radishes will grow on most soil types, but a light, friable soil is best. When planted for the market, the seeds should be planted every 10 days. Radishes usually are intercropped with other vegetables since they mature in a short period of time and do not require much space. If they are not intercropped they should be planted in rows 12 to 15 inches apart and the seed should be planted thick and later the plants thinned to 2 or 3 inches apart (1).

The most common insects are aphids, cabbage maggots and flea beetles. Control measures are listed in the table on insect control.

Harvesting begins as soon as the roots reach edible size. The early varieties become strong and pithy if they are not harvested soon enough. The radishes are pulled by hand and tied in bunches of six to twelve, then they are washed before marketing. Chopped ice is used if the radishes are shipped long distances to market.

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ROOT VEGETABLES

Root crops are important in the diet throughout the world. In the temperate zone we depend largely on potatoes, somewhat less on sweet potatoes. Other crops, such as cassava or manioc, yam, taro and dasheen are more important in tropical markets.

CASSAVA

Cassava *(Manihot utilissima)*, also called tapioca, yuca or manioc, is grown in all tropical countries for its starchy roots (13) (28). A coarse meal also is made from the roots and is used to make the tapioca of commerce, and in some countries (e.g., Brazil) the meal is used to cover some cooked foods when eaten. Two types, the sweet and the bitter, are available. The bitter type has more poisonous hydrocyanic acid, than the non-bitter type, which disappears in cooking. The roots have 25 to 30 per cent starch.

Cassava is a heavy feeder but is quite drought resistant and seldom irrigated. With irrigation, high yields, up to 30 tons per hectare or more, are obtained. For convenience in digging as well as for better yields a deep friable soil is best. Digging can be very difficult when roots are deep or the ground is hard.

Propagation is from stems cut from the previous crop which often are stacked in the shade until they begin to sprout, when they are cut into 8 to 10 inch lengths for horizontal plantings in furrows 4 inches deep, or into 12 inch lengths for vertical planting, with 4 to 6 inches in the ground. The vertical planting is probably the best and has been reported to give 30 per cent higher yields (5).

Spacing is 4 x 3 feet and 9 to 12 months are required for maturity (19). Yields average from 6 to 12 tons per acre. Planting is best at the beginning of the rainy season.

Varieties Valencia, Itu and Crema have performed well in Mexico. Dr. A. Krochmal has an excellent variety collection in the Virgin Islands. Although cassava is originally from South America it is widely grown in Asia and Africa (15).

SWEET POTATO

Sweet potato (*Ipomoea batatas*) is an important crop in the Caribbean area and in the United States. Since the newer, more palatable varieties are not generally known in most tropical countries the crop has not attained the importance of cassava. Through breeding, geneticists have greatly increased the vitamin content (9).

Sweet potatoes require a warm season and a growing period of 4 to 6 months (6). Cool night temperatures (below 68° F) are favorable for tuber formation. Irrigation is beneficial but sweet potatoes will tolerate considerable drought. Soil should be reasonably loose for best yields, but sweet po-

tatoes may be grown even on heavy clay soils provided they are planted on ridges and have good drainage. Heavy applications of fertilizer are not advisable in the Tropics.

The crop usually is grown from slips produced from tubers grown in hotbeds in the United States where earliness is important (4). Cuttings from the vines are used in tropical areas. These are 12 to 18 inches long and usually are pushed in with a stick and watered unless the ground is wet. Damp, cloudy weather is best for this type of transplanting. About 4 to 5 tons per acre is a good yield of tubers. Spacing at 12 to 15 inches gives best yields (18) (26).

Plant breeders have produced many new varieties, some with high vitamins, others with disease resistance. Some varieties suggested for trial in the Tropics are Nemagold, Apache, Orange Little Stem, Yellow Jersey, Nugget, Cliett Bunch Puerto Rico, Centennial, Goldrush, Mameya, Cobre, Sunnyside and Triumph. Apache has high carotene, resists black rot and nematodes (2). Nemagold is resistant to nematodes and is useful for canning (8). Goldrush is especially useful for baking (16). Centennial is a high yielding Puerto Rico type (23). Nugget is resistant to internal cork and tolerant to fusarium wilt. It is 7 to 10 days earlier than Puerto Rico and has high market and cooking quality (27). Three new varieties, Koedoe, Eland and Hartbees, are reported from South Africa to be good keepers and slow to sprout (17).

Since viruses have become serious, checking foundation stock for planting material is being done in some areas. The most serious insect pest is usually the sweetpotato weevil. This may be controlled by 2 per cent dieldrin dust or 2.5 per cent heptachlor dust applied when shoots begin to emerge (1). Some benefit is thought to be obtained by planting cuttings instead of slips.

Tubers should be cured at 85° F and 90 per cent humidity for 5 to 7 days, then stored at 55° to 60° F and 85 to 90 per cent humidity (18).

Yams

Yams (*Dioscorea alata*) and other species are commonly grown in some parts of the Tropics. Yams have twining vines and need staking or trellising. They are planted 4 x 3 feet in loose soil with pieces of about ¼ lb., each with 2 or 3 eyes. The crop is ready in 9 to 10 months and yields are about 5 to 6 tons per acre (20). Roots are used as sweet potatoes but are not as palatable to most tastes and they have not become popular in areas where cassava or sweet potatoes grow well (31).

Potatoes

Potatoes (*Solanum tuberosum*) do well in the Tropics at higher elevations and may produce yields of 5 tons or more per acre. Probably they should not be grown below 3,000 to 4,000 ft. elevation since they grow best below 70° F. Potatoes are more susceptible to disease in tropical areas, especially late blight which occurs at high humidity and temperatures below 60° F. Weekly spraying with Phygon XL will prevent infection unless there is much rain but the most satisfactory control is the use of the new late blight resistant varieties.

Ona, Merrimac, Kennebec, Cherokee, and Ontario looked promising in trials conducted in Haiti. In Central America, Alpha and Voran have given good results at lower elevations where late blight does not occur. The following varieties have been reported to have resistance to late blight: Catoosa, Anita, Bertita, Conchita, Erendira, Navajo (2), Bungama (3), Kennebec, Sebago, Menominee, Calrose (10), Aquila, Essex (19), Ona (25), Pungo and Boone. Superior yields in tropical areas have been reported for Ontario, Ona, Kennebec, Merrimac, Sequoia, Teton, Pontiac, Harford, Sebago, Alpha, Voran, Dakota Chief, Marygold, Ashworth, La Soda, Cherokee and Erendira.

Seed dormancy often is a problem in the Tropics where cold storage often is not available. Potatoes normally require 2 months dormancy or more to sprout. Tests of gibberellin and other chemicals have been tried but commercial procedures have not been worked out. Mexico recommends storing 2 weeks at 54° F and later at 37° F, then at room temperature for sufficient time to sprout before planting. It is recommended to treat spring seed after cutting, one hour in 1 lb. sodium thiocyanate in 12 gal. water (14).

Planting is usually 30 inches between rows, 8 inches between plants. Whole tubers 2 oz. in size are preferred. Cut pieces of the same size may be used if planting in a warm soil. Seed should be covered 2 to 3 inches deep (19).

Fertilizers containing 40 to 50 lbs. of nitrogen per acre and 100 to 150 lbs. phosphate have given good results. In some cases 20 to 30 lbs. of potash also may be needed. If irrigation is available the soil moisture should be kept at a high level throughout the period of growth.

In hot areas the tubers should be gathered im-

mediately when mature to prevent sun damage. Optimum storage is at 50° F and 80 to 90 per cent humidity. It is desirable to handle potatoes carefully to avoid bruising.

Dasheen or Taro

Dasheen or Taro (*Colocasia esulenta*), the Trinidad type, or *Colocasia antiquorum,* the Egyptian type, is grown easily at the lower elevations where potatoes do not thrive. Tubers have a higher food value than potatoes but they need 7 months to mature (12). They should be planted as whole tubers in rows 42 to 48 inches apart and 24 inches apart in the row. Only 3 varieties are recommended: Trinidad, Sacramento and Ventura, but hundreds of varieties are available (33). The tubers are used in the same way as potatoes, either baked, boiled or fried. Newly emerged leaves can be boiled as greens but cannot be used raw (32).

A fairly constant soil moisture is needed for best results. An average yield is 3 to 5 tons but as high as 10 tons have been obtained under irrigation.

This crop is especially popular in the West Indies and Hawaii but also is grown commercially in Egypt and other tropical countries.

A near relative *Xanthosoma* is known as yautia and tanier. It produces higher yields in the West Indies and stores well (11).

Other Root Vegetables

Arrowroot includes several species used both as a vegetable and for a flour sold as arrowroot. Purple arrowroot (*Canna edulis*) has been cultivated in Queensland with yields of 5 to 8 tons of tubers per acre (22). It is propagated by rhizomes planted 3 x 2 feet and requires 6 to 8 months to mature. The West Indian arrowroot (*Maranta arundinacea*) has pointed starchy rhizomes and is the commercial arrowroot. It is propagated by tubers or suckers planted 6 inches deep in furrows 30 inches apart and spaced 15 inches at the beginning of the rainy season. It requires a fertile soil, with good drainage and a moist hot climate. Yields are 4 to 6 tons per acre at 10 to 11 months after planting, of which 12 per cent is dry arrowroot (22).

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SESAME

(Sesamum indicum)

Seeds of sesame are important as a source of oil for cooking in Asia and Africa. It is therefore used as a food crop in that area while in the United States it is an industrial crop. Sesame thrives best in semiarid seasons and warm temperatures (1). The variety Inamar yields well in Haiti.

Sesame is sown in rows 30 inches apart and thinned to 6 to 7 inches apart in the row. In some areas of Asia it is sown broadcast. The crop matures in about 5 months and is harvested when the first pods open. The plants are cut near the ground and are stacked in sheaves to dry. Fertilizer requirements are not known but certainly phosphates help in most Asiatic soils.

Diseases that may occur include fusarium wilt, southern blight and leaf spots. Insects are usually not severe.

Great care is needed to avoid loss of seed in handling. Good yields are 800 to 1,000 lbs. of seed per acre. Better varieties are being bred that do not shed their seeds easily, so as to increase yields.

Seeds contain 50 to 54 per cent oil, 25 per cent protein and 11 per cent carbohydrates. The pressed cake makes good livestock feed if the oil is removed. Seeds are widely used on cakes and pastries.

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SOUTHERN PEA OR COWPEA

(Vigna sinensis)

Cowpeas or Southern peas are considered to be native of Central Africa (10). They also are reported to be native to Afghanistan, Iran and India (11). They are classified into 13 groups by Brittingham (1) all of which will inter-cross. The Southern pea is a bushy or procumbent type of plant usually grown in rows 3 feet apart and spaced 2 to 3 inches in the rows. The asparagus or yard long type is climbing and needs a trellis. It is chiefly of value for the tender pods. The catjang type has cylindrical pods with closely packed seeds typified by the Lady (or Rice) variety. There are many varieties varying from the Blackeye and Purple Hull to the Cream Crowder and Acre.

Breeding programs in Florida, Alabama, Mississippi, Louisiana, Texas and California have released the following varieties: Calhoun Crowder, Dixilee, Texas Purple Hull 49, Alacrowder, Alalong, California Blackeye 5, Cream 52, Texas Cream 8, Monarch Blackeye, Climax, Producer, Topset, Extra Early Blackeye, Mississippi Crowder, Two-Crop Conch and Baby Bush Purple Hull. Foreign varieties reported are Poona in India; Malabar, Havana and Reeves in Australia; Garbancito, Chinito, and Azulgrande, which are mildew resistant varieties from Costa Rica (2), and Acre from Jordan.

Six viruses are known to cause disease of Southern peas and most varieties are susceptible; however, Lousiana Purchase, Arlington, Buff, Brabham, Six Weeks, and Victor are resistant to yellow mosiac virus. These viruses can be transmitted by bean leaf beetles.

High lime soils may cause chlorosis and poor nodulation (5). Nematode resistant varieties might be necessary where nematodes are common.

Cowpeas need a warm soil for good germination. Soil temperature should be 70° F or above (3).

Phosphate increases earliness and yields (8) but nitrogen gives only a slight increase in yield (9).

Cucumber mosaic and other viruses may cause serious damage (6). Hemipterous insects cause damage to seeds by sucking.

Cowpeas have a high vitamin content in the tender snap stage. The green shelled peas are not as high in vitamins as the snaps but are popular in the United States for freezing. The dry shelled peas are liked for cooking like dry beans. Because of better adaptability than beans to hot climates, Southern peas should have an important place among tropical vegetables.

Peas are harvested when the color of the pods is still green but close to the turning point of green to yellow. Storage of peas for 48 hours at 100° F

improved the mechanical shell-out of seeds as much as 37 per cent for the variety California No. 5 and 21 per cent for the Conch variety. Storage treatments did not improve the seed shell-out of the variety Alabama Crowder. Younger peas benefit more from storage than mature peas (4).

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SQUASH

(*Cucurbita* spp.)

Squash is grown commonly in the Tropics as well as in the temperate zone. Most of the improved varieties come from the temperate regions. The chief problems in tropical areas are mosaic, cucumber beetles, downy mildew, melonworms, pickleworms, etc.

The Alagold variety is resistant to mosaic but yields poorly under tropical conditions. It is also very late maturing. A better variety is the Butternut which appears to be well adapted to the Tropics and has produced 6 to 8 tons per acre in Central America. The squash will keep in open storage for 2 to 3 months and cooking quality is excellent. A native Central American squash called "pipian" is relatively free of diseases but yields are somewhat low. The best summer squash types are the Cocozelle types of which Caserta is the most promising.

The summer squash is grown in hills 4 x 4 feet and the winter squash at 6 x 8 or 8 x 8 feet. For home use they often are grown in the boundaries and allowed to run over the rock walls or fences.

Manure is a good fertilizer where it is available. Otherwise, diammonium phosphate at 200 lbs. per acre gives good results.

The cucumber beetles may be controlled with 10 per cent chlordane or 1.5 per cent dieldrin dust. Dusting with dieldrin is helpful in controlling pickleworms.

Regular spraying with dithane or parzate will help in controlling leaf diseases but resistant varieties would be best where they are available.

The summer squash is harvested while tender, preferably about half to two-thirds mature. The Butternut is harvested when mature and firm.

TOMATO

(*Lycopersicon esculentum*)

Tomatoes are important and very popular in the diet of people in the Tropics. The crop is widely adapted and usually can be grown at some time of the year in any agricultural area provided varieties are carefully chosen. The rainy period usually is considered difficult for growing tomatoes due to the disease problems. Irrigation is required for good yields in the dry season.

Rains are damaging for several reasons. In the first place, reduction of sunlight tends to decrease yields (6) while increased light gives better growth (13). Yields are best at 70° to 80° F day temperature and 50 to 70° F night temperature (17). The critical night temperature for setting fruit is 64° F (17).

The main factor in the rainy season is the increase of diseases. Early blight, fruit rots, septoria leaf spot, cladosporium leaf mold, gray leaf spot, etc., are especially prevalent in the tropical rainy season. When temperatures go below 60° F for even short periods at a high humidity, late blight (*Phytophthora infestans* (Mont.) DBy.)) appears. An additional problem is that continual daily rains wash off the fungicides so that sprays lose their effectiveness. The excess moisture also is conducive to fruit cracking which allows rotting.

Obviously if varieties could be found with resistance to diseases, and if they are also free from

cracking of fruit, the growing of tomatoes in the rainy season would be relatively easy. An attempt was made to screen varieties for their ability to produce in the rainy season in El Salvador from 1957–1961. Of a total of 121 varieties tried, Sioux, Texto 2, Urbana, Red Top, Roma and Summer Prolific were consistently good producers when weekly sprays of maneb were used. Especially promising were the Hawaiian multiple resistant hybrids, Indian River, Cuyano, Egg and Santa Catalina.

Trials in Haiti in 1961–62 have shown that Roma, Red Top, Indian River, Hawaiian hybrids, San Marzano, Campbell 146, Urbana and Hotset have some promise in the rainy periods. No resistant varieties for late blight are known for tropical areas. Rockingham and Surecrop, developed at New Hampshire Experiment Station, are reported to have resistance to late blight but they have not been tried under late blight conditions in the Tropics as far as the authors know.

It was thought at first that determinate varieties would be required for the rainy season but the use of plant stakes permits the use of any variety.

Resistance to fruit cracking is comparatively rare in the larger fruited varieties. High resistance has been shown by Glamour, Heinz 1370, Summer Prolific and most of the small fruited varieties such as Roma, Red Top and San Marzano.

High temperatures at low elevations may affect the yield. Varieties such as Summer Prolific, Hotset, Victor, Westernred, and Red Cloud might have value in such areas.

In the Tropics where diseases are so plentiful, it is very important to have disease-free plants for transplanting. MC–2, a liquid methyl bromide gas to which 2 per cent chloropicrin has been added as a warning agent, is a good seedbed treatment for control of weeds, nematodes and fungi. This is applied under polyethylene covers which are left on for 24 hours (1).

Figure 74. TOMATO VARIETY TRIAL AT THE DAMIEN EXPERIMENT STATION IN HAITI. ONLY BY REPLICATED VARIETY TRIALS CAN THE BEST VARIETIES BE RECOMMENDED.

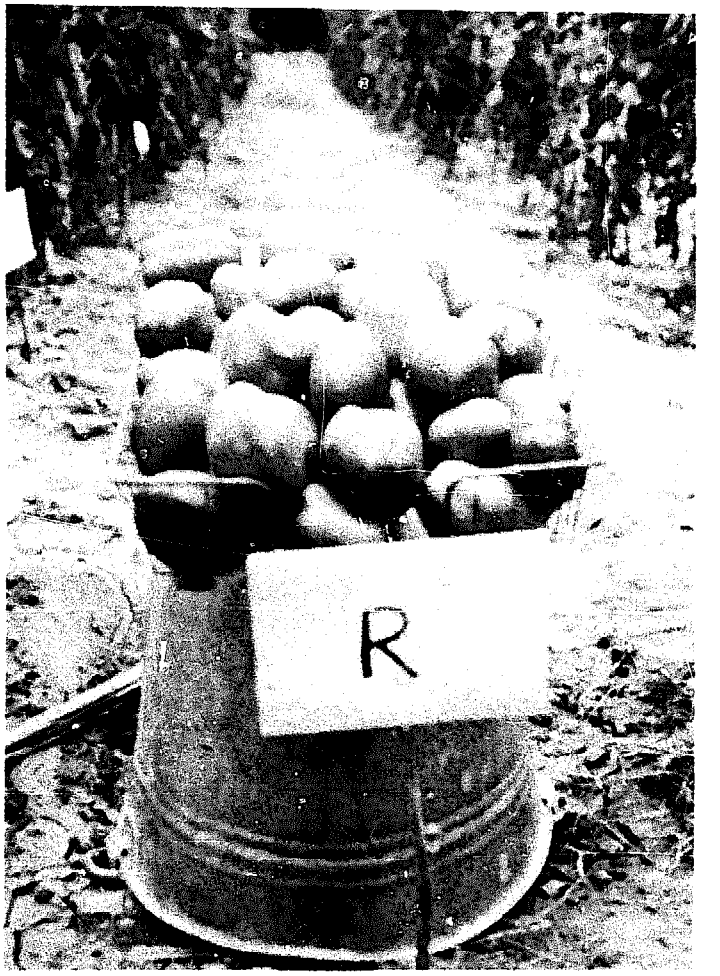

Figure 75. THE TOMATO VARIETY ROMA DOES WELL IN THE TROPICS.

The seed is sown in rows 6 inches apart and 2 to 3 inches wide at the rate of 100 seeds per foot. They should not be covered more than ½ inch deep. They will need watering once or twice a day until they emerge after 6 or 7 days. In case of heavy rains they must be protected by covers of burlap or palm leaves until they become established.

The best plants are 6 to 10 inches tall with stems of pencil-size. Smaller plants can be used but more care is needed in getting them established. Topping or pruning the larger plants reduces yields. Larger plants can be used by covering at least two-thirds of the length of the stem in the soil when transplanting.

Transplanting should be done directly from the seedbed. Holding plants after digging for several

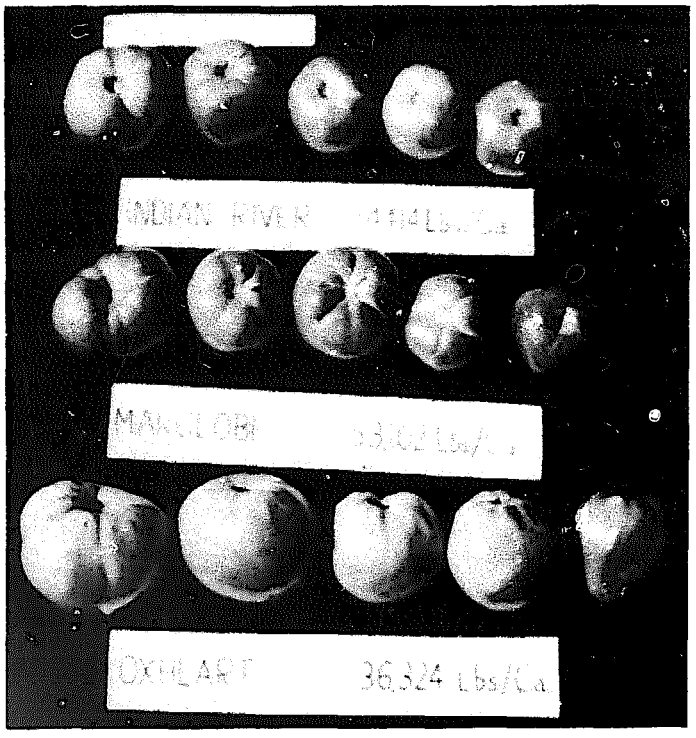

Figure 76. THE INDIAN RIVER VARIETY OF TOMATO YIELDED VERY WELL IN TOMATO TRIALS IN HAITI. A CARREAU (CA) IS APPROXIMATELY THREE ACRES.

days before transplanting reduces yields. A rapid method for hand transplanting is by the use of a spade to open the soil. A second man carrying the plants inserts the plant to the proper depth and the man with the spade firms the soil with his foot. A third man follows with the starter solution which can be made at the rate of 5 lbs. of 11–48–0 or 3 lbs. of 18.5–50–0 in 50 gallons of water with ½ lb. of Parzate or Dithane Z–78. A cupful is poured around each plant immediately after setting. If conditions are dry, the plants should be irrigated as soon as possible.

Spacing at 4 x 2 feet gives good yields for indeterminate varieties like Indian River. Determinate varieties might be set a little closer depending on the size of the plants. Varieties like VBL 3180 could easily be set at 8 to 12 inches in 4 foot rows.

Since earliness is not an important factor in the Tropics, pruning usually will not be profitable. During dry periods irrigation will be needed for good crops. Tomatoes are not adapted to drought conditions and sufficient water should be applied to keep the plants growing vigorously at all times. Frequency is not important as long as sufficient water is applied; however, excessive irrigation may increase fruit cracking (16).

Fertilizers for tomatoes should be high in phosphorus. A 2 N – 4 P – 1 K ratio has been found most favorable for early flowering (12). Excess nitrogen is associated with puffiness of fruit and blossom-end rot (14). Too much nitrogen without phosphate may cause abundant vegetative growth and no fruit. Heavy applications of phosphates can be made safely on tomatoes (7). Potash generally has given no response and an excess may cause abnormalities in the fruit.

Diseases become a major problem when growing tomatoes in the rainy season in the Tropics. Spraying in the seedbed with Parzate or Dithane Z–78 will be needed. Use of either of these in the starter solution is also beneficial when transplanting. Beginning one or two weeks after transplanting, weekly sprays with maneb are advisable. The most destructive disease of tomatoes in tropical areas is early blight (*Alternaria solani* (Ell. & G. Martin) Sor.). Although some varieties have been reported to be resistant, none have had sufficient resistance for tropical regions. Some varieties have resistance to collar rot but it is still a good policy to use Parzate or Dithane Z–78 in the seedbed and in the starter solution when transplanting.

Resistance to fusarium wilt is important in the Tropics and fortunately many resistant varieties are now available; however, when nematodes are present the resistance may not be effective (8). Resistance to gray leaf-spot (*Stemphylium solani* Weber) also is available in a number of varieties including Manapal, Marion, Floralou and Indian River. Nematode resistance is present in some of the Hawaiian hybrids and several selections including Anahu.

In the Caribbean area and other warm areas with high humidity the leaf mold (*Cladosporium fulvum* Cke.) becomes a serious factor. Since there are few resistant varieties of the usual commercial types available, spraying will be needed. Maneb spray is effective only when the humidity is below 92 per cent. Some resistance has been shown by Improved Bay State, Vetomold, Waltham Mold Resistant, Globelle, Indian River, Floralou and Tuckers Forcing (3).

Viruses such as tobacco mosaic and cucumber mosaic are found in all countries. Tobacco mosaic may be carried on the seed but may be controlled by treating with a 10 per cent solution of trisodium phosphate for 10 minutes (9). Since tobacco mosaic also is spread by contact, cigarette smoking is not advisable in the tomato field.

Tomatoes are so widely grown that many different diseases are likely to occur. A good reference

for identification is Doolittle (4). Bacterial wilt is especially likely in soils with poor drainage during the rainy season and may be controlled by planting only on well-drained land. Newly developed tomatoes with high resistance to bacterial wilt as well as cracking and other diseases are being developed for release by the Hawaii Agricultural Experiment Station (5). (Illus. page 8.)

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TURNIP

(Brassica rapa)

Turnips are widely grown in the Tropics but prefer cool weather and should be grown in the winter and at high elevations.

Shogoin (Japanese) is a popular variety that has a mild turnip flavor. Golden Ball, Purple Top, Strap Leaf, Just Right, and Purple Top Milan should be tried.

Turnips are grown for the root and for the greens. The greens are high in minerals, calcium, iron and vitamin A. They also contain appreciable quantities of thiamine and ascorbic acid.

Turnips thrive best on a deep rich loam but will grow on all types of soil. Turnips require nitrogen and phosphorus but most lateritic soils of the Tropics seem to have sufficient potash. Fertilizer trails are necessary to determine the amount of fertilizer to use

The seeds are planted in rows 12 to 15 inches apart and the seedlings thinned to 2 to 6 inches (1).

Most of the diseases and insects affecting the turnip also are injurious to cabbage and are listed in the table on insect control.

Turnips are harvested like beets. For use as greens, the plants are thinned and the foliage is cooked.

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WATERMELONS

(Citrullus vulgaris)

Watermelons are universally popular and are grown nearly everywhere; however, there are many tropical areas where they fail to produce satisfactorily. Observations in Central America have indicated that watermelons should be grown only at the lower elevations where sufficient heat occurs for normal development. A sandy soil is generally preferred but good melons can be grown on heavier soils if the weather is warm enough.

The leading variety is the Charleston Gray because of its disease resistance and good shipping and eating qualities; however, in the Mediterranean area, the Chilean variety is commonly grown. An-

thracnose resistance is a valuable characteristic in the Tropics. Charleston Gray. Garrisonian and Hope Diamond are released as anthracnose resistant. In general, melons are smaller in the tropical regions than in the temperate zone and production is generally less. In the Caribbean, watermelons weighing only one or two pounds are commonly marketed. In Central America, Charleston Gray watermelons weighing 35 to 40 pounds are grown at the lower elevations.

Wilt resistance may be valuable in some areas. Varieties with good resistance are Purdue Hawkesbury and Blue Ribbon Klondike. Charleston Gray rates moderate resistance. Congo and Blackstone are slightly resistant and Florida Giant (Black Diamond) and Garrisonian are susceptible (8). Some new varieties that might be tried are Improved Peacock, Golden Midget, Market Midget, Charleston Gray 133, Crimson Sweet, Graybelle, Shipper, Rio Gray and Jubilee (3).

Planting is done in hills 10 x 4 or 8 x 4 feet, leaving one or two plants per hill. Fruit setting is dependent on the amount of leaves. Fertilizers usually should include nitrogen and phosphorus. Good results have been obtained in the Tropics with diammonium phosphate at the rate of 150 to 300 lbs. per acre in bands. This may be applied before planting or as a side-dressing after plants are established and before they begin to run. Nitrogen increases the number of pistillate flowers and fruit set (4).

Pruning defective melons and limiting the set to 2 melons per vine gives earlier and larger melons (5). Pruning does not increase yields but does increase fruit size (4).

When anthracnose first appears maneb should be applied at 1.5 lbs. per 100 gal. of water or alternating maneb and zineb sprays may be used. Applications should be repeated every week or 10 days (7). Powdery mildew causes pimples on melons in Mississippi and Texas and reduces marketability (6). Where nematodes are severe, hill treatment with chloropicrin or methyl bromide might be advisable (1).

Harvesting watermelons is done in a number of ways. The time from flowering to ripe melons in the large varieties averages 45 days. At this time testing for ripeness can begin. Thumping the melon with the finger often is used. When ripe, a dull sound is given, and when green, a "ping" sound. Experienced harvesters can tell by the exterior color change to a duller appearance.

After the melon is cut the cut surface of the stem should be painted with a copper sulfate paste to prevent stem end rot.

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Chapter 4

DISEASE AND NEMATODE CONTROL

NEMATODES

Nematodes, or eelworms, are animals too small to be seen without a microscope. They occur throughout the Tropics, and about 50 are known to be damaging to crops. As most of them do best in warm temperatures they are more destructive in the Tropics than in the temperate zone. Since they are not visible to the naked eye, the average person sees only the damage symptoms on the crop. As this damage is usually to the roots, one sees only the effect on the part of the plant above the ground. The nematode-affected plants lack vigor, wilt easily, and indicate a lack of fertilizer as a result of the destruction of the roots. Roots may show galls or excessive root branching and rotting or dead areas (6).

Nematodes may be classified according to their damage (1). There are those that form root galls (root knot), while others form root lesions, root rot, or excessive root branching. Some injure or destroy root tips and some attack leaves, stems, bulbs, tubers, or flowers.

Nematodes are very widespread and although the science of nematology is relatively new there are over 12,000 named species, of which 1500 are described as plant parasitic. The life cycle varies but is usually 3 to 4 weeks. They develop more rapidly at higher temperatures (above 80° F) but cannot tolerate temperatures above 140° F (1).

They damage many important crops not only by their feeding but also by facilitating secondary infection by bacteria and fungi and by spreading soil-borne viruses. In extreme cases total loss of a crop may occur by the combination of nematodes and disease (5). Even varieties resistant to Fusarium wilt may lose their resistance when attacked by nematodes (19, 20 and 25).

The cost to farmers caused by 43 known species is estimated at 89 million dollars in California alone (3) and at over a billion dollars annually in the United States (1).

Nematodes are spread easily from infected soils to clean soils by the feet of human beings or animals, by machinery, or plant roots. They are most easily carried in wet soil and spread rapidly in crops where irrigation is done by surface methods. Seeds and transplants are principal means of carrying nematodes to clean land (14).

Effective control of nematodes requires a combination of methods. It is essential that growers realize the value of these practices. Use of chemicals is beyond the reach of most farmers in developing countries, and only high income crops would justify their use in the field; however, there are soil management practices that are helpful without depending on chemicals entirely.

The use of clean seeds and clean plants is perhaps the cheapest method of control. For example, grapevine cuttings can be submerged for 5 minutes in water at 125° F (51° C) and immediately afterwards should be submerged in a cold water bath at 45° F for cooling. This is effective on several nematodes (17). The hot water treatment also is useful in treating seeds (16). A solution of Nemagon (DBCP) also can be used in dipping the plants (18).

It also is helpful to fumigate the seedbeds in which plants are produced. Chemicals useful for this purpose are EDB, Vapam and MC_2 (11). These also control fungi and weed seeds. A plastic cover is necessary in using MC_2 since it is highly volatile. This should be done about 2 weeks before planting the seeds. DD and DBCP also can be used. Since only small areas are used the cost is much less than using chemicals in the field. A reasonably good crop can be produced with tomatoes and other annual crops if clean plants are used in transplanting.

Small quantities of soil may be sterilized satisfactorily by use of steam. The soil is heated in a 55-gallon drum, as shown in Fig. 78. The top of the drum should be removed and perforated with many small holes. This is placed on three metal supports about six inches above the bottom of the drum. The

tank is put on cement blocks or stones at a height suitable for having a fire underneath. The bottom of the drum is filled to a level of four inches with water. The soil is placed on the perforated piece to a point one inch below the top of the drum, and covered with banana leaves or burlap. A wood fire should continue to burn until a temperature of 140° F at the top of the soil has been maintained for at least 30 minutes. If a thermometer is not available, a sweet potato can be put six inches below the surface of the soil. When the potato is cooked the soil has had sufficient heat. The soil can be used after it cools to air temperature.

By avoiding the growing of nematode-susceptible crops in periods of high temperatures the damage from nematodes can be lessened. Nematodes are especially active at temperatures above 80° F. In areas where temperatures are lower at certain periods of the year, the susceptible crops can be grown in the cool season and resistant crops in the warm period.

Weed control is essential in any system of nematode control (26). A great number of weed species are hosts to various destructive nematodes and could nullify other efforts to reduce nematode damage. Some common weeds are very susceptible to nematode attack (4). For information on weed control see Chapter 5.

Dry fallow is a practical control where dry periods of 3 months or more occur. It is necessary to plow about 12 inches deep and to allow the soil to dry thoroughly (9, 28). This method is practical only where moldboard plows are available and definite dry periods occur. Dry fallow cannot be used in organic soils in the Tropics because of destroying the organic matter (23). Flooding is useful in some areas and destruction of nematodes apparently is due to the hydrogen sulfide produced (24). Flooding must actually cover the soil for 60 to 200 days. It does not entirely eliminate the nematodes (30).

Crop rotation is the most practical control with crops of low or moderate return and is a practice that most farmers can use. Resistant crops are grown in rotation with the susceptible crops and aid in reducing the nematode population; however, crops resistant to one species of nematode actually may build up populations of other nematode species. Care is necessary in choosing the nematode-resistant crops.

Pangola grass grown one year with good weed control gives excellent nematode control for tomato production in Florida (30). *Crotalaria spectabilis*

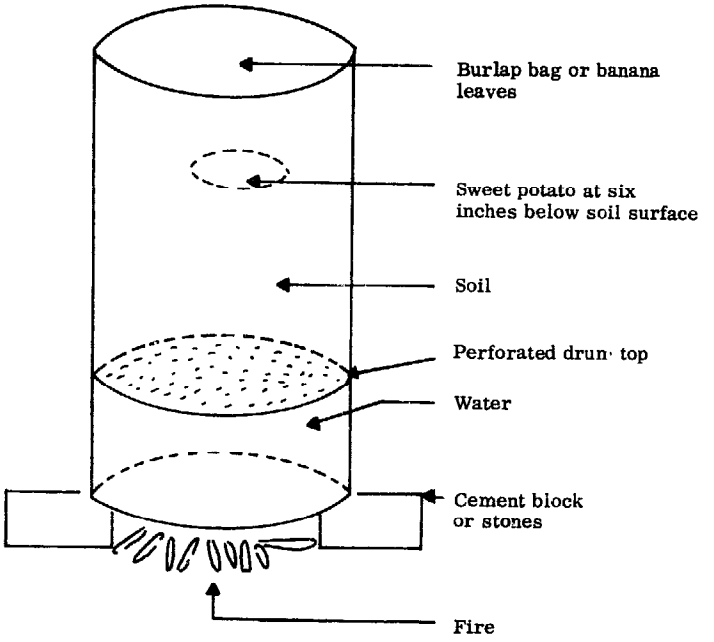

Figure 78. HOME MADE SOIL STERILIZER.

grown for 2 or 3 months in the summer reduces several kinds of nematodes (22). Coastal bermuda reduces root knot but increases other nematodes (11). Plant species found to be highly resistant to a wide range of nematodes are marigolds (*Tagetes* spp.), *Crotalaria* spp., *Solanum grandiflorus, Lantana camara, Senecio cineraria,* and asparagus (30). More study is needed to determine the crops most effective in nematode control. Some crops which are toxic to nematodes are useful in permanent plantings such as orchards and tea and coffee plantations. They are grown between the trees and attract the nematodes to enter the roots where they apparently are killed by the toxins in the plant roots (30). Marigolds seem especially useful and *Crotalaria spectabilis* also is used for this purpose (11).

Organic mulches and manures have given good results in some experiments but our present knowledge does not justify their recommendation; however, since more than 50 species of fungi are known to prey on nematodes these treatments would seem to justify further study (21).

Chemicals are by far the most effective means of controlling nematodes, but because of their expense can be used only in the field on high income crops. Their use in seedbeds is practical except where farmers lack capital to purchase the equipment and chemicals. In the field, chemicals such as DBCP (Nemagon and Fumazone) can be applied in the row before planting to permit growing such susceptible crops as tomatoes and melons but this chemical is toxic to onions, potatoes, sweet potatoes

Table 6. NAMES AND FORMULAS OF COMMON FUNGICIDES

COMMON NAME	TRADE NAMES *	FORMULATION	ACTIVE INGREDIENTS
Captan	Orthocide, Captan	N-(trichloromethylthic) 4-cyclohexene-1,2-dicarboximide	50% or 75% WP Various % dusts
Chloranil	Spergon	Tetrachloro-para-benzoquinone	
Copper fixed	Copper-Hydro, C.O.C.S., Copper A	Low soluble coppers	23%–53% WP
Dichlone	Phygon XL	2,3-dichloro-1,4 naphthoquinone	50% WP 1–4% dust
Dyrene	Dyrene	2,4-dichloro-6-(O-chloro-anilino) triazine)	50% WP
Ferbam	Ferbeck, Fermate, Ferradow, Karbam black, Nu-leaf	Ferric dimethyldithiocarbamate	
Karathane	Karathane, Mildex	4,6-dinitro-2-(1-methyleptyl) phenyl crotonate	25% WP
Maneb	Manzate, Dithane M–22	Manganous ethylene bis (dithiocarbamate)	80% WP 4.9% dust
Nabam	Dithane D–14, Parzate, Liquid Nabam Fungicide	Disodium ethylenebis-dithiocarbamate	19% liquid 93% WP
Terraclor	Terraclor	Pentachloronitrobenzene	75% WP 20% dust
Thiram	Arasan, Tersan, Thiram, Naugets Delsan A–D, Panoram	bis (dimethylthio carbamoyl) disulfide	75% WP
Zineb	Dithane Z–78, Fungicide A, 12 A Blightox, Parzate Zineb Fungicide	Zinc ethylenebisdithiocarbamate	65% WP 4.5% dust
Ziram	Zerlate, ZC, Karbam White, Corozate, Zirbeck, Fuklasin	Zinc dimethyldithiocarbamate	76% WP 5.3% dust

* These are only a few of the trade names and are listed as examples.

Table 7. APPROXIMATE QUANTITIES OF FUNGICIDES EQUIVALENT TO ONE OUNCE

FUNGICIDE	NUMBER OF LEVEL TABLESPOONS
Bichloride of mercury (soluble powder)	1.0
Captan (wettable powder)	3.5
Choloranil (wettable powder)	3.7
Dichlone (wettable powder)	3.7
Ferbam (wettable powder)	5.0
Semesan	2.7
Sulfur (wettable powder)	3.0
Thiram (wettable powder)	3.0
Zineb (wettable powder)	3.7
Ziram (wettable powder)	5.5

and peppers (10). DBCP also can be used in treating orchard trees (8). This should be applied with a chisel applicator at least 6 inches deep (2). While this is too expensive for the low income farmer, there are instances in the Tropics where the use of chemicals is profitable.

The most satisfactory solution to the nematode problem is the development of resistant varieties; breeding work along this line has developed resistant varieties of tomato, pepper, lima beans, sweet potatoes and southern peas (cowpeas). Resistant rootstocks are now available for citrus, peach, plum and grape. The field is promising and work continues along this line (12, 15). One of the problems is that varieties resistant at mild temperatures (20 to 25° C) are more susceptible at higher temperatures (30 to 35° C) (13).

A combination of methods that utilizes resistant varieties, crop rotations, weed control, and other management practices probably will permit economical crop production with a minimum use of chemicals.

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DISEASES

Diseases constitute a serious problem in the Tropics because the causal organisms reproduce at a high rate due to favorable environmental conditions. It may be necessary to use shorter spray cycles in tropical areas than in temperate regions due to the rapid spreading of fungus diseases.

Fungicides can be used as a dust or spray. The advantages and disadvantages are discussed under insecticides. Sprays usually are preferred since they stick to the plant surfaces better than dust. Most fungicides contain a spreader and sticker but if they are not included in the fungicide they can be purchased separately and added according to the manufacturer's directions.

The fungicide should be applied before there is evidence of any plant damage. On some diseases a cycle of 10 days may be sufficient but on others a 3 day cycle may be necessary in the Tropics. Only experimental trials can give one an idea of the right fungicide and cycle to use for a specific disease in tropical areas.

Bordeaux mixture is very effective in preventing several diseases but it is not suggested in this handbook since it has to be made up each time it is used and any unused portion must be discarded. A wooden, earthenware or glass vessel is necessary for mixing, which is a disadvantage since these are not available in some places in the Tropics. Another problem is that the nozzles of the sprayer frequently get clogged when Bordeaux is used. Bordeaux mixture may injure such crops as cucumbers,

muskmelons and tomatoes. Since there are many disadvantages in using Bordeaux, fixed copper compounds and organic fungicides have been suggested for trial. Some trade names for the organic fungicides have been suggested for trial. Some trade names for the organic fungicides are listed in Table 6. The most common fixed copper compounds are basic copper sulfate, copper oxychloride, copper oxychloride sulfate and cuprous oxide. These compounds are sold under various trade names and should be used according to the manufacturer's directions.

Seed treatment chemicals will not be discussed since most of the reliable seed companies treat their seeds before they are sold. In a few cases seed treatment is suggested in Table 8.

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Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES [1]

CROP	DISEASE	DESCRIPTION	CONTROL
Artichoke	Black Rot	Black infection on heads.	Varieties with compact heads are more resistant.
	Leaf spot	Small irregular gray spots on leaf may cover whole leaf.	Zineb or Maneb.
	Powdery mildew	White mold on lower surface of leaf.	Karathane.
Asparagus	Cercospora	Spots on stems and branches.	Maneb.
	Rust	Elongated, orange-red powdery particles on stems and foliage.	Ferbam. Rust resistant varieties such as Mary and Martha Washington.
Bean	Anthracnose *See Photo Fig. 79*	Brown sunken spots with pink centers on pods.	Crop rotation. Obtain seed from disease-free areas. Resistant varieties. Phygon XL, Fermate, Zineb.
	Ashy stem blight	Cankers on stem below cotyledon.	Treat seed with Ceresan.
	Bacterial blight	Large brown dry spots on leaves surrounded by yellow borders.	Rotation, sanitation, clean seed, resistant varieties.
	Damping-off	Death of young seedlings.	Seed treatment with captan, chloranil or thiram.
	Fusarium yellows	Green foliage changes to yellow eventually killing the plants.	Use seed from areas free of the disease. Treat seeds with Semesan and Ceresan.
	Mosaic	Mottled (light and dark green and curled leaves).	Resistant varieties. Control aphids.
	Powdery mildew	Darkening of leaf, covered with powdery mold.	Resistant varieties. Sulfur.
	Rust	Minute reddish brown circular spots.	Pinto 5 or 14, Columbia Pinto, Rico 23.
	Yellow Mosaic	Mottling of yellow and green which enlarge until whole plant becomes yellow.	Isolate from clover, corn or gladiolus. Control aphids.
Beet	Black root	Tip of root turns black, leaves wilt and yellow.	Hot water treatment for Phoma plus captan or thiram.
	Damping-off	Death of young seedlings.	Chloranil, thiram seed treatment.
	Leaf Spot	Small brown flecks which become ashy gray areas.	Rotation. Insoluble copper, zineb and ziram sprays.
Broccoli	Black leg	Gray spots speckled with tiny black dots on leaves and stem.	Rotation. Clean seed. Hot water seed treatment. 122°F–20 min.
Brussels Sprouts	Black rot	Minute brown specks and leaves turn yellow and drop.	Rotation. Clean seed. Hot water seed treatment. 122°F–20 min.
Cabbage Cauliflower Kale	Club root	Large irregular swellings on roots. Stunted plants.	Lime to make soil slightly alkaline. Use Terrachlor 3 lbs/50 gal. in transplanting water.
Kohlrabi	Downy mildew	Mildew is visible on the under side of the leaves with yellowing above.	Insoluble copper sprays or chloronil in seedbed. Zineb or maneb spray.
	Fusarium yellows	Yellow-green leaves. Stunted plants. Lower leaves drop.	Grow resistant varieties such as Jersey Queen, Resistant Detroit, Marion Market, Badger Market, Globe, Wisconsin, Ballhead and Wisconsin All-season.

Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES (Continued)

CROP	DISEASE	DESCRIPTION	CONTROL
	Mosaic	Mottled distorted leaves, plants stunted.	Control aphids. Rogue out diseased plants.
Carrot	Leaf blight	Black or brown spots on leaves and stalks. Older leaves dry and die.	Insoluble copper. Zineb, maneb or ziram spray.
	Yellows	Yellow young leaves. Red and twisted old leaves.	Control leaf hoppers with Malathion; 2 tablespoons per gallon of water.
Cassava	Die-back	Lesions on leaves and die-back of twigs and branches.	Try zineb or maneb sprays.
	Leaf spot	Brown or light brown spots.	Try maneb spray.
	Rust	Small circular spots on leaves.	Try ferbam or zineb sprays.
Celery	Celery mosaic	Clearing of veins, petioles shortened, plants stunted.	Control aphids.
	Early blight	Small, circular, yellow brown spots on old leaves.	Fixed copper, dyrene, maneb, nabam with zinc sulfate. Growth resistant variety, Emerson Pascal.
	Fusarium yellows	Yellow leaves, stunted plants.	Grow resistant varieties as Michigan Golden, Florida Golden or Forbes Golden Plume. Green celeries are generally resistant.
	Pink rot	Water soaked spots and white to pink cottony growth at base of stalk.	Rotation. Remove and destroy diseased plants, calcium cyanamid 1,000 lb. per acre a month before planting.
Corn	Bacterial wilt	Wilted and dwarfed plants. Yellow slime oozes from cut stalk.	Grow resistant varieties as Stowell's Evergreen, Golden Cross Bantam, Marcross, Spancross or Whipcross.
	Corn stunt virus	Yellowing of leaves, stunting and lack of grain.	Control of vector *Dalbulus maidis*. Grow resistant varieties.
	Helminthosporium leaf blight	Narrow lesions 1–5 in. long on leaves.	Rotation, seed treatment, zineb or maneb spray.
	Seedling decay and seeding blight	Seeds decay in soil. Young plants die.	Treat seeds with thiram dust at 5 1/2 oz. per 100 lbs.
	Smut *See Photo Fig. 80.*	Large white galls on stalks, ears and tassels.	Remove galls and destroy.
Corn	Stalk rot	Stunting and weakening of plant.	Rotation.
Cucumber	Anthracnose	Reddish brown, circular spots on leaves, elongated, tan cankers on stems, sunken spots on fruits.	Treat the seeds with 1:1,000 corrosive sublimate. Spray with Ziram and captan on young plants and maneb on older plants.
	Bacterial wilt *See Photo Fig. 81.*	Large vines wilt and die. Young plants die rapidly.	Control beetles with aldrin. Remove and destroy wilted plants.
	Damping-Off	Young seedlings wilt and die.	Treat seeds with thiram dust at 3 oz. per 100 lbs.
	Downy mildew *See Photo Fig. 82.*	Yellow, angular spots on older leaves. Leaves dry, curl and die.	Ashley, Pixie or Palomar or use maneb after runners form.
	Gummy stem blight	Gummy exudations and wilting of vines, often where they touch water.	Plant in clean ground. Some varieties are more tolerant.

Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES (Continued)

CROP	DISEASE	DESCRIPTION	CONTROL
Cucumber (cont.)	Mosaic *See Photo Fig. 83.*	Mottled (green and yellow) and curled leaves. Warty, misshapen and spotted fruits. Stunted plants.	Grow resistant slicing cucumber varieties as Ashley, Niagara, Challenger, Ohio MR 200, Tablegreen MR, Sensation Hybrid or Ohio MR 17. Ohio MR 25, Yorkstate Pickling or Wisconsin SMR 12 as pickling varieties.
	Root knot nematodes	Galls on roots, stunted plants.	Treat soil with nematocide or use rotation.
	Scab	Sunken, dark-brown spots on fruits. Gummy substance oozes from fruits.	Grow scab resistant cucumber varieties as Highmoor, a slicing variety, or Wisconsin SR 6 and Wisconsin SMR 12, pickling varieties.
Eggplant	Damping-off	Young seedlings wilt and die.	Use 1 tbsp./gal. of Captan 50 to water seedlings. Treat seeds with thiram at 4 oz. per 100 lb.
	Fruit rot	Brown and shrunken stems at soil line. Brown or gray spots on leaves. Large ringed circular brown spots on fruit.	Grow resistant varieties as Florida Beauty or Florida Market.
	Phomopsis blight	Canker at base of stem. Sunken areas on fruit.	Hot water seed treatment plus chloranil. Spray with insoluble copper; resistant varieties.
	Verticillium wilt	Slow wilting and stunting of plants.	Do not rotate with tomatoes or potatoes.
	Yellows	Conspicuous yellowing from tip downward.	Dust with sulfur at weekly intervals in seedbed.
Lettuce	Aster yellows	Yellowing, curling and twisting of inner leaves.	Control leaf hoppers with Malathion, 2 tablespoons per gallon.
	Big vein	Whitening along veins which thicken or crinkle.	Fumigate seed bed. No resistance known.
	Downy mildew	Yellowish spots on upper side and white mold below.	Spray with nabam plus zinc sulfate or zineb.
	Drop	Wilting of outer leaves; soft rot on stems and old leaves.	Avoid poorly drained soils. Plant lettuce on lifted beds. Rotation, deep plowing.
	Mosaic	Mottling of leaves and stunting of plant.	Use disease-free seed and control aphids with Malathion, 2 tablespoons per gallon.
	Tipburn	Margins of leaves turn brown and dry.	Grow tip burn resistant varieties such as Great Lakes, Cornell 456 and Pennlake.
Lima bean	Bacterial spot Downy mildew Leaf blight or Podspot	White downy mold in patches or covering the entire pod, a purple border between healthy and diseased portions.	Spray with maneb or zineb.
Muskmelon	Anthracnose	Vines are defoliated, young fruits die.	See Cucumber.

Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES (Continued)

CROP	DISEASE	DESCRIPTION	CONTROL
Muskmelon (cont.)	Bacterial wilt	Entire plant wilts and dies.	See Cucumber.
	Damping-off	Stem is watersoaked and plant falls over and dies.	See Cucumber.
	Downy mildew	Irregular brownish spots on older leaves. Leaves dry, curl and die.	Grow resistant varieties as Smith's Perfect, Seminole, Georgia 47, Edisto and Home Garden.
	Gummy stem blight (*Mycosphaerella citrullina*)	Brown gummy exudates on stems; vines are girdled and wilt.	Rotation, seed treatment spray with Dithane M45.
	Leaf spot	Small, round, brown spots on leaves.	Rotate crops, spray with fixed copper.
	Mosaic	Mottled (green and yellow) and curled leaves, stunted plants.	Kill perennial weeds, control aphids and striped cucumber beetle with malathion, 2 teaspoons per gallon of water.
	Powdery mildew	Powdery mold on upper surface of leaf.	Karathane, Resistant varieties: PMR 45, 5, 6, Georgia 47, etc.
	Root knot	Stubby root system. Plant stunted and yellow.	See Cucumber.
Okra	Verticillium wilt	Yellow and wilted leaves, stunted plants.	Only grow okra once every three years.
Onion	Downy mildew	Elongated gray spots.	Spray with nabam plus zinc sulfate, dyrene or maneb.
	Pink root	Roots turn pink and later black. May stunt plants and prevent bulbing.	Grow resistant varieties.
	Purple blotch	Water soaked spots, at first brown, later purplish.	Same as for downy mildew.
	Smut	Black blisters filled with masses of fungus on leaves. May kill young plants.	Rotation. Use formaldehyde solution on soil—1 teaspoon to 1 quart of water.
	Sunscald or blast	White necrotic areas on leaf and tips. Appears at high temperatures.	Same as for downy mildew to prevent secondary infection.
Peas	Bacterial blight	Large water soaked spots on pods, irregular dark spots on leaves.	Purchase disease-free seed from low rainfall areas.
	Fusarium wilt	Yellowed leaves, wilted plants. Inside of stems are lemon yellow.	Grow wilt resistant varieties as Alaska, Improved Gradus, Dwarf Alderman, Alderman and Teton.
	Root rot	Yellowish, unhealthy plants, yellowish brown, red or black stems below ground and roots.	Rotation. Use well drained soil or plant peas on raised beds.
	Seed decay	Seed rots in soil.	Treat seeds with thiram dust at 3 oz. per 100 lbs.
Peas (Southern) Cowpea, Blackeyed pea	Ashy stem blight	Sunken cankers near base of stem at warm temperatures.	Treat seeds with Ceresan. Resistant varieties.
	Fusarium wilt	Tap root bright red, firm and turgid.	Grow resistant varieties.
	Leaf blight	Small reddish brown circular spots on leaves.	Spray with insoluble copper or zineb.
	Powdery mildew	White powdery mold on leaves.	Spray with sulfur.

Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES (Continued)

CROP	DISEASE	DESCRIPTION	CONTROL
Pepper	Anthracnose *See Photo Fig. 84.*	Large, dark-brown or black spots on fruits.	Plant clean seed. Use zineb spray.
	Bacterial leaf spot *See Photo Fig. 85.*	Small, yellowish-green spots on young leaves. Spots 1/8 to 1/4" in diameter with dead brown centers with dark margins on older leaves. Rough corky spots on fruits.	Treat seeds for 5 minutes in a 1:2,000 corrosive sublimate solution. Treat seed with dichlone or thiram dust of 4 oz. per 100 lbs. Spray with insoluble copper.
	Blossom-end rot	Light-colored sunken, water soaked spots near blossom end of fruits. One-third of fruit may become dark and shriveled.	Avoid excessive use of nitrogen. Use ample amounts of superphosphate and lime. Always maintain even soil moisture.
	Cercospora leaf spot	Circular, water soaked spots 1/4 to 1/2" in diameter. White centers and dark margins.	Treatment same as for bacterial leaf spot.
	Damping-off	Seed decay in soil. Young plants wilt and die.	Treat seeds with dichlone and thiram dust at 4 oz. per 100 lbs.
	Fusarium wilt	Wilting and death of plants.	Good drainage; plant on ridges.
	Mosaic	Mottled green and yellow and curled leaves. Fruits are sometimes yellowed or show green ring spots. Stunted plants.	Grow resistant varieties as Keystone Resistant Giant, Liberty Bell, Yolo Wonder and Rutgers World Beater No. 13.
Potato	Blight-early	Leaves show small, irregular, dark brown spots which enlarge and have target-like markings.	Plant disease free tubers. Spray every 10 days with a fixed copper or maneb.
	Blight-late	Dark, irregular dead areas on leaves and stems. Disease kills plants early in the season.	Plant disease free tubers. Grow resistant varieties as Sebago, Saco, Kennebec, Pungo, Essex, Ona, Merrimac, Florita, Gabriela and Conchita.
Potato	Leaf roll	Upward rolling of lower leaves. Yellow and stunted plants. Brown specks in tubers.	Plant disease free tubers. Grow resistant varieties. Katahdin and Saco are resistant to tuber discoloration and have some resistance to leaf rolling. Kennebec, Sebago and Chippewa are resistant to tuber discoloration. Grow certified seed.
	Mosaic	Mottled light and dark green and curled leaves, stunted plants.	Grow resistant varieties as Cherokee, Chippewa, Katahdin, Kennebec, Pungo, Saco and Sebago.
	Rhizoctonia scurf	Black glistening sclerotia from 1/4" in diameter to continuous masses on tubers. Can cause decay of shipping bags in tropics.	Treat seed pieces with bichloride of mercury.
	Scab *See Photo Fig. 86.*	Rough, scabby, raised or pitted spots on tubers.	Grow resistant varieties as Cayuga, Cherokee, Early Gem, Menominee, Ontario and Seneca.
Spinach	Blight or yellows	Yellow and curled leaves, stunted plants, low yields.	Grow resistant varieties as Virginia Savoy and Old Dominion.
	Blue mold	Yellow spots on upper surfaces of leaves. Downy, purple or blue-colored mold on undersides of leaves.	Grow Wisconsin Bloomsdale, Badger Savoy, etc.

Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES (Continued)

CROP	DISEASE	DESCRIPTION	CONTROL
	Seed decay	Seed rots in soil.	Hot water treatment, 122°F for 25 minutes. Dust with thiram at 4 oz. per 100 lbs. of seed.
	White rust	White pustules on underside of leaf.	Spray with zineb or maneb.
Squash	Bacterial wilt	See Cucumber.	See Cucumber.
Squash or Pumpkin	Mosaic	Yellow spots on leaves and sometimes on fruit.	Remove and destroy diseased plants. Control aphids and cucumber beetles with 2 teaspoons of malathion in 1 gallon of water.
	Scab	See Cucumber.	Do not grow cucumbers or squash in same soil oftener than once in 3 years.
Sweet-potato	Black rot or foot rot	Black, sunken, roundish spots on sweet potatoes. Black cankers on underground parts of stem.	Use plants with clean, white roots. Remove and destroy diseased plants. Do not plant sweet potatoes in same soil every year. Soak in solution of 5 lb. borax in 30 gal. of water.
	Internal cork	Dark brown corky areas in tubers, slight mottling of leaves.	Resistant varieties such as Allgold, Nancy Hall, Ranger, etc., should be planted.
	Pox	Small dark, dry spots on surface of potato.	Rotation, clean seed, adjust soil to pH 5.0 to 5.2.
	Root rot	Yellowing and stunting or dying of the foliage.	Rotation. Use clean seed. Use certified seed.
	Scurf	Small brown specks on roots that spread under favorable conditions.	Use clean seed and plant in clean seed bed. Use certified seed.
	Stem rot or wilt	Yellow and wilted plants. When cut across, stems have a black discoloration and roots have a black ring.	Same control as for black rot.
Taro	Blight (*Phytophthora colecasiae*)	Enters bruises. Therefore walk through field as little as necessary.	Basic copper spray at 2 week intervals, 5–10 months after planting.
Tomato	Anthracnose	Small, circular, sunken spots on the fruit.	Spray with zineb, maneb or ziram.
	Bacterial canker	Spots on fruits are superficial, circular, slightly raised, white rings with red dot in center.	Hot water, 122°F for 25 min., seed treatment plus dusting with dichlone or ceresan M and fumigate seed bed.
	Bacterial speck or spot	Numerous black stipples on fruit and leaves.	Same as for bacterial canker. Spray every 7 days with insoluble coppers.
	Bacterial wilt	Wilting and death of plants. Milder infections cause protuberances on stem.	Good drainage. Graft on resistant species. Resistant varieties when available.
	Big bud	Witches' broom effect at nodes. Enlarged calyx with no fruit.	Destroy diseased plants and solanaceous weeds.
	Blight-Early	Leaves show small irregular dark-brown spots which enlarge into circular spots with target-like markings. Brown cankers on stem. Dark decayed spots at stem end of fruits.	Spray with maneb every 7 days. (Will burn young plants. Do not use in seed bed or starter solution.) Use Parzate in the seed bed and for a starter solution.

Table 8. SUGGESTED DISEASE CONTROL FOR VEGETABLES (Continued)

CROP	DISEASE	DESCRIPTION	CONTROL
Tomato (cont.)	Blight-Late *See Photo's Fig. 87 and Fig. 88*	Dark water-soaked spots on leaves, large water-soaked spots on fruits, white growth on underside of leaves. Spots on fruits turn brown and leaves wither.	Spray with Phygon XL every 7 days.
	Blossom end rot	Small to large decayed spots at blossom end.	Avoid droughts or moisture stress.
	Fusarium wilt	Gradual yellowing and wilting of foliage. Browning of woody tissue under the outer green portion of stem. Plants may die.	Grow wilt resistant varieties as Pan America, Southland, Jefferson, Manalucie, Homestead, Indian River, Manapal, Urbana or Roma.
	Gray leaf spot	Small spots that have light centers and dark margins on leaves, dark specks in center of spots. Leaves may be killed. Low yield.	Grow resistant varieties as Indian River, Manapal or Floralou. Spray with maneb or zineb.
Tomato	Leaf mold	Mildew like fungus destroys leaves in wet weather.	Grow resistant varieties. Spray with maneb or zineb.
	Cercospora leaf mold	Yellowing on upper surface of leaf with yellow mold beneath.	Dwarf Stone & Marglobe resistant. Use maneb, zineb or fixed copper.
	Cladosporium leaf mold	Yellowing of upper leaf surface with dark mold on under surface.	Ziram and resistant varieties, Bay State, Globelle, Vetomold, Waltham M. Proof, Indian River.
	Mosaic	Mottled green and yellow and curled leaf foliage, stunted plants, low yields.	Caused by tobacco mosaic virus. Do not smoke while working with tomatoes.
	Root knot nematode	Galls or swelling on roots, stunted plants.	Grow resistant varieties as Hawaiian varieties: Anahu, Kolea and hybrids.
	Spotted wilt	Leaves turn brown and droop. Also dieback from tip.	Grow tomato 100 yds. or more from weeds or flowers.
	Verticillium wilt	Stem is shortened, whole plant may wilt and die.	Grow resistant varieties as Red Top V9, CPC–2, Porte, H1350.
Watermelon	Anthracnose *See Photo Fig. 89.*	Round, water-soaked spots on fruit, dark spots on leaves. Spots on fruits are small and raised at first, later they are larger and sunken.	Grow resistant varieties such as Charleston Gray, Congo, Fairfax and Blackstone. Spray maneb, zineb or fixed copper every 7 days.
	Root knot nematodes	Galls or swellings on roots. Stunted plants.	Rotation. Treat soil with Nematocide.
	Wilt	Stunted seedlings, wilted vines, low yields, plants die. Wilting starts at tips of runner and spreads to entire vine.	Grow resistant varieties as Kleckley No. 6, Improved Stone Mountain No. 5, Fairfax, Charleston Gray, Miles, Hawkesbury, Missouri Queen, Leesburg, Klondike R–7, and Baby Klondike.
Yam	Anthracnose	Leaf spots enlarge rapidly, eventually destroying whole leaf.	Spray with maneb or zineb. Use resistant varieties.
	Cercospora leaf spot	Large areas of leaf destroyed.	Spray with maneb or zineb.

[1] Part of the information in this table was obtained from U.S.D.A. Farmers' Bul. 46. "Insects and Diseases of Vegetables in the Home Garden, (1963)." Recommendations on disease control are always changing due to recent research, and new releases of this publication should be requested every year.

Figure 79. ANTHRACNOSE ON BEAN PODS. SPORES ARE PRODUCED IN THE CENTER OF THE DARK SPOTS. U.S.D.A. Photograph.

Figure 80. CORN PLANT AFFECTED BY SMUT. THE LARGE BLISTER-LIKE GROWTHS CONTAIN MASSES OF DARK FUNGUS SPORES. *U.S.D.A. Photograph.*

Figure 81. BACTERIAL WILT OF CUCUMBER. THE WILTING BEGINS IN A SINGLE BRANCH AND EVENTUALLY KILLS THE PLANT. ***U.S.D.A. Photograph.***

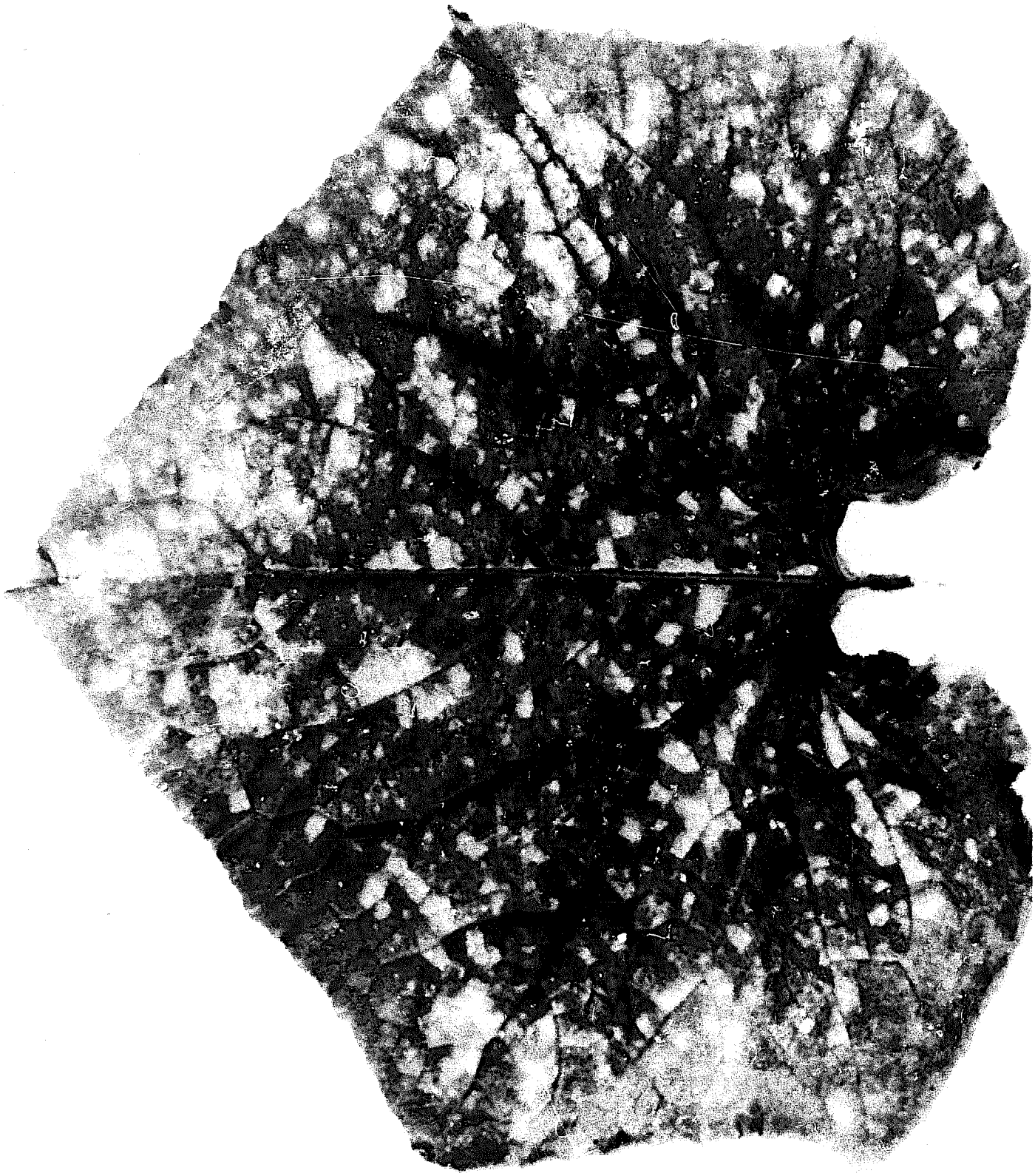

Figure 82. EARLY STAGES OF DOWNY MILDEW ON CUCUMBER LEAF. THE SPOTS ARE YELLOW-GREEN AND EVENTUALLY KILL THE OLDER LEAVES. U.S.D.A. Photograph.

Figure 83. CUCUMBERS SHOWING DARK, WARTY SWELLINGS AND MOTTLING CAUSED BY THE CUCUMBER MOSAIC VIRUS. LEAVES OF INFECTED PLANTS ARE MOTTLED WITH YELLOW-GREEN. U.S.D.A. Photograph.

Figure 84. ANTHRACNOSE SPOTTING OF PEPPERS. *U.S.D.A. Photograph.*

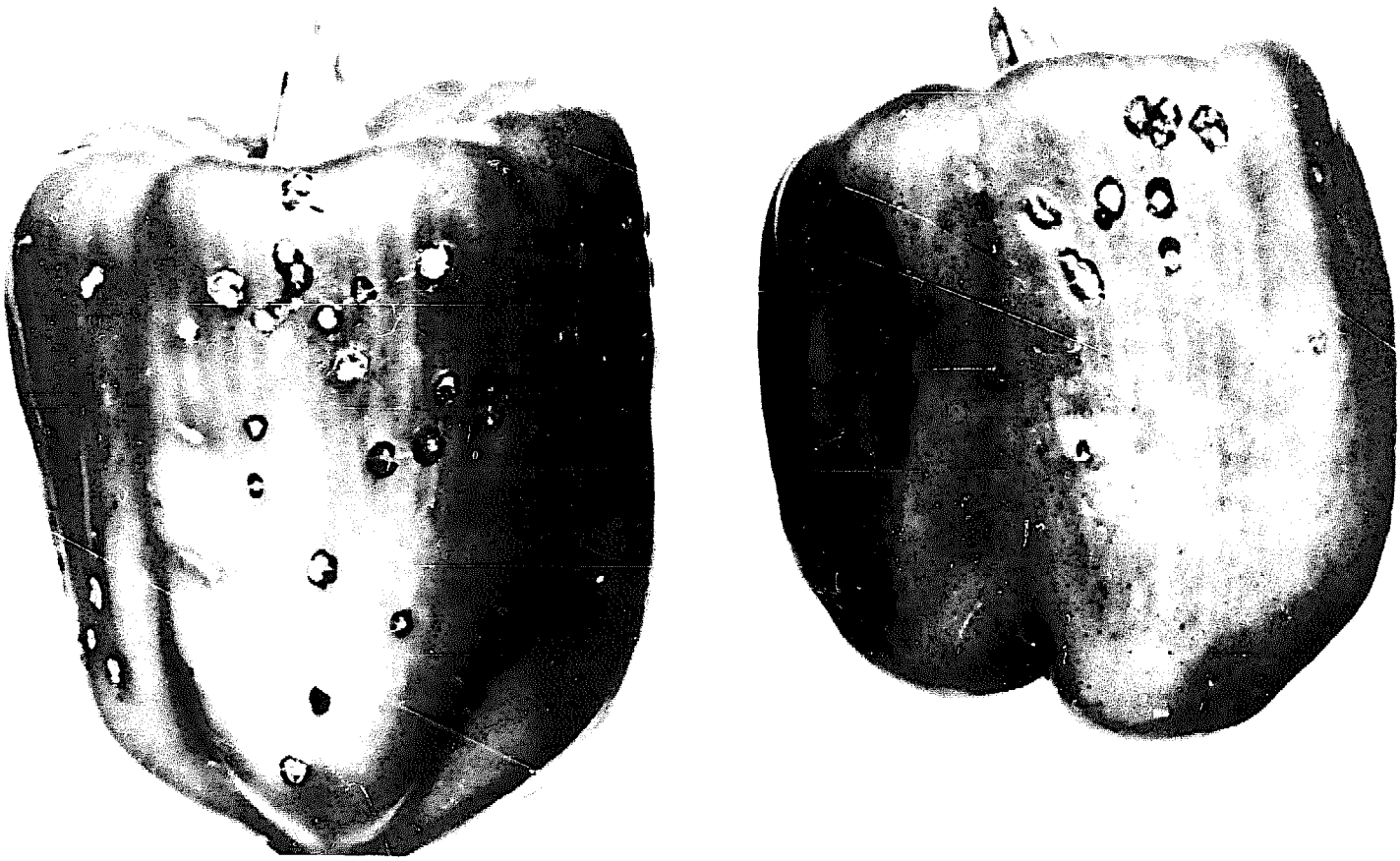

Figure 85. BACTERIAL SPOT ON PEPPER. THE SPOTS ARE SLIGHTLY RAISED AND HAVE A CRACKED, ROUGHENED SURFACE. *U.S.D.A. Photograph.*

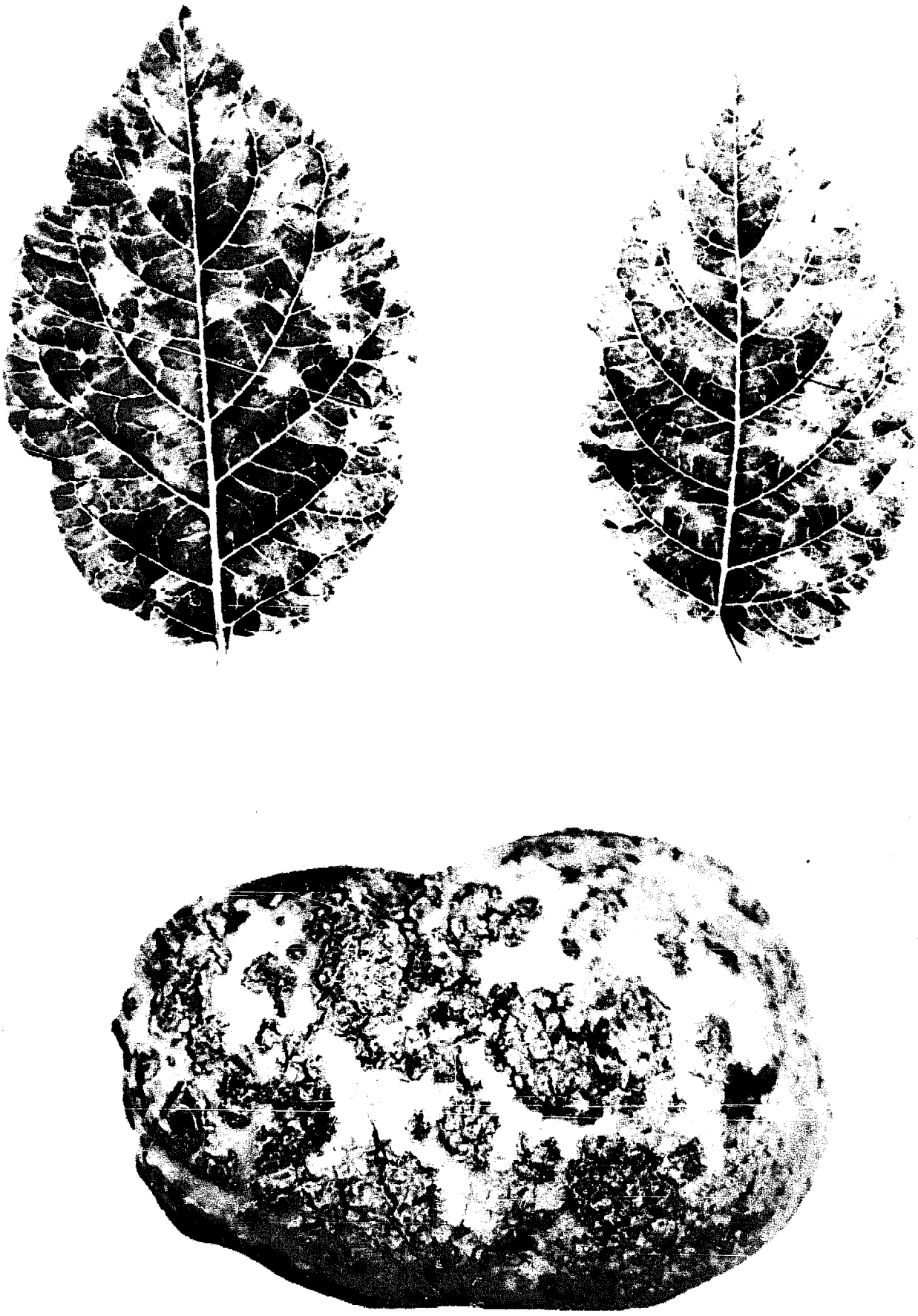

Figure 86. POTATO TUBER SHOWING SEVERE INFECTION OF SCAB AND LEAVES OF THE GREEN MOUNTAIN VARIETY AFFECTED WITH MILD MOSAIC. NOTE YELLOW PATCHES ON LEAVES. U.S.D.A. Photograph.

Figure 87. TOMATO LEAF SHOWING DARK, WATER-SOAKED SPOTS CHARACTERISTIC OF LATE BLIGHT. U.S.D.A. Photograph.

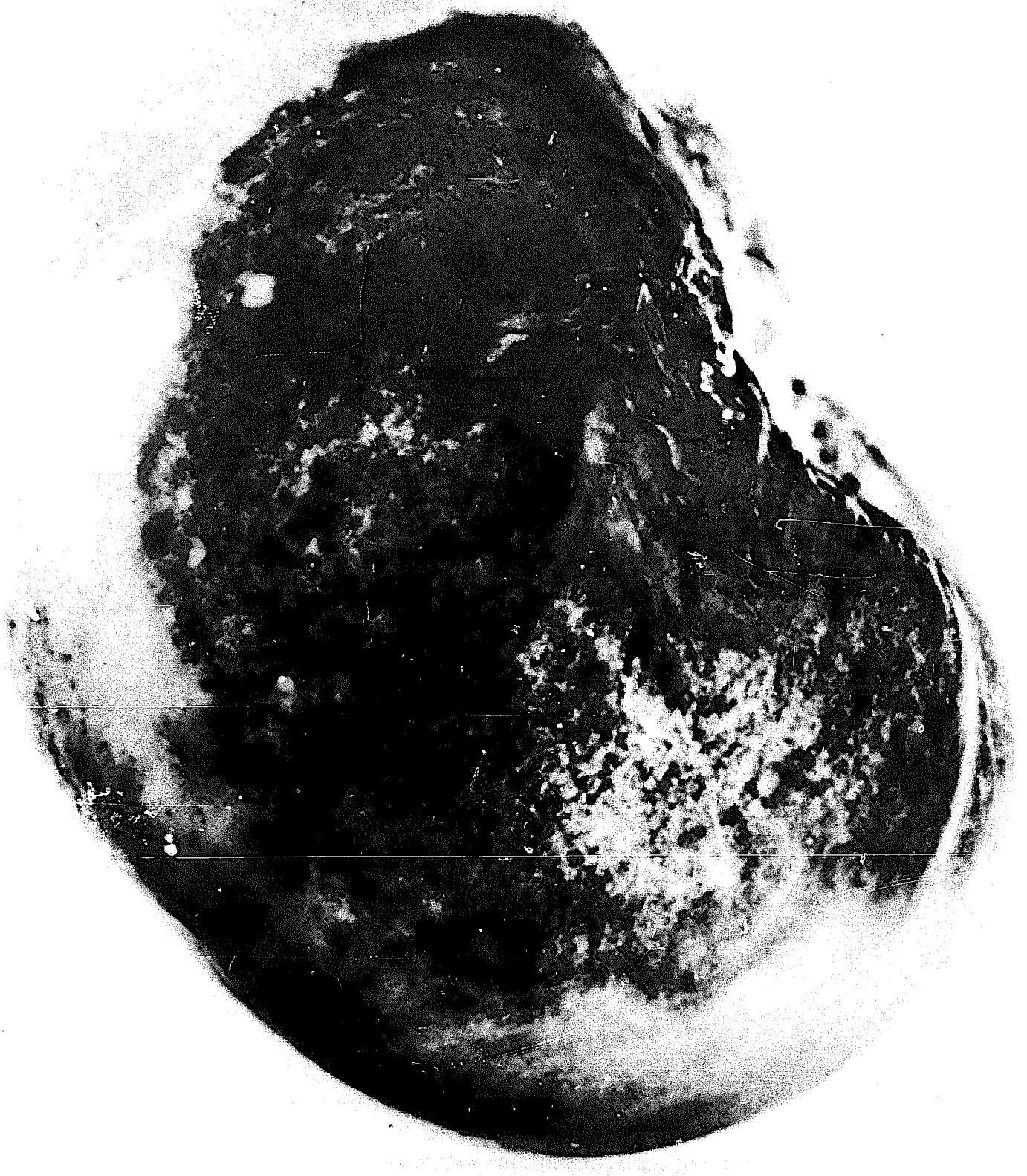

Figure 88. LATE BLIGHT ROT OF TOMATO. THE SPOT IS FIRM AND HAS A WRINKLED SURFACE. U.S.D.A. Photograph.

Figure 89. WATERMELON FRUIT SHOWING SHRIVELING AND DECAY CAUSED BY STEM END ROT. U.S.D.A. Photograph.

Chapter 5

WEEDS AND THEIR CONTROL

Weeds are defined as plants out of place. Even useful plants may become weeds when they occur in areas where they are not wanted. In the Tropics where rainfall is excessive, weeds such as nutsedge (*Cyperus* spp.), bindweed (*Convolvulus arvensis*) and bermuda grass (*Cynodon dactylon*) may become so well established as to prevent crop production. In areas of low rainfall where irrigation is practiced, weed seeds produced along the ditch banks are carried to the fields in the irrigation water where they germinate and compete with the intended crop.

Weed control, including the loss of yields and reduced quality, ranks among the highest costs of crop production and certainly among the most important (7). The annual cost of weeds was estimated to be 3 to 5 billion dollars to United States in 1951 (1). In 1966 it was estimated to be five billion dollars. This damage to crops includes competition for moisture, nutrients and space, reduction of quality, harboring insects, diseases and nematodes. The heaviest competition is in the first 30 to 90 days of the crop. Weeds are not only rapid growing but also have high requirements for moisture and nutrients (5, 6, 17, 20). Some weeds use 2 to 3 times as much moisture as the crop being grown and are also heavy feeders.

Hundreds of species of weeds exist in various parts of the world. Some of the ones that are most widely spread are listed in Table 19. These are listed by their scientific names because the common names are different in each country. Thirteen perennial weeds and 19 annual species are included, three of which are parasitic. Many species important in local areas could be added. For example, a grass (*Imperata cylindrica*) is very serious pest in cultivated fields in South Asia. Another grass (*Hyparrhenia rufa*) can be troublesome in Central America.

Weed control is basic to efficient crop production. This may be accomplished in a number of ways. Hand pulling or cutting is the most primitive and has become too expensive to use in many countries. In developing countries where capital is lacking to purchase machinery or chemicals it may be the only method that can be used until purchasing power improves.

Mechanical control consists of hoeing, mowing, disking, plowing and cultivation. Control efforts are mainly to (1) prevent seed formation, (2) to avoid transporting weed seeds or roots and (3) to prevent top growth on perennials. Most farmers do not realize how rapidly weeds can multiply when they are allowed to go to seed. One plant can produce hundreds of thousands of seeds and cause heavy expense in weed control the following season. Since only a few weeds are spread by roots or cuttings the prevention of seed formation will automatically prevent spread of most weed species. Controlling weeds in the crop is not enough as the weeds allowed to seed on the borders or along the irrigation ditches can sow the whole field the next year.

The mechanical controls such as hoeing or cultivating must be done when the weeds are small, to be effective. Weeds are killed more easily in the seedling stage. Some species of rapidly growing annuals may produce seed within a few weeks after emergence. Control should be early before seeds are formed. In addition, weeds are much easier to destroy in the early stages.

Preventing weed seed from entering the farm on machinery, in packing materials, in hay or litter for livestock, in animal manures, by the wind and in irrigation water requires constant attention. Crop seeds may carry weed seeds. It is important to plant clean seed. Animal manures used for fertilizers are responsible sometimes for heavy weed infestation.

Perennial weeds are difficult to control. In countries where the wooden "point" plow is used, the deep-rooted perennial weeds escape and actually thrive from the plowing. Well-established perennial weeds can be controlled mechanically only by frequent cutting or cultivating. The first 10 days of new growth is at the expense of the rootstocks but after about 14 days the leaves begin to send food

back to the roots. The principle of control is to keep the tops cut off at 10 to 14 day intervals. This will eventually destroy the root reserves and weaken the weed plants so that they die. Bindweed can be controlled in one season in this way (20). This method also has controlled bermuda grass in one season. Since perennials also grow from seed it is important to avoid reinfestation from outside the field after it has been cleared.

Another good practice where sufficient water is available is to irrigate the land before planting to allow the weeds to sprout. Then these can be destroyed by harrowing or disking before planting. Another practice in areas where rains are scarce is to plant the crop deep leaving a dry mulch through which the weed seeds will not germinate.

Clean seeds are highly important. The use of certified seed has become a standard practice in most of the United States and pure seed laws are in effect in nearly all states. Similar laws should be encouraged in all countries.

Rotation of row crops with broadcast crops will aid in weed control if cultivation is practiced on the row crop. Flooding for 60 days will kill weeds but no horticultural crop will tolerate flooding (3).

Smothering by the use of paper mulches, straw or other materials can be used if the crop returns justify the cost. Smother crops are also possibilities for controlling some weeds that cannot tolerate shade. Bermuda grass areas have been controlled with a sweet potato crop. Fertilizers have been used on the theory that the crop will respond more readily than the weeds. This is expensive and generally not effective (18).

Geese or other poultry have been used at times when labor was scarce (14). This involves fencing, markets for the poultry and the possibility of damage to crops.

The rapid development in recent years of herbicides for the control of weeds in crops in the United States has made the use of chemicals the most important means of weed control in the United States. The sale of chemicals for herbicides now exceeds that of insecticides or fungicides.

The most successful of these are pre-emergence chemicals that are applied to the land to kill the young weed seedlings as they emerge. If applied at the proper dosage the crop is able to emerge and grow. Some of these are trifluralin, DNBP, EPTC, amiben, CDEC, calapon, and pebulate. These will be found in Table 11 which gives also representative trade names. The actual use of crops is given in Table 12.

Chemical weed-control methods save labor and may be effective if care is exercised in their use. Since labor is less expensive in the Tropics than in the temperate regions, it is best to consider the economy of weed control before starting investigations with chemicals.

If chemicals are used for weed control, certain precautions should be taken:

1. Always follow the recommendations of the manufacturer.
2. Be careful that there are no residues on the harvested product.
3. Soil moisture is necessary for effective action of pre-emergence sprays.
4. Smaller rates are desirable on light soils and higher rates on heavy soils.
5. When using wettable powders, agitate the liquid during spraying.
6. Band application should be used on widely spaced crops to save on the cost of the herbicide.
7. Use pre-emergence oils and oil emulsions at 20 to 60 gallons per acre and at 40 to 80 pounds per square inch pressure.

When using the same sprayer for insecticides, fungicides and herbicides, it is very important to be sure that the sprayer is clean after an herbicide application, as a small amount in the tank may kill vegetable crops. Water is sufficient to clean a sprayer for some herbicides, but for other herbicides, a cleaning solution is desirable. One can use 5 lbs. of tri-sodium phosphate, 1 gal. of household ammonia and 5 lbs. of sal soda in 100 gal. of water. This should be mixed well with water and left in the sprayer for 36 hours, then should be pumped through the sprayer. The sprayer should be rinsed several times with water after this.

If 2,4–D has been used in a sprayer, it is desirable not to use the sprayer for other insecticides, fungicides or herbicides as it is very difficult to remove 2,4–D from a sprayer. If a copper spray is used before a herbicide, put 1 gallon of vinegar in 100 gallons of water and let it stand in the sprayer for 2 hours before using it. The sprayer then should be rinsed thoroughly.

New information and new chemicals are being released continually. It is well to check on the lastest recommendations before making any large purchases.

Some of the newer herbicides are picloram

(tardon) which is more toxic than 2,4–D or 2,4,5–T and trifluralin (treflan) which is finding a wide use against seedlings of many weed species. Dalapon for grass weeds and monuron for quackgrass control are being more widely used (20, 2, 8, 12). Herbicides may behave somewhat differently in the Tropics than they do in temperate zones (17).

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Table 9. FRUIT DISEASES AND SUGGESTED CONTROL

CROP	DISEASE NAME		SYMPTOMS	CONTROL	REFERENCE[1]
	COMMON	SCIENTIFIC			
Apples	Scab	*Venturia inaequalis*	Spoils fruits for market.		(17)
Avocado	Root rot	*Phytophthora cinnamomi*	Causes wilting and death of trees	Good drainage.	(31)
Bananas	Panama disease	*Fusarium oxysporum var. cubense*	Causes wilting and death of trees by destroying roots.	Resistant varieties.	(4) (29)
	Sigatoka	*Mycosphaerella musicola*	Causes yellow spots and dead areas on leaves	Spray with light oil in mist spray at 1 to 1½ gal/acre.	(26)
	Freckle disease	*Macrophoma musae*	Discolors fruits and causes uneven ripening.	Maneb spray every 2 weeks.	(13)
	Moko bacterial wilt	*Xanthomonas solanacearum*	Causes wilt; occurs in wild Heliconia plants.	Remove male flowers of Heliconia near plantation.	(3) (4) (29)
Betel nut	Koleroga	*Botryobasidium*	Attacks green fruits and foliage causing them to drop.	Try M45 Spray or Bordeaux.	(22)
	Foot rot	*Ganoderma lucidum*	Trees wilt as though suffering from drought.	Remove infected trees.	(22)

[1] For references, see page 117

Table 9. FRUIT DISEASES AND SUGGESTED CONTROL (Continued)

CROP	DISEASE NAME COMMON	DISEASE NAME SCIENTIFIC	SYMPTOMS	CONTROL	REFERENCES
Cacao	Witches' broom	*Marasmius perniciosus*	Causes abnormal branching; fruits drop.	Pruning; resistant hybrids.	(5)
	Swollen shoot	Virus complex	Branches swell and yellow spots appear on mature leaves.	Remove infected trees; lindane spray. Selections from Amazon are resistant.	(5)
	Cushion gall	*Fusarium decemcellulare* and *F. roseum*	Forms a gall on seedlings and adult trees through seeds and wounds.	Resistant varieties.	(8)
Citrus	Gummosis	*Phytophthora parasitica*	Attacks near ground and trees may die.	Prune and paint with Bordeaux paste.	(12)
	Tristeza	Virus	Wilting and death of tree.	Resistant root stocks. Clean budwood.	(6)
	Exocortis	Virus	Causes scaly bark of root-stock and death of tree.	Resistant root stocks. Clean budwood.	(6)
	Aerial gummosis	*Physalospora rhodina*	Gumming and death of twigs and branches.	Spray with Captan. Avoid pruning.	(12)
Coconut	Bud rot	*Phytophthora palmivora*	Causes wilting and death of terminal bud.	Pruning and burning. Maneb spray.	
	Red ring	*Aphelenchoides* nematodes	Rapid wilting of leaves and red ring in trunk.	Clean pruning. Good drainage.	(5)
	Cadang Cadang	Probably virus	Yellow mottle and decline; palm finally dies.	Suggest weed control.	(15)
Coffee	Rust	*Hemileia vastatrix*	Affects leaves.	Copper sprays.	(30)
	Leaf-spot	*Mycena citricolor* (*Omphalia flavida*)	Causes defoliation in American tropics.		(30)
Grape	Anthracnose	*Elsinoe ampelina*	Circular spots on fruits and young shoots.	Copper or zineb sprays.	(16)
	Black rot	*Guignardia bidwellii*	Attacks new foliage and berries which turn black and mummify.	Copper sprays.	(16)
	Downy mildew	*Plasmopara viticola*	Yellow spots on leaves followed by white, moldy growth on under side of leaves.	Copper or zineb sprays.	(16)
	Powdery mildew	*Uncinula necator*	White powdery growth may cause defoliation.	Sulfur dust or spray.	(16)
	Root rot	*Phymatotrichum omnivorum*	Destroys roots and causes death of vine on alkaline, arid soils.	Resistant root stocks.	(16)
	Pierce's disease	Virus	Delayed foliation, gradual dying of roots and decline of vines.	No remedy. Use resistant varieties.	(16)
Guava	Fruit rot	*Glomerella cingulata*	Mummifies green fruit and rots ripe fruit.	Captan or copper sprays.	(1)

Table 9. FRUIT DISEASES AND SUGGESTED CONTROL (Continued)

CROP	DISEASE NAME COMMON	DISEASE NAME SCIENTIFIC	SYMPTOMS	CONTROL	REFERENCE [1]
Guava (Continued)	Mushroom root rot	*Clitocybe tabescens*	Rots roots and kills trees.	Remove infected trees.	(23)
Loquat	Fireblight.	*Erwinia amylovora*	Twigs die back.	Prune below dead areas.	(19)
	Scab	*Spilocaea eriobotryae* (*Fusicladium eriobotryae*)	Spoils fruits.	Copper spray at blossoming. Maneb spray every 15 days from petal fall.	
Lychee	Fruit rots		Spoils fruits.	Control fruit flies.	
Mango	Anthracnose	*Glomerella cingulata*	Dark spots on fruits	Captan spray.	(2)
Orange	See citrus				
Papaya	Mosaic	Virus	Transmitted by *Myzus persicae* from cucumbers and watermelons. Causes bitter flavor in fruits.	Malathion spray for Aphids. Remove infected plants.	(18)
	Anthracnose	*Glomerella cingulata* *Colletotrichum gloeosporioides*	Enters wounds in ripe fruit.	M45 spray at 10 day intervals.	(21)
	Dieback	Undetermined	Attacks crown and leaves causing rot.	Cut back below rotting stem.	(24)
	Stem-end rot	*Ascochyta caricae*	Affects young fruits causing them to drop and on mature fruits as black circular spots.	Spray with maneb.	(10)
	Root rot	*Phytophthora parasitica*, etc.	Plants wilt and die.	Set clean plants on well-drained land.	(27)
Passion Fruit	Mosaic	Virus	Transmitted from cucumbers by aphids (*Myzus persicae*)	Avoid cucumbers near plants.	(25)
	Wilt	*Fusarium oxysporum* var. *passiflorae*	Plants wilt and die.	Plant in clean soil.	(20)
Peach	Leaf rust	*Tranzschelia discolor*	Rust-like spots on leaves.	Suggest zineb or maneb spray.	(17)
	Brown rot	*Monilinia fructicola*	Rotting of fruit.		
Pepper, black	Foot rot	*Phytophthora palmivorum*	Affects roots and crown.	Grow grass between vines and prune lower branches.	(11)
Rubber	Anthracnose	*Glomerella cingulata*	Young leaves have dark spots with yellow border causing them to drop.	Resistant varieties.	(28)
	South American leaf blight	*Dothidella ulei*	Severe defoliation.		(14)
	Leaf spot	*Helminthosporium heveae*	Spotting on leaves causing them to drop.		(9)

[1] Numbers refer to list on separate page.

Table 10. COMMON WEEDS

Scientific	Common (English)[1]	Type[2]	Propagated by[3]	Descriptive Notes	Suggested Control
Agropyron repens	Quackgrass	P	S,R,C	Spreading grass	Frequent cultivation or Monuron, atrazine
Alhagi camelorum	Camel thorn	P	S	Erect, thorny, legume deep rootstocks	Clean cultivation
Amaranthus spp.	Pigweed	A	S	Erect, leafy, rapid growing	Clean cultivation or trifluralin pre-emergence treatment
Brassica spp.	Mustard	A	S	Broad leaf, rapid growing	Clean cultivation or 2, 4–D, DNBP
Cardaria draba	White top	P	S	Erect, creeping roots	Frequent cultivation
Cenchrus spp.	Sand bur Grass bur	A	S	Erect grass, spiny burs, mostly in sandy soils	Clean cultivation
Centaurea repens	Russian knapweed	P	S,R	Erect, creeping roots, purple flowers.	Clean cultivation
Chenopodium spp.	Lamb's quarters	A	S	Erect, gray foliage	Clean cultivation
Cirsium arvense	Canada thistle	P	S,R	Erect, creeping roots, prickly leaves, rose-purple flowers.	Frequent cultivation
Convolvulus arvensis	Field bindweed	P	S,R	Creeping vines	Frequent cultivation 2, 4–D spray
Cuscuta spp.	Dodder	A	S	Yellowish vine, parasitic	Frequent cutting or CIPC, DCPA
Cynodon dactylon	Bermuda or devilgrass	P	S,R,C	Creeping stolons making dense sod	Frequent cultivation or Dalapon spray, EPTC, dichlobenil
Cyperus rotundus	Nutsedge	P	S,R	Erect, quickgrowing	Frequent cultivation or summer fallow; dalapon, vernolate
Digitaria spp.	Crabgrass	A	S	Creeping decumbent	Clean cultivation or trifluralin, amiben, diphenamid 5, DCPA
Echinochloa spp.	Barnyardgrass	A	S	Erect, rapid growing	Clean cultivation or NPA spray, propanil, EPTC
Eleusine indica	Goosegrass	A	S	Erect, rapid growing	Clean cultivation or EPTC, CIPC, DCPA, trifluralin
Euphorbia esula	Leafy spurge	P	S,R	Erect, milky sap	Frequent cultivation
Fumaria officinalis	Fumitory	A	S	Decumbent, smoky green, red flowers, rapid growing	Clean cultivation or CDEC
Lamium amplexicaule	Henbit	A	S	Low, rapid growing	Clean cultivation or CDEC, pebulate, DNBP
Malva spp.	Mallow cheese weed	A	S	Broadleafed, bushy	Clean cultivation
Orobanche ramosa	Broom rape	A	S	Parasitic on roots, purple flowers	Hand pulling
Polygonum convolvulus	Black bindweed	P	S	Vines, heart-shaped leaves	Clean cultivation or 2, 4–D spray

Table 10. COMMON WEEDS (Continued)

Scientific	Common (English)[1]	Type[2]	Propagated by[3]	Descriptive Notes	Suggested Control
Portulaca oleracea	Purslane	A	S	Decumbent fleshy stem	Clean cultivation or CDEC, CIPC
Setaria spp.	Foxtail	A	S	Grass with dense spikes	Clean cultivation or amiben, trifluralin
Sonchus asper	Sow thistle	P	S	Prickly leaves	Clean cultivation or DNBP spray
Sorghum halepense	Johnsongrass	P	S,R	Tall grass, red glumes	Frequent cultivation or dalapon
Striga asiatica	Witchweed	A	S	Root parasite on corn, sorghum, etc.	Rotation
Trianthema portulacastrum	Horse purslane	A	S	Decumbent, broader leaf than Portulaca	Disk before planting
Tribulus terrestris	Puncture vine	A	S	Creeping, with spiny burs	Clean cultivation
Typha latifolia	Cattail	P	S	Rapid growing water plant	Prevent seeding
Urtica spp.	Nettles	A	S	Cause intense itching when touched	Clean cultivation or 2, 4–D

[1] Most weeds have different names in each language.
[2] A = Annual; P = Perennial
[3] S = Seeds; R = Roots; C = Cuttings

Table 11. SOME HERBICIDES USED ON VEGETABLE CROPS

COMMON NAME	ACTIVE INGREDIENTS	TRADE NAMES
Amiben	3-amino-2, 5-dichlorobenzoic acid	Vegiben
Atrazine	2-chloro-4, ethylamino-6, isopropylamine-s-triazine	Gesaprin Atrazine
CDAA	2-chloro-N, N-diallyl acetamide	Randox
CDEC	2-chloroallyl diethyldithio-carbamate	Vegadex
CIPC	Isopropyl N-3-chlorophenyl carbamate	CIPC
Dalapon	2,4-dichloropropionic acid	Dowpon
DCPA	Dimethyl 2, 3, 5, 6-tetrachloro-terephthalate	Dacthal
Dichlobenil	2, 6-dichlorobenzonitrile	Casoron
Diphenamid	N, N-dimethyl-2, 2-d, phenylacetamide	Dymid
DNBP	4, 6-dinitro-O-sec-butyl phenol	Premerge
EPTC	Ethydi-N-dipropylthiocarbamate	Eptam
Monuron	3-(pi-chlorophenyl)-1, 1 dimethylurea	Karmex-W
NPA	N-1 naphthylphthalamic acid	Alanap 3
Pebulate	N-propyl N=ethyl N-butylthiocarbamate	Tillam (R–2061)
Picloram	4-amino-3, 5, 6-trichloropicolinic	Tordon
Propanil		Stam F--34
Stoddard Solvent	Mixed hydrocarbons	Varsol, Sovarsol
Trifluralin	alpha, alpha, alpha-trifluoro-2, 6 dinitro-N-N-dipropyl-p-tolvidine	Treflan
Vernolate	N-propyl-di-N-propylthiolcarbamate	Vernam

Table 12. HERBICIDES FOR WEED CONTROL IN VEGETABLES

CROP	HERBICIDES[1]	TIME TO APPLY	COMMENT
Asparagus (seed bed)	DPBP	2 days before asparagus seedlings emerge.	Weeds must be visible for DNBP action.
Asparagus (mature)	Monuron	Before and after cutting.	Agitate well during application.
Beans	DNBP	Just before emergence.	Controls only annual weeds between 65–80° F. Incorporate in soil immediately after application.
Lima bean	EPTC	Just before emergence.	" " "
Soy bean	Trifluralin	Pre-emergence.	" " "
Beet	Stoddard Solvent 60–80 gal. per acre.	One day before emergence.	Controls annual weeds only.
	CIPC	At seeding time.	Controls annual weeds only.
	CDEC	Apply immediately after seeding.	1/2 to 1 inch of rain or irrigation is needed within 2 days after application.
Cabbage, Broccoli, Cauliflower	CDEC	Apply immediately after seeding.	1/2 to 1 inch of rain or irrigation is needed within 2 days after application.
Carrot, Parsley	Stoddard Solvent 75 gal. per acre.	When carrots have 2 to 4 true leaves.	Controls only annual weeds less than 2 inches high and when temperature is below 80° F.
Cassava	Amiben	At planting time.	Irrigation or rain is needed 10–14 days after application.
Celery	Stoddard Solvent 75–100 gals. per acre.	When plants have 2 true leaves.	See Carrot.
	CDEC	Post-transplant.	See Beet.
Corn, Sweet	Atrazine	After planting, before emergence.	For annual weeds and nutsedge. Heavier application for quack grass.
	2, 4–D	Post-emergence.	Do not spray in leaf whorl.
Dasheen or Taro	Amiben	Pre-emergence.	See Cassava.
Muskmelon, Cucumber, Watermelon	NPA granular	Post-emergence.	For annual weeds.
	DCPA	4–6 weeks after seeding.	
Onion	CIPC	After emergence or after transplanting.	For annuals.
	DCPA	Pre-emergence or after clean cultivation.	
Pea	DNBP	When plants are 4 to 8 inches high.	
	Trifluralin	Pre-emergence.	See Bean.
Pigeon Pea	Amiben	Pre-emergence.	See Cassava.
Potato	DNBP	2 weeks after planting or before emergence.	
	Dalapon	2 weeks after planting or before emergence.	For annual grasses.
Pumpkin, Squash	DNBP	Pre-emergence.	See Bean.
Spinach	CDEC	Immediately after planting.	1 inch rain or irrigation needed within 2 days.
Sweet Potato	Amiben granular	After transplanting before weeds emerge.	May control weeds for 2 months.
Tomato (direct seeded)	CDEC	See Spinach.	See Spinach.
Tomato (transplanted)	Pebulate	Incorporate in soil within minutes after application.	Can transplant immediately after application.
Yam	Amiben	See Cassava.	See Cassava.

[1] Part of this information was obtained from "1963 Vegtable Production Recommendations" by P. A. Minges, et. al., New York State College of Agriculture, Ithaca, N. Y.

Chapter 6

INSECT CONTROL

Insect control is a continuous operation in the Tropics as there is no cold season to reduce the population of insects. Parasites and predators tend to limit the insects but there is always danger of an outbreak at any time.

Some of the more common insecticides are listed in Table 13. Most of the common insecticides are made up into wettable powders which contain only a stated percentage of the toxicant. They also are made into dusts diluted to lower percentages suitable for direct application to the crop. Generally it is cheaper to buy the insecticide with the highest percent of the active ingredient because freight is a large part of the cost in countries far from the factory sources.

Whatever material is used, it must contain the correct amount of the active ingredient. Spray programs should be started early before plants show severe damage. To determine this, it is necessary to inspect the crop frequently during the growing season in order to detect the first appearance of the insects. Some insects that are difficult to detect require sprays at fixed times. For example, cutworms are so general in some tropical areas that soil treatment before planting is essential for success.

It is possible to spray too often. Sprays may destroy the beneficial insects that regulate populations of aphids or mites and actually cause them to increase more rapidly. It is necessary to use good judgment in the spray program. When hand spraying is done, "spot" spraying will save labor and reduce the damage to beneficial insects. Some insects appear on only a few plants at first and

Table 13. COMMON INSECTICIDES

Common Name	Formulation	Amount to Mix per Gallon of Spray (Quality per U.S. gallon [1])	
Carbaryl (Sevin)	50 WP	2 tbsp.	10 gms.
Chlordane	40 WP	1.5 tbsp.	14 gms.
DDT	50 WP	2 tbsp.	10 gms.
	25 EC	1 tbsp.	
Dieldrin	50 WP	1.5 tbsp.	14 gms.
Dicofol (Kelthane)	18.5 EC	1 tsp.	
	18.5 WP	3 tsp.	18 gms.
Malathion	25 WP	2 tsp.	14 gms.
Malathion	57 EC	2 tsp.	
Methoxychlor	50 WP	2 tbsp.	14 gms.
Toxaphene	40 WP	3 tbsp.	28 gms.

Poison bait spray for fruit flies:
Dissolve 1 lb. protein hydrolysate in 3 gal. water. Stir and add 2 lbs. 25% malathion wettable powder. Use coarse spray in scattered droplets.

[1] One gallon is usually sufficient for 500 square feet. These are only suggested rates of application.

Legend: WP=wettable powder. tbsp.=level tablespoon.
EC =emulsifiable concentrate. tsp. =level teaspoon.

Table 14. INSECTICIDE DILUTION TABLE

QUANTITY OF WATER	QUANTITY OF WETTABLE POWDER INSECTICIDES				
100	1 lb.	2 lb.	3 lb.	4 lb.	5 lb.
50	8 oz.	16 oz.	1 1/2 lb	2 lb.	2 1/2 lb
5	0.8 oz.	1.6 oz.	2.4 oz.	3.2 oz.	4 oz.
1	5 gms.	10 gms.	14 gms.	18 gms.	23 gms.

Table 15. FACTORS FOR CONVERSION OF ACTIVE INGREDIENT TO TOTAL QUALITY OF INSECTICIDE

PER CENT ACTIVE INGREDIENT	FACTOR FOR CONVERSION
20	5.0
25	4.0
40	2.5
50	2.0
75	1.3

Table 16. APPROXIMATE QUANTITIES OF INSECTICIDES TO WEIGH ONE OUNCE

INSECTICIDE	NO. OF LEVEL TABLESPOONS
1. Chlordane wettable powder	3
2. DDT wettable powder	6
3. Malathion wettable powder	4
4. Methoxychlor wettable powder	4
5. Sevin wettable powder	6
6. Toxaphene wettable powder	3

spraying the infested plants sometimes will prevent further spread.

Simple methods of control could be used in small gardens where sprays are not available. Destroying insects by hand is sometimes cheaper and less trouble than obtaining the proper spray and sprayer. Melon plants severely affected by aphids can be destroyed by burying in the ground. Larger insects can be collected and destroyed. Hornworms on tomatoes are destroyed easily by hand when they occur in small numbers.

Some insects occur on nearly all crops but the same species do not attack all crops. Aphids are common on practically all crops in the Tropics. Although the species differ, the same control methods usually are effective for all. Ants, leafhoppers and spider mites attack a wide range of crops. For convenient reference they are listed with each crop in Tables 17 and 18.

Table 17. SUGGESTED INSECT CONTROL FOR FRUITS

CROP	INSECT NAME COMMON	INSECT NAME SCIENTIFIC	DAMAGE	CONTROL[1]	REFERENCES
Acerola	Weevil	*Anthonomus unipustulatus*	Small larva feeds in fruits.	Malathion spray.	1
Apple	Aphids	*Aphis* spp.	Feed on young growth causing curling of leaves.	Malathion spray.	15
	Codling moth	*Laspeyresia pomonella*	Young worms enter calyx or where fruits touch.	Spray DDT at blossom drop. Carbaryl spray later at 3 week intervals.	15
	Pear leaf blister mite	*Eriophyes pyri*	Cause russetting and deformed fruits.	Malathion spray.	15
	Quetta borer	*Aeolesthes sarta*	Bore into trunk.	Pruning and hand picking.	10
	San Jose scale	*Aspidiotus perniciosus*	Grayish scales suck juices and kill twigs and limbs.	Malathion spray during growing season.	15
Avocado	Mites	*Oligonychus* sp.	Suck juices and cause browning of the leaf.	Dicofol spray.	13
	Scale	*Melanaspis aliena*	Occur on twigs and fruit.	Malathion spray.	13
	Seed weevil	*Conotrachelus perseae*	Larvae feed in or near the seed.	Destroy or bury infected fruits.	13
Banana	Root weevil	*Cosmopolites sordidus*	Larvae feed in the corm.	Spray suckers with Carbaryl before planting. Destroy old stem by chopping in pieces.	13

Table 17. SUGGESTED INSECT CONTROL FOR FRUITS (Continued)

CROP	INSECT NAME COMMON	INSECT NAME SCIENTIFIC	DAMAGE	CONTROL[1]	REFERENCES
Banana (Continued)	Scab moth	*Nacoleia octasema*	Larvae feed on female flowers and young fruits.	Spray with Carbaryl.	13
	Stem borer	*Metamasius hemipterus sericeus*	Larvae feed in stems.	See Root Weevil above.	13
Cacao	Borer	*Xyleborus* sp. etc.	Larvae bore into trunk.	Spray Dieldrin on trunks.	13
	Leaf-cutting ants	*Atta* spp.	Defoliate plants.	Mirex 450 bait. Dieldrin dust in nests.	5
	Pod borer	*Acdrocercops cramerella* etc.	Bore into fruits.	Carbaryl spray.	13
Citrus	Aphids	*Toxoptera aurantii*	Feed on young leaves; transmit tristeza virus.	Malathion spray.	
	Leaf-cutting ants	*Atta* spp.	Defoliate trees.	Dieldrin or Chlordane.	
	Fruit flies	*Anastrepha* spp., *Ceratitis capitata*	Maggots enter fruits causing decay.	Malathion bait spray.	
	Orange dog	*Papilio* spp.	Gray larvae with offensive odor on young leaves.	Hand pick or spray with Carbaryl.	
	California red scale	*Aonidiella aurantii*	Cover leaves, branches and fruits.	Usually controlled by fungus parasites in the Tropics. Can use Malathion spray if needed.	
	Spider mite	*Tetranychus* spp.	Suck juices from leaves turning them a gray color.	Sulfur or Dicofol spray.	
Coconut	Moth	*Artona catoxantha*	Larvae feed on leaves; heavy damage at times in Fiji.	Suggest Carbaryl spray.	11
	Palm weevils	*Rhynchophorus* spp.	Larvae tunnel into heart of palm and kill the plant.	Dieldrin spray.	11
	Scale	*Aspidiotus destructor*	Affects leaves.	Malathion spray.	11
Coffee	Leaf-cutting ants	*Atta* spp.	Defoliate plants	Dieldrin or Mirex 450 bait. Chlordane dust.	5
	Bean borer	*Hypothenemus (Stephanoderes) hampei*	Attack beans in Africa and Brazil.	Clean up infested fruits. Spray with Dieldrin.	9
	Green Scale	*Coccus viridis*	Attacks leaves along veins.	Malathion spray.	13
Date	Scale	*Parlatoria* spp.	Attack leaves near trunk.	Malathion spray.	
	Wasps	*Polistes* spp. etc.	Adults feed on ripe or nearly ripe fruits.	Dust nests with Chlordane; trap with fresh liver bait.	7
Fig	Fruit beetle	*Cotinis mutabilis*	Adults feed on ripe or nearly ripe fruits.	Clean up old straw stacks or manure piles; hand pick; spray with Carbaryl.	4

Table 17. SUGGESTED INSECT CONTROL FOR FRUITS (Continued)

CROP	INSECT NAME		DAMAGE	CONTROL[1]	REFERENCES
	COMMON	SCIENTIFIC			
Grape	Leafhopper	*Empoasca decipiens* etc.	Suck juices causing leaves to turn gray.	Malathion or DDT spray soon after grape bloom.	
	Berry moth	*Paralobesia viteana*	Destroys young fruit in cluster.	Carbaryl spray at petal fall and later.	
	Phylloxera	*Phylloxera* sp.	Attack roots causing decline and death of vines.	Resistant rootstocks.	
	Wasps	*Polistes* spp. etc.	Feed on ripe fruit.	See Date.	7
Grapefruit	See Citrus.				
Guava	Aphids	See Apple.			
	Fruit flies	*Anastrepha striata*, *Dacus* spp.	Maggots attack fruit.	Malathion bait spray.	21
	Green Scale	*Coccus viridis*	Occur on branches.	Malathion spray.	1
Lemon	See Citrus.				
Lime	See Citrus.				
Lychee	Fruit flies	*Ceratitis capitata* etc.	Maggots attack fruits causing decay.	Malathion bait spray.	21
Mandarin	See Citrus.				
Mango	Fruit flies	*Anastrepha* spp. etc.	Maggots feed on ripe or nearly ripe fruits.	Malathion bait spray. Clean up and bury infested fruit.	21
	Treehopper	*Aconophora pugionata*	Feed on leaves.	Carbaryl spray.	1
	Scale	*Aulacaspis tubercularis*	Occurs on branches esp. in India.	Malathion spray.	1
Olive	Fruit fly	*Dacus oleae*	Very destructive to fruits.	Malathion bait spray.	21
	Scale	*Parlatoria* spp.	Occurs on branches.	Carbaryl spray.	
Orange	See Citrus.				
Papaya	Green peach aphid	*Myzus persicae*	Carries mosaic virus.	Malathion spray. Do not plant cucumbers or melons near papaya.	14
	Fruit flies	*Toxotrypana curvicauda*	Larvae feed in interior.	Destroy or bury all dropped fruits. Malathion bait spray.	1
	Scale	Various	Leaves and young fruit.	Malathion spray.	1
	Whiteflies	*Trialeurodes* spp.	Feed on leaves.	Carbaryl spray.	22
Passion fruit	Aphids	See Papaya.			16
	Fruit flies	See Papaya.			16
	Mites	Several	Feed on foliage.	Dicofol.	16

Table 17. SUGGESTED INSECT CONTROL FOR FRUITS (Continued)

CROP	INSECT NAME COMMON	INSECT NAME SCIENTIFIC	DAMAGE	CONTROL [1]	REFERENCES
Peach	Oriental fruit moth	*Grapholitha molesta*	Larvae feed in fruits.	Carbaryl or DDT spray.	20
	San Jose scale	*Aspidiotus perniciosus*	Gray scale covers branches.	Malathion spray.	20
	Leafhopper	*Homalodisca insolita*	Transmits phony peach disease.	Malathion or Carbaryl sprays.	20
	Peach tree borer	*Sanninoidea exitiosa*	Larvae bore in trunk near soil level.	Spray trunk with DDT 4 times at 4 week intervals. Begin Aug. 1 in northern hemisphere.	20
Pineapple	Mealybug	*Dysmicoccus brevipes*	Feeds at base of fruit; transmits wilt.	Malathion spray.	1
	Scale	*Diaspis bromeliae*	Feeds on leaves.	Malathion spray.	2
Plums	Plum curculio	*Conotrachelus nenuphar*	Grubs bore into fruits causing them to drop.	Dieldrin every 10 days. Begin at petal fall.	
	Mites	*Tetranychus* spp.	Suck juice from leaves and cause them to fall.	Dicofol spray.	
Pomegranate	Fruitworm	*Euzophera punicaella*	Larvae enter young fruit and cause rotting.	Suggest early spray with Carbaryl.	10
Sapodilla	Fruit flies	*Anastrepha serpentina* etc.	Maggots feed in fruits and cause decay.	Malathion bait spray.	21
Strawberry	Mites	Various	Suck juice from leaves. Form light webbing.	Dicofol spray.	3
	White grubs	*Phyllophaga* spp.	Grubs feed on roots and cause plants to wilt..	Dieldrin, 3 lbs. per acre active ingredient on soil before planting. Work in well.	3,8
Tangelo	See Citrus.				
Tangerine	See Citrus.				
Tea	Mites	See Strawberry			18

[1] See Table 13 for formulas.

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES [1]

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Asparagus	Asparagus beetle *See Photo Fig. 90.*	Adult: metallic blue to black, orange to yellow markings 1/4" long.	Spray with 57% Malathion.	Do not apply within 1 day before harvest.
	Cutworm	See Peas.	Bait—3% toxaphene.	
Beans	Bean aphid	Adult and young. Tiny black insect like cabbage aphid. Bean aphids cluster on stems and under leaves.	Malathion spray	Do not apply within 1 day before harvest.
	Bean leaf beetle *See Photo Fig. 91.*	Adult: Reddish to yellowish, black spots on back 1/4" long.	50% wettable DDT	Do not apply within 7 days before harvest for DDT.

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Beans (Continued)	Corn earworm *See Photo Fig. 101.*	Green, brown or pink, light stripes along sides and on back, 1 3/4" long.	50% wettable Methoxychlor or 50% WP Sevin	Do not apply within 3 days before harvest.
	Leafhoppers	Adult: Green wedge shaped, 1/8" long. They fly quickly when disturbed.	Spray with Malathion. Spray with Sevin.	Do not apply within 1 day before harvest.
	Lima bean pod borer *See Photo Fig. 108.*	Pink, pale yellow head, 5/8" long, wriggles violently when disturbed.	Same as for bean leaf beetle.	
	Mexican bean beetle	Adult: copper colored, oval, 1/4" long, 16 black spots on back. Larva: orange to yellow, spiny, 1/3" long.	Spray with Malathion. Spray with 5 lb. of active Carbaryl per acre.	Do not apply within 1 day before harvest.
	Spotted cucumber beetle *See Photo Fig. 121.*	Yellowish green, 12 black spots on back, 1/4" long.	Same as for bean leaf beetle.	Do not apply within 7 days before harvest.
Beet	Beet webworm *See Photo Fig. 92.*	Yellow to green, a black stripe and numerous black spots on back, 1-1/4" long.	50% Wettable DDT or Carbaryl.	Do not eat beet tops if sprayed with DDT.
	Blister beetle *See Photo Fig. 93.*	Gray, black or striped, slender 1/2 to 3/4" long.	Same as for beet webworm.	
	Cutworms	See Peas.		
Cabbage Broccoli and Cauliflower	Cabbage, aphid *See Photo Fig. 94.*	Adult and young: tiny green, blue soft bodied covered with a fine whitish wax. Aphids cluster on leaves.	Remove and destroy heavily damaged plants early in the season. Apply Malathion spray.	Do not apply Malathion within 1 day of harvest.
	Cabbage looper *See Photo Fig. 95.*	Pale-green measuring worm, light stripes down back 1-1/2" long. Doubles up when it crawls.	Early application: 40% Wettable powder Toxaphene. Late application: Malathion.	Toxaphene should be used before formation of parts of plants to be eaten; after this stage Malathion should be used.
	Cabbage webworm	Dull grayish yellow, fat, 5 brownish-purple stripes down back, 1/2" long.	Apply Malathion spray.	Do not apply within 1 day before harvest.
	Diamond back moth	Larva: light green slender, 1/3" long. It wriggles rapidly when disturbed and often drops from the plant and hangs by a silken thread.	Same as for Cabbage looper.	
	Harlequin bug *See Photo Fig. 105.*	Adult and young: Black brilliantly colored with red and yellow, shield shaped, 3/4" long.	Early application: DDT spray.	Do not apply DDT after formation of the part to be eaten.
Cabbage	Imported cabbageworm	Velvety green, 1 1/4" long.	Same as for cabbage looper.	Do not apply within 1 day before harvest.

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Cabbage (Continued)	Root maggots	Yellowish white, legless 1/4" to 1/3" long.	Apply Chlordane spray when first two leaves appear. Repeat after thinning or transplanting. Add 2 level tsp. of 40% chlordane to each gal. of transplanting water. Use 3/4 cup per plant.	Do not apply Chlordane to plants past seedling stage.
Carrot	Celeryworm	Green, banded with black and yellow markings, 2" long.	Remove caterpillars by hand.	
	Carrot rust fly *See Photo Fig. 96.*	Larva: yellowish, white, legless, 1/3" long.	Apply Chlordane to soil surface and work in thoroughly before planting.	
	Aster leafhopper	Adult and young: Light greenish yellow, slender, wedge shaped, very active, several pairs of tiny black dots on face, 1/8" long.	Apply 50% wettable DDT as spray or Carbaryl.	Do not use treated tops for feed or food.
Celery	Celery leaf tier *See Photo Fig. 97.*	Greenish, up to 3/4" long.	Apply 50% wettable DDT as spray.	Do not apply DDT after the bunch begins to form or the stalk is half grown, whichever is earlier.
Cucumber	Aphids	See Muskmelon.		
	Pickleworm	Yellowish white, brownish head, 3/4" long. Dark spots on young worm.	Apply Carbaryl (Sevin).	Do not apply within 1 day before harvest.
	Beetles (*Diabrotica* spp.) *See Photo Fig. 121*	Several species; all feed on leaves and young seedlings.	Carbaryl or Methoxychlor.	Do not apply insecticides within one day before harvest.
Eggplant	Aphids	Adults and young are tiny, green to black and soft bodied, cluster on underside of leaves.	Apply Malathion spray.	Do not apply Malathion to eggplant within 3 days before harvest.
	Colorado potato beetle *See Photo Fig. 98.*	Adult: yellow, black-striped 3/8" long. Larva: brick-red humpbacked, 3/5" long.	Apply 50% Wettable DDT spray.	Do not apply DDT to eggplant within 5 days before harvest.
	Eggplant lace bug *See Photo Fig. 102.*	Adult: Grayish to light brown; flat, lacelike wings, 1/16" long. Nymph: yellowish, louselike, spiny, up to 1/10" long.	Apply Malathion spray.	Do not apply Malathion to eggplant within 3 days before harvest.
	Flea beetles *See Photo Fig. 114.*	Black, brown or striped jumping beetles, about 1/16" long.	Apply DDT spray early in season and Methoxychlor later.	Apply DDT before formation of the fruits and after formation of the fruits. Use Methoxychlor.
	Hornworm *See Photo Fig. 106.*	Green, diagonal lines on sides, horn on rear end, up to 4" long.	Handpick worms. Apply 50% TDE wettable powder as a spray.	Do not apply TDE to eggplant within 1 day before harvest.
	Whitefly	Small white flies on leaves.	Use Malathion spray.	See Aphids.

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Lettuce	Aphids	See Muskmelon.		
	Wireworms *See Photo Fig. 130.*	Yellow to white; dark heads and tails; 1/2—1-1/2 in. long.	Apply 3/4 cup of 40% Chlordane in 2-1/2 gal. of water to 1,000 sq. ft. of soil. Work in soil to 6" or 8".	Do not apply within 1 year before planting carrots or parsnips.
	Cabbage looper *See Photo Fig. 95.*	Pale-green measuring worm, light strips down back, 1-1/2" long, doubles up when it crawls.	Spray with 40% Toxaphene before thinning and with Malathion after thinning.	Same as for aphids.
	Cutworms	See Peas.		
	Fall armyworm *See Photo Fig. 104.*	Light green to black, striped white inverted Y on front of head, 1/3" long.	Apply 50% wettable DDT to grasses and weeds near garden.	
	Aster leafhopper	Adult and young. Light greenish yellow, slender wedge shaped, very active, up to 1/8" long.	Apply Malathion sprays when plants are 1/2" hign and repeat every week.	Same as for aphids.
Muskmelon and Cantaloupe	Aphids	Feed on underside and curl the leaf.	Spray with Malathion.	Do not treat within 1 day before harvest.
	Pickleworm	Yellowish white, brownish head, 3/4" long.	Spray with Carbaryl at weekly intervals.	Do not treat within 1 day before harvest.
	Spider mite *See Photo Fig. 120.*	Adult and young. Tiny (barely visible to naked eye), red or greenish red. On underside of leaves.	Spray with Malathion or Dicofol.	Do not treat within 2 days before harvest.
	Striped cucumber beetle *See Photo Fig. 125.*	Adult: yellow to black, 3 black stripes down back 1/5" long. Larva: white, slender, brownish at ends, 1/3" long.	Spray with Malathion or use Methoxychlor.	Same as for Pickleworm.
Okra	Aphids	See Eggplant.		
	Corn earworm *See Photo Fig. 101.*	Green, brown or pink. 1-3/4" long.	Apply Carbaryl dust or spray.	Do not apply Carbaryl within 1 day of harvest.
	Bollworms	Spiny small gray caterpillar in pods.	Carbaryl.	See Earworm.
	Stink bug *See Photo Fig. 119.*	Adult: brown, green or black, with or without markings, shield shaped 5/8" long and 1/3" wide. Stink bugs discharge a foul odor.	2 lbs. active Carbaryl per acre.	See Earworm.
Onion	Onion maggot	White root maggot, legless 1/3" long. Found in bulbs.	Apply Malathion spray.	Do not apply Malathion within 3 days before harvest.
	Cutworms	See Peas.		
	Onion thrips *See Photo Fig. 111.*	Adult: yellow or brownish, winged, active, 1/25" long. Larva; white, wingless.	Same as for Onion maggot.	Same as for Onion maggot.

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Pea (Blackeye) cowpea	Cowpea curculio *See Photo Fig. 99.*	Adult: Black humpbacked snout beetle, 1/4" long.	Spray with Toxaphene.	Do not apply Toxaphene within 7 days before harvest.
	Stink bug *See Photo Fig. 119.*	Suck pods and cause dark seed.	See Okra.	See Okra.
Peas (Garden)	Aphids	See Eggplant.		
	Cutworms *See Photo Fig. 100.*	Cutworms are dull gray, brown or black and may be striped or spotted. They are stout, soft bodied and smooth, 1-1/4" long.	Apply Toxaphene dust or spray to soil surface in the late afternoon.	Do not apply Toxaphene to foliage of peas.
	Lima-bean pod borer	See Beans.		
	Pea weevil *See Photo Fig. 112.*	Adult: Brownish, white black and grayish markings, 1/5" long.	Apply Malathion spray while adults are within the blossoms.	
	Root maggots	Several species (including seed corn and cabbage maggots) yellowish white, legless 1/4 to 1/3" long.	See Onion maggot.	
Pepper	Aphids	See Eggplant.		
	Cutworms	See Peas.		
	Flea beetles	See Eggplant.		
	Hornworms *See Photo Fig. 106.*	Green, diagonal lines on sides, prominent horn on rear end. 4" long.	Handpick worms. Spray with 50% wettable TDE powder.	Not not apply TDE within 1 day before harvest.
	Pepper weevil *See Photo Fig. 113.*	Adult: Black snout beetle, gray or yellow markings 1/8" long. Snout is half the length of the body.	Apply Toxaphene or DDT every week to 10 days.	Do not apply DDT within 5 days before harvest.
Potato	Aphids	See Eggplant.		
	Colorado potato beetle *See Photo Fig. 98*	Adult: yellow, black striped, 3/8" long. Larva: brick red, humpbacked, 3/5" long.	Spray with 50% wettable Carbaryl.	
	Flea beetles *See Photo Fig. 114.*	See Eggplant.	1 lb. active Carbaryl per acre.	
	Leafhoppers *See Photo Fig. 115.*	Adult: Green, wedge shaped, up to 1/8" long. They fly quickly when disturbed.	Spray with DDT or Methoxychlor or Malathion.	
	Millipedes *See Photo Fig. 109.*	Brown or grayish, wormlike, hard-shelled, many pairs of legs, 1 to 1 1/4" long.	Spray with DDT.	Do not apply on tubers.
	Mole cricket *See Photo Fig. 110.*	Adults and nymphs: Light brown, large, beady eyes, short, 1 1/2" long.	Spray 3/4 cup of 40% wettable Chlordane on 1,000 sq. ft. of soil and mix in upper 6" or apply ready mixed 3% Chlordane bait. Use 1 lb. of bait for 1,000 sq. ft. Apply in late afternoon after a rain.	

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Potato (Cont.)	Potato tuberworm *See Photo Fig. 116.*	Pinkish-white, brown head, up to 1/2" long.	Spray with DDT. Keep out weeds.	Do not expose tubers to infested foilage after digging.
	Sowbugs	Dark-gray, oval, flattened body, 7 pairs of legs, 1/2" long.	Spray soil with 50% wettable DDT.	Do not apply on tubers.
	White-fringed beetles *See Photo Fig. 128.*	Adult: Dark gray snout beetles, light band along sides of body 1/2" long.	Apply 1/4 lb. of DDT or 1/8 lb. of Chlordane per 1,000 sq. ft. of soil surface before planting. Work into top 3" of soil. Mix 1/2 lb. of 50% DDT or 1/4 lb. of 50% Chlordane in 2 1/2 gal. of water.	
Potato	White grubs *See Photo Fig. 129.*	White or light yellow, hard brown heads, curved 1/2 to 1 1/2" long.	Treat surface of soil with 1/4 lb. of Chlordane per 1,000 sq. ft. Mix 1/2 lb. of 50% Chlordane in 2 1/2 gal. of water.	Do not apply excessive amounts of Chlordane to the soil.
	Wireworms	See Lettuce.		
Radish	Root maggots	Yellowish white, legless 1/4 to 1/3" long.	Spray with Chlordane when first leaves appear and repeat shortly after thinning.	Do not apply to plants past the seedling stage.
Squash and Pumpkin	Aphids	See Eggplant.		
	Cutworms	See Peas.		
	Pickleworm	See Cucumber.		
	Spider mites	See Muskmelon.		
	Squash bug *See Photo Fig. 122.*	Adult: brownish, flatback stink bug, 5/8" long.	Handpick adults and eggs. Trap bugs under boards placed on soil. Try Malathion or Carbaryl spray.	
	Squash vine borer *See Photo Fig. 123.*	Larva: white, up to 1" long.	Partial control with Carbaryl spray. Start application when runners develop, repeat once a week.	
	Cucumber beetles *See Photo Figs. 121, 125.*	See Cucumbers.		
Sweet Corn	Corn earworm *See Photo Fig. 101.*	Green brown or pink, light stripes along sides and on back, 1-3/4" long.	Spray with DDT early in the season. Use 2 tsp. of 25% DDT emulsifiable concentrate in 1 gal. of water. Spray whole plant. Later spray silk every 2 days. Carbaryl can be used.	Do not feed DDT treated foliage to animals

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Sweet Corn (Cont.)	Corn sap beetles	Adults: Usually black, 3/16" long. Larva: white or cream colored. 1/4" long.	Apply Malathion spray after silks appear and repeat 10 days later.	
	Cutworms	See Peas.		
	Leafhopper (*Dalbulus maidis*)	Transmits corn stunt.	Carbaryl (Sevin).	
	Lesser cornstalk borer *See Photo's Fig. 104 and 124.*	Enters young stalks soon after emergence and causes them to wilt and die.	Rotate crops; avoid weedy areas. Spray or dust with Dieldrin on soil when beans have 2 true leaves.	
	Root maggots	See Radish.		
	White grubs	See Potatoes.		
	Wireworms	See Lettuce.		
Sweet Potato	Flea beetles	See Eggplant.		
	Sweet potato weevil *See Photo Fig. 126.*	Adult: Reddish snout beetle, shiny, ant-like, slender-bodied, bluish black head, 1/4" long.	Apply 2 to 2-1/2% Dieldrin dust along the row in a strip 6 to 8" wide. Apply soon as roots begin to enlarge and repeat 2 weeks later.	Do not apply Dieldrin within 21 days before harvest.
	Wireworms	See Lettuce.		
Tomato	Aphids	See Eggplant.		
	Blister beetles	Gray, black or striped, slender, 1/2 to 3/4" long.	Spray with Methoxychlor.	Do not apply within 1 day before harvest.
	Colorado potato beetle	See Potato.	Apply DDT spray.	Do not apply within 5 days before harvest.
	Cutworms	See Peas.		
	Flea beetles	See Eggplant.		
	Hornworms *See Photo Fig. 106.*	Green, diagonal lines on sides, prominent horn on rear end, 4" long.	Handpick worms. Spray with Toxaphene.	Do not apply Toxaphene within 3 days before harvest.
	Spider mites	See Muskmelons.		
	Stalk borer *See Photo Fig. 124.*	Slender, 1 1/4" long, young borer; creamy white, dark purple band around body. Several brown or purple stripes running lengthwise down the body.	Remove and destroy weeds. Avoid planting in weedy or sod areas.	
	Stink bugs	See Okra.		
	Tomato fruitworm	Green, brown or pink, light stripes along sides and on back, 1 3/4" long.	Apply 50% wettable DDT or Carbaryl spray.	Do not apply DDT 5 days before harvest.
	Tomato russet mite	Can be seen with a 20 X magnification hand lens. White and pear shaped.	Spray with 40% wettable sulfur when fruits set and repeat every 2 weeks.	Use 3 tablespoons per gallon of water. High concentrations may injure plants.

Table 18. SUGGESTED INSECT CONTROL FOR VEGETABLES (Continued)

CROP	INSECT	DESCRIPTION	CONTROL	CAUTION
Watermelon	Cucumber beetles *See Photo Fig. 121, 125.*	See Cucumber.		
	Aphids	Causes leaves to curl and deform.	Spot spray with Malathion. Destroy infested plants.	
	Cutworms	See Peas.		
	Pickleworms	See Cucumber.		

[1] Part of the information in this table was obtained from U.S.D.A. Farmers' Bul. 46. "Insects and Diseases of Vegetables in the Home Garden (1963" and Agriculture Handbook No. 120, "Insecticide Recommendations of the Entomology Research Division for the Control of Insects attacking Crops and Livestock for 1963." Insect control recommendations always are changing due to research work and changing regulations of the Federal Food, Drug and Cosmetic Act. The above mentioned publications usually are revised each year and the most up-to-date publications should be requested from the United States Department of Agriculture.

PRECAUTIONS

Insecticides used improperly can be injurious to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the labels.

Keep insecticides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and animals cannot reach them. Promptly dispose of empty insecticide containers; do not use for any other purpose.

When handling an insecticide, wear clean, dry clothing.

Avoid repeated or prolonged contact of insecticide with your skin.

Wear protective clothing and equipment if specified on the container label. Avoid prolonged inhalation of insecticide dusts or mists.

Avoid spilling an insecticide concentrate on your mouth. If you spill any on your skin or clothing, remove contaminated clothing immediately and wash the skin thoroughly with soap and water. Launder the clothing before wearing it again.

After handling an insecticide, do not eat, drink, or smoke until you have washed your hands and face. Wash any exposed skin immediately after applying an insecticide.

Avoid drift of insecticide to nearby wildlife habitats, bee yards, crops, or livestock. Do not apply insecticides under conditions favoring drift from the area to be treated.

Many insecticides are highly toxic to fish and aquatic animals. Keep insecticides out of all water sources such as ponds, streams, and wells. Do not clean spraying equipment or dump excess spray material near such water.

Do not apply insecticides to plants during hours when honey bees and other pollinating insects are visiting them.

Have empty insecticide containers buried at a sanitary land-fill dump, or crush and bury them at least 18 inches deep in a level, isolated place where they will not contaminate water supplies. If you have trash-collection service, thoroughly wrap small containers in several layers of newspaper and place them in the trash can.

Excellent references to have available are "Agriculture Handbook No. 321, 1967" and "Safe Use of Agricultural and Household Pesticides" available from Agricultural Research Service, U.S. Department of Agriculture.

GENERAL (Mixing rates and fruit and vegetable controls)

Mixing rates given on the commercial packages seldom include the amounts to mix small quantities. In Table 14 will be found the amounts calculated from the rate per 100 gallons usually given. Table 15 gives factors for conversion to stated percentages. For example, if the percent of active ingredient is one, 2 lbs. of a 50% wettable powder will be needed or 4 lbs. of a 25% wettable powder concentrate. Table 16 gives a guide for measuring small amounts in level tablespoons.

Table 17 is a suggested list of controls for fruit insects. This is not complete but an attempt has been made to include the common insects that might be encountered. The species that occur in the United States have been checked with Department of Agriculture specialists while those from tropical areas are taken from available foreign publications.

The list of controls for vegetable insects (Table 18) is more complete since many of these crops are planted also in temperate climates. Two excellent references for those that occur in the United States are "Home and Garden Bulletin 46" authored by L. R. Reed and S. P. Doolittle, 1963; and "Insects and Diseases of Vegetables in the Home Garden" U.S. Dept. Agr. 48 pp.

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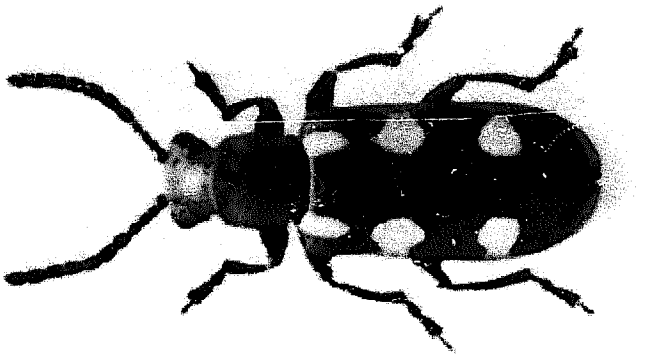

Figure 90. Asparagus Beetle.

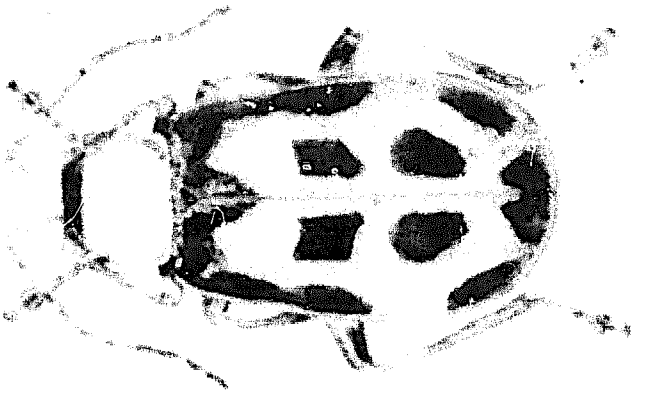

Figure 91. Bean Leaf Beetle.

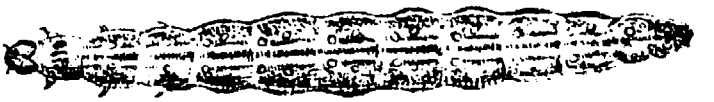

Figure 92. Beet Webworm.

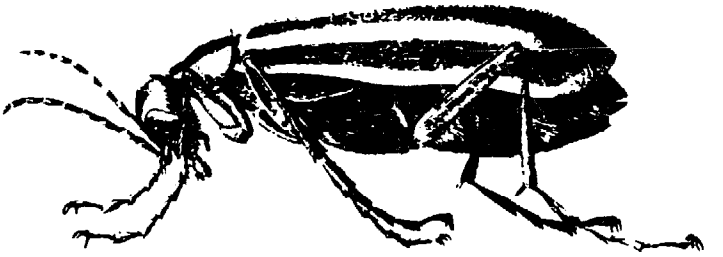

Figure 93. Blister Beetle.

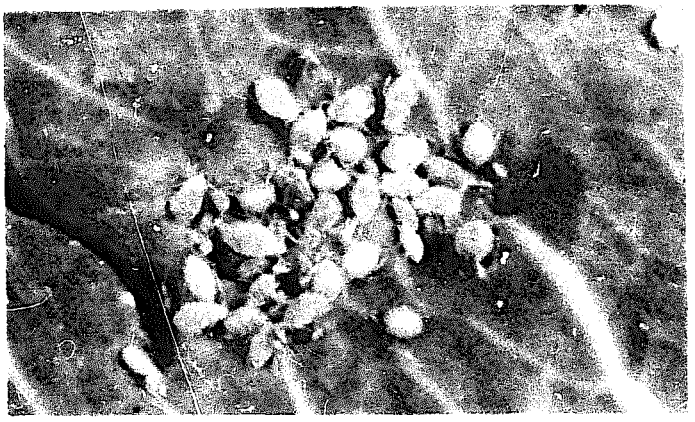

Figure 94. Cabbage Aphids.

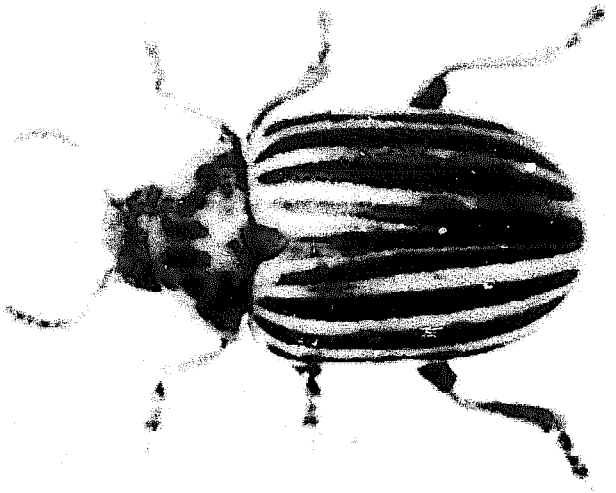

Figure 98. Colorado Potato Beetle.

Figure 95. Cabbage Looper.

Figure 96. Carrot Rust Fly Larva.

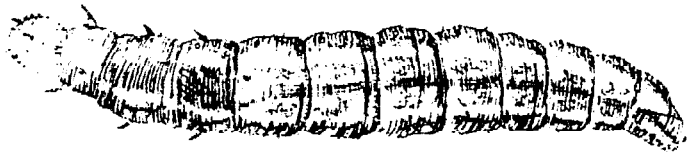

Figure 97. Celery Leaf Tier.

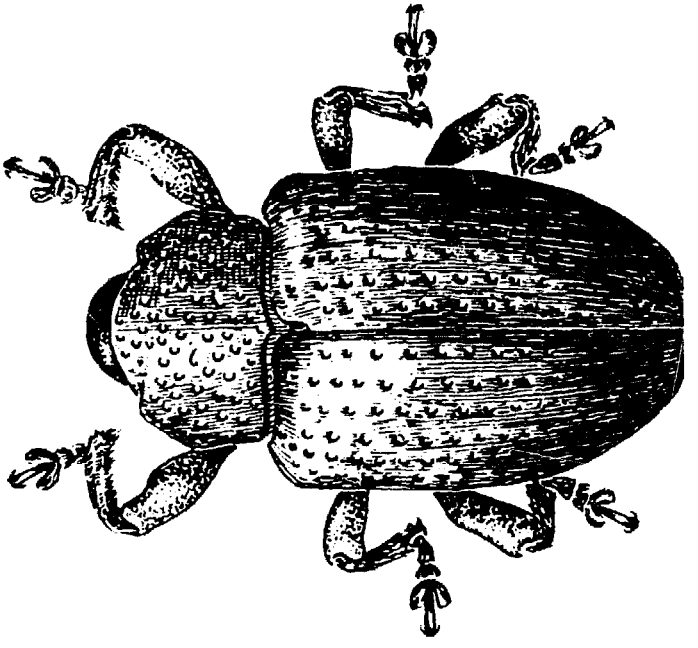

Figure 99. Cowpea Curculio Adult

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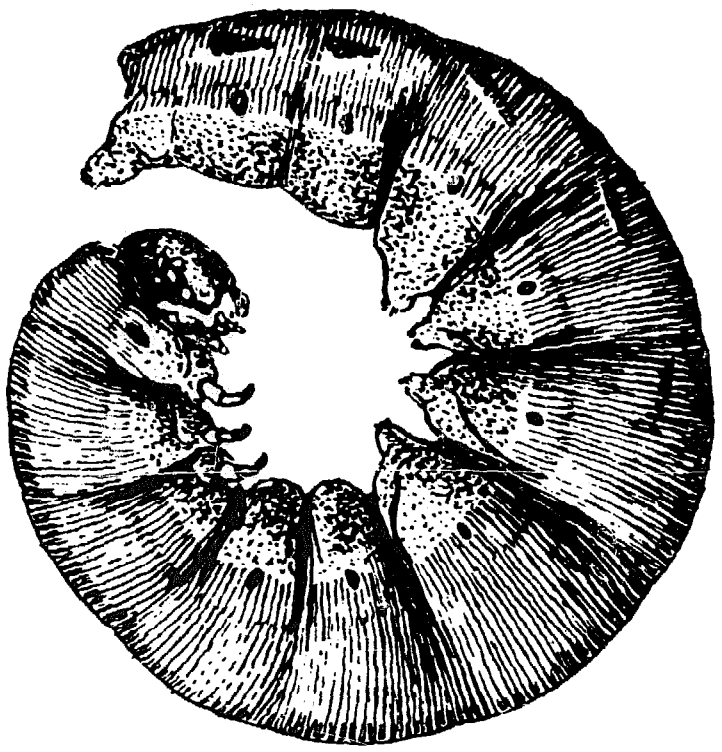

Figure 100. Cutworm.

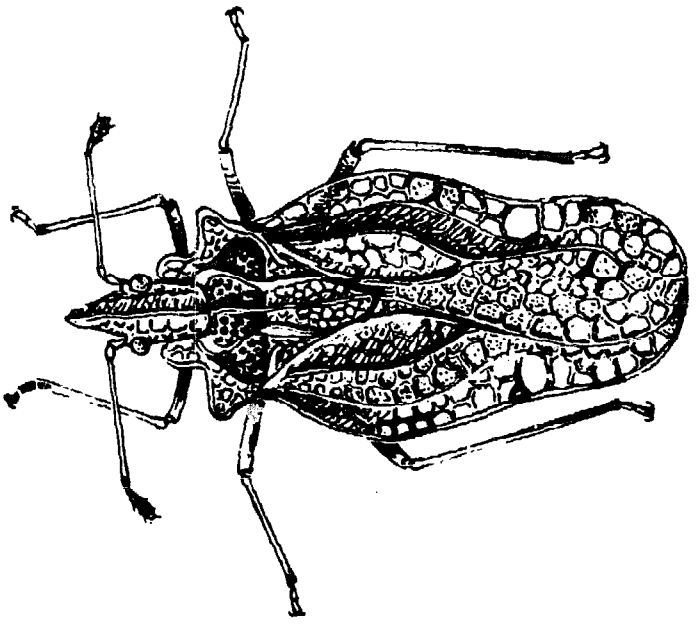

Figure 102. Eggplant Lace Bug.

Figure 103. European Corn Borer.

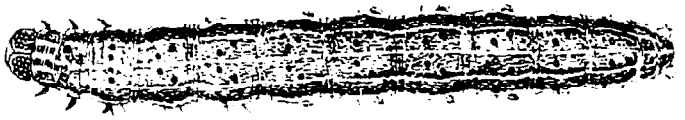

Figure 104. Fall Armyworm.

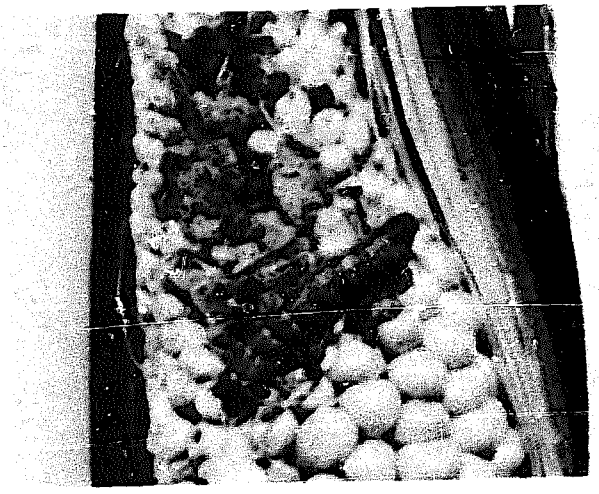

Figure 101. Corn Earworm.

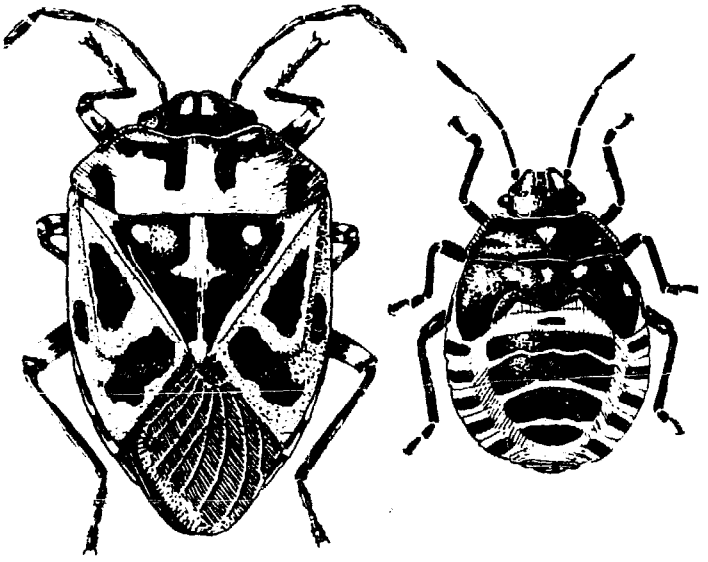

Figure 105. Harlequin Bug.

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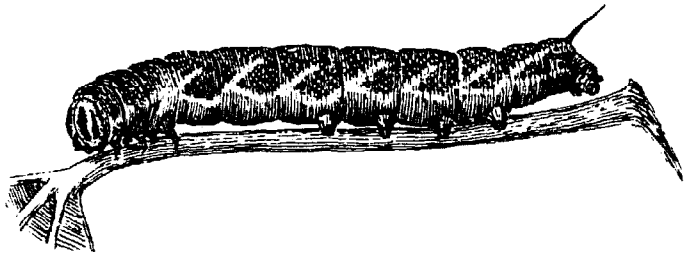

Figure 106. Hornworm.

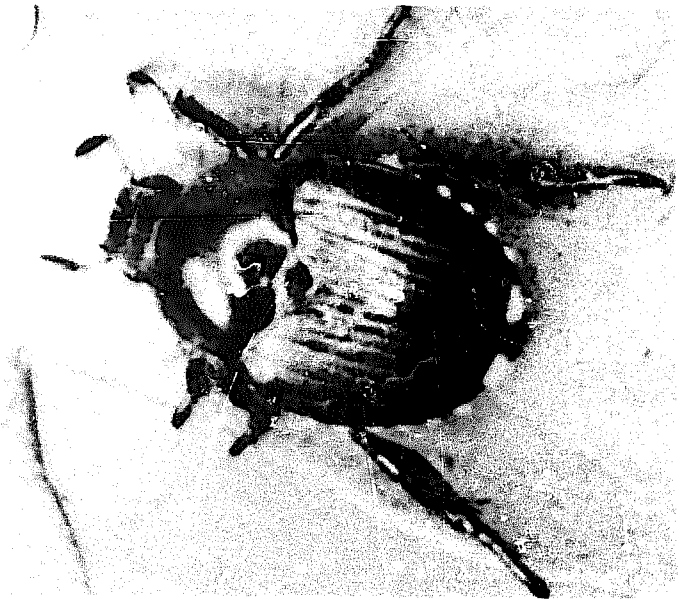

Figure 107. Japanese Beetle.

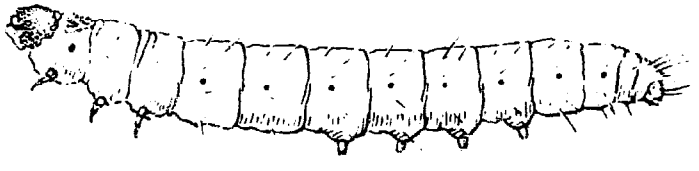

Figure 108. Lima-bean Pod Borer.

Figure 109. Millipede.

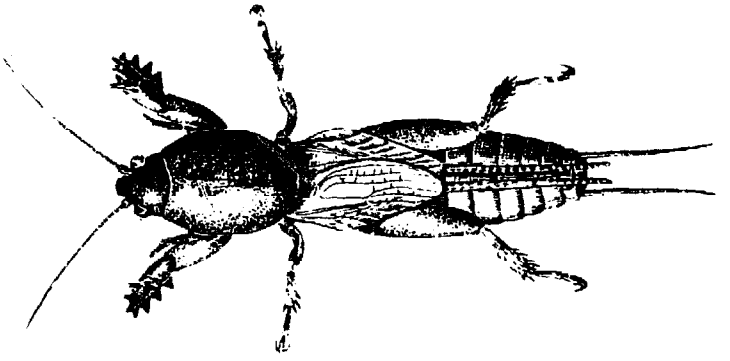

Figure 110. Mole Cricket.

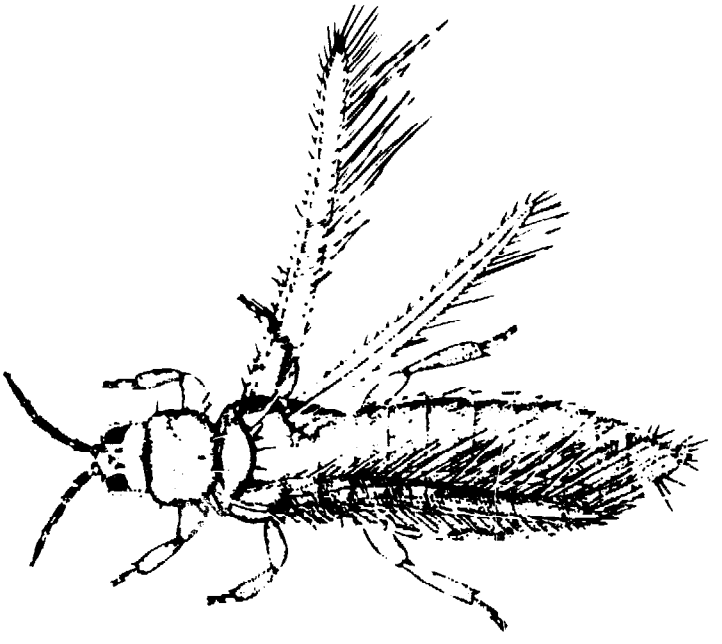

Figure 111. Onion Thrips.

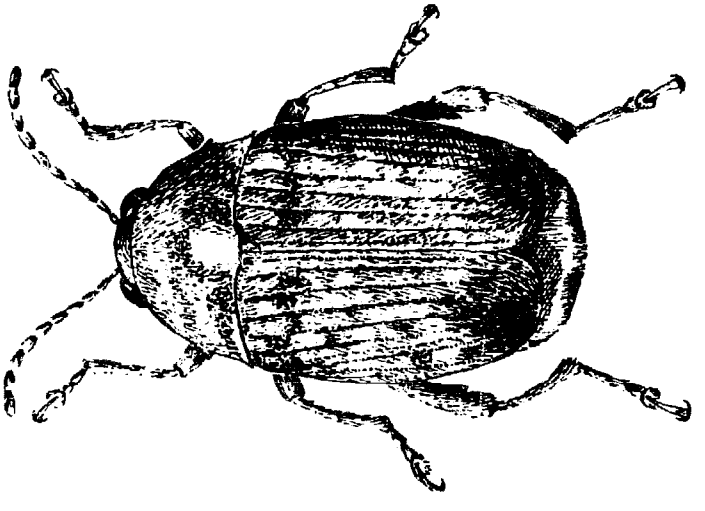

Figure 112. Pea Weevil Adult.

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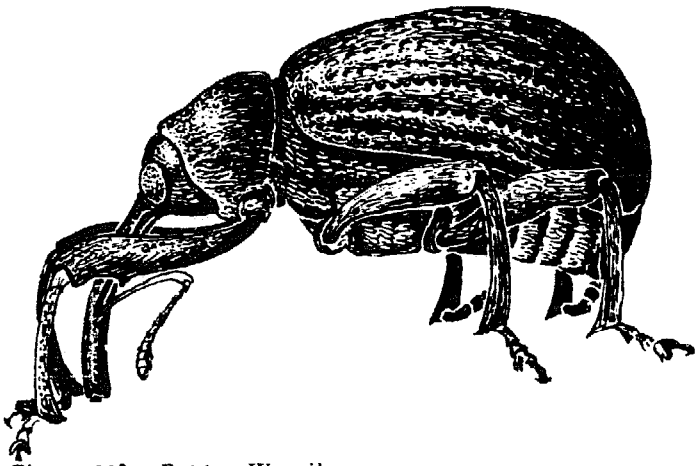

Figure 113. Pepper Weevil.

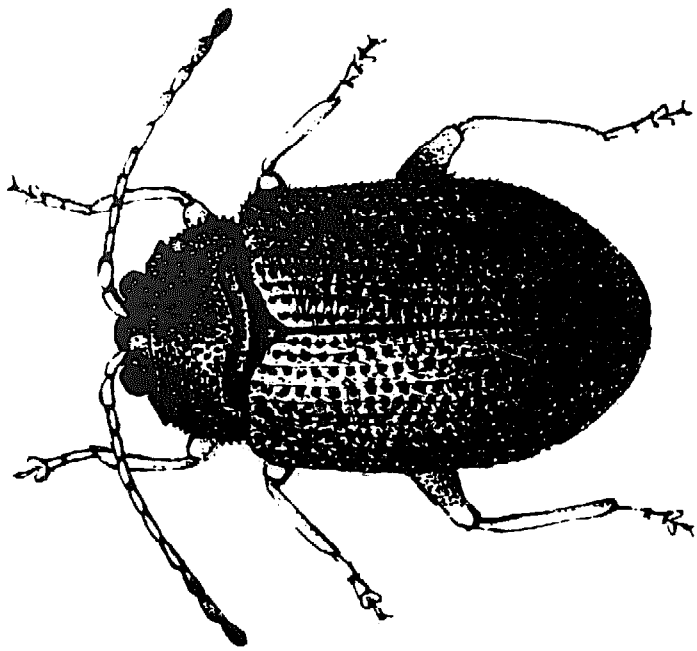

Figure 114. Potato Flea Beetle.

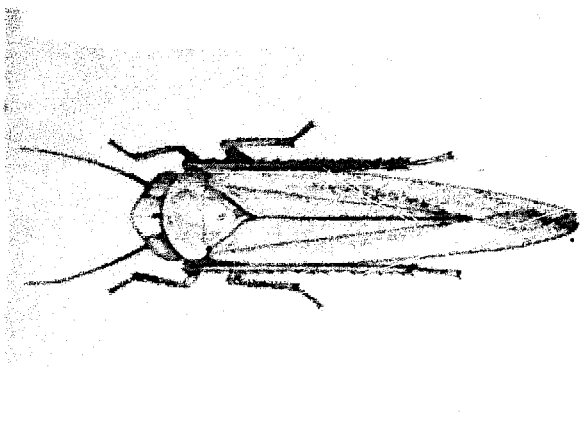

Figure 115. Potato Leafhopper.

Figure 116. Potato Tuberworm Larva.

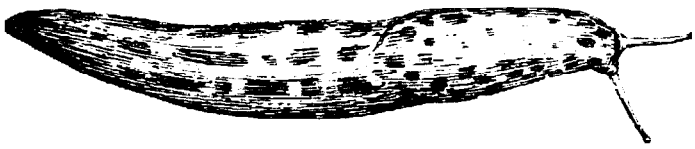

Figure 117. Slugs.

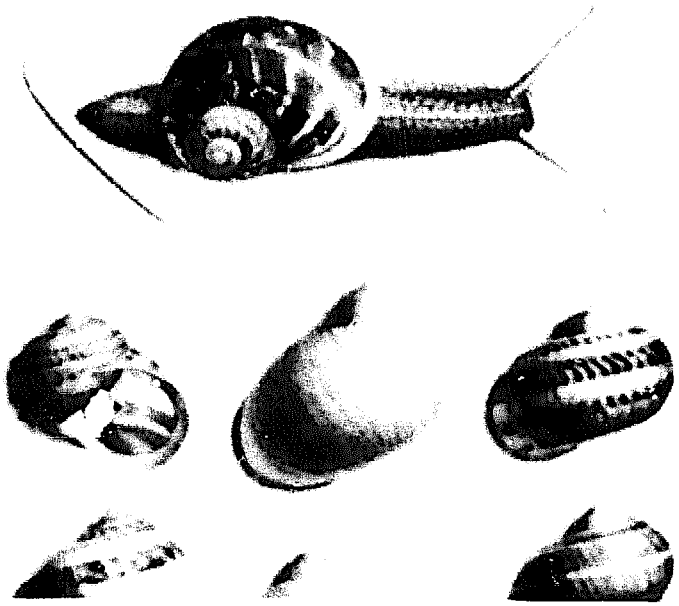

Figure 118. Snail.

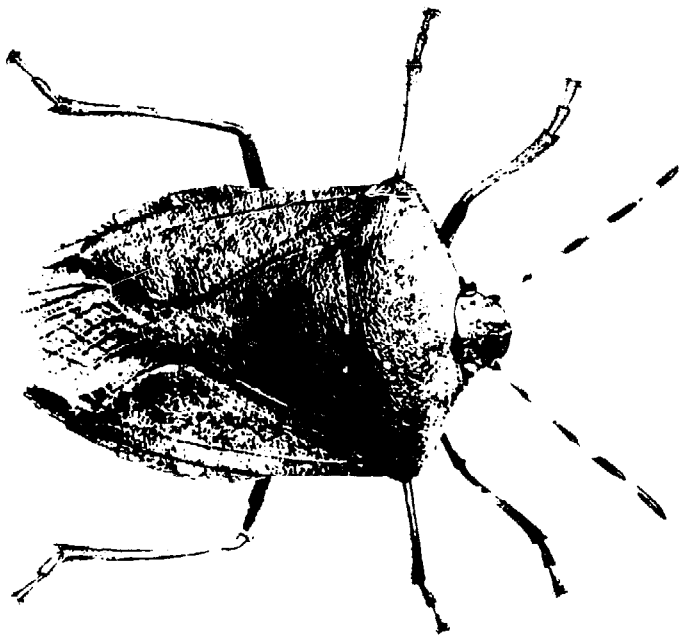

Figure 119. Southern Green Stink Bug.

U. S. D. A. Photographs

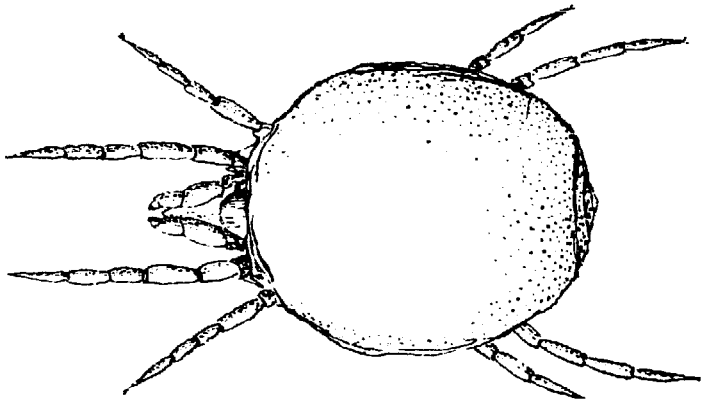

Figure 120. Spider Mite.

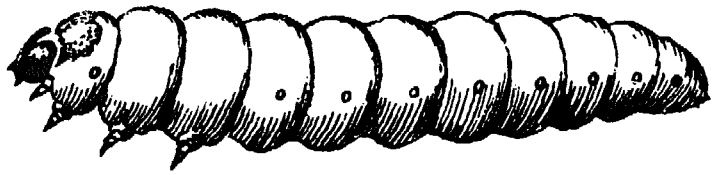

Figure 123. Squash Vine Borer.

Figure 124. Stalk Borer.

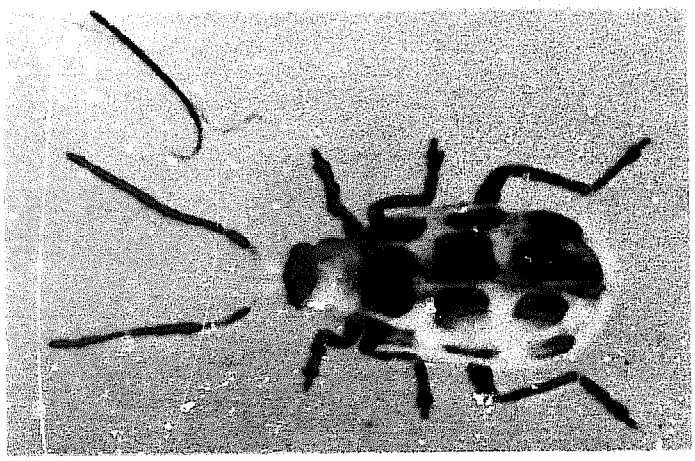

Figure 121. Spotted Cucumber Beetle.

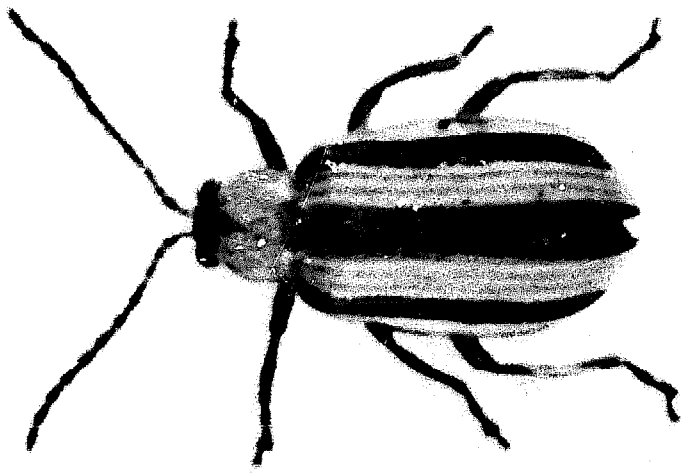

Figure 125. Striped Cucumber Beetle.

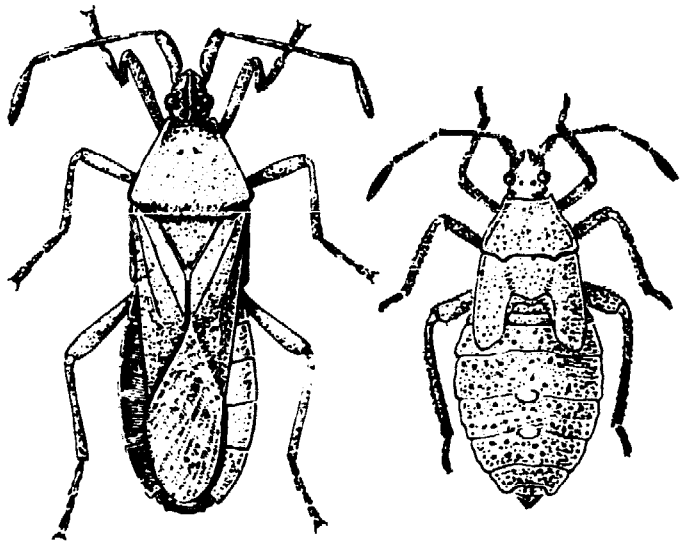

Figure 122. Squash Bug.

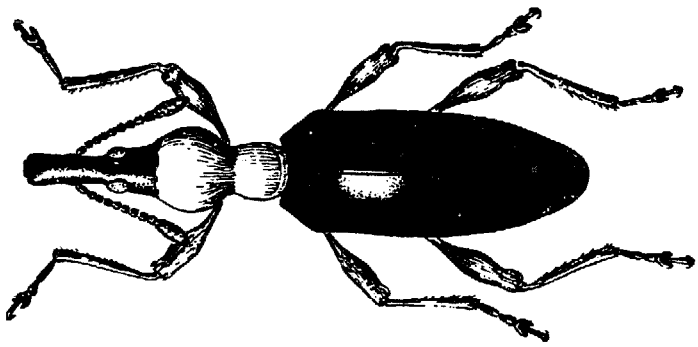

Figure 126. Sweet Potato Weevil.

U. S. D. A. Photographs

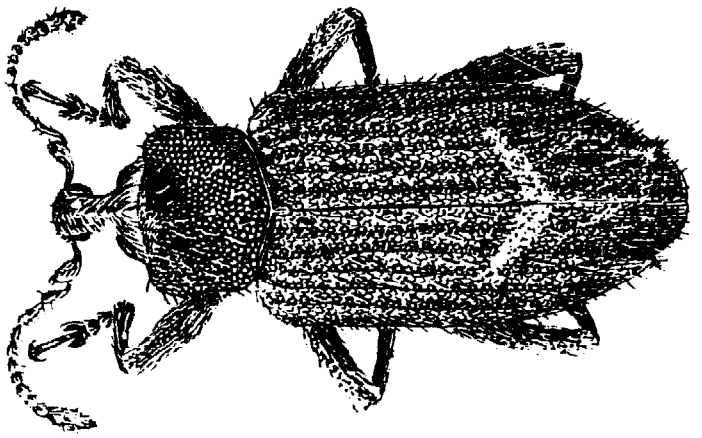

Figure 127. Vegetable Weevil.

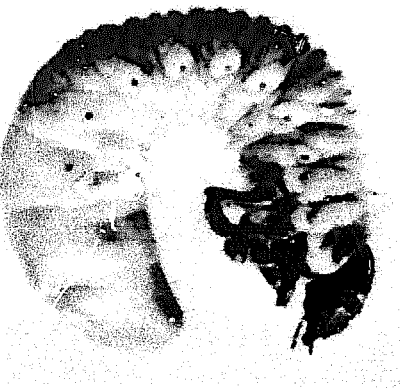

Figure 129. White Grub Larva.

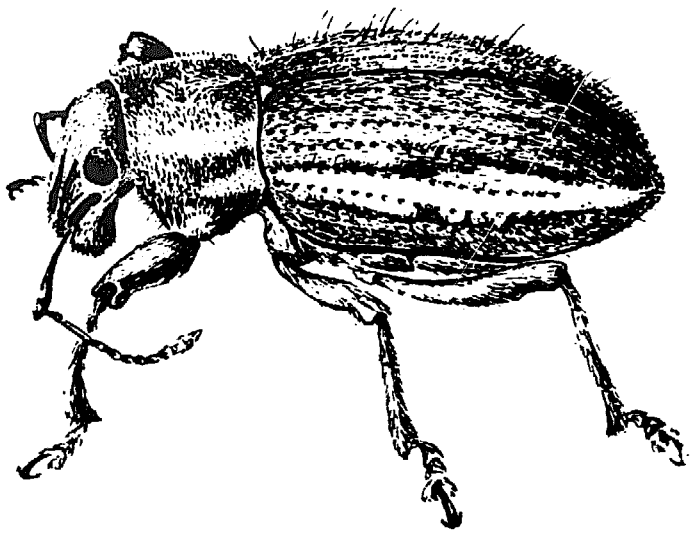

Figure 128. White-fringed Beetle.

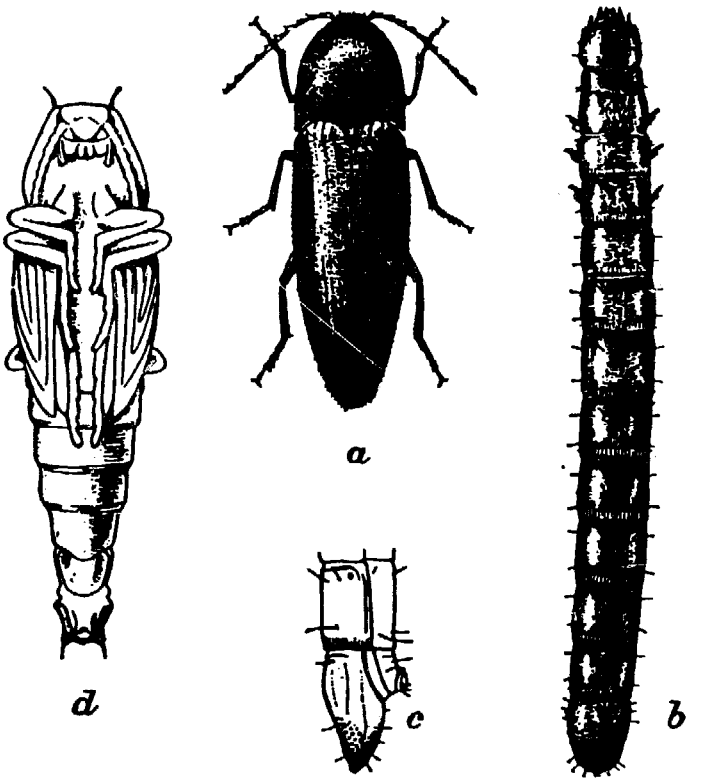

Figure 130. Wireworm.

U. S. D. A. Photographs

Chapter 7

PLANT MATERIAL

The introduction of new varieties for the tropical areas is very important. In areas where variety trials have not been conducted, the first step would be to start variety trials. In order to conduct variety trials, it is important to know where to obtain experimental plant material.

Since it is not easy to select varieties without some kind of trial, the best method will be to select varieties with the characters desired. For example, disease resistance, earliness, etc. could be used to make your selections. Length of day also will be a factor. Varieties adapted to the same latitude should be selected.

The list of seed sources is by no means complete. It includes some wholesale seedsmen as well as retailers. Plant breeders have been omitted because their supplies are insufficient for general distribution. Therefore, seeds should be ordered from private companies.

VEGETABLE SEED SOURCES[1]

Commercial

NAME	ADDRESS	CROPS
Arthur Yates & Co.	Sydney, Australia	All Crops
Asgrow Export Corporation	Milford, Conn.	All Crops
W. Atlee Burpee Co.	Hunting Park Ave. at 18th St. Philadelphia 32, Pa.	All Crops
Corneli Seed Co.	101 Choteau Ave., St. Louis 2, Mo.	All Crops
Dessert Seed Co.	P.O. Box 181, El Centro, Calif.	Onions, etc.
Ferry-Morse Seed Co.	Box 100, Mountain View, Calif.	All Seeds
Glecklers	Metamora, Ohio	Tomato
Joseph Harris Seed Co.	Rochester 11, New York	Tomato, beans, etc.
Northrup King & Co.	1500 Jackson St. N.E. Minneapolis 13, Minn.	All Crops
J. E. Ohlsen's ENKE	Linnesgade 14, Copenhagen, Denmark	All Crops
Pieters, Wheeler Seed Co.	Gilroy, Calif.	All Crops
Peto Seed Co.	Box 138, Saticoy, Calif.	Tomato
Reuter Seed Co.	320 N. Carrolton Ave., New Orleans 9, La.	All Crops
Rogers Bros. Co.	P.O. Box 2188, Idaho Falls, Idaho	Beans, Peas
Seed Research Specialists	Modesto, Calif.	All Crops
Simpson Nursery Co.	Monticello, Fla.	Watermelons
Stokes Seeds Ltd.	Ste. Catherine Ontario, Canada	All Crops
Takii and Co., Ltd.	180 Umekoji-Imokuma Kyoto, Japan	All Crops esp. hybrids
Twilley, O. S.	Salisbury, Md.	Cucurbits, tomato
Vaughan's Seed Co.	601 W. Jackson Blvd., Chicago 6, Ill.	All Crops
Vilmorin, Andrieux & Co.	Paris, France	All Crops
Willhite Melon Seed Farms	Weatherford, Texas	Watermelons

[1] This is by no means a complete list of seed companies and the authors do not recommend these seed companies but are merely suggesting a few possible sources of vegetable seeds. There are many other seed companies that are just as reliable as the ones listed.

Chapter 8

EQUIPMENT, SUPPLIES AND MATERIALS

Introduction

One of the main problems that confronts a horticulturist working overseas for the first time is that of obtaining equipment, supplies and materials. A horticulturist working in the United States can look in the classified section of a telephone directory and have the information he wants in a few minutes and receive his supplies and materials in a matter of days.

This situation does not exist in many of the areas overseas where a horticulturist might be working. It usually is not possible to take all the reference material overseas that one would like.

If one does not know a ready source of supplies he must write to someone else to determine a source of supplies and then write to the company for prices and other information before requisitioning the supplies and equipment. This type of operation may delay a project from one to six months before the materials and supplies are available for use.

A partial list of equipment, materials and supplies is presented here to give the horticulturist an idea where some of the important items can be located. There are many sources for most of the items listed but only one or two are indicated for each item to save space.

The authors do not endorse or recommend any of the companies listed in this book since many other companies may supply these items. The list is presented only as a possible source of the items.

SOURCE OF EQUIPMENT, MATERIALS AND SUPPLIES

ITEMS	REMARKS	SOURCE
1. Applicators	For use on 1 lb. cans for Dowfume MC–2	Arrow Products Co. 447 Lincoln St. Carlstadt, N. J.
2. Bags-polyethylene	For planting trees	Dobeckman Co. 1700 - 5th St. Berkley 10, Calif.
3. Calculator	For statistical analysis	Friden, Inc. San Leandro, Calif.
		Monroe Calculating Machine 555 Mitchell St. Orange, N. J.
4. Dusters		D. B. Smith Export Co. Smith Bldg. Main St. Utica 2, N. Y.
5. Embossers	For labelling trees	Dymo Industries, Inc. 525 Bridge St. Duryea, Pa.
6. Fertilizers	Chelates of Iron, Manganese and Zinc	Division of Geigy Chemical Corp. P. O. Box 430 Yonkers, N. Y.
	Diammonium phosphate	Olin Mathieson Chemical Corp. Mathieson Bldg. Baltimore, Maryland
	General	Esso Chemical Co. 15 West 51st St. New York 19, N. Y.
7. Fungicides	Phygon XL	U. S. Rubber Co. Naugatuck Chemical Div. Naugatuck, Conn.
7. Fungicides	Tri-Basic copper sulphate	Tennessee Corporation 614 Grant Building Atlanta, Ga.
	Manzate, Parzate Spreader-Sticker Delsan A–D Arasan SF–M	E. I. du Pont de Nemours & Co. Wilmington, Delaware
	Captan Orthocide 50W	California Chemical Ortho Division P. O. Box 7067 Orlando, Florida

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5. Embossers	For labelling trees	Dymo Industries, Inc. 525 Bridge St. Duryea, Pa.
6. Fertilizers	Chelates of Iron, Manganese and Zinc	Division of Geigy Chemical Corp. P. O. Box 430 Yonkers, N. Y.
	Diammonium phosphate	Olin Mathieson Chemical Corp. Mathieson Bldg. Baltimore, Maryland
	General	Esso Chemical Co. 15 West 51st St. New York 19, N. Y.
7. Fungicides	Phygon XL	U. S. Rubber Co. Naugatuck Chemical Div. Naugatuck, Conn.
7. Fungicides	Tri-Basic copper sulphate	Tennessee Corporation 614 Grant Building Atlanta, Ga.
	Manzate, Parzate Spreader-Sticker Delsan A–D Arasan SF–M	E. I. du Pont de Nemours & Co. Wilmington, Delaware
	Captan Orthocide 50W	California Chemical Ortho Division P. O. Box 7067 Orlando, Florida

SOURCE OF EQUIPMENT, (Continued)

ITEMS	REMARKS	SOURCE
8. General Agricultural Equipment		National Agricultural Supply Co. Fort Atkinson, Wis.
		Seed Trade Buyers Guide 327 So. La Salle St. Chicago 4, Ill.
9. Glue	Cement for repairing burlap bags	Val - A Company 700 - 710 W. Roog St. Chicago 9, Ill.
10. Herbicides	Alanap 3	Naugatuck Chemical International 1230 Avenue of Americas New York 20, N. Y.
	Dowpon (Dalapon) Premerge Dowfume MC-2 Dowcide G (Pentachloro-phenate)	Dow Chemical Co. Midland, Michigan
	Sinox P.E.	F. M. C. International 161 East 42nd St. New York 17, N. Y.
	Chlore IPC Emulsifiable Concentrate	Pittsburgh Plate Glass International Geneva, Switzerland
	Eptam 6 EC Tillam 6 EC	Stauffer Chemical Co. 380 Madison Ave. New York 17, N. Y.
	Mylone Crag Sesone	Union Carbide Inter-America, Inc. 270 Park Avenue New York 17, N. Y.
	Lorox	E. I. du Pont de Nemours & Co. Wilmington, Delaware
	Amiben	Amchem Products, Inc. Ambler, Pa.
	Stoddard Solvent	Esso Research and Engineering Co. P. O. Box 51 Linden, N. J.
	Simazin Atrazin	J. R. Geigy S. A. Basel, Switzerland
11. Insecticides	Diazinon 25% WP Diazinon 60% E Diazinon 40% M	Division of Geigy Chemical Co. P. O. Box 430 Yonkers, N. Y.
11. (Cont.)	Sevin 50 W	Union Carbide International Co. 270 Park Avenue New York 17, N. Y.
	DDT 50% W (Deenate) Marlate 50 Methoxychlor	E. I. du Pont de Nemours & Co. Wilmington, Delaware
	Dieldrin 50% W	Miller Products Co. 7737 N. E. Killingsworth Portland, Ore.
	Aldrin	Stauffer Chemical Co. 380 Madison Ave. New York 17, N. Y.
12. Labels	Plastic for marking trees and shrubs	Economy Label Sales Co. P. O. Box 350 Daytona Beach, Fla.
13. Markers	Plastic for marking plots and seed bed	Life Markers P. O. Box 216 Clyde, Michigan
14. Measuring equipment		Keuffel and Esser Co. Adams and Third St. Hoboken, N. J.
15. Meteorological equipment		The Bendix Corp. Bendix International Division 205 East 42nd St. New York 17, N. Y.
16. Mist Propagator		Al Saffer and Co. 130 West 28th St. New York 1, N. Y.
17. Nursery Equipment		A. M. Leonard & Sons, Inc. Piqua, Ohio
18. Office Equipment		General Services Administration Federal Supply Service 50 Seventh St. N. E. Atlanta 23, Ga.
		Chas. J. Lane Corp. 105 Chambers St. New York 7, N. Y.
		Art Steel Co. Inc. 170 West 23rd St. New York 63, N. Y.
19. Pencils	Waterproof for labelling markers	Yoho and Hooker Youngstown, Ohio
20. Photographic Equipment	Negative files Files for Kodachrome slides	The Mega-File Co. Box 405 Doylestown, Pa.
		Eastman Kodak Co. Rochester, N. Y.

ITEMS	REMARKS	SOURCE
21. Plastic film	For covering nursery beds	Gering Plastics Division of Studebaker Packard Corp. Kenilworth, N. J.
22. Pollinating Supplies	Tassel & Silk Bags	Corn States Hybrid Service 803 Kee Way Des Moines 14, Iowa
22. Pollinating Supplies	Plastic vials for cacao or tomatoes (3/8" diameter x 1" long)	Lusterioid Container Co. Inc. 10 West Parker Ave. Maplewood, N. J.
23. Radio Equipment		O. O. Mallegg Inc. Daily News Building 400 West Madison Chicago, Ill.
24. Scientific Equipment		Arthur H. Thomas Co. P. O. Box 779 Philadelphia 5, Pa.
		Fisher Scientific Co. 635 Greenwich St. New York, N. Y.
25. Seed Packet		Disbrow Manufacturing Co. 181 South 18th St. East Orange, N. J.
26. Soil Analysis	Plant tissue analysis	Thorton Laboratories P. O. Box 2880 Tampa, Fla.
27. Soil Testing Equipment	Soil moisture meter for Bouyoucos blocks	Industrial Instruments 89 Commerce Road Cedar Grove, N. J.
	Bouyoucos Soil Moisture Blocks	Irrigation Development Corp. 260 Madison Ave. New York 16, N. Y.
	Soil Samplers, etc.	Soiltest Incorporated 4711 West North Ave. Chicago 39, Ill.
28. Sprayers		D. B. Smith Export Co. Smith Building Main Street Utica 2, N. Y.
29. Tags	White tags to identify seed sacks	Dennison Company Framingham, Mass.

Chapter 9

CONVERSION FACTORS

There are many types of measurements used in the Tropics. The metric system is used in most of the tropical countries but there are a few countries that use the Imperial system of measurements. The metric system has the advantage that it is based on tenths which facilitates easy calculations. In some countries, terms such as tarea, carreau, cuerda, manzana and faddan are used for land measurement. A tarea at one time was considered the amount of land a man could plow in a day with a team of oxen and is about 1/16 of a hectare.

Many different terms are used for measurements and only a few of the more important terms are included in the following tables. A uniform method of presenting scientific data is needed throughout the world so that the data will be understood by all people. The metric system probably will be adapted universally some day, but until it is, conversion tables are needed to convert one system to another readily.

AREA

Metric			
1 square	=	0.155	sq. in.
centimeter	=	100	sq. millimeters
1 square meter	=	1,550	sq. inches
	=	10.764	sq. feet
	=	1.196	sq. yards
	=	10,000	sq. centimeters
1 square	=	0.3861	sq. mile
kilometer	=	254.427	cuerdas
	=	1,000	sq. meters
1 are	=	100	sq. meters
	=	0.01	hectare
	=	0.0247	acre
1 hectare	=	2.471	acres
	=	0.775	carreau
	=	10,000	sq. meters
		100	ares
Imperial			
1 square inch	=	6.452	sq. centimeters
	=	1/144	sq. foot
	=	1/1296	sq. yard
1 square foot	=	929.088	sq. cm.
	=	0.0929	sq. meter
1 square link	=	62.7264	sq. in.
1 square yard	=	8,361.3	sq. cm.
	=	0.8361	sq. meter
	=	1,296	sq. inches
	=	9	sq. feet
1 square rod	=	25.292	sq. meters
	=	272.25	sq. feet
	=	30.25	sq. yards
1 square mile	=	2.59	sq. km.
	=	102,400	sq. rods
	=	658.98	cuerdas
	=	640	acres
1 acre	=	0.4047	hectare
	=	0.3135	carreau
	=	43,560	sq. feet
	=	4,840	sq. yards
	=	4,046.87	sq. meters
	=	160	sq. rods
	=	.579	manzana
	=	615	tareas
1 caballeria	=	64.58	manzanas
	=	43.15	hectares
	=	111.5	acres
1 carreau	=	3.18	acres
(Haiti)	=	1.29	hectares
1 cuerda	=	625	sq. varas
(Puerto Rico)	=	42,306	sq. feet
	=	3,930	sq. meters
1 dunum	=	100	sq. meters
1 manzana	=	10,000	sq. varas
1 tarea	=	1/6.44	acre
(Dominican	=	1/16	hectare
Republic)	=	629	sq. meters
1 faddan	=	4,200	sq. meters

IRRIGATION

1 acre foot	=	325,851	gallons
1 second-foot	=	448.8	gallons per minute
	=	3,600	cubic ft. per hour
1 horse power	=	550	foot pounds per second
1 acre inch	=	3,630	cubic feet
	=	27,154	gallons
Velocity	=	$0.75\ \sqrt{2\ g\ h}$	
		gravity	
g	=	32.2	
h	=	head in feet and tenths	

IRRIGATION (Continued)

Area	=	D^2 x .7854
D	=	Diameter of pipe in feet and tenths
Problem		1 foot head 24" pipe
Volume	=	$0.75 \sqrt{2 g h}$
	=	$0.75 \sqrt{64.4 \times 1'}$
	=	$0.75 \sqrt{64.4}$
	=	0.75 x 8.02 = 6.02
A = Area	=	D^2 x 0.7854
	=	2^2 x 0.7854
	=	4 x 0.7854 = 3.1416
Quantity	=	AV
Q	=	quantity in second feet
Q	=	3.14 x 6.02
Q	=	18.9
		10 - 20 sec. ft. good for 160 acres

LENGTH

Metric

1 millimicron	=	0.001	micron
1 micron	=	0.001	millimeter
1 millimeter	=	0.001	meter
	=	0.0394	inch
1 centimeter	=	10	millimeters
	=	0.3937	inch
	=	0.01	meter
1 meter	=	39.37	inches
	=	3.281	feet
	=	1,000	millimeters
	=	100	centimeters
	=	1.2	varas
1 hectometer	=	100	meters
	=	109.36111	yards
	=	328.0833	feet
1 kilometer	=	3,281	feet
	=	1,094	yards
	=	0.621	mile
	=	1,000	meters

Imperial

1 mil	=	1/1000	inch
	=	0.0254	millimeter
1 inch	=	25.4	millimeters
	=	2.54	centimeters
1 hand	=	4	inches
	=	10.16	centimeters
1 link	=	1/100	chain
	=	7.92	inches
	=	0.22	yard
	=	0.201	meter
1 foot	=	30.48	centimeters
	=	0.3048	meter
	=	12	inches
1 yard	=	0.9144	meter
	=	91.44	centimeters
	=	3	feet
	=	4.525	links
1 brasa	=	6	feet
	=	1.83	meters
1 vara	=	32.71	inches
	=	83.29	centimeters
1 rod	=	25	links
	=	5.025	meters
	=	198	inches
	=	16.5	feet
	=	5.5	yards
1 chain	=	4	rods
	=	22	yards
	=	66	feet
	=	100	links
	=	20.116	meters
1 mile	=	1,609.347	meters
	=	1.609	kilometers
	=	5,280	feet
	=	1,760	yards
	=	320	rods

PRESSURE

Metric

1 atmosphere	=	14.696	pounds per sq. in.
	=	760	mm. of mercury at 0° C.
	=	1,036	cm. of water
1 gm. per square centimeter	=	0.4912	lb. per sq. in.
1 kilogram per sq. meter	=	0.20482	lb. per sq. ft.
	=	0.0014223	lb. per sq. ft.

Imperial

1 pound per sq. in.	=	70.307	grams per sq. cm.
1 pound per sq. ft.	=	0.48824	grams per sq. cm.
	=	4.8824	kilograms per. sq. m.

VARIOUS

1 foot per second	=	0.68	miles per hour
1 degree of latitude	=	68.7	miles
1 degree of longitude	=	69.17	miles

VOLUME

Metric

1 cubic millimeter	=	0.000,000,001	cu. meter
1 milliliter	=	0.03382	fluid ounce
	=	0.001	liter
1 centiliter	=	0.01	liter
	=	0.61	cubic inch

VOLUME (Continued)

1 liter	=	33.82	fluid ounces
	=	2.113	U.S. pints liquid
	=	1.057	U.S. quarts liquid
	=	0.9081	quart, dry
	=	0.2642	U.S. gallon
	=	0.11351	U.S. peck
	=	0.221	Imperial gallon
	=	1,000	milliliters or cc.
	=	0.0353	cubic foot
	=	61.02	cubic inches
	=	0.001	cubic meter
1 cubic centimeter	=	0.061	cubic inch
	=	1,000	cubic millimeters
1 decalitre	=	10	liters
	=	18.162	dry pints
	=	9.081	dry quarts
	=	1.135	pecks
	=	0.283	bushel
1 hectoliter	=	100	liters
	=	2.8378	bushels
1 cubic meter	=	61,023.38	cubic inches
	=	35.314	cubic feet
	=	1.308	cubic yards
	=	264.17	U.S. gallons
	=	1,000	liters
	=	28.38	U.S. bushels
	=	1,000,000	cu. centimeters
	=	1,000,000,000	cu. millimeters
1 cubic kilometer	=	1,307,942,000	cu. yards

Imperial

1 teaspoon (level)	=	0.17	fluid ounce
	=	6	cubic centimeters
1 tablespoon (level)	=	0.5	fluid ounce
	=	3	teaspoons (level)
	=	18	cu. centimeters
1 fluid ounce	=	1/128	gallon
	=	29.57	cubic centimeters
	=	2	tablespoons (level)
	=	29.562	milliliters
	=	1.805	cubic inches
	=	0.0625	U.S. pint (liquid)
1 gill	=	1/32	gallon
	=	1/4	liquid pint
	=	7.21875	cubic inches
	=	0.118	liter
1 cup	=	0.5	pint
	=	8	fluid ounces
1 U.S. pint (liquid)	=	473.2	milliliters
	=	2	cups
	=	0.5	quart
	=	0.4732	liter
	=	28.875	cubic inches
	=	16	fluid ounces
	=	1/8	gallon
1 pint (dry)	=	0.550	liter
	=	33.60	cubic inches
	=	0.5	quart (dry)
	=	0.0625	peck
	=	1/64	bushel
1 U.S. quart liquid	=	946.3	milliliters
	=	57.75	cubic inches
	=	32	fluid ounces
	=	4	cups
	=	1/4	gallon
	=	2	U.S. pints (liquid)
	=	0.946	liter
1 quart dry	=	1.1012	liters
	=	67.20	cubic inches
	=	2	pints (dry)
	=	0.125	peck
	=	1/32	bushel
1 cubic inch	=	16.387	cubic centimeters
1 cubic foot	=	28,317	cubic centimeters
	=	0.0283	cubic meter
	=	28.316	liters
	=	7.481	U.S. gallons
	=	1,728	cubic inches
1 U.S. gallon	=	16	cups
	=	3.785	liters or cc.
	=	231	cubic inches
	=	4	U.S. quarts
	=	8	U.S. pints
	=	8.3453	pounds of water
	=	128	fluid ounces
	=	0.8327	British Imperial gallon
1 British Imperial gallon	=	4.546	liters
	=	1.201	U.S. gallons
	=	277.42	cubic inches
1 boardfoot	=	144	cubic inches
	=	1/12	cubic foot
	=	2,359	cubic centimeters
1 cubic yard	=	0.7646	cubic meter
	=	46,656	cubic inches
	=	27	cubic feet
1 cord	=	128	cubic feet
	=	3.624	cubic meters
1 peck	=	8.809	liters
	=	537.605	cubic inches
	=	16	pints (dry)
	=	8	quarts (dry)
	=	0.25	bushel
1 U.S. bushel	=	35.24	liters
	=	0.3524	hectoliter
	=	2,150.42	cubic inches
	=	1.2444	cubic feet
	=	0.03524	cubic meter
	=	4	pecks
	=	32	quarts
	=	64	pints
1 barrel	=	7,056	cubic inches
	=	105	dry quarts
	=	115.626	liters

1 U.K. bushel	=	2,219.36	cubic inches
	=	36.37	liters
Other			
1 almud	=	0.98	cubic foot
	=	27.75	liters
1 fanega	=	2	almudes

WEIGHT

Metric			
1 milligram	=	0.001	gram
	=	0.0154	grain
1 centigram	=	0.01	gram
	=	0.1543	grain
1 gram	=	0.0353	avoirdupois ounce
	=	15.4324	grains
1 decagram	=	10	grams
	=	154.324	grains
1 hectogram	=	100	grams
	=	3.53	avoirdupois ounces
	=	1,543.24	grains
1 kilogram	=	1,000	grams
	=	353	avoirdupois ounces
	=	2.2046	avoirdupois pounds
	=	10	hectograms
1 quintal	=	100	kilograms
(metric)	=	220.46	pounds
1 metric ton	=	1,000	kilograms
	=	2,204.6	pounds
	=	1.102	short tons
	=	0.984	long ton
Imperial			
1 dram	=	1/256	avoirdupois pound
(avoirdupois)	=	27.34	grains
	=	1.772	grams
1 dram	=	1/96	apoth. pound
(apothecaries)	=	1/8	apoth. ounce
	=	60	grains
	=	3.8879	grams
1 grain	=	1/7000	avoirdupois pound
	=	0.064799	gram
1 ounce			
(avoirdupois)	=	28.3496	grams
	=	437.5	grains
	=	1/16	pound
1 pound			
(avoirdupois)	=	453.593	grams
	=	0.45369	kilograms
	=	16	ounces
1 stone	=	14	pounds
	=	6.350	kilograms
1 hundred-weight (cwt)	=	45.36	kilograms
	=	100	avoirdupois pounds
1 quintal	=	100	pounds
1 short ton	=	907.184	kilograms
	=	0.9072	metric ton
	=	2,000	pounds
	=	20	quintals
Other			
1 arroba			
(Puerto Rico)	=	25.36	pounds
1 arroba			
(Brazil)	=	33.00	pounds
	=	15	kilograms

YIELD

Metric			
1 kilogram			
per hectare	=	0.89	pound per acre
1 hectoliter			
per hectare	=	68.88	pounds per acre
	=	1.148	bushels (60 pounds) per acre
1 quintal			
per hectare	=	89.214	pounds per acre
	=	1.4869	bushels (60 pounds) per acre
	=	100	kilograms per hectare
	=	0.446	ton (2,000 lb.) per acre
Imperial			
1 pound			
per acre	=	1.121	kilograms per hectare
1 bushel (60 pounds) per			
acre	=	0.871	hectoliter per hectare
	=	67.26	kilograms per hectare
1 ton (2,000			
lb.) per acre	=	2.242	metric tons per hectare

Table 19. CENTIGRADE—FAHRENHEIT CONVERSION TABLE

On the centigrade scale, the temperature of melting ice is 0° and that of boiling water is 100° at normal atmospheric pressure. In the Fahrenheit scale, these two equivalent temperatures appear at 32° and 212°, respectively. The formula for converting Fahrenheit to centigrade is C=5/9 (F—32) and the formula for converting centigrade to Fahrenheit is F=9/5 C+32.

C	C or F	F	C	C or F	F
—73.33	—100	—148.0	— 5.00	23	73.4
—70.56	— 95	—139.0	— 4.44	24	75.2
—67.78	— 90	—130.0	— 3.89	25	77.0
—65.00	— 85	—121.0	— 3.33	26	78.8

Table 19. CENTIGRADE—FAHRENHEIT CONVERSION TABLE (Continued)

C	C or F	F	C	C or F	F
—62.22	— 80	—112.0	— 2.78	27	80.6
—59.45	— 75	—103.0	— 2.22	28	82.4
—56.67	— 70	— 94.0	— 1.67	29	84.2
—53.89	— 65	— 85.0	— 1.11	30	86.0
—51.11	— 60	— 76.0	— 0.56	31	87.8
—48.34	— 55	— 67.0	0	32	89.6
—45.56	— 50	— 58.0	0.56	33	91.4
—42.78	— 45	— 49.0	1.11	34	93.2
—40.0	— 40	— 40.0	1.67	35	95.0
—37.23	— 35	— 31.0	2.22	36	96.8
—34.44	— 30	— 22.0	2.78	37	98.6
—31.67	— 25	— 13.0	3.33	38	100.4
—28.89	— 20	— 4.0	3.89	39	102.2
—26.12	— 15	5.0	4.44	40	104.0
—23.33	— 10	14.0	5.00	41	105.8
—20.56	— 5	23.0	5.56	42	107.6
—17.8	0	32.0	6.11	43	109.4
—17.2	1	33.8	6.67	44	111.2
—16.7	2	35.6	7.22	45	113.0
—16.1	3	37.4	7.78	46	114.8
—15.6	4	39.2	8.33	47	116.6
—15.0	5	41.0	8.89	48	118.4
—14.4	6	42.8	9.44	49	120.2
—13.9	7	44.6	10.0	50	122.0
—13.3	8	46.4	10.6	51	123.8
—12.8	9	48.2	11.1	52	125.6
—12.2	10	50.0	11.7	53	127.4
—11.7	11	51.8	12.2	54	129.2
—11.1	12	53.6	12.8	55	131.0
—10.6	13	55.4	13.3	56	132.8
—10.0	14	57.2	13.9	57	134.6
— 9.44	15	59.0	14.4	58	136.4
— 8.89	16	60.8	15.0	59	138.2
— 8.33	17	62.6	15.6	60	140.0
— 7.78	18	64.4	16.1	61	141.8
— 7.22	19	66.2	16.7	62	143.6
— 6.67	20	68.0	17.2	63	145.4
— 6.11	21	69.8	17.8	64	147.2
— 5.56	22	71.6	18.3	65	149.0
18.9	66	150.8	60	140	284
19.4	67	152.6	66	150	302
20.0	68	154.4	71	160	320
20.6	69	156.2	77	170	338
21.1	70	158.0	82	180	356
21.7	71	159.8	88	190	374
22.2	72	161.6	93	200	392
22.8	73	163.4	99	210	410
23.3	74	165.2	100	212	413
23.9	75	167.0	104	220	428
24.4	76	168.8	110	230	446
25.0	77	170.6	116	240	464
25.6	78	172.4	121	250	482
26.1	79	174.2	127	260	500
26.7	80	176.0	132	270	518
27.2	81	177.8	138	280	536
27.8	82	179.6	143	290	554
28.3	83	181.4	149	300	572
28.9	84	183.2	154	310	590
29.4	85	185.0	160	320	608
30.0	86	186.8	166	330	626
30.6	87	188.6	171	340	644
31.1	88	190.4	177	350	662
31.7	89	192.2	182	360	680
32.2	90	194.0	188	370	698
32.8	91	195.8	193	380	716
33.3	92	197.6	199	390	734
33.9	93	199.4	204	400	752
34.4	94	201.2	210	410	770
35.0	95	203.0	216	420	788
35.6	96	204.8	221	430	806
36.1	97	206.6	227	440	824
36.7	98	208.4	232	450	842
37.2	99	210.2	238	460	860
37.8	100	212.0	243	470	878
43	110	230	249	480	896
49	120	248	254	490	914
54	130	266	260	500	932

The numbers in the "C" or "F" column refer to temperatures in either centigrade or Fahrenheit degrees. If used to represent centigrade degrees, the equivalent temperature in Fahrenheit is listed in the "F" column. If used to represent Fahrenheit the equivalent is listed in the "C" column.

Table 20. CONVERSION OF OUNCES TO FRACTIONS OF A POUND

Ounce	Per cent of a Pound	
1	0.0625	or 0.06
2	0.125	or 0.13
3	0.1875	or 0.19
4	0.250	or 0.25
5	0.3125	or 0.31
6	0.375	or 0.38
7	0.4375	or 0.44
8	0.500	or 0.50
9	0.5625	or 0.56
10	0.625	or 0.63
11	0.6875	or 0.69
12	0.750	or 0.75
13	0.8125	or 0.81
14	0.875	or 0.88
15	0.9375	or 0.94

Table 21. NUMBER OF PLANTS PER ACRE AT GIVEN SPACINGS

Inches	No. of Plants	Inches	No. of Plants	Inches	No. of Plants
12 x 1	522,720	20 x 3	104,544	30 x 15	13,939
12 x 3	174,240	20 x 4	78,408	30 x 18	11,616
12 x 4	130,680	20 x 6	52,272	30 x 24	8,712

Table 21. NUMBER OF PLANTS PER ACRE AT GIVEN SPACINGS (Continued)

Inches	No. of Plants	Inches	No. of Plants	Inches	No. of Plants
12 x 6	87,120	20 x 9	34,848	30 x 30	6,969
12 x 9	58,080	20 x 12	26,136		
12 x 12	43,560	20 x 15	20,909	36 x 3	58,080
		20 x 18	17,426	36 x 4	43,560
15 x 1	418,176			36 x 6	29,040
15 x 3	139,382	24 x 3	87,120	36 x 9	19,360
15 x 4	104,544	24 x 4	65,340	36 x 12	14,520
15 x 6	69,696	24 x 6	43,560	36 x 15	11,616
15 x 9	48,484	24 x 9	29,040	36 x 18	9,680
15 x 12	34,848	24 x 12	21,780	36 x 24	7,260
		24 x 15	17,424	36 x 30	5,808
18 x 1	348,390	24 x 18	14,520	36 x 36	4,840
18 x 3	116,160	24 x 24	10,890		
18 x 4	87,120			40 x 3	52,272
18 x 6	58,080	30 x 3	69,696	40 x 6	26,136
18 x 9	38,720	30 x 4	52,272	40 x 12	13,068
18 x 12	29,040	30 x 6	34,848	40 x 18	8,709
18 x 15	23,232	30 x 9	23,232	40 x 24	6,534
18 x 18	19,360	30 x 12	17,424	40 x 30	5,227
				40 x 36	4,356
42 x 3	49,782	48 x 12	10,890	60 x 12	8,712
42 x 6	24,891	48 x 18	7,260	60 x 18	5,808
42 x 12	12,445	48 x 24	5,445	60 x 24	4,356
42 x 18	8,297	48 x 30	4,356	60 x 30	3,484
42 x 24	6,223	48 x 36	3,630	60 x 36	2,904
42 x 30	4,978	48 x 42	3,111	60 x 42	2,489
42 x 36	4,148	48 x 48	2,722	60 x 48	2,178
				60 x 54	1,936
48 x 3	43,560	60 x 3	34,848	60 x 60	1,742
48 x 6	21,780	60 x 6	17,424		

Table 22. NUMBER OF PLANTS PER HECTARE AT GIVEN SPACINGS

Centimeters	No. of Plants	Centimeters	No. of Plants	Centimeters	No. of Plants
25 x 2	2,000,000	75 x 50	26,666	125 x 60	13,333
25 x 5	800,000	75 x 60	22,222	125 x 75	10,400
25 x 10	400,000	75 x 75	17,777	125 x 80	10,000
25 x 15	266,666	100 x 2	500,000	125 x 90	8,888
25 x 20	200,000	100 x 5	200,000	125 x 100	8,000
25 x 25	160,000	100 x 10	100,000	125 x 125	6,400
50 x 2	1,000,000	100 x 15	66,666	150 x 5	133,333
50 x 5	400,000	100 x 20	50,000	150 x 10	66,666
50 x 10	200,000	100 x 25	40,000	150 x 25	26,666
50 x 15	133,333	100 x 30	33,333	150 x 50	13,333
50 x 20	100,000	100 x 40	25,000	150 x 75	8,888
50 x 25	80,000	100 x 50	20,000	150 x 100	6,666
50 x 30	66,666	100 x 60	16,666	150 x 125	5,200
50 x 35	57,142	100 x 75	13,333	150 x 150	4,444
50 x 40	50,000	100 x 80	12,500	175 x 5	114,280
50 x 45	44,444	100 x 90	11,111	175 x 10	57,140
50 x 50	40,000	100 x 100	10,000	175 x 25	22,856
75 x 2	666,666	125 x 2	400,000	175 x 50	11,428
75 x 5	266,666	125 x 5	160,000	175 x 75	7,618
75 x 10	133,333	125 x 10	80,000	175 x 100	5,714
75 x 15	88,888	125 x 20	40,000	175 x 125	4,571
75 x 20	66,666	125 x 25	32,000	175 x 150	3,809
75 x 25	53,333	125 x 30	26,666	175 x 175	3,265
75 x 30	44,444	125 x 40	20,000		
75 x 40	33,330	125 x 50	16,000		

Table 23. NUMBER OF TREES PER ACRE AT GIVEN SPACINGS

Feet	No. of Plants	Feet	No. of Plants	Feet	No. of Plants
6 x 1	7,260	10 x 1	4,356	18 x 4	605
6 x 2	3,630	10 x 2	2,178	18 x 6	404
6 x 3	2,420	10 x 3	1,452	18 x 8	303
6 x 4	1,815	10 x 4	1,089	18 x 10	242
6 x 5	1,452	10 x 5	871	18 x 12	202
6 x 6	1,210	10 x 6	726	18 x 14	173
		10 x 7	622	18 x 16	152
7 x 1	6,223	10 x 8	544	18 x 18	132
7 x 2	3,111	10 x 9	484		
7 x 3	2,074	10 x 10	435		
7 x 4	1,556			20 x 8	272
7 x 5	1,244	12 x 2	1,815	20 x 10	218
7 x 6	1,037	12 x 4	907	20 x 12	184
7 x 7	889	12 x 6	605	20 x 14	156
		12 x 7	454	20 x 16	136
8 x 1	5,445	12 x 10	363	20 x 18	121
8 x 2	2,722	12 x 12	302	20 x 20	109
8 x 3	1,815				
8 x 4	1,361	14 x 2	1,556		
8 x 5	1,089	14 x 4	778	24 x 12	151
8 x 6	907	14 x 6	518	24 x 16	114
8 x 7	778	14 x 8	389	24 x 20	92
8 x 8	680	14 x 10	311	24 x 24	76
		14 x 12	259		
9 x 1	4,840	14 x 14	222		
9 x 2	2,420			30 x 20	72
9 x 3	1,613	16 x 2	1,361	30 x 30	48
9 x 4	1,210	16 x 4	680	30 x 40	36
9 x 5	968	16 x 6	454		
9 x 6	807	16 x 8	340		
9 x 7	691	16 x 10	272	40 x 40	27
9 x 8	605	16 x 12	227		
9 x 9	528	16 x 14	194		
		16 x 16	170		

In order to obtain the number of plants per acre, divide 43,560 by the product of the spacing in the rows expressed in feet.

Table 24. NUMBER OF TREES PER HECTARE AT GIVEN SPACINGS

Meters	No. of Plants	Meters	No. of Plants	Meters	No. of Plants
2 x 0.25	20,000	5 x 1.0	2,000	8 x 1	1,250
2 x 0.50	10,000	5 x 1.5	1,333	8 x 2	555
2 x 0.75	6,666	5 x 2.0	1,000	8 x 3	416
2 x 1.0	5,000	5 x 2.5	800	8 x 4	312
2 x 1.25	4,000	5 x 3.0	666	8 x 5	250
2 x 1.50	3,333	5 x 3.5	571	8 x 6	208
2 x 1.75	2,857	5 x 4.0	500	8 x 7	178
2 x 2.0	2,500	5 x 4.5	444	8 x 8	156
		5 x 5.0	400		
3 x 0.5	6,666				
3 x 1.0	3,333	6 x 1	1,666	9 x 1	1,111
3 x 1.5	2,222	6 x 2	833	9 x 2	555
3 x 2.0	1,666	6 x 3	555	9 x 3	370
2 x 2.5	1,333	6 x 4	416	9 x 4	277
3 x 3.0	1,111	6 x 5	333	9 x 5	222
		6 x 6	277	9 x 6	185
4 x 0.5	5,000			9 x 7	158

Table 24. NUMBER OF TREES PER HECTARE AT GIVEN SPACINGS (Continued)

Meters	No. of Plants	Meters	No. of Plants	Meters	No. of Plants
4 x 1.0	2,500	7 x 1	1,428	9 x 8	138
4 x 1.5	1,666	7 x 2	714	9 x 9	123
4 x 2.0	1,250	7 x 3	476	9 x 10	111
4 x 2.5	1,000	7 x 4	357		
4 x 3.0	833	7 x 5	285		
4 x 3.5	714	7 x 6	238	10 x 10	100
4 x 4.0	625	7 x 7	204		

In order to obtain the number of plants per hectare, divide 10,000 by the product of the spacing in the rows expressed in meters.

Table 25. RANDOM NUMBERS: 1 TO 10

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
6	10	8	4	8	4	2	3	1	8	6	1	1	4
5	4	10	10	4	1	4	2	9	9	3	8	9	3
2	9	3	3	3	7	5	10	8	3	2	6	6	1
7	1	2	8	7	5	7	4	6	10	1	7	4	5
8	5	9	2	10	3	1	7	5	5	8	10	10	9
3	8	4	7	2	6	3	6	10	4	9	2	8	10
9	3	6	9	9	2	9	5	3	2	7	9	2	6
4	7	1	5	5	8	10	8	4	1	5	3	7	7
1	2	7	1	6	9	6	9	2	6	10	5	3	8
10	6	5	6	1	10	8	1	7	7	4	4	5	2

XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV
3	10	4	6	4	8	9	4	1	8
5	4	8	4	8	5	2	5	6	6
1	1	1	10	5	4	8	7	3	1
9	3	2	2	3	10	7	3	9	9
2	8	10	7	7	6	4	10	5	4
6	6	5	3	10	2	5	9	8	2
4	5	7	5	2	9	6	1	7	7
10	7	6	1	4	7	10	2	4	3
7	9	9	9	1	1	3	6	2	10
4	2	3	8	9	3	1	8	10	5

Table 26. RANDOM ARRANGEMENT OF NUMBERS FROM 1 TO 30

Taken from Table VI in Field Plot Technique by Leonard and Clark

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
29	12	15	20	6	13	16	23	1	10	2	20	15	29	4	18	8	7	6	14
27	1	26	7	22	26	15	9	20	15	29	6	25	26	2	15	13	30	3	22
5	23	23	15	26	22	19	28	4	7	12	5	12	28	5	16	4	14	7	19
20	3	24	30	1	21	22	4	3	13	6	7	16	3	16	21	39	6	14	3
10	25	9	27	25	3	8	14	7	5	30	1	23	23	13	25	20	4	20	2
21	16	12	4	2	23	26	5	24	21	26	3	5	11	17	12	1	15	24	27
11	13	1	13	9	28	20	2	29	29	13	24	26	21	9	22	11	22	11	29
7	19	28	2	8	16	30	18	22	11	19	30	21	6	7	30	21	23	25	1
14	29	19	12	3	1	17	24	16	4	20	13	4	7	1	10	23	27	28	12
25	5	8	23	27	4	12	25	6	12	8	25	13	16	30	5	14	1	18	23
2	21	17	26	20	5	7	8	23	6	28	2	6	15	26	19	22	19	1	26
18	26	11	9	21	18	24	1	12	25	4	17	1	18	6	14	12	24	21	4
4	9	2	21	29	8	5	22	5	18	27	27	10	4	11	4	26	17	10	18

Table 26. RANDOM ARRANGEMENT OF NUMBERS FROM 1 TO 30 (Continued)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
23	17	30	18	18	10	23	26	17	1	24	18	18	12	27	13	18	18	13	13
30	10	21	16	10	29	4	19	8	26	5	15	22	10	20	7	2	26	16	9
8	27	25	1	5	30	21	29	11	23	7	14	2	27	12	8	16	8	9	5
17	6	16	8	17	17	27	12	30	20	11	11	27	1	14	29	3	2	27	16
13	30	3	14	30	11	9	30	13	2	21	26	3	14	22	9	19	12	29	8
26	14	10	29	11	15	28	16	27	27	3	23	17	19	10	2	28	13	22	20
22	11	5	19	7	9	13	3	21	30	16	9	28	5	25	23	7	25	17	21
24	28	7	11	4	25	6	10	14	8	15	10	11	13	15	17	17	5	26	11
9	2	6	25	12	7	2	11	10	14	23	4	8	22	18	11	25	21	8	25
28	24	29	3	28	6	3	15	13	3	9	19	7	8	8	3	6	11	5	6
15	8	13	5	24	2	14	17	2	19	22	12	30	2	21	6	10	10	19	17
16	22	20	17	14	14	11	27	26	24	14	16	14	20	28	24	30	3	2	28
12	7	22	6	15	12	10	6	25	16	10	8	19	9	29	20	27	9	4	30
6	20	4	22	23	24	29	20	28	28	1	21	9	30	23	28	15	16	15	24
3	4	18	10	16	19	25	13	19	9	17	22	29	17	19	26	24	20	23	7
1	15	27	28	13	27	18	7	9	22	25	28	20	24	24	1	9	29	12	15
19	18	14	24	19	20	1	21	18	17	18	29	24	25	3	27	5	28	30	10

Chapter 10

BOOKS AND GENERAL REFERENCES

There are many publications dealing with various phases of tropical horticulture. It is obviously impossible to include all, and often publications from other countries are not generally available. The selected list below is given for the convenience of the horticultural worker when he has no local library available. Prices have been omitted since they are changing from year to year.

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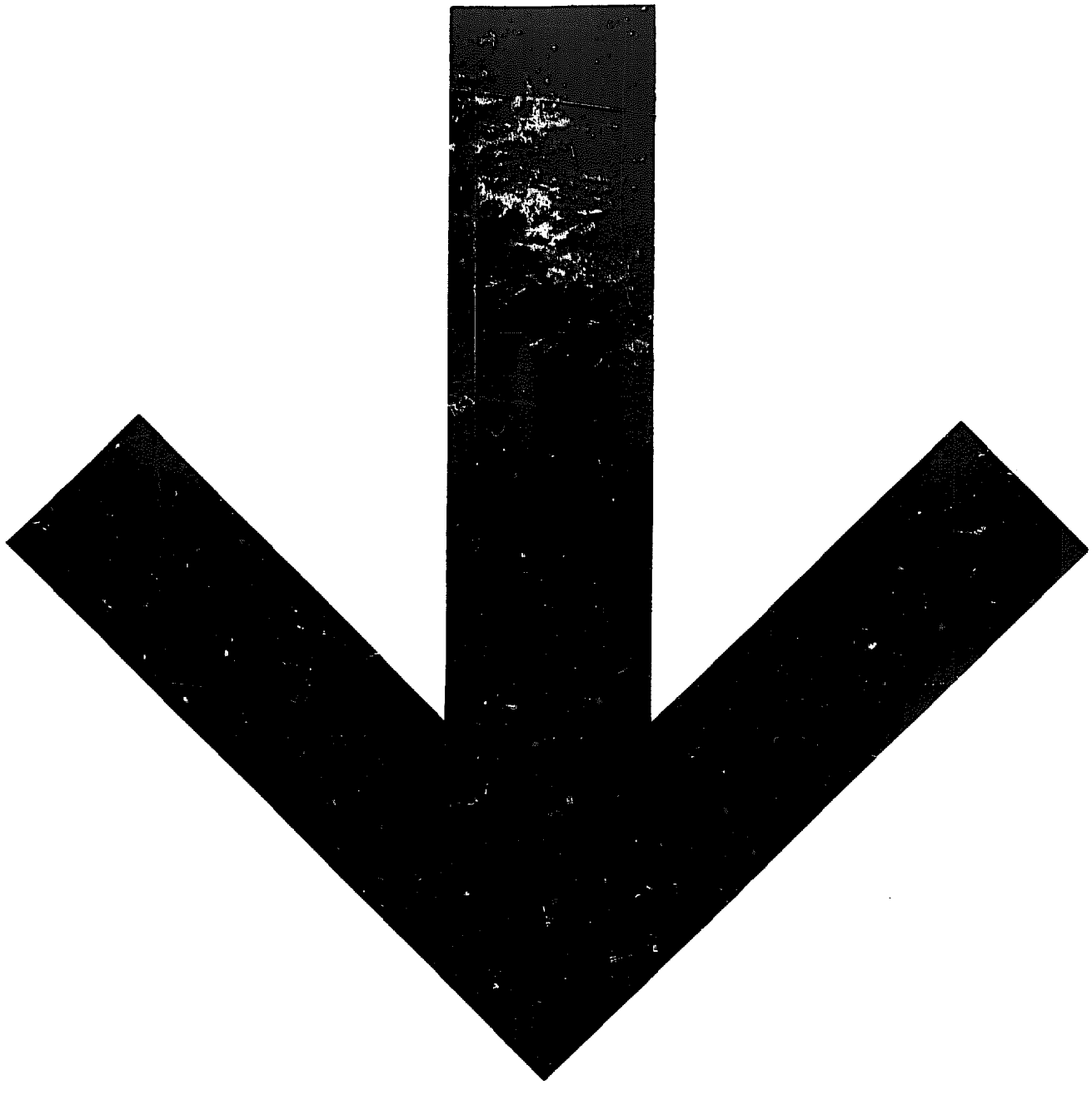

APPENDIX A

Insects Alphabetically by Common Name

Common Name	*Scientific Name*
aphids	*Aphis* spp.
aphids	Aphididae, spp of
asparagus beetle	*Crioceris asparagi* (L.)
aster leafhopper	*Macrosteles fascifrons* (Stål)
banana root borer	*Cosmopolites sordidus* (Germar)
bean aphid	*Aphis fabae* Scopoli
bean leaf beetle	*Cerotoma trifurcata* (Forster)
beetles or cucumber beetles	*Diabrotica* spp.
beetle	*Strategus* spp.
beet webworm	*Loxostege sticticalis* (L.)
black citrus aphid	*Toxoptera aurantii* (Fonscolombe)
blister beetles	*Epicauta* spp.
bollworm	*Earias* sp.
borer	*Xyleborus* sp.
cabbage aphid	*Brevicoryne brassicae* (L.)
cabbage maggot	*Hylemya brassicae* (Bouché)
cabbage webworm	*Hellula rogatalis* (Hulst)
cabbageworm	*Pieris* spp.
California red scale	*Aonidiella aurantii* (Maskell)
carpenter bee	*Xylocopa sonorina* Smith
carrot caterpillar	*Papilio* sp.
carrot rust fly	*Psila rosae* (F.)
celery leaf tier	*Udea rubigalis* (Guenée)
coconut scale	*Aspidiotus destructor* Signoret
coconut weevil	*Rhynchophorus palmarum* (L.)
codling moth	*Laspeyresia pomonella* (L.)
coffee bean borer	*Hypothenemus (Stephanoderes) hampei* (Ferrari)
coffee leaf miner	*Leucoptera coffeella* (Guérin-Méneville)
Colorado potato beetle	*Leptinotarsa decemlineata* (Say)
corn earworm, tomato fruitworm	*Heliothis zea* (Boddie)
corn sap beetles	*Carpophilus dimidiatus* (F.)
cowpea curculio	*Chalcodermus aeneus* Boheman
cowpea weevil	*Callosobruchus maculatus* (F.)
cutworms	Noctuidae, spp. of
diamondback moth	*Plutella xylostella* (L.)
eggplant lace bug	*Gargaphia solani* Heidemann
European corn borer	*Ostrinia nubilalis* (Hübner)
grape berry moth	*Paralobesia viteana* (Clemens)

Common Name	*Scientific Name*
fall armyworm	*Spodoptera frugiperda* (J. E. Smith)
flea beetles	Chrysomelidae, spp. of
fruit beetle	*Cotinis mutabilis* Gory & Percheron
fruit flies	*Anastrepha* spp.
fruit fly	*Anastrepha serpentina* (Wiedemann)
fruit fly	*Anastrepha striata* Schiner
fruit flies	*Dacus* spp.
fruit flies	Tephritidae, spp. of
fruit & shoot borer	*Leucinodes orbonalis* Guenée
fruitworm	*Euzophera punicaella* Moore
green peach aphid	*Myzus persicae* (Sulzer)
green scale	*Coccus viridis* (Green)
green shield scale	*Pulvinaria psidii* Maskell
harlequin bug	*Murgantia histrionica* (Hahn)
honey bee	*Apis mellifera* L.
hornworm	*Manduca* spp.
imported cabbageworm	*Pieris rapae* (L.)
Japanese beetle	*Popillia japonica* Newman
katydids or longhorn grasshoppers	*Sexava coriacea* (L.)
katydids or longhorn grasshoppers	*Sexava nubila* Stål
katydids or longhorn grasshoppers	*Sexava karnyi* Leefmans
katydids or longhorn grasshoppers	*Sexava novaeguineae* Brancisk
leaf-cutting ants	*Atta* spp.
leafhopper	*Dalbulus maidis* (Delong & Wolcott)
leafhoppers	*Empoasca* spp.
leafhopper	*Empoasca decipiens* Paoli
leafhopper	*Homalodisca insolita* (Walker)
lesser cornstalk borer	*Elasmopalpus lignosellus* (Zeller)
lima-bean pod borer	*Etiella zinckenella* (Treischke)
loopers (cabbage looper)	*Trichoplusia ni* (Hübner)
mealybugs	*Planococcoides njalensis* (Laing)
Mediterranean fruit fly	*Ceratitis capitata* (Wiedemann)
melon fly	*Dacus cucurbitae* Coquillett
melonworm	*Diaphania hyalinata* (L.)

Common Name	*Scientific Name*
Mexican bean beetle	*Epilachna varivestis* Mulsant
Mexican fruit fly	*Anastrepha ludens* (Loew)
millipedes	Diplopoda, spp. of
mining scale	*Howardia biclavis* (Comstock)
mites	Acarina, spp. of
mites	*Oligonychus* sp.
mole cricket	*Gryllotalpidae*, spp. of
moth	*Artona catoxantha* (Hampson)
moth	*Eucosmophora* sp.
moth	*Hidari irava* (Moore)
olive scale	*Parlatoria oleae* (Colvée)
olive fruit fly	*Dacus oleae* (Gmelin)
onion maggot	*Hylemya antiqua* (Meigen)
onion thrips	*Thrips tabaci* Lindeman
orange dog	*Papilio* spp.
oriental fruit fly	*Dacus dorsalis* Hendel
oriental fruit moth	*Grapholitha molesta* (Busck)
palm weevil	*Rhynchophorus* spp.
papaya fruit fly	*Toxotrypana curvicauda* Gerstaecker
pea weevil	*Bruchus pisorum* (L.)
peach tree borer	*Sanninoidea exitiosa* (Say)
peach twig borer	*Anarsia lineatella* Zeller
pear leaf blister mite	*Eriophyes pyri* (Pagenstecher)
pear thrips	*Taeniothrips inconsequens* (Uzel)
pepper weevil	*Anthonomus eugenii* Cano
phylloxera	*Phylloxera* sp.
pickleworm	*Diaphania nitidalis* (Stoll)
pineapple mealbug (scale)	*Dysmicoccus brevipes* (Cockerell)
pineapple scale	*Diaspis bromeliae* (Kerner
plum curculio	*Conotrachelus nenuphar* (Herbst)
pod borer	*Acrocercops cramerella* (Snellen)
potato flea beetle	*Epitrix cucumeris* (Harris)
potato leafhopper	*Empoasca fabae* (Harris)
potato tuberworm	*Phthorimaea operculella* (Zeller)
pustule scale	*Asterolecanium pustulans* (Cockerell)
Quetta borer	*Aeolesthes sarta* (Solsky)
red-banded thrips	*Selenothrips rubrocinctus* (Giard)
red spiders or spider mites	Tetranychidae, spp. of
rhinoceros beetle	*Oryctes rhinoceros* L.
San Jose scale	*Aspidiotus perniciosus* Comstock
scab moth	*Nacoleia octasema* (Meyrick)
scale	*Aulacaspis tubercularis* Newstead
scale	Coccoidea, spp. of
scale	*Melanaspis aliena* (Newstead)
scale	*Parlatoria* spp.
seed-corn maggot	*Hylemya platura* (Meigen)
seed weevil	*Conotrachelus perseae* Barber
silky cane weevil	*Metamasius hemipterus sericeus* (Olivier)
southern green stink bug	*Nezara viridula* (L.)
sowbugs	Isopoda, spp. of
spider mite	*Tetranychus* spp.
spotted cucumber beetle	*Diabrotica undecimpunctata howardi* Barber
squash bug	*Anasa tristis* (De Geer)
squash vine borer	*Melittia cucurbitae* (Harris)
stalk borer	*Papaipema nebris* (Guenée)
stink bug	Pentatomidae, spp. of
striped cucumber beetle	*Acalymma vittatum* (F.)
sweetpotato weevil	*Cylas formicarius elegantulus* (Summers)
sweetpotato whitefly	*Bemisia tabaci* (Gennadius)
thrips	*Frankliniella* spp.
tomato russet mite	*Aculus lycopersici* (Massee)
treehopper	*Aconophora pugionata* (Germar)
vegetable weevil	*Listroderes costirostris obliquus* (Klug)
wasps	*Polistes* spp.
weevil	*Anthonomus unipustulatus* (Champion)
whiteflies	*Trialeurodes* spp.
white grubs	*Phyllophaga* spp.
white-fringed beetles	*Graphognathus* spp.
wireworms	Elateridae, spp. of

APPENDIX B

Insects Alphabetically by Scientific Names

Scientific Name	*Common Name*
Acalymma vittatum (F.)	striped cucumber beetle
Acarina, spp. of	mites
Aconophora pugionata (Germar)	treehopper
Acrocercops cramerella (Snellen)	pod borer
Aculus lycopersici (Massee)	tomato russet mite
Aeolesthes sarta (Solsky)	Quetta borer
Anarsia lineatella Zeller	peach twig borer
Anasa tristis (De Geer)	squash bug
Anastrepha spp.	fruit flies
Anastrepha ludens (Loew)	Mexican fruit fly
Anastrepha serpentina (Wiedemann)	fruit fly
Anastrepha striata Schiner	fruit fly
Anthonomus eugenii Cano	pepper weevil
Anthonomus unipustulatus (Champion)	weevil
Aonidiella aurantii (Maskell)	California red scale
Aphididae, spp. of	aphids or plant lice
Aphia spp.	aphids
Aphis fabae Scopoli	bean aphid
Apis mellifera L.	honey bee
Artona catoxantha (Hampson)	moth
Aspidiotus destructor Signoret	coconut scale
Aspidiotus perniciosus Comstock	San Jose scale
Asterolecanium pustulans (Cockerell)	pustule scale
Atta spp.	leaf-cutting ants
Aulacaspis tubercularis Newstead	scale
Bemisia tabaci (Gennadius)	sweetpotato whitefly (on eggplant)
Brevicoryne brassicae (L.)	cabbage aphid
Bruchus pisorum (L.)	pea weevil
Callosobruchus maculatus (F.)	cowpea weevil
Carpophilus dimidiatus (F.)	corn sap beetles
Ceratitis capitata (Wiedemann)	Mediterranean fruit fly
Cerotoma trifurcata (Forster)	bean leaf beetle
Chalcodermus aeneus Boheman	cowpea weevil
Chrysomelidae, spp. of	flea beetles
Coccoidea, spp. of	scale
Coccus viridis (Green)	green scale
Conotrachelus nenuphar (Herbst)	plum curculio
Conotrachelus perseae Barber	seed weevil
Cosmopolites sordidus (Germar)	banana root borer
Cotinis mutabilis Gory & Percheron	fruit beetle
Crioceris asparagi (L.)	asparagus
Cylas formicarius elegantulus (Summers)	sweetpotato weevil
Dacus spp.	fruit flies
Dacus cucurbitae Coquillett	melon fly
Dacus dorsalis Hendel	oriental fruit fly
Dacus oleae (Gmelin)	olive fruit fly
Dalbulus maidis (Delong & Wolcott)	leafhopper
Diabrotica spp.	beetles or cucumber beetles
Diabrotica undecimpunctata howardi	Barber spotted cucumber beetle
Diaphania hyalinata (L.)	melonworm
Diaphania nitidalis (Stoll)	pickleworm
Diaspis bromeliae (Kerner)	pineapple scale
Diplopoda, spp. of	millipedes
Dysmicoccus brevipes (Cockerell)	pineapple mealbug (scale)
Earias sp.	bollworm
Elasmopalpus lignosellus (Zeller)	lesser cornstalk borer
Elateridae, spp. of	wireworms
Empoasca spp.	leafhoppers
Empoasca decipiens Paoli	leafhoppers
Empoasca fabae (Harris)	potato leafhopper
Epicauta spp.	blister beetles
Epilachna varivestis Mulsant	Mexican bean beetle
Epitrix cucumeris (Harris)	potato flea beetle
Eriophyes pyri (Pagenstecher)	pear leaf blister mite
Etiella zinckenella (Treischke)	lima-bean pod borer
Eucosmophora sp.	moth
Euzophera punicaella Moore	eggplant lace bug
Frankliniella spp.	thrips
Gargaphia solani Heidemann	fruitworm
Graphognathus spp.	white-fringed beetles
Grapholitha molesta (Busck)	oriental fruit moth
Gryllotalpidae, spp. of	mole cricket

Scientific Name	*Common Name*
Heliothis zea (Boddie)	corn earworm, tomato fruitworm
Hellula rogatalis (Hulst)	cabbage webworm
Hidari irava (Moore)	moth
Homalodisca insolita (Walker)	leafhopper
Howardia biclavis (Comstock)	mining scale
Hylemya antiqua (Meigen)	onion maggot
Hylemya brassicae (Bouché)	cabbage maggot
Hylemya platura (Meigen)	seed-corn maggot
Hypothenemus (Stephanoderes) hampei (Ferrari)	coffee bean borer
Isopoda, spp. of	sowbugs
Laspeyresia pomonella (L.)	codling moth
Leptinotarsa decemlineata (Say)	Colorado potato beetle
Leucinodes orbanalis Guenée	fruit & shoot borer
Leucoptera coffeella (Guérin-Méneville)	coffee leaf miner
Listroderes costirostris obliquus (Klug)	vegetable weevil
Loxostege sticticalis (L.)	beet webworm
Macrosteles fascifrons (Stål)	aster leafhopper
Manduca spp.	hornworm
Melanaspis aliena (Newstead)	scale
Melittia cucurbitae (Harris)	squash vine borer
Metamasius hemipterus sericeus (Olivier)	silky cane weevil
Murgantia histrionica (Hahn)	harlequin bug
Myzus persicae (Sulzer)	green peach aphid
Nacoleia octasema (Meyrick)	scab moth
Nezara viridula (L.)	southern green stink bug
Noctuidae, spp. of	cutworms
Oligonychus sp.	mites
Oryctes rhinoceros (L.)	rhinoceros beetle
Ostrinia nubilalis (Hübner)	European corn borer
Papaipema nebris (Guenée)	stalk borer
Papilio spp.	orange dog
Papilio sp.	carrot caterpillar
Paralobesia viteana (Clemens)	grape berry moth
Parlatoria spp.	scale
Parlatoria oleae (Colvée)	olive scale
Pentatomidae, spp. of	stink bugs
Phthorimaea operculela (Zeller)	potato tuberworm
Phyllophaga spp.	white grubs
Phylloxera sp.	phylloxera
Pieris spp.	cabbageworm
Pieris rapae (L.)	imported cabbageworm
Planococcoides njalensis (Laing)	mealybugs
Plutella xylostella (L.)	diamondback moth
Polistes spp.	wasps
Popillia japonica Newman	Japanese beetle
Psila rosae (F.)	carrot rust fly
Pulvinaria psidii Maskell	green shield scale
Rhynchophorus spp.	palm weevil
Rhynchophorus palmarum (L.)	coconut weevil
Sanninoidea exitiosa (Say)	peach tree borer
Selenothrips rubrocinctus (Giard)	red-banded thrips
Sexava coriacea (L.)	katydid, longhorn grasshopper
Saxava nubila Stål	katydid, longhorn grasshopper
Sexava karnyi Leefmans	katydid, longhorn grasshopper
Sexava novaeguineae Brancsik	katydid, longhorn grasshopper
Spodoptera frugiperda (J. E. Smith)	fall armyworm
Strategus spp.	beetle
Taeniothrips inconsequens (Uzel)	pear thrips
Tephritidae, spp. of	fruit flies
Tetranychidae, spp. of	red spiders, spider mites
Tetranychus spp.	spider mite
Thrips tabaci Lindeman	onion thrips
Toxoptera aurantii (Fonscolombe)	black citrus aphid
Toxotrypana curvicauda Gerstacker	papaya fruit fly
Trialeurodes spp.	whiteflies
Trichoplusia ni (Hübner)	cabbage looper
Udea rubigalis (Guenée)	celery leaf tier
Xyleborus sp.	borer
Xylocopa sonorina Smith	carpenter bee

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