VEGETABLE GARDENING IN THE CARIBBEAN AREA

Agriculture Handbook No. 323

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

VEGETABLE GARDENING IN THE CARIBBEAN AREA

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Vegetable Gardening in the Caribbean Area

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INTRODUCTION

Vegetable gardening is the art and science having to do with culture of the plants commonly known as vegetables. Included are a broad variety of edible herbaceous plants or plants with some part useful for culinary purposes. The edible part may be the leaves, stems, underground parts, flower heads, seeds, or the entire fruit.

Vegetables not only provide variety in what would otherwise be an extremely monotonous diet but also supply dietetic elements essential to the well-being of the human body.

Although modern transportation facilities enable residents of the more cosmopolitan parts of the Caribbean area to import a wide variety of produce, such foods usually are expensive. Where vegetables can be grown in a home garden, they are apt to be cheaper, fresher and therefore more nutritious, and available in greater variety. Many residents of the Caribbean area still are so remote from transportation centers that they must grow their own fresh produce or do without.

Almost any vegetable can be grown at some place in the Tropics, provided the proper variety, season, elevation, and soil conditions are selected. The Caribbean area, lying wholly within the Tropics, offers, for the most part, favorable climatic conditions for vegetable gardening. Most of the land areas lie at low or middle elevations where there is no frost hazard. In most areas there is a 12-month growing season with abundant sunshine almost every day.

Many vegetable crops are well adapted to the Caribbean area because they originated in the Torrid Zone. Examples are lima bean, chayote, cowpea, eggplant, pepper, potato, sweetpotato, and tomato and possibly the common bean, muskmelon, okra, and soybean. Native varieties of some of these vegetables still are found wild in the Tropics. Unfortunately, many of the better varieties of these crops have lost their adaptation to tropical conditions through many generations of selection and breeding in the Temperate Zones. It is important for the vegetable grower to have as much information as possible about adapted varieties, cultural methods, and pest control.

This handbook is the second revision of the bulletin, "Vegetable Growing in Porto Rico," by H. C. Hendricksen in 1906 (*16*).[1] The first complete revision was the circular, "Vegetable Gardening in the Tropics," by N. F. Childers, H. F. Winters, P. Seguinot Robles, and H. K. Plank in 1950 (*8*). This revision has been prepared to meet the continuing need for information on vegetable gardening, particularly in the Caribbean area. It may be useful, also, to gardeners in other areas of the Tropics. Some of the sections may seem unnecessarily elementary to the more advanced gardeners, but they are intended for individuals entirely without experience in gardening. By following the directions and suggestions given in the following chapters, any beginning gardener can produce a wide variety of delicious and nutritious vegetable crops adapted to tropical conditions (fig. 1).

The information and recommendations included in this handbook are based on many years' experience in Puerto Rico and the U.S. Virgin Islands, the authors' observations in other areas of the American Tropics, and a review of numerous publications on the subject.[2] (See p. 112.)

The scope of the subject and the area of the world covered are much too broad to be treated adequately in a single publication of this size. Thus, it is suggested that the reader supplement the information presented here with experiences and recommendations of local growers and of the nearest agricultural research or teaching institutions. Their suggestions will be particularly valuable with respect to varieties that are locally desirable and to the best methods for dealing with prevailing insect and disease problems.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 110.

[2] A recent publication by H. D. Tindall contains similar information with particular application to tropical areas of West Africa. (See Additional References, p. 112.)

FIGURE 1.—Trial garden in tropical area containing, *left to right*, lima bean, head lettuce, carrot, beet, head cabbage, and tomato.

VEGETABLES IN THE DIET

The diet of most tropical residents is low in fresh vegetables, particularly the green and leafy types that are valuable for their high vitamin and mineral contents. A survey, published in 1946 (*32*), of diets in Puerto Rico, which are fairly typical of those in most of the Caribbean area, showed an unbalanced condition. The consumption of leafy and green vegetables was only about half of that needed for an adequate diet whereas consumption of starchy and protein vegetables was more than adequate. By 1963 the nutritional level had improved, but deficiencies still appeared to exist (*49*). Apparently, then, vegetable gardening should be expanded in the Caribbean area, with particular emphasis on the green and leafy types.

Vegetables especially high in minerals and vitamins are green and lima beans, broccoli, carrot, collard, cowpea (whole pods with peas), lettuce, mustard, parsley, sweetpotato, tomato, and turnip tops. Vegetables moderately high in minerals and vitamins are beet tops, Chinese cabbage, head cabbage, celery, chard, corn, eggplant, green onion, peas, potato, and spinach. Vegetables of relatively low nutritive value are beet root, chayote, cucumber, the melons, okra, radish, and turnip. Readers especially interested in the nutritive value of vegetables should consult one or more of the following publications: *(11, pp. 103-104; 20; 31; 33, pp. 112-117; 35; 63).*

VEGETABLE BREEDING IN THE TROPICS

The vegetable varieties available in the continental United States and other temperate countries usually are well adapted to those areas. They have been developed through long-time breeding and selection. Some of these varieties also perform satisfactorily when planted in the Tropics at some season of the year. An extensive, coordinated vegetable-breeding program is greatly needed in the Tropics to produce varieties with climatic adaptation that will resist the insects and diseases present in the different areas.

Several varieties of any given vegetable may be needed to maintain year-round production of that vegetable in a given location. Varieties that will perform well in the warm rainy season might not be at all satisfactory during the cool dry season. The greatest need seems to be for vegetable varieties adapted to the warm rainy season. They can best be produced by selecting and breeding in areas with this type of climate. Each vegetable gardener is a plant breeder if he selects plants with outstanding performance from which to save seed for future crops. He has gone one step further if he eliminates the poorer plants from the progeny before they start to flower and before he selects parent plants for the next generation.

Most of the vegetable-improvement investigations have been conducted by agencies of the various governments. The Agricultural Experiment Station of the University of Puerto Rico has conducted breeding programs with bean, sweet corn, cucumber, eggplant, pepper, pigeonpea (gandul), squash, tomato, and other vegetable crops. It cooperates with vegetable breeders of the Southeastern United States in testing their latest breeding lines for adaptability to conditions in the Caribbean area. The Hawaii Agricultural Experiment Station has produced a series of tomato varieties with local adaptation and is experimenting with F_1 hybrids. Varieties of the edible-podded or sugar pea also have been produced. The Interamerican Institute for Agricultural Sciences at Turrialba, Costa Rica, has conducted vegetable-breeding projects, particularly with the tomato. The Indian Agricultural Research Institute has produced a virus-resistant variety of eggplant. Seeds of these improved varieties probably are available from the governmental agencies that produced them. The governments of some tropical countries have set up special agencies to sell seed to the public.

The improvement of food crops through breeding and selection is one of the programs in which the Rockefeller Foundation cooperates with the governments of tropical countries. Potatoes and beans are the vegetable crops that have received the most attention in Mexico, Central America, and South America.

Some investigations in vegetable improvement for the Caribbean area have been carried out by private corporations, such as the United Fruit Company in Honduras and the Shell Foundation in Venezuela.

CLIMATIC RELATIONSHIPS

Climate has a profound effect upon the growth of plants, particularly those introduced and not well adapted, such as vegetables. The most important variables of climate insofar as the gardener is concerned are temperature and moisture, but all of the climatic effects are interrelated. Humidity is of the greatest importance in growth of plant parts aboveground, but it is closely related to moisture. Light is the essential source of energy for plant growth. It can be reduced in intensity by the utilization of artificial screens or trees to exclude direct sunlight. The use of artificial light to extend the day length for gardens is not practical in most areas. Wind can be controlled in limited areas by strategically placed windbreaks. The temperatures experienced in the Caribbean area are moderate for the most part and usually are within the range that will permit the cultivation of some vegetable crops. Moisture usually is the climatic variable of greatest importance to the vegetable gardener and is the one most manageable through irrigation and drainage. Also, it is the climatic variable most lacking or poorly distributed in many parts of the Caribbean area.

Although the Caribbean area lies entirely within the Tropics, considerable variation in climate occurs both between the different land areas and within each area annually. To the north and east of the Caribbean Sea, the Greater and Lesser Antilles experience a relatively uniform climate because of the easterly trade winds. The causes of local variations in the climate of Puerto Rico and the U.S. Virgin Islands, often within relatively short distances, are discussed in detail by Smedley *(53)*. To the south and

TABLE 1.—*Elevations, annual mean temperatures, and rainfall for stations bordering the Caribbean Sea*

Station	Elevation	Mean temperature				Average annual rainfall			
		Years recorded	Low month [1]	High month [1]	Annual	Years recorded	Low month [1]	High month [1]	Annual
	Feet	*Number*	*° F.*	*° F.*	*° F.*	*Number*	*Inches*	*Inches*	*Inches*
Cuba:									
Havana	80	42	71.2(1)	81.0(8)	76.4	42	1.29(2)	8.12(10)	45.53
Camaguey	393	8	71.1(2)	81.1(8)	76.8	8	0.89(12)	7.73(8)	52.47
Jamaica, Kingston	25	10	75.6(12)	80.1(4)	76.8	10	0.39(3)	6.61(10)	31.93
Haiti, Port-au-Prince	134	80	75.2(12)	82.4(7)	79.3	80	1.26(1)	8.98(5)	52.60
Dominican Republic, Santo Domingo	46	50	75.2(1,2)	80.8(8)	78.1	50	1.64(2)	7.70(9)	55.98
Puerto Rico:									
Cayey	1,400	25	68.9(1)	76.0(8)	73.0	25	1.82(3)	7.82(9)	59.38
Mayaguez	80	25	74.5(1)	79.7(8)	77.5	25	1.77(2)	10.97(9)	75.20
Ponce	40	25	75.8(2)	81.7(8)	79.2	25	0.59(3)	6.08(9)	36.88
San Juan	47	30	74.9(1,2)	80.5(8,9)	78.0	30	2.42(3)	6.51(5)	60.00
San Juan (Airport)	15	30	74.1(2)	80.4(8)	77.7	30	2.69(3)	7.90(11)	69.58
Virgin Islands:									
Charlotte Amalie	38	28	76.9(2)	83.0(8)	80.1	44	1.92(3)	6.31(10)	45.25
Truman Field	15	----	75.9(1)	82.4(8)	----	9	1.85(3)	8.83(9)	46.25
Christiansted	80	----	----	----	----	12	0.84(3)	4.74(11)	32.58
Fredricksted	25	----	----	----	----	9	0.74(3)	5.40(11)	39.57
Alexander Hamilton Field	51	----	76.2(1,2)	82.0(8)	79.3	10	1.94(3)	7.69(9)	45.51
Antigua:									
Gaynors	50	----	----	----	----	25	1.28(3)	5.24(9)	38.84
Diamond	8	----	----	----	----	25	1.47(2)	5.65(11)	43.76
Martinique, Fort-de-France	472	26	74.3(1,2)	78.8(8)	76.8	30	2.28(3)	9.13(9)	72.44
St. Vincent, Kingstown	80	----	----	----	----	20	3.53(2,3)	11.92(11)	91.25
Barbados, Seawell Airport	183	5	77.2(2)	80.8(6,8,9)	79.3	10	1.46(3)	6.93(10)	50.12
Grenada:									
Pearls Airport	22	11	78.2(1)	81.3(5,6,8, 9,10)	80.3	11	2.00(3)	10.63(11)	67.03
Richmond Hills	37	37	78.3(2)	82.1(10)	80.5	37	2.43(4)	9.33(11)	76.41
Trinidad, Piarco	41	10	76.1(1)	79.9(5)	78.3	10	1.06(3)	10.59(6)	68.89
Curacao, Dr. Plesman Airport	25	10	79.2(2)	83.8(9)	81.5	30	0.59(4)	5.04(11)	22.83
Colombia:									
Barranquilla	39	----	----	----	----	5	0.00(2,3)	8.20(10)	33.37
Cartagena	10	5	77.9(1)	81.9(6)	80.1	5	0.00(1,2,3)	6.21(6)	35.07
Bogotá	8,397	7	56.3(7)	58.8(3,4)	57.5	7	1.48(8)	5.33(11)	37.38
Canal Zone:									
Balboa	30	53	79.2(10,11)	82.2(4)	80.3	57	0.57(2)	10.02(10)	69.02
Cristobal	40	53	79.5(11)	81.5(4)	80.6	86	1.46(3)	22.53(11)	130.08
Panamá	----	----	77.0(11)	79.9(4)	78.3	----	0.51(2)	9.45(11)	63.31
Costa Rica, Limón	10	----	----	----	----	9	4.43(9)	17.79(12)	129.83
El Salvador, San Salvador	2,230	40	71.6(11,12)	75.6(4)	73.0	30	0.12(2)	12.79(9)	69.88

See footnote at end of table.

TABLE 1.—*Elevations, annual mean temperatures, and rainfall for stations bordering the Caribbean Sea*—Continued

Station	Elevation	Mean temperature				Average annual rainfall			
		Years recorded	Low month [1]	High month [1]	Annual	Years recorded	Low month [1]	High month [1]	Annual
	Feet	*Number*	*° F.*	*° F.*	*° F.*	*Number*	*Inches*	*Inches*	*Inches*
Honduras, San Pedro Sula	249	5	73.6(1)	82.6(5)	79.2	20	1.46(4)	8.11(9)	52.44
Mexico, Mérida	72	50	73.4(1)	82.2(5)	78.4	40	0.67(3)	6.81(9)	36.61

[1] Month is indicated by number in parentheses.

west of the Caribbean Sea the coasts of Venezuela, Colombia, and Central America are much more variable in climate, particularly in rainfall, than are the Antilles. This variation is due largely to exposure, or lack of exposure, of the coasts to moisture-laden winds and to elevation of the land masses behind the coasts. Seasonal variations are similar for the entire Caribbean area. Climate, particularly rainfall, is profoundly affected by the North Atlantic hurricane season, which extends from June to November. Other factors affecting climate are temperature, wind, and humidity. Elevations, mean temperatures, and rainfall data for stations bordering the Caribbean Sea are in table 1.

Temperature

Variations of 3° to 5° F. in mean temperature from one location to another have a marked effect on the success with which different kinds and varieties of vegetables can be grown in the Tropics (fig. 2). Temperature difference between summer and winter in the Tropics may be only 5° to 10°, whereas in the Temperate Zone it may be more than 50°. For example, on the island of Puerto Rico, there is about 5° difference in mean temperature between the warmest period of the year, in August, and the coolest, in January or February (fig. 3). The cooler months are best for planting most vegetable crops. The

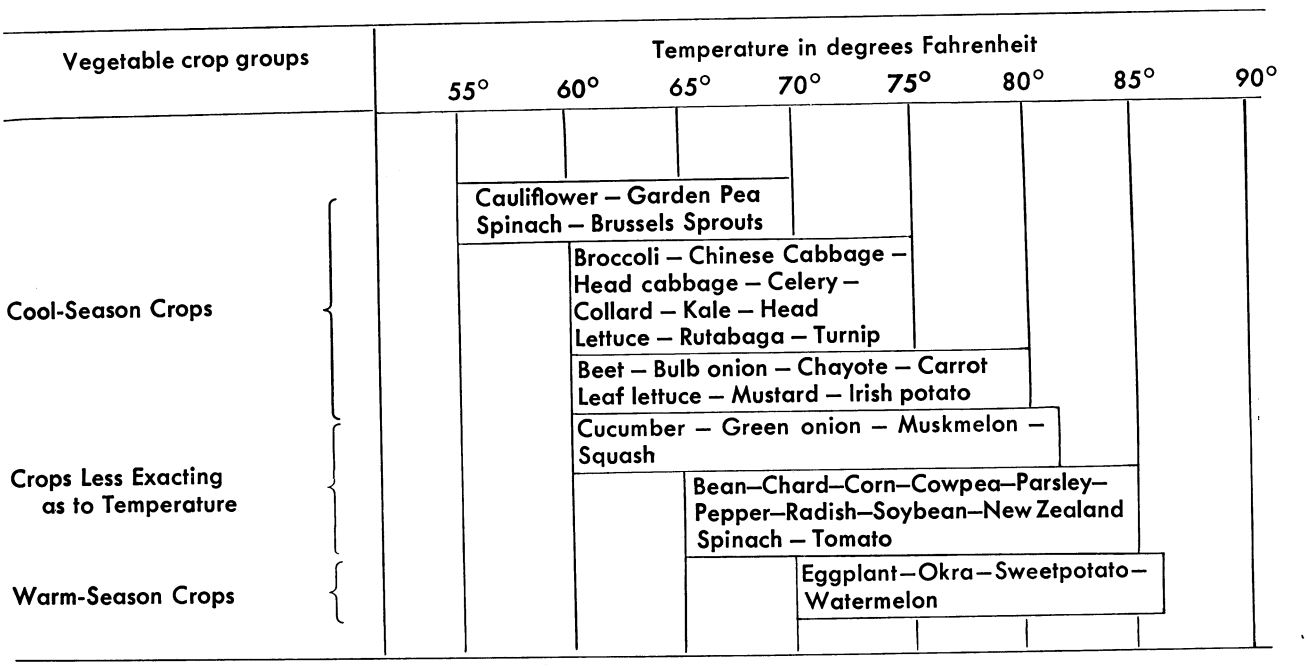


FIGURE 2.—Approximate temperature range required by vegetable crop groups for satisfactory performance.

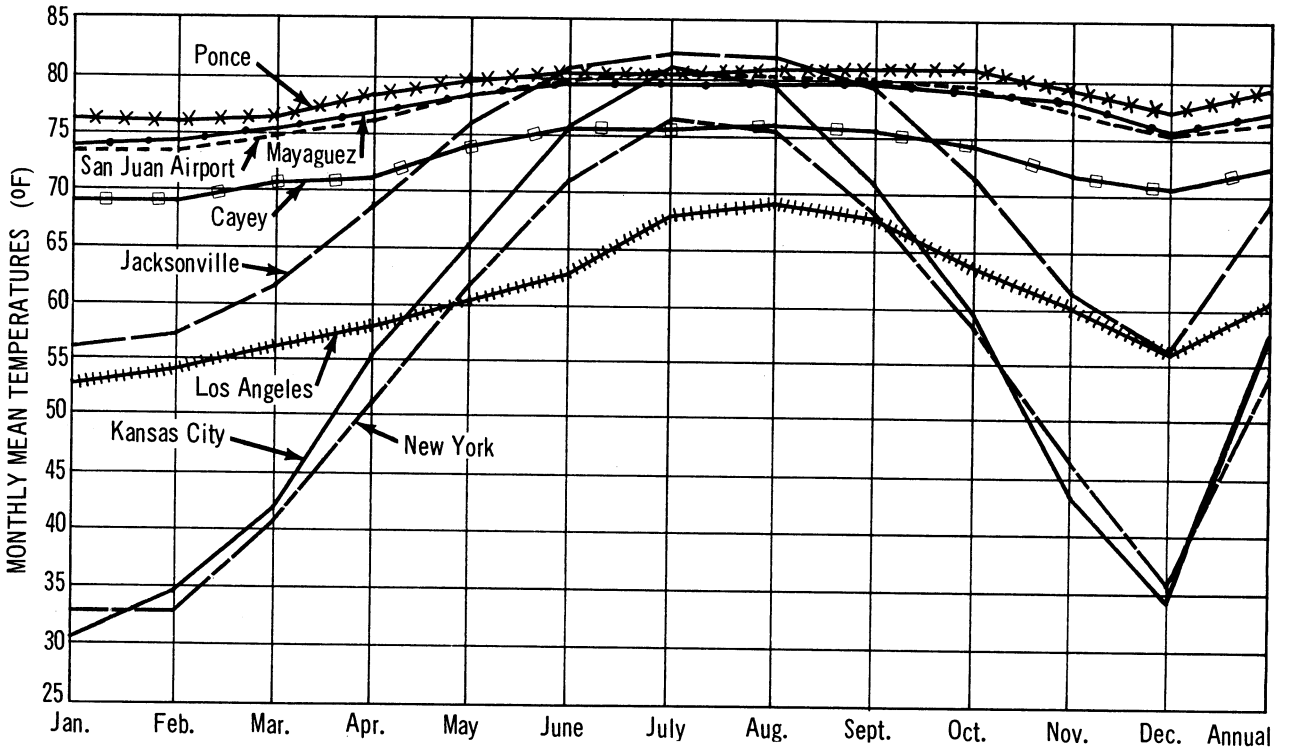


FIGURE 3.—Monthly mean temperatures of cities in the Tropics (Puerto Rico) and in the North Temperate Zone (continental United States).

mean temperature for any month at sea level as compared with that at higher elevations, however, may differ as much as 5° to 10° or more (table 1 and fig. 3). San Juan at 47 feet above sea level has an annual mean temperature of 78°, whereas Cayey at 1,400 feet has an annual mean of 73°.

The effect of elevation and, therefore, of temperature on growth of edible-podded pea variety Melting Sugar grown at 80, at 2,600, and at 3,200 feet in Puerto Rico is shown in figure 4. All peas were planted within approximately the same week. Photographs were taken, respectively, on October 23, October 20, and October 18, 1945. Yields were in proportion to vegetative growth. English pea variety Telephone responded similarly.

Cartagena, Colombia, near sea level, has an annual mean temperature of 80.1° F., whereas Bogota at 8,397 feet has an annual mean temperature of 57.5°. Most warm-season vegetables cannot be grown at this elevation. Not far inland from the Caribbean coast, also in Colombia, a peak of the Sierra Nevada de Santa Marta with 19,030 feet elevation, has a permanent snowcap.

At a given elevation one location may be cooler than another, depending upon rainfall, cloud cover, and prevailing breezes. For example, mainly because of low rainfall, the annual mean temperature for Ponce, P.R., is 1.7° F. higher than the annual mean temperature for Mayaguez, P.R. Both cities are near sea level. Ponce receives about 37 inches of rainfall annually; Mayaguez receives 75.2.

At or near the Equator, where the mean temperature is almost the same for all months, vegetables are grown at different elevations in accordance with their temperature requirements. Thus, eggplant being transported to markets up the mountain may pass cabbage being sent to markets down the mountain. In fact, the same exchange of cool- and warm-season crops between high and low elevations occurs in most sections of the Tropics, but season also plays an important part in the availability of different vegetables in the upper and lower latitudes of the Tropics.

Rainfall

The rainfall pattern of the Caribbean area is marked by one rather well-defined wet season and one dry season each year. The wet season generally extends from May to November but considerable variation has been noted. In par-

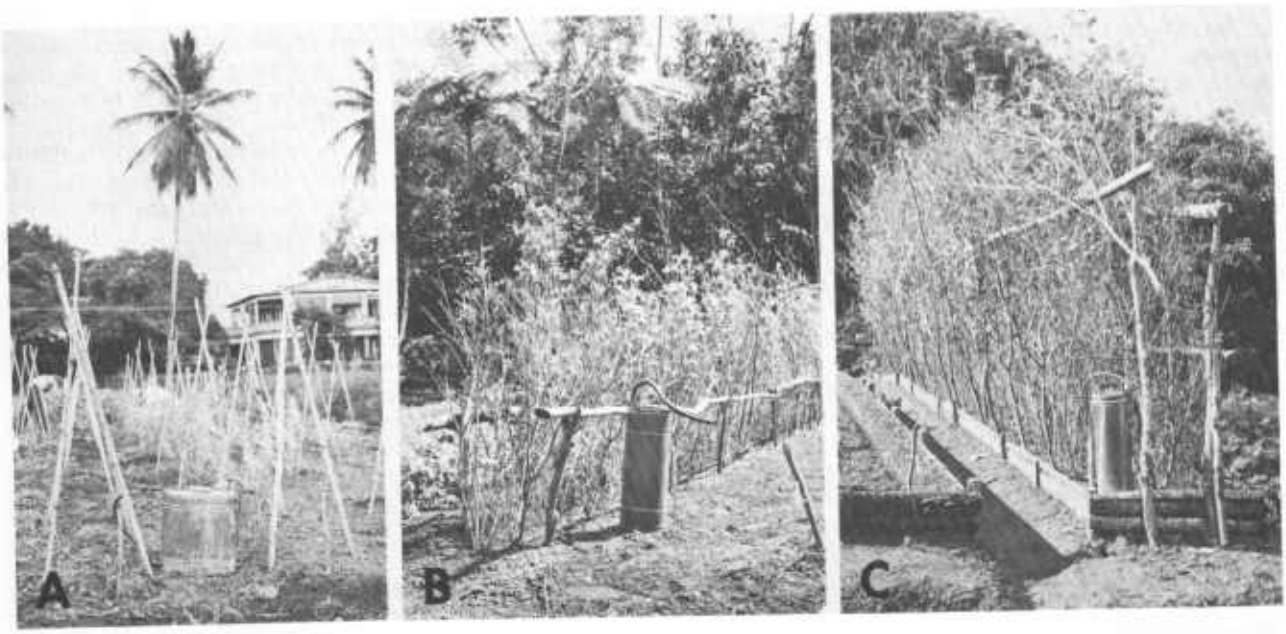


FIGURE 4.—Effect of elevation and, therefore, of temperature on growth of edible-podded pea variety Melting Sugar in Puerto Rico: *A*, Planted at 80 feet; *B*, planted at 2,600 feet; *C*, planted at 3,200 feet.

ticularly wet areas the rains may continue until January. Considerable annual variation in rainfall also occurs from year to year, depending upon the passage of hurricanes near or through a given area. Usually some rain is recorded during the dry season but at Cartagena, Colombia, none was recorded from January through March for 5 years. During those 5 years, the annual average rainfall was 35.07 inches. In these dry sections of the Caribbean area, vegetable gardening is possible only during the rainy season of the year unless water is available for irrigation. Many low islands and lee coasts of large islands receive no more total rainfall than Cartagena, but the rainfall may be better distributed throughout the year. Year-round gardening is possible in such areas only by very careful conservation of water. The usual custom is to replant the vegetable garden each year at the onset of the rainy season.

Rainfall may vary markedly from place to place over relatively short distances, with differences in elevation having an important influence on the pattern. Warm, moisture-laden air is carried inland by the trade winds, is forced to ascend as it strikes the mountains, and is cooled. The resulting condensation falls as rain. Thus, in the relatively small island of Puerto Rico parts of the northeastern mountains received an annual average of 183.51 inches of rain over a 10-year period, whereas the city of Ponce on the south coast received an annual average of only 36.88 inches.

In many tropical regions heavy rainfall is a limiting factor to vegetable growing for several months of the year, particularly where the soil is heavy and poorly drained. A period of prolonged heavy rainfall may severely stunt or kill vigorous fruiting tomato plants within a week. The disastrous effect of heavy rainfall in summer production of tomatoes was clearly demonstrated in 1947 at Mayaguez, P.R. *(40, 1947)*. Excellent tomato crops were grown in both soil and gravel culture under greenhouse protection when only average to poor crops were grown in the field under prevailing rainy conditions.

Relative humidity for Puerto Rico and the U.S. Virgin Islands averages about 80 percent *(53)*. Humidity is related to rainfall and is highest during the rainy season.

Wind

Continuous winds may be a limiting factor to vegetable gardening, particularly in insular climates. Plants in exposed areas may be retarded or killed by a whipping, twisting action and by desiccation during dry periods. Under these conditions it is difficult or impossible to grow vegetables without some provision for windbreaks. (See p. 34.)

The steady northeast trade wind of the Caribbean area also has a moderating effect upon the climate. Before striking land this wind has been cooled and moistened by passing over the open water. No point of land in the Caribbean area

is far from the sea, so all are affected to some degree. The strongest winds occur during July when an average maximum speed of about 18 miles per hour has been recorded. The weakest winds are during October or November; at the same location winds averaged 5 miles per hour. Wind diminishes in intensity at nightfall and increases in intensity after daybreak.

Climatic Requirements of Vegetables

Figure 2 shows the temperature range over which certain vegetables can be grown most successfully. Using these temperatures and local temperatures for the different seasons as guides *(44)*, the gardener can determine at what season to plant the different vegetable crops. Data for a particular location can be obtained from the nearest weather station. Mean temperatures at low elevations are frequently too high for best performance of some vegetables, such as cabbage, whereas warm-season crops, such as eggplant and okra, are likely to perform well. Although the crops given in figure 2 grow best at the temperatures indicated under average conditions, satisfactory crops outside the specified temperature ranges can be obtained under special conditions—a particularly good growing season; shading with palm leaves, cheesecloth, or other materials; or the use of gravel culture. (See p. 83.)

Several vegetables have been grouped in figure 2 for practical purposes, despite the fact that all do not have the same optimum temperature range. For some crops, such as the garden pea, the optimum temperature range is relatively narrow; for others, such as the cucumber, it is fairly wide. Vegetables planted during May and June north of the Equator will develop and mature in increasingly warm weather, whereas those planted during October and November will mature in increasingly cool weather. The opposite is true south of the Equator, where the seasons are reversed. Thus, north of the Equator, cool-season crops, such as cabbage, should succeed well if planted from October to December, inclusive, and warm-season crops, such as okra and eggplant, from March to June. At low elevations a wider variety of vegetables usually can be grown during the cool winter season than during the warm summer season, and at medium to high elevations many vegetables can be grown throughout the year.

LIGHT RELATIONSHIPS

Length of day may have a pronounced effect on the vegetative growth, flowering, and tuberization of some vegetables. The difference in day length between summer and winter is less in the Torrid than in the Temperate Zones. In Puerto Rico at 18° N. latitude, days vary from 11 hours, 3 seconds in December to 13 hours, 12 minutes in June (fig. 5). At the Equator day and night length are about equal the year round. Near Washington, D.C., however, at 39° N. latitude in the Temperate Zone, day length is about 9½ hours in December and 15 hours in June.

McClelland (*27*) has shown that in Puerto Rico some varieties of bulb onion, such as White Ber-

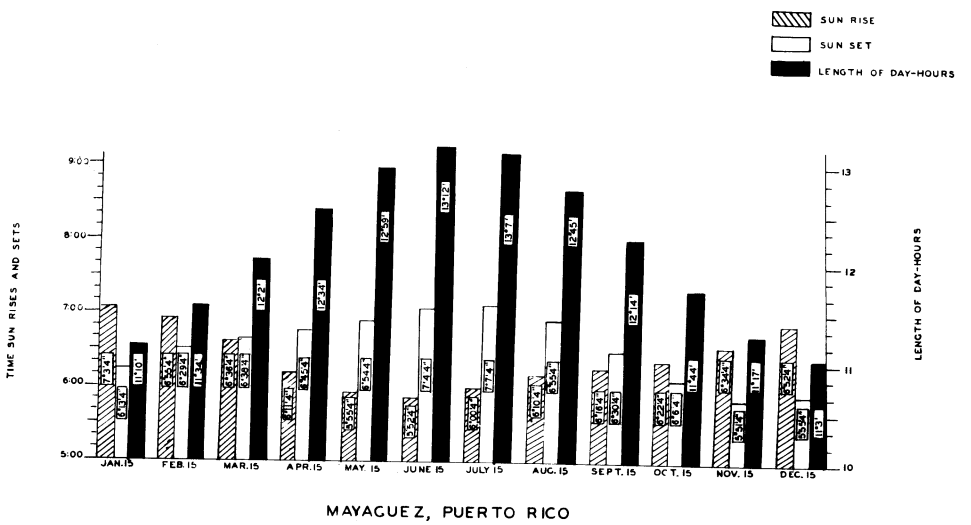


FIGURE 5.—Time of sunrise and sunset and length of day on the 15th day of each month at Mayaguez, P.R.

muda, form bulbs best if they mature during the increasingly longer days of spring, but make vigorous top growth and no bulbs during the short days of winter. The bulb onion varieties Prizetaker and Yellow Globe Danvers formed bulbs only when the day was lengthened to 15 hours by artificial light. With potato varieties Irish Cobbler, Red Bliss Triumph, and Lookout Mountain, the longer days favored top growth, whereas short days favored tuberization. Red Bliss Triumph was the least sensitive to day length; Lookout Mountain, the most.

In the vegetable trials conducted in Puerto Rico (*10*), sweet corn produced the largest stalks and ears when the crop matured in April to June. This was true also of field corn in Puerto Rico (*27*). The soybean variety Seminole also produced its best crop under these light conditions.

Time of sunrise and sunset varies with longitude in the Caribbean area. Some variation in day length and in sunlight reaching vegetables at a given longitude can also be the result of shading from nearby mountains early in the morning or late in the evening, or both. For example, sweet corn grows and produces better at a given season near the top of the mountains than in nearby deep narrow valleys.

SOILS

The soil serves not only to physically support the plants grown on it, but also to supply minerals and other elements essential to growth. It is also the reservoir from which water is drawn into the plants.

Soils of the Caribbean area, and the Tropics generally, vary as much as or more than soils in temperate climates. They differ in texture, structure, and organic matter and mineral element content. Soil texture is determined by the relative amounts of clay, sand, and silt that make up a particular soil.

Soils high in the very small clay particles are heavy soils. The movement of both air and water through them may be extremely slow, resulting in a waterlogged condition that is unfavorable to the growth of most plants. Some soils high in clay particles will expand into a sticky mass when wet and contract with drying to develop deep cracks. Clay particles, however, have a strong attraction for the important fertilizer elements and are the most important component of soils.

Because of the larger particle size, sandy soils exhibit no plasticity and cannot hold large amounts of water or plant nutrients. Sandy soils are apt to be droughty soils and may require frequent irrigation when planted to vegetable crops.

The properties of silt particles are intermediate between those of clay and sand particles, but silt alone probably is not sufficiently active chemically to make a good soil. The ideal garden soil would have a combination of the three particle sizes. Such a soil is known as loam. Loams may be classed as clay, silt, or sandy loams. In selecting a site for a vegetable garden, preference should be given to soils of these types. They have the greatest potential for producing the widest variety of vegetable crops.

The structure of a soil is the result of the grouping of the soil particles into units or aggregates. Soil structure is affected by tillage, by the organic matter content, and by the presence of calcium and other elements. The structure of most soils can be improved by management practices. A well-aggregated soil is also well aerated, has good water drainage, and is easy to cultivate.

The soils of beach areas are apt to be sandy; those in the higher mountain areas are usually stony or gravelly. Throughout the Caribbean area are found small deposits of sedimentary soils that are presently above the flood stage of the stream that formed them. Such sites are well suited for vegetable gardens since the stream may supply much needed irrigation water.

In the Caribbean area and the Tropics generally, latosolic soils are predominant types. The term "latosol" has replaced the term "laterite." Latosol includes the soil groups known as laterites, reddish-brown lateritic soils, yellowish-brown lateritic soils, red-yellow podzolic soils, and several kinds of latosols. All latosolic soils are well weathered and leached, usually to great depths. They are usually yellow to red; the red color is due to iron compounds. Such soils are naturally infertile but can be made to produce by careful management.

GARDEN PLANNING

Choosing Location and Crops

Garden Location

For practical reasons the choice of a plot for the home garden often is restricted to the land immediately surrounding the gardener's house. Even so, some selection may be possible. A good garden site should meet as nearly as possible the following specifications:

(1) A somewhat flat or gently sloping surface.

(Steep slopes are undesirable unless bench terraced.)

(2) Well-drained loamy soil, high in organic matter and plant nutrients.

(3) Protected from winds by buildings, windbreaks, or neighboring hills.

(4) Located beyond the range of roots and shade of trees and hedges that might compete with the vegetables for light, water, and nutrients. (Shade of a distant high tree on the sunny side, however, may assist in lowering the temperature at midday, thus making it possible to grow the cool-season crops over a longer season.)

(5) Near the home and not readily accessible to thieves.

(6) Near a source of unpolluted water for irrigation.

(7) Near the market if some or all of the produce will be sold for profit.

(8) Protected from animals.

Crops and Varieties to Plant

In the Tropics north of the Equator most vegetables grow better during the cool, relatively dry winter season between October and May than during the warm, rainy summer season. Local environment is also a factor. (See p. 3.) In general, vegetables that have performed moderately well to well the year round under conditions of the Caribbean area near sea level are green bean, beet, broccoli, Chinese cabbage, head cabbage, carrot, cassava, chard, eggplant, leaf lettuce, mustard, okra, green onion, pepper, pigeonpea (gandul), radish, Ceylon spinach, New Zealand spinach, sweetpotato, tomato, and "yautía" (tanier). Most of these vegetables, particularly broccoli, Chinese cabbage, head cabbage, and tomato, performed better during the cool dry season than during the warm rainy season. On the other hand, eggplant, okra, pepper, Ceylon spinach, and New Zealand spinach performed somewhat better during the warm season than during the cool.

Vegetable varieties suitable for planting in the Caribbean area are listed in table 2. Additional varieties are suggested for Puerto Rico by Aponte Aponte (*3*); for Barbados, British Guiana, Trinidad, and other tropical areas by Hill (*18*); for Haiti by Mortensen and Bullard (*33*); for Curacao by Mullison and Mullison (*34*); and for the Virgin Islands by Thompson (*60*). It is also suggested that the gardener consult local growers and agricultural institutions for further recommendations on varieties that have performed satisfactorily in his locality.

TABLE 2.—*Vegetable varieties likely to succeed in the Caribbean area* [1]

Crop	Varieties	Remarks
Amaranth (Chinese spinach)	Tampala	
Asparagus	Mary Washington	Can be grown from seed or divisions.
Bean:		
Bonavist or hyacinth	Black-, brown-, or white-seeded	Seed can be obtained from local markets.
Bush green	Black Valentine, Bountiful, Contender, Improved Tendergreen, Stringless Green Pod, Tendergreen, and Puerto Rico improved white varieties, such as Bonita.	Other varieties (p. 61) are probably as satisfactory.
Bush wax	Pencil Pod Wax, Surecrop Stringless Wax	
Pole green	Blue Lake 231, Florigreen, Rust Resistant Kentucky Wonder.	Other varieties are probably as satisfactory.
Bush lima	Burpee Bush, Fordhook 242, Improved Fordhook Bush.	
Pole lima	Burpee Sunnybrook, Early Leviathan, Ford Mammoth, King of the Garden.	Last will bear for several years if protected from insects.
Beet	Crosby Egyptian, Detroit Dark Red, Early Wonder, Improved Blood Red.	Other varieties may perform satisfactorily. Tops of all these table varieties may be used for greens.
Broccoli	Calabrese, Propageno	

See footnote at end of table.

TABLE 2.—*Vegetable varieties likely to succeed in the Caribbean area*—Continued

Crop	Varieties	Remarks
Brussels sprouts	Improved Long Island	
Cabbage, head	Copenhagen Market, Early Jersey Wakefield, Golden Acre, Marion Market, Succession, Wisconsin All Seasons.	First three are early varieties with small heads. Succession is among the best with large heads.
Cabbage, Chinese	Chi-Hi-Li, Pe-Tsai, Wong-Bok	First is generally more satisfactory.
Cantaloup (See muskmelon)		
Carrot	Danvers Half Long, Imperator, Morse Bunching, Red Core Chantenay.	First is most productive.
Cauliflower	Early Market, Early Patna, Early Snowball, Maincrop Banaras, Maincrop Patna, Royal Purple.	Royal Purple produces heads with purple tint.
Celery	Florida Green Pascal, Golden Self Blanching, Utah, Waltham Summer Pascal.	Second is most commonly used.
Ceylon spinach (Malabar nightshade).	Any available locally	Can be propagated by seed or cuttings.
Chinese spinach (See amaranth)		
Chard (Swiss chard)	Fordhook Giant, Lucullus, Rhubarb	Rhubarb chard has red petioles.
Chayote	White or cream	Select desirable type fruit from market.
Collard	Georgia (Southern), Louisiana Sweet, Vates	
Corn, sweet (See sweet corn)		
Cowpea	Blackeye, Brown Crowder, Cream Lady, Yardlong.	Perform satisfactorily at low to medium altitudes only.
Cucumber	Ashley, Chinese Long, Henderson, Model, Palmetto, Palomar, Puerto Rico 39, Santee, Wisconsin SMR 15.	Puerto Rico 39 is most mildew resistant.
Dasheen (See taro)		
Eggplant	Black Beauty, Puertorican Beauty, Rosita	Last has white fruits blotched with pale purple.
Endive	Broad Leaved Batavian, Sutton's Extra Fine Green Curled.	First is partly self-blanching.
Gandul (See pigeonpea)		
Garlic	Any variety available	Bulbs are divided into cloves for planting.
Kale	Dwarf Siberian, Vates	Curled varieties are more attractive but likely to harbor insects.
Kohlrabi	Early White Vienna	
Leek	American Flag	
Lettuce: Head	Great Lakes, Imperial 847, Imperial 44, Mignonette.	Last is most heat resistant and can be grown in summer as leaf lettuce.
Leaf	Black Seeded Simpson, Mignonette, Ruby, Salad Bowl, Slobolt.	Last is slowest to send up seedstalks in warm weather.

See footnote at end of table.

TABLE 2.—*Vegetable varieties likely to succeed in the Caribbean area*—Continued

Crop	Varieties	Remarks
Malabar nightshade (See Ceylon spinach).	----------	----------
Muskmelon (cantaloup)	Smith's Perfect, Texas Resistant No. 1, local varieties.	----------
Mustard	Florida Broad Leaf, Fordhook Fancy, Tendergreen (mustard spinach).	Other varieties probably are as suitable. Curled varieties are likely to harbor insects.
New Zealand spinach	New Zealand	Soak seed for 24 hours before planting.
Okra	Clemson Spineless, Gold Coast, Louisiana Evergreen, Perkins Spineless, White Velvet.	Last is a favorite locally.
Onion:		
Bulb	Early Harvest, Excel 986, L36, Louisiana Red Creole, Texas Early Grano, White Creole, White Grano, Yellow Bermuda.	Seed must be fresh.
Green bunching	Evergreen (Nebuka), Evergreen Long White Bunching, Japanese Bunching, native varieties.	Can be propagated by division after becoming established.
Parsley	Extra Curled Dwarf, Moss Curled, Paramount, and plain or single.	Curled varieties have not produced seed in Tropics.
Parsnip	Hollow Crown	Other varieties are probably as satisfactory.
Pea:		
Edible-podded	Dwarf Gray Sugar, Manoa Sugar, Melting Sugar.	Last is a white-seeded variety that may be eaten as shelled peas.
English (green)	Alderman, Telephone	Both are tall.
Pepper	Blanco del País, California Wonder, Chato, Corozal, Yolo Wonder, Yolo Wonder L.	First has thin pale-green flesh.
Pigeonpea (gandul)	Kaki, Saragateado, Totiempo	Fresh seed should be obtained locally.
Potato	Green Mountain, Katahdin, Red Bliss Triumph.	----------
Pumpkin	Alagold, Large Cheese, Small Sugar	First is superior in flavor.
Radish	Earliest Scarlet Button, Scarlet Globe, Sparkler, White Icicle.	Other varieties probably perform equally well.
Rhubarb	Victoria	Plant seed in permanent location.
Rutabaga	Purple Top Yellow	----------
Salsify	Mammoth Sandwich Island	----------
Soybean	Hardee, Improved Pelican, Lee, Seminole	----------
Spinach	----------	Try several varieties at high elevations only.
Squash	Black Zucchini, Borinquen, Butternut, Camaguey, Cocozelle Bush, Fortuna, Golden Straightneck, Yellow Summer Crookneck.	----------

See footnote at end of table.

TABLE 2.—*Vegetable varieties likely to succeed in the Caribbean area*—Continued

Crop	Varieties	Remarks
Sweet corn	Improved USDA–34, Puerto Rico 50	Perform satisfactorily at low to medium altitudes only.
Sweetpotato	Canela, Don Juan, Mameya, Porto Morado, Red Velvet, Rico, U.P.R. 3.	
Swiss chard (See chard)		
Tanier (See taro)		
Taro (dasheen, tanier)	Trinidad, any available locally	Select best types from market.
Tomato	Campbell 146, Floralou, Homestead 24, Indian River, Manalucie, Marglobe, Michigan State Forcing, Pritchard, Roma, Rutgers, Selección Platillo.	Hybrids have not been thoroughly tested in Tropics.
Turnip	Purple Top White Globe, Shogoin	Second is a foliage turnip, grown largely for greens.
Watermelon	Blacklee, Charleston Gray, Congo, Sugar Baby, Tom Watson.	Better variety is needed.
Yam	Agua, Congo Yellow, Guinea, Guinea Yellow, Mapuey Morado, Potato, Purple Ceylon, Tongo.	
Yautía	Any available locally	Select best types from market.

[1] It is suggested that the gardener consult local growers and agricultural institutions for further recommendations on crops and varieties that have performed satisfactorily in his locality. See sections on culture of individual crops for additional information.

In selecting vegetables for the garden, the grower should consider their nutritive value. Among the root crops, carrot is highest in vitamins and minerals, but relatively low in food value. Legumes—green beans, lima beans, cowpeas, and soybeans—are high in vitamins, minerals, and protein. Vegetables of the greens group—broccoli, chard, lettuce, mustard, and parsley—are particularly high in vitamins and minerals. Vegetables of the starchy type—potato, sweetpotato, and corn—are primarily energy foods. Under home garden conditions the area available usually is not large enough to supply the family with these energy foods, but some can be raised if space is available. This is also true for cucumber, pumpkin, watermelon, and many of the squashes, which are low in food value. Yellow-orange squashes, however, are high in vitamin A content.

Planting Plans

To make the best possible use of land throughout the year, an advance planting plan of the garden should be prepared. The accompanying plans for small, medium-size, and large gardens at different elevations and mean-temperature levels are suggested merely as guides. Each gardener should make substitutions for some of the crops to suit his own tastes, needs for food, and climatic conditions. The plans cover elevations and approximate mean annual temperatures of: (1) Sea level to 1,000 feet at about 76° F.; (2) 1,000 to 2,500 feet at about 73°; and (3) 2,500 to 3,500 feet at about 68°.

In selecting vegetables, the gardener should examine the data in figure 2 in order to choose crops that are likely to perform most satisfactorily under his environmental conditions. He should then check his selections individually with the section on culture of individual crops to determine other specific requirements. (See p. 35.) He must remember that south of the Equator the seasons are the reverse of those to the north. For example, at Tamatave, Madagascar (*44, p. 682*), about 15° south of the Equator, the cool dry season is at its peak in July (70.5° F.) and the warm rainy season in January (80.5° F.). Near and on the Equator the mean temperature varies little throughout the year. Thus, at Quito, Ecuador, which is almost on the equatorial line, the mean temperature varies from 56.6° F. in July to 58.0° in October (*44, p. 675*). In view of these seasonal differences throughout the Tropics, the planting

dates in the accompanying plans for cool- and warm-season crops need to be adjusted according to local conditions.

Plants such as broccoli, cabbage, eggplant, onion, pepper, and tomato, which require transplanting from flats, pots, or seedbeds, should be planted 3 to 6 weeks early so they will be properly developed for transplanting to the garden on the dates recommended in the plans.

To obtain good yields of top-quality vegetables, the garden must receive some attention almost daily, with a total of several hours a week. An inexperienced gardener should start with a small area of ground and a few of the more easily grown crops, then expand to a larger garden and greater diversity of vegetables as interest and experience develop.

Plans for a medium-size garden are suggested for sea level to 1,000 feet and from 1,000 to 2,500 feet. A plan for a small garden is suggested for elevations and temperature conditions from 2,500 to 3,500 feet. For gardens where additional land is available, a supplementary plan is given to increase the size of the small and medium-size gardens to provide a larger quantity and variety of vegetables. In the absence of natural protection, some provision for windbreaks should be made in these garden plans. (See p. 34.)

The planting date for gardens at sea level has been suggested as October 15, and at the higher elevations as December 1, since these are the usual dates for starting gardens in humid sections of the West Indies. These dates are entirely arbitrary. The actual date land preparation and planting can be started will depend upon the vagaries of weather. An unusually prolonged rainy season may delay planting for 2 or 3 weeks. A short rainy season may advance the date of planting. In many of the low dry islands and lee coastal areas of the Caribbean area, the only good moisture conditions of the year may occur during the hurricane season. In such areas the gardener must be ready to take advantage of the moisture whether it comes as early as July or as late as November. It is possible to start a garden at almost any season of the year, following one of the planting plans and other recommendations appropriate for that date or season.

A wide variety of produce will not necessarily be available in these gardens at all times of the year. It is not intended—in fact, conditions do not make it possible—to have all the crops listed during each month. Only the more easily grown and better known crops are suggested in the planting plans. The more experienced gardener may wish to add or substitute others at the beginning.

Where rainfall is likely to be heavy at times, raised beds should be constructed, particularly during the rainy season, in order to obtain optimum drainage. (See p. 6.) When not in use, the ground in certain areas should be manured, dug up, and left fallow until needed.

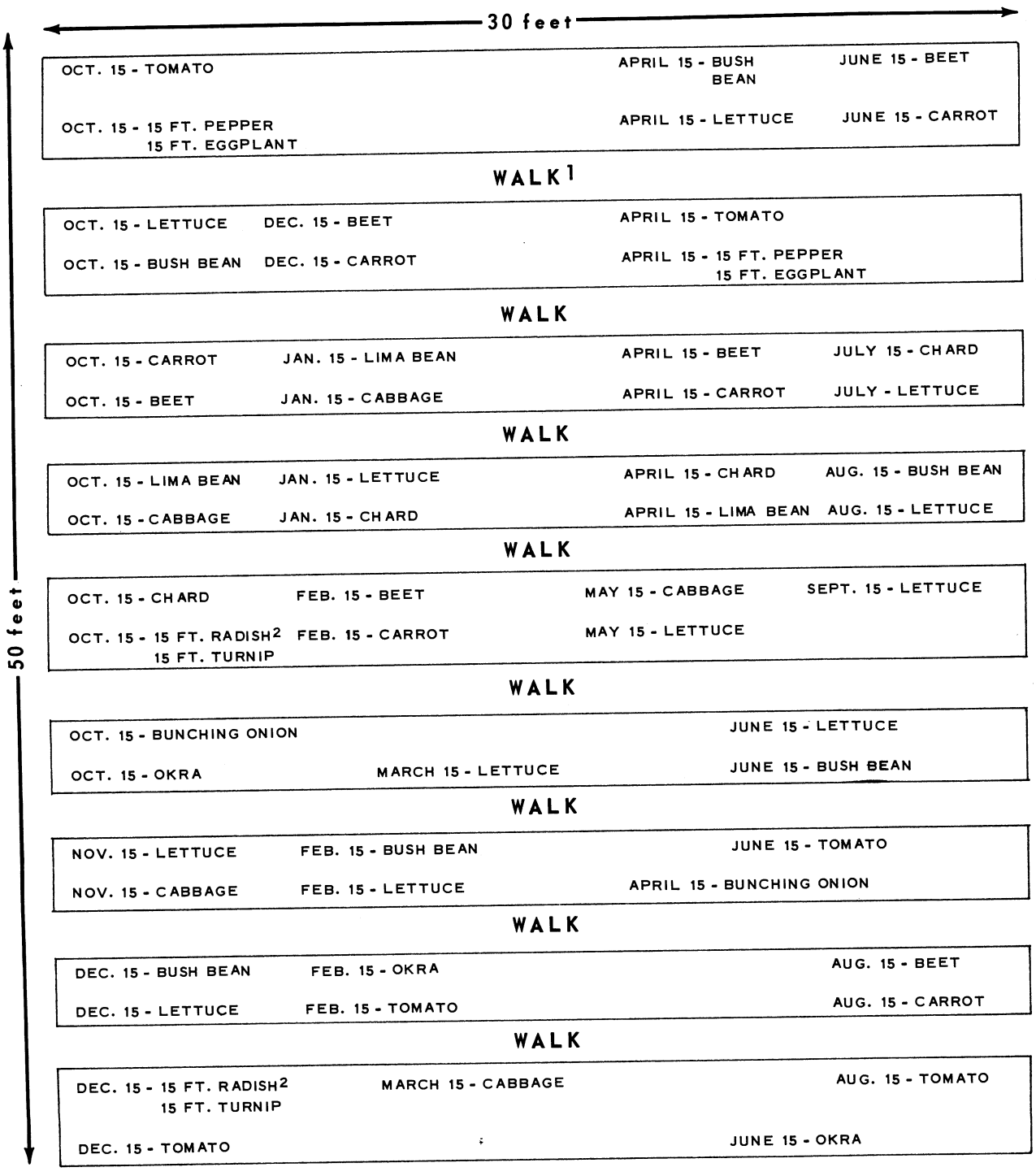
PLAN FOR MEDIUM-SIZE GARDEN AT ELEVATION BETWEEN SEA LEVEL AND 1,000 FEET; ANNUAL MEAN TEMPERATURE ABOUT 76° F.—The garden plan in figure 6 covers an area 30 by 50 feet, divided into 9 plots by walks. With good use of the land throughout the year and proper disease and insect control, a garden of this size should provide enough green vegetables for a family of four or five. A few starchy vegetables, such as sweetpotato, yautía, and potato, could be grown in a garden of this size by judicious management and companion cropping. Chayote, squashes, sweetpotato, and other vine crops might be grown on the fence to provide a windbreak.

Vegetables that can be substituted for those in the plan include broccoli, collard, sweet corn, cucumber, kale, kohlrabi, mustard, bulb onion, and summer squash grown in the proper season. New Zealand spinach can be substituted for one or two summer plantings of chard. Broccoli can be substituted for cabbage in November or January. Chinese cabbage can be substituted for cabbage at any period of the year, but both of these crops produce best in the cool season. Soybeans can be substituted for lima or green beans, particularly when planting in April.

A 15-foot row of each of two tomato varieties such as Homestead 24 and Rutgers should be planted. Homestead 24 comes into bearing 2 weeks earlier than Rutgers. A 15-foot row of only one variety could be planted each month, rather than a 30-foot row every 2 months. A few plants of Roma, Indian River, and Selección Platillo, as well as the small-fruited plum-, cherry-, or pear-type tomatoes could be planted during the summer. These small-fruited varieties are more likely than the others to bear a satisfactory crop under adverse conditions at low elevations. In particularly favorable locations or seasons lima bean, eggplant, okra, pepper, and tomato may remain productive much longer than indicated in the plan. At such times only the gardener can judge when to start replacements.

By doubling the size, this garden could also be made to produce most of the starchy vegetables required by a medium-size family. The plan suggested in table 3 for increasing the size of gardens at medium elevations can be used here. For some families it might be desirable to eliminate the crop of dry shell beans and grow more sweet corn, sweetpotatoes, yams, or yautías.

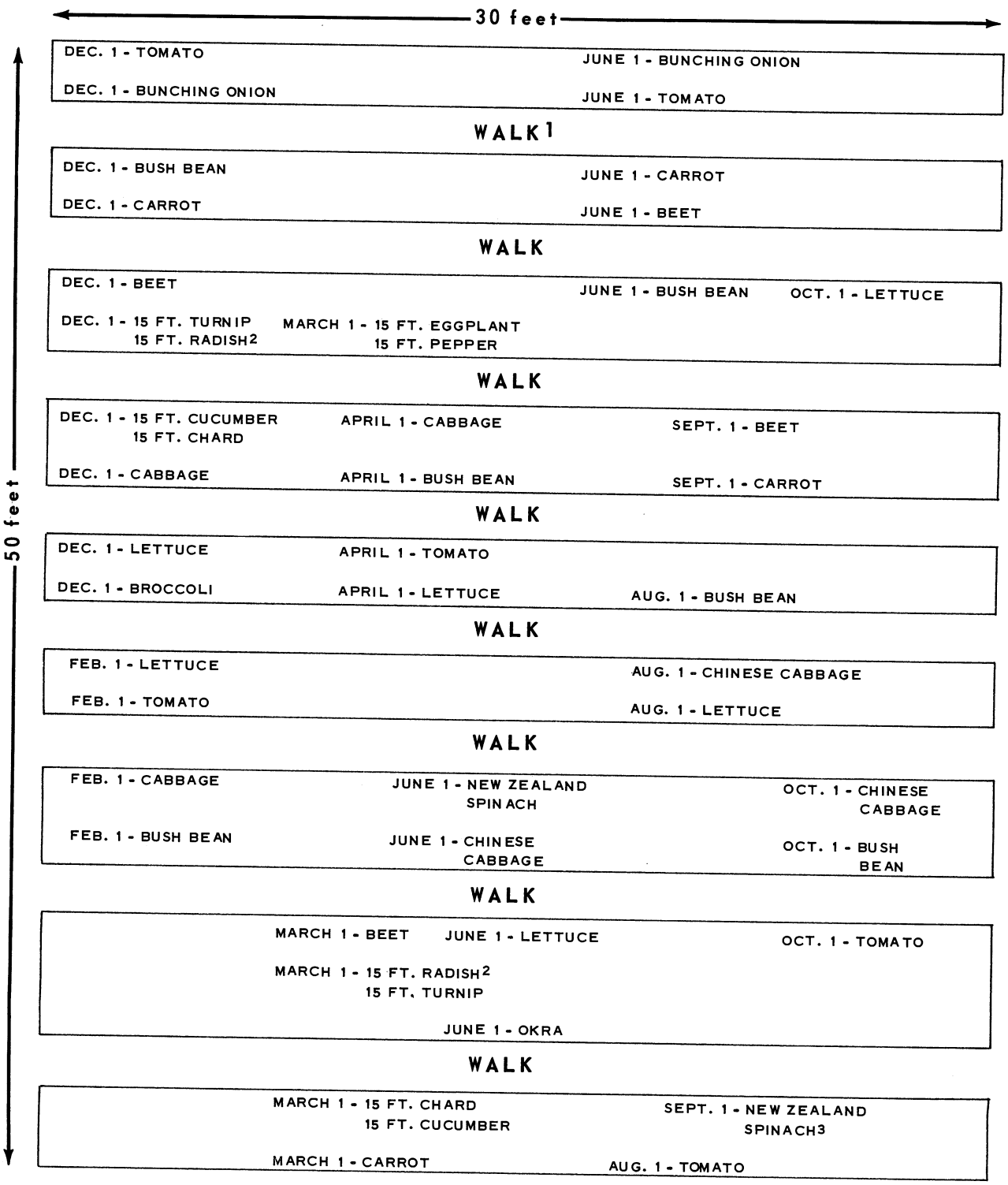
PLAN FOR MEDIUM-SIZE GARDEN AT ELEVATION BETWEEN 1,000 AND 2,500 FEET; ANNUAL MEAN TEMPERATURE ABOUT 73° F.—Suggestions given for the medium-size garden at low elevations (fig. 6 and table 3) apply for the most part to the garden suggested in figure 7 for middle eleva-



[1] Walks should be at least 2 feet wide; for recommended spacing between rows of vegetables consult table 6.

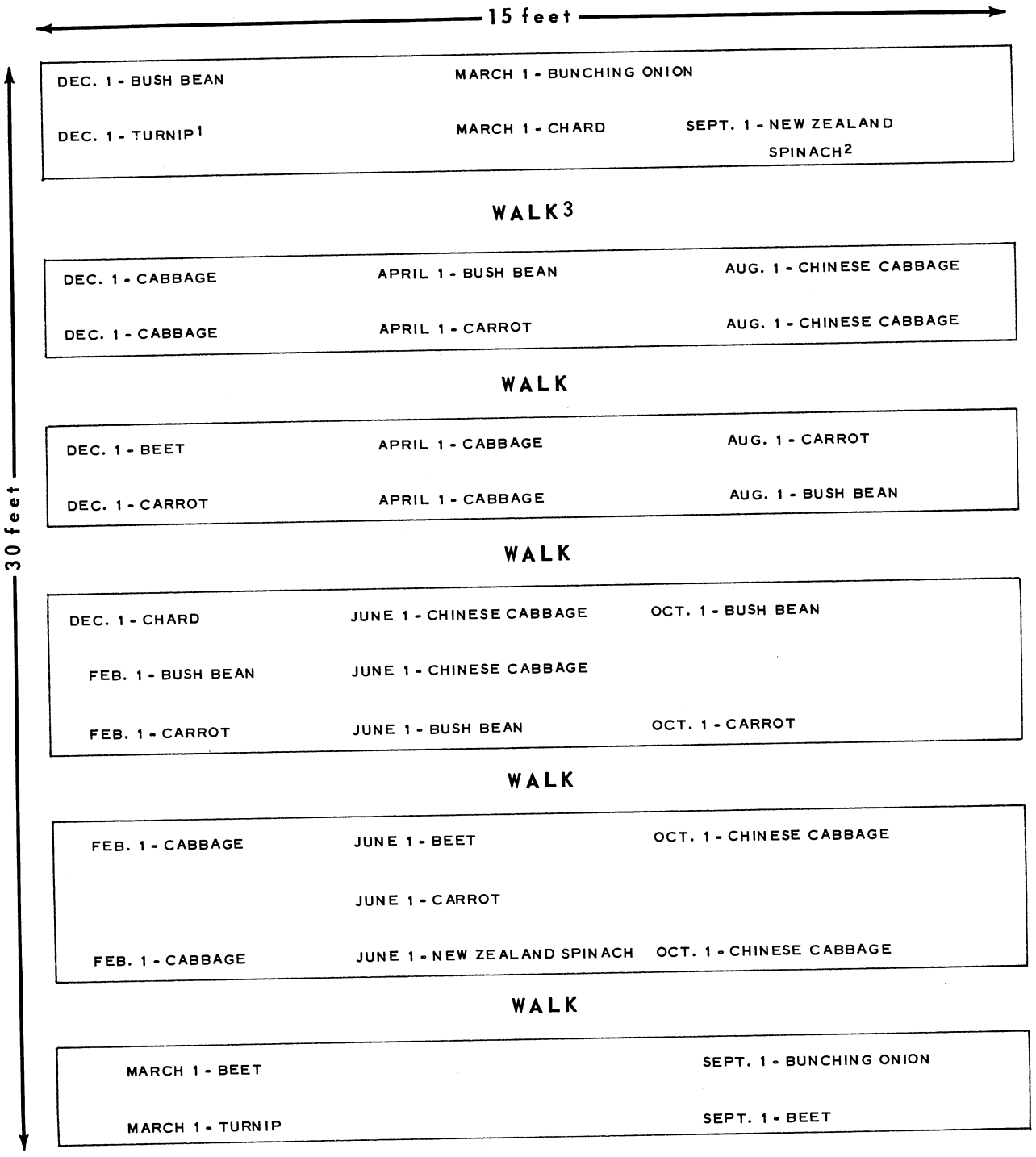
[2] Radish can be sown broadcast between rows of other crops.

FIGURE 6.—Suggested 12-month planting plan for medium-size home vegetable garden located at an elevation between sea level and 1,000 feet.



[1] Walks should be at least 2 feet wide; for recommended spacing between rows of vegetables consult table 6.
[2] Radish can be sown broadcast between rows of other crops.
[3] Mustard can be substituted for New Zealand spinach.

FIGURE 7.—Suggested 12-month planting plan for medium-size home vegetable garden located at an elevation between 1,000 and 2,500 feet.



[1] Kohlrabi can be substituted for turnip.
[2] Mustard can be substituted for New Zealand spinach.
[3] Walks should be at least 2 feet wide; for recommended spacing between rows of vegetables consult table 6.

FIGURE 8.—Suggested 12-month planting plan for small home vegetable garden located at an elevation between 2,500 and 3,500 feet.

TABLE 3.—*Length of rows for additional crops to increase home garden from medium size to large*

Crop	Distance between rows	Length of row when planted in—		
		December	March	July
	Feet	*Feet*	*Feet*	*Feet*
Bean, bush dry shell [1]	1½	----------	----------	390
Corn, sweet	3	90	90	----------
Pigeonpea (gandul)	3	----------	90	----------
Squash (calabaza type) [2]	3	60	----------	----------
Sweetpotato	3	120	----------	----------
Yam	3	----------	90	----------
Yautía [3]	3	----------	90	----------

[1] Double cropped with December sweet corn, calabaza, and sweetpotato plantings.

[2] Planted between sweet corn rows, December.

[3] Planted between sweet corn rows, March.

tions. However, with the approximately 3-degree cooler mean temperature, the cool-season crops, such as broccoli, cabbage, Chinese cabbage, and kohlrabi, will perform slightly better and over a longer season. On the other hand, warm-season crops, such as eggplant, okra, and pepper, will perform better during the warm months. Kohlrabi can be substitued for turnip and mustard for New Zealand spinach. If extra land is available, the size of this garden can be increased by adding the crops shown in table 3.

PLAN FOR SMALL GARDEN AT ELEVATION BETWEEN 2,500 AND 3,500 FEET; ANNUAL MEAN TEMPERATURE ABOUT 68° F.—A plan for a small garden is suggested for high elevations (fig. 8) because this is a more common size for gardens at such elevations. This may be the result of remoteness from large cities, which are a good outlet for surplus garden vegetables, or of the character of the land, which is steeper, less fertile, and somewhat less suited to vegetable growing than land at low elevations. Produce from this garden should meet the needs of a family of two or three.

This small garden can be expanded by adding crops adapted to higher elevations. At high elevations warm-season crops, such as eggplant and okra, should be planted only in a small way for trial. Pepper, on the other hand, may give fair yields during the warmer months. True spinach may fail unless the mean temperature is below about 65° F. Other crops that may be included or used as replacements for those suggested in figure 8 at high elevations are arracacha ("apio"), asparagus, broccoli, cauliflower, celery, collard, endive, kale, leek, mustard, parsley, parsnip, peas, potato, rhubarb, rutabaga, salsify, taro ("malanga" or dasheen), and yautía. Sweet corn and sweetpotato of the presently available varieties usually do not produce very well at high elevations.

At elevations above 3,500 feet and mean temperatures below 65° F., the number of vegetables than can be produced decreases during the cold season; in fact, most vegetables produce best during the warm season under these conditions.

Seed

Source

Having decided which vegetable crops he can expect to perform reasonably well, and having considered his climate, elevation, soil, and family needs, the gardener must secure seed. In some tropical areas the local agricultural agencies will maintain seed stocks for sale to the public. Usually the desired varieties are not available locally. The purchase of seed packets locally, even those prepared by reliable companies, should be avoided unless the seeds are known to be absolutely fresh. Most of the recommended varieties can be ordered from commercial seed companies located in the Temperate Zone.

Using seed of inferior varieties or seed with poor germination can be a costly mistake. Not only the time and effort of preparing the seedbed will be lost but also the gardener will be without the desired vegetables for some time. Use fresh seed, ordering the quantity needed for planting at each season of the year. Gardeners living in remote areas or where unusual delays are experienced in mail deliveries may wish to order a supply of seed sufficient for 6 to 12 months. In the Caribbean area the cool dry season of December to March is suggested for such shipments. Most of the seed companies are experimenting with some form of vapor seal, such as aluminum foil, plastic bags, or tin cans for packaging seeds (*15*). It would be well for the gardener to request some such packaging when he submits his order.

Growing Your Own Seed

In general, it is not wise under tropical conditions to grow or save seed from a garden. A crop left in the garden for seed ripening may occupy the land two or three times as long as when it is grown only for the edible portion. Also, seed of some crops may harbor disease organisms.

Seed of locally adapted varieties that are insect or disease resistant should be saved as supplies probably cannot be obtained elsewhere. These include several of the beans, sweet corn, cucumber, eggplant, pepper, and tomato.

Crops that normally produce seed under most conditions in the West Indies and Hawaii (*11, p. 39*) are bean, broccoli, Chinese cabbage, corn, cow-

pea, cucumber, eggplant, Imperial 44 head lettuce, Black Seeded Simpson leaf lettuce, melons, green and white mustards, okra, some varieties of onion, pepper, soybean, and tomato. Vegetable crops that will seed under tropical conditions only with special technical handling are beet, head cabbage, carrot, chard, collard, bulb onion, and parsley. Hill (*18*) discusses several aspects of vegetable seed production in the Tropics.

Treating and Storing

Good germination of vegetable seeds can be preserved under tropical conditions by immediately storing seed not used over calcium chloride or calcium oxide (quicklime) in airtight containers (fig. 9). These chemicals can be obtained at local chemical supply stores or drugstores. Thin layers of cotton and blotting paper should be used between the chemical and the seed. The seeds are in paper envelopes or cloth bags. These chemicals keep the air and seeds dry within the container, which is essential in maintaining viability under tropical conditions. The container should be kept under refrigeration or at least in a cool place. Seed of several different vegetables can be preserved for 2 years or longer at better than 90-percent germination when stored in this manner (*21, p. 27*).

FIGURE 9.—Storing vegetable seeds to preserve good germination under tropical conditions.

Excessive drying of some vegetable seeds reduces germination. In California, pole bean seeds stored at room temperature with a moisture content of 9.8 percent gave 61-percent germination after 1 year; seed stored over silica gel at 5-percent moisture gave only 12-percent germination (*15*). If seed is stored without protection from high humidity and relatively high mean temperatures, viability to produce good stands of some crops may be lost within a few weeks. Fresh, dry, unleached wood ashes also have been used to preserve the viability of garden seed in the Tropics. Equal volumes of ashes and well-dried seed are thoroughly mixed and stored in a tightly sealed bottle or other container.

Corn seed that has been dried on the cob can be kept free from weevils for several months by rolling the husked ears in lime. When corn seed is stored without treatment, germination of the seed may be destroyed within 3 months by high humidity or weevils or both (*39*). (See the sections concerning weevils, p. 95, and control of sweet corn insects, p. 102.)

Treatments for controlling seedborne diseases that appear on the seedlings, such as damping-off, are discussed under the section on vegetable diseases. (See p. 104.)

Germination Tests

If seed has been stored for several months, its ability to germinate can be checked by the following simple test:

Soak a small towel and two plates in boiling water for a few minutes; allow to cool; put the towel in one plate with a few seeds between a fold and invert the second plate over the first to reduce evaporation. Keep the towel continuously moist, but not soaked. Determine percentage germination within 4 to 8 days.

At least 50 percent of the seed should germinate in tests to insure an adequate stand when it is sown in the garden. With a germination percentage of 50 percent, twice as much seed should be sown as suggested. (See Planting the Garden, p. 25.) A 75-percent germination indicates that about one-third more seed should be planted than suggested.

GARDEN MANAGEMENT

After a garden site has been chosen, there are a number of practices the gardener can follow to insure reasonably good growth and production of vegetable crops. Usually the site will not be ideally situated in all respects. (See p. 9.) In high-rainfall areas a diversion ditch is sometimes necessary to prevent surface water from damaging the garden. Judicious tree removal may be necessary to prevent competition from roots and shading of the garden site. Fencing may be needed to prevent damage by wandering animals and pilfering. More often than not, however, soil and water will be the factors most limiting to vegetable gardening in the Caribbean area and in the Tropics generally.

Soil Improvement

The best soil for growing vegetables is a well-drained sandy loam, high in organic matter. Such a soil is rarely available to the average gardener in the Caribbean area. Nevertheless, it is frequently possible to grow satisfactory crops of vegetables by special treatments of heavy, infertile soils. Soil improvement under these conditions may be effected by one or all of the following practices:

(1) Loosen the soil for better drainage and aeration by adding large quantities of manure, compost, or cachaza (sugarcane mill filter-press cake), volcanic black sand, river or beach sand, or river silt.

(2) Apply commercial fertilizers.

(3) Apply agricultural limestone.

(4) Irrigate judiciously, avoiding excessive watering.

(5) Improve surface drainage by using raised beds and grass-lined ditches constructed with very gradual grades.

(6) Cultivate frequently when the soil is moist but not muddy.

Soil Preparation

The first step after the garden site has been laid out is the removal of all possible obstructions, such as rocks, roots, and stumps. All herbaceous vegetation should then be chopped down and plowed or spaded under. The soil should receive a heavy application of pulverized limestone before it is plowed unless the soil is known to be sweet or alkaline. After 3 or 4 weeks a liberal dressing of animal manure or leaf mold should be applied and the soil plowed or spaded a second time. Some particularly heavy soils may require a third working to put them in condition. Where chemical fertilizers are readily available, about 50 pounds of 5-10-5 analysis fertilizer should be scattered over the 30- by 50-foot plot before the final working. If chemical fertilizers are difficult to obtain, they should be saved for later use.

When gardens are on bench terraces (fig. 10), liberal quantities of animal manure and compost may be required to improve the unproductive exposed subsoil frequently found there. This condition can be improved also by placing on the lower terrace the topsoil obtained from constructing the terrace immediately above. Gardens should not be planted on dry, steep, unterraced hillsides where topsoil has been largely washed away, leaving only the infertile subsoil.

Steps in preparing bench terraces for planting are:

(1) Dig a trench 1 foot deep and 1 foot wide where each row of vegetables is to go. On narrow terraces the trenches will parallel the inner edges or surface drainage channels. On broad terraces, such as the one shown in figure 10, the rows should be perpendicular to the drainage channel. Otherwise the inner rows may become waterlogged during extended rainy periods.

(2) Loosen the soil at the bottom of the trench with a spading fork.

(3) Place in the trench any organic matter available, to a depth of 3 to 6 inches and dig it in. Animal manure is preferred, but any plant refuse may be used.

(4) Sprinkle the organic matter with lime but withhold the lime if fresh manure is used.

(5) Replace the soil over the organic material, leaving it slightly mounded.

(6) Lime this surface soil at the rate of 10 pounds per 100 row feet and rake it in.

(7) At time of planting apply a covering of pulverized organic material such as well-rotted leaf compost, animal manure, or cachaza.

(8) Repeat the process each year, digging the trench in what was the path between rows the preceding year.

A modification of this method, called "bastard trenching," is recommended by Herklots (*17*) to prepare plots of barren latosolic soil for planting vegetables. A trench 2½ feet wide and 1 foot deep is dug across one end of the plot and the soil carried to the far end. This trench is filled with organic material and limed as outlined above. It is then covered with the soil obtained by excavating the adjacent 2½-foot strip. The procedure is repeated until the entire length of the plot has been dug; then the last trench is covered with the soil removed from the first.

FIGURE 10.—Vegetables growing on handmade terrace built on a 45-percent slope.

Plant Beds

In tropical regions receiving heavy rainfall good surface drainage of the soil must be provided. Raised beds are commonly used to divert excess moisture when the soil is of medium to heavy texture. The beds may be 6 to 12 inches high, 3 to 6 feet wide, and any convenient length. Paths between beds are from 1½ to 2 feet wide. Raised beds have the advantages of being easy to work, looking neat, and being less subject to trampling because their paths provide a place to walk and stand. Beds that are edged with boards, galvanized iron, or rocks generally have less trouble with weeds migrating from the paths. Bordered beds also are less subject to soil erosion and are easier to spade because of being less trampled.

During periods of low rainfall, raised beds have the disadvantage of drying faster and requiring more frequent watering. They should not be used during the dry season unless they are already constructed. Mulching will help retard drying out of the soil.

The walks between the beds can become plant beds the second year. The soil should first be loosened with a spading fork, then covered with a 3- to 6-inch layer of animal manure or other organic material. Lime should be added if needed and the soil from the old beds used to cover the new.

Fertilizers

Animal Manures

Animal manure is the most useful form of fertilizer and it is often the only form available to the home gardener. Manure frequently makes the difference between an excellent and an average to poor crop. It not only is a source of plant nutrients but also aids root growth by making the soil more porous and crumbly and promoting good aeration and drainage. Quality of manure varies with the animal producing it, the feed the animal receives, and the age and care of the manure. As a rule, poultry manure is best, with that from the horse, cow, pig, and rabbit following in the order given. Animal manures in general are

relatively high in nitrogen and potash but low in phosphorus. Since many tropical soils are low in phosphorus also, it is wise to apply some commercial fertilizer with manure. Manure applied alone to crops such as tomatoes, beans, and peas may result in a highly vegetative condition of the tops with average to poor growth of flowers, roots, or fruits. Manure applied alone to leafy vegetables—lettuce, chard, kale, mustard, and endive—may be satisfactory since the leaves are the desired product. Poultry manure is relatively high in nitrogen and gives good response with the leafy crops. Fresh manure can be used provided it does not touch the plants.

Strawy manure may contain weed seeds in varying quantities. If the manure is applied to the garden area a few weeks in advance, the seeds will germinate and most of the seedlings can be destroyed when the seedbed is prepared. Rotted or composted manure usually is more beneficial to the soil than is fresh manure and composting will kill the weed seeds. The method for preparing manure compost is the same as for plant composts except that a layer of fresh animal manure is substituted for the chemical fertilizer.

Composts and Other Organic Materials

The main benefit of compost is the improvement of aeration and drainage through the better physical condition of the soil thus created. Composts also help prevent baking and cracking of the soil after rains. A compost pile can be prepared by building up successive layers of (1) organic materials—lawn clippings, leaves, or tender hedge clippings—with manure; (2) then soil; and (3) then a fertilizer such as ammonium sulfate, ammonium nitrate (*64, pp. 16–17*), or sodium nitrate in the order named. The layers of organic material should be 6 inches thick. The fertilizer and soil are sprinkled over each layer, making the pile 3 to 6 feet high if necessary (fig. 11).

Excessive heating may result if the compost pile is over 5 or 6 feet wide. Where commercial nitrogen fertilizers are not available, complete fertilizer mixtures, such as 10-10-5, may be used instead. For each 100 pounds of organic material, 10 pounds of superphosphate and 5 pounds of ammonium sulfate should be added.

Weeds and diseased plants from the garden can be used for organic materials if properly composted and sufficiently aged. Well-prepared compost heaps will heat, thus destroying practically all weed and grass seeds and disease organisms. The compost heap should be sheltered from rains to reduce leaching. In dry regions a compost pit is preferred and water should be added when dry plant materials are used.

The compost pile should be kept moist, but not soaked, all the time. The heap should be turned with a shovel or fork at 3-week intervals over a period of about 3 months.

Cachaza (filter-press cake from sugarcane mills) is good for improving the soil provided it

FIGURE 11.—Well-constructed compost pile with depressed top and steep sides.

has been well decomposed before application. Fresh cachaza applied to the vegetable garden may cause nitrogen deficiency or yellowing of the foliage. The application of fresh sawdust, straw, or similar materials may produce the same effect. When these materials are used fresh, plenty of manure or commercial nitrogen fertilizer or both must be applied.

Chemical Fertilizers

Under tropical conditions chemical fertilizers should be used with almost every planting, supplemented with manure when available. Most commercially mixed fertilizers contain the three important nutrients—nitrogen, phosphorus, and potassium—the percentage of each available nutrient being designated by a numerical formula. For example, 100 pounds of 10-10-5 fertilizer contains 10 pounds of nitrogen, 10 pounds of phosphorus, and 5 pounds of potassium, totaling 25 pounds of available plant nutrients. The remaining 75 pounds consist of inert ingredients or fillers, such as sand or lime.

When using relatively low-analysis fertilizers such as 5-10-5, 10-10-5, 6-9-5, or 5-10-10 at planting, the average application is about one medium handful to 3 feet of row. The amount of fertilizer in an average-size hand about half closed and held upright is 3 to 4 tablespoonfuls. For rows approximately 18 inches apart this application corresponds to 800 to 1,000 pounds per acre. For concentrated fertilizers such as 11-48 ammonium phosphate, slightly less than this quantity should be used at planting.

TABLE 4.—*Quantity of chemical fertilizer per 25 feet of row at various row spacings to approximate standard acreage rates* [1]

Spacing between rows (inches)	Standard acreage rates					
	200	400	600	800	1,000	1,200
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
12	0.12	0.25	0.35	0.50	0.60	0.75
18	.18	.37	.55	.75	.90	1.10
24	.25	.50	.75	1.00	1.25	1.50
30	.30	.62	.90	1.25	1.50	1.80
36	.37	.75	1.10	1.50	1.80	2.20
42	.43	.85	1.25	1.75	2.10	2.50
48	.50	1.00	1.50	2.00	2.40	3.00

[1] Roughly, 6 to 9 medium handfuls of fertilizer will weigh 1 pound. This will vary with hand size and the weight of the fertilizer.

For side dressings of fertilizer while the plants are growing, apply a medium handful of fertilizers—ammonium sulfate, ammonium nitrate, sodium nitrate, 11–48 ammonium phosphate, or equivalent material—to both sides of each 6 row feet 3 to 4 inches from the base of the plants. This corresponds to a side dressing of 300 to 400 pounds per acre at 18-inch row spacing. The fertilizer-application data in table 4 should be valuable in calculating the amount needed in moderately large or commercial vegetable gardens (*11, p. 35*).

Methods of applying fertilizer are shown in figure 12. A complete fertilizer should be applied with manure at planting time and a side dressing

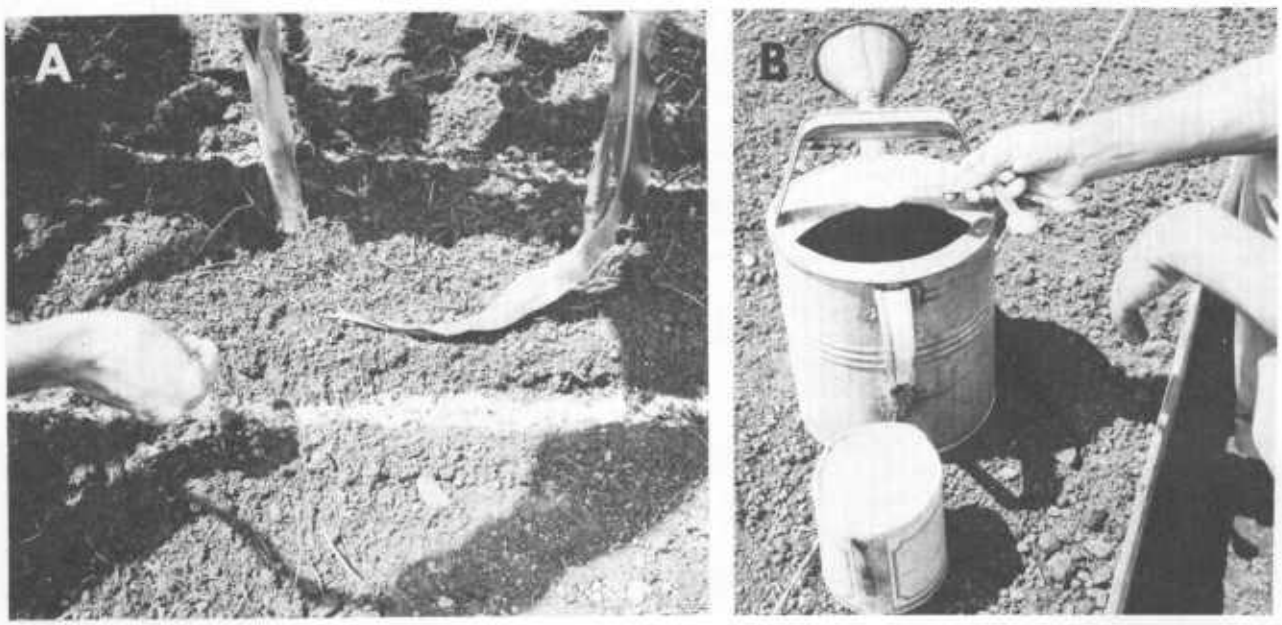


FIGURE 12.—Methods of applying fertilizers: *A*, Applying side dressing of ammonium sulfate to corn; *B*, dissolving complete fertilizer in water to sprinkle on young seedlings.

of commercial fertilizer such as ammonium sulfate should be applied after the plants have become well established. A complete fertilizer applied to seedlings induces rapid and strong growth. If fertilizers are available only in 200-pound bags, which may be too much for a single gardener, neighboring gardeners can buy a bag together.

Since nitrogen dissolves easily in rain or irrigation water and penetrates the soil rapidly, it can be applied as a surface side dressing. Potash and, particularly, phosphate dissolve much more slowly and should be applied in 3-inch furrows and covered with soil. The furrows are run on either side of the row and not closer than 2 inches from the plants. When the soil is heavy, side dressings by furrow are particularly recommended; when the soil is sandy, side dressings of all fertilizers can be applied on the soil surface. Fertilizer elements will not be readily available to the roots until after a rain or an irrigation. Fertilizers should never touch the seed, leaves, or plant roots, or burning and killing will result.

Relatively little research has been done on the need for so-called minor elements—boron, copper, iron, magnesium, manganese, molybdenum, and zinc—in vegetable crop production in the Tropics. Deficiencies of these minor elements may limit growth under some tropical conditions, particularly where leaching from heavy rainfall may be pronounced. Excessive amounts of some nutrients such as water-soluble manganese may create deficiencies of others such as iron (*19*); or the reverse manganese-iron relationship may exist (*54*).

In Puerto Rico during trials with vegetables symptoms closely corresponding to minor-element deficiencies were noted from time to time (*52*). In Michigan (*24, p. 19*) boron and manganese deficiencies were reported most likely in alkaline soils, particularly with red beet, head cabbage, cauliflower, head lettuce, rutabaga, spinach, and turnip. Symptoms of boron deficiency are black corky areas in the beet flesh, rough cankers on the outside of the beet, blackened small center leaves in head lettuce, cabbage, and cauliflower, and small deformed center leaves on spinach. Manganese deficiency is easily seen on beet leaves as a fading of color between the green veins.

Minor-element fertilizers, when needed, can be thoroughly mixed with sand or the main garden fertilizer, since uniform application of small concentrated quantities is difficult. Boron is generally applied at the rate of 6 ounces of common borax per 1,000 square feet and manganese at the rate of 1 pound of manganese sulfate per 1,000 square feet. When boron-susceptible vegetables are interspersed with others less likely to show these deficiencies, only 3 ounces of borax per 1,000 square feet for the entire garden area should be used. Some vegetables are injured if borax is applied at the higher rate.

Copper deficiency is not likely where copper sprays such as bordeaux mixture are used. Zinc deficiency is economically important only on a few vegetables growing under unusual soil conditions in Florida and California (*52, pp. 168–169*). Foliar symptoms of zinc deficiency are the same for bean, squash, and tomato. Some leaves are abnormally small and mottled with dead areas; others are uniformly chlorotic. A pinch of zinc sulfate in 10 gallons of water sprayed over the plants should counteract zinc deficiency. Iron deficiency also results in chlorosis of the tip leaves and is most likely to appear on alkaline soils. It can be counteracted with iron sulfate—a pinch of the sulfate in 10 gallons of water. If supposedly minor-element deficiency symptoms are persistent and pronounced, each minor element should be checked separately on neighboring plants to determine which one, if any, gives the most striking response.

Lime

Most vegetables grow best when the soil is somewhat acid to slightly acid (pH 5.5 to 6.5) but some, such as cabbage, grow well in sweet to slightly alkaline soil (pH 7.0 to 7.5). Acid soils can be sweetened by adding some form of lime. Powdered limestone, either dolomitic or coral, usually is the form most available in the Tropics. If it is necessary to import lime, the hydrated form may be cheaper since less is required. Calcium, one of the elements contained in lime, is essential for plant growth. If a soil is suspected of being too acid, the gardener can apply lime to a small area at the rate of 10 pounds of ground limestone per 100 square feet of area and observe subsequent growth of the vegetable crops for any improvement. If it is found that lime is needed, the form available should be broadcast on the soil surface at the proper rate shown for that form in table 5, and worked in by raking.

In some areas soil samples can be tested by local agricultural agencies or experiment stations. One-half pint of soil is sufficient for each test. If it is needed, lime can be applied at the rate recommended.

The yellow and red latosolic soils of many high-rainfall areas of the Tropics are apt to be deficient in most of the elements needed for growth of vegetable crops. This is particularly true where row crops have been grown without an adequate management program. Under such conditions, the alkaline salts are among the first to be leached.

In southern Brazil, Mikkelsen, Freitas, and McClung (*30*) conducted a 2-year study of the ef-

TABLE 5.—*Approximate quantity of liming materials required per 1,000 square feet to reduce acidity in garden soil*

Material [1]	Quantity for soil having initial pH of —		
	Below 5.0 (very acid)	5.0 to 5.5 (acid)	5.6 to 6.0 (moderately acid)
Ground limestone ---------- pounds	100	75	50
Limestone meal ---------- do	100	75	50
Hydrated lime ---------- do	75	50	35
Marl, 50 percent $CaCO_3$ ---------- bushels	6	4	2
Marl, 90 percent $CaCO_3$ ---------- do	3	2	1
Sugar factory refuse ---------- do	3	2	1

[1] Other refuse-lime materials, such as water softener lime, are equally good *provided they contain no toxic substances.*

fects of liming and fertilizing virgin areas of the acid (pH 4.9) yellow to red lateritic Campo Cerrado soils. Yields of corn, cotton, and soybean increased sharply with the application of dolomitic limestone. The limestone corrected excessive soil acidity, supplied calcium and magnesium as plant nutrients, and increased the uptake of native nitrogen, phosphorus, and sulfur. There are 400 million acres of such soils in the central plateau of Brazil.

Gardens planted on acid soils may require annual application of lime and organic materials. In addition to supplying calcium and magnesium for plant growth and neutralizing acid soils, lime causes a flocculation of the clay particles. Rotted organic material alone may actually make a clay soil more sticky. The flocculation caused by lime improves the physical condition of the soil by making it more crumbly.

West Indian soils formed from limestone and soils of arid coastal areas should not require the addition of lime. Some soils may contain excesses of the soluble salts of calcium, sodium, and other elements. These alkaline soils may have pH readings above 8.0. Garden vegetables planted on them will grow poorly and will exhibit varying degrees of yellowing of the foliage. Such soils should be avoided in locating vegetable gardens. If no other soil is available, samples should be submitted to the local agricultural agencies for analysis and recommendations as to how the condition can be corrected. Sulfur or aluminum sulfate can be added to correct excessive alkalinity.

Planting the Garden

Before any seeds are sown, the surface soil should be broken into the finest particles possible. Seeds absorb the moisture necessary for germination from the soil. Better contact between seed and soil is obtained in finely divided soil than in rough soil, resulting in earlier and better germination. Seeds of most vegetable crops are rather small. If planted in rough soil, many seeds will fall in the crevices between clods and be covered too deeply for the seedlings to emerge above the surface.

The soil surface can be pulverized by repeated raking. Soils high in clay are particularly difficult to prepare. A dry cloddy soil can be put in condition by sprinkling it with water late in the evening and raking it thoroughly early the following morning. The soil usually will be in good planting condition after 2 or 3 days of this treatment. The more useful hand tools for preparing, planting, and maintaining a garden are shown in figure 13. In the man's right hand are a claw

FIGURE 13.—Hand tools for preparing, planting, and maintaining a garden.

weeder, measuring spoons, trowel, and a machete. Other items are sprinkling nozzle for garden hose, garden line with stakes, and labeling stakes. Over his left shoulder are a rake, hoe, spading fork, and a sprinkling can.

Direct Seeding in Garden

After locating the plot, selecting the vegetables to be grown, procuring seed, planning his garden, and preparing the soil, the time comes for the gardener to lay out his garden and plant the seed. As aids to this operation, information about row spacing, planting depth, seed requirements, time to maturity, and estimated yields are shown in table 6. The procedures necessary to prepare a garden for direct seeding are illustrated in figure 14.

After the garden soil has been prepared for planting and after the beds are built up, if needed for surface drainage, a layer of rotted manure is added (fig. 14, *A*). Commercial fertilizer is applied over the manure; then both manure and chemical fertilizer are thoroughly mixed with the

TABLE 6.—*Spacing, planting depth, seed requirement, time required for maturity, and estimated yield of vegetables in the Tropics*

Crop	Spacing of plants [1]		Planting depth	Seeds per foot of row [2]	Quantity of seed or plants per 25-foot row	Time required to reach maturity [3]	Estimated yield per 25-foot row
	In row	Between rows					
	Inches	*Inches*	*Inches*	*Number*		*Days*	
Asparagus	18–24	36	¾–1	----------	12 to 16 plants	365–730	2 pounds.
Bean, bush green	3–6	18–24	¾–1½	4–6	4 ounces	42–56	12 pounds.
Bean, bush lima	6–8	18–24	¾–1½	3–4	3 ounces	60–80	6 pounds.[4]
Beet	2–3	18–24	½–1	12–15	½ ounce	65–100	20 pounds.
Broccoli	15–18	18–30	½	----------	12 to 15 plants	65–85	8 pounds.
Brussels sprouts	15–24	18–30	½	----------	12 to 15 plants	120	2 pounds.
Chinese cabbage	3–12	15–24	½	8–10	1 packet	95–100	18 to 30 heads.
Cabbage, head	12–24	18–24	½	----------	12 to 25 plants	70–100	12 to 25 heads.
Carrot	2–3	15–18	½	30–40	¼ ounce	74–108	20 pounds.
Cauliflower	15–18	24–30	½	----------	16 to 20 plants	56–118	16 to 20 heads.
Celery	6–12	15–24	⅓–⅜	----------	25 to 50 plants	110–150	25 to 50 heads.
Chard	6–12	15–24	¾–1	4–6	1 packet	60–75	25 pounds.
Collard	18–24	36	½	----------	12 to 15 plants	80–100	30 pounds.
Corn, sweet	10–15	36	1–2	2–3	2 ounces	90–120	30 ears.
Cucumber	36–48	48–60	½	----------	⅛ ounce	56–65	15 pounds.
Eggplant	24–36	30–36	½	----------	8 to 12 plants	89–132	50 pounds.
Endive	12–15	15–18	½	----------	⅛ ounce	56–92	12 pounds.
Kale	18–24	12–15	½–1	----------	⅛ ounce	52–91	15 pounds.
Kohlrabi	18–24	3–6	½–1	12–15	1 packet	50–98	15 pounds.
Leek	15–18	2–3	½	----------	1 packet	132–160	----------
Lettuce, head	12–15	18–24	½	----------	20 to 25 plants	46–70	20 to 25 heads.
Lettuce, leaf	6–12	6–12	½	12–24	1 packet	46–70	25 to 30 bunches.
Mustard	4–6	18–24	½	20–30	1 packet	48–59	25 pounds.
Okra	12–15	36	½	4–6	½ ounce	55–60	30 to 40 pounds.
Onion, bulb	4–6	18–24	½	20–30	1 packet	120	----------
Onion, green	4–6	18–24	½	20–30	1 packet	120	10 pounds.
Parsley	4–6	12–18	½	20–30	1 packet	75	5 pounds.
Parsnip	4–5	15–18	½	12–15	1 packet	139	24 pounds.
Pea	2–6	13–24	1–1½	4–6	2 to 4 ounces	57–78	5 pounds.
Pepper	12–18	24–36	½	----------	16 to 25 plants	96–112	15 pounds.
Potato	12–15	18–24	3–4	----------	20 to 25 seed pieces [5]	75–100	20 pounds.
Pumpkin	36–96	48–96	½–1	----------	½ ounce	112	30 to 40 pounds.
Radish	1–2	12–18	½	30–40	½ ounce	23–30	20 dozen.
Rhubarb	24–36	24–36	½	----------	12 to 16 plants	132	----------
Rutabaga	3–6	18–24	½	20–30	1 packet	72	15 pounds.
Spinach, New Zealand	12–15	18–24	½	6–12	2 ounces	63–76	10 pounds.
Squash	36–48	36–96	1–1½	----------	1 ounce	47–89	25 to 40 pounds.
Tomato	24–48	36–48	½	----------	6 to 12 plants	54–90	50 pounds.
Turnip	3–6	15–24	½	20–30	1 packet	70–75	10 pounds.
Watermelon	36–48	72–120	1–2	----------	⅛ ounce	100	100 pounds.

[1] Wider spacing may be desirable where mechanical equipment is used for planting, cultivating, or harvesting.

[2] More seed should be planted if germination tests show low seed viability.

[3] Time is given as the approximate number of days to produce crop, from planting seed in the garden or from transplanting plants to the garden.

[4] Shelled.

[5] Each seed piece should weigh 2 to 3 ounces; thin slices with buds should not be used.

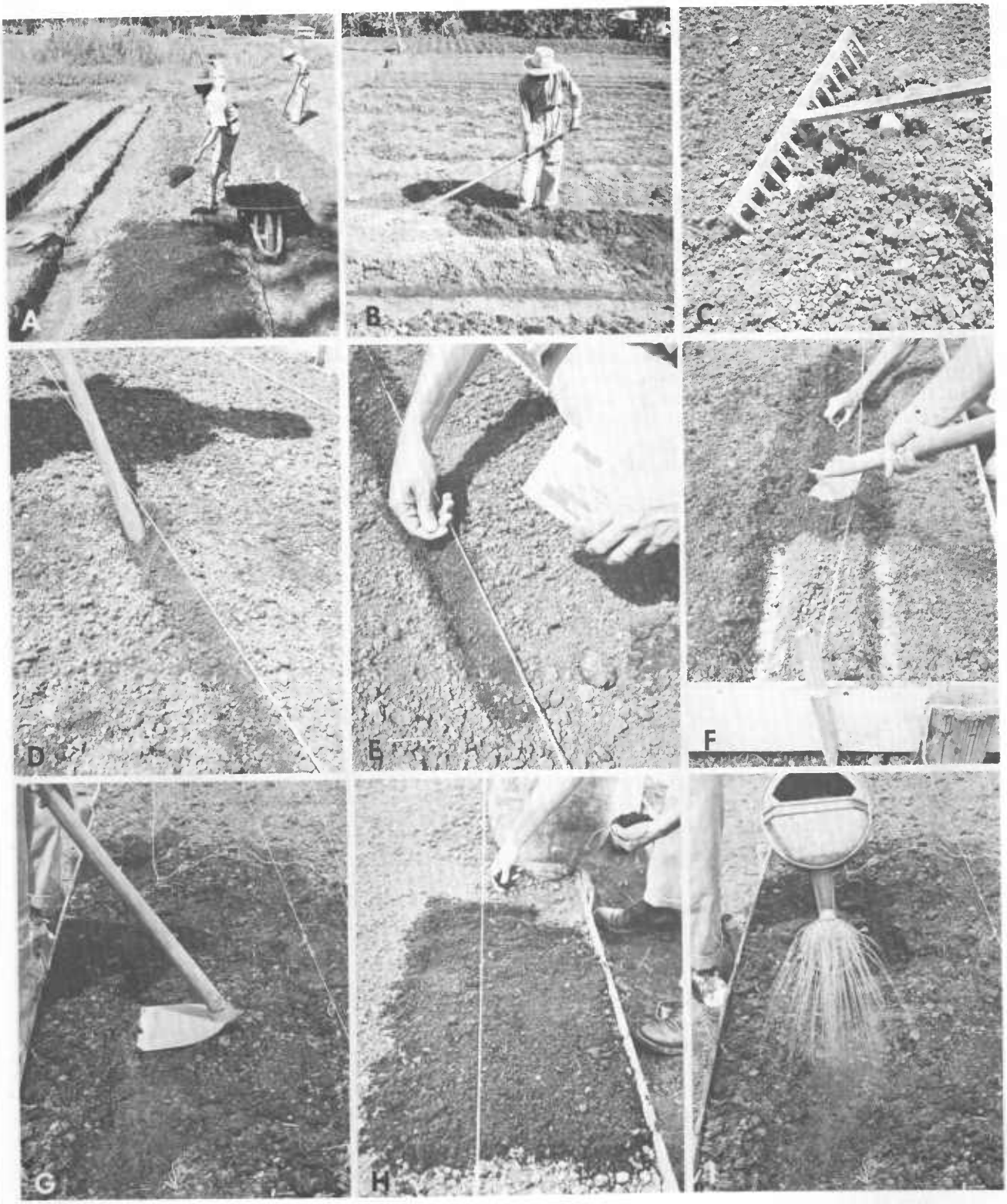


FIGURE 14.—Preparing the garden for direct seeding: *A*, Adding layer of rotted manure to seedbed; *B*, applying commercial fertilizer and thoroughly mixing soil to 3 or 4 inches; *C*, removing clods with rake; *D*, preparing furrows with end of hoe handle; *E*, planting small seeds; *F*, preparing furrow with corner of hoe; *G*, pulling soil over furrow with hoe; *H*, distributing manure over planted seed; *I*, watering seedbed.

upper 3 to 4 inches of soil (fig. 14, *B*). (See also p. 20.) Removal of the large clods with a rake will leave a fine seedbed (fig. 14, *C*).

A cord should be stretched between two stakes to insure straight rows that look neat and also facilitate cultivation and prevent loss or damage of plants by machinery.

A stake bearing the vegetable name and date of planting should be set at the end of each row.

Small seeds, such as carrot and turnip, are planted about ½ inch deep (fig. 14, *E*). The furrow can be prepared with a hoe handle (fig. 14, *D*) to give a narrow row or, where more space is available, with the square end of a 1- by 4-inch stake. These broad but shallow furrows are particularly useful for direct seeding of beet, carrot, lettuce, mustard, radish, and turnip. More plants and therefore higher yields can be secured by scattering the seed laterally in the furrow as the row is planted.

For large seeds, such as beans and corn, the furrow (fig. 14, *F*) is made 1½ to 3 inches deep with the corner of a hoe. Fertilizer for these crops is first applied in parallel bands on either side the seed row. After the seed is distributed in the row the soil is pulled over the furrow with a hoe or rake and tamped lightly (fig. 14, *G*).

In general, small seeds are covered about ½ inch deep; large seeds 1 to 2 inches deep. Seed should be planted slightly deeper in sandy soil than in clay soil. It is also best to plant somewhat more shallow than recommended in table 6, provided special care is taken to maintain even and plentiful, but not excessive, soil moisture around the seed. Soil moisture can be retained by sprinkling a thin layer of pulverized compost, rotted cachaza, or, preferably, well-rotted manure over the seeded area (fig. 14, *H*), or by using a thin mulch (1 inch deep) of lawn clippings or similar fine material. When planting is completed, the seeded area should be well watered (fig. 14, *I*). After the seeds have germinated, the mulch should be pulled back slightly to allow them to emerge freely.

Under tropical conditions where cutworms, mole crickets, damping-off, or poor seed germination tend to interfere with the early stages of growth, it is wise to plant about twice the quantity of seed specified in table 6. This is particularly true for small-seeded crops. Planting too many seeds is poor practice, however, as it will entail hand thinning later in the season and closely spaced seedlings are more susceptible to damping-off. If the germination percentage is high for large-seeded vegetables, only slightly more seed than recommended should be planted.

Beet and chard seeds tend to produce two or more plants from a single seed, so the planting rate should be the same as that recommended in table 6. Chard plants require wide spacing in the row for best development and so should not be planted too closely together.

Thinning Seedlings

Most seedlings should be thinned at the 3- to 4-leaf stage. Thinning should not be delayed until the seedlings are badly crowded, spindly, and competing with each other; but thinning beet and carrot where the seedlings are delicate must be delayed. Excessive early removal of these seedlings may result in poor stands. Plants in fertile soil and likely to receive a good water supply can be left closer together than those that may receive limited quantities of water. It is best at first to space the plants approximately as indicated in table 6. By observing and experimenting, the gardener may later decide to space the plants closer or wider, depending upon local growing conditions. Close spacing will delay maturity of root crops, but this may be desirable to spread the harvest over a longer period.

Growing Transplants

Some vegetables can be grown more easily and successfully by planting the seed in flats (fig. 15, *A*) or in special seedbeds, after which they are transplanted to pots or cans or another seedbed before being set out in the field. The main reasons for transplanting some vegetables are to simplify irrigation, weeding, and control of insects and diseases in the seedling stage and to utilize the garden area more efficiently. Where transplants are available from a local professional gardener, it may be better to buy the plants ready for immediate transplanting to the field than to grow them at home.

Vegetables that benefit from transplanting are broccoli, head cabbage, cauliflower, celery, eggplant, kohlrabi, lettuce, onion, pepper, New Zealand spinach, and tomato.

With extreme care almost any vegetable can be transplanted successfully. Vegetables that transplant most easily are broccoli, head cabbage, celery, eggplant, lettuce, onion, parsley, sweetpotato, and tomato. More difficult to transplant are beet, Chinese cabbage, spoon cabbage, chard, chayote, and New Zealand spinach. Most difficult to transplant, unless special care is given, are beans, carrot, corn, cowpea, mustard, okra, peas, potato, radish, soybean, and turnip.

A good loose fertile topsoil free from nematodes is most desirable for growing seedlings in cans, flats, pots, or raised seedbeds. Nematodes, diseases, and insects can be killed by placing the soil in a shallow pan and baking it in an oven for 2 hours at about 180° F., or by pouring boiling

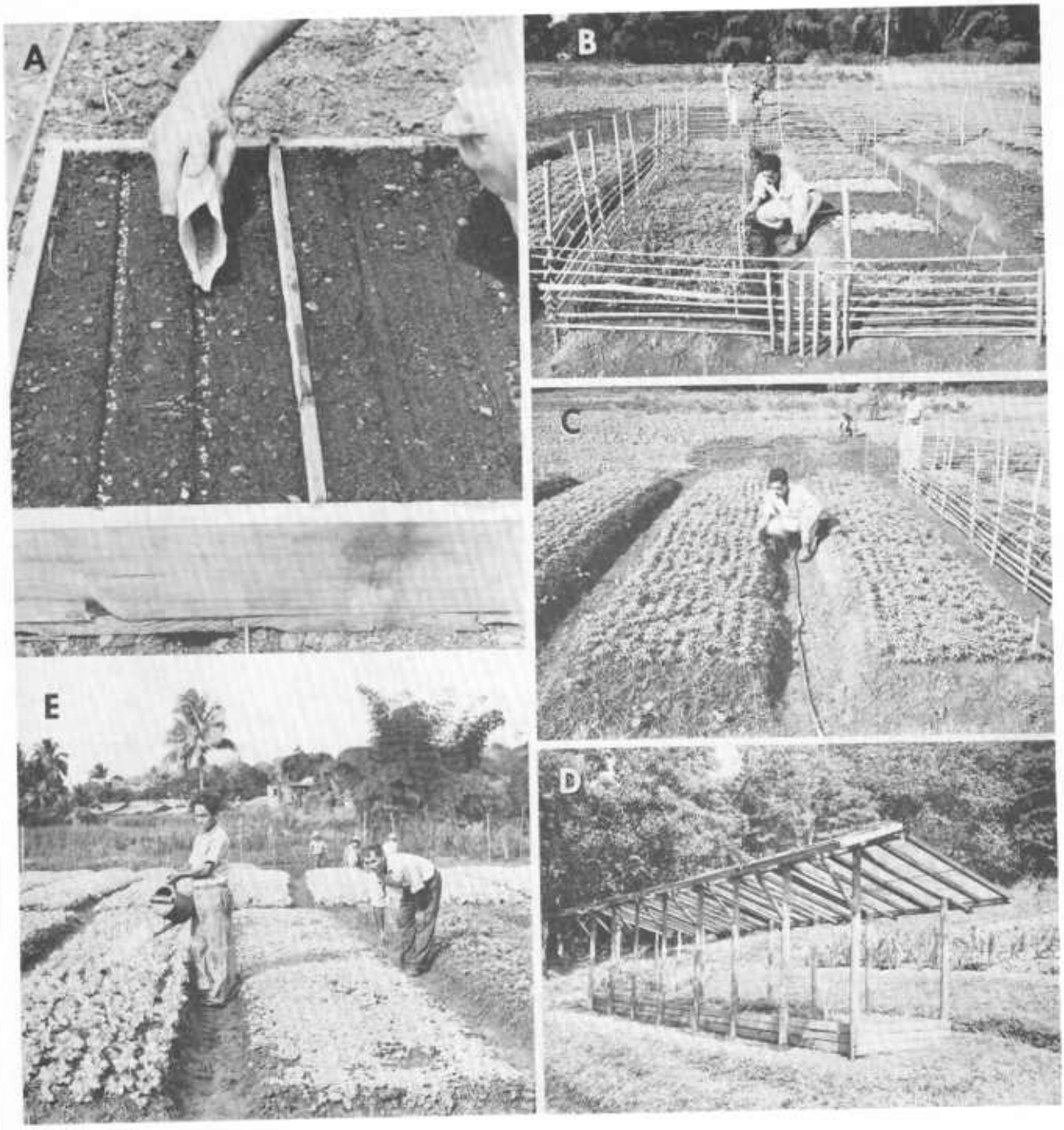


FIGURE 15.—Growing seedlings for transplanting: *A*, Sowing tomato seed in a flat; *B*, outdoor raised seedbeds; *C*, nearby beds for transplanting tomato seedlings; *D*, sheltered seedbed; *E*, growing Black Seeded Simpson leaf lettuce: seedbed at right center; transplants at left center; seedbed on right contains interplanted radishes and coriander.

water over the soil at the rate of 1 gallon of water to 1 gallon of soil. Drenching the soil with formaldehyde at the rate of 1 part 40 percent formaldehyde in 50 parts of water is effective for soil sterilization; chloropicrin (tear gas) and D–D (for nematodes and insects only) also can be used according to the manufacturer's recommendation. Soil treated by these three chemicals, however, cannot be used for 10 days to 2 weeks.

In using these chemicals and other soil fumigants extraordinary caution should be taken. Please read cautions on pages 85 and 103 before attempting to handle, mix, or apply them.

Heavy soil can be improved by mixing it with one-third well-rotted manure and one-third sand. Sandy loam can be improved by mixing one part compost or well-rotted manure to two parts of soil. Immediately after the seed has been planted, the soil should be sprinkled until it is moderately wet. Good drainage in the bottom of cans, flats, and pots is important. Drainage can be improved by placing a layer of stones or broken pieces of pots in the bottom of the container. Seedlings will grow well in cans or pots provided they receive regular and adequate watering.

Figure 15, *A*, *B*, and *C*, illustrates the process of growing tomato seedlings for transplanting. Tomato seed is sown in a flat of rich fertilized soil (fig. 15, *A*); the piece of wood shown is used to make furrows. An outdoor raised seedbed (fig. 15, *B*) can be used also for growing seedlings for transplanting. A bamboo fence protects this seedbed against dogs and other animals. Seedlings grown in flats or outdoor seedbeds should be transplanted at the 3- to 4-leaf stage to other flats or to another seedbed in the field (fig. 15, *C*), spacing the seedlings about 6 inches apart. A sheltered seedbed (fig. 15, *D*) protects seedlings from beating, washing rains in the summer. When the tomato seedlings are 6 to 8 inches tall, they can be transplanted to the field.

Figure 15, *E* shows the common method used by vegetable gardeners for growing Black Seeded Simpson leaf lettuce in the Caribbean area. The bed at the right is used for germinating seed; seedlings are transplanted to other beds as shown at left. The bed at the extreme right contains radishes and coriander seeded and growing together.

The soil about the roots of seedlings in flats or seedbeds should first be cut into squares with a knife when transplanting. Handle these squares carefully to avoid loss of roots and to retain as much soil around the roots as possible. Wetting the soil before transplanting helps hold it together. Seedlings of head cabbage, cauliflower, eggplant, kohlrabi, onion, pepper, and tomato are set slightly deeper in the field than their depth in the pots or seedbeds. Soil is placed about the roots until the hole is half full and then the soil is firmed; 1 or 2 cups of water are then poured into the hole and allowed to settle. Finally the hole is filled with loose pulverized topsoil. If no rains fall immediately after transplanting, the plants should be irrigated daily, or when necessary, until they are established.

Transplanting is best done in late afternoon or on a cloudy day. Wilting during the next day can be reduced by shading with leafy branches of hibiscus or other vegetation stuck in the ground, or by placing paper caps, north side open, over each plant in the form of a wigwam held up by a small stick. Also, a long cloth strip held up V-shaped by stakes and a wire or string immediately above the plants may be used. Daily care is necessary for satisfactory seedling progress.

Homemade paper cups or pots for growing transplants can be constructed as follows:

> Cut entire newspaper sheets into strips 6 inches wide, place a pint milk can or bottle near one edge of the paper strip, and roll the paper up with the container. Leave about 2½ inches of the paper strip below the bottom of the container, fold this paper tightly against the bottom, and remove the container, thus making a cup. Fill the cups with prepared soil and set them close together in a wooden flat or other container.

A good practice for keeping seedlings growing rapidly in the seedbed is to sprinkle them with a fertilizer solution once a week (fig. 12, *B*). A solution of 3 to 4 level tablespoonfuls of a complete fertilizer, such as 10-10-5, in a 3-gallon sprinkler can of water serves this purpose and also can be used in place of tapwater when seedlings are transplanted to the field; 1 pint of solution in each hole is sufficient.

Damping-off Disease

Damping-off is a common disease of young plants in seedbeds. It is identified principally by a water-soaked constriction of the stem just above the soil surface, which causes the seedling to fall over. Pretreatment of the soil with chemicals, boiling water, or baking in an oven is recommended to prevent this disease. (See p. 104.) If damping-off starts in the seedbed, the control measures recommended on page 104 should be started immediately.

Companion Cropping

Companion cropping, or intercropping, is growing two or more vegetables at the same time in alternating hills, rows, or other arrangement on the same area of ground (fig. 16). As land around houses is frequently limited, it is wise to make the most of available area by intensive use. Better use of land often is made by interplanting comparatively short- and long-season crops. For

FIGURE 16.—Companion cropping: *A*, Rosita eggplant and Mary Washington asparagus growing together; *B*, Don Juan sweetpotatoes growing between guava trees (*Psidium* sp.).

example, radishes or leaf lettuce can be planted in or between rows of sweet corn, eggplant, okra, pepper, and tomato. Radishes and coriander can be seeded and grown together (fig. 15, *E*, extreme right); the radishes are pulled within 20 to 30 days, after which the coriander occupies the full space and is harvested later. Radish seeds can be planted with parsnip seeds to mark the rows until the parsnips germinate, as well as to supply radishes. Rosita eggplant will mature before being crowded by Mary Washington asparagus (fig. 16, *A*); and Don Juan sweetpotatoes have been grown between guava trees (*Psidium* sp.) at the Puerto Rico Agricultural Experiment Substation, Isabela (fig. 16, *B*).

When planted at the same time as the more slowly maturing crop, the short-season crop can be harvested before competition and shading from the companion crop becomes a limiting factor.

Succession Planting

In the Tropics several vegetable crops can be grown on the same ground during a 12-month period by planting another vegetable as soon as the first has been harvested. This is known as succession planting. Enough time should be allowed between each crop to plow, pulverize, and properly prepare the soil for the next crop.

Crop Rotation

If plenty of land is available, better results can be obtained by rotating a given crop between two or three areas. The same crop, or a closely related one, should not be planted on the same ground time after time during the same year. Besides depleting the soil of nutrients, this favors buildup of diseases and insects on that particular crop. Vegetables such as beans, potato, and tomato, which are susceptible to a large number of diseases, should be rotated from one garden site to another. In small gardens it is difficult to avoid some succession plantings of one crop on the same soil, but it is particularly important to avoid succession plantings of the cole crops, which include brussels sprouts, Chinese cabbage, head cabbage, cauliflower, kohlrabi, mustard, radish, rutabaga, and turnip. Eggplant after tomato or tomato after eggplant is not advisable, nor is root crop after root crop or bean after bean. Examples of good sequences as given by Frazier (*11, p. 15*) are as follows:

After—	*Plant one of the following—*
Beet or chard	Bean, tomato, eggplant, okra, cabbage, lettuce, or onion.
Cabbage or broccoli	Chard, lettuce, onion, beet, carrot, bean, tomato, or eggplant.
Lettuce	Bean, carrot, cabbage, beet, onion, radish, turnip, or tomato.
Onion	Bean, radish, beet, cabbage, lettuce, carrot, or turnip.
Carrot	Lettuce, broccoli, cabbage, bean, New Zealand spinach, or onion.
Daikon or radish	Bean, chard, eggplant, tomato, okra, lettuce, or onion.
Turnip	Chard, onion, New Zealand spinach, bean, eggplant, or tomato.
Cowpea or bean	Beet, chard, broccoli, cabbage, lettuce, onion, tomato, eggplant, or carrot.
Eggplant	Beet, chard, broccoli, cabbage, lettuce, onion, carrot, or daikon.
Tomato	Broccoli, cabbage, chard, lettuce, onion, carrot, beet, radish, turnip, bean.

Cultivation

A day or two after a good rain or irrigation, the ground should be cultivated unless it is mulched. Cultivate with a hand hoe, a hand wheel cultivator, or motor-driven equipment. The object is to loosen the soil and discourage weeds. Working in the garden too soon after a rain or irrigation, when the soil is muddy, results in puddling, hardening, and cracking of the soil. Weeds are easiest to eliminate when they are

small, most difficult when large, deeply rooted, and heavily competitive with the vegetables. Care should be taken not to cultivate deeper than 1 to 2 inches and to keep the cultivator blades away from the vegetable roots to avoid injuring them. Cultivating will proceed rapidly and easily if the tools are kept sharp.

Mulching

Mulching with plant debris conserves soil moisture, reduces weed growth, keeps the soil cool, reduces soil erosion, and adds nutrients. The mulch must be at least 2 inches thick, preferably 3 to 4 inches, to be most beneficial. A moderately heavy mulch aids greatly in tiding the plants over short dry periods; it also reduces the amount of water and the number of irrigations needed. Mulch material can be leaves, lawn and tender hedge clippings, cane trash, straw, or similar substances. Plants or vegetable debris that have been diseased or insect ridden should not be used because of danger of distributing pests and weed seeds over the garden. If certain grasses that form roots readily from the stems are to be used, they should be dried in the sun for a few days before they are applied.

A thin mulch of well-rotted manure (fig. 14, *H*), cachaza, lawn clippings, a burlap bag, or banana leaves can be used to cover newly planted seed to maintain an even soil moisture and insure good germination, particularly in low-rainfall or windy areas, where the evaporation rate is rapid. When the plants begin to appear, the mulch should be pulled aside a little to permit the plants to grow freely. Subsequently, the mulch can be spaded into the soil. Manure or commercial fertilizer, particularly nitrogen, should be applied with a heavy mulch to prevent the crop from developing nitrogen deficiency.

Irrigation

In the Caribbean area gardens frequently are planted during October, when the rainy season is tapering off, to benefit from the light rains before the dry season sets in. If, however, a garden is to be maintained throughout the year and good production of high-quality vegetables is desired, some provision for irrigation with unpolluted water is essential. Dry periods of 2 to 3 weeks or more are not uncommon during the rainy season, and rainfall in the dry season is not sufficient to support good plant growth.

Plants judiciously irrigated grow more evenly and faster, are of better quality, and yield two or three times more than those that do not get enough water. Radishes grown slowly under drought conditions are bound to be pithy and "hot." Crops such as cabbage, endive, lettuce, and the root crops probably will be bitter and tough in texture. In most areas a good irrigation once a week to a depth of 4 to 6 inches is sufficient. In sandy soil two or three irrigations usually are necessary. One heavy irrigation is much better than several light superficial waterings applied once or twice a day, except possibly for leaf lettuce, where daily sprinkling seems to help increase the size of the leaves. Sweetpotatoes also respond well to frequent light waterings. Late afternoon is the best time for irrigating the garden. Watering during the morning is recommended for seedbeds where damping-off may be a problem.

Where land is almost level, furrow irrigation is generally more satisfactory than other irrigation methods for established vegetable crops, particularly bean, lettuce, and tomato, which are susceptible to leaf diseases. In order to receive full benefit from the irrigation water, vegetables transplanted to the field during the dry season should be set in the bottom of the irrigation furrow if the soil is sandy, or at the side of the furrow if the soil is heavy. When the plants become large, the furrow is shifted to between the rows. If the beds are level, the surface of the soil can be flooded by building a small dike around the outside.

Figure 17 illustrates some irrigation systems used in commercial vegetable growing in the Caribbean area. A gasoline motor-driven pump (fig. 17, *A*) fills a nearby concrete reservoir (fig. 17, *C*), from which water is supplied by gravity to the furrow irrigation system shown (fig. 17, *D*). This same pump can also deliver water from a nearby stream with sufficient pressure to operate rotating sprinklers (fig. 17, *B*), such as those shown here irrigating broccoli and celery fields. Figure 17, *E* shows a field being irrigated by a portable oscillating pipe system. Pond water is delivered by concrete-lined ditch to a sump; the water is then pumped to the oscillating pipe system by equipment and power similar to that in figure 17, *A*.

Sprinkler or overhead irrigation (fig. 17, *B*) requires expensive equipment, the water may wash sprays and dust materials from the leaves, and the extra wetting of the leaves may encourage fungus diseases. However, if the land is rolling, the soil light in texture, and the water supply limited, the sprinkler system is best (*59, p. 132*). The water can be applied by rotary sprinkler heads (fig. 17, *B*) or by oscillating pipes (fig. 17, *E*). The rotary head system with portable pipe is popular in the United States. The supply lines for the sprinkler system can be portable or permanently installed above or below ground. Additional information on the installation and operation of small and large irrigation systems can be obtained from Rohwer (*50*) and Staebner (*55*).

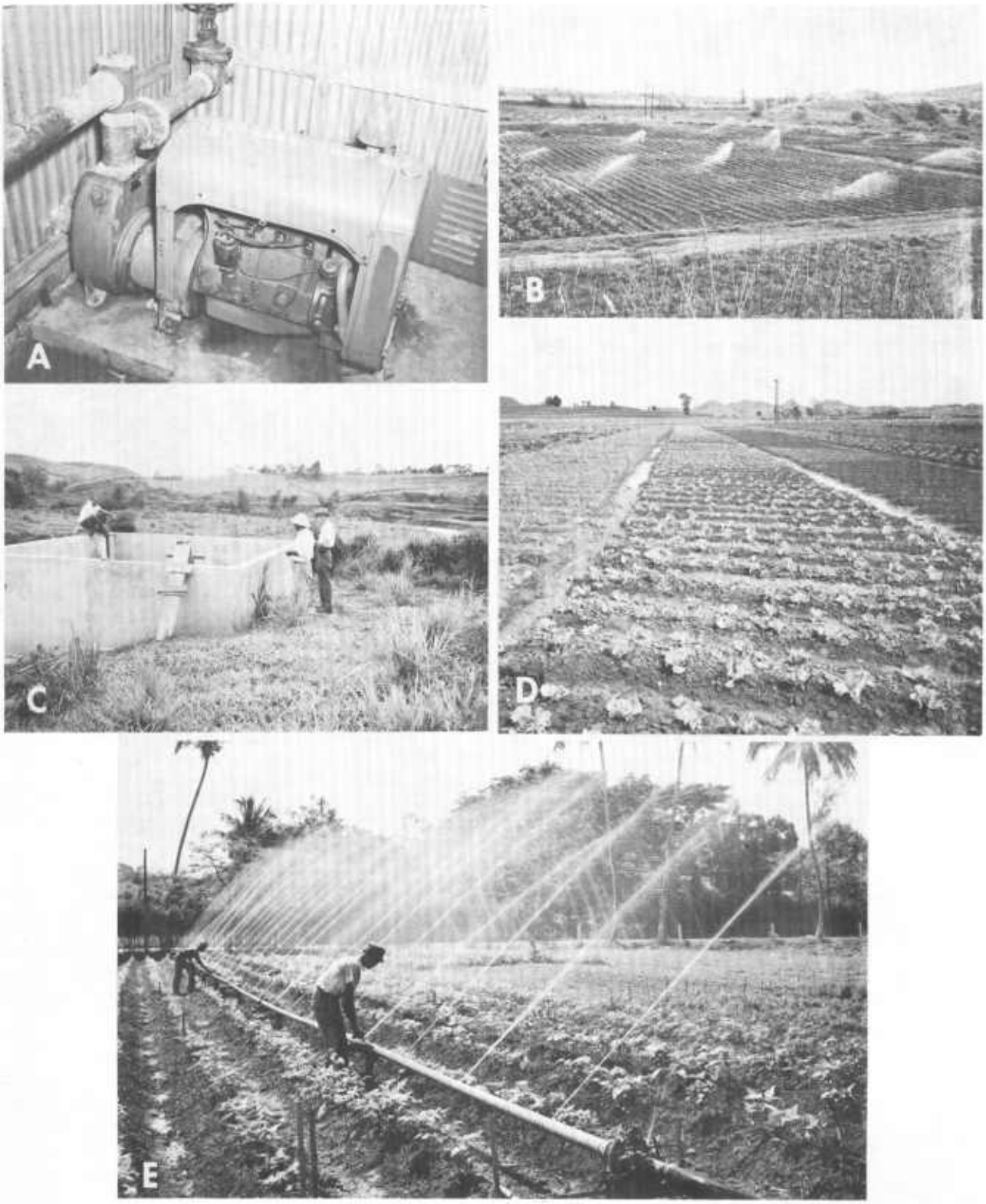


FIGURE 17.—Irrigation systems for growing vegetables in the Caribbean area: *A*, Gasoline motor-driven pump; *B*, irrigating with rotary sprinklers; *C*, concrete reservoir; *D*, furrow irrigating; *E*, irrigating with portable oscillating pipe system.

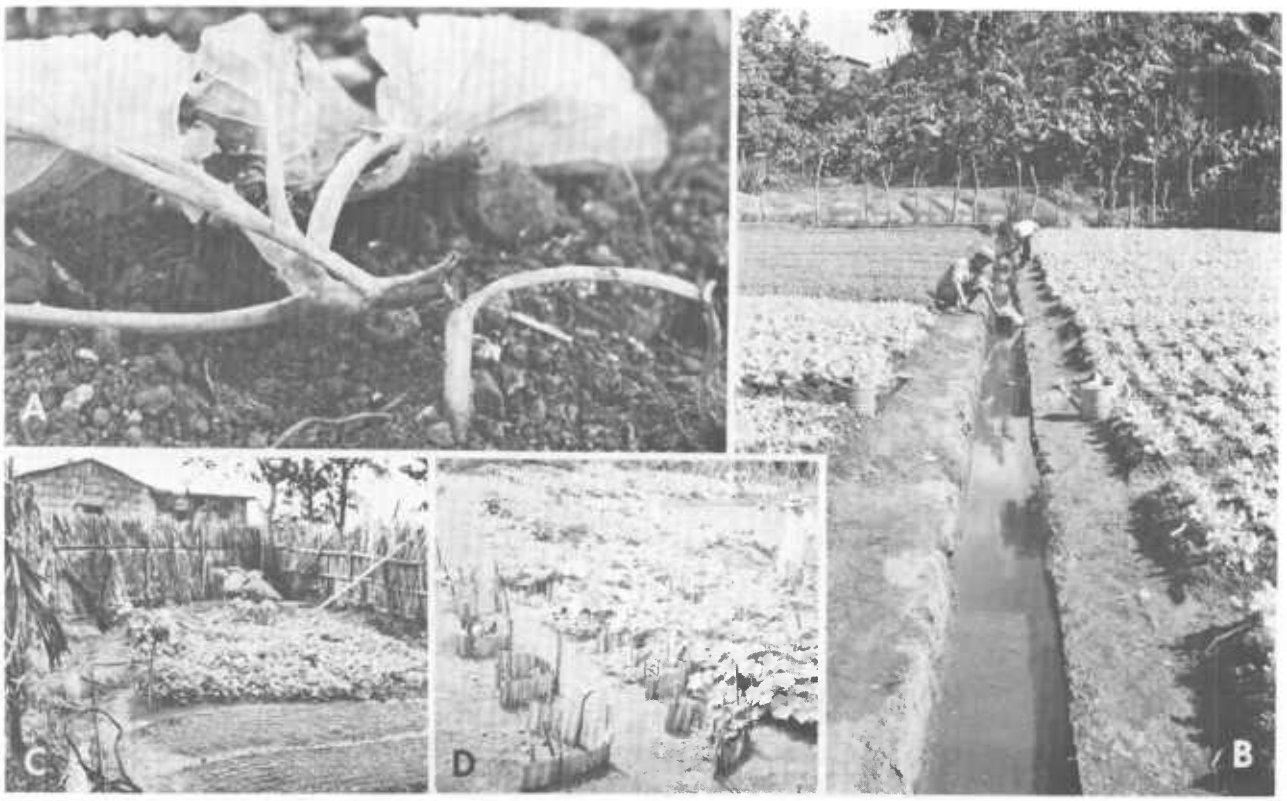


FIGURE 18.—Windbreaks: *A*, Young vegetable plant twisted and broken by wind; *B*, commercial garden protected by a hill; *C*, coconut palm-leaf fence; *D*, use of galvanized iron strips and boards to protect cucurbit seedlings.

Hydraulic rams are sometimes used in hilly sections to force water economically from low streams to high ground. The garden is then irrigated by gravity flow from storage tanks or reservoirs. In some locations it is possible to water gardens by gravity flow from a mountain spring (fig. 10).

Windbreaks

Windbreaks (fig. 18) are almost a necessity for most planting sites under tropical conditions, particularly in exposed coastal areas of the Caribbean area where a continuous strong breeze blows most of the time. Partial protection by trees, buildings, and hills is particularly valuable. If not protected in some way, tender young seedlings may be twisted and broken by the wind (fig. 18, *A*). The commercial garden shown in figure 18, *B* is protected from prevailing winds by a hill in the background. In one area, coconut palm-leaf fences (fig. 18, *C*) proved effective for a distance of 30 to 40 yards on the leeward side. Wild cane or cut bamboo culms would be as effective in fences as palm leaves. Pieces of galvanized iron or board (fig. 18, *D*) can be used as temporary windbreaks to protect individual hills of cucurbit seedlings, which are very susceptible to wind damage.

Temporary protection from the wind can be provided by planting rows of taller crops—banana, corn, elephant grass, papaya, pigeonpea, or sorghum. Sugarcane fields also provide excellent protection. A fence covered with vines of pole bean, chayote, cucumber, passionfruit, sweetpotato, or yam not only provides food for the family but also serves as a windbreak for the garden. Where the garden plot is permanently located, it can be surrounded by fruiting bushes and trees that will supply the family with fruit and also serve as a windbreak. Avocado, citrus, guava, mango, and the West Indian cherry can be grown throughout the Caribbean area.

CULTURE OF INDIVIDUAL CROPS

Cucurbits

Cucurbitaceae

The chayote, cucumber, gourd, melon, pumpkin, squash, and a few other related plants all belong to this large plant family. The members are widely distributed throughout the world. Most of the cucurbits are herbaceous annual vines, which climb by means of tendrils. Some, such as the chayote, will climb into the tops of tall trees if not limited to shorter supports. The cucurbits take up more room than most other vegetable crops. To save space in the small home garden, the vines can be trained over a fence or trellis. Bush types, where available, are much more economical of space in the garden than standard types. Usually only a few plants of each kind are needed for one family.

The young shoots of cucumber and of pumpkin are sometimes cooked and eaten like spinach, and the flowers of pumpkin are eaten in some countries. The fruits of the different cucurbits are prepared for eating in a variety of ways. The melons are eaten as fresh fruits; cucumbers are eaten raw in salads or are made into pickles; the various squashes and pumpkins are baked, boiled, or fried as vegetables and some are made into pies.

Chayote

"Apupu," "Güisquil," "Tayote," "Mirliton"
***Sechium edule* (Jacq.) Sw.**

The chayote (fig. 19, *A*) is a perennial high-climbing vine. It requires trellising and can be planted along the garden fence as a windbreak. It resembles the cucumber in growth and the squash in use of the fruits. The fruits of different varieties vary in color from ivory white to dark green; in size, from those weighing a few ounces to those weighing over 2 pounds; in surface, from quite regular to deeply wrinkled or corrugated and from smooth to very prickly; and in form, from almost spherical to a long, flattened pear shape. Each fruit contains one large flat seed, which may or may not be surrounded by fibers. The seed is edible.

The chayote grows satisfactorily at all elevations in the Caribbean area, but best above 1,000 feet. The chayote prefers a moderately rainy climate; it grows poorly in dry regions. Two or three plants trained on the fence should be adequate for an average family.

The chayote is propagated by planting the matured fruits horizontally, with the large end slightly downward and thinly covered with soil. Shoot cuttings taken from the base of the plant can be rooted in shaded nursery beds and transplanted as soon as a number of roots have formed. The seedbed should contain a mixture of manure and commercial fertilizer. Plants are spaced 4 to 6 feet apart along the fence or trellis. Side dressings of a complete fertilizer at monthly intervals keep the vines vigorous and bearing. Harvest begins 3 to 5 months after planting and extends over several months. The fruits can be harvested 25 to 30 days after they are set.

Chayotes are boiled like squash, then buttered or creamed; fried alone or as fritters; stuffed

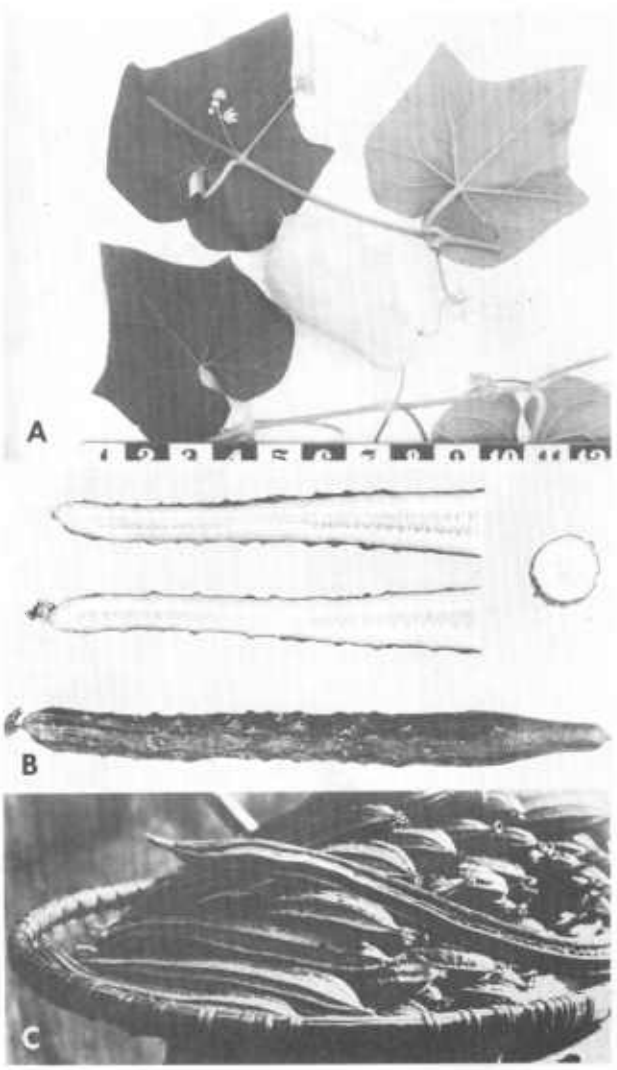


FIGURE 19.—*A*, Chayote flowers, fruit, and vine; *B*, cucumber variety Chinese Long; *C*, angled loofah.

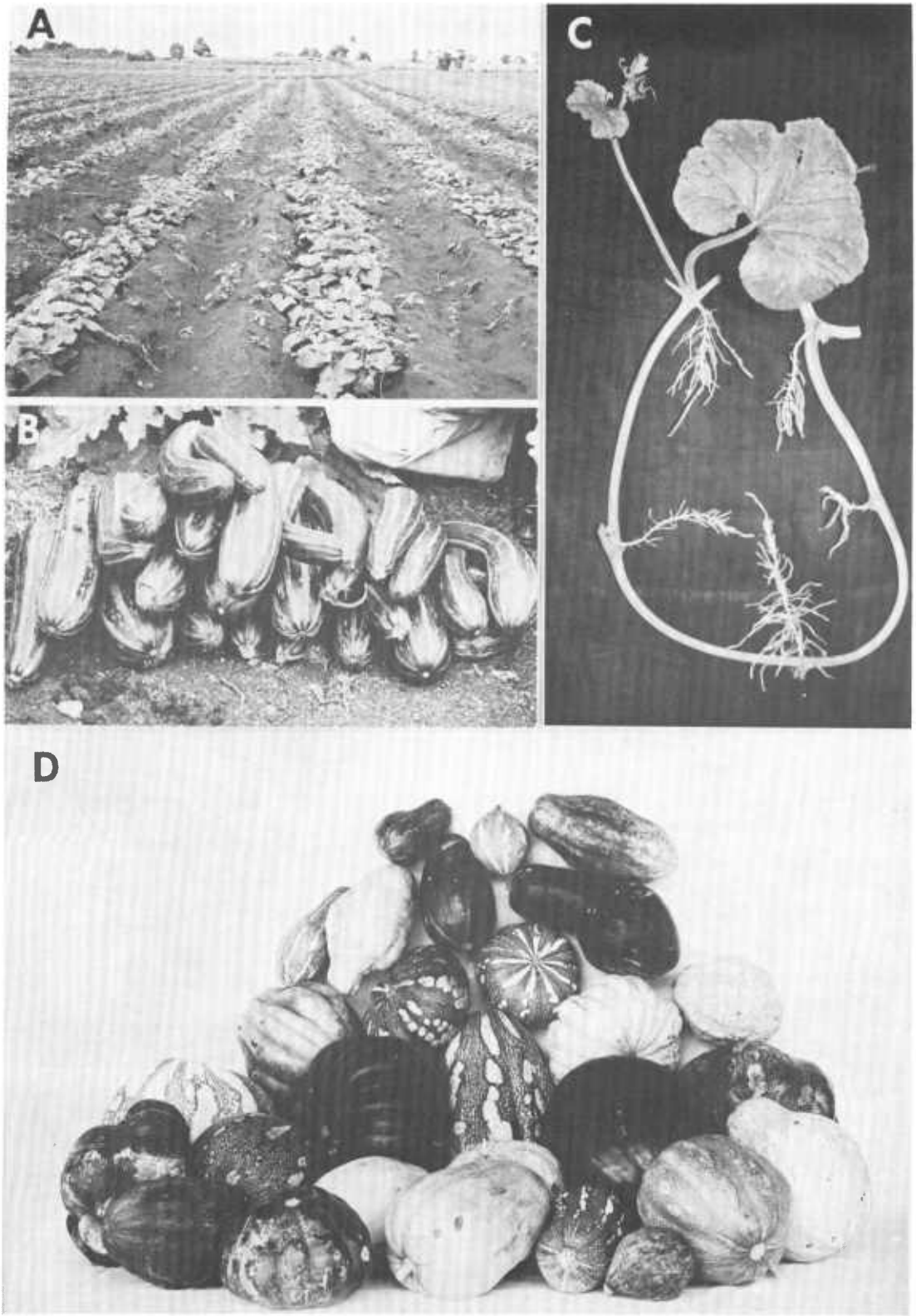


FIGURE 20.—*A*, Cucumber variety Puerto Rico 39; *B*, summer squash variety Cocozelle; *C*, vine cuttings for propagating squash plants; *D*, West Indian squash ("calabaza") strains.

with cheese or ground meat and baked; or made into pickles. The stem tips and young leaves may be boiled and eaten like greens.

PESTS AND DISEASES.—Chayote is remarkably free from pests and diseases but those that are found are in common with the cucumber, page 37.

Cucumber

"Pepinillo"

***Cucumis sativus* L.**

The cucumber is widely grown in the Caribbean area, both for export (*51*) and local market. It is a favorite salad vegetable and is used to some extent for making pickles.

Cucumber varieties are divided into two types, white spined and black spined. The spines are the slender stickers that protrude from the warts when the fruits are young. They are easily rubbed off as the fruits are harvested. White-spined cucumbers turn creamy when mature; black-spined cucumbers turn yellowish orange. Pickling cucumbers are black spined; most of the others are white spined.

The variety Puerto Rico 39 (fig. 20, *A*), developed by the Puerto Rico Agricultural Experiment Station, is widely grown because of its resistance to downy mildew (*Pseudoperonospora cubensis* (Berk. & Curt.) Rostow.). It can be used as a salad vegetable and for making pickles, but its quality is not so good as that of most continental slicing varieties because of early development of the seed. In a test of pickling varieties conducted in 1960, Rico Ballester, Ramos Caro, and Vélez Fortuño (*45*) obtained 11,600 pounds per acre of 3-, 4-, and 5-inch fruits from Puerto Rico 39, but only 5,000 pounds per acre each from Wisconsin SMR 15 and Model.

Several species of parasitic nematodes attack the roots of cucumbers, resulting in weakened plants and reduced yields. Pérez Lopez and Mendoza Barbosa (*38*) grew the variety Puerto Rico 39 experimentally on soil treated with the nematocide DD (1,3-dichloropropene and 1,2-dichloropropane). Yields from the treated plots averaged 5,800 pounds per acre as opposed to 5,200 pounds from untreated plots. The Puerto Rico 39 outyielded other varieties in this test also.

In a cucumber variety test, with insects and diseases controlled, Murillo Argüello, Gurdián Gólcher, and Wiltbank (*36*) reported excellent yields of Ashley, Palomar, and Stono in Costa Rica.

Varieties Ashley, Palmetto, Palomar, and Santee can be grown successfully in coastal regions during the dry season provided an insect control program is followed and irrigation is given when needed. Yields of 7,000 pounds per acre were obtained for the variety Henderson at the U.S. Army Air Base near Isabela, P.R. The variety China or Chinese Long (fig. 19, *B*) is extremely vigorous and productive under climatic conditions of the Caribbean area, but the vines require trellising.

FIGURE 21.—Squash leaf damaged by melonworm (*Diaphania hyalinata* (L.)).

The cucumber requires a loose fertile soil with good drainage. The hill system is recommended for the home garden with one or two shovelfuls of manure or well-rotted cachaza mixed in each hill. If organic manures are not available, a mixed chemical fertilizer high in potash is recommended. The harvest will begin 50 days after planting the seed. Cucumbers can be harvested at any size and at any stage of maturity, but they should be gathered at 2- to 3-day intervals. Production will be reduced if the fruits are allowed to attain the full yellow-ripe stage.

The West Indian gherkin (*Cucumis anguria* L.) is sometimes cultivated for the small burlike fruits which are used for pickling. Although the West Indian gherkin is closely related to the cucumber, the vine resembles that of the watermelon.

PESTS AND DISEASES.—Unless proper control measures are taken, the cucumber and its allies, such as melon, pumpkin and squash, are frequently heavily attacked by melonworms (fig. 21), pickleworms, plant bugs, squash bugs, and cucumber leaf beetles of several species. The melonworm (*Diaphania hyalinata* (L.)) attacks both the foliage and fruits of these vegetables. A number of general plant pests also attack cucurbits. Nematodes may at times become a factor to reckon with. Some diseases, including damping-off, downy mildew, powdery mildew, anthracnose, scab or leak fungus, and cucumber mosaic virus, also attack cucurbits.

Muskmelon (Cantaloup)

"Melón"
***Cucumis melo* L.**

Best yields of muskmelon have been obtained during the winter and spring in sandy loam soils in the relatively warm dry coastal areas of the West Indies. Fair to good crops also have been obtained in summer, but diseases were sometimes troublesome because of the high rainfall. The variety Smith's Perfect performed satisfactorily in the Isabela region of Puerto Rico (*46*). A native mildew-resistant muskmelon is grown in winter, principally near Ponce; its quality is fair to good, but yield is low. Yields of this and several other varieties on heavy soil in winter at Mayaguez, P.R., were poor despite fair to good vine growth. Texas Resistant No. 1 should be tested in the Caribbean area. Muskmelons are widely grown in India (*68, p. 322*).

This dessert vegetable, like the watermelon, requires extra space in the garden, is not easily grown, and is low in food value. Culture and management are much the same as for the watermelon. (See p. 39.) Weekly to 10-day sprays for mildew control are usually necessary, particularly during rainy periods. A well-drained irrigated sandy loam soil with a pH of 6.0 to 6.7 is desirable. When the melon nears maturity, the color changes from dark green or grayish green to yellowish green. For home use the melons of most varieties can be left until the fruit slips from the stem.

PESTS AND DISEASES.—See pests and diseases of cucumber, page 37.

Pumpkin and Squash

"Calabaza," "Calabacín"
***Cucurbita* spp.**

Many native strains of pumpkin and squash are grown in the Tropics. These strains usually possess some resistance to the prevailing insects and diseases and should be retained unless others are found to be more satisfactory. Quality of the fruit is fair to good if they are allowed to mature properly, but the yield may be low. The many varieties differ in fruit size, shape, color, and quality. The West Indian squashes ("calabazas") (fig. 20, *D*) seem mostly to be *Cucurbita pepo* L. The fruits average 5 to 6 pounds, with some weighing as much as 10 pounds.

Several superior varieties of squash have been selected in Puerto Rico. Camaguey is relatively resistant to mosaic and the leaf diseases. Fortuna and Borinquen are recommended as being more productive and of better quality than unselected kinds. In favorable locations the "calabaza" will trail over the ground for a year or longer, blooming heavily but setting good crops only at the beginning and end of the rainy season. Particularly desirable types can be propagated by vine cuttings (fig. 20, *C*).

Variety Butternut does well in Central America and should be tested more extensively throughout the Caribbean area.

Alagold, Large Cheese, and Small Sugar pumpkin varieties should be tested more extensively.

The fruit of any pumpkin or squash can be eaten at the young tender stage but it is wasteful to use the large-fruited types at this stage. The summer squashes ("calabacín") are bred especially to be eaten at this young tender stage. The plants are more prolific and will continue to produce over long periods if the fruits are removed regularly as they attain usable size. Bush types of the different varieties are now offered by northern seed dealers. Variety Yellow Summer Crookneck produced satisfactorily under irrigation in the sandy loam soil near Isabela, P.R. Good firm fruits were produced in profusion; it is one of the showiest crops in the garden. Summer squash variety Cocozelle grew and produced well at sea level and at 2,600 feet (fig. 20, *B*) during winter and early spring. It appeared to be resistant to insects and diseases; but when this variety was grown successively on the same ground, its resistance decreased. Black Zucchini and Golden Straightneck also produced well.

Since pumpkin and squash vines take up a good deal of space, they should be planted only in large gardens. Pumpkin and squash are grown in hills spaced 6 to 8 feet apart for vine types and 4 feet apart for bush types. To conserve space, they can be planted in corn, near a fence, or at the edge of the garden, with the vines allowed to grow out over the adjacent areas. Best results can be obtained by digging a hole 2 feet wide and 1 foot deep for each hill, into which two or three shovelfuls of manure are placed with topsoil covering the manure. Four to six seeds of pumpkin and six to eight seeds of squash are planted 1 to 1½ inches deep in each hill. The seedlings are thinned to three per hill. In commercial gardens vine-type pumpkins and squash are planted 3 to 4 feet apart in rows spaced 8 feet apart; bush types are planted 3 feet apart in rows spaced 6 feet apart.

A sandy loam soil rich in humus is best suited to pumpkin and squash, but they will tolerate heavier soils than the melons. Where vine borers are prevalent, some of the nodes should be covered with soil to encourage stem rooting.

PESTS AND DISEASES.—See pests and diseases of cucumber, page 37.

Watermelon

"Sandía," "Patilla"
***Citrullus vulgaris* Schrad.**

The watermelon resembles the cucumber and muskmelon to some extent, but the leaves are more deeply lobed and the vines more freely branching. The numerous varieties exhibit various colors and mottlings of the rind; white, yellow, or bright-red pulp; and white, red, brown, or black seeds. The varieties grown in the Caribbean area are red fleshed with black seeds.

Although the native home of the watermelon is thought to be tropical Africa, varieties bred for temperate adaptability are frequently unsatisfactory in the Tropics. Vine growth may be excellent, but fruit set is often light and the fruits are small and low in sugar. Fair to good crops have been reported on sandy loam soil under irrigation near Isabela, P.R., and on St. Thomas, U.S. Virgin Islands (*62, 1932, p. 12*). Some melons of the variety Tom Watson weighed 35 pounds; this variety outyielded Blacklee by one-third. Blacklee, however, was sweeter and had darker pulp than Tom Watson. Charleston Gray (fig. 22, *A*), Sugar Baby (fig. 22, *B*) and Congo (fig. 22, *C*), have yielded well in more recent trials. Charleston Gray is resistant to anthracnose and fusarium diseases, Congo to anthracnose, and Blacklee to fusarium. The seedless variety Graybelle (fig. 22, *D*) is recommended for trial.

The Philippines have a sizeable watermelon industry (*58*). Local varieties include De Jaspe, Meck, and Valencia. Planting season is from October to February, depending on locality. In India (*68, p. 321*) best crops are grown when planted in January and February on gravelly riverbanks where the roots can reach water. A

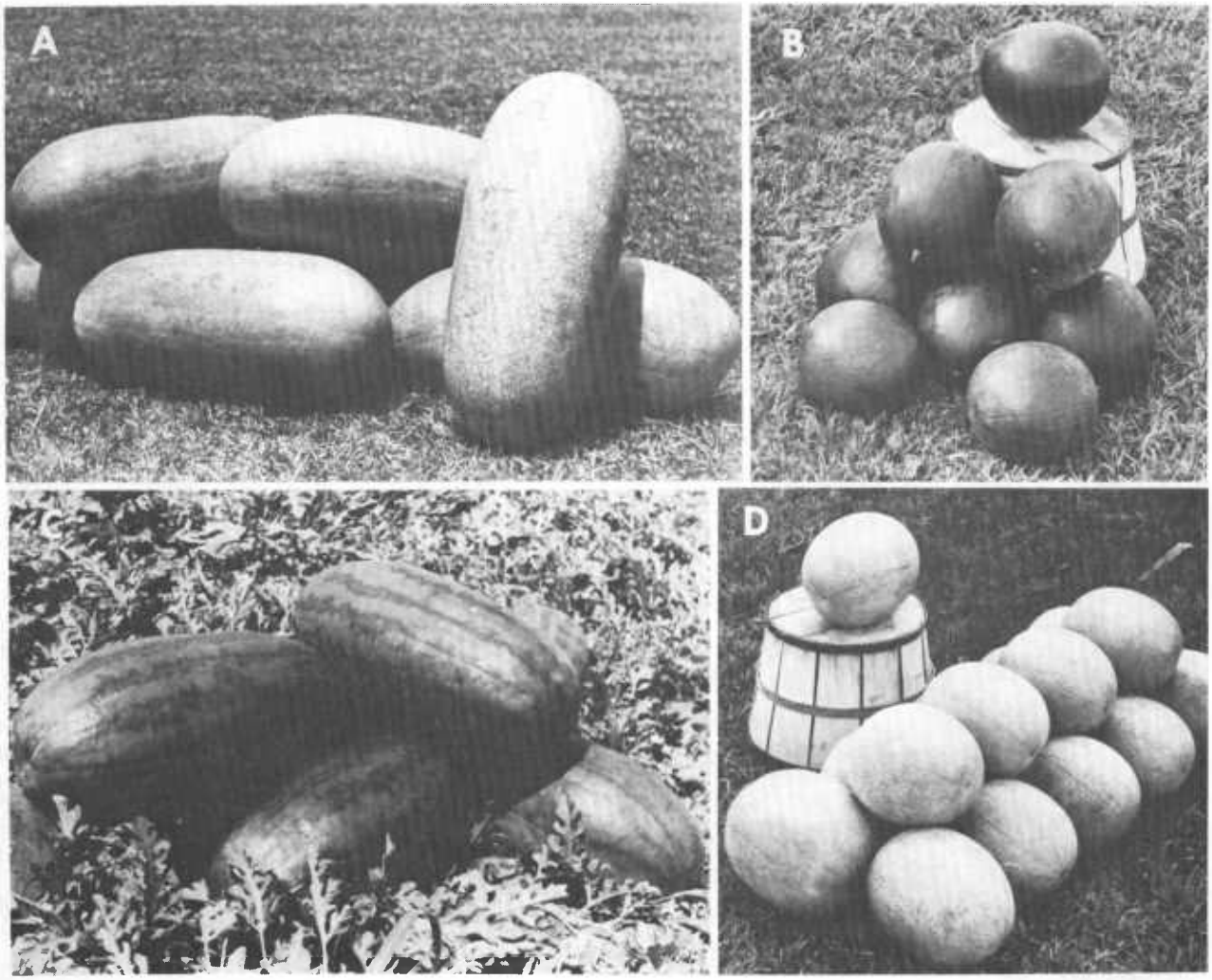


FIGURE 22.—Watermelon varieties: *A*, Charleston Gray; *B*, Sugar Baby; *C*, Congo; *D*, Graybelle (seedless).

heavy application of manure in the hills is recommended.

Watermelons are not a particularly good crop for the home garden, since they take up a good deal of space for several months and are relatively low in food value. Where plenty of garden space is available, however, the watermelon adds variety and is a good dessert vegetable. Watermelons grow best on well-drained sandy loam soil. They will not tolerate poor drainage and for this reason often fail on heavy soils. They will tolerate a soil acidity of pH 5.0. A commercial fertilizer high in phosphorus, such as 3-12-4, at the rate of 300 to 600 pounds per acre is used, in addition to 2 to 3 shovelfuls of manure in each hill. Watermelons have responded well to applications of well-rotted cachaza, which contains a moderate supply of phosphorus. Seeds are planted 6 per hill with hills spaced 6 to 10 feet apart. In commercial plantings the plants are spaced 3 to 4 feet apart in rows 6 to 10 feet apart. The plants should be thinned to 2 or 3 per hill. Cultivation to control weeds is needed until the vines begin to cover the entire area; then the larger weeds are pulled by hand.

Where only a few plants are grown, the female flowers should be pollinated by hand, preferably during the morning. Then the flowers should be covered with small paper bags to keep the pollen from being washed off by rain. A strong vine can support only 2 fruits of the large-fruited varieties. Straw may be placed beneath the developing fruits to prevent them from touching the wet soil.

Thumping the melon with the finger is a common method of determining maturity. Green melons give a metallic ring; the mature melons a muffled, dead sound. Two inches of stem should be left on the fruit at harvest to prevent the organisms causing fruit rot from entering the fruit.

Pests and Diseases.—Watermelons suffer from the same pests and diseases as cucumbers. In addition, fusarium wilt may kill susceptible varieties when watermelons are planted on infected soil.

Other Cucurbits

The fruits of several other cucurbits are eaten, usually at the immature stage as boiled vegetables, in some countries but are unknown in others. Examples are the wax gourd (*Benincasa hispida* Cogn.); white-flowered or bottle gourd (*Lagenaria siceraria* (Mol.) Standl.); angled loofah (*Luffa acutangula* (L.) Roxb.) (fig. 19, *C*); smooth loofah or dish-rag gourd (*L. cylindrica* (L.) Roem.); bitter cucumber (*Momordica charantia* L.); and snake gourd (*Trichosanthes anguina* L.). Culture of all these is like that of cucumber except that support is needed for the vines. In many areas they perform better than imported vegetable varieties.

The cassabanana ("pepino") (*Sicana odorifera* (Vell.) Naud.) is grown in the West Indies and in Central and South America for the 12- to 24-inch orange-crimson fruits. The ripe fruits are made into preserves or macerated in water to give a pleasing drink. When young and tender, the fruits are boiled and eaten like summer squash.

The oyster nut (*Telfairea pedata* Hook.) is cultivated in Kenya and other African countries for the large seeds, which are roasted for eating or made into confections.

The "caihua" or "caibi" (*Cyclanthera pedata* Schrad.) is grown in tropical America. Usually only the skin and underlying flesh are eaten.

Seeds of these cucurbits usually are not available from seed houses. Sometimes they can be obtained from Chinese market gardeners. If so, this will indicate edible varieties. Directions can be secured, also, as to the proper stage at which the cucurbit is to be eaten and the plant part to be eaten.

Fruit Vegetables

Eggplant

"Berenjena"
***Solanum melongena* L.**
Solanaceae

The eggplant ("brinjal" in areas with an oriental influence) is a perennial shrubby herb usually grown as an annual. The fruits of most cultivated eggplants are smooth, but some will be armed with spines, at least on the fruit stem and calyx lobes. The fruits vary in color from white through rose to dark purple, and in shape from perfectly round to extremely elongated. The smaller varieties bear rounded fruits only about 3 inches in each dimension; long-fruited varieties may attain 1 foot in length with a diameter of 2½ to 5 inches at the widest part. Most varieties are intermediate in size between these extremes.

The eggplant is a popular warm-season crop in the Tropics. It grows well throughout the year at low elevations in the Caribbean area (fig. 23, *A*) and gives fair to good yields at elevations up to about 2,500 feet during the warm season; it has been a complete failure above 3,000 feet in Puerto Rico. Three to six good plants should be adequate for the average-size family. Young plants produce the most and best fruits, but older plants may continue to produce fair to good fruits for a year or more.

Both the pink long-fruited variety Rosita (fig. 23, *B*) and the dark-purple variety Puertorican Beauty developed by the Agricultural Experiment Station of the University of Puerto Rico are resistant to the frequently destructive bacterial

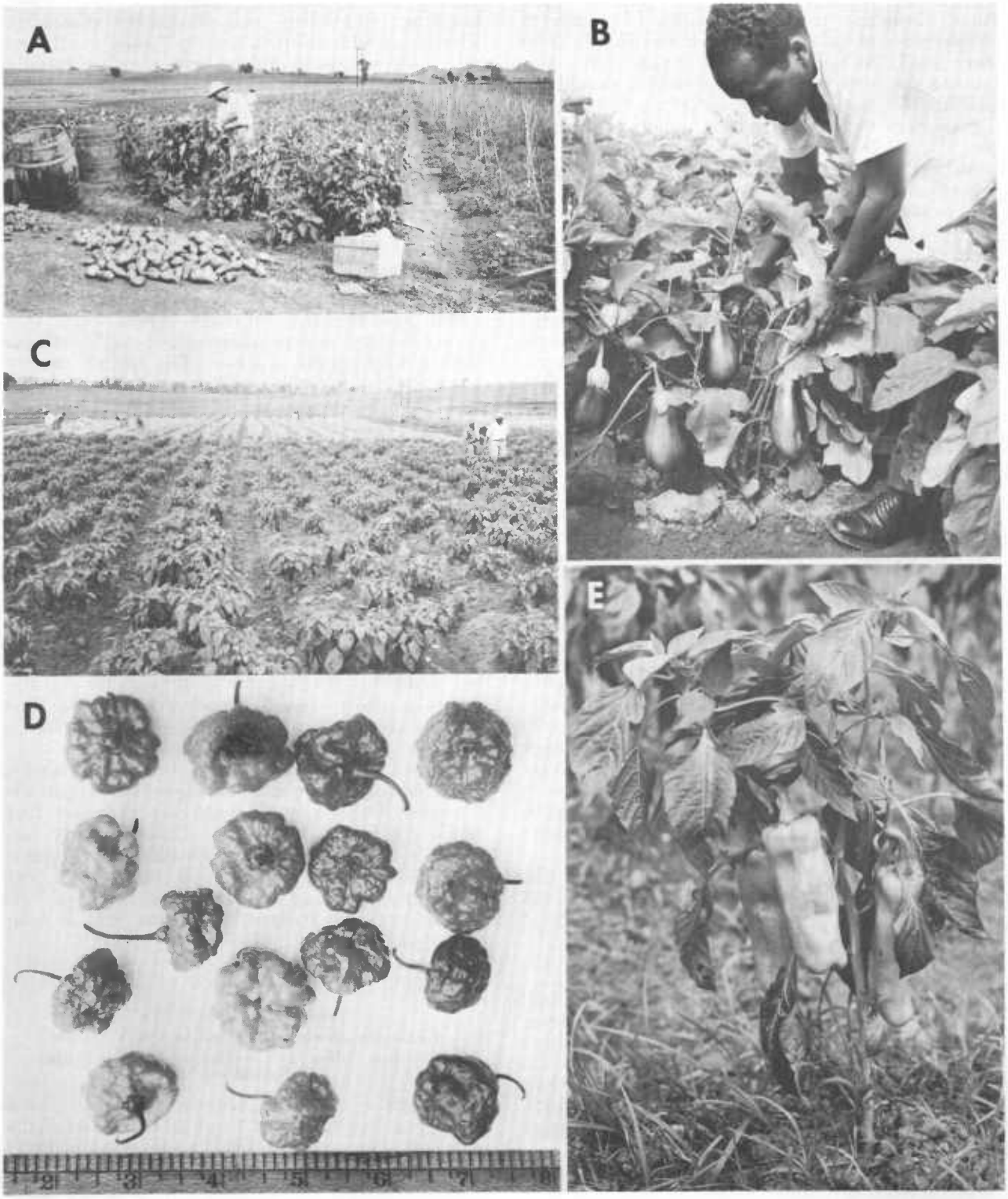


FIGURE 23.—*A*, Field of eggplant; *B*, long-fruited eggplant variety Rosita; *C*, field of pepper variety California Wonder used for export to mainland; *D*, small-fruited peppers for seasoning other foods; *E*, large thin-walled pepper for stuffing.

wilt. Rosita is the most popular variety in Puerto Rico. Resistance to bacterial wilt is found also in the varieties Matale from Ceylon and Kopek from Java (*65*). Black Beauty has given high yields under some conditions, but this variety should not be planted where bacterial wilt is a problem.

Seeds are soaked overnight to improve germination before being planted in a seedbed. The seedlings are grown to the 3- or 4-leaf stage, transplanted to another seedbed, and set in the field when they are 5 to 7 inches tall. The spacing recommended in the field is 2 to 3 feet apart in rows 2½ to 3 feet apart, according to the vigor of the variety. It is important to keep young plants growing vigorously by regularly irrigating when necessary and spraying to keep the foliage free from flea beetles and lace bugs. Any early setback to the young plants will significantly reduce yields.

Side dressings of a complete fertilizer at monthly intervals when the plants begin to produce (fig. 12, *A*) should help maintain production over many months. Irrigation by furrow is essential during dry periods.

Fruits should be harvested regularly when they are a good size and the skin shows a slick luster. Fruits allowed to ripen on the plants will reduce subsequent yields.

Pests and Diseases.—Lace bugs and flea beetles are probably the most destructive insects attacking eggplant in the West Indies. An aphid, the hemispherical scale, a leaf roller, the tobacco hornworm, and a large number of minor pests may occasionally cause damage, probably because of the wide distribution of closely related wild plants. Anthracnose, bacterial wilt, and other diseases may tend to reduce yields, particularly when eggplant or closely related vegetables such as tomato and potato are planted successively on the same ground. Bacterial wilt is controlled by planting resistant varieties.

Okra

"Quingombo"
***Hibiscus esculentus* L.**
Malvaceae

Okra (fig. 24, *A*) is a coarse erect annual plant with more or less hispid stems and attractive dark-eyed sulfur-yellow flowers. Its fruits are borne in leaf axils below the growing point. Okra is well adapted to the hot humid conditions of the Tropics. It yields best at low elevations, particularly during the warm months in regions where rainfall is not excessive. A short row usually is sufficient in the average home garden. When well tended, the plants will bear for several months.

The seeds are planted in hills 12 to 15 inches apart in rows 36 inches apart. Germination can be improved by soaking the seed for a day before planting; unswollen seed should be discarded. Plants are later thinned to 2 to 3 good plants per hill. The plants should be kept growing rapidly by regular irrigation when necessary and by side dressings of a complete fertilizer at 4- to 6-week intervals. The pods must be harvested at intervals of 2 or 3 days when the tips are tender and the peduncles break with a snap. If pods are left to mature on the plants, they are too tough for consumption; this practice also reduces yields.

Variety White Velvet outyielded all other varieties in several trials at Mayaguez, P.R. Other varieties recommended for the West Indies are Clemson Spineless, Gold Coast, Louisiana Evergreen, and Perkins Spineless. Gold Coast is a dwarf variety said to tolerate heat well and bear over a long period of time. The Indian variety Pusa Sawani is recommended as a heavy cropper and for resistance to yellow-vein mosaic.

Okra pods are often used to thicken soups and stews. They can be served as a boiled vegetable, but people not accustomed to the slickness of okra may not care for it prepared this way. Okra is frequently combined with eggplant, tomato, onion, and other vegetables. Another method of preparing okra is to slice the pods into ¼- to ½-inch pieces, roll the pieces in corn meal or flour, and fry them in fat.

The closely related plant roselle (*Hibiscus sabdariffa* L.) is grown for the fleshy red calyces (fig. 24, *C*) which have a tart flavor. An excellent reddish sauce, similar in appearance and flavor to cranberry sauce, is made from roselle. The calyces are used to color and season other foods, often as a substitute for lime juice.

Pests and Diseases.—The cotton aphid (fig. 24, *B*) is perhaps the worst single pest of okra in the Tropics. Other pests include corn earworm, leaf beetles, and pink bollworm. Okra is fairly susceptible to root-knot nematode damage. Okra is damaged by the fusarium wilt fungus and leaf spot fungus during especially wet rainy periods although under average conditions okra is relatively disease free.

Pepper

"Pimiento," "Chili," "Ají"
***Capsicum annuum* L.—Bell or Sweet Pepper**
***Capsicum frutescens* L.—Hot or Tabasco Pepper**
Solanaceae

Peppers are upright branching annual plants that grow to a height of 1 to 2 feet. Fruits of the different kinds can be small to large (fig. 23, *D* and *E*), thin or thick walled, and in shape from wider than long to very long and tapering. They are red or yellow at maturity. In flavor peppers vary from sweet to mildly or quite pungent.

The most popular pepper cultivated in the Car-

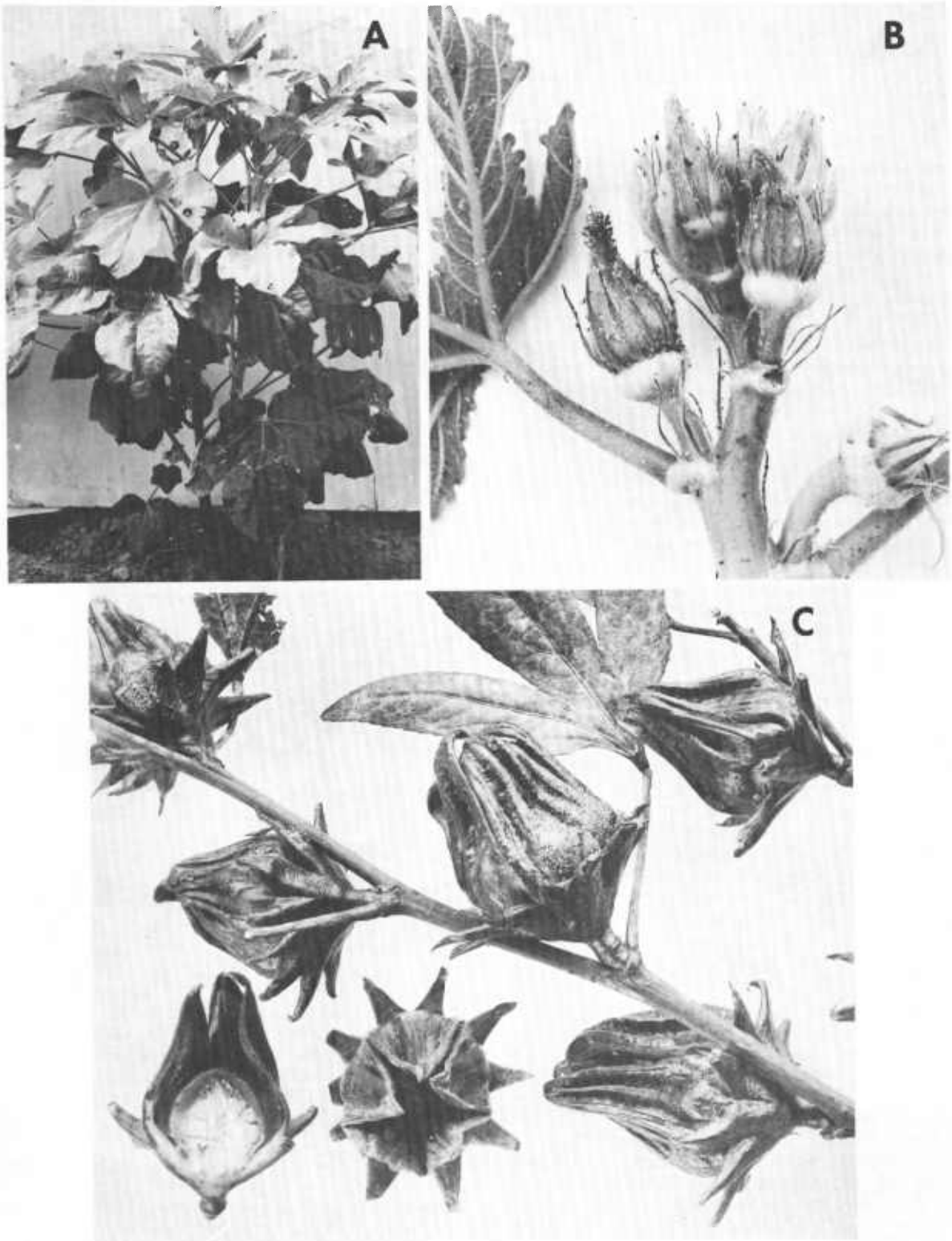


FIGURE 24.—*A*, Okra; *B*, cotton (melon) aphid (*Aphis gossypii* Glover) on okra; *C*, roselle.

ibbean area is the large bell or sweet type for use in cooking or salads or for export to the mainland (*51*). The variety California Wonder has produced satisfactory crops in Puerto Rico for export (fig. 23, *C*). Small peppers of various shapes are grown in the Caribbean area for seasoning other foods; large thin-walled peppers are used for stuffing.

Tabasco and chili peppers are cultivated to a lesser extent in the West Indies. The typical hot pepper has extremely pungent, small round fruits that are used as a condiment. Long-fruited chili types are grown in a few home gardens. The perennial plants are often more branched and taller than the bell type and may bear smaller leaves.

The culture is the same for all types of peppers. The seeds are sown in protected boxes or beds and covered with fine soil. When the seedlings are about 6 weeks old, they are transplanted to the garden at a spacing of 12 to 18 inches in rows 2 to 3 feet apart.

Good crops can be obtained at elevations from sea level to 3,000 feet when peppers are planted in fall, winter, and spring; fair to good crops when they are planted in summer if rainfall is not excessive. The pepper is less tolerant of heat than the eggplant. Fruit set is poor during extremely hot weather and fruit already on the plants is apt to sunscald.

Mosaic is the main factor limiting pepper growing in the Caribbean area. The Agricultural Experiment Station of the University of Puerto Rico has developed several improved mosaic-resistant pepper strains that are thick walled, sweet, and of good quality. These strains were developed by crossing native mosaic-resistant peppers with a high-quality continental variety, such as California Wonder (fig. 23, *C*). The local trade prefers the thin-walled variety Blanco del País for cooking, but the thick-walled varieties are popular on the continental markets in winter and early spring, which is the shipping season from Puerto Rico.

Variety Yolo Wonder is now recommended for planting in the West Indies. It resembles California Wonder but is resistant to tobacco mosaic. Variety Yolo Wonder L, a reselection from California Wonder, is said to combine mosaic resistance with a taller plant type, which provides protection to the fruit from sunscald. Sweet varieties Chato and Corozal are recommended for Puerto Rico.

Seed can be saved from fruits of locally adapted hot varieties since the home garden usually will require only a plant or two. Where more hot peppers are needed, varieties Anaheim, Hungarian Yellow Wax, Louisiana Red Cayenne, and Tobasco can be tried.

Peppers are harvested when they are large enough for use, or when ripe. Large sweet peppers are usually picked while still green. The fruits can be left on the plant after reaching maturity without deteriorating. They are picked by cutting or breaking the brittle stems to leave a portion on the fruit. Peppers can be harvested for home use when quite young but the young fruits will wilt readily.

Pests and Diseases.—Peppers are attacked with varying degrees of severity by a large number of general pests. Most common among these are aphids, armyworms, cutworms, flea beetles, leaf miners, mole crickets, plant bugs, thrips, tobacco hornworms, and weevils. Generally, pepper pests do not severely limit production; but should infestations be extensive, control measures should be taken promptly. If DDT WP is used on peppers, an aphicide should be included to avoid buildup of aphid populations. Diseases injuring pepper include damping-off, mosaic virus, bacterial leaf spot, cercospora leaf spot, anthracnose, bacterial wilt, and downy mildew.

Sweet Corn (Maize)

"Maiz dulce"
***Zea mays* L.**
Poaceae

Sweet corn varieties bred for temperate climates often perform poorly in the Tropics, because of their susceptibility to yellow stripe mosaic, a leaf spot caused by *Helminthosporium turcicum* Pass., and because of poor climatic adaptation. Failures have been reported in Cuba (*9*), Hawaii (*11*), and Venezuela (*25*). For many years variety USDA-34 (fig. 25, *A* and *C*) developed by the Federal Experiment Station, Mayaguez, P.R. (*42*) has been the most widely adapted sweet corn variety for the Tropics. It is tall, vigorous, productive, and disease resistant. Continued selection at the Federal Experiment Station produced the Improved USDA-34 (*6*), with improvements in sweetness and tenderness and with yellow kernels. More recently the University of Puerto Rico selected the variety Puerto Rico 50 from Improved USDA-34. Puerto Rico 50 resembles variety Golden Bantam in the ear but retains the plant characters and disease resistance of USDA-34. Both Improved USDA-34 and Puerto Rico 50 are recommended for trial. USDA-34 remains the standard sweet corn variety for the Tropics.

The varieties Giant White, Golden Beauty, and Sugar Corn are grown in India; and American varieties Country Gentleman and Golden Bantam have been recommended for spring planting in Hong Kong. The many hybrid varieties now being offered by northern seed firms

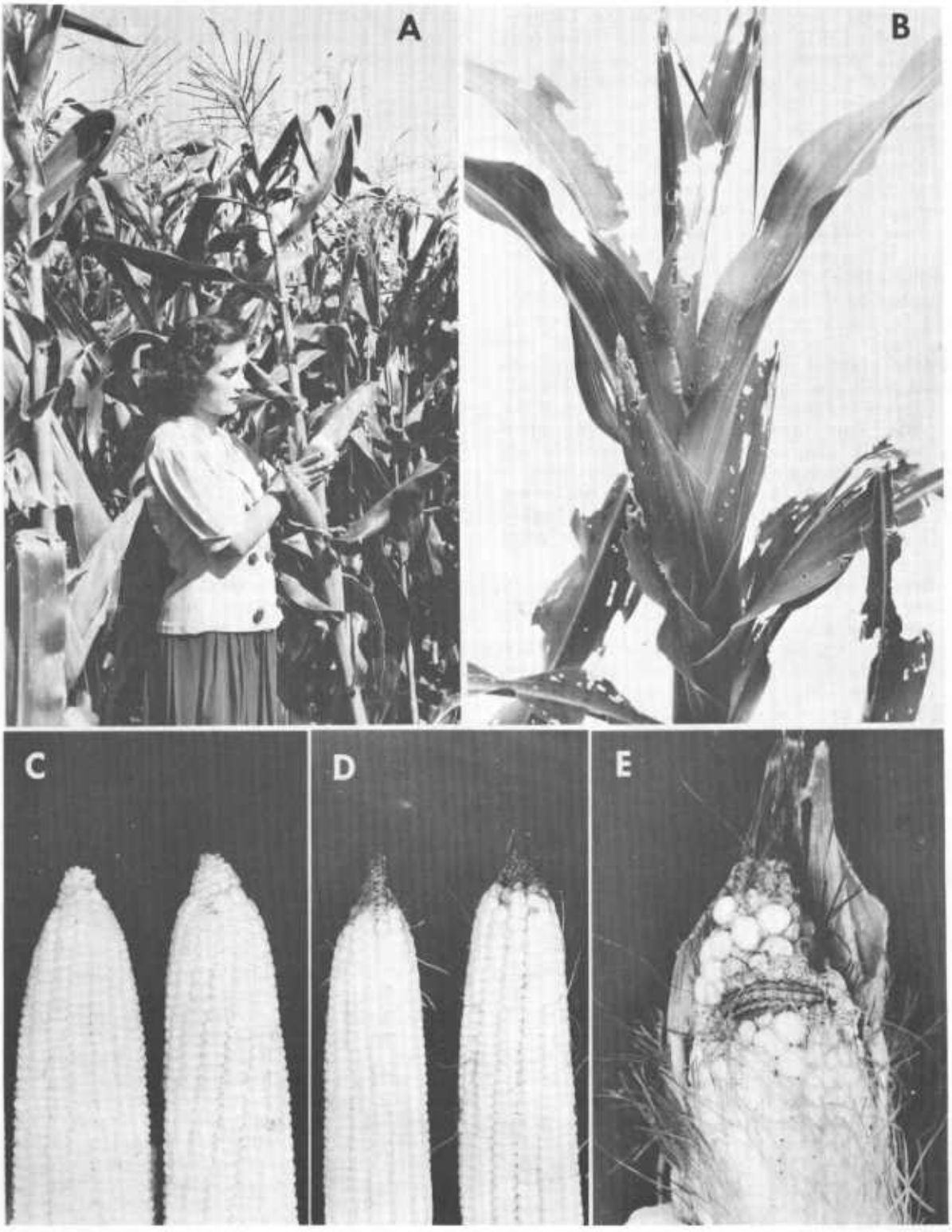


FIGURE 25.—*A*, Sweet corn variety USDA–34; *B*, corn plant damaged by fall armyworm; *C*, ears of USDA–34 sweet corn free from silk fly injury; *D*, sweet corn injured by silk fly; *E*, corn earworm (tomato fruitworm) (*Heliothus zea* (Boddie)) feeding on ear of corn.

have not been adequately tested in the Tropics. The ears of all field corn varieties can be eaten as a vegetable if harvested at the proper stage.

Corn may require too much room for inclusion in small gardens, but where enough land is available, excellent ears can be had throughout the year. Variety USDA-34 and the varieties selected from it perform best at lower elevations. Fair to good crops have been obtained at 2,600 feet during spring and early summer; only fair to poor crops were obtained in early spring at 3,200 feet. A better sweet corn variety is needed for the high elevations in the Tropics.

Complete fertilizer and manure where available should be mixed with the soil before planting sweet corn. During the rainy season the seed should be planted on ridges 6 to 8 inches high and spaced 3 feet apart. Two or three kernels are dropped at intervals of 10 to 15 inches in the row. The plants are then thinned to one good stalk per hill. Either one or two side dressings of ammonium sulfate or a complete fertilizer is advisable at about 4-week intervals, beginning when the corn is knee high. Irrigation is highly essential during dry periods to obtain a good yield of large-size, high-quality ears.

Variety Puerto Rico 50 should produce two good ears per plant. When ready for harvest, the ears should be of good size and firm and should show dry brown silks at the tips. The kernels should be at the milk or soft dough stage, which can be determined by pulling back the shuck at the tip of the ear and breaking one or two kernels with the thumbnail. Ears should be checked frequently because the ideal stage for harvest lasts for only a day or 2 before the kernels become tough. A succession of plantings at 2-week intervals will provide a better supply of corn for table use than will one large planting.

Since sweet corn seed may be difficult to secure in many areas of the Tropics, 1 year's supply should be saved from the best dry-season planting. The ears should be well matured on the plant, then hung in a dry cool place until the cob is dry. Ears selected for seed should be large and from disease-free plants. The grains can then be shelled from the cob and stored as recommended. (See p. 19.)

Pests and Diseases.—Sweet corn, particularly young corn plants at the beginning of the dry season, is very heavily attacked in most places in the American Tropics by the fall armyworm (fig. 25, *B*), the lesser cornstalk borer, the southern cornstalk borer, the cutworm, the silk fly (fig. 25, *C* and *D*), and the corn earworm (fig. 25, *E*). Unless these insects are controlled (*4*), the sweet corn crop will be either destroyed or badly damaged. Various other general pests can cause less severe damage. Corn is not too frequently attacked by disease since newer resistant varieties have been developed. A leaf spot, mosaic virus, a rust, a bacterial wilt, and a smut fungus sometimes appear on plants in tropical areas.

Tomato

"Tomate," "Gitomate"
***Lycopersicon esculentum* Mill.**
Solanaceae

The tomato is a sprawling herbaceous plant cultivated as an annual for its fruits. It is a nutritious and refreshing vegetable whether used raw in salads or cooked in a variety of ways.

Although the tomato will grow at nearly all elevations in the Caribbean area, the available varieties produce best during the relatively cool dry season at elevations lower than about 2,500 feet. The minimum and mean temperatures at higher elevations are usually too low during winter and rainfall is too abundant in summer to grow tomatoes. This agrees in general with experience in Hawaii at the higher elevations (*11, p. 88*). A relatively cool, rather dry climate with plenty of sunshine, such as that prevailing in winter near Ponce and Isabela, P.R. (fig. 26, *A*), is ideal for tomato production, provided irrigation is available when needed.

Although high summer temperature can be an important factor in reducing yields in the Tropics, particularly those of the large-fruited varieties, excessive rainfall is considered to be the most detrimental factor. During summer (80° F.) under greenhouse protection at Mayaguez, P.R., excellent crops of the variety Michigan State Forcing have been grown when crops in the field under heavy rainfall were unsatisfactory.

Garden tomatoes may be arbitrarily grouped into three types: (1) The determinate, low-growing, bushy type with each branch ending in a flower cluster and new shoots appearing laterally on the stems; (2) the indeterminate, large-fruited type (fig. 26, *B*) that grows tall when staked and pruned and sprawling when not staked; and (3) the indeterminate, small-fruited type that produces numerous plum-, pear- or cherry-shaped fruits (fig. 26, *B*).

The determinate type has the advantage of flowering and fruiting early and over a shorter period than the indeterminate types. Under adverse rainy conditions varieties of the determinate type sometimes set and mature a greater weight of fruits than the large-fruited indeterminate types. Plantings of the determinate type must be made more frequently than those of the indeterminate types since the determinate plants are shorter lived. The determinate type should not be pruned. A low supporting framework of bamboo may help to reduce diseases by keeping the foliage and fruits off the ground. Varieties of the determinate type that have performed best

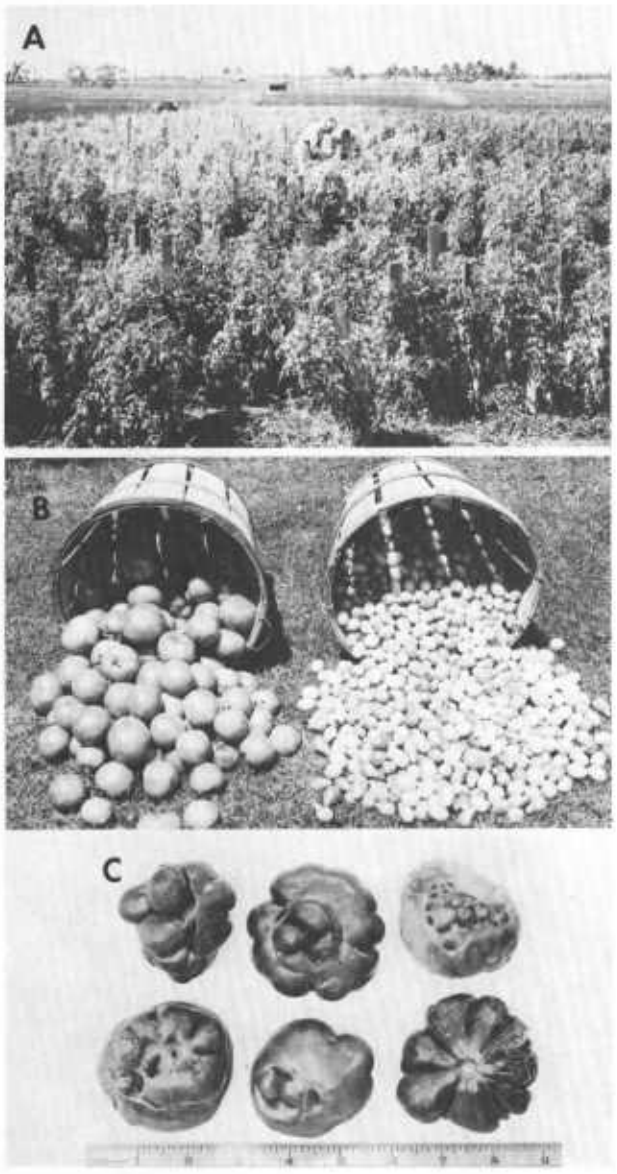


FIGURE 26.—*A*, Field of staked Marglobe tomatoes grown in northwestern Puerto Rico; *B*, large-fruited tomato varieties (*left*) and indeterminate small-fruited plum, pear, and cherry types (*right*); *C*, native West Indian types of tomatoes.

under West Indian conditions are Pritchard and Homestead 24. Both are tolerant or resistant to fusarium wilt, and Pritchard also resists the nail-head rust disease.

Varieties of the large-fruited, indeterminate type that have produced best under field conditions in the West Indies are Michigan State Forcing, Rutgers, and Marglobe. Several newer varieties, Floralou, Indian River, and Manalucie, developed for the winter and spring crops in the Southeastern United States also have produced well. Floralou and Indian River are multiple-disease resistant and Manalucie is resistant to fusarium wilt. Variety Campbell 146 is grown in Puerto Rico for commercial canning. The many hybrid varieties available in temperate regions have not been sufficiently tested in the West Indies for recommendation.

The small-fruited, indeterminate plum-, pear-, and cherry-shaped types of tomato (fig. 26, *B*) set heavy crops of fruit under somewhat adverse summer conditions, such as warm rainy weather, and are not quite so susceptible to attack by insects and diseases. A few of these plants, of which there are several varieties, should be maintained in the home garden to provide fruits when other varieties are likely to fail because of adverse climatic conditions. Variety Roma is grown in Puerto Rico for commercial production of tomato sauce and paste.

Several native tomato varieties (fig. 26, *C*) in the Caribbean area are more resistant than continental varieties to high temperatures and diseases during the warm rainy season. The quality of these native varieties is low and the fruits are undesirable because of their knotty furrowed character. They are suited only for cooking. Selección Platillo, selected in Puerto Rico from the old local variety Platillo, withstands diseases and produces more fruit during the warm rainy season than any other variety tested in Puerto Rico. It, too, is used only for cooking.

One of the great difficulties in tomato production during the rainy season is that the almost daily showers wash off the fungicides almost as soon as they are applied. Of 121 tomato varieties grown during the rainy season in El Salvador from 1957 to 1961, Mortensen and Bullard (*33*) found that only Red Top, Roma, Sioux, Summer Prolific, Texto 2, and Urbana were consistently good producers when weekly sprays of maneb were applied. More promising were the Hawaiian multiple-resistant hybrids, Cuyano, Egg, Indian River, and Santa Catalina. Trials in Haiti in 1961–62 by the same investigators showed Campbell 146, the Hawaiian hybrids, Hotset, Indian River, Red Top, Roma, San Marzano, and Urbana to have promise for rainy-season production.

Another troublesome deterrent to rainy-season production of tomatoes is the fruit cracking common in the large-fruited varieties. Resistance has been reported in Glamour, Heinz 1370, and Summer Prolific (*33*), and in breeding lines developed by workers at the Agricultural Experiment Station of the University of Puerto Rico. Small-fruited varieties such as Red Top, Roma, and San Marzano and the currant tomato (*Lycopersicon pimpinellifolium* (Jusl.) Mill.) are highly resistant to cracking.

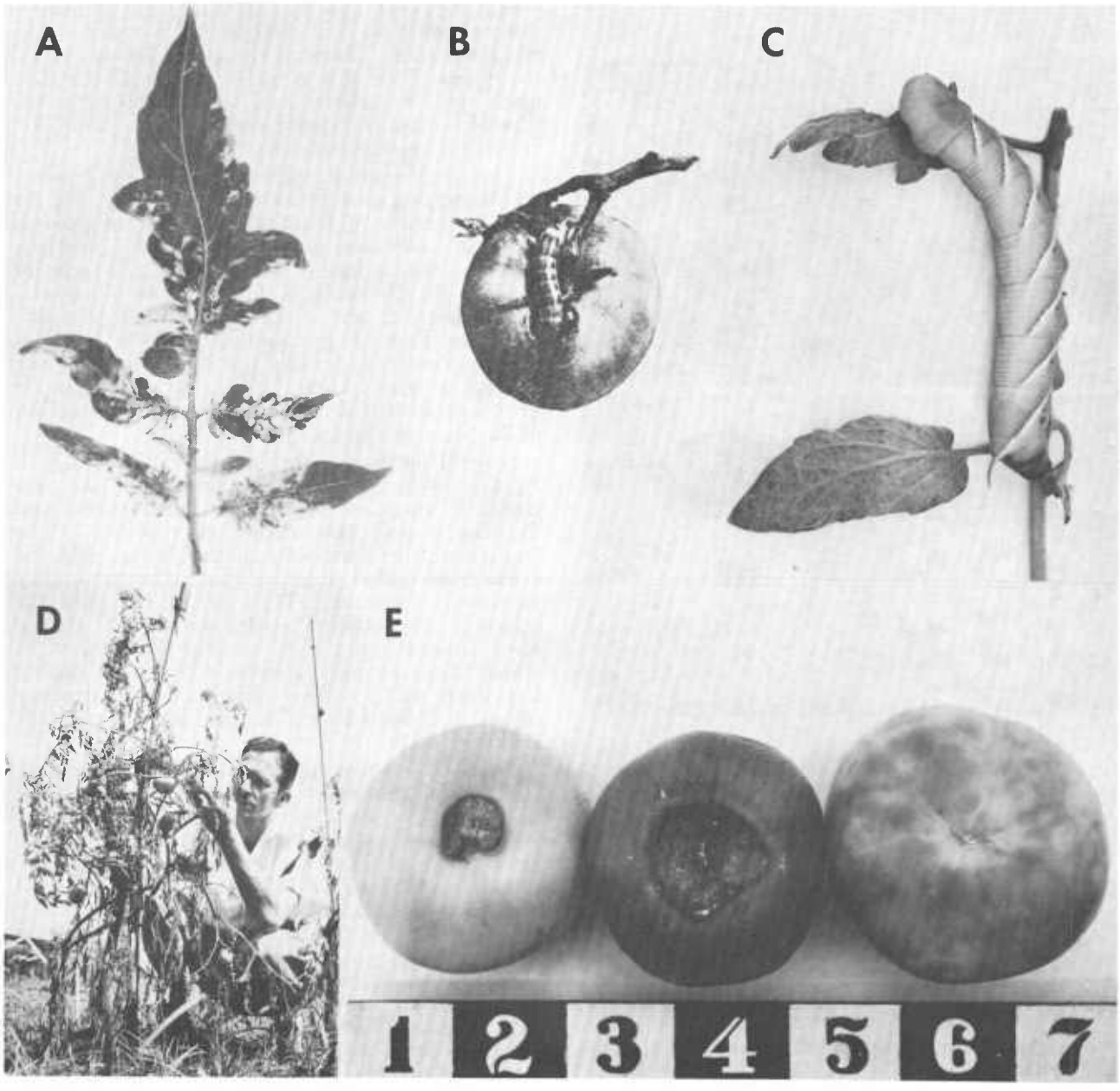


FIGURE 27.—*A*, Mottled leaves of tomato plant, symptom of tobacco mosaic virus; *B*, corn earworm (tomato fruitworm) (*Heliothus zea* (Boddie)) on tomato; *C*, tobacco hornworm (*Protoparce sexta* (Johanson)) on tomato leaves; *D*, tomato plants defoliated by late blight during periods of heavy rains; *E*, tomatoes showing progressive degrees of blossom-end rot (*left and center*) and tomato with mottled appearance presumably caused by nutritional imbalance (*right*).

Tomato seed is broadcast or planted in rows in well-prepared seedbeds (fig. 15). When the seedlings are about 3 to 4 inches high (fig. 15, *C*), they are transplanted to neighboring beds; when 6 to 8 inches high, they are transplanted to the garden. Long, leggy plants can be transplanted if their lower sections are laid down in a furrow and only the upper 4 to 6 inches of the tops exposed. Plants are spaced at about 2 to 4 feet in rows 3 to 4 feet apart, depending upon the tools available for cultivation. For the home garden the first transplanting can be made to clay or peat pots, cans, or cartons. This method may give stronger plants for transplanting to the field location.

At time of transplanting, 2 tablespoonfuls of a

complete fertilizer low in nitrogen and high in phosphorus, such as 4–12–18, should be applied in strips on either side of the plant at a distance of 3 to 4 inches from the base and at a depth of about 3 inches. When fruits begin to set, side dressings of ammonium sulfate at 3- to 4-week intervals will aid in sizing the fruit and keeping the vine vigorous. Frequent cultivation is necessary to loosen the soil and eliminate weeds that may be a source of mosaic and other diseases.

On heavy soil during the rainy season the plants should be set on raised beds or ridges and staked (*40, 1947*). In the dry season they can be grown on the level and furrow irrigated if water is available. Where the soil is sandy and the rainfall moderately light, the net returns per acre are higher without staking and pruning.

Staked plants should be pruned to about two main stems and all side branches removed as they appear. This will require visiting the planting every 2 or 3 days. Young plants showing mottled or deformed leaves, common symptoms of tobacco mosaic virus (fig. 27, *A*), should be removed immediately and burned or buried, after which the grower's hands should be washed with soap. It is possible to transfer mosaic from one plant to another during pruning, spraying, and other operations. A person using tobacco products may be a source of mosaic infection, since tomatoes can be infected with mosaic disease from tobacco. Tobacco users should wash their hands with soap and water before working with tomato plants. Furthermore, they should not smoke or chew tobacco while working with tomatoes. During ripening the fruit borne on mosaic-infected plants often develops yellow areas over the surface, which can reduce their market value.

The careless use of herbicides in the vicinity of home gardens can cause injury to tomato plants that is often mistaken for mosaic disease. The herbicide causes the upper stem to twist and the leaves to become malformed. The plants will die if they have received much of the herbicide. With herbicide injury the entire field usually shows the injury at one time while mosaic disease will start with isolated plants.

For the best flavor, tomatoes in the home garden should be picked when fully ripe. Full-size green tomatoes will ripen if they are picked and placed on the window sill or in a sunny place. Commercial tomatoes harvested for shipment are picked when full size but green. They are packed uniformly by standard procedure (*51*) in medium and large sizes, transported overnight to the shipping point, and loaded as soon as possible on refrigerated ships or freight planes. Extreme care in handling commercial tomatoes is essential at all times to reduce bruising and subsequent rotting.

Pests and Diseases.—Insects and other pests attacking the tomato include the corn earworm (tomato fruitworm) (fig. 27, *B*), cutworm, flea beetles, and tobacco hornworm (fig. 27, *C*). Several species of sucking insects attack principally the fruit, and root-knot nematodes attack the roots. The tomato is damaged by more diseases than most other vegetable crops. During the warm rainy season the foliage may be attacked by early blight, gray leaf spot, or several other bacterial or fungal spots. Night temperatures below 60° F. with rain or high humidity will favor development of late blight (fig. 27, *D*). Mosaic (fig. 27, *A*) and possibly other virus diseases can reduce yields if introduced into tomato fields. Fusarium and bacterial wilts can be severe if the soil has become contaminated. The fruit is attacked by anthracnose and several other rots caused by bacteria and fungi.

The tomato is subject to a number of physiological disorders not caused by disease organisms, but which are often followed by invasions of various rots. Blossom-end rot (fig. 27, *E*), a necrosis of subsurface tissue at the blossom end of the fruit, shows up as the fruit starts to ripen. It is caused by calcium deficiency at times of moisture stress when the fruit is very young. The disorder can be prevented by maintaining uniform soil moisture and avoiding excessively high rates of soil fertility. Fruit cracking at maturity also may be prevented to some extent by maintaining uniform soil moisture. A nutritional imbalance can cause a mottled appearance on tomato fruits (fig. 27, *E*). Sunscalding of the exposed fruit often follows complete or partial defoliation by leaf diseases.

Greens, Stem, and Leafy Salad Vegetables

Most greens, stem, and leafy salad vegetables yield well during winter and throughout the year at high elevations in the Tropics.

Amaranth or Chinese Spinach

***Amaranthus* spp.**
Amaranthaceae

Several species of *Amaranthus* are used for food in different parts of the Tropics. Leaves of the different species or varieties are either red, variegated, or green. The green form of *A. gangeticus* L. is most commonly cultivated for use as boiled greens. It is an upright branched annual. The young leaves and stem tips are ready to eat 3 to 6 weeks after the seed is sown. The red-leaved species (probably *A. tricolor* L.) can be planted any time of the year, but *A. gangeticus* grows best in the latter part of the dry season and early part of the rainy season.

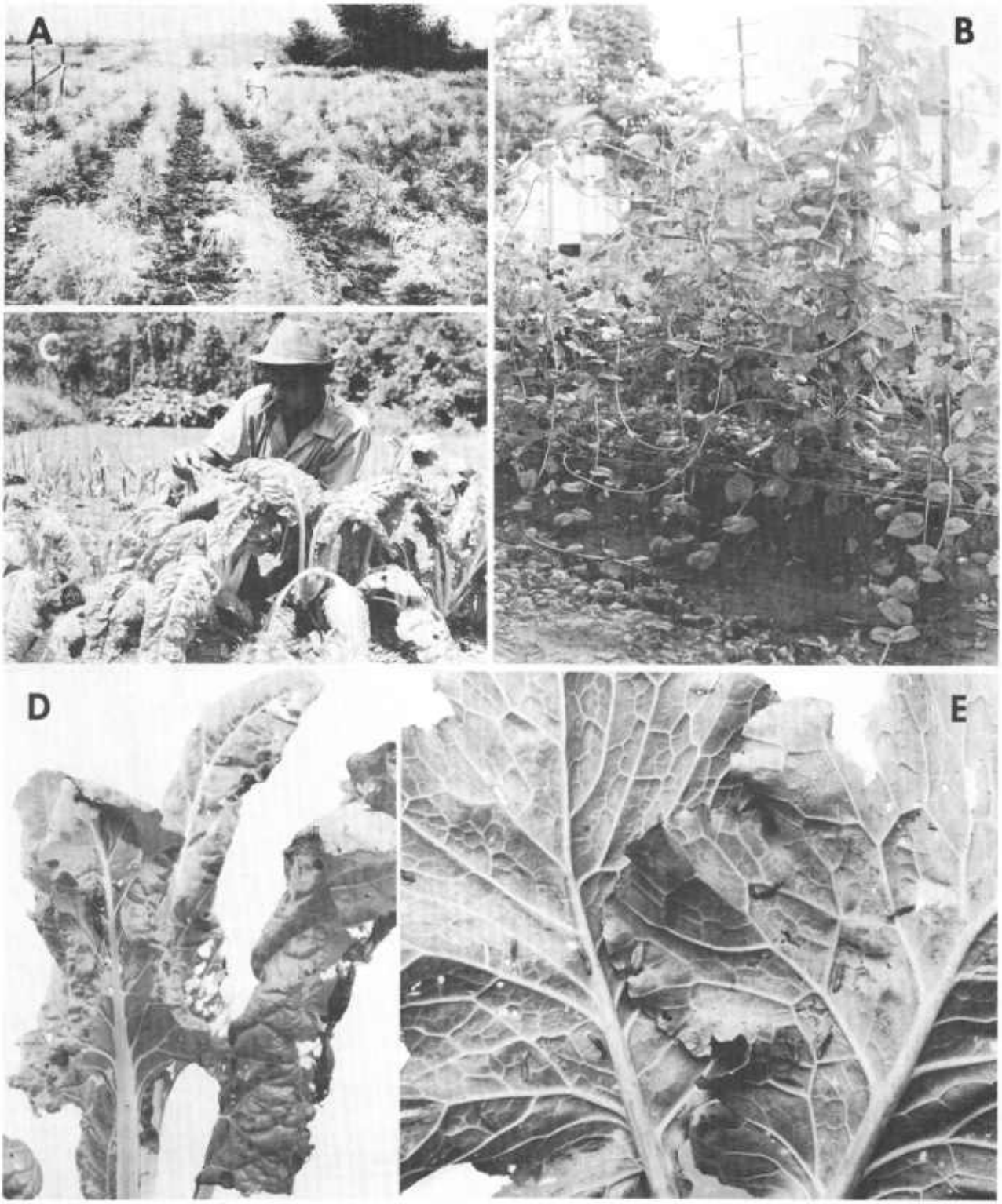


FIGURE 28.—*A*, Field of asparagus variety Mary Washington; *B*, Ceylon spinach on trellis; *C*, chard; *D*, chard leaves damaged by the southern beet webworm (*Pachyzancla bipunctalis* (F.)); *E*, collard leaves damaged by larvae of diamondback moth (*Plutella maculipennis* (Curtis)).

Amaranth or Chinese spinach grows well and rapidly at all altitudes in the West Indies. The green-leaved variety Tampala, which can be obtained from United States seedsmen, is satisfactory. Direct broadcast seeding is practiced and the seedlings are thinned when quite young to 3 inches apart. The thinnings can be used for greens.

PESTS AND DISEASES.—No specific pests or diseases attack amaranth or Chinese spinach.

Asparagus

"Aspárago"
***Asparagus officinalis* L.**
Liliaceae

Asparagus (fig. 28, *A*), a herbaceous perennial, is cultivated for its edible spears or young shoots. It grows best in the Tropics at higher elevations, but it can grow at low elevations having a cool dry season during part of each year.

Yields of asparagus in the Tropics generally have not compared favorably with yields in the Temperate Zone. The home gardener who is accustomed to the flavor of fresh asparagus may wish to maintain a small plot even though the yields are moderate to low.

Asparagus can be grown from seed or from imported dormant crowns. The seed is sown in rows in a seedbed and grown for several months until the seedlings are about 1 foot high, then they are transplanted to a well-drained sandy loam soil high in organic matter. The seedlings are set in a trench about 14 inches wide and 12 inches deep. A layer of well-rotted manure is placed in the bottom of the trench and covered with soil in which the seedlings are set. Additional manure is applied as a mulch from time to time until the ditch is completely full. This crop responds well to large applications of animal manure. Nitrogen and phosphorus applied as ammonium phosphate (16–20) are valuable supplements to manure and can be applied either before or after the harvest season.

Cutting begins within about 2 years after transplanting the seedlings to the field, or 1 year after setting the crowns. Production of the new shoots follows a dormant period. To induce dormancy, withhold water for 2 to 3 months at the beginning of the cool dry season. Then cut the tops off and hoe or disk and irrigate the area regularly. Spears may be harvested when they are 6 to 8 inches long over a period of 3 to 6 weeks. The cut is made about an inch below ground. A mulch of dried grass can be placed over the rows at the beginning of the harvest season if blanching is desired. The lower ends of freshly harvested spears should be placed in a pan of water under refrigeration to maintain their high quality until they can be cooked.

After harvest, the tops should be allowed to develop for several months to store food in the fleshy roots for the next crop. Because there are no cold winters to induce a rest period under tropical conditions, asparagus tends to lose vigor in a few years. Variety Mary Washington is recommended as being vigorous and disease resistant.

PESTS AND DISEASES.—Leaf beetles eat the foliage and the edible shoots of asparagus. Asparagus is generally disease free in the Caribbean area but during rainy seasons a rust may appear.

Broccoli

"Brecol"
***Brassica oleracea* var. *botrytis* L.**
Cruciferae

This cabbage relative is cultivated for the thickened heads of flower buds that are formed just before the stage of stem elongation and flower expansion. It is one of the most satisfactory vegetables that can be grown in the home garden and has increased in popularity in recent years.

Broccoli grows well during the cool season at all elevations in the Caribbean area; at high elevations it grows well at all seasons except the warmest heavy-rainfall period. Yields have generally been best from plantings made during the cool months and maturing during the early spring rains.

Broccoli is not hard to grow. It is more productive and withstands heat and drought better than its close relative cauliflower. The large center cluster of buds develops first and is harvested just after the individual flower buds become distinguishable (fig. 29, *A*). About the time the center head is harvested, it is advisable to give a side dressing of complete fertilizer, or 16–20 ammonium phosphate. This stimulates development of the edible side shoots, which may be harvested over a period of 2 months. As the stems below the flower clusters are succulent and edible, from 5 to 8 inches may be cut with the main flower head and 3 to 4 inches with the side shoots. These stems may be split before cooking so that they will cook as fast as the flowers. The cut top of the center stem may rot after harvest if rainfall is abundant or overhead irrigation is used. Rotting may be prevented by placing a moisture-proof paper cap, such as a paper cup, over the cut surface on the stalk. Making a slanting cut at harvest may also aid in preventing stem rot.

The culture of broccoli is the same as for head cabbage. Calabrese and Propageno strains of Italian green sprouting broccoli have given good results in the West Indies and in Hawaii.

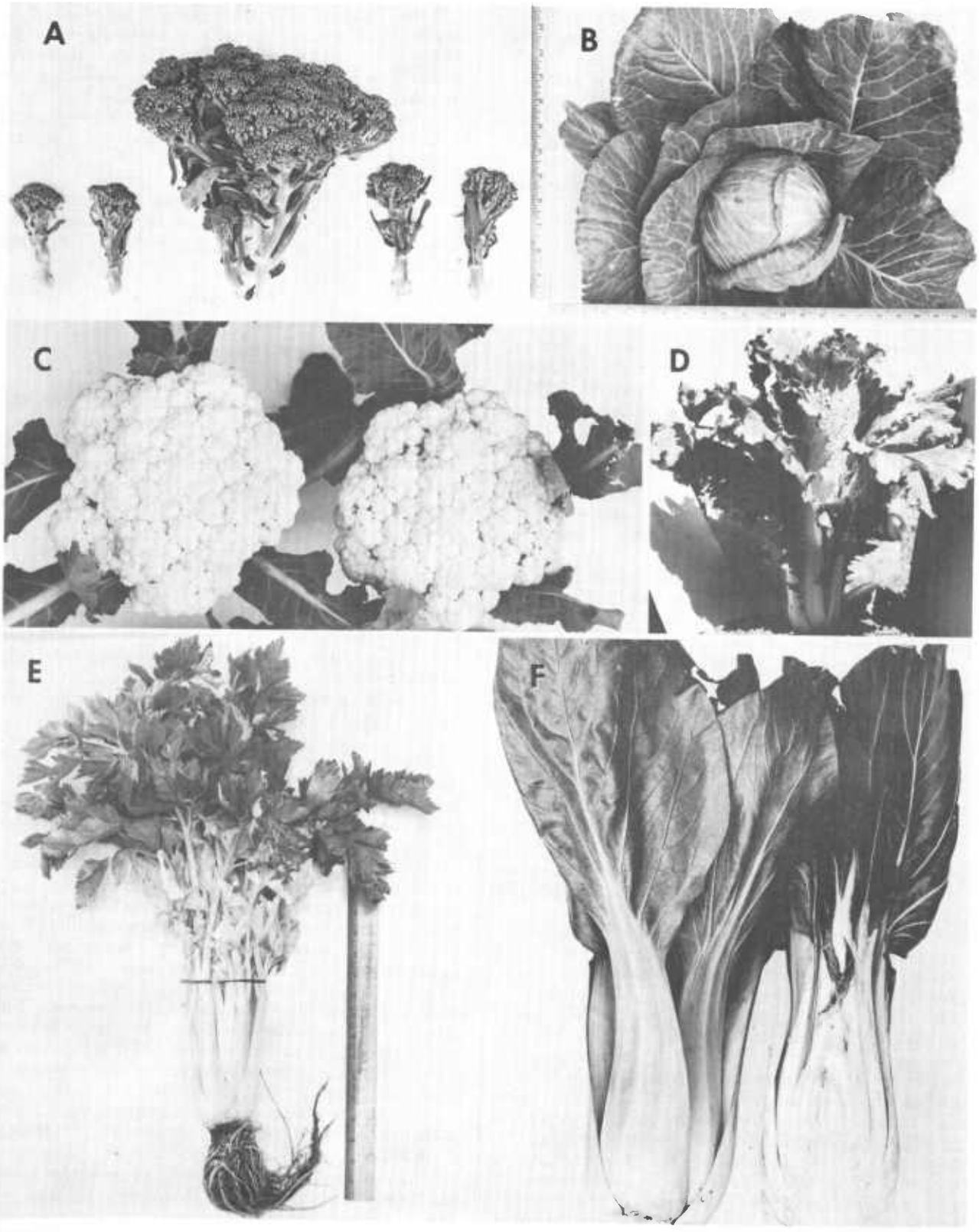


FIGURE 29.—*A*, Broccoli variety Calabrese, large center head and small side shoots; *B*, cabbage variety Golden Acre; *C*, Indian cauliflower variety Early Patna; *D*, Chinese cabbage variety Chi-Hi-Li; *E*, celery variety Golden Self Blanching; *F*, spoon cabbage.

De Cicco is recommended for trial. Purple-leaved strains are preferred in some areas of the Tropics.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Brussels Sprouts

"Col de Bruselas"
***Brassica oleracea* var. *gemmifera* DC.**
Cruciferae

This member of the cabbage family is cultivated for the small axillary buds or heads that are borne laterally on the tall erect stems. It is a long-season crop adapted to the cool temperatures (55° to 65° F.) found only at high elevations in the Tropics.

At 3,000 feet in Puerto Rico, only a small percentage of the plants of variety Improved Long Island formed small cabbagelike heads in the leaf axils and these were strong in flavor.

At elevations where this crop can be grown, the seed may be planted directly in the field like Chinese cabbage, or the seedlings can be transplanted from seedbeds like head cabbage. (See pp. 26 and 28.) The small budlike heads can be harvested when firm and 1 to 2 inches in diameter. Some of the lower leaves may be removed if the buds become crowded. This crop should withstand moderate frosts at high elevations in the Tropics (*59, p. 311*). The buds are cooked like cabbage.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Cabbage

"Repollo de Col"
***Brassica oleracea* var. *capitata* L.**
Cruciferae

The main stem axis of the head or true cabbage is short and thick. The head is formed by the development of the densely packed leaves about the growing point. Head cabbage is used both for cooking and for salads. Its use for pickling or sauerkraut is not common in the Tropics.

Head cabbage can be grown throughout the year in the Caribbean area, but the largest and heaviest heads are produced during the cool winter and early spring seasons. Most standard varieties produce satisfactorily, but All Seasons, Copenhagen Market, Golden Acre (fig. 29, *B*), and Succession have produced the largest percentage of good heads under trial conditions. Heads weighing from 2 to 4 pounds can be produced during the warm season and heads weighing from 4 to 6 pounds during the cool season. At 3,000-foot elevation during the cool season, heads weighing from 7 to 9 pounds are not uncommon. The savoyed and red-leaved varieties generally do not perform well in the Tropics. It is more difficult to control insects on the savoyed leaves.

In addition to the usual preparation of the soil with manure and complete fertilizer before planting, apply a side dressing of ammonium sulfate or a complete fertilizer shortly after the heads begin to form. A side dressing of nitrogen is particularly important if the cabbage begins to head while still small or if the leaves show yellowing. One tablespoonful per plant should be adequate.

Although the early-maturing Golden Acre performed satisfactorily in trials, the soil moisture had to be kept relatively uniform by regular irrigation during dry periods. Heads of this variety tend to crack open when a dry period is followed by an irrigation or by heavy rainfall. A combination planting of Golden Acre for early harvest and Succession or Copenhagen Market for later harvest is suggested. Varieties having small heads, such as Golden Acre and Early Jersey Wakefield, should be spaced 12 inches apart in the row; varieties with large heads, such as Copenhagen Market, Marion Market, and Succession, should be spaced about 18 inches apart. The late-maturing large flat or drum-head varieties generally do not perform as well in the Tropics as the early-maturing conical or round-headed varieties.

The young seedlings must be kept stocky and moderately vigorous before and after transplanting. A vigorous start with these seedlings makes a tremendous difference in subsequent size of the heads. Seedlings stunted by drought, low fertility, or insects will give mediocre to poor yields.

PESTS AND DISEASES.—The cabbage looper and Gulf white butterfly caterpillars can speedily make a shambles of plantings of cabbage and other cruciferous plants. Diamondback moth caterpillars are a third major pest. Figure 28, *E* shows the damage caused to collards by the caterpillars of the diamondback moth (*Plutella maculipennis* (Curtis)). This is perhaps the most damaging and difficult pest to control on plants of the cabbage family in the Caribbean area. The underside of the leaves is first riddled and then heads are perforated. Several diseases may appear when cabbage and its allies are planted during the wettest parts of the year. These diseases include bacterial black rot, black leg fungus, and wilt or yellows.

Cauliflower

"Coliflor"
***Brassica oleracea* var. *botrytis* L.**
Cruciferae

The cauliflower plant resembles other members of the cabbage group until maturity when the flower heads (fig. 29, *C*) and upper stems are

thickened into a fleshy white or purple-red mass. White varieties are more frequently seen than the colored.

Cauliflower is more exacting in climatic requirements than broccoli or head cabbage. It performs best during the cool months at higher elevations, where the mean temperature is between 55° and 65° F. It is a waste of time and effort to try to grow cauliflower in warm moist areas of the Tropics. Handling the seedlings and cultural requirements are about the same as for cabbage. Lime should be added to acid soils to bring the pH to 5.5 to 6.5.

To secure a succession of crops, the seeds can be sown at 4-week intervals from late September to December. Protection of the seedbeds is necessary where heavy rains occur at this season. A well-prepared rich soil is essential. The incorporation of animal manure is particularly beneficial, and a light side dressing of ammonium sulfate can be given after the seedlings are transplanted to the garden. They must be kept growing rapidly. Cutting starts in 12 to 18 weeks. Blanching, if desired, is done by tying the outer leaves over the flower head for a few days to protect it from the bright sun. Varieties recommended for trial are Early Market, Early Patna, Early Snowball, Maincrop Banaras, Maincrop Patna, and Royal Purple.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Celery

"Apio"

***Apium graveolens* L.**

Umbelliferae

Celery is a biennial herb, grown as an annual for the long succulent leafstalks, which are eaten either raw or cooked (fig. 29, *E*). The leaves are used to flavor soups and stews and may be dried for later use.

Celery grows best under the cool conditions of high elevations where the mean temperature is between 60° and 70° F. It is best suited to a climate of warm days, cool nights, and abundant sunshine. The percentage of good bunches grown during cool months at sea level in the Tropics can be less than 50. The somewhat tougher stalks and leaves of the small bunches grown at sea level can be used for flavoring. Celery will occupy the soil for the relatively long period of about 5 months before reaching full maturity. Plants can be harvested, however, at any time after they are half grown.

Unless celery receives special attention in fertilizing, spraying, and irrigating, it is almost bound to fail. It does not perform well on light sandy soil or very heavy clay. Heavy additions of organic matter in the form of manure or compost are necessary in most soils and will improve the chances for success in light sandy soil or very heavy clay. A trench about 12 inches deep should be dug and partly filled with the manure or compost and then covered to the top with soil.

Seed should be sown in specially prepared seedbeds or flats of rich soil. When the seedlings are a few inches high, they should be transplanted to pots or another seedbed. Seeds germinate best if pretreated by being placed between moistened cloths for 1 or 2 days before planting. A thin mulch over the seedbed keeps the soil moist during germination. Partial shade is advisable for the delicate seedlings.

A complete fertilizer high in nitrogen, such as 10–10–5, should be applied in shallow trenches on either side of the plants at transplanting. This application is repeated in about 4 weeks, followed again by another of ammonium sulfate as a side dressing within 2 to 3 weeks.

Celery quickly suffers from lack of water during droughts. Irrigation at frequent intervals, preferably by furrows, is necessary to keep the stalks tender, well flavored, and growing rapidly. The plants should be spaced about 6 to 12 inches apart in the row. Slightly closer spacing will aid in blanching, but also will reduce plant size.

Figure 29, *E* shows variety Golden Self Blanching grown at 2,600 feet in Puerto Rico. This variety has yellowish leafstalks and does not require blanching, although blanching helps reduce the strong flavor and increase the quality if the crop has been grown under high temperature and dry conditions. Green varieties are blanched by wrapping and tying heavy paper around the bunch for approximately 10 days before harvest. Blanching should be done during cool dry weather since warm moist weather may cause rotting of the wrapped plants. Although green varieties, such as Utah, require special blanching procedure, some gardeners prefer to eat the green stalks or chop them into small pieces for soups. The green stalks are more nutritious than the yellow. Other varieties recommended for trial are Florida Green Pascal, Sutton's White Gem, and Waltham Summer Pascal. Smallage is recommended as being highly disease resistant.

PESTS AND DISEASES.—General pests include aphids, armyworms, cutworms, leaf miners, thrips, and webworms. Of these, aphids and thrips are probably the most damaging although they seldom limit production. Hemispherical scales occasionally infest celery. The general recommendations given for thrips will satisfactorily control this pest. Celery is commonly attacked by two fungus blights, as well as by damping-off disease, bacterial soft rot, mosaic virus, and yellows or wilt fungus. In addition, a physiological disorder known as black heart sometimes appears when plants are excessively moist.

Ceylon Spinach

"Acelga Trepadora," "Bretaña," "Libato"
***Basella rubra* L.**
Basellaceae

Ceylon spinach (fig. 28, *B*), vine spinach, or Malabar nightshade is not a true spinach, but its leaves resemble spinach and are used in the same way (*66*). It is a vigorous plant of running and climbing habit that is widely distributed in the Tropics, particularly in moist lowlands. It grows well on a variety of soils, seemingly without regard to fertility. Moisture is important and the plants make their best growth during warm rainy periods, when most other vegetable crops perform poorly.

Ceylon spinach can be grown from seed or cuttings. The seeds should be planted near the end of the dry period in protected boxes or beds and the seedlings transplanted in a row 1 to 2 feet apart at the beginning of the rainy period. Cuttings should be taken at the beginning of the rainy period. They can be planted directly in the permanent location and given extra shade and water until growth begins.

Although Ceylon spinach will produce fair crops with little or no fertilization, more and better quality foliage can be produced by liberal applications of complete fertilizer, manure, and water. The vines should be trellised to keep the foliage free of dirt. Light shade seems to be beneficial.

The young leaves and about 3 inches of the stem tips are picked for home use as a vegetable. When cooked, Ceylon spinach is not as slick as many greens.

In some areas a variety with reddish petioles and stems is encountered, but the green variety is more common in cultivation.

PESTS AND DISEASES.—Ceylon spinach is relatively free of insect pests and diseases in the Caribbean area. Nematodes can be troublesome. The aboveground parts are sometimes attacked by a leaf and stem spot and a stem rot disease.

Chard

"Acelga"
***Beta vulgaris* var. *cicla* L.**
Chenopodiaceae

Chard, also known as Swiss chard, leaf beet, or spinach beet (fig. 28, *C*), lacks the fleshy root of the beet. It is characterized by succulent dark-green leaves, which are usually crinkled or savoyed, and thick, fleshy white midribs and leafstalks. The leaves or the entire top can be eaten for greens or the crisp leafstalks can be separated for cooking like asparagus or celery. Chard is one of the most satisfactory vegetables that can be grown in the Tropics. It is easy to grow and it succeeds at all elevations in the Caribbean area because of its wide tolerance to heat (65° to 80° F.). Chard yields better than most greens crops.

Chard usually is seeded directly in the row since it does not stand transplanting as well as many other vegetable plants. The seedlings should be thinned to 6 to 12 inches apart in the row. The first leaves should be ready to eat within about 60 days. The outer leaves of the plants should be cut regularly as they reach tender maturity; new leaves will continue to develop and furnish high-quality greens for several months.

Chard requires a complete fertilizer at planting, manure if available, and side dressings of ammonium sulfate at about 3-week intervals thereafter. Frequent irrigation should be provided during dry periods to keep the plants tender and growing rapidly.

Fordhook Giant and Lucullus are suitable varieties. Rhubarb is a suitable red-leaved variety.

PESTS AND DISEASES.—See pests and diseases of beet, page 66. The southern beet webworm (fig. 28, *D*) attacks leaves of chard, beet, other vegetables, and weeds.

Chinese Cabbages

***Brassica* spp.**
Cruciferae

CHINESE CABBAGE, "REPOLLO CHINO" (*Brassica campestris* L.)—The names Chinese cabbage and celery cabbage are commonly used in the Caribbean area and in most English-speaking areas of the Tropics to designate the heading varieties of *Brassica campestris* L.

Chinese cabbage is one of the easiest and most productive vegetables grown in the Tropics (fig. 29, *D*); returns are among the best for the labor and garden space involved. Where greens, celery, and head cabbage are scarce, this vegetable is popular, particularly in chopped salads, among people accustomed to eating leafy vegetables. It can also be cooked in the same ways as head cabbage. Chinese cabbage can be grown practically all year at all elevations in the West Indies, but forms the largest and best quality heads during the cool season at high elevations. During the warm season, Chinese cabbage tends to form loose heads. Variety Chi-Hi-Li (Michihli) with long tapering heads usually is favored over Wong Bok and Pe-Tsai. Chiefoo, also recommended in Hawaii, forms short thick heads like Wong Bok and Pe-Tsai.

Chinese cabbage can be transplanted like head cabbage, although excellent results have been obtained by planting seed directly in the field row and later thinning to one good plant at 12-inch intervals. A satisfactory crop can be obtained

somewhat sooner by direct seeding. Chinese cabbage should be kept growing rapidly by a side dressing of nitrogen or complete fertilizer when heads begin to form and by regular irrigation if necessary. The heads are harvested when they are solid and measure from 6 to 8 inches across.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53. In addition, should rot symptoms appear, harvest the young Chinese cabbage plants at once to avoid a strong flavor.

OTHER CHINESE CABBAGES AND MUSTARDS (*Brassica* spp.).—This group of vegetables is difficult to describe. The members are variously referred to as spoon cabbage, Chinese white cabbage, Chinese mustard, or Chinese kale. Several species of *Brassica* are represented. The leaves are eaten boiled as greens or in soups. The plant known as Chinese kale is a nonheading variety of *Brassica oleracea*.

The spoon cabbage group is sometimes erroneously referred to as white mustard. Most of them probably are botanical varieties of *B. campestris* L., but some may be varieties of *B. juncea* (L.) Czern. & Cosson. Spoon cabbage (fig. 29, *F*) is the nonheading oriental cabbagelike group of mustards usually with long upright spoon-shaped leafstalks. Some varieties have a spreading growth with short, broad leafstalks. Spoon cab-

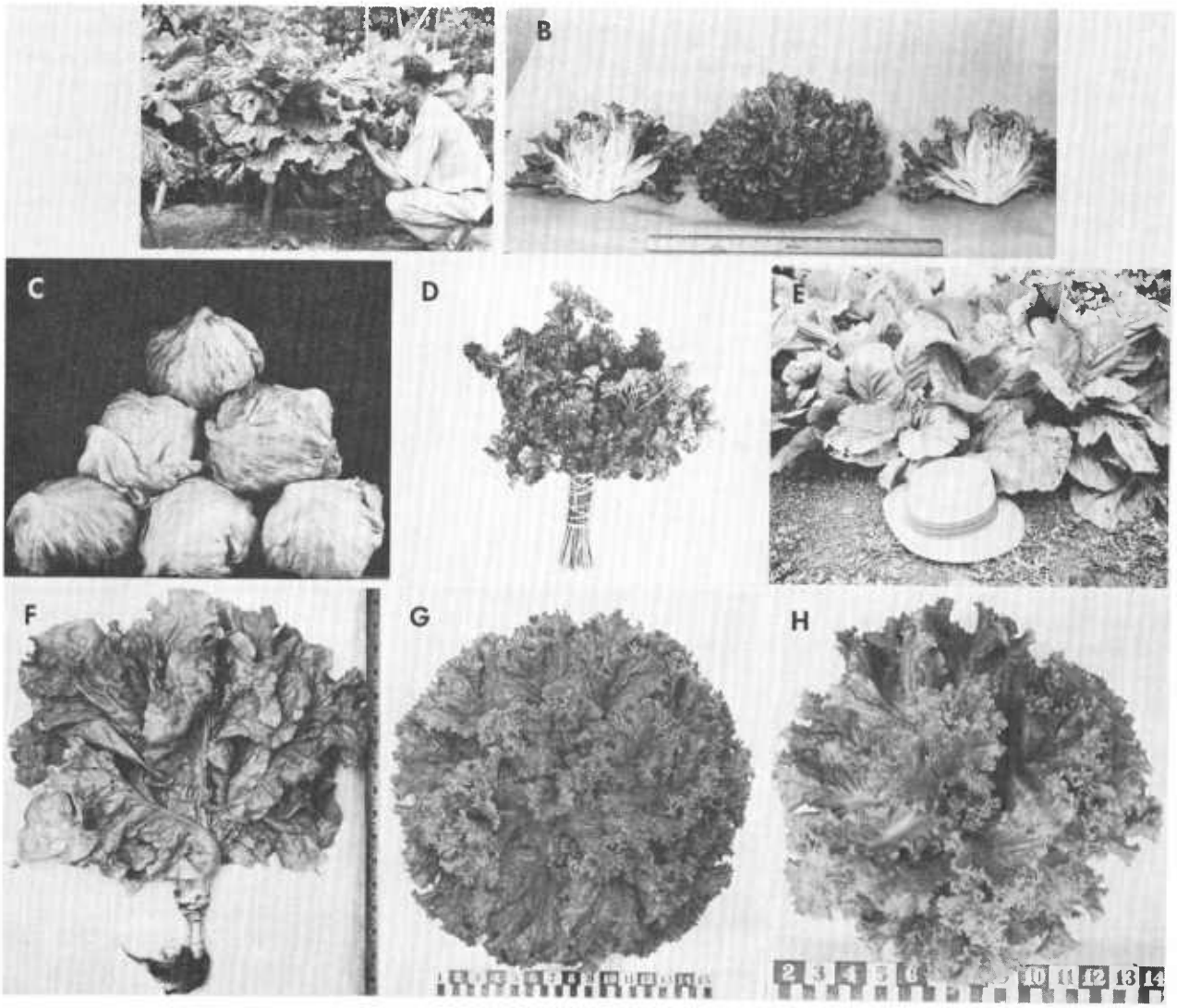


FIGURE 30.—*A*, Collard variety Southern; *B*, endive variety Broad Leaved Batavian; *C*, head lettuce variety Imperial 44; *D*, parsley variety Extra Curled Dwarf; *E*, mustard variety Florida Broad Leaf; *F*, leaf lettuce variety Black Seeded Simpson; *G*, leaf lettuce variety Slobolt grown in winter at low elevation; *H*, leaf lettuce variety Slobolt grown in summer at low elevation.

bage is a favorite vegetable in tropical areas with oriental populations. Each package of seed is likely to show much variation among the plants, and oriental gardeners often mix seed of several types to have a succession of greens. Seeds can be planted in the field at specified planting distances, or the seedlings can be transplanted from pots or seedbeds. They require the same management as head cabbage, including a complete fertilizer at planting with a side dressing of ammonium sulfate 4 to 6 weeks after planting. Many of the types perform better than head cabbage during the warm rainy season. In Hawaii varieties Shakushina and Pak Choy are used.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Collard

***Brassica oleracea* var. *acephala* DC.**
Cruciferae

Collard is a nonheading cabbage (fig. 30, *A*) that grows to a height of 3 or 4 feet before seeding. It is one of the most dependable greens in the hot, southern parts of the United States. It thrives particularly well during the cool season in the Caribbean area at all elevations, but quality is best at the higher elevations where it performs well throughout the year. The outer leaves of collard are removed when full size but still tender. They are cooked as greens. The plants may stand from October until June before seeding.

The seed should be sown in protected beds during October and the young plants moved to the garden at 1½- to 2-foot spacing after about 1 month. Later plantings can be seeded directly in the row and the seedlings thinned to 9 to 12 inches apart. As the plants become larger, they should be thinned again. The thinned plants can be used for greens. Varieties recommended are Georgia (Southern), Louisiana Sweet, and Vates.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Endive

"Escarola"
***Cichorium endivia* L.**
Compositae

This annual or biennial herb produces a dense rosette of divided, curly, or broad leaves (fig. 30, *B*) with toothed margins. The leaves have a characteristic bitter taste that is reduced by blanching. Endive is used in salads like lettuce, or it may be cooked like spinach.

Quality and growth are best during winter and spring at high elevations in the Tropics. Endive will withstand light frosts (*59, p. 262*), so can be grown throughout the year at all elevations. The leaves tend to be strong and tough during warm weather, and the centers sometimes rot during the rainy season. Growth is best where a plentiful supply of manure and commercial fertilizer is used to prepare the bed.

The seed can be sown in rows about 15 to 18 inches apart and the seedlings later thinned to 12 to 15 inches apart in the row. A side dressing of ammonium sulfate 4 to 6 weeks after the seedlings appear will help maintain good quality and tenderness of the foliage. When the plants have reached full size, the leaves can be tied together for 10 to 14 days to blanch the center leaves. Variety Broad Leaved Batavian forms a large rosette of leaves with the center ones naturally self-blanching. If rain falls frequently during the blanching period, the bunches should be inspected daily. Those with rot beginning at the centers can be harvested immediately. The curled varieties grow well but become spattered with soil during rainy weather since the leaves lie flat against the ground. Sutton's Extra Fine Green Curled is recommended.

PESTS AND DISEASES.—See pests and diseases of lettuce, page 58.

Kale

"Col Rizada"
***Brassica oleracea* var. *acephala* DC.**
Cruciferae

Kale is similar to collard in general appearance. It is usually a much smaller plant, however, with the leaves often divided to the midrib and more or less curled. Culture is the same as for collard.

The outer leaves are removed when mature in size but still tender and cooked as greens. This vegetable performs best above 1,000 feet in the West Indies, but fair crops have been obtained during the winter at sea level. A few feet of row devoted to this vegetable should be adequate in a home garden. Varieties recommended are Dwarf Siberian and Vates.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Lettuce

"Lechuga"
***Lactuca sativa* L.**
Compositae

The two types of this well-known salad vegetable most commonly grown in the West Indies are head (fig. 30, *C*) and leaf lettuce (fig. 30, *F*, *G*, *H*). Both types produce good crops at high elevations, but head lettuce can be grown at low elevations during the cool dry season only. A third type, Indian Lettuce, (*Lactuca indica* L.) is grown in the oriental tropics for use as cooked greens.

In the Tropics lettuce seed is generally sown in

boxes or beds of soil that can be protected from heavy rains. The young seedlings are delicate and do not recover easily from transplanting unless the leaves are about 2 inches long. The strongest plants are secured by direct seeding.

Lettuce will tolerate a variety of soils but grows best on a rich, light, well-drained soil. Excellent results can be obtained by digging liberal quantities of animal manure into the soil. Leaf size can be increased by applying ammonium sulfate as a side dressing or in dilute solution about 2 weeks after transplanting the seedlings. The dry fertilizer or solution will cause severe burning of the leaves if it is allowed to come into direct contact with them. A thorough sprinkling of the plants immediately after fertilizer is applied will lessen the danger of burning. Lettuce requires excellent soil drainage for best growth. Often it is necessary to plant it on raised beds to secure adequate drainage. An ample water supply is equally important and daily sprinkling of the leaves during dry periods seems to be beneficial.

HEAD LETTUCE.—Head lettuce varieties Imperial 44 (fig. 30, *C*) and Great Lakes produced moderately firm heads weighing from 1½ to 3½ pounds at 2,600 feet in Puerto Rico. At sea level Imperial 44 produced fair heads weighing from ¾ to 1½ pounds, but this was possible only from December to March. Less than 75 percent of the plants formed good heads, particularly at low elevations. The nonheading plants can be used as leaf lettuce. Several head lettuce varieties tested at low elevation in Puerto Rico produced flower stalks quickly during the summer months. Variety Imperial 847 should be tested.

Variety Mignonette formed small high-quality heads during the cool season at sea level. It matured in about 65 days whereas most larger varieties required about 80 days. The reddish-green outer leaves make this variety a distinctive type. Mignonette is more heat resistant than most heading types. It can be grown as a leaf lettuce during the summer, but should be harvested when young to avoid the development of bitterness. Tipburn of Mignonette during the summer can be prevented to some extent by regular furrow irrigation in dry periods.

The cos or romaine types of head lettuce can be grown during the winter at high elevations. Heads are cylindrical, upright, and somewhat loose. Flavor of this lettuce when properly grown is excellent.

LEAF LETTUCE.—Leaf lettuce is popular in the Tropics. Beds of light yellow lettuce, principally variety Black Seeded Simpson (fig. 30, *F*), are a common sight in and near the large cities during the cool season. Under the warm temperature conditions of summer, Black Seeded Simpson sends up flower stalks, thus reducing the number and size of the leaves. The U.S. Department of Agriculture developed the heat-resistant variety Slobolt (fig. 30, *G*, *H*), which resembles Black Seeded Simpson in appearance but is better adapted to year-round tropical conditions (*7*). Slobolt, as the name indicates, is slow to send up flower stalks under high temperature conditions. The individual plants grow to very large size at low elevation during the winter and to medium size during the summer. This variety is particularly recommended where the mean temperature is between 75° and 80° F. The recently introduced varieties Salad Bowl and Ruby (*33*) are said to be very tolerant to heat also and to be slow in bolting.

Leaf lettuce can be planted directly in the garden and later thinned, using some of the thinnings on the table and transplanting others to new rows on either side and close to the main row. Thus, these side rows of seedlings are ready to harvest when the plants in the main row are about gone. For this type of management the original rows should be spaced 18 to 24 inches apart.

A method frequently used in small market gardens in Puerto Rico is to sow the seed over well-manured beds (figs. 14 and 15). Seedlings are transplanted at the 3- to 4-leaf stage to neighboring beds at distances of 6 to 12 inches both ways.

A liberal supply of manure and a complete fertilizer relatively high in nitrogen should be used at planting. Leaf lettuce must be kept growing rapidly by frequent furrow irrigations during dry periods and by a side dressing of ammonium sulfate 2 to 3 weeks after the seedlings are up and well established. During the summer the use of cheesecloth, burlap, palm leaf, or lath shade to reduce the heat of the sun is helpful in growing crisp, sweet leaves.

Leaf lettuce is a good crop to intercrop with slow-maturing large crops, such as corn, tomato, and eggplant. In fact, lettuce grows well and is often of higher quality when cultivated under the medium to thin shade of these plants. Leaf lettuce can be harvested within 30 to 40 days after planting. Entire plants can be harvested, or only the lower leaves of a stalk can be removed when they are a good size, thus permitting the plant to continue to produce new leaves for a month or longer.

PESTS AND DISEASES.—Lettuce is not heavily attacked by any single pest in tropical America. General pests, including aphids, armyworms, flea beetles, leafhoppers, leaf miners, spider mites, thrips, webworms, and wireworms, are sometimes found associated with lettuce plants. The cabbage looper can be very damaging if large numbers of its more usual host plants are planted nearby. (See cole crop pests for control measures of the cabbage looper, p. 98.) During wet weather downy mildew and cercospora leaf spot can be damaging. Yellows and mosaic viruses

are also sometimes present if leafhopper or aphid populations are high.

Mustard

"Mostaza"
***Brassica juncea* (L.) Czern. & Cosson.**
Cruciferae

This group of mustards is usually grown for cooked greens since the pubescent leaves are objectionable to most people in salads. There are smooth-leaved varieties, however, which make excellent salads when young and tender. Mustard grows particularly well at higher elevations in the Tropics (fig. 30, *E*) but does not always produce seed there.

Fair crops have been grown at sea level in summer, but for acceptable quality only young leaves were harvested. Seeds are planted in rows 18 to 24 inches apart and the plants later thinned to 4 to 6 inches apart. A few feet of row should supply the needs of one family. Leaves are ready to harvest in about a month. The outer leaves of the bunches should be harvested when full grown but still tender. If harvested later, they will be tough and strong. The plants usually go to seed during the spring and summer and should be harvested completely when the seedstalks begin to appear. Varieties Florida Broad Leaf and Fordhook Fancy grow well in the Caribbean area. Tendergreen or mustard spinach (*Brassica perviridis* (Bailey) Bailey) is more resistant to heat and drought than are varieties of *B. juncea*. It matures rapidly and is ready for use in about 30 days.

PESTS AND DISEASES.—Pests are those of cabbage family plants. Mustard appears to be relatively disease resistant.

New Zealand Spinach

"Espinaca de New Zealand"
***Tetragonia expansa* Murr.**
Aizoaceae

New Zealand spinach is a spreading annual herb with thick fleshy leaves and small greenish flowers in the axils of the leaves. New Zealand spinach is a good substitute for true spinach at elevations and temperatures where true spinach does not succeed. It grows satisfactorily throughout the year and seeds freely under West Indian conditions. It is fairly drought resistant. A few plants will produce enough greens for the family for many weeks, provided liberal quantities of fertilizer at planting are followed by monthly side dressings of ammonium sulfate to keep the foliage tender and vigorous. The seed, which should be soaked for 24 hours before planting, is sown in rows 1½ to 2 feet apart, and the plants are later thinned to about 12 to 15 inches apart. About 3 inches of the branch tips and tender leaves are removed for greens. Additional side shoots appear for later use.

PESTS AND DISEASES.—See pests and diseases of beets, page 66.

Parsley

***Petroselinum crispum* (Mill.) Nym.**
Umbelliferae

This low-growing biennial herb is cultivated for its leaves, which are used for garnishing, flavoring, and, to some extent, for salads.

Parsley grows well throughout the season at high elevations, but fair crops can be grown in the lowlands. Figure 30, *D* shows parsley variety Extra Curled Dwarf that was grown at a 3,200-foot elevation in Puerto Rico. The older leaves are harvested from the outside of the plants. One crop is grown in the garden for a year or more. Temperate climate varieties, such as Extra Curled Dwarf or Moss Curled and Paramount, do not go to seed under West Indian conditions. The smooth or plain-leaved varieties are more popular locally, probably because of their resemblance to coriander.

Seeds will germinate better if soaked for 12 to 24 hours before planting. The small seeds are sown about one-fourth inch deep and covered with a mulch until the plants begin to appear. A complete fertilizer at time of transplanting and subsequent side dressings of a nitrogen fertilizer at monthly intervals will help keep the plants vigorous and the leaves tender. Only a few plants in the garden will supply all home needs. The plants may be used with other herbs to form an ornamental border for the vegetable garden. In locations without suitable soil for a vegetable garden, a few parsley plants can be grown in boxes or other containers in a protected area of the property. There is some market demand for parsley at holidays, especially during Holy Week in the Caribbean area, but the market can be quickly flooded.

PESTS AND DISEASES.—See pests and diseases of celery, page 54.

Rhubarb

***Rheum rhaponticum* L.**
Polygonaceae

Rhubarb is not especially recommended for the Tropics, but it can be grown in many locations if particular care is given to its requirements. Rhubarb is grown for the large thick leafstalks or petioles, which make excellent sauces and pies. No other part of the plant is edible. It is a peren-

nial crop and should be placed at the side of the garden. A short row will meet the needs of the average family. The best results with rhubarb in the Tropics have been obtained under the climatic conditions found at elevations above 3,000 feet.

In the Tropics rhubarb is usually started from seed, but it can be established from dormant crowns if these can be imported from temperate regions. Seeds are drilled thinly in rows 2 to 3 feet apart and covered with about one-half inch of soil. When they are a few inches high, the plants are thinned to about 2 to 3 feet apart in the row. In thinning, the most vigorous plants and especially those showing the most reddening of the leafstalks should be left. Transplanting small seedlings is possible but recovery may be slow.

Rhubarb responds well to heavy applications of manure and commercial fertilizer, particularly nitrogen. At high elevations the plant is semidormant in the cold months and should be forced into vigorous growth with nitrogen and irrigation when the temperature begins to rise. At low and medium elevations in the Tropics, rhubarb can be treated as an annual or biennial by planting seed each year.

The soil should be well prepared and enriched with manure and a complete fertilizer. The seeds are planted at the beginning of the cool part of the year and the plants thinned, as previously described. Uniform soil moisture should be maintained by irrigation. Side dressings of ammonium sulfate at monthly intervals also help maintain vigorous growth. The outer leaves can be removed when petioles are large enough for use; petioles of the later thinnings also can be used.

Plants are kept growing vigorously throughout the first season, when they are harvested periodically. With the advent of the second dry season, the plants are allowed to rest for a few weeks, after which they are forced into growth by applying water and fertilizer. Not all plants will survive the rainy season or the following dry season. For this reason a new planting is started each year and when it is in production, the old planting is discontinued. The variety Victoria was the most satisfactory grown in the West Indies. Rhubarb variety Sutton's, recommended for the plains of India, could be tried in the warmer sections of the Caribbean area.

Research has shown that rhubarb juice, which contains an oxalate, is valuable for reducing corrosion of the teeth caused by excessive acid in lemon juice and cola drinks (*1*).

Pests and Diseases.—Rhubarb is relatively free from pests and diseases. Occasionally, weevils attack stems. Rots caused by fungi are sometimes found on rhubarb stems.

Spinach

"Espinaca"
***Spinacia oleracea* L.**
Chenopodiaceae

The true spinach is an annual plant with a rosette of thick leaves varying from arrow shaped to broadly rounded, according to the variety. Male and female flowers are produced on separate plants. Spinach is eaten as boiled greens or raw in salads.

Temperatures in most regions of the Tropics are too high for satisfactory growth of spinach. It can be grown satisfactorily during winter in Hong Kong (*17*) and in the Caribbean area at elevations where mean temperatures range from 55° to 65° F. for at least part of the year. It grows best on slightly acid to alkaline soil. Abundant manure, water, and commercial fertilizer are needed to produce tender, high-quality foliage.

Pests and Diseases.—Aphids, cutworms, webworms, and weevils are the usual pests of true spinach. Plant diseases are usually uncommon except in very wet areas where damping-off disease and downy mildew sometimes occur. Mosaic virus also attacks spinach.

Other Greens[3]

The leaves and shoots of several other plants are used for food in some areas of the Tropics, but in other areas they are not even recognized as being edible. In the West Indies, water cress (*Nasturtium officinale* R. Brown) is eaten as a salad and is sometimes cultivated along mountain streams. Propagation is either by imported seed or by stem pieces. The leaves and stems of purslane (*Portulaca oleracea* L.) can be eaten either raw or cooked. French seed catalogs list varieties of purslane that are said to be more erect and vigorous than the wild type but they have not been tested in the Caribbean area.

Hibiscus manihot L. is grown in some areas for its edible leaves. The young shoots of sweetpotato (*Ipomoea batatas* (L.) Lam.) and *I. reptans* (L.) Poir. are eaten as cooked green vegetables in some areas.

Legume Vegetables

Leguminosae

All the vegetables described under this heading belong to the family Leguminosae and at the mature stage are particularly valuable in the diet as sources of vegetable protein. The plants also are valuable as rotation crops since they enrich

[3] The recent publication by G. J. A. Terra lists 658 species of plants, the leaves and young shoots of which are eaten as boiled greens in some parts of the Tropics. (See Additional References, p. 112.)

the soil with nitrogen, which becomes available to crops following in the rotation. For the greatest benefit to the soil, the plants should be spaded under immediately after the crop is harvested. Many legume vegetables are adapted to the Caribbean area (figs. 31, 32, 33).

Where leguminous plants are to be grown on new garden locations, inoculation of the seed with cultures of nitrogen-fixing bacteria may promote more luxuriant growth. A mixed inoculant suitable for all the common peas and beans can be purchased from mail order seed houses. Usually a garden-size packet is offered for home vegetable gardeners. Once used, the inoculant will remain alive in the soil for many years.

Cowpea

"Fríjol"

***Vigna sinensis* (Torner) Savi.**

The cowpea (fig. 31, *A*) is an annual beanlike bush or twining plant. Three types are commonly found in cultivation—(1) the dwarf nonclimbing type with pods carried above the foliage (fig. 31, *A*), (2) the standard twining type, and (3) the twining or Yardlong type with long twisted pods, which is designated as *V. sesquipedalis* (L.) Fruwirth.

FIGURE 31.—*A*, Dwarf cowpea with pods held above the foliage; *B*, immature pods of the Goa bean.

The standard twining type is most commonly cultivated in the Caribbean area and in most other parts of the Tropics. In the southern United States several dwarf varieties have been developed in recent years because of their greater adaptation to mechanized agriculture.

The cowpea grows satisfactorily at all elevations in the Caribbean area, but yields less during the season of heavy rainfall. The standard varieties Blackeye, Brown Crowder, and Cream Lady yield satisfactorily at near sea level. Yields of Yardlong were only fair.

The cowpea, like other legumes, is high in food value. The pods, when young and tender, can be used like snap beans, or the seed can be allowed to develop to the green tender stage for cooking like lima beans. The crop also can be left to mature, then harvested and cooked like dried beans. The cowpea will grow on a wide variety of soils provided drainage is good. Culture is similar to that for soybeans. It is frequently interplanted with corn. The Yardlong type requires trellising to prevent the 2- to 3-foot long pods from touching the ground.

PESTS AND DISEASES.—See pests and diseases of kidney bean, page 62. A leaf beetle *Cerotoma ruficornis* (Olivier) also attacks the leaves of cowpea (fig. 32, *A*) and other legumes.

Kidney (Common) Bean

"Habichuela," "Fríjol"

***Phaseolus vulgaris* L.**

The kidney bean (fig. 33, *A*) also is called French bean in many areas of the world. In the United States it is called bush or snap bean when grown for the green pods. The plants are dwarf (bush) or climbing (pole) annual herbs with white or lilac flowers. There are many varieties with white or colored seeds, with considerable variation in seed size.

Beans can be grown throughout the year at low to moderately high elevations and at temperatures from 65° to 80° F., but best production is obtained in the winter and spring when rainfall is not excessive. Fair crops of bush bean varieties have been obtained, however, at elevations of 2,000 to 3,000 feet in spite of rains. Beating rains can reduce the crop by aggravating diseases, interfering with pollination, and perhaps knocking off some of the blossoms.

The bush varieties Black Valentine, Bountiful, Contender, Stringless Green Pod, Tendergreen, and Improved Tendergreen, and the golden- or

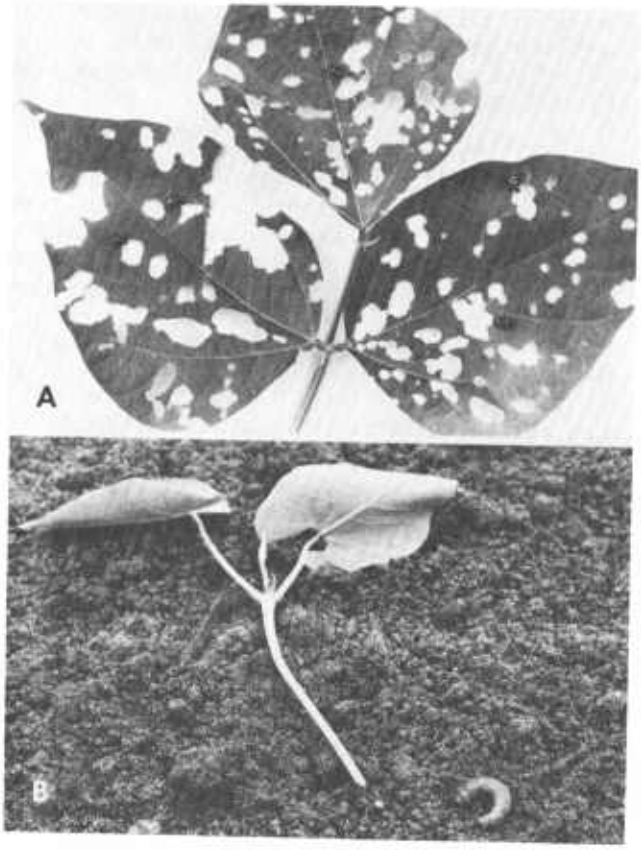


FIGURE 32.—*A*, Cowpea leaf riddled by leaf beetles (*Ceratoma ruficornis* (Olivier)); *B*, typical cutworm injury to bean plant.

waxy-podded varieties perform well from October to May, and also in summer when an attempt is made to control the leafhopper, a serious pest in many tropical regions. Bountiful is especially susceptible to leafhopper damage. At Isabela, the Agricultural Experiment Station of the University of Puerto Rico has selected a number of improved bush bean lines highly resistant to local insects and diseases. The best of these are No. 1329 (fig. 33, *A*), No. 1395, No. 1435, and No. 1632. Selection No. 1632 is a white-seeded bean recently named Bonita. Beans of these selections can be used as snap green beans if harvested when the pods are young, or they can be grown for dry beans. Yields have amounted to as many as 374 pounds of shelled dry beans per acre (*41, 1945–46*). No. 1329, No. 1395, and No. 1435 have superior cooking quality.

Rust-resistant strains of Kentucky Wonder, Blue Lake 231, and Florigreen are pole bean varieties with acceptable yields. The variety McCaslan should be tested.

Bean seeds should be planted from about ¾ to 1½ inches deep and spaced 3 to 6 inches apart in the row for bush varieties and 12 to 18 inches for pole varieties. A heavy application of well-rotted manure should be mixed with the soil during seedbed preparation and a complete fertilizer high in phosphorus added in furrows on either side of the seed furrow at planting time (fig. 14, *F*). For best production, beans should be kept growing vigorously to develop a good-size plant before flowering begins. A side dressing of ammonium sulfate is recommended when the first pods are setting; fertilizing at this time should prolong the harvesting season and increase the size of the pods.

The pods should be harvested while young and tender and before they become "lumpy," which is an indication of maturity and toughness. Picking at 3- to 4-day intervals keeps the plants producing freely; vines are weakened by allowing pods to hang on until mature. It is best to harvest beans while the plants are dry to avoid spreading pod and leaf diseases. Harvested pods should be either cooked or refrigerated immediately to maintain good cooking quality.

Bush varieties have a harvest period lasting for 2 to 3 weeks; pole varieties usually bear an additional 2 to 3 weeks. Bush varieties bear a week or so before pole varieties. Irrigation is necessary during dry periods, particularly during the harvest season.

Although bush varieties are easier to plant and manage in home gardens, pole varieties usually bear better per unit of ground and do not need to be planted so frequently. Tripods of bamboo poles are good supports for pole varieties.

The scarlet runner bean (*Phaseolus coccineus* L.) produces well at high elevations in the Tropics during the dry season, but does not produce well in the lowlands.

PESTS AND DISEASES.—A wide variety of insects and diseases attack the leguminous plants. Most damaging among the insects are bean leaf beetles, leafhoppers, the lima bean pod borer, and corn earworms. Cutworms are particularly troublesome to beans (fig. 32, *B*), the cucurbits, and tomatoes. Dry beans in storage may become infested with bean weevils. Diseases commonly affecting legumes include anthracnose fungus, bean mosaic virus, powdery mildew, root rot fungus, and rust.

Lima Bean

"Haba Lima"
***Phaseolus lunatus* L.**

The lima bean plant is a perennial dwarf or twining herb usually cultivated as an annual. The pods are flat and somewhat curved and contain several white, colored, or mottled seeds. Many cultivated varieties differ in appearance of pods and seeds and in plant habit. Dried seeds of the

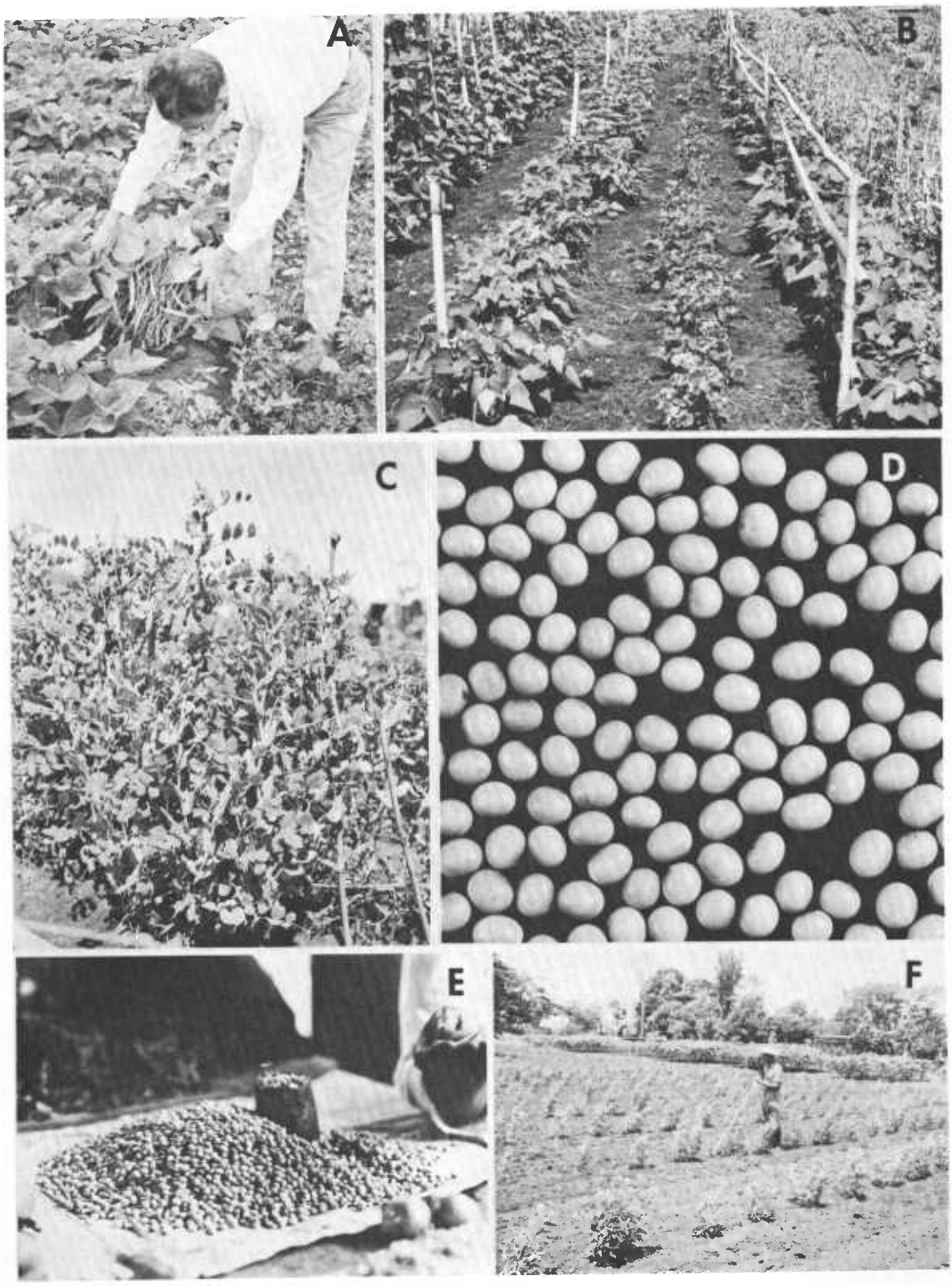


FIGURE 33.—*A*, Kidney bean selection (No. 1329); *B*, lima beans showing relative resistance to leafhopper damage—*left to right*, King of the Garden pole lima and Imperial Fordhook, Henderson, and Fordhook bush limas; *C*, edible-podded pea variety Melting Sugar; *D*, large yellow-seeded soybean variety Seminole; *E*, green shelled pigeonpeas (gandules); *F*, field of young pigeonpeas.

lima bean for cooking are known as butter beans. In the home garden they are grown almost entirely for green shell beans.

The culture of lima beans is the same as for kidney (common) beans except that more space is required for the plants. The seed should be planted ¾ to 1½ inches deep and 3 to 4 inches apart in rows spaced 1½ to 2 feet apart. About 1 pound of the large-seeded or ¾ pound of the small-seeded varieties is required for 100 feet of row. In heavy soils it is sometimes helpful to set the large seeds on edge with the hilum down to avoid breaking the emerging shoots.

Results with lima beans in the West Indies have been variable. Pod borers and leafhoppers appear to be the principal pests. Insect damage is greatest during the warm moist season until about October, when fair sets of pods have been noted on both cultivated and native varieties (*40, 1937, p. 59*). Summer temperature can be an important limiting factor, for temperatures above 80° F. are generally known to reduce set.

Good yields of 30 varieties of small- and large-seeded, pole and bush lima beans were obtained (*43, p. 62*) at Mayaguez, P.R., when the crop was planted at the beginning of the cool dry season. Best yielders were the large-seeded pole varieties, including Early Leviathan, Ford Mammoth, and Burpee Sunnybrook, which produced, respectively, 533, 524, and 512 bushels of shell beans per acre, about 54 percent being hulls. The glossy foliage of the small-seeded bush varieties was more susceptible to leafhoppers, which caused curling, discoloring, and dropping of the leaves.

At Mayaguez in 1945 the variety Henderson planted in January was severely injured by leafhoppers, whereas Fordhook was relatively resistant (fig. 33, *B*). Fordhook 242 is recommended for trial in warm climates.

Good yields of lima beans have been reported in Hawaii for large-seeded varieties, such as Fordhook Bush, Fordhook Pole, and King of the Garden (*11, pp. 78–79*). Small-seeded varieties, such as Henderson, Baby Potato, and Hopi, also yielded well. Although a factor in Hawaii, the pod borer is effectively controlled by dusts or sprays. At Mayaguez fair yields with Fordhook Bush were obtained in summer when the crop was sprayed for leafhoppers.

The lima bean can be harvested over a longer period than green beans. Under good conditions vines of King of the Garden will bear for several years. For best cooking quality they should be harvested before the beans reach the white stage. Only experience will indicate the best stage for picking.

Lima beans contain traces of hydrocyanic acid, but the quantity usually is not sufficient to be of any concern. The colored- or mottled-seeded varieties contain more than the American white-seeded varieties, but native West Indian white-seeded races also may be toxic in the raw state. Soaking the dry beans in water for a few hours before cooking will dissipate the poison. Both this water and the first water in which the beans are boiled for a few minutes can be discarded as a precaution.

PESTS AND DISEASES.—See pests and diseases of kidney bean, page 62.

Pea

"Guisante," "Petit pois," "Arveja"
***Pisum sativum* L.**

This is the common garden pea of temperate climates. It is an annual herb with compound tendril-tipped leaves. The different varieties vary in size from dwarfs 1 foot high to plants 7 feet high. Two types are cultivated, the English or green pea and the edible-podded (fig. 33, *C*) sno or sugar pea. Varieties of the English or green pea types can be distinguished by the inflated young pods, which become filled as the seeds enlarge. The seeds are removed from the pods for cooking at maturity, but while still green. The developing peas of the edible-podded type distend the thin walls of the pod. The pods are cooked and eaten at this young stage like snap beans or are mixed with other foods. If allowed to grow to maturity, this type also must be shelled before it can be used.

Peas are a fairly satisfactory home garden crop in the highland Tropics for the home gardener accustomed to the flavor of fresh peas as compared with the canned product. The English pea type does not produce well at low elevations even in winter. The temperature range for good production is relatively low and narrow (55° to 65° F.). During winter and spring, fair to good crops of the variety Telephone, an English type, were grown at 3,200 feet in Puerto Rico. Variety Melting Sugar (figs. 4 and 33, *C*), an edible-podded type, produced almost twice as much as Telephone. Melting Sugar gave fair to good summer crops at these higher elevations (fig. 4) and a fair winter crop at sea level. The Hawaii Agricultural Experiment Station has released a new powdery mildew-resistant variety Manoa Sugar that is said to tolerate the warm lowland climate of Hawaii (*12*).

Sometimes peas can be grown well on moderately fertile soil without the application of fertilizer. However, complete fertilizers at planting and a later side dressing of superphosphate appear desirable under most conditions. Fertilizer should be placed in furrows 2½ inches on either side of the row and 1 inch deeper than the seed (fig. 14, *F*).

Double rows of peas are planted 6 inches apart and later the seedlings are thinned from 2 to 6

inches apart in the row. Some support will be needed for the vines of the tall varieties. A fence made of bamboo, chicken-wire, or small branches of trees stuck into the ground (fig. 4) is usually satisfactory.

PESTS AND DISEASES.—See pests and diseases of kidney bean, page 62.

Pigeonpea

"Gandul," "Gandur," "Fríjol de Palo"
***Cajanus cajan* (L.) Millsp.**

The pigeonpea (gandul) (*23*) is an erect, branched perennial shrub with narrow trifoliate leaves, which can grow to a height of 10 or 12 feet. It bears small yellow and maroon pealike flowers in axillary racemes. The pods are pealike, hairy, and obliquely constricted between the 3 to 7 seeds. The many varieties differ in the size and vigor of the plant, in period of production, and in seed color. Seeds vary from white to red or almost black; some are spotted. The pigeonpea is a popular food crop in the West Indies (fig. 33, *E*). The reported farm value in Puerto Rico for the year 1957–58 was $1,665,000, when a total of 111,000 hundredweights was harvested. According to Lloréns and Olivieri (*26*), about 75 percent of the Puerto Rican production is canned for local consumption and for export.

The pigeonpea (fig. 33, *F*) will grow on a wide variety of soils, attaining a height of 3½ to 4½ feet on poor soil in dry regions and 11 to 12 feet on rich loamy soil in moist regions. It is one of the most drought-resistant vegetables because of its extensive fibrous root system, which also serves as a soil-holding mat. The pigeonpea can be planted on the slopes of bench terraces to hold the soil. It grows well at low to moderately high elevations.

If pigeonpea is grown for a windbreak, the seed is planted in rows 2 to 4 feet apart. For a tall woody windbreak, the blossoms should be removed for some time to promote thick vegetative growth. The seedlings should be thinned to about 2 feet apart at the end of the first year if the windbreak is to be maintained for 2 years or longer. The windbreak should be planted 8 to 10 feet from the nearest vegetable to avoid competition. If grown principally for food, the pigeonpea is planted from February to May in rows 6 to 8 feet apart with 2 to 3 feet between plants. The pigeonpea is commonly interplanted with corn, squash, or beans, but this practice is likely to result in reduced yields of both crops. For plantings made after May, a spacing of 3 feet is given in rows 3 feet apart. Pigeonpeas can be treated as annual or biennial plants. After the first crop, the plants should be pruned to encourage branching for the second crop.

Several varieties of pigeonpea are grown in the West Indies. The short-growing variety Totiempo is planted in March or April and bears for about 6 months, from November to April, with intermittent flowering at other seasons. The early variety Kaki (Caqui), planted about the same time, is more productive but fruits for only 3 months, beginning in mid-December. The late variety Saragateado is less productive than Kaki. Pod borers are serious pests during the summer months on varieties, such as Totiempo, which are in fruit at that time, but they are relatively unimportant on early varieties fruiting during the cool dry season. Yields of seed may reach 800 pounds per acre when pigeonpeas are planted as a pure crop. Fertilizing is not recommended. The shelled half-ripe seed is stewed and eaten with rice and chicken or used in vegetable soups, curries, and similar dishes.

Soybean

"Habichuela soya"
***Glycine max* (L.) Merr.**

This hairy annual legume bears large long-stalked trifoliate leaves and many small two- to four-seeded pods closely set in short racemes along the main stalk and side branches. Most varieties grow stiffly erect to 2 feet tall, but some are semiprocumbent. Leaves, stems, and pods are softly pubescent.

The planting of soybeans should be encouraged because of their extremely high nutritive value. Under most tropical conditions this vegetable will produce heavily, particularly when planted as the days grow longer. The large yellow-seeded variety Seminole (fig. 33, *D*) has performed satisfactorily at all seasons in Puerto Rico. Growth and production were definitely highest when Seminole was seeded in February to March.

White- and black-seeded varieties of soybean are sometimes cultivated. Varieties recommended for trial in the West Indies are Lee, Hardee, and Improved Pelican (*33*), but only Hardee has seed large enough to be of value as a vegetable.

When planted during the rainy season, soybeans should be seeded on ridges 6 to 8 inches high, 18 to 24 inches apart. Seeds are planted 3 to 5 inches apart in the row. Succession plantings can be made every 3 to 4 weeks, so that a continuous supply will be available throughout the year. A complete fertilizer or ammonium phosphate should be applied before planting, either in furrows on both sides of the seed furrow, or 1 or 2 inches beneath the seed furrow. If the soil is very acid, lime should be applied to bring the pH to about 6.5. Irrigation is sometimes necessary, particularly during the early stages of development.

Soybeans are best for eating when cooked like lima beans. The tedious task of shelling can be made easier by soaking the small pods in boiling

water for a few minutes then dipping them in cool water. The plump seeds then can be forced out of the pods by slight pressure between the thumb and forefinger.

PESTS AND DISEASES.—See pests and diseases of kidney bean, page 62.

Other Legume Vegetables

Several leguminous plants are grown for food in some parts of the Tropics but are unknown in other parts. Of particular interest is the "chícharo," also called bonavista, Egyptian kidney, or hyacinth bean (*Dolichos lablab* L.). This twining perennial produces clusters of fragrant white or purplish-red flowers that are followed by edible pods. The mature white, black, or reddish beans also are edible.

The Goa, four-angled, or winged bean (*Psophocarpus tetragonolobus* DC.) (fig. 31, *B*) is well adapted to low moist areas of the Tropics. It is a strong-growing twining herb with tuberous roots. The pale-blue flowers are followed by four-winged pods that sometimes attain a length of 8 inches. The immature pods are sliced and boiled as a vegetable.

The sword bean (*Canavalia gladiata* DC.) is sometimes grown for the young pods that are sliced and boiled as a vegetable. It is said to be more palatable than the jack bean or "haba de burro" (*C. ensiformis* (L.) DC.). The two species are distinguishable by the hilum of the seeds. The hilum of the *C. gladiata* is more than one-half the length of the seed, whereas that of *C. ensiformis* is only about one-third as long.

The "gallito," a small leguminous tree (*Sesbania grandiflora* (L.) Pers.), is cultivated as a vegetable crop. The leaves, young pods, and flowers are stripped from their stalks and lightly steamed or boiled. The flowers also are dipped in batter and fried.

The peanut or groundnut (*Arachis hypogaea* L.) is cultivated in coastal parts of the Caribbean area with light, friable, well-drained soil. It is planted toward the end of the rainy season and harvested during the dry season. The varieties available locally probably are better adapted than imported varieties.

The bambarra or Madagascar groundnut (*Voandzeia subterranea* Thouars.) is a common article of food in tropical Africa. Like the peanut, it has been introduced in other areas. The kandela bean (*Kerstingiella geocarpa* Harms) is similar to the bambarra groundnut.

Several oriental bean species have been introduced in the West Indies and can be cultivated by the home gardener. All are edible. The more common are adzuki bean (*Phaseolus angularis* (Willd.) Wight.), mung bean (*P. aureus* Roxb.), rice bean (*P. calcaratus* Roxb.), and cluster bean (*Cyamopsis psoralioides* (Lam.) DC.).

Root Crops

Beet

"Remolacha"
***Beta vulgaris* L.**
Chenopodiaceae

The garden beet is a biennial herb cultivated as an annual. It produces a rosette of long-petioled erect dark-red or yellowish-green leaves. The main axis of the root system thickens into a red-fleshed tapering or globular organ. Beets are a valuable crop in the garden, not only for the fleshy roots but also for the tops, which can be used as greens.

Beets grow best under cool conditions. Good results have been obtained throughout the year at elevations above 3,000 feet in the Caribbean area. At lower elevations the best crops were grown during the cool season. Beets can be grown during the summer at low elevations, but their size, quality, and color may be somewhat inferior.

Special attention must be given to preparing a fine seedbed to insure good germination and early growth. Manure and complete fertilizers should be incorporated into the soil before planting. In tests in Puerto Rico, the addition of 300 to 500 pounds per acre of common salt (sodium chloride) (*16, p. 24*) often doubled root size. Figure 34, *D* shows beet variety Detroit Dark Red grown at a low elevation. The beets on the right are from a field receiving 500 pounds per acre of common salt; beets on the left received no salt. Beets do not perform well on very acid soil. When the soil is very acid, lime should be applied to bring the pH to around 6.0 to 6.5.

The seed should be distributed in a row 4 inches wide to achieve good spacing of the plants. Germination can be improved during dry weather by covering the seed row with a layer of rotted manure (fig. 14, *H*), paper, or cloth to conserve moisture. Soil should be kept moist by regular irrigation. In beet the entire dried fruit or seed ball is planted. The seed balls frequently contain more than one seed, so that two or three plants may be expected to develop from each. As the plants develop, they should be thinned to about 2 to 3 inches apart; the thinnings can be used for greens. Beets should be harvested before they become overmature, tough, and woody. They are boiled whole before peeling to avoid leaching the dark-red color. The various dark-red varieties performed about equally well. (See table 2, p. 10.)

PESTS AND DISEASES.—No specific insects attack beets, but flea beetles can be very damaging to foliage at times. Other general feeders include weevils, leaf rollers, and webworms (fig. 28, *D*). Damping-off disease can be serious when plants

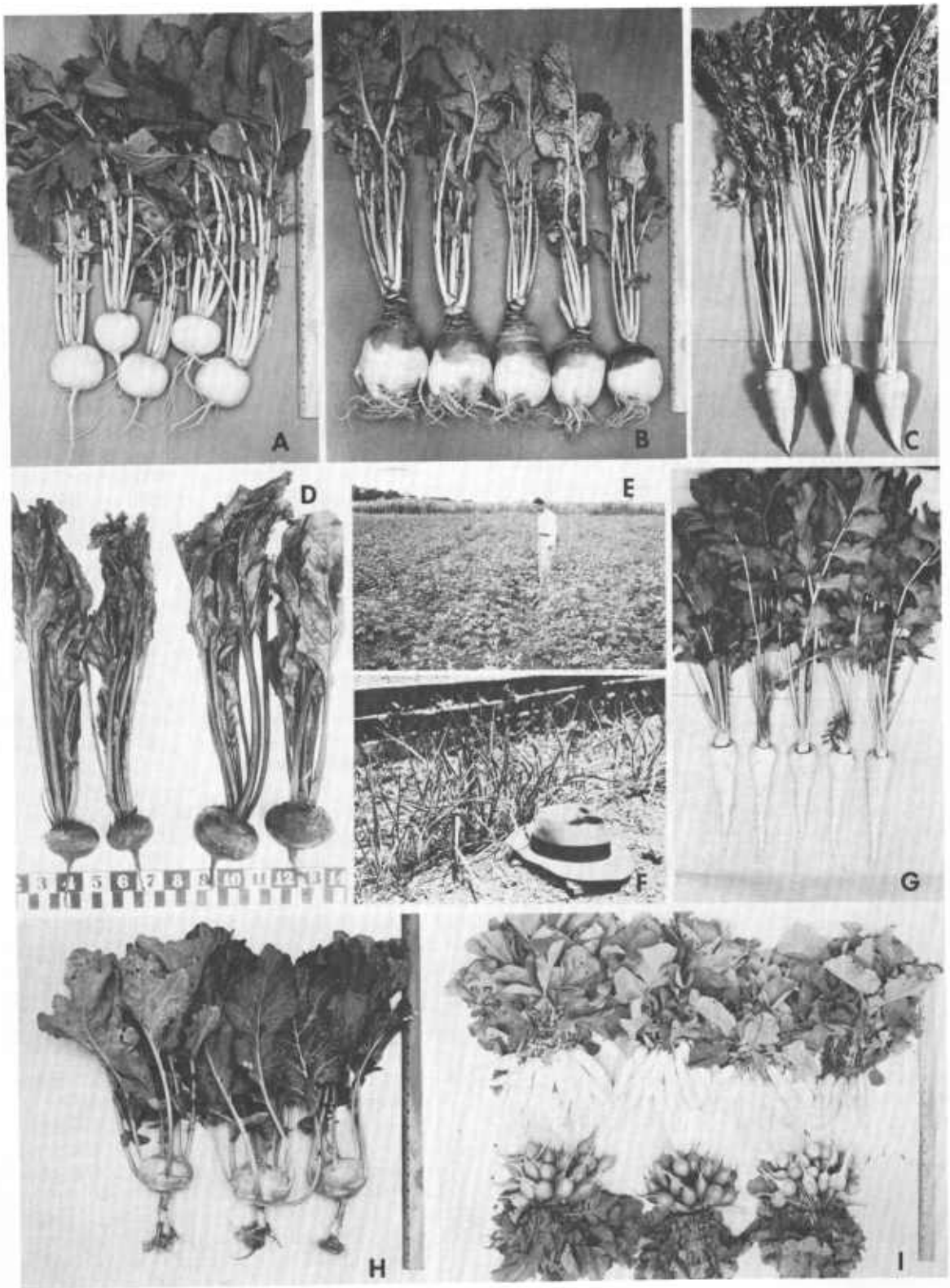


FIGURE 34.—*A*, Turnip variety Purple Top White Globe; *B*, rutabaga; *C*, carrot variety Danvers Half Long; *D*, beet variety Detroit Dark Red; *E*, field of potatoes; *F*, salsify (vegetable-oyster); *G*, parsnip variety Hollow Crown; *H*, kohlrabi variety Early White Vienna; *I*, seven radish varieties.

are very young. Leaf spot is common during rainy seasons but does not often cause severe damage.

Carrot

"Zanahoria"
***Daucus carota* L.**
Umbelliferae

The carrot (fig. 34, *C*) is a biennial herb with a swollen taproot and fernlike foliage. The roots are eaten either raw or cooked. The many varieties usually are named for characteristics of the roots, such as flesh color, for season, and for shape. The early-season, short- or medium-rooted varieties usually have performed better in most tropical locations than other varieties.

Carrots are a fairly dependable crop in the Caribbean area. In Puerto Rico, they have grown satisfactorily every month of the year at high and low elevations, but they produce best during the cool winter and spring seasons. Carrots tend to be "strong" and tough under high temperature and dry conditions, and the coloring is subdued under a combination of high temperature and heavy rainfall. The principal limiting factor during the heavy rainfall season is that the seeds and delicate seedlings may be washed out of the soil. Windbreaks are essential in windy areas.

Carrots develop best in light, sandy, well-drained soil. In heavy soil the roots are sometimes gnarled, poorly shaped, and difficult to prepare for cooking. In Puerto Rico, variety Danvers Half Long (fig. 34, *C*) has been superior in yield to Imperator, Morse Bunching, and Red Core Chantenay in the heavy soils. Germination is sometimes low during hot dry weather. A mulch of well-rotted manure or similar material (fig. 14, *H*) helps to keep the soil moist during germination. Seeds should be distributed in a row 4 inches wide so that the carrots will later stand 2 to 3 abreast in the row. When the carrots are about the size of the little finger, the plants are thinned to stand about 2 inches apart. Thinnings can be used in salads. Harvesting can be started when the roots are about 1 inch in diameter at the crown and continued until the planting is exhausted. The smaller roots tend to shrivel rapidly after harvest.

The soil should be kept as uniformly moist as possible. A period of wet weather following a dry spell can cause splitting of the roots, which is sometimes followed by rotting.

PESTS AND DISEASES.—The most damaging North American carrot pest, the carrot caterpillar, is not found in the American Tropics. Its swallowtail butterfly relatives are only minor pests or attack pipevine (*Aristolochia*) or citrus trees. Several general pests, including cutworms and leafhoppers, can be troublesome. Leaf spot and blight fungus sometimes cause leaf damage or defoliation during long rainy periods but they do not often kill the plant. Yellows or wilt virus stunts plants. Bacterial root rots sometimes cause damage during cool rainy seasons of greater than average rainfall.

Cassava

"Guacamote," "Yuca"
***Manihot esculenta* Crantz.**
Euphorbiaceae

Cassava (fig. 35, *A*) is not a crop for the small home vegetable garden, but it is an important food crop in many areas of the Tropics. It is a shrubby perennial grown widely for the large fleshy, tuberous, starchy roots, which are frequently used in soups and stews and from which a coarse flour, bread, and commercial tapioca are made. Some cassavas are bitter, some are sweet. The sweet types are grown mainly for eating as vegetables. The bitter types contain a higher percentage of poisonous hydrocyanic acid in the juice of the roots than the sweet types. The bitter types are grown mainly for the extraction of the flour. The poison is dissipated when the tubers are grated for extraction of the flour or when they are pared and boiled or roasted. The starch is washed from the grated roots. While the starch is still moist, it is pressed through fine mesh screens onto a hot stove to form commercial tapioca, or dried without heat to form the flour used in bakery products.

Cassava is relatively drought resistant. It is best suited to rich friable soils of the lower elevations, but it is a heavy feeder and should not be replanted on the same ground unless a good fertilization program is maintained. Propagation is by 10- to 12-inch mature stem cuttings planted 3 feet apart in rows 4 feet apart during periods when rains are most likely to fall. The stem cuttings are planted in a near horizontal position with about three-fourths of the cutting below the soil. Tubers can be harvested within 9 to 12 months after planting, depending upon climatic conditions and the variety grown. From 5 to 8 tons of tubers can be obtained from an acre, depending chiefly upon soil fertility.

PESTS AND DISEASES.—Various general pests are minor on cassava. When present in large numbers, maggots of the stem-mining fly (*Lonchaea chalybea* Wiedemann) may severely damage terminal shoots. Control of this pest is difficult because of its feeding habits. A fungus can cause defoliation and tip dieback in cassava. Other diseases are rust and fungal leaf spot. If diseases or insect pests cause serious damage to the young shoots, the gardener should consult local agricultural authorities for control measures.

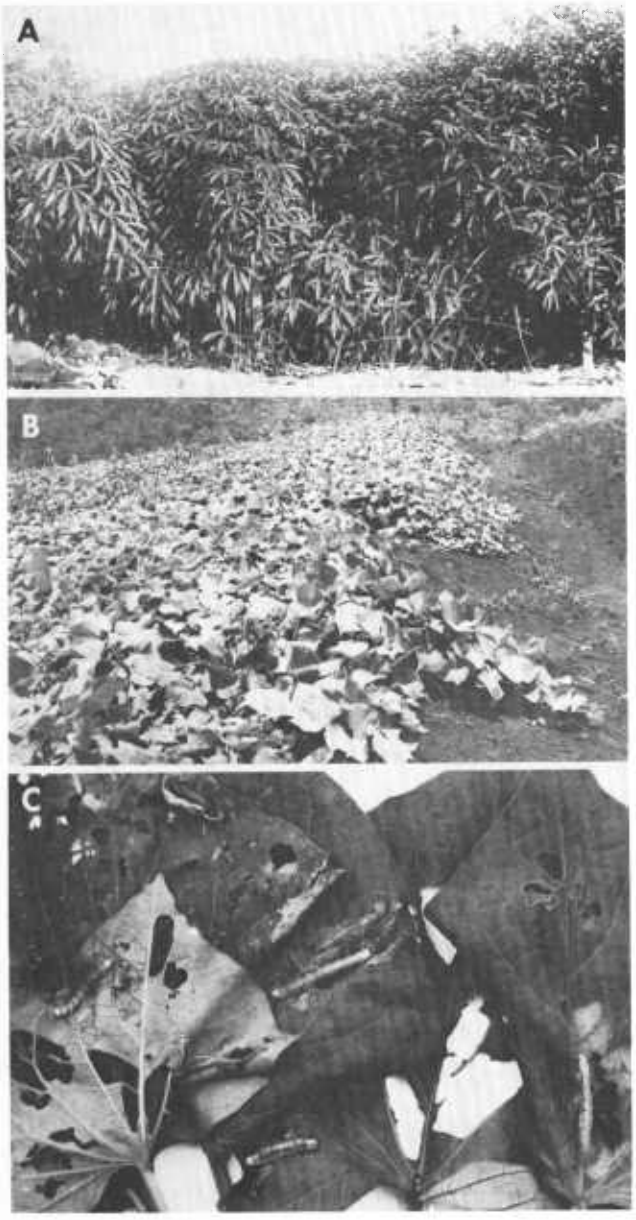


FIGURE 35.—*A*, Cassava; *B*, sweetpotato vines; *C*, sweetpotato leaves damaged by leaf roller (*Pilocrocis tripunctata* (F.)).

Garlic

***Allium sativum* L.**
Liliaceae

Garlic and onion are similar in appearance but the garlic leaves are narrow and keeled and are not hollow; onion leaves are circular and hollow. Garlic produces a crowded mass of bulblets or cloves inside the sheathing leaf bases; onion usually produces one bulb. Both are widely used in the Tropics as flavoring for soups, meats, and stews.

The cloves of garlic are used like onion sets for propagation. Cultural and climatic requirements are similar to those for the bulb onion. (See p. 71.). The crop performs best if planted at the beginning of the cool season at low to medium altitudes. Garlic is harvested 3 to 4 months after planting, usually after the tops have died. The bulbs are cured for about 2 weeks in a warm dry place. Fully ripened clusters or bulbs will keep for about 1 year.

PESTS AND DISEASES.—See pests and diseases of onions, page 72.

Jerusalem-artichoke

"Topinambur"
***Helianthus tuberosus* L.**
Compositae

The Jerusalem-artichoke is a perennial herb that produces erect shoots 3 to 5 feet tall, which bear small but typical sunflowers in profusion. The roots become a tangle of red-, purple-, or white-skinned knobby tubers, which are the edible portion.

The Jerusalem-artichoke (fig. 36, *A*) is widely adapted to both temperate and tropical locations. It tolerates poor soils better than most crops, but does not thrive under excessive rainfall and wet soil conditions. Production is best in rich lowland areas receiving about 50 inches of annual rainfall.

The seed tubers are planted about the time new shoots appear from the base of old plants, which is several weeks in advance of the rainy season. The tubers are spaced 1 foot apart in rows 2½ feet apart and cultivated and watered until established. Once established, the Jerusalem-artichoke competes well with weeds. To promote good top and root development, remove the flowers as they appear.

The tubers require 2½ to 3 months to reach good size. All can be harvested at one time or those on the outside of the row can be harvested first before they harden. Some tubers may be left in the ground over the dry season for seed, or they may be lifted and stored in dry sand in an unglazed earthenware pot. In India the white-skinned variety Sutton's White is preferred to red- and purple-skinned varieties.

PESTS AND DISEASES.—General feeders at times are pests either to tubers or foliage of the Jerusalem-artichoke. Leaf spot can damage plants in wet weather and powdery mildew can damage them in dry weather.

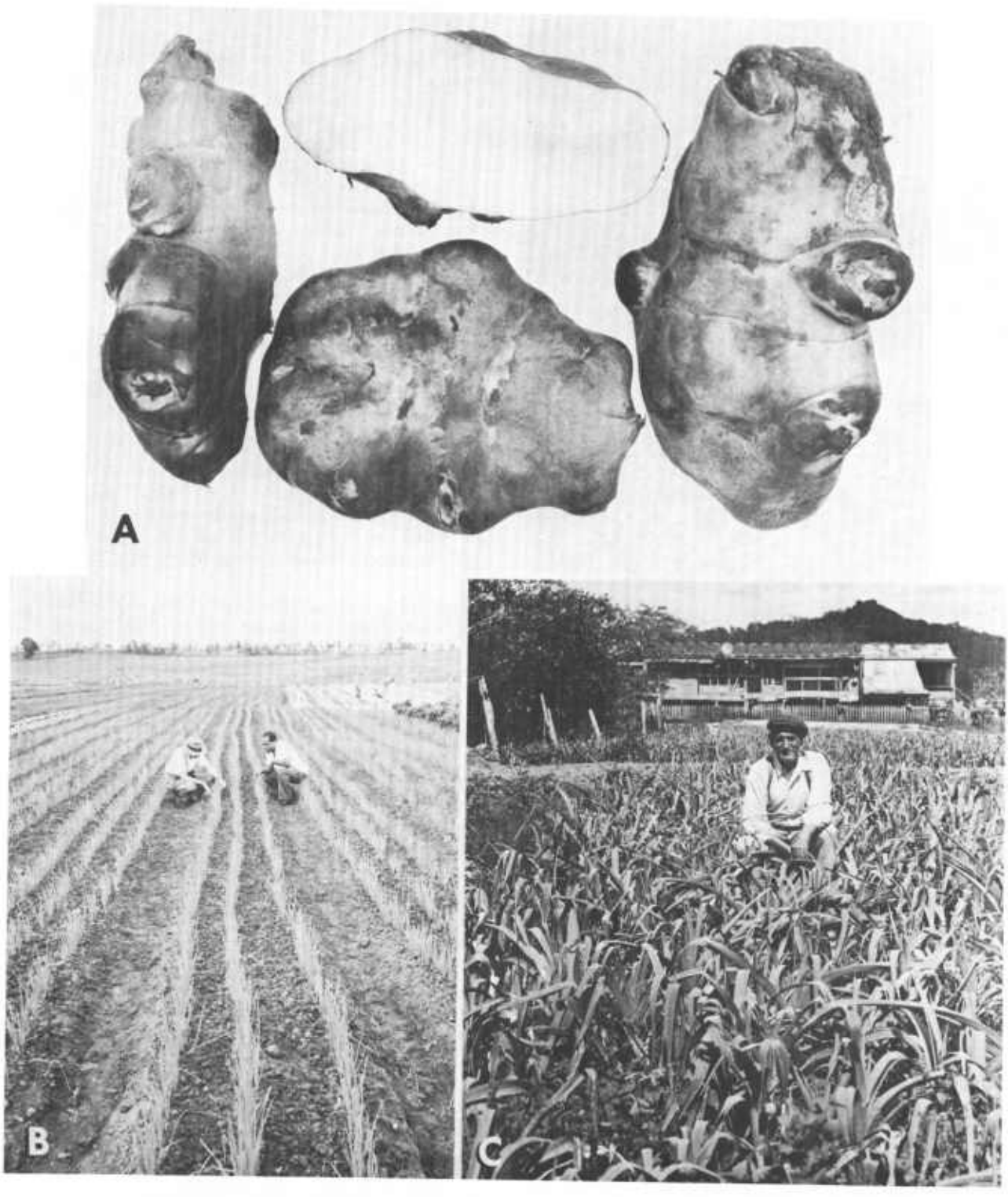


FIGURE 36.—*A*, Tubers of Jerusalem-artichoke; *B*, field of bulb onion seedlings; *C*, field of leek.

Kohlrabi

"Col Rábano"
***Brassica oleracea* var. *gongylodes* L.**
Cruciferae

Kohlrabi is a biennial plant of the cabbage family cultivated as an annual for the fleshy turniplike stems (fig. 34, *H*).

Propagation and culture of kohlrabi is similar to that for cabbage. (See p. 53.) Seed can be sown directly in rows, however, and the plants thinned to 4 to 6 inches apart. Best crops can be obtained at the high elevations during most of the year and at the low elevations during the cool season. The aboveground enlargement of the stem is peeled and cooked like a turnip. Variety Early White Vienna has performed particularly well in the West Indies, but purple varieties do well in other tropical locations. The bulblike stem should be harvested when it is about 2 inches in diameter; it becomes stringy and of poor quality when allowed to grow large. The younger leaves are used for greens if not too severely injured by insects.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Onions

***Allium* spp.**
Liliaceae

BULB ONION ("Cebolla") (*Allium cepa* L.).—The bulb onion is a biennial bulbous plant with circular hollow leaves. The stout seed stem, usually produced the second year, is topped by an umbel of small white flowers. All parts of the plant contain the pungent principle that makes onions desirable as seasoning herbs. Onions are edible either raw or cooked. Seedlings of bulb onions (fig. 36, *B*) may be harvested for green onions or allowed to grow into mature bulbs. The tops of young plants are often used in salads, and bunches of the young plants are sold as green onions.

The onion is a long-day plant. Most varieties bred for the temperate zones will not produce satisfactory bulbs if days are less than 12 hours long. Onion plants form the largest and best bulbs if the seed is sown in seedbeds in the fall and transplanted to the garden when the seedlings are large enough to handle. The bulbs then enlarge and mature as the days lengthen during March, April, and May (fig. 5). The bulbs can be harvested for immediate use before they mature or they can be allowed to mature more fully. Some of the tops will break over near the neck as maturity approaches; at this time all the tops should be broken over so the crop will mature uniformly. Harvesting while the tops are still somewhat green aids in curing the bulbs. They are allowed to dry for a few days before tops are removed, then they are stored in a dry well-aerated place. Onion bulbs will keep longer under refrigeration than at ambient temperatures.

The bulb onion variety White Bermuda was selected for its ability to produce bulbs under the natural day lengths in Bermuda. This variety bulbs well in Puerto Rico (*40, 1926, pp. 14–19*) but is not recommended because of poor keeping quality. The variety Yellow Bermuda is superior to the White Bermuda in keeping quality. The variety Excel 986, selected from Yellow Bermuda, is said to keep better than other Bermuda onions. Bermuda onions will keep for only a few weeks at best.

Varieties Louisiana Red Creole (*47*) and Texas Early Grano can be stored for months. Eclipse, L 36, White Creole, and White Grano are recommended for trial (*33*). Variety Early Harvest is also recommended. Green onions can be produced rapidly for table use by planting imported sets. Sets are small bulbs grown the previous season from seed in temperate regions, then stored over winter as dry bulbs. If allowed to grow to mature bulbs, the seed stems must be removed as they appear.

GREEN BUNCHING ONIONS. ("Cebollín") (*Allium fistulosum* L.).—Several species of *Allium* are grown for green bunching onions in different parts of the Tropics. The most common green onions probably are harvested from plantings of bulb onion after the plants are in vigorous growth but before bulbs have formed.

The green bunching onion *A. fistulosum* differs from *A. cepa* in having no distinct bulb. The stems are clustered and several shoots arise from each crown. The bunching onions are popular for home gardens. They are excellent when eaten raw either alone or in salads, or in sandwiches, or when added to soups. A native variety and the variety New Long White Bunching from continental sources have grown well throughout the year at all elevations in Puerto Rico. In fact, the green bunching onion is one of the few vegetables that consistently survives heavy rainfall. Variety New Long White Bunching has now been replaced in catalogs by such names as Evergreen (Nebuka), Evergreen Long White Bunching, and Japanese Bunching. All are similar and could be identical.

Sets or side shoots of native green bunching onion varieties can be obtained at almost any time of the year from local growers. They are set directly in the field. Seed can be obtained from continental seed houses. The seeds are first planted in close rows in seedbeds. When the seedlings are 6 to 8 inches high, they are transplanted in the garden to a depth of 1½ inches and at distances of 3 to 4 inches in rows 12 to 18

inches apart. Rows can be planted 6 inches apart to save space, but weeding and cultivation then become tedious. In transplanting, the tops are clipped back to 3 inches and all but about one-half inch of the roots are removed. Once the crop is established from seed it may be propagated by divisions.

LEEK (*Allium porrum* L.).—Leek (fig. 36, *C*) resembles bunching onion, but the leaves are flat like those of garlic. The overlapping leaf bases form a neck that is almost as thick as the single cylindrical bulb. Leek produces well at medium elevations in the Tropics. Leek is always grown from seed. Its culture is about the same as for the bunching onion except the soil is gradually mounded around the plants in the later stages of growth to blanch the stems. Leek may be used in soups for flavoring or boiled and served in white sauce. The variety American Flag is recommended.

SHALLOT (*Allium ascalonicum* L. (*A. cepa* L.)).—The shallot is a perennial onion that develops small pointed bulbs in loose clusters but all arising from a common disk. It is propagated by division of the bulbs. Shallots are grown in some areas for production of green onions and in others for the mature bulbs.

PESTS AND DISEASES.—Onion thrips are the worst threat to onion production almost everywhere. Lesser pests include mole crickets, fall armyworms, leaf miners, cutworms, and wireworms. Onion bulbs are subject to a bacterial soft rot when near maturity if the weather is wet. Leaf anthracnose and downy mildew are occasionally found on onion family members. Purple blotch fungus and leaf anthracnose fungus sometimes appear on leaves and kill young plants.

Parsnip

"Chirivía"
***Pastinaca sativa* L.**
Umbelliferae

The parsnip is a biennial plant cultivated for its swollen tapering roots that are eaten as a cooked vegetable (fig. 34, *G*). Unlike its relative the carrot, the parsnip has pale-cream or white flesh.

Good crops were grown at higher elevations in the Caribbean area (*40, 1946, p. 25*) when the seed was planted in the early part of the year. A long season—4 to 5 months—is required for maturity. The soil should be prepared to a depth of 10 to 12 inches to facilitate the deep-rooting habit of this vegetable. Parsnip seed is sown in rows 15 to 18 inches apart for hand cultivation. Since germination is slow, radish seed can be mixed with parsnip seed for home gardens. The radishes will serve as an extra crop and also mark the row until the parsnip seedlings appear. Parsnip seed is extremely short lived under warm humid conditions, and special care is required to keep it viable. (See p. 19.) When the plants are 5 to 6 weeks old, they should be thinned to 2 to 4 inches apart in the row. Special weeding attention must be given to the delicate seedlings; otherwise they will be smothered by weed growth.

Quality of the parsnip variety Hollow Crown was good (*40, 1946, p. 25*). Cooked by the standard system of sugaring and buttering, these parsnips were as good as or better than those grown in the North Temperate Zone.

PESTS AND DISEASES.—See pests and diseases of celery, page 54.

Potato

"Papa," "Patata," "Turma"
***Solanum tuberosum* L.**
Solanaceae

The potato is a good home garden crop only when the climate is suitable, equipment and materials for spraying are available, and the soil is fertile, well drained, and preferably of the sandy loam type (fig. 34, *E*). The potato should not be included in the small garden where land is at a premium; it is not an easy crop to grow and amateurs may not get their seed back.

The potato is native to the Andean highlands of South America. It produces tubers best with a mean temperature just above 60° F. (*59, p. 352*), but yields well with temperatures ranging between 60° and 75°. Little or no tuberization occurs above 80°. The varieties Green Mountain, Katahdin, and Red Bliss Triumph produced well—200 to 250 bushels per acre—in a sandy loam soil at the substation of the Agricultural Experiment Station of the University of Puerto Rico (*41, 1945–46*) near Isabela, when planted in October to November and allowed to mature during the cool weather. Fair yields of Red Bliss Triumph were obtained when planted in June. Day length is important in tuberization of some varieties. (See p. 8.)

Seed stock should be certified and obtained from a reliable company. Seed potatoes used in the Tropics are frequently those shipped in for food or those saved from a locally grown crop—risky sources because of possible disease contamination.

A heavy application of complete fertilizer high in phosphorus and low in nitrogen, such as 3–12–12, 2–16–8, or 4–12–8, should be worked into the soil before planting or placed in the furrows near the seed pieces at planting. Fertilizer must not touch the seed pieces or burning and rotting will result. Excessive use of manure or nitrogen gives excellent top growth but low yield of tubers.

Potatoes will mature within 90 to 100 days and should be dug on a dry day after most of the tops have died. They store best under refrigeration of 32° to 45° F. Potatoes stored at this temperature range will sweeten and darken excessively when fried. This can be prevented by leaving them at room temperature for a week after removing them from storage before they are used. Where refrigeration is not available, potatoes should be stored in a well-aerated, cool dark place.

PESTS AND DISEASES.—Insects attacking the potato under West Indian conditions are aphids, cutworms, leafhoppers, white grubs, wireworms, and other minor pests of related wild plants. One of the most serious pests of these solanaceous plants in North America, the Colorado potato beetle, has not yet spread to the Antilles or widely into the American tropics. Diseases are early and late blights, scab, mosaic, and fusarium wilt.

Radish

"Rábano"

***Raphanus sativus* L.**

Cruciferae

The radish is an annual herb (fig. 34, *I*), grown for the swollen root that is eaten as a salad vegetable because of the piquant flavor. The leaves can be cooked as a green vegetable. Seeds of both red and white varieties are offered by seedsmen.

Radishes are widely grown in the Tropics; it is one of the easiest short-period vegetable crops to raise. Nearly all varieties perform well. (See table 2, p. 12.) Earliest Scarlet Button is the most popular on the local markets. The quality of this variety, although fair to good throughout the year, is excellent when grown at the higher elevations in the winter. During the summer at sea level, when the temperature is high and particularly when a drought occurs 1 or 2 weeks before radishes are mature, all radishes are likely to be tough, pithy, and very "hot." Also, the roots may elongate rather than enlarge normally. This can be prevented to some extent by enriching the soil with manure and commercial fertilizers and applying irrigation water regularly when needed. Palm leaf or cheesecloth shade also helps to reduce the temperature. As radishes are a short-season crop (3 to 5 weeks), they can be easily intercropped in the row or between the rows of many long-season crops. A row 3 to 4 inches wide can be sown and later thinned so that the plants are spaced about 1 to 2 inches apart and stand 3 abreast in the row. About 5 to 6 row feet are usually sufficient for family use.

Radishes are commonly grown in beds with coriander for local markets (fig. 15, *E*). (See p. 29.) The seeds of the two crops are mixed and broadcast over the bed. The radishes are harvested first, after which the coriander occupies the full space.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Rutabaga

"Colinabo"

***Brassica napus* var. *napobrassica* L.**

Cruciferae

Rutabaga (fig. 34, *B*) resembles the turnip but is larger and more nutritious and keeps somewhat better under ordinary storage conditions.

Although the temperature range required is the same as that for turnip (60° to 70° F.), the rutabaga often grows well at a somewhat lower mean temperature. Good crops are grown at medium to high elevations in the mountains of Puerto Rico during the cool season, but only fair crops are grown during this season at sea level. During the heavy-rainfall warm season, the roots tend to elongate irregularly rather than to enlarge and their quality is poor.

Culture for rutabaga is the same as for turnip and carrot, except that rutabaga requires about 5 weeks longer to mature. Purple Top Yellow is a satisfactory variety.

PESTS AND DISEASES.—See pests and diseases of head cabbage, page 53.

Salsify

"Salsifí"

***Tragopogon porrifolius* L.**

Compositae

Salsify (vegetable-oyster or oyster plant) (fig. 34, *F*) is a biennial with long narrow strap-shaped leaves and a somewhat thickened root, 9 to 12 inches long. The parsniplike roots, which have an oyster flavor, can be used in soups or cooked like carrots.

Salsify can be grown at all seasons at high elevations and during the winter at sea level. Culture is similar to that of parsnip.

The seedlings should be thinned to 3 to 4 inches apart in the row. Soil should be deep sandy loam, rich in organic matter; roots in heavy soil tend to be deformed. Salsify requires a growing period of 3½ to 4 months. The variety Mammoth Sandwich Island is recommended.

PESTS AND DISEASES.—This chicory relative is not known to be affected by any specific pests or diseases in the Caribbean area, but general pests and diseases are occasionally seen.

Sweetpotato

"Batata," "Camote"
***Ipomoea batatas* (L.) Lam.**
Convolvulaceae

The sweetpotato (fig. 35, *B*) is a trailing herbaceous perennial, which roots at the nodes. It is grown for the edible starchy tubers. The many varieties differ considerably in plant characters. The leaves vary from deeply lobed to entire. Color of the leaves, petioles, and stems varies from deep purple to pure green. The tubers can be yellow, red, or purple on the exterior and the flesh from almost pure white through shades of yellow to deep orange; and finally the vines can be greatly elongated or short and bushlike. Most sweetpotato varieties produce flowers of pale magenta resembling those of morning-glory under tropical conditions.

The sweetpotato is an excellent and dependable tropical vegetable for the larger home gardens. It requires too much space in small gardens except where the vines can be grown on a fence or low wall. The sweetpotato is a warm-season crop (70° to 80° F.), requiring a growing period of 4 to 6 months. It grows well at sea level throughout the year and at higher altitudes during the summer provided the weather is not too cool. The ideal soil for sweetpotatoes is a rich sandy loam underlain with clay. The crop can be grown on a wide variety of soils provided drainage is naturally good or the slips are planted on beds or ridges in areas where soil is a heavy clay and rainfall is abundant. With poor aeration and drainage of the soil, the roots will be long and thin and yields will be light. Fair crops are obtained in semiarid districts where most vegetables will hardly thrive. Moderate rainfall, however, is beneficial, and irrigation should be provided where available, particularly during the early growing period.

Although manure has benefited the sweetpotato when applied to soils deficient in humus, the general recommendation is to use the available manure on other vegetable crops where the effect on yields will be more pronounced. In fact, fair to good crops of sweetpotato are often obtained in the Tropics without the addition of any commercial fertilizers or manure. Heavy applications of manure or nitrogen fertilizer are not advisable; they produce excessive vine growth at the expense of root development. Either complete fertilizer high in phosphorous and low in nitrogen or superphosphate alone is a good sweetpotato fertilizer under tropical conditions.

Totiempo is a common local variety in the West Indies, but its yields are much lower than those from Mameya, Porto Morado, and Red Velvet. Don Juan, another common local variety, gives fair to average yields. Among the newer varieties developed by the Agricultural Experiment Station of the University of Puerto Rico, Canela, Rico, and U.P.R. No. 3 are recommended (*37*). The variety Cobre, from the same source, is more productive but of little value for processing. Where named varieties of known performance are not available, the gardener can select the most desirable types from local markets for propagation material. Yields of sweetpotato are usually best when the crop is planted in the spring.

Seed pieces are either entire small tubers or cross sections of slender cylindrical roots. Seed pieces from the crown of a plant or the upper part of the root are the most satisfactory. Tip cuttings from mature vines about 12 to 18 inches long are frequently used for propagation. After defoliation, the lower half of the cuttings should be inserted in holes made with a sharp stick and the soil firmed about the cuttings. Sprouts or slips can be obtained by the close planting of tubers in sand beds at a depth of 3 to 4 inches. Within a month to 6 weeks a number of sprouts should rise from each tuber. These slips are pulled with roots attached and transplanted to the field in furrows 4 to 5 inches deep. Planting distances should be 1 to 1½ feet in rows 2 to 4 feet apart. The 2-foot spacing is desirable on light soil where ridging is not necessary. On heavy soils a 4-foot spacing between rows is sometimes necessary in order to build the ridges high enough. During dry weather both freshly set cuttings and rooted slips should be shaded temporarily. To establish the runners when rainfall is not adequate, frequent irrigation should be provided after planting. Light waterings are better than infrequent soakings. It is sometimes wise to wait until a series of rains has started before planting and thus eliminate the need for irrigation at this time.

Spring-planted sweetpotatoes can be left in the ground for 3 to 6 months. Tubers will continue to increase in size for several months as long as growing conditions are favorable. Some tubers can be left in the ground during the dry season for storage and later used as seed pieces. If the tubers are harvested during the rainy season, one of the best means of storing them is in dry wood ashes in a well-ventilated room. Tubers to be stored should be harvested with as little bruising as possible. A storage period of 2 to 4 weeks after harvest is desirable to increase sugar content and eating quality. The tubers should be inspected every few days to make sure that weevils have not started to tunnel through them. The entire stock can be ruined in a short time by this insect.

Under no conditions should the vines be pruned for livestock food. Marked decreases in yield are likely to result.

PESTS AND DISEASES.—Several species of gold-

bugs or tortoise beetles attack sweetpotatoes in the American Tropics but seldom are as damaging or as numerous as those found in temperate areas. By far the worst sweetpotato enemy is the red and black sweetpotato weevil. Aphids, armyworms, flea beetles, leaf beetles, leafhoppers, leaf miners, webworms including the sweetpotato leaf roller (fig. 35, *C*), and wireworms also attack sweetpotatoes. The principal sweetpotato diseases are black rot fungus, internal cork, and stem rot or wilt fungus.

Turnip

"Nabo"

***Brassica rapa* L.**

Cruciferae

The turnip is a biennial herb (fig. 34, *A*) commonly cultivated as an annual for its swollen roots, which are eaten cooked as a vegetable. The leaves are useful as greens.

Turnips are frequently grown in the Tropics and limited quantities are produced for the market. The turnip is less nutritious than the carrot and the tops are not so popular as beet tops for greens.

Turnips grow best in cool weather at all elevations. Poor crops were grown during the summer at 2,600 feet elevation in Puerto Rico, but satisfactory yields were obtained during all seasons at 3,200 feet. Varieties Purple Top White Globe and Shogoin are recommended. Shogoin tops are better for greens; Purple Top White Globe produces better roots (*11, p. 76*).

Turnip seeds are planted in the same way as beets and carrots, but the seed germinates more quickly and the plants grow faster. Turnips respond well to additions of phosphorus and nitrogen to the soil; the potash content is usually adequate in tropical soils. Turnips are harvested when the roots are about 2½ inches in diameter. The tops can be removed and used for greens; seedlings removed in thinning also can be used for greens. Rutabagas may be substituted for the turnip at higher elevations. In fact, rutabagas are sold on some markets as turnips.

Pests and Diseases.—See pests and diseases of head cabbage, page 53.

Yam

"Name"

***Dioscorea* spp.**

Dioscoreaceae

The true yams (*Dioscorea* spp.) (fig. 37, *A*, *B*) are climbing vines with underground tubers. The cultivated species bear edible starchy tubers that resemble the potato (*Solanum tuberosum* L.) in food value and taste. Many wild species contain the poisonous principle dioscorine and are inedible. The yam should not be confused with moist-flesh varieties of sweetpotato (*Ipomoea batatas* (L.) Lam.), which are sometimes erroneously called yams.

Tubers of the true yam are a highly nutritious food. Among the starchy root crops grown in the Tropics this crop ranks next to the cassava, sweetpotato, and yautía in importance.

In habit of growth and cultural requirements the yam is somewhat similar to the sweetpotato; botanically it is not even closely related. It is adapted to a wide variety of soils, but grows best in fertile clay soils and poorest in light sandy soils. Good soil aeration is essential to good tuber development. For good aeration and drainage the soil is commonly built into ridges from 12 to 18 inches high. First the entire field is plowed; then furrows are opened 4 to 6 feet apart and a few inches of dead vegetable matter, compost, or manure placed in the furrows and covered with 2 or 3 inches of soil. This is followed by another layer of vegetable matter, after which the ridges are covered with soil to the desired height. A chemical fertilizer, such as 5–8–12, can be incorporated when the ridges are built. This system can be adapted to the family garden by constructing individual hills in the same way, but spacing them 3 to 4 feet apart.

Yams are planted from late February to May, when the soil is in suitable condition following a spring rain. Seed pieces are either the crowns (stem ends) of large tubers or entire small tubers and are planted 1 to 2 feet apart on the ridges and covered with 2 to 3 inches of soil. Spacing depends upon size of plant and tubers usually produced by the variety being planted. If the hill method is used, one seed piece is planted per hill. Each seed piece should weigh 4 to 5 ounces to provide sufficient nourishment to give the young plant a good start. Sections of the lower part of the tuber can also be planted, but they are not so satisfactory as the crown. Rotting of the seed pieces can be prevented by dipping them in bordeaux mixture, a compound containing copper sulfate, while the cut is still fresh. Treated material should never be used for food.

The vines should be supported to increase growth and yields. Bamboo stakes can be used (fig. 37, *A*) or, in small home gardens, yams can be planted along the fence.

A crop planted in the spring matures in the fall and winter. Tubers can be left in the ground during the dry winter months without deteriorating. In harvesting, care should be taken not to injure the thin-skinned tubers or rot may develop. Tubers intended for seeding the subsequent crop can be left in the ground until planting time.

Several species and varieties of yams are cultivated in the Caribbean area. Each variety has a distinct tuber shape (fig. 37, *B*). The most popular yam, known locally as Guinea, is a

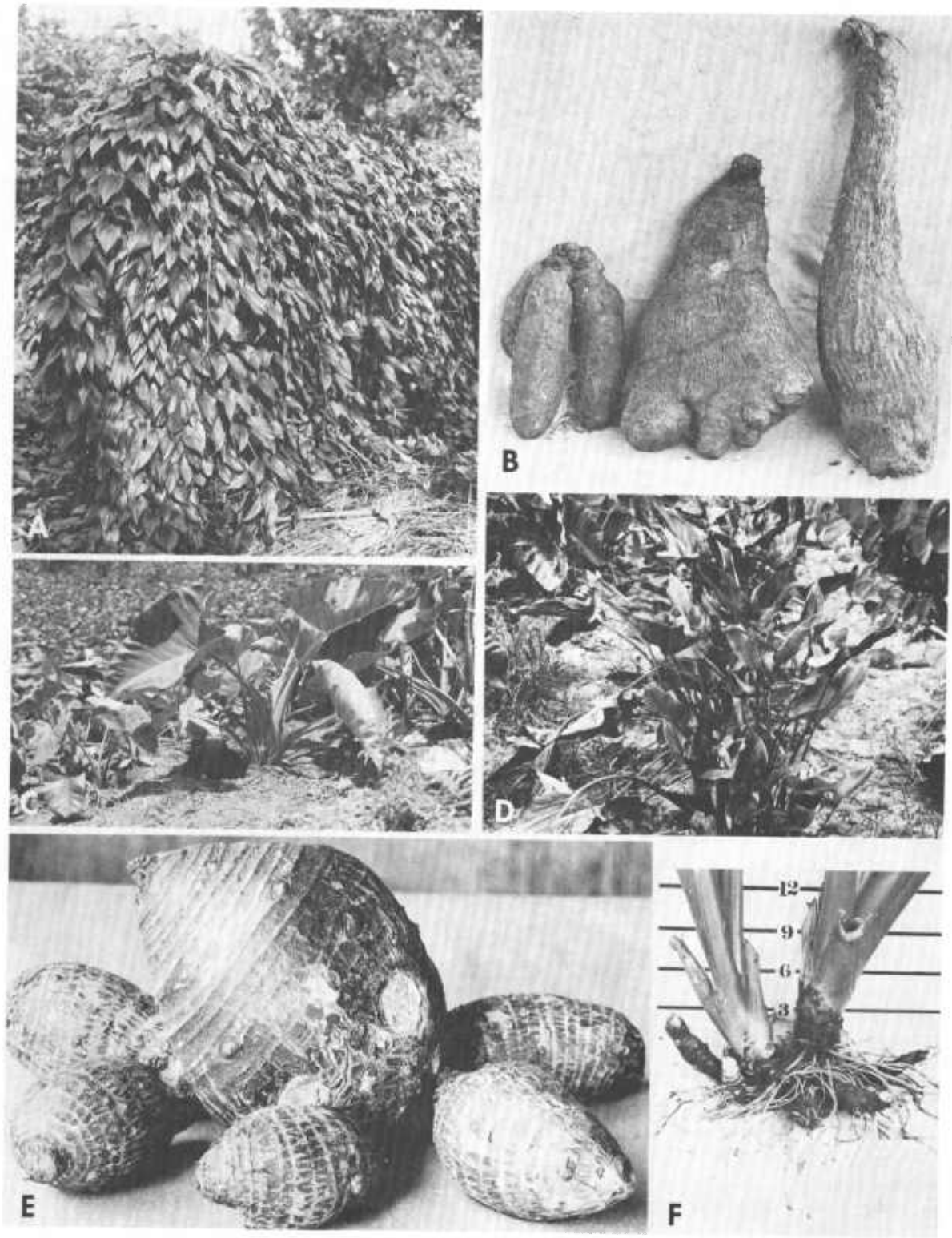


FIGURE 37.—*A*, Yam vines (*Dioscorea alata* L.) trellised on bamboo framework; *B*, three varieties of *D. alata* showing distinct tuber shapes; *C*, yautía planting; *D*, edible-leaved yautía (*Xanthosoma brasiliense* Engl.); *E*, edible central corm and lateral tubers of taro variety Trinidad Dasheen; *F*, developing tubers at base of yautía plant. (Measure is inches.)

variety of *Dioscorea cayenensis* Lam. It is widely distributed over the area, but is best suited to upland clays. The tubers, which often weigh 6 pounds, have white sweet flesh free from fiber. This yam matures earlier than others and the larger tubers can be carefully detached from the stem, leaving the smaller ones to mature later. Other white-fleshed varieties are Tongo (*D. aculeata* L.), Potato, and Agua (Water), which is a variety of *D. alata* L. (*13*). Purple-fleshed varieties are Purple Ceylon and Mapuey Morado. A yellow-fleshed variety of *D. cayenensis* is known locally as Congo Yellow or Guinea Yellow. It produces better than other local varieties in sandy soils. The foliage of *D. alata* is illustrated in figure 37, *A*, and tubers of three distinct varieties of this species in figure 37, *B*. Gardeners unfamiliar with yam varieties should obtain their planting stock from local varieties known to be edible and productive.

Pests and Diseases.—Yams are essentially free from pests and disease. Underground root feeders such as white grubs and wireworms occasionally attack tubers but attacks are seldom serious. Leaf spot fungus and anthracnose fungus sometimes appear but are relatively unimportant.

Yautía and Taro

Araceae

The yautías (*Xanthosoma* spp., fig. 37, *C*, *F*) and taros (*Colocasia* spp., fig. 37, *E*) are perennial tuberous plants with large "elephant-ear" leaves. Species of both genera are common in gardens through the Caribbean area. Superficially the members of the two genera are similar; botanically they are quite different. Yautías are distinguished from taros by having the petiole (leaf stem) attached to the very edge of the leaf at the junction of the two basal lobes of the leaf. In taros the petiole is attached within the leaf outline.

The vernacular names used in different parts of the Caribbean area for different members of the two groups of plants are considerably confused. In addition to the name taro, plants identified as *Colocasia* spp. are variously called dasheen, malanga, tania, tanier, tanyah, and yautía malanga. The various species and varieties of *Xanthosoma* are called belembe, calalu, eddo, malanga, and nut eddoe in addition to yautía.

In most varieties of yautía only the lateral tubers are edible (fig. 37, *F*); in taros (fig. 37, *E*) both the central corm and the lateral tubers are used for food. The mature central corms of taros vary in weight from about ½ pound to 7 or more pounds, according to the variety. The lateral tubers of both yautía and taro are smaller, varying at maturity from 3 ounces to about 1 pound. The tubers of all types usually are two to four times longer than wide and about as big as a medium-size potato. They can be cooked like potatoes or made into soups. Some kinds of yautías such as the belembe or calalu (*Xanthosoma brasiliense* Engl.) do not produce edible-size tubers, but the tender leaves and shoots (fig. 37, *D*) are cooked and eaten like greens. Young taro (dasheen) leaves are an essential ingredient of the West Indian stew known also as "calalou."

In Japan, in parts of Southeast Asia, and in the South Pacific area, these plants and related plants belonging to the genera *Alocasia*, *Amorphophallus*, and *Cyrtosperma* are cultivated for use as starchy vegetables and for extraction of the starch (*29*).

Trinidad Dasheen (fig. 37, *E*) (*Colocasia esculenta* (L.) Schott.) is one of the superior varieties of taro. Its corms, tubers, and young leaves are edible. This variety, unlike most of the others, does not have strongly acrid leaves and underground parts, but none of them should be eaten or tasted when raw. Cooking destroys the acridity.

Fifteen cultivars of yautía from the eastern Caribbean area are described by Gooding and Campbell (*14*).

Yautía and taro can be grown at all elevations in the Caribbean area, but they produce best at medium elevations in moist regions. Low land bordering rivers and streams, which is too moist for sweetpotato and yam, is well suited to yautía and taro. These crops will tolerate a wide variety of soils, producing from 7 to 15 tons of tubers per acre.

The top section of the rootstalk, a few inches above and below ground level, is preferred for planting, although the tubers or any part of the rhizome system having eyes can be used. The tubers or pieces of the rhizomes are set at a depth of 3 to 5 inches and covered lightly with soil; the crowns are set slightly deeper than they grew previously. The best planting time is the cool season between December and April, although plantings can be made at any season if moisture is adequate. Planting distance in soils of average fertility is from 1½ to 3 feet. In fertile soils and with tall-growing varieties, the planting distance should be somewhat wider. From 8,000 to 10,000 propagation pieces are needed to plant an acre.

A full crop can be harvested within 10 to 12 months. Tubers can be harvested individually as they mature, leaving the smaller ones to enlarge before the plant is removed, or the entire plant can be pulled by hand when the soil is moist and most of the tubers have matured. The tubers are ready to harvest when they become white at the tips.

When there are a number of plants of a large variety, the plants can be harvested quickly by

FIGURE 38.—*A*, "Apio" or "arracacha" (*Arracacia xanthorrhiza* Bancroft); *B*, West Indian or Bermuda arrowroot (*Maranta arundinacea* L.); *C*, rhizomes of ginger plant (*Zingiber officinale* Rosc.).

three men working together. Two men with garden shovels loosen tubers, roots, and soil on one side of the plant; the third man bends the plant to the ground. Some tubers may be left in the ground over the dry season for use as seed the following season.

PESTS AND DISEASES.—Yautía and taro are comparatively disease and pest free. White grubs and wireworms can damage tubers but generally do not limit production. During very dry weather aphids and red spider mites sometimes appear in large numbers on foliage but do not damage the plants severely. Root-knot nematode infestations will stunt the plants and reduce yields. Storage rots can occur when corms are stored in damp places.

Other Root Crops

Many other root vegetables are used for food in different parts of the Tropics. Some form an important part of the diet of the local population of one area and are almost unknown in other areas. The West Indian or Bermuda arrowroot (fig. 38, *B*) (*Maranta arundinacea* L.) produces tubers suitable both for use as a starchy vegetable and for extraction of arrowroot starch. The tuberous roots of edible canna (*Canna edulis* Ker.) are used in the same ways but their quality is poor when prepared as a vegetable. The small potato-like tubers of "topee-tambu" or "llerenes" (*Calathea allouia* (Aubl.) Lindl.) are liked in certain areas because they remain crisp even after considerable boiling. The large tuberous roots of "ti" (*Cordyline terminalis* (L.) Kunth) are eaten in parts of New Guinea. Several leguminous plants bear tuberous roots that are edible but are not high-quality foods. Examples are the Goa or four-angled bean (*Psophocarpus tetragonolobus* DC.) (fig. 31, *B*); the yam bean (*Pachyrrhizus erosus* (L.) Urban); and kudzu (*Pueraria* spp.)

In Guatemala and Mexico the perennial underground tubers of the chayote (*Sechium edule* (Jacq.) Sw.) (fig. 19, *A*) sometimes are used for food. The tubers are formed during the second season's growth. Because the vine is killed when the tubers are removed, these tubers usually are not harvested.

Several root crops are cultivated in and probably are endemic to the Andean Region. The most familiar is the now widely cultivated potato. The "apio," "arracacha," arracacia, Peruvian carrot, or Peruvian parsnip (*Arracacia xanthorrhiza* Bancroft) (fig. 38, *A*) is cultivated in the highlands from Venezuela to Bolivia and to a limited extent in parts of the West Indies and Central America. The roots bear resemblance to both carrot and parsnip to which they are related. Much less extensive in cultivation but of considerable importance in the areas in which they are grown are the "oca" (*Oxalis tuberosa* Mol.), the "ullucu" (*Ullucus tuberosus* Lozan.), and the "añu" (*Tropaeolum tuberosum* R. & P.).

The lotus root (*Nelumbo nucifera* Gaertn.), an aquatic plant, is one of the unique vegetables of the oriental subtropics. It is grown in Hawaii for food but in the Caribbean area only as an ornamental plant. The roots are sliced for addition to soups or stews of beef or pork. Another aquatic plant, the "matai" or Chinese waterchestnut (*Eleocharis dulcis* (Burm. f.) Trin. ex Henschel) is grown in some subtropical areas. The edible corms are an ingredient in numerous Chinese dishes.

Flavoring and Seasoning Herbs

Many flavoring and seasoning herbs are used in different areas of the Tropics. In the West Indies plants of favorite kinds are frequently maintained in clay pots or kerosene tins along with the family's collection of ornamental plants. The most frequently grown is orégano. Both a *Lippia* species and *Coleus aromaticus* Benth. in Wall. are grown for this flavor and both are propagated by cuttings. Once established, the plants can be maintained for many years.

The foliage of young coriander or "culantro" plants (*Coriandrum sativum* L.) is commonly used for seasoning and for garnishing. It is grown from seed planted directly on well-prepared soil and harvested when the seedlings are 5 to 10 inches tall. Market gardeners specializing in leaf lettuce often will have a small plot of coriander also (fig. 15, *E*). Sesame or "ajonjolí" (*Sesamum indicum* L.) is managed in the same way but requires a longer growing season since the ripe seeds are the desired product.

Many seasoning herbs can be started from seed, then maintained as perennials or by reseeding each year. The kinds more frequently seen in West Indian gardens are: anis seed or "anís" (*Pimpinella anisum* L.); basil or "albahaca" (*Ocimum basilicum* L.); dill or "hinojo" (*Anethum graveolens* L.); rosemary or "romero" (*Rosmarinus officinalis* L.); sage (*Salvia officinalis* L.); spearmint or "menta" (*Mentha spicata* L.); and sweet marjoram or "mejorana" (*Majorana hortensis* Moench.).

Another condiment cultivated particularly in some highland areas of the Tropics is horseradish (*Armoracia lapathifolia* Gilib.). It is propagated from root cuttings. Roots of the horseradish-tree (*Moringa oleifera* Lam.) are used for the same purpose in low warm areas but are inferior to the roots of the horseradish itself. The leaves, flowers, and young pods of the tree are eaten as vegetables.

Ginger or "jengibre" (*Zingiber officinale* Rosc.) is commonly grown in the home garden of the West Indies (fig. 38, *C*). (See p. 78.) The condiment ginger is prepared from the dried rhizome of the plant. Turmeric or "tumérico" (*Curcuma longa* L.) is grown as an ingredient for curry. The tender hearts of lemon grass shoots "limoncillo" (*Cymbopogon citratus* (DC.) Stapf) are used in flavoring.

Specific recommendations on culture, harvest, and use of these plants are given in MacMillan's book (*28, p. 278*), which is usually available at public libraries containing collections of agricultural literature.

COMMERCIAL VEGETABLE GROWING IN THE TROPICS

Commercial vegetable production in the Tropics has by no means reached the degree of proficiency and magnitude that it has in many sections of the Temperate Zone, particularly in the United States. The tropical field is open to expansion in the production of vegetables not only for fresh consumption but also for canning and freezing. Some favored areas in Cuba, Mexico, Hawaii, U.S. Virgin Islands, and Puerto Rico (figs. 17, *B, D*; 20, *A*; 23, *A, C*; 26, *A*; 39, *A, B, C, D*) have exported vegetables at one time or another in sizeable quantities to the heavily populated sections of the United States. With nothing being exported from Cuba at present, other areas such as Honduras and the Bahamas are experimenting with the production of vegetables for export. These vegetables are grown and shipped principally during the late winter when fresh vegetables are scarce on the continental markets. Vegetables commonly exported to the United States are bulb onion, cabbage, cucumber, eggplant, pepper, sweet corn, sweetpotato, tomato, and the na-

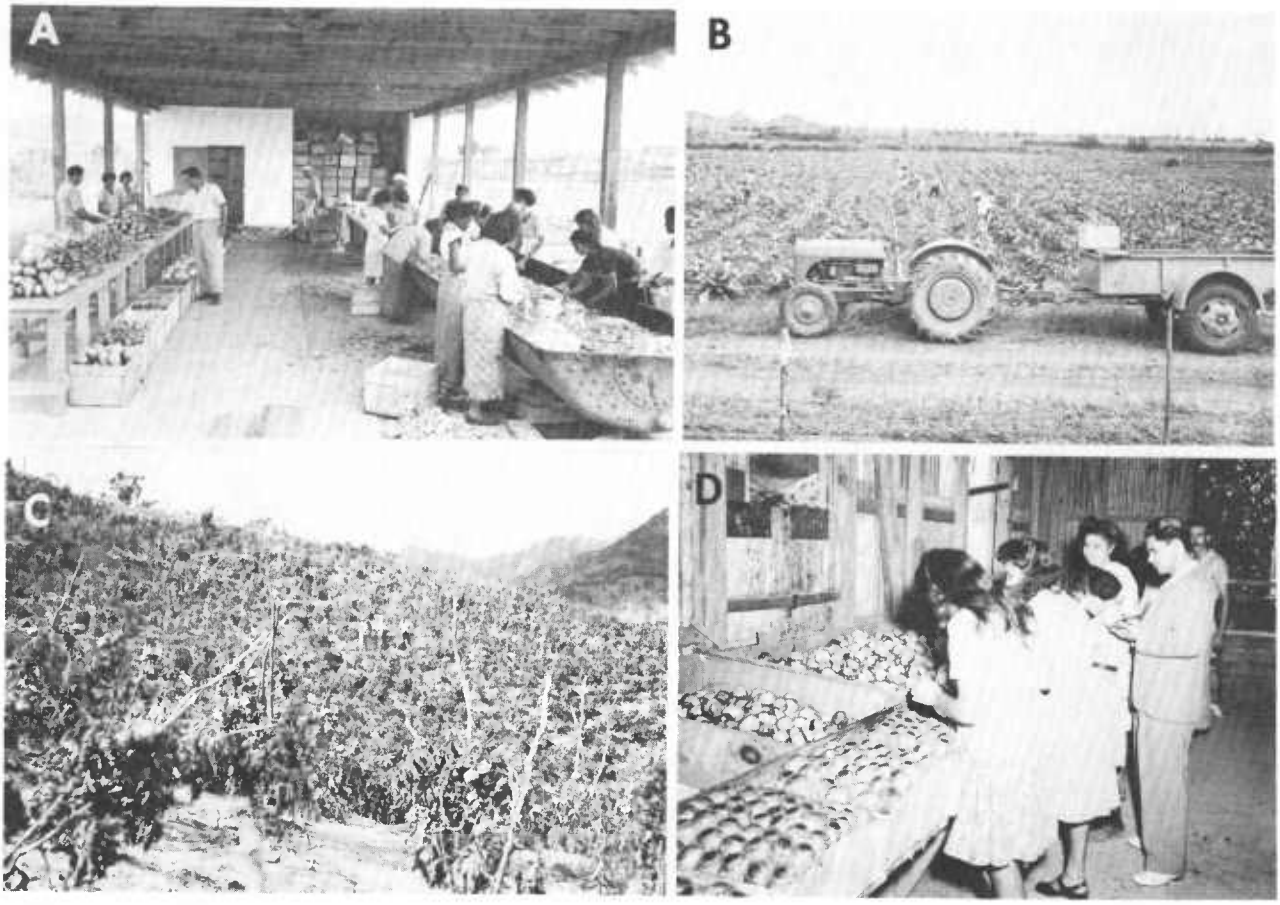


FIGURE 39.—*A*, Shaded open-air vegetable-packing shed in the Caribbean area; *B*, modern machinery for cultivating and harvesting commercial gardens; *C*, commercial field of tomato variety Master Marglobe on sloping land; *D*, wrapping and packing green tomatoes for export to the United States.

tive tropical crops such as pigeonpea (gandul) and yautía for newcomers to the United States from the Tropics.

Much of the cleared fertile bottom land in the Tropics is already planted to banana, cacao, pineapple, sugarcane, and other well-known tropical crops, but there still is good land not in use or that needs to be cleared and irrigated. In fact, some of the land now in major tropical crops might be profitably shifted within limits to vegetables. A sugarcane grower near Ponce, P.R., reported better returns from a few acres of vegetables during World War II than from an equal area of cane. For large-scale commercial gardening, the rich level lowlands are best adapted not only because they are fertile, but also because of ease of irrigation (fig. 17) and efficient use of mechanized equipment (fig. 39, *B*).

Many areas in the Tropics have a distinct advantage over those in the temperate climates in their 12 sunny months of the year with no frost hazard when vegetables can be grown. Some tropical areas, however, are too rainy and warm for good vegetable production during at least part of the year. Also, their soils are not always particularly well adapted for growing vegetables. Some areas are so far from centers of consumption that the cost of transportation, if available, is prohibitive.

The island of Puerto Rico has good, average, and poor areas for commercial vegetable growing. The northwest corner of the island near Isabela, for example, is particularly well adapted to vegetable production throughout most of the year. The land in this area is gently rolling, the soil a well-drained sandy type, rainfall around 50 inches a year, and provision for irrigation good. Commercial crops of cucumber, eggplant, pepper, tomato, and other fresh vegetables already have been grown in this area for shipment to the New York market. The low-rainfall section on the south coast and to the west in the Lajas Valley also is well suited to vegetable production. Some water is available for irrigation in most of this area. Sunshine there is abundant almost every day and the soils are of a moderate to good fertility. Tomatoes have been grown commercially during the dry winter months in some of the interior valleys near Jayuya (*2*) (fig. 39, *C*). The green tomatoes were packed by a cooperative for shipment to the New York market (fig. 39, *D*).

Tomatoes are presently being grown with irrigation in the dry south-central part of Puerto Rico. The commercial acreage of varieties Roma and Campbell Soup 146 was estimated at 900 acres for 1963. Tomato sauce, paste, and canned tomatoes are processed. Tomato paste is processed also on Montserrat by a Canadian company. This company farms 250 acres and purchases additional tomatoes from local farmers.

Pigeonpeas are grown in Puerto Rico both for local consumption and canning. During the 1953–54 season 250,000 cases of canned pigeonpeas were processed (*48*).

Persons with good training and experience in production of specific crops, such as the bean, eggplant, pepper, and tomato, should be successful in commercial vegetable gardening in many tropical areas, particularly if the prospective grower can effectively utilize modern planting, cultivating, and harvesting machines and modern packing materials. Past experience shows the need for using some mechanized equipment in truck gardening if growers in tropical countries are to compete successfully on a sizeable scale with growers in the Temperate Zone. This point is stressed because it seems to be one of the main deterrents in the progress of tropical agriculture. The hazards of maintaining and operating machinery in the Tropics appear to be no greater than in the United States. The high humidity and salt water mist may be greater factors in some areas, but they are probably no worse than the subzero weather, high humidity, and salt water breezes on Long Island, N.Y., where truck gardening has become a big industry.

The main difficulty with farm machinery in the Tropics is the frequent lack of regular and efficient maintenance standards, such as greasing, oiling, and painting. Also, relatively inexperienced labor is often hired to run tractors and machines, when only industrious, carefully trained men should do the job. Also, replacement parts for the machinery are sometimes difficult to obtain. This can be overcome, however, by using equipment from companies doing an export business and having local representatives.

A supply of spare parts and maintenance equipment should be kept on hand as insurance against breakdowns that hold up the work. If the enterprise is large enough to justify two or more tractors, for example, parts can be interchanged if the tractors are of the same make, and at least one tractor can be kept operating while parts for the other are en route. There are a number of such ways to keep an agricultural business operating. Difficulties can usually be surmounted or adjusted if the grower has enough ingenuity.

A frequent objection to the use of mechanized equipment in the Tropics is that it eliminates hand labor, of which there is often an oversupply. This is a normal development, however, in the evolution through which Temperate Zone countries have progressed to attain their present

high efficiency and service to the world. Indeed, it is almost impossible to produce vegetables on a large scale with ox teams, hoes, hand sprayers, and machetes. The margin of profit, if any, is likely to be too narrow. In the depression year of 1932, in the U.S. Virgin Islands, a grower worked a little over one-half a day to plow and harrow an acre of ground with a tractor; he worked 2½ days to plow that same acreage with bulls, at about double the cost of labor.[4] Only those growers who can obtain high production of high-quality vegetables, however, will be able to adopt the modern improved production methods.

Many of the recommendations given in this circular for growing vegetables in the home garden can be used for commercial production. Before starting to grow a vegetable on the commercial scale, however, it is important first to be reasonably sure that the crop will *grow and produce well* under the prevailing climatic and soil conditions and that it can be profitably marketed. Reliable commission agents at importation centers might be consulted as to sales and boat or airplane shipment.

For small gardens of 1 or 2 acres, oxen, mules, and hand labor can be used. On light to medium-heavy soils, the large-wheeled garden tractors, with attachments of plow, disk, seeder, cultivator, and mowing machine are satisfactory. For vegetable gardens of 5 to 10 acres or more, the lighter wheel or crawler tractor with attachments is desirable. This tractor of about 25 horsepower at the drawbar is usually large enough to plow at least a single furrow in heavy soils and to double disk and cultivate. A power takeoff also can be used with it for standard row-crop sprayers. The medium-size crawler tractors are excellent for large-scale heavy plowing and disking. Small to medium-size enterprises can use 20- to 30-horsepower outfits. More specific recommendations on the equipment needed for vegetable gardens of different sizes and types can be obtained from representatives of the local experiment stations or colleges and from reputable manufacturers.

When machinery is to be used in planting vegetables, the row spacing must be adjusted to fit the cultivating, spraying, and harvesting attachments. Also, enough space must be left at the end of each row for the tractor to turn around. Machinery can be used on land having up to about a 15-percent slope. Where there is a slight slope, the rows should be laid out on the graded contour, using a carpenter's or engineer's level and target. This is particularly true where rainfall is moderate to heavy. Construction of broad-base terraces is advisable on land having a 5- to 15-percent slope. Bench terraces will be needed for slopes greater than 15 percent, but these are often expensive. The use of contour plantings, with and without terraces, not only preserves the soil but also helps retain rainfall, which is highly essential for shallow-rooted vegetables. Likewise, all cultural operations, including furrow irrigation, are facilitated by contour planting.

Where possible, get in touch with the appropriate official of your local government for assistance and instructions in laying out the graded contour rows and terraces. Also, local governments usually have publications available on this subject.

Adequate facilities should be provided in or near the field for shading harvested vegetables until they can be washed, graded, and packed (fig. 39, *A*). Vegetables never should be left in the sun longer than a few minutes after harvest. Harvesting of most crops can be started early in the morning, but to prevent spread of leaf diseases in some crops, such as beans, harvesting should not be started until the foliage is dry. Vegetables for export can be harvested in the afternoon and cooled at night while en route to refrigerated boats.

Proper refrigeration facilities are needed to keep the vegetables in good condition until they can be marketed, shipped, or processed. Large refrigeration companies in the United States can be consulted for specific recommendations on cost and construction of storages and size of equipment needed. Necessary figures on kind and size of crop, rate of loading, outside temperatures, and length of storage period should be supplied to the company. Low temperatures—32° to 60° F., depending upon the vegetable (*59, p. 171*)—are extremely important in retarding ripening and deterioration. For roughly every 10-degree rise in temperature above 32° F., the rate of ripening is doubled and the storage life reduced by one-half.

In conclusion, it should be pointed out that more attention, equipment, materials, and better trained labor are required for some commercial crops, such as beans and tomatoes, than for easily grown crops, such as plantain, yautía, and pigeonpea. The manager must be on the job almost every day. To make the enterprise an economic success, a competent manager must supervise the job and see that the crops are planted, sprayed, cultivated, and harvested properly and at the correct time.

[4] VIRGIN ISLANDS AGRICULTURAL EXPERIMENT STATION. Agr. News Notes 41: 1. 1932. [Processed.]

VEGETABLE GROWING BY GRAVEL CULTURE

During World War II a few United States Army bases were built where there was neither soil nor rainwater. The soil around other bases was so heavily infested with human disease organisms that vegetables for troop consumption could not safely be grown in it. This problem was solved in barren Ascension Island, in British Guiana, in Japan, and in other areas by using the gravel-culture system, also known as nutriculture (*61*), hydroponics, and chemical gardening. Some of these gardens called for a sizeable financial investment and several acres of land. In Japan, where cold temperatures were a factor in winter, some of the gardens were established under glass. For vegetable varieties adapted to gravel culture in Curacao, Netherlands Antilles, see Mullison and Mullison (*34*).

The gravel-culture method of growing vegetables has several advantages, particularly in tropical regions where the beds can be used almost every month of the year. Once the beds and pumping system are established, several common vegetable-growing practices—plowing, disking, weeding, and composting—can be reduced or eliminated. Insect and disease control measures also are frequently reduced or simplified. Excess moisture around the roots—definitely a problem in heavy rainfall tropical regions—is not a factor with properly managed gravel-culture beds. Rain falling into the beds is bypassed in the drainage system, so it does not dilute the nutrient solution stored in the tanks. Quality of supervision and management of gravel-culture benches, however, must be high. The operators should have some training in chemistry, as well as in practical gardening. Periodic checking of the nutrient solution is necessary to maintain proper acidity and to bring the nutrients up to standard levels.

The chief disadvantage of the gravel-culture system is the initial expense of installing the beds, solution tank, and other specialized equipment, such as time clock, solution pumps, solution-testing equipment, and gasoline or electric motors. This system of growing vegetables is probably best adapted to areas where it is difficult to grow them by any other means. A hydroponic garden can be as simple or as complicated as the operator wishes. Hydroponics in its simplest application is described in experiment station circulars from Florida (*56*) and Illinois (*5*).

At Mayaguez, P.R., in 1946–47, two crops of Michigan State Forcing tomatoes (fig. 40, *A*, *B*) and Slobolt leaf lettuce were grown by the gravel-culture system under greenhouse conditions (*40*, *1947*, *pp. 36–39*). The yield of tomatoes was definitely better than that from a neighboring bench of local river-bottom soil given standard applications of chemical fertilizers. Growth and quality of leaf lettuce were satisfactory in both the gravel and soil.

Raised concrete beds with solution tanks beneath were used in these trials, but ground-level beds of concrete, asphalt, or possibly aluminum are more economical and equally as satisfactory. A number of parallel ground-level beds can be fed with solution from a single reservoir tank, supplied through a trough running at a right angle to the beds. The beds can be any length up to about 100 feet. A bench width of about 4 feet facilitates crop management. Walks between beds should be rock or asphalt to reduce splashing soil and disease spores onto the plants.

For descriptions of the equipment and technique for growing vegetables by gravel culture, the reader is referred to the literature cited (*22*, *57*, *61*, *67*) at the end of this handbook.

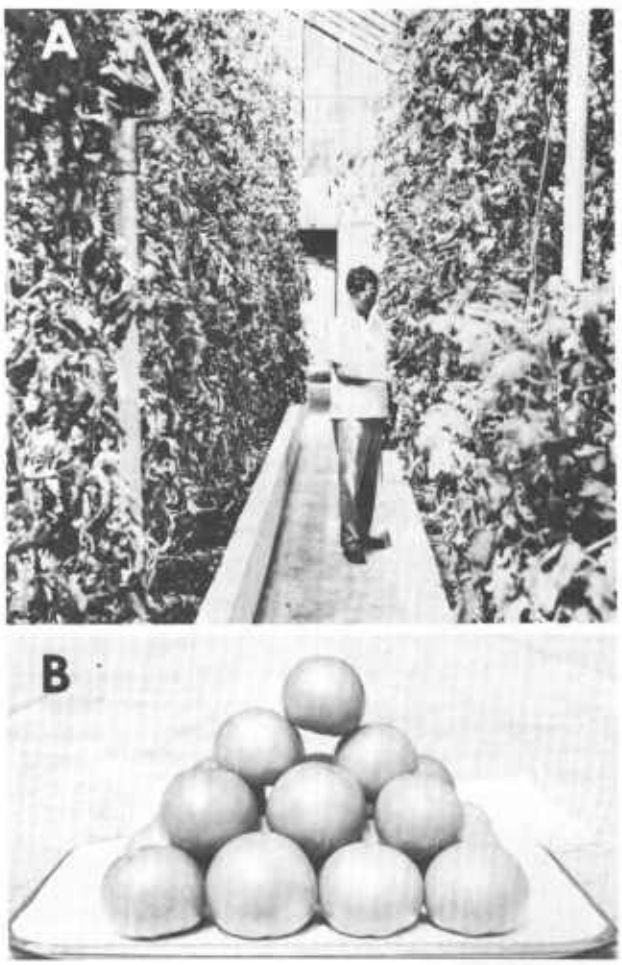


FIGURE 40.—Tomato variety Michigan State Forcing grown by gravel-culture system in Puerto Rico: *A*, Greenhouse in which tomatoes are grown; *B*, tomatoes grown by gravel culture.

GENERAL PEST CONTROL

Along with the advantages of a year-round growing season and rapid growth, vegetable production in the Subtropics and Tropics has the disadvantage of being subjected to continuous attack by a wide variety of pests, including insects, nematodes, slugs, snails, and organisms that cause plant diseases. In order to produce greater quantities of wholesome, nutritious foods in tropical regions, adequate plant pest control must be provided.

Measures appropriate for pest control in the temperate areas are not always completely successful when applied in tropical and subtropical regions. Ecological, physiological, and behavioral differences between pests of temperate and tropical areas are substantial. Species of many tropical insect pests do not often build up high-level infestations as do many species of temperate insects. Instead, tropical insects generally remain at an apparently innocuous but actually very damaging level throughout much or all of the year. Continuously high levels among opposing predators and parasites of tropical insects usually prevent noticeable outbreaks. Plant diseases, particularly those caused by fungi and viruses, are especially damaging in tropical regions. Relatively high humidity during much of the year in many places encourages the growth of harmful fungi. Insect virus vectors are present almost constantly. Nematodes seem almost ubiquitous in tropical areas, although marked observable damage is confined to areas where large acreages of susceptible crops are grown year after year in the same place. The common tropical practice of changing garden locations minimizes the effects of nematodes on small gardens.

All aspects of tropical pest control cannot be covered in a single handbook. If additional information is required, aid should be sought from local agricultural experts or from other publications dealing with specific subjects.

The gardener or small farmer must be constantly alert for signs of plant pests. Regular, frequent spot inspections of individual plants from the time of planting until harvest will permit the grower to provide control measures before plants are severely injured. When the damage is clearly visible, much of the loss has already been incurred. Inspection may reveal eggs, small caterpillars or larvae, or other early stages of insects. Wilting leaves may indicate nematode infestation. Snails and slugs are usually readily observed. Many plant diseases have specific characteristics that are recognizable before extensive damage occurs.

After a plant pest problem has been detected, much can be done to reduce the harmful effects. Control methods can be divided into two broad categories—(1) cultural control and (2) chemical (pesticidal) control.

Cultural Methods of Control

Cultural control is inexpensive and often a valuable adjunct to the chemical control of plant pests. Such cultural control measures include the following:

(1) Plant on well-drained, fertile soil. Fertilizers should be used when needed because healthy, well-nourished plants are better able to withstand the ravages of some kinds of insects and diseases. Good drainage is helpful since many plant diseases are aggravated by excessively moist conditions.

(2) Destroy crop residues after harvest by plowing under or burning. Trash and other crop residues often serve as breeding places for insects and causal organisms of plant diseases. Plowing also exposes soil insects to birds and other predators.

(3) Rotate crops, if at all possible, to reduce insect or disease buildups.

(4) Selective planting and correct harvest timing may completely avoid a plant pest or disease. Considerable yield increase and savings in chemical costs are often obtained.

(5) Use mechanical protectors made from old tin cans, heavy paper, or coarse leaves to protect plants from birds and certain other pests.

(6) Control weeds to prevent injurious competition between crop plants and weeds and grasses.

(7) Plant disease- or insect-resistant crop varieties suited to your particular area when they are available. Resistant varieties often can reduce chemical control expenses.

(8) Purchase certified disease-free seed and plants when possible.

(9) Handpick some pests, especially large insects, slugs, and snails.

Chemical Control

When other means of plant pest control fail, then pesticides must be used. The best pesticide must be selected for a given job. Consideration must be given to suitability of the pesticide to the type of crop, cost, availability, residues, and safety in handling with available equipment. Among the pesticides on the market are those that are rather specific for a particular plant and actually may be harmful to some other plants. Costs of pesticides are prohibitive in many parts of the world; there, cultural and hand means of control must be relied upon. Outside of the major large-scale agricultural areas of the world, some pesticides are not readily available, so it

would seem advantageous to rely on fewer kinds but broad-spectrum chemicals.

Safe Use of Pesticides

Pesticides can be injurious to warm-blooded animals including man, livestock, birds, and other wildlife if care in handling and use is not taken.

(1) Read and follow the directions and precautions listed on the label of the container. Use only the amount stated on the label. Overdosage or improper timing of application of pesticides may injure the plant or leave harmful residues on fruits and vegetables. If a label recommends that the pesticide not be applied to a given plant, follow the advice or injury to the plants or crops may result. It is preferable to use the least toxic chemical if it will give results equivalent to those of more toxic chemicals.

(2) Use care when handling, mixing, and applying agricultural chemicals. Repeated or prolonged contact with the skin should be avoided. Pesticides should be kept out of the eyes, nose, and mouth. Respirators must be used when applying certain pesticides to avoid inhalation of pesticide dusts or mists. Pesticide labels should always indicate if respirators are necessary and what types are required. Contamination of clothing should be avoided when spraying or dusting. Pesticides should be mixed outdoors or in well-ventilated places. Oil-based sprays and concentrates should be handled as if they are inflammable. Application of pesticides should be regulated to avoid contamination of household utensils, dishes, water supplies, and human or animal food. Baits should be carefully placed where children and pets cannot reach them. Drift should be kept to a minimum to prevent interference with beneficial insects, wildlife, and plants. Runoff in high-rainfall areas can carry damaging quantities of chemicals into streams or lakes where fish may be destroyed. Particular care should be taken not to contaminate streams or other water sources with pesticides either during application or when cleaning the spray equipment.

(3) Pesticides should always be stored in their original closed, properly labeled containers in a dry place, inaccessible to children, unprotected humans, rodents, pets, and livestock. Avoid storing herbicides near seeds or fertilizers. Empty pesticide containers are especially hazardous. Empty bags or cardboard containers should either be buried or burned in an open area where inhalation of smoke can be avoided. It is not recommended that herbicide containers be burned. Containers of this type should be buried. Crush and bury bottles or cans in locations where water supplies will not be contaminated.

(4) Persons handling pesticides should be familiar with emergency procedures. SHOULD ACCIDENTAL POISONING BY AGRICULTURAL CHEMICALS OCCUR, A PHYSICIAN SHOULD BE CONSULTED IMMEDIATELY. If poison control centers have been established in areas where this handbook is used, their location and telephone number should be known. In the event of an accident, the following temporary measures should be taken while waiting for professional medical aid:

(a) If pesticides have been spilled on the skin or clothing, remove contaminated clothing immediately and wash the skin thoroughly with soap and water. Launder the clothing before wearing it again.

(b) If gaseous pesticides have been inhaled, remove the victim to the open air and get medical attention as quickly as possible. If respiration has stopped, give artificial respiration until regular breathing is restored.

(c) If pesticides get into the eyes, flush thoroughly with lukewarm water for at least 15 minutes and get medical attention as quickly as possible.

(d) If pesticides have been swallowed, follow first aid instructions, if listed, on the label. Call a physician immediately. In the absence of specific first aid instructions, some general treatments are often helpful. In many cases the stomach should be emptied as soon as possible. A warm salt water solution containing 1 tablespoon of salt in a glass of water will often induce vomiting. Inserting a finger into the throat is also effective. After vomiting has occurred, a mixture of raw egg white mixed with either water, or flour and water, or milk will often be beneficial. The victim should be kept quiet and comfortable and, if shock occurs, should be kept warm. NEVER ATTEMPT TO ADMINISTER ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

Avoiding Harmful Residues in Food

Chemical residues are the pesticide deposits that may remain on vegetable crops when they are harvested and marketed.

Generally no danger of harmful pesticide residues remains *provided the correct pesticide in the concentration and amount prescribed for the particular crop is used at the proper time.* Troubles begin when gardeners or small farmers fail to follow directions stated on the pesticide label. Reasoning that "if a little is good, then more will be better" is all too common. Application of excessive quantities of pesticides can leave harmful residues. Care must be taken when measuring concentrates having high percentages of active ingredients. A specified time often must elapse between the last application of a pesticide and harvest. Residues persist for varying periods of

time, ranging from a few hours or weeks, to much longer, depending upon the stability of the compound. Every vegetable grower should be aware of pesticide residue dangers and follow a pest control program designed to provide adequate control without using excessive quantities of pesticides.

Availability, Stocking, and Storage of Pesticides

Availability and storage of pesticides in tropical areas is an important consideration for successful pest control. An extremely high percentage of pesticides is manufactured in either the United States or Europe. Sources of supply in tropical areas are limited, and even these sources are handicapped by distance from the manufacturer. Too often orders are made yearly or biannually and the long storage period results in a loss of efficacy before sale to the user. For example, rotenone compounds can often lose a substantial amount of their insecticidal value by the time they find their way into the hands of the local gardener or farmer.

Few local dealers can afford to stock all types of pesticides that might be available, so the gardener or small farmer must depend upon a limited number of broad-range chemicals. Stocking the wide variety of formulations and concentrations commonly sold in the United States also is generally not practical. A single concentration of a wettable powder or an emulsifiable concentrate will usually serve the purpose. Formulations with a high percentage (50 percent or over) of active ingredient save shipping and storage costs.

Dry formulations, including dusts and wettable powders, are particularly susceptible to rapid deterioration unless properly stored. Such pesticides should be placed in cool dry places for longest storage life. Emulsifiable concentrates and granular pesticides deteriorate much less rapidly and are preferred in warmer areas, especially when used by the gardener or small farmer.

Basic Chemicals Recommended for Tropical Purposes

Many different kinds of chemicals and formulations are available and can be recommended, but those enumerated in this handbook represent materials that are particularly suited for use in warm places. The considerations were availability, storability, costs, ease of handling, safety, and applicability to a variety of situations. As new products become available and as existing chemicals become cheaper, this list will be subject to change. The formulations suggested are those demanding the least variation in amounts of active material per unit of water. Experience has shown that the bewildering variety of formulations on the market today often result in calculation error.

Specific Formulations for Pest Control

INSECTICIDE SPRAYS

Insecticide	*Formulation* [1, 2]	*Amount of purchased product to mix with—*	
		100 gallons water	*1 gallon water*
Carbaryl (Sevin)	50-percent WP	2 pounds	2 level tablespoons.
Chlordane	40- or 50-percent WP	3 pounds	1½ level tablespoons.
	or		
	45-percent EC	2½ pints	2 teaspoons.
DDT	50-percent WP	2 pounds	2 level tablespoons.
	or		
	25-percent EC	1 gallon	1 tablespoon.
Diazinon	50-percent EC	1 quart	1 teaspoon.
Dicofol (Kelthane)	18.5-percent EC	1 pint	1 teaspoon.
	or		
	18.5-percent WP	3 pounds	1 level tablespoon.
Malathion	57-percent EC	1 quart	2 teaspoons.
Naled	8-pound-per-gallon EC	1 pint	1½ teaspoons.
Rotenone	Derris or cube root powder (5 percent rotenone content).[3]	5 pounds	4 level tablespoons.
Sulfur	Wettable sulfur	5 pounds	3 level tablespoons.
Toxaphene	40-percent WP	5 pounds	3 level tablespoons.
	or		
	60-percent EC	2½ pints	1 tablespoon.

[1] Apply 1 quart of spray per 50 feet of row or 125 square feet (87 gallons per acre).

[2] WP = wettable powder; EC = emulsifiable concentrate. Products on the market contain various percentages of actual insecticide. If you buy a product in which the percentage differs from that called for in this table, mix proportionately more or less of it with water.

[3] If available powder is of a lower rotenone content, use proportionately more of it. First mix the powder with a small quantity of water; then add remaining water.

INSECTICIDE DUSTS

Insecticide	Active Ingredient Percent
Carbaryl	3
Chlordane	5
DDT	5
Diazinon	2
Dicofol	2
Malathion	4
Naled	3
Rotenone	1
Sulfur	25
Toxaphene	5

Apply an even, light coating of dust at the rate of 1 ounce per 50 feet of row or 125 square feet (22 pounds per acre). Force dust through the foliage so it reaches both sides of the leaves. Apply dust when the air is still.

INSECTICIDE BAITS

CHLORDANE.—Mix 3 level tablespoons of 40- or 50-percent WP, 12 pounds of wheat bran, and 1½ quarts of fresh lubricating oil (20 to 30 SAE viscosity).

METALDEHYDE.—Use a commercially prepared bait.

Distribute the chlordane bait evenly over the soil surface at the rate of 1 pound per 1,000 square feet of garden space (40 pounds per acre). Use the metaldehyde bait as directed on the container. Be sure not to contaminate parts of the plants to be eaten with either bait.

FUNGICIDES

Bordeaux mixture
Captan 50-percent WP [1]
Karathane 25-percent WP
Maneb 80-percent WP
Sulfur WP
Zineb 75-percent WP

[1] See footnote 2, under "Insecticide Sprays," page 86.

NEMATOCIDES

DD-Mixture
Dowfume W-85
Nemagon
Fumazone 86

PLANT INJURY WARNING

Do not use the following products on the crops listed or serious losses may result:

DDT—On cucurbits (cucumber, melon, squash).
Toxaphene—On cucurbits, young tomato plants, lettuce, and escarole for 3 weeks following seeding or transplanting.
Chlordane—On cucurbits.
Copper compounds (bordeaux mixture, Copper A Compound)—On corn, turnip, mustard greens.
Dicofol (Kelthane)—On eggplant.
Semesan—On lima bean.

Do not mix emulsifiable concentrates with wettable powders or with sulfur. They are generally not physically compatible.

Types of Pesticide Formulations and Their Uses

Most pesticides encountered by noncommercial pest control operators will be in a prepared form to which water alone is usually added. Nevertheless, an understanding of the basic terminology and definitions used in pesticide formulations is needed to properly evaluate and understand the potentialities of chemicals for particular situations.

Carriers are substances such as talc, clays, gypsum, and solvents that are used in conjunction with pesticides to facilitate their application. *Diluents* reduce concentration of active ingredients and phytotoxicity of pesticides. Carriers can also act as diluents. *Adjuvants* are relatively nontoxic materials added to pesticides to enhance contact with an insect or plant, to enable mixing immiscible liquids, or to retard settling of suspended materials. Adjuvants include *emulsifiers* that allow water-oil mixtures; *wetting agents* that reduce surface tension and facilitate the spread of pesticide; *stickers* that by chemical or physical means increase adhesion between a pesticide and an applied surface; *synergists* that are compounds, such as piperonyl butoxide, used in conjunction with a toxicant to increase its effectiveness; and *deflocculating agents*, such as agar and gum arabic, which prevent clumping and settling of particles in solution. Carriers, diluents, emulsifiers, wetting agents, stickers, synergists, and deflocculating agents are usually added to prepared pesticides during manufacture.

Pesticides generally are applied as dusts, liquid sprays, granules, or fumigants. Dusts and granules are purchased ready to apply. Liquid sprays must be prepared by mixing water with dry powder (wettable or soluble) or with liquid concentrate (suspension or emulsifiable). Sprays can also be in aerosol form or as oil solutions or water suspensions. Some of the solutions and suspensions are made up with wettable powder or emulsifiable concentrates. Fumigants are purchased in liquid form ready to apply. Each type of formulation has its own peculiar advantages and individual local requirements and conditions should govern usage.

Dusts are composed of an active pesticidal ingredient plus an inert carrier. Dusts are especially useful in hilly or muddy areas where heavy spray rigs are hard to handle. Dusting is faster than spraying and is advantageous when the water supply is short.

Wettable powders are composed of an active pesticidal ingredient plus an inert carrier, much the same as dust except that wetting agents are added. Wettable powder formulations are often abbreviated as 25-percent WP,[5] 50-percent WP, etc., which means that 25 percent or 50 percent of the wettable powder is the active ingredient, with the inert carrier substances composing the remainder.

Emulsifiable concentrates are composed of a

[5] The abbreviations WP (wettable powder), EC (emulsifiable concentrate), and E (pounds active ingredient per gallon of finished pesticide) are used throughout this handbook.

water-insoluble pesticide that is dissolved in a solvent carrier, such as oil, plus an emulsifier that permits mixing with water. Emulsifiable concentrates are abbreviated as 25-percent EC, 50-percent EC, which means that 25 percent or 50 percent of the formulation is the active ingredient, with the emulsifier and inert ingredients composing the remainder. Abbreviations such as 2E, 4E, and 6E indicate 2, 4, and 6 pounds of active ingredients per gallon of concentrate. Emulsifiable concentrates permit the mixing of insoluble pesticides with water.

Water spraying with either wettable powders or emulsifiable concentrates is much more widely practiced than dusting at present because (1) the water spray disperses more efficiently than dust, (2) less drift is involved, (3) the costs of dust diluents are high, (4) dust carriers tend to separate from the toxic principle in the air, (5) dusts present an inhalation hazard to the operator, and (6) for a given amount of active ingredient, wettable powders and emulsifiable concentrates require less storage space than dust.

Granular pesticides are composed of absorptive clays or diatomaceous earths impregnated with toxicants mixed with a suitable solvent. Particle size can be regulated to suit the need. Such particles greatly minimize drift and, since they do not adhere readily to plant surfaces, decrease residue deposits. Granules are especially useful for the control of soil insects and for those attacking row crops, such as corn.

Selecting and Preparing Pesticides

When selecting a pesticide, a number of considerations are important. Among these are:

(1) *Select the best pesticide for a particular problem.* Pesticides are often rather specific for given pests or diseases. Some are phytotoxic either at all times or under particular environmental conditions. If two kinds of materials are to be applied simultaneously, compatibility with one another must be considered. A compatibility chart, which can be obtained from the Meister Publishing Co. of Willoughby, Ohio, published for the American Fruit Grower magazine, is inexpensive and supplies complete information. Incompatibility between chemicals can result in severe damage to or destruction of the crop, difficulties in operation and maintenance of application equipment, or mixing problems. Costs of the chemical itself and of application must be evaluated. Other factors being equal, it is probably best to use the least toxic material.

(2) *Carefully measure concentrations and amounts of sprays and dusts.* Severe phytotoxicity or destruction of the plant may result or harmful residues may remain on the plant if excessive amounts of pesticides are used. Accurate measurements are particularly important when small quantities are required. Follow the directions on the pesticide label exactly.

(3) *Prepare only the quantity of pesticide needed.* Many pesticidal materials deteriorate rapidly after they are mixed; use them promptly.

(4) *Apply pesticides uniformly and thoroughly.* Careless, incomplete application of pesticides can result in poor control or in chemical damage to plants.

Most pesticide requirements of the gardener are for limited quantities, so recommendations given in this handbook have been presented in terms of small measure.

In some respects, preparing small quantities of pesticides is more difficult than preparing large amounts. Measurements must be carefully made. It can never be stressed too strongly that even an apparently insignificant excess may be toxic to the plant as well as to the pest or causal organism of a disease and may result in unsafe or harmful residues.

The gardener or small farmer should have a measuring cup, teaspoon and tablespoon measuring spoons, and a mixing container of suitable size. With these simple items, everyday pest control dilutions can be easily and accurately made. Should larger amounts of pesticides be needed, full information is as follows:

Calculating dilutions for larger quantities of pesticides need not be a mystery if directions are followed carefully. Various methods have been published but those given below are simple and lend themselves to a variety of practical situations. *In all cases it is first necessary to determine the total active ingredient required.*

Dry Concentrates: If a wettable powder or dust is to be used, find the active ingredient required and then set up a proportion to give the amount of wettable powder or dust needed as outlined in the examples.

Example 1. Prepare 100 gallons of a 2.5-percent DDT solution in water using 50-percent DDT WP. (Remember, 100 gallons of water weighs 834 pounds.):

0.025×834 pounds

$= 20.85$ pounds active ingredient,

then,

$$\frac{\text{20.85 pounds active ingredient}}{\text{50 percent}} = \frac{x}{\text{100 percent}}$$

or 41.7 pounds of 50-percent DDT WP

Example 2. Prepare 100 pounds of 5-percent DDT dust from a dust containing 20-percent DDT. Use talc or other suitable carrier:

0.05 × 100 pounds
= 5 pounds active ingredient,
then,

$$\frac{\text{5 pounds active ingredient}}{\text{20 percent}} = \frac{\text{x}}{\text{100 percent}}$$

or 25 pounds of 20-percent DDT dust
PLUS 75 pounds of carrier

Liquid Concentrates: If an emulsifiable concentrate or oil emulsion is to be used, find the active ingredient required and then divide this quantity by the active ingredient in the concentrate or emulsion you are using.

Example 1. Prepare 50 gallons of spray containing 5-percent DDT solution in water using 6E DDT concentrate:

0.05 × 417 pounds
= 20.85 pounds active ingredient,
then,

$$\frac{\text{20.85 pounds active ingredient}}{\text{6 pounds}}$$

= 3.48 gallons of 6E DDT concentrate

Example 2. Prepare 10 gallons of 1-percent diazinon spray using a 50-percent diazinon EC. (1 gallon water weighs 8.34 pounds.):

0.01 × 83.4 pounds
= 0.834 pounds active ingredient,
then,

$$\frac{\text{0.834 pounds active ingredient}}{\text{4 pounds}}$$

= 0.208 gallons of 50-percent diazinon EC

Sometimes it is necessary to calculate the amount of pesticidal sprays or dusts needed per acre. The basic equation is:

$$Q = \frac{A \times R}{C}$$

Q = Quantity of concentrate required in pounds wettable powder, gallons of emulsifiable concentrate, or pounds of dust.
A = Number of acres.
R = Pounds of active ingredient required per acre.
C = Concentration (percent active ingredient per pound wettable powder, pounds active ingredient per gallon of emulsifiable concentrate, or percent active ingredient per pound of dust).

Example 1. Prepare, using a 6E chlordane concentrate, a spray to be applied to 5 acres of land at the rate of 1 pound per acre using a 500-gallon capacity spray rig that can deliver 100 gallons of spray per acre. The spray rig tank must be filled only once:

$$Q = \frac{\text{5 acres} \times \text{1 pound/acre}}{\text{6 pounds/gallon}}$$

= 0.83 gallons of 6E chlordane concentrate
PLUS 500 gallons of water

Example 2. How many gallons of 2E chlordane concentrate are required to prepare a spray for a 5-acre field with 2 pounds of active ingredient per acre?

$$Q = \frac{\text{5 acres} \times \text{2 pounds/acre}}{\text{2 pounds/gallon}}$$

= 5 gallons of 2E chlordane concentrate

Tables of Measurements

The following data concerning measure, weight, capacity, and dilution are useful when mixing chemicals:

Linear Measure:
One inch = 2.54 centimeters = 25.4 millimeters
One foot = 12 inches = 30.5 centimeters = 0.3048 meter
One yard = 3 feet = 0.9144 meter
One rod = 5.5 yards = 16.5 feet = 5.029 meters
One mile = 1,760 yards = 5,280 feet = 1.6094 kilometers
One millimeter = 0.0394 inch = about 1/25th inch
One centimeter = 10 millimeters = 0.3937 inch = about 2/5 inch
One decimeter = 10 centimeters = 3.937 inches
One meter = 10 decimeters = 3.28 feet = 39.37 inches
One kilometer = 1,000 meters = 0.6214 mile

Square Measure:
One square foot = 144 square inches = 0.0929 square meter
One square yard = 9 square feet = 0.8361 square meter
One square rod = 272.25 square feet = 30.25 square yards = 25.293 square meters
One acre = 43,560 square feet = 4,840 square yards = 0.4047 hectare
An area 4 rods by 4 rods = 16 square rods = 0.1 acre
One square mile = 640 acres = 259 hectares
One square meter = 1,550 square inches
One hectare = 2.471 acres = 10,000 square meters

Capacity Measure (Liquid):

One level tablespoonful = 3 level teaspoonfuls
One fluid ounce (U.S.) = 2 tablespoonfuls = 29.57 milliliters
One cupful = 8 fluid ounces
One pint = 2 cupfuls = 16 fluid ounces = 473.2 milliliters
One quart (U.S.) = 2 pints = 32 fluid ounces = 0.9463 liter
One gallon (U.S.) = 4 quarts = 128 fluid ounces = 231 cubic inches = 0.1337 cubic foot = 3.785 liters
One milliliter = almost exactly 1 cubic centimeter
One liter = 1,000 milliliters = 1.057 liquid quart (U.S.)

Weight:

One ounce (avoirdupois) = 28.3 grams
One pound (avoirdupois) = 16 ounces = 453.6 grams
One ton (U.S. short) = 2,000 pounds = 907.185 kilograms
One gram = 100 milligrams = 0.0353 ounce
One kilogram = 1,000 grams = 35.27 ounces = 2.205 pounds
One ton (metric) = 1,000 kilograms = 2,204 pounds = 1.1023 short tons
One milligram per kilogram = 1 part per million

Application Equipment for Pest Control

Attention to the right kind of application equipment is just as important as proper methods of treatment and use of the correct pesticide for a given purpose. Today there is a type and size of sprayer or duster for every imaginable purpose. Many of these are rather specialized, so the prospective user should carefully select equipment that is versatile enough to fill a number of needs. Considerations in the selection of pesticide application equipment include (1) special properties of the chemical to be used, (2) appropriate capacity for the majority of the jobs for which the equipment is to be used, and (3) convenience and ease of operating the equipment.

EQUIPMENT USED FOR HERBICIDE SPRAYING SHOULD NOT BE USED TO SPRAY ANY OTHER KIND OF PESTICIDE. IF IT MUST BE USED, CLEAN CAREFULLY ACCORDING TO MANUFACTURER'S RECOMMENDATIONS OR SEVERE PHYTOTOXICITY MAY RESULT.

Several types of sprayers (fig. 41) and dusters (fig. 42) seem especially suitable for small garden plantings. Sprayers include intermittent and continuous hand sprayers, compressed air sprayers, knapsack sprayers, and motor blower sprayers. Dusters include plunger dusters, crank dusters, and knapsack dusters.

Intermittent and Continuous Hand Sprayers (fig. 41, *A*).—These sprayers are the common "flit" gun type. Their low cost, safety, and versatility provide a very economical and practical means of treating small garden plots. Tanks may be constructed of stainless steel, nickel-plated or painted steel, brass, copper, or glass with capacities of from about 4 ounces to 3 quarts. Usage and durability desired will govern materials but, in general, it usually pays to buy a good-quality sprayer.

Hand sprayers consist of a tank for holding spray materials, an air pump and nozzle for breaking up and expelling the spray in particles of proper size, and a siphon tube for delivering the spray materials from the tank to the air pump nozzle.

Intermittent hand sprayers discharge spray only on the forward stroke of the air pump, whereas continuous sprayers have a one-way valve that permits air to be compressed in a chamber between the valve and the nozzle. When the pump is drawn back for another stroke, the air compressed in the chamber continues to operate the sprayer. Continuous hand sprayers often have nozzle adjustments for varying the coarseness of the spray. Continuous sprayers should not be used for sprays consisting of suspended solids unless directions specifically permit because nozzle orifices are generally too small.

Intermittent and continuous hand sprayers are relatively trouble free; but if compression is lost, withdraw the pump handle as far as possible and put a few drops of thin oil in the air hole at the end of the cylinder to lubricate the plunger cup. Carefully clean and store in a dry place after use.

Compressed Air Sprayers (fig. 41, *B*).—Compressed air sprayers are particularly useful around a small vegetable garden plot. Tanks are usually constructed of galvanized steel and capacity is from 1½ to 5 gallons. A wide variety of nozzle disks to provide solid cone, hollow cone, flat fan, and coarse, fine, and stream sprays is available.

Compressed air sprayers consist of a tank fitted with a handle or shoulder strap for easy transport; a pressure-tight filler cap that fits into the open-topped or funnel-topped tank; an air pump that compresses air in the tank above the spray solution; and a discharge tube that allows the spray to go from the tank into delivery equipment consisting of a hose, a spray control valve, and an extension tube equipped with a spray nozzle.

This type of spray tank can be used for any type of spray material and operates at low pressures from 30 to 50 pounds per square inch. The tank should not be filled more than three-fourths full of spray in order to permit satisfactory working pressures. Occasional agitation will keep spray materials properly mixed. The principal drawback of this kind of sprayer is that it must be placed on the ground and pumped periodically to provide the compressed air needed for operation.

Knapsack Sprayers (fig. 41, *C*).—Knapsack

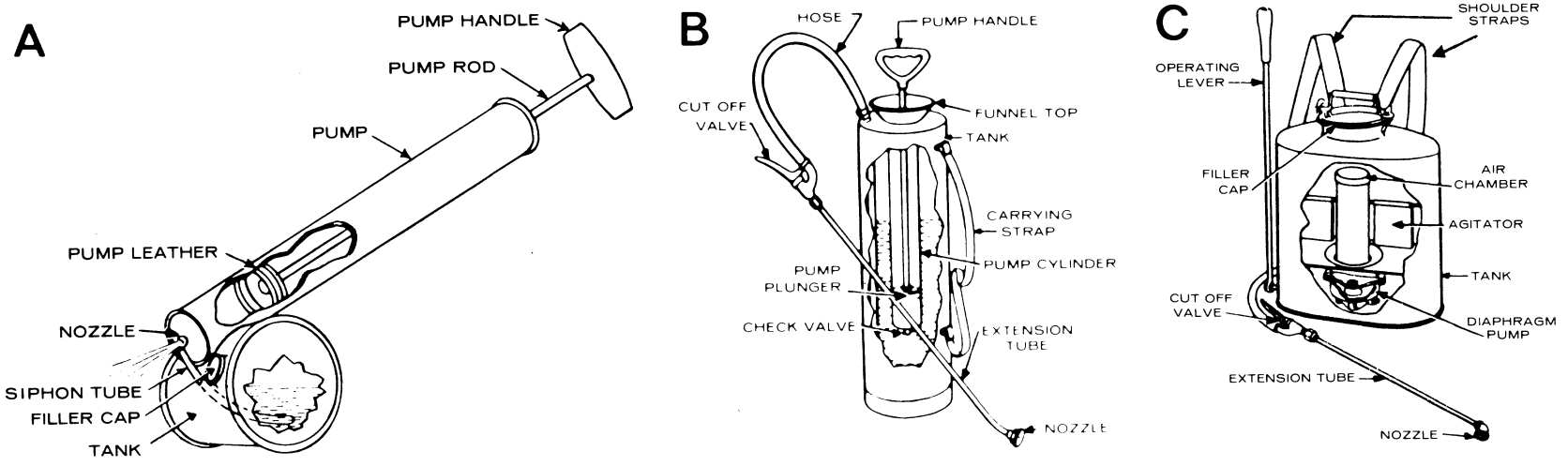


FIGURE 41.—Types of sprayers: *A*, Intermittent and continuous hand sprayer; *B*, compressed air sprayer; *C*, knapsack sprayer.

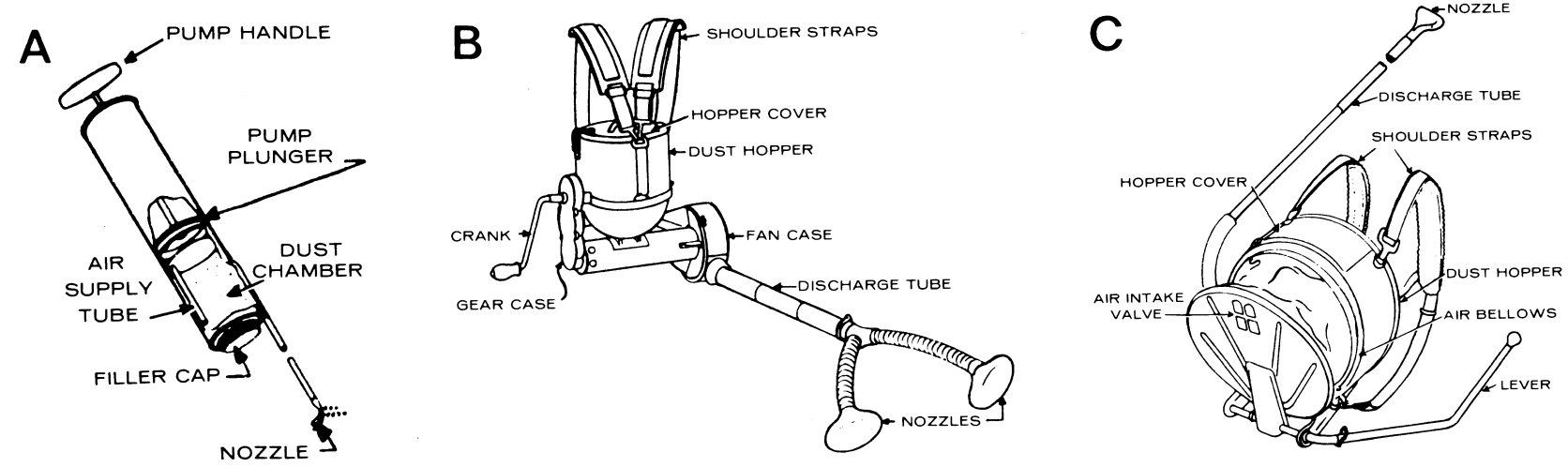


FIGURE 42.—Types of dusters: *A*, Plunger duster; *B*, crank duster; *C*, knapsack duster.

sprayers are probably the most convenient and useful sprayers, consistent with low cost and ease of upkeep, that can be purchased for the large-scale gardener or small farmer.

Knapsack sprayers are carried on the back by means of shoulder straps. The tanks are constructed of copper or galvanized steel and capacity is from 4 to 6 gallons. A lever extending to the front of the operator permits pumping while carrying the sprayer.

Two main types are commonly available; one has a double action external slide-type pump delivering up to 180 pounds per square inch pressure but requires constant pumping; the other type has an internal displacement chamber that builds up air pressure for operation at about 80 pounds per square inch in much the same manner as a compressed air pump. Only intermittent pumping is required for the second type of pump. Agitators activated by pumping action keep chemicals mixed in each type of sprayer. A full line of nozzles is available for knapsack sprayers.

After it is used, the sprayer must be thoroughly cleaned by pumping clean water through the system. The nozzle must be disassembled and cleaned also.

Motor Blower Sprayers.—These motor-driven portable sprayers can be carried on the back. A two- or four-cycle gasoline engine supplies the power to give a low-volume, low-pressure, efficient machine that can be used as a sprayer or as an air blast mist blower. Some models will handle dust as well as sprays. Motor blower sprayers are expensive, but are indispensable to the large-scale gardener or small farmer because they can be used to spray a considerable area. Maintenance is a problem, but with care a motor blower will give long service.

Plunger Dusters (fig. 42, *A*).—A plunger duster is the least complex of all dusting devices. It is particularly useful in the small garden when small quantites of dust must be accurately applied. Dust capacity varies from 1 to 3 or 4 pounds.

Plunger dusters are composed of an air pump, a dust chamber, and a discharge assembly. The pump handle is withdrawn, allowing air to enter the air chamber through a supply tube equipped with a one-way valve. As the pump is pushed forward, the inlet valve closes and another exit tube with a second one-way valve opens, allowing dust in the dust chamber, which has been put into motion by the air pressure, to be expelled. Discharge assemblies in plunger dusters often have deflector caps or adjustable nozzles that allow the dust to be directed.

Metal plunger dusters are durable, easy to maintain, and relatively inexpensive.

Crank Dusters (fig. 42, *B*).—Crank dusters are perhaps the most useful type for the average large-scale gardener or small farmer. They are intended for continuous operation in small acreages.

Crank dusters are carried in front of the operator by means of shoulder straps. They consist of a dust hopper with a capacity of from 5 to 25 pounds, a gear case chamber containing hand-cranked high-speed gears, and a fan that blows dust from the gear case chamber out through the discharge tube. The discharge tube can be supplied with two nozzles so as to bracket two rows.

Knapsack Dusters (fig. 42, *C*).—Knapsack dusters are also very useful for the large-scale gardener or small farmer. They differ from crank dusters in that the duct flow is intermittent rather than continuous. Efficient dusting of widely spaced plants or spot dust application is easier with the knapsack duster than with the crank duster. As the name suggests, it is carried on the back.

An air current provided by bellows draws dust from the hopper into the discharge apparatus where it is driven out with each positive stroke of the lever. The bellows can be placed on top of the dust chamber or on one side. Knapsack duster capacity is about the same as that for the crank duster.

After dusters are used, the dust that is still in the duster should be removed completely from both the hopper and discharge apparatus. Then the slip-joints on the discharge tube should be lubricated and the dusters stored in a dry place.

VEGETABLE INSECTS[6]

A large number of insects are general feeders and attack many different vegetable crops. Other insects feed only on specific kinds of vegetables or groups of vegetables. The descriptions and habits of the general feeders will be discussed first. The specific pests and the control of both groups will be discussed under the various crops. Directions for mixing the sprays, dusts, and baits recommended for insect control on the various crops, and instructions for their use are given on pages 88 and 89. Use the insecticides only on the crops for which they are recommended. Use only dosages specified and observe specified waiting periods between last application and harvest.

[6] The section on Vegetable Insects was revised at the galley proof stage by F. P. Cuthbert, Jr., entomologist, Entomology Research Division, Agricultural Research Service, Charleston, S.C.

General Insects

Ants

In tropical areas ants not only tend aphids and certain other sapsucking insects for their honeydew excretion but also are harmful to the plants because of leaf cutting and attacking seedlings, plant stems, and seeds.

Consult local agricultural authorities for control measures.

Aphids

Aphids, sometimes called plant lice, attack most vegetable crops at some time if not regularly. These sluggish soft-bodied insects are yellowish, greenish, or blackish and about 1/8 inch long. They cluster in large numbers, usually on the undersides of leaves or on the terminal shoots, and suck the sap from the plants.

During feeding, aphids inject a toxic digestive juice into the plant with resultant spotty discoloration or blighting of the leaves. Aphids also exude a sticky sugary honeydew on which sooty mold fungus thrives and further harms the plant by interfering with photosynthesis. When infestations are heavy, aphids can kill a plant. Aphids are also probably the most important insect vectors of viruses causing plant diseases.

Armyworms

Armyworm caterpillars are among the most serious insect pests of vegetable crops. They are variable in color and may become 1½ inches long. In tropical areas the fall armyworm is the most damaging pest of this type. Armyworms sometimes appear suddenly in great numbers, often destroying entire fields. They tend to prefer grasses but also eat the foliage of many vegetable crops. Control measures must be taken before armyworms become too large. Carefully inspect the plant parts, especially near the base, for the appearance of the young worms. In highland areas, cool wet periods are sometimes followed by outbreaks of fall armyworm because of interference with biological control.

Predatory birds eliminate many armyworms and should not be molested. However, insecticide control measures are often needed. Poison baits placed across the line of march of worms moving from one field to another will sometimes protect vegetable plantings from invasion.

Asparagus Beetle

Adult asparagus beetles are metallic blue to black with yellowish markings. They are about ¼ inch long and have a reddish head. The larvae are sluggish, humpbacked, gray or olive, and reach a size of 1/3 inch. The adults and larvae eat the foliage of asparagus and disfigure the shoots.

Cabbage Caterpillars

The three most important species of cabbage caterpillars are the cabbage looper, the diamondback moth, and the Gulf white butterfly.

The cabbage looper is a pale-green measuring worm with light stripes along its back. It doubles up or loops when it crawls and is 1½ inches long when full grown. Loopers feed on the undersides of the leaves, producing ragged holes.

The diamondback moth larva (fig. 28, *E*) is light green, slender, and up to 1/3 inch long. It wriggles rapidly when disturbed, and often drops from the plant and hangs by a silken thread. The larva eats small holes in the leaves and tunnels into tender buds.

Larvae of the Gulf white butterfly are 1½ inches long when mature, are yellow, and have four purplish stripes. They feed on the upper and lower sides of the leaves, producing ragged holes.

Corn Earworm

Larvae of the corn earworm (fig. 25, *E*) are green, brown, or pink with longitudinal stripes. When mature, they may be up to 1¾ inches long. Corn earworms are general feeders and attack many different vegetables. They tunnel into the fruit of tomatoes, the pods of beans and okra, the heads of cabbage, and the ears of corn.

Cutworms

Cutworms (fig. 32, *B*) are greenish, brownish, or grayish hairless caterpillars up to 1½ inches long. They curl up tightly when disturbed.

Cutworms are among the most damaging pests of many kinds of vegetable crops, especially to young plants or newly set transplants. Cutworms injure plants in one or more of three ways: (1) cutting off stems at the soil surface, (2) feeding on the foliage, or (3) feeding on the root. Cutworms hide during the day but can often be found by digging into the ground near the base of plants.

Cutworm injury to transplants can be prevented by placing a stiff 3-inch cardboard collar around the stems, 1 inch beneath the soil surface and 2 inches above. Allow at least ½ inch between the stem and collar. A paper drinking cup with the bottom cut out can also be used.

Flea Beetles

Flea beetles are hard, black, brown, or striped, are 1/16 to 1/8 inch long, and have enlarged hind legs for jumping. They attack many kinds of vegetable crops. Infested leaves look as if they had been peppered with fine birdshot. When

large numbers of flea beetles are present, foliage can be so badly damaged that it is incapable of sustaining the plant. Young plants, especially transplants, are quite vulnerable. The many small feeding holes provide an entry for a number of organisms that cause plant diseases. Flea beetles also are vectors of viruses causing plant diseases.

Field Crickets

These common jumping insects are black or dark brown and ⅔ to 1 inch long. When abundant, they may cause substantial losses to seeds, seedlings, and fruits of beans, cucumber, melons, squash, and tomatoes. Usually, however, field crickets are not serious pests.

Deep plowing that buries the eggs is an effective cultural control.

Grasshoppers

Grasshoppers are greenish or grayish, jumping, strong flying insects up to 2 inches long. During the dry season in tropical regions, grasshopper populations sometimes build up so that they become serious garden pests. They often devour an entire crop. Damage is particularly severe when the vegetable-growing area is surrounded by wasteland or by other crops on which grasshoppers have not been controlled.

Natural enemies, especially birds and lizards, usually keep grasshoppers under control in the Tropics.

Hornworms

Hornworms (fig. 27, *C*) are large (3 to 4 inches long when mature) green caterpillars with L-shaped white markings on their sides and a conspicuous horn on their tail. They eat the leaves and tender stems of tomato, potato, pepper, and related plants.

Handpicking is an effective control when the larvae are not too abundant.

Leafhoppers

Leafhoppers are wedge-shaped green or tan insects ⅛ to ¼ inch long. They usually infest the undersides of leaves. Damaged foliage curls or crinkles and becomes yellowed or bronzed; plants may be dwarfed. Leafhoppers also cause extensive damage through transmission of viruses that cause plant diseases.

Many species of leafhoppers are found in tropical regions. They attack many kinds of vegetable crops although small plots usually are not severely affected unless large cultivated areas are nearby. Leafhoppers fly vigorously and spread rapidly. Nymphs are similar in appearance to adults but are smaller and cannot fly.

Leaf Miners

Leaf miners are tiny white or yellow legless maggots of small black or black and yellow flies. They damage plants by tunneling between the upper and lower leaf surfaces, making winding whitish mines 1/32 to 1/16 inch wide.

Leaf miners are common pests of young plants. Heavy infestations can severely retard growth although plants are seldom killed. Leafy vegetables are disfigured by leaf miner attacks.

Leaf miners are hard to control because of their mining habits.

Millipedes

Millipedes are 1 to 3 inches long, cylindrical, many-segmented, tough-shelled, reddish, greenish, black or striped wormlike creatures with many legs, arranged two pairs per body segment. They attack roots, tubers, and other plant parts in contact with the ground.

During wet seasons in the Tropics, millipedes sometimes appear in large numbers. At such times they are important to the gardener because they shift from their primary role as scavengers of dead plant material and attack living plants.

Cleanup of dead plant trash aids greatly in suppressing millipede populations.

Mole Crickets

Mole crickets are brownish crickets up to 1½ inches long with very large front legs adapted for digging. They live in tunnels beneath the surface of the ground.

When numerous, mole crickets can damage many kinds of vegetable crops. The characteristic burrows with their raised trail of earth at the soil surface reveal the presence of mole crickets. Mole crickets are more common and cause their greatest damage to crops planted in sandy or loamy soils. They attack the plant stems as well as the roots and are devastating in seedbeds.

Plant Bugs

Many species of plant bugs are serious pests of vegetable gardens. The tarnished plant bug, an elongated brownish insect with irregular white, yellow, and reddish-brown splotches, is one of the most serious despite its length of only ¼ inch. Stink bugs or shield bugs can be equally damaging in tropical regions. Damage by plant bugs resembles that of aphids except that it is more

obvious. Leaves can be deformed, stems scarred and discolored, and fruit dwarfed and pitted.

Slugs and Snails

Snails have shells; slugs do not. Both have grayish slimy legless bodies.

During the rainy season when numbers are greatest, slugs and snails can damage vegetable gardens severely. Slugs and snails sometimes live for a year or more, and their damage can continue for a long period. Large holes eaten out of leaves by slugs and snails frequently destroy young plants. Slugs and snails feed mainly at night but their presence is revealed by a shiny sticky trail produced by a secretion from the undersurface of the body.

Handpicking is often a satisfactory control for slugs and snails in the small garden. Plant refuse in sheltered areas sometimes serves as a hideaway where slugs and snails can be caught and destroyed.

Spider Mites

Spider mites, tiny eight-legged spider relatives, usually damage plants most severely during periods of dry, hot weather. Plant foliage becomes blotched with pale, yellow, white, or reddish-brown spots. The undersurface of affected leaves appears to have been lightly dusted with a very fine white powder that, when magnified, can be seen to consist of empty spider mite skins and eggs suspended on silken strands. The whitish, greenish, or reddish mites are up to about 1/16 inch long and feed on plant sap with two slender lancelets that form their mouth parts.

Thrips

Thrips are minute (often less than 1/16 inch long), slender, agile yellowish or reddish-brown insects, wingless or with two pairs of very slender fringed wings that are laid over the back when the thrips are resting. Foliage damaged by this tiny sap-feeding insect may be silvered, bleached, or wilted and covered with tiny dots of black excrement.

Thrips are all too often ignored in tropical areas unless they heavily infest a major cash crop. Many species of thrips can be found in damaging numbers, especially during dry seasons or drought. Heavy infestations may destroy entire fields of vegetable crops.

Thrips also infest alternate weed hosts, making control difficult.

Webworms

Several species of small yellowish-green, webbing caterpillars are found in the Tropics. Beans, cabbage, cucurbits, eggplant, peas, and tomatoes are particularly vulnerable, but other crops are attacked also. Webworms may destroy entire fields during rapid population outbreaks, after which they often migrate to adjoining fields.

Destroying weeds in the vicinity of garden plots aids in webworm control.

Weevils

Adult weevils are grayish-brown or black beetles, 1/4 to 1/2 inch long with an elongated snout. The larvae are dirty white grubs with dark heads.

Both larvae and adults of many species are important pests on many kinds of vegetable crops. The common vegetable weevil of Southern United States does not occur widely in the American Tropics but other equally damaging species are prevalent.

White Grubs

White grubs, the larvae of May beetles, are white or light-yellow, thick U-shaped grubs with brownish heads. They may be 1/2 to 1 1/2 inches long when full grown. White grubs have much the same feeding habits as wireworms. The life span of a grub ranges up to 2 or 3 years, and severe damage can occur over a relatively long period. Vegetables should not be planted in soil that has been in grass sod, a favorite egg-laying site for May beetles.

A cultural control measure for white grubs is to pasture infested fields with hogs for several months. Hogs will usually root out and eat the grubs, almost eliminating them. A large tropical toad, *Bufo marinus* F., is an excellent predator of white grubs and, if not already present in a locality, should be considered for introduction. The cattle egret, a native of Africa, that is now expanding its range in the American Tropics and Subtropics, is another important white grub predator and should not be molested.

Wireworms

Wireworms are slender, shiny, hard-skinned larvae of the common click beetles. They are usually cream or light tan with dark heads and tails, and are up to 1 1/2 inches long. They feed below the ground, chewing off roots or tunneling through tubers and other underground plant parts. Wireworms also feed on newly planted seeds. The long larval life cycle of 1 to 5 years makes the wireworm an especially severe pest. The damage of this insect is frequently underestimated.

Insects Attacking Specific Crops

Asparagus

Insect	*Description and Damage*	*Control*
Asparagus leaf beetle	Foliage eaten and stems scarred by bluish-black beetles and grayish-green larvae.	Dust or spray with carbaryl, DDT, rotenone, or malathion (pp. 86, 87).
Cutworms	Shoots cut off or fed on by soil-inhabiting caterpillars.	Dust or spray with toxaphene or use chlordane bait (pp. 86, 87).
Leaf miners	Foliage tunneled by tiny maggots.	Dust or spray with malathion (pp. 86, 87).

CAUTION.—Do not apply malathion, carbaryl, or rotenone within 1 day of harvest. Do not apply DDT during the cutting season. Apply toxaphene only after harvest season is over. Do not contaminate edible parts of the plants with chlordane bait.

Beans

Bush beans, pole beans, lima beans, cowpeas.

Insects	*Description and Damage*	*Control*
Corn earworm	Brown to green caterpillars boring into pods.	Dust or spray with DDT or carbaryl (pp. 86, 87).
Bean leaf beetle	Regular-shaped holes eaten in leaves by green, yellow, or red beetle with black markings.	Dust or spray with DDT, carbaryl, or rotenone (pp. 86, 87).
Lima bean pod borer	Pods bored by small pink caterpillar.	Dust or spray with DDT or carbaryl (pp. 86, 87).
Field crickets	Dark-brown jumping insects damaging seedlings or pods.	Use chlordane bait (p. 87).
Grasshoppers	Greenish or grayish hopping insects feeding on leaves.	
Fall armyworm	Black to greenish caterpillars with light stripes, feeding on foliage and pods.	Dust or spray with DDT or use chlordane bait (pp. 86, 87).
Aphids	Soft-bodied sucking insects clustered on leaves.	Dust or spray with malathion (pp. 86, 87).
Thrips	Foliage silvered or bleached by tiny elongated insects.	
Mites	Leaves webbed and discolored by very small eight-legged spider relatives.	Dust or spray with sulfur or dicofol (pp. 86, 87).
Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with DDT or carbaryl (pp. 86, 87).
Weevils	Pods bored by white or yellow fat-bodied grubs.	
Leafhoppers	Leaves yellowed or bronzed by small wedge-shaped insects.	Dust or spray with malathion or carbaryl (pp. 86, 87).

CAUTION.—Do not apply rotenone to any of these crops within 1 day of harvest. Do not apply malathion to cowpeas within 3 days of harvest or to the other crops within 1 day. Do not apply DDT to cowpeas after the pods begin to form or to the other crops within 7 days of harvest. Do not apply

dicofol to cowpeas at any time; do not apply to the other crops within 7 days of harvest. Do not feed plants treated with DDT or dicofol to dairy animals or animals being finished for slaughter. Do not contaminate edible parts of the plants with chlordane bait.

SPECIAL INSTRUCTIONS.—Excessive amounts of DDT may damage the foliage of beans. To control the corn earworm and lima bean pod borer, apply pesticides to foliage when pods begin to form and at 10-day intervals thereafter. To control the bean leaf beetle and leafhopper, apply insecticides to foliage when insects are first observed and at 10-day intervals as needed. Heavy aphid infestations usually require two to three applications at weekly intervals.

Beets and Swiss Chard

Insects	*Description and Damage*	*Control*
Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with DDT (pp. 86, 87).
Webworms	Leaves webbed together and eaten by small caterpillars.	Dust or spray with malathion or DDT (pp. 86, 87) as soon as egg masses are found on underside of leaves.

CAUTION.—Do not apply malathion to beets or chard within 7 days of harvest. Do not apply DDT to chard after the seedling stage. Do not use DDT-treated beet tops for food.

Carrots

Insects	*Description and Damage*	*Control*
Cutworms	Leaves cut off near ground by soil-inhabiting caterpillars.	Dust or spray with toxaphene (pp. 86, 87).
Leafhoppers	Leaves yellowed or bronzed by small wedged-shaped insects.	Dust or spray with malathion or carbaryl (pp. 86, 87).

CAUTION.—Do not apply malathion within 7 days of harvest.

Celery and Parsnips

Insects	*Description and Damage*	*Control*
Aphids	Soft-bodied sucking insects clustered on leaves.	Dust or spray with malathion (pp. 86, 87).
Hemispherical scale	Stems and twigs encrusted with immobile armored insects.	
Thrips	Tiny elongated insects in crevices at base of leaves.	
Webworms	Leaves webbed together and eaten by small caterpillars.	
Armyworms and cutworms.	Leaves cut off and eaten by soil-inhabiting or climbing caterpillars.	Dust or spray with toxaphene or apply chlordane bait (pp. 86, 87).
Leaf miners	Leaves tunneled by tiny maggots.	Dust or spray with diazinon (pp. 86, 87).

CAUTION.—Do not apply malathion within 7 days or diazinon within 10 days of harvest. Do not apply toxaphene to celery after plants are half mature or after they start to bunch. Do not contaminate edible parts of plants with chlordane bait. Do not use parsnips tops treated with toxaphene for human consumption.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two or three applications at weekly intervals. Begin spraying for webworms as soon as egg masses are found on undersides of leaves.

Cole Crops

Cabbage, broccoli, cauliflower, collard, mustard, turnip, rutabaga, radish, kale, kohlrabi, brussels sprout.

Insects	*Description and Damage*	*Control*
Cabbage looper	Ragged holes eaten in leaves by pale-green, white-striped caterpillar.	Dust or spray with DDT, toxaphene, malathion, or naled (pp. 86, 87). Direct the insecticide to the undersides of the leaves. Repeat treatment once a week.
Diamondback moth	Small holes eaten in leaves and buds by small green caterpillar.	
Gulf white butterfly	Ragged holes eaten in leaves by velvety yellow and purple caterpillar.	
Aphids	Soft-bodied sucking insects clustered on leaves.	Dust or spray with naled, diazinon, or malathion (pp. 86, 87).
Leaf miners	Leaves tunneled by tiny maggots.	
Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with DDT (pp. 86, 87).
Webworms	Leaves webbed together and eaten by small caterpillars.	
Cutworms	Plants cut off at ground by soil-inhabiting caterpillars.	Dust or spray with toxaphene (pp. 86, 87).
Mole crickets	Seedlings uprooted by brown burrowing crickets.	Dust or spray soil surface with chlordane (pp. 86, 87) before planting.

CAUTION.—Do not apply DDT or toxaphene to cabbage, broccoli, brussels sprout, cauliflower, or kohlrabi after the edible parts start to form. Do not apply DDT or toxaphene to collard, mustard, rutabaga, or kale after the seedling stage. Do not apply naled to rutabaga, radish, or kohlrabi at any time or to the other crops within 4 days of harvest. Do not apply diazinon to mustard, rutabaga, kohlrabi, or brussels sprout at any time. Do not apply diazinon to collard, turnip, radish, or kale within 10 days of harvest, to cabbage within 7 days of harvest, or to broccoli or cauliflower within 5 days of harvest. Do not apply malathion to broccoli, turnip, or rutabaga within 3 days of harvest or to the other crops within 7 days of harvest.

SPECIAL INSTRUCTIONS.—The cabbage looper must be controlled in its early stages of larval development. Large mature loopers are extremely resistant to insecticides. Apply insecticide at weekly intervals as soon as true leaves appear, in areas known commonly to harbor the looper or when larvae appear. NOTE: DDT is not effective against the cabbage looper. To control the diamondback moth and Gulf white butterfly, apply the insecticide when insects appear and at 7-day intervals as needed. Heavy aphid infestations usually require two or three applications at weekly intervals. Begin spraying for webworms as soon as egg masses are found on undersides of leaves.

Cucurbits

Cantaloup, cucumber, squash, watermelon, pumpkin.

Insects	*Description and Damage*	*Control*
Striped cucumber beetle.	Stems and leaves of seedlings fed on by black, yellow-striped beetles.	Dust or spray with carbaryl or malathion (pp. 86, 87).
Melonworm	Leaves eaten by pale-green, white-striped caterpillars.	
Pickleworm	Flowers, fruit, and leaf buds tunneled by caterpillars that are cream colored with black spots later becoming pale green.	
Squash bug	Brownish stink bugs that suck juice from plants.	

Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with carbaryl (pp. 86, 87).
Webworms	Leaves webbed together and eaten by small caterpillars.	
Leaf miners	Leaves tunneled by tiny maggots.	Dust or spray with malathion (pp. 86, 87).
Aphids	Soft-bodied sucking insects clustered on leaves.	
Plant bugs	Small sucking insects that cause wilting of leaves or vine tips.	
Cutworms	Plants cut off at ground by soil-inhabiting caterpillars.	Use chlordane bait (p. 87).
Field crickets	Dark-brown jumping insects damaging seedlings and fruit.	
Grasshoppers	Greenish or grayish hopping insects damaging foliage.	

CAUTION.—Do not apply malathion to pumpkins within 3 days or to other cucurbits within 1 day of harvest. Do not contaminate edible parts of the plants with chlordane bait.

SPECIAL INSTRUCTIONS.—To minimize injury to honey bees and other pollinating insects, delay application of insecticides until late in the afternoon. Heavy aphid infestations usually require two or three applications at weekly intervals. Begin spraying for webworms as soon as egg masses are found on undersides of leaves.

Eggplant, Potato, and Tomato

Insects	*Description and Damage*	*Control*
Hornworms	Large caterpillars eating foliage and occasionally fruit.	Dust or spray with carbaryl (pp. 86, 87).
Lace bugs (eggplant pest).	Small sucking insects with lacy wings. Damaged leaves turn yellow and die.	Dust or spray undersides of leaves with malathion (pp. 86, 87).
Corn earworm (tomato pest).	Brown to green caterpillars tunneling into fruit and stems.	Dust or spray with DDT or carbaryl (pp. 86, 87).
Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with carbaryl (pp. 86, 87).
Aphids	Soft-bodied sucking insects clustered on leaves and stems.	Dust or spray with malathion (pp. 86, 87).
Field crickets	Dark-brown jumping insects damaging seedlings and fruit.	Use chlordane bait (p. 87).
Grasshoppers	Greenish or grayish hopping insects feeding on leaves.	
Millipedes	Hard-shelled, many-legged pests of seedlings, fruits, or potato tubers.	Dust or spray with DDT (pp. 86, 87).

CAUTION.—Limit carbaryl applications on potato to foliage only. Do not apply malathion to eggplant within 3 days or to tomatoes within 5 days of harvest. Do not apply DDT to eggplant or tomatoes within 5 days of harvest. Remove excess residues from eggplant by washing or brushing at time of harvest. Do not contaminate edible parts of the plant with chlordane bait.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two or three applications at weekly intervals. Begin spraying for webworms as soon as egg masses are found on undersides of leaves.

Lettuce and Endive

Insects	*Description and Damage*	*Control*
Aphids	Small soft-bodied insects clustered on leaves.	Dust or spray with malathion (pp. 86, 87).
Leafhoppers	Leaves yellowed or bronzed by small wedge-shaped insects.	
Leaf miners	Leaves tunneled by tiny maggots.	
Spider mites	Leaves webbed and discolored by very small eight-legged spider relatives.	
Thrips	Leaves silvered or bleached by tiny elongated insects.	
Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with DDT or carbaryl (pp. 86, 87).
Armyworms	Foliage eaten by caterpillars up to 1½ inches long.	Dust or spray with DDT or use chlordane bait (pp. 86, 87).
Webworms	Leaves webbed together and eaten by small caterpillars.	Dust or spray with malathion or DDT (pp. 86, 87).
Wireworms	Underground plant parts eaten or tunneled by hard, shiny larvae.	Before planting, broadcast 4 pounds of 10-percent chlordane granules per 1,000 square feet of soil surface and work it into the upper 4 to 6 inches of soil.
Slugs or snails	Foliage eaten by slimy, legless shelled or shell-less pests.	Use a commercial pellet bait containing metaldehyde.

CAUTION.—Do not apply malathion within 7 days of harvest of head lettuce or endive or within 14 days of harvest of leaf lettuce. Do not apply DDT to lettuce or endive after the seedling stage. Do not apply carbaryl to head lettuce within 3 days or to leaf lettuce and endive within 14 days of harvest. Do not contaminate edible portions of the plants with the chlordane or metaldehyde bait.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two or three applications at weekly intervals. Begin spraying for webworms as soon as egg masses are found on undersides of leaves. Baits for slugs and snails should be scattered in the vicinity of damaged plants in piles of four or five pellets each.

Okra

Insects	*Description and Damage*	*Control*
Pink bollworm	Pinkish larvae boring into pods.	Dust or spray with carbaryl or DDT (pp. 86, 87).
Corn earworm	Brown to green caterpillars boring into pods.	
Aphids	Small soft-bodied insects clustered on leaves.	Dust or spray with malathion (pp. 86, 87).
Leaf miners	Leaves tunneled by tiny maggots.	
Thrips	Leaves silvered or bleached by tiny elongated insects.	
Plant bugs and green stink bugs.	Small to medium size, shield-shaped insects sucking juice from tender foliage and pods.	Dust or spray with carbaryl or DDT (pp. 86, 87).
Flea beetles	Many small holes eaten in foliage by tiny jumping beetles.	
Leafhoppers	Leaves yellowed or bronzed by small wedge-shaped insects.	Dust or spray with malathion or carbaryl (pp. 86, 87).

CAUTION.—Do not apply malathion to okra after the pods begin to form. Do not apply DDT within 7 days of harvest.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two or three applications at weekly intervals.

Onions and Garlic

Insects	*Description and Damage*	*Control*
Onion thrips	Tiny elongated insects causing white blotches on leaves.	Dust or spray with DDT or malathion (pp. 86, 87).
Mole crickets	Seedlings uprooted by brown burrowing crickets.	Apply chlordane bait or dust or spray with toxaphene (pp. 86, 87).
Fall armyworm	Black to greenish caterpillars with light stripes feeding on leaves.	
Cutworms	Leaves and small plants cut off by soil-inhabiting caterpillars.	
Leaf miners	Leaves mined by tiny maggots.	Dust or spray with malathion (pp. 86, 87).
Wireworms	Roots or bulbs eaten or tunneled by hard, shiny larvae.	Before planting, broadcast 4 pounds of 10-percent chlordane granules per 1,000 square feet of soil surface and work into the upper 4 to 6 inches of soil.

CAUTION.—Do not apply toxaphene to green or bunching onions or to garlic after the edible parts start to form. Do not apply DDT to green or bunching onions. Do not apply malathion to onions or garlic within 3 days of harvest.

Pepper

Insects	*Description and Damage*	*Control*
Hornworms	Large caterpillars eating foliage.	Dust or spray with carbaryl (pp. 86, 87).
Aphids	Small soft-bodied insects clustered on leaves.	Dust or spray with malathion (pp. 86, 87).
Thrips	Leaves silvered or bleached by tiny elongated insects.	
Armyworms and cutworms.	Young plants or foliage of older plants destroyed by climbing or soil-inhabiting caterpillars.	Dust or spray with toxaphene (pp. 86, 87).
Flea beetles	Many small holes eaten in leaves by tiny jumping beetles.	Dust or spray with DDT or carbaryl (pp. 86, 87).
Plant bugs	Small sucking insects that cause wilting of leaves or buds.	
Mole crickets	Seedlings uprooted by brown burrowing crickets.	Apply chlordane bait (p. 87).
Weevils	Snout beetles feeding on foliage, buds, or fruit; fat larvae tunneling buds and fruit.	Dust or spray with DDT (pp. 86, 87).
Leaf miners	Leaves tunneled by tiny maggots.	Dust or spray with diazinon (pp. 86, 87).

CAUTION.—Do not apply malathion within 3 days or toxaphene or DDT within 7 days of harvest. Remove excess residues of DDT by washing or brushing. Do not apply diazinon after first blooms appear.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two or three applications at weekly intervals.

Spinach

Insects	*Description and Damage*	*Control*
Aphids	Small soft-bodied insects clustered on leaves.	Dust or spray with malathion (pp. 86, 87).
Cutworms	Leaves or small plants cut off by soil-inhabiting caterpillars.	Dust or spray with toxaphene or use chlordane bait (pp. 86, 87).
Webworms	Leaves webbed together and eaten by small caterpillars.	Dust or spray with malathion or DDT (pp. 86, 87).
Weevils	Foliage or buds damaged by snout beetles or their larvae.	Dust or spray with DDT (pp. 86, 87).

CAUTION.—Do not apply malathion within 7 days of harvest. Do not apply toxaphene within 21 days of harvest; make one application only. Do not apply DDT after the seedling stage. Do not contaminate the edible parts of the plants with the chlordane bait.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two or three applications at weekly intervals. Begin spraying for webworms as soon as egg masses are found on undersides of leaves.

Sweet Corn

Insects	*Description and Damage*	*Control*
Corn earworm	Brown to green caterpillars damaging ears, especially near tips.	Spray silks with carbaryl (p. 86) the day after earworms appear; repeat four times at 2- to 3-day intervals.
Southern cornstalk borer.	Buds and stalks bored by cream-colored caterpillar with black spots.	Dust or spray with DDT (pp. 86, 87).
Lesser cornstalk borer.	Young plants tunneled and killed by small, greenish, soil-inhabiting caterpillars.	Spray DDT (p. 86) to soil in a 6-inch strip as plants break through ground.
Aphids	Small soft-bodied insects clustered on leaves and tassel.	Dust or spray with malathion (pp. 86, 87).
Spider mites	Leaves webbed and discolored by very small eight-legged spider relatives.	
Fall armyworm	Buds or tassels heavily damaged by black to greenish, light-striped caterpillars; ears sometimes attacked.	Dust or spray with carbaryl or DDT (pp. 86, 87).
Weevils	Stalks and young plants attacked by snout beetles.	
Cutworms	Young plants cut off by soil-inhabiting caterpillars.	Apply chlordane bait (p. 87).
Wireworms	Roots and sprouting seed eaten by hard, shiny larvae.	Before planting, broadcast 4 pounds of 10-percent chlordane granules per 1,000 square feet of soil surface and work it into the upper 4 to 6 inches of soil.

CAUTION.—Do not apply malathion within 5 days of harvest. Do not feed DDT-treated forage to dairy cows or to animals being finished for slaughter. Do not contaminate edible parts of the plants with chlordane bait.

SPECIAL INSTRUCTIONS.—Heavy aphid infestations usually require two to three applications at weekly intervals.

Sweetpotato

Insects	*Description and Damage*	*Control*
Tortoise beetle ------	Gold, or gold-striped, or black-marked, helmet-shaped beetles feeding on leaves.	Dust or spray with DDT (pp. 86, 87).
Sweetpotato weevil --	Shiny ant-like beetles or their cream to pink larvae tunneling in roots and vines.	Apply 2 to 2½ percent dieldrin dust along the row in a strip 6 to 8 inches wide. Direct the dust to the surface of the soil at the base of the plants. Apply as soon as roots begin to enlarge and repeat 2 weeks later.
White grubs --------	Robust U-shaped grubs feeding on roots.	Before planting, broadcast 4 pounds of 10-percent chlordane granules per 1,000 square feet of soil surface and work it into the upper 4 to 6 inches of soil.

CAUTION.—Do not apply dieldrin within 21 days of harvest.

OTHER VEGETABLE PESTS

Nematodes

Symptoms of nematode injury are stunted or sickly looking plants with no visible damage to aerial parts; roots may show numerous knots or galls or may be distinctly enlarged or swollen. A nematode is a microscopic roundworm that cannot be observed without high magnification and special detection techniques.

Nearly all of the common vegetable crops are susceptible to many kinds of parasitic nematodes. Nematodes often become a production problem in gardens planted in the same place each year, particularly on light sandy soils. The damage caused by nematodes to vegetable crops can be particularly severe on soils low in organic matter, soil nutrients, and moisture.

Control—Avoiding infested soils is the most practical control method for the small gardener to use. Rotation with a nonsusceptible crop or with some other use of the land such as a poultry yard or animal lot could be followed each year or two. Some crops such as pangolagrass (*Digitaria decumbens* Stent.) and pigeonpea are resistant to certain types of nematodes, but no single crop is resistant to all types of nematodes found in tropical soils. If the soil is well fertilized and tended, grass rotations will suppress weed growth. Weeds should be controlled at all times in garden areas since many are excellent hosts for nematodes. Some vegetables such as cabbage, cauliflower, endive, lettuce, mustard, onion, pigeonpea, potato, and turnip are more tolerant than others to root-knot nematodes. Vegetable varieties reported to be nematode resistant in northern areas should be tested in tropical gardens.

Moderate nematode infestations do not always severely retard growth of vegetable crops or reduce yields under good growing conditions. Careful attention to the fertilizer program and irrigation and the addition of organic matter to the soil will keep the plants growing vigorously. Turning over the soil several times at monthly intervals by plowing or spading when it is bare of crops will aid in reducing the population of nematodes. In the Caribbean area this is particularly effective during the dry season.

If nematodes become excessively damaging, the soil can be treated with a chemical nematocide before planting. Preparations available commercially for use as fumigants contain either dichloropropene-dichloropropane (DD-Mixture), ethylene dibromide (Dowfume W–85), or dibromochloropropane (Nemagon, Fumazone 86). These chemicals are available in various formulations. Nemagon is available as a granular formulation, which is best applied 5 to 6 inches deep in furrows, alone or mixed with fertilizer, and covered with soil. *It is important that all chemicals used to kill nematodes in the soil be handled and applied according to the instructions given by the manufacturer. Read the label carefully.*

Rats and Mice

Rats and mice can cause extensive losses both in gardens and in places where produce is stored. They eat both seeds and mature vegetables, especially beans, corn, peas, and tomatoes.

Control—Cats effectively control rats and mice for the small home gardener. Eliminating hiding places such as trash piles or heavy underbrush in the vicinity of the garden will aid control measures. Baited snap traps can be placed in rat or mouse runways. Should these procedures fail, commercially prepared baits containing warfarin or other anticoagulants can be applied *according to the directions shown on the individual package.* CAUTION SHOULD BE TAKEN TO KEEP TREATED BAITS OUT OF THE REACH OF CHILDREN AND PETS.

VEGETABLE DISEASES

A number of plant diseases are so universally found in the Caribbean area that they can be classified as general in nature. These general diseases and their control will be discussed first and then more specific diseases and their control will be discussed.

DISEASE CONTROL RECOMMENDATIONS LISTED IN THE GENERAL VEGETABLE DISEASE SECTION ARE THOSE FREQUENTLY USED. PESTICIDES USED FOR SPECIFIC VEGETABLES ARE DISCUSSED IN GREATER DETAIL UNDER THE SPECIFIC VEGETABLE DISEASE SECTION. FOR CONTROL ON SPECIFIC VEGETABLES, DIRECTIONS ON PESTICIDE PACKAGES SHOULD BE CAREFULLY FOLLOWED, INCLUDING ATTENTION TO PREVENTION OF EXCESSIVE PESTICIDE RESIDUES AT HARVEST.

General Vegetable Diseases

Damping-off Disease

Damping-off is probably the most severe disease of seedlings and young plants in tropical regions, especially those growing in seedbeds. A number of fungus species commonly living in the soil cause this disease, which is sometimes called wirestem or black root. High soil moisture content and high humidity promote the quick spread of damping-off.

Symptoms—Seed decay, blackening of roots and stem at the soil surface, a water-soaked constriction of the stem just above the soil surface, and collapse of the plant—all identify damping-off.

Control—Damping-off is aggravated by wet conditions, so any drainage or other procedures that permit less retained moisture in soil help greatly. Before planting, treat seedbeds with boiling water, by baking the soil, or with a 2-percent solution of formaldehyde. Copper oxide or captan effectively control damping-off.

Drench the soil thoroughly with a spray made of 1½ level teaspoons of copper oxide to a gallon of water. A copper oxide drench is usually preferred for use on celery, lettuce, and tomato. Copper oxide sprays can be used on beet, carrot, chard, eggplant, green bean, kohlrabi, and pepper.

Apply a spray made of 1 level tablespoon of 50-percent captan WP to a gallon of water. This amount will treat 200 row feet or 500 square feet of garden space.

Another recommended control for damping-off is treating seeds with Semesan, 50-percent captan WP, or copper oxide before planting. Treat only the seed required for immediate planting. (See p. 19.) Place one level teaspoonful of any of these chemicals in a small jar with the seed, and cover the container tightly and shake thoroughly for about a minute. Excess powder in the bottom of the container can be saved and used again. Plant seed covered with the dust immediately after treatment. (See p. 26.) Destroy surplus treated seed by burning or burying. Do not use treated seed for food, feed, or oil. The chemicals used for seed treatment are poisonous. Both chemicals and treated seeds should be kept out of the reach of children, pets, and domestic animals.

Powdery Mildew

Powdery mildew is one of two mildews regularly found in tropical areas. A number of species of fungus are the causal organisms of powdery mildew. It is most prevalent during the dry parts of the year in places having a well-defined rainy season or is found year round at high elevations where cool, cloudy weather is common. During periods when environmental conditions are particularly favorable to the fungus, leaves and young stems of the plant can be killed.

Symptoms—Powdery mildew appears as a white talcumlike growth primarily on the upper leaf surface. As the disease progresses, the infected areas become brown and dry.

Control—Sulfur sprays and dusts have been used for powdery mildew control but can cause phytotoxicity, so excessive amounts should not be applied, especially on cucurbits. Karathane is an excellent specific fungicide to use on cucurbits. Apply a spray made of 1½ level teaspoons of 25-percent Karathane WP to a gallon of water. This amount will treat 200 row feet or 500 square feet of garden space.

Downy Mildew

In the Tropics, downy mildew is most frequently encountered in high-humidity, high-temperature areas. Where there is a well-defined rainy season, this airborne fungus is very common during that season. A number of species and strains of fungus cause downy mildew symptoms that vary somewhat, depending on the plant species affected.

Symptoms—Undersurfaces of leaves develop a mold that is often whitish but sometimes is purplish or almost black. The corresponding upper leaf surfaces appear yellow at first and then turn brown; then the leaves curl and die. Brown or black necrotic areas appear from the root crown extending downward. In advanced stages minute cracks appear or the root splits open. Decay bacteria are often associated with downy mildew.

Control—Control should be exercised as soon as symptoms appear because downy mildew spreads extremely rapidly. Bordeaux mixture used in a 6:6:100 formulation effectively controls downy mildew. A spray made of 1 level tablespoon of 80-percent maneb WP or 4 level teaspoons of 75-percent zineb WP to a gallon of water will also control downy mildew. For light infestations, apply a spray made of 1 level tablespoon of 50-percent captan WP to a gallon of water. This amount will treat 200 row feet or 500 square feet of garden space. When downy mildew-resistant plants are available, they should be used.

Fungal Leaf Spot

Many fungi cause leaf spotting. Practically every kind of vegetable crop can be affected by one or more of these species at one time or another. When damage is severe, extensive crop loss may result.

Symptoms—Fungal leaf spot symptoms are many and varied. Spots vary greatly from circular to irregular and from quite small to fairly large. Color is typically light tan with dark-brown borders but also can be black, gray, brown, or reddish brown. Leaf spots are followed by drying and defoliation. NOTE: It is often difficult to distinguish fungal leaf spot from bacterial leaf spot, described in the next section, but bacterial leaf spots will appear watery and will never have the tiny specklike black or dark-brown fruiting bodies that are often associated with fungal leaf spots.

Control—Crop rotation with unrelated plants effectively controls fungal leaf spot. Good plant health is important, so good drainage and fertilization should be considered. Bordeaux mixture or copper compounds usually control most fungal leaf spots. A spray made of 4 level teaspoons of 75-percent zineb WP to a gallon of water will also control many fungal leaf spots. This amount will treat 200 row feet or 500 square feet of garden space. When resistant varieties are available, they should be planted.

Bacterial Leaf Spot

Several species of bacteria cause leaf spotting. They are usually not strongly pathogenic and gain entrance principally through plant parts damaged by insects, farming equipment, and excessive watering, or through growth and wind cracks. Leaf spot bacteria are harbored in the soil and are probably transported to the plant by rain splashes or by insects.

Symptoms—Bacterial leaf spot symptoms are variable, but infections frequently begin with numerous small brown to yellowish, circular to angular, water-soaked appearing spots that enlarge rapidly and coalesce until the leaf is covered. A halo may appear around the spot. Infection often is found on older leaves, first commencing at leaf margins and progressing inward. Leaves finally deteriorate and drop. Some leaf spot bacteria also invade stems and fruits.

Control—Crop rotation, good drainage, resistant varieties, and clean seed often keep bacterial leaf spot under control. For the home gardener a commercial fixed copper controls leaf spot effectively. Follow directions on the package for the particular crop to be treated.

Mosaic

Mosaic viruses are found everywhere and on many kinds of vegetable crops. Weeds are excellent reservoirs for the virus, making control doubly difficult. Mosaic ranks as one of the more destructive plant diseases although in many instances it results in stunting or weakening of the plant rather than death.

Symptoms—Mosaic is characterized by mottling of leaf surfaces. In addition, leaves can become distorted, wrinkled, or stunted, or can have curled edges. Stems infested with mosaic can be streaked or necrotic. Fruits also suffer from mosaic; wart-

like spots, knobbiness, loss of color, and spotting are typical symptoms.

Control—Resistant varieties, when available, are perhaps the best insurance against mosaic viruses. Weed control in the vicinity of the garden also helps. Control of the aphid or leafhopper vectors prevents extensive damage by some mosaics. At this time (1967) no chemical directly controls mosaic.

Rust

Rust fungus, although very common, does not often become economically important on tropical vegetable crops. However, when rust pustules appear on the plant, control measures are indicated. Leguminous plants in particular, such as beans and peas, should be observed for rust symptoms. Rust infections result in stunted plants and lowered yield.

Symptoms—Rust pustules can appear on any aboveground plant part but the undersides of leaves are favored. The minute slightly elevated pustules are dirty white when young, but become distinctly reddish brown with age. Hundreds of rust pustules can grow on a single leaf. When mature, rusts release millions of spores that are quickly spread by air currents. Heavy rust infestations eventually kill foliage and cause it to drop.

Control—Maneb and zineb applied at the same strength listed for downy mildew are effective against rust. Bordeaux mixture also controls rust. Rust-resistant varieties of plants should be planted whenever available if rust is a frequent problem.

Specific Vegetable Diseases

Carrot Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Yellows or wilt (virus).	Young leaves yellow at center of crown spreading to shoots; stunted roots.	Control leafhopper vectors. See general pest section.	----------
Root rot (bacteria)--	Decayed or soft roots.	Provide good drainage and do not overcrowd plants. Rotate crops. Treat seeds 10 minutes in water at 126° F. (52° C.).	----------

Some general diseases occasionally can be encountered on carrots. See the section on general vegetable diseases for information on symptoms and control.

Celery Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Early blight (fungus).	Small circular yellow-brown spots on mature leaves becoming larger and grayer as the fungus develops; this disease later spreading to the stalks.	Bordeaux mixture ----------	[1]
		75-percent zineb WP, 4 level tsp./gal. water.	[1]
Late blight (fungus)-	Small yellow spots on leaves becoming dark gray-brown, speckled with tiny black dots.	Same control as for early blight. If late blight is common, plant resistant varieties.	----------

[1] No time limit when used as recommended. Remove residues by washing and stripping.

In addition to the major specific diseases above, bacterial soft rot and yellows or wilt fungus may be encountered. The only remedies at the present time are planting resistant varieties and destroying diseased plants. Damping-off disease and mosaic virus also often attack celery seedlings. See the section on general vegetable diseases for information on symptoms and control.

A physiological disorder, black heart, sometimes appears during wet, warm weather. Leaf margins become discolored. In irrigated areas, avoid excess watering to help control black heart.

Sweet Corn Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Smut (fungus)	Large irregularly shaped white galls on stalks, ears, and tassels; growths bursting, releasing black fungus spores.	Remove and destroy galls. Rotate crops.	
Wilt (bacteria)	Stunted and wilted plants, tassels whitening early; slimy yellow substance oozing from cut stalks.	Plant wilt-resistant varieties	

Other corn diseases include bacterial or fungal leaf spot, mosaic virus, and rust. See the section on general vegetable diseases for information on symptoms and control. Planting resistant corn varieties has done much to check disease incidence in this important crop, so investigate the possibility of obtaining seed with resistant qualities.

Cole Crop Diseases

Cabbage, broccoli, cauliflower, collard, mustard, turnip, rutabaga, radish, kale, kohlrabi, brussels sprouts, Chinese cabbage.

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Black rot (bacteria)	Black leaf veins; black ring near outside edge of crosscut stem; yellowed leaves.	Plant disease-free seed. Do not plant where cabbage has been grown within 1 year. Follow at least 3-year rotation if previous planting was diseased. Treat seed from diseased plants in hot water, 30 minutes at 50° C. Destroy all diseased plants.	
Black leg (fungus)	Grayish spots speckled with tiny black dots especially on stems near ground; stem girdling; wilted foliage.	Same control as for black rot. Treat seeds with 28.6-percent Semesan dust, 1 ounce per 15 pounds seed.	
Yellows or wilt (fungus).	Yellowish-green leaves often starting on one side of the plant, followed by leaf drop.	Plant resistant cabbage varieties, such as Jersey Queen, Resistant Detroit, Wisconsin All Seasons, Marion Market.	

Other harmful cole crop diseases include damping-off, downy and powdery mildews, and mosaic. Mosaic, which produces mottled leaves, can be especially severe on head cabbage and can be reduced by prompt aphid control.

SPECIAL INSTRUCTIONS.—These common crucifer diseases cannot be controlled with sprays.

Cucurbit Diseases

Cantaloup, cucumber, squash, watermelon, chayote, pumpkin.

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Anthracnose (fungus).	*Fruits*—round sunken spots with pinkish-tan centers that later darken.	Rotate crops and do not replant oftener than once in 3 years. Plant only clean seed.	
	Foliage—red-brown circular cankers.	Bordeaux mixture	(1)
	Stems—elongated tan spots.	75-percent zineb WP, 4 level tsp./gal. water.	(1)
Scab or leak (fungus).	Sunken dark-brown spots on fruits; gummy ooze exuding from spots.	Remove and destroy fruit showing scab symptoms; do not replant in same area for 3 years.	
		Bordeaux mixture	(1)
		80-percent maneb WP, 1 level tbsp./gal. water or 50-percent captan WP, 1 level tbsp./gal. water.	(1)

[1] No time limit when used as recommended. Remove residues by washing.

Cucurbits also are frequently attacked by downy and powdery mildews, damping-off disease, and cucumber mosaic virus. See the section on general vegetable diseases for information on symptoms and control. Crop rotation is advisable if disease symptoms persist because of the rather great disease susceptibility of cucurbits.

Eggplant, Potato, and Tomato Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Wilt (bacteria)	Progressive wilting beginning at midday and recovering overnight; slimy yellowish substance oozing from cut parts.	Rotate crops, omitting these plants as successive plantings. Plant resistant varieties; sprays are of no value.	
Fusarium wilt (fungus).	Yellowing and wilting of foliage beginning with lower leaves; browning of woody tissue under green part of stem.	Same control as for bacterial wilt	
Early blight (fungus).	Irregular small dark-brown spots becoming circular bull's-eyes on foliage; cankers on stems that sometimes girdle at ground level; dark leathery decayed spots at stem end of fruit.	Bordeaux mixture 75-percent zineb WP, 4 level tsp./gal. water. 80-percent maneb WP, 1 level tsp./gal. water. Apply fungicides every 7 to 10 days.	[1] [1] [1]
Late blight (fungus)	Dark water-soaked spots on leaves, white water-soaked spots on fruits; spots enlarging and turning brown; white fungus growth on undersides of leaves in wet season.	Same control as for early blight but apply about 30 days after plants flower. Plant resistant varieties (potato).	
Rhizoctonia canker or black scurf (fungus).	Hard shiny black bodies on roots or on tubers; brown cankers on sprouts and stolons; sprouts dying or developing numerous side branches; lower leaves drooping or decaying but not dropping.	Plant disease-free seed pieces in clean soil.	
Anthracnose (fungus).[2]	*Fruits*—round sunken spots with pinkish-tan centers on fruits, later darken. *Foliage*—red-brown circular cankers. *Stems*—elongated tan spots.	80-percent maneb WP, 1 level tbsp./gal. water. Bordeaux mixture	[1] [1]
Scab (fungus) [3]	Rough scabby, raised, or pitted spots on tubers.	Plant scab-resistant varieties. Plant in uninfested soil.	
Blossom end rot (calcium deficiency generally appearing during drought).[4]	Large, dark, sunken corky spots at blossom end of fruits, especially if soil dries rapidly while plants are making vigorous growth.	Avoid excessive use of nitrogenous fertilizers. Use adequate amounts of lime and superphosphate.	
Fruit rot (fungus)[5]	Brown shrunken stems at soil line; brown or gray leaf spots; large, ringed, circular brownish spots on fruits.	Plant resistant varieties such as Florida Market or Florida Beauty.	

[1] No time limit when used as recommended. Remove residues by washing.
[2] Disease of eggplant and tomato.
[3] Disease of potatoes.
[4] Physiological disorder of tomato.
[5] Disease of eggplant.

Other eggplant, potato, and tomato diseases include fungal leaf spot and a gray leaf mold that can be controlled in the same manner as fungal leaf spot. See the section on general vegetable diseases for information on symptoms and control.

Legume Diseases

Pigeonpeas, cowpeas, bush beans, lima beans, pole beans, soybeans.

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Anthracnose (fungus).	*Pods and stems*—brown sunken spots. *Leaves*—elongated dark red-brown cankers.	75-percent zineb WP, 4 level tsp./gal. water. Bordeaux mixture	[1] [1]
Root rot (fungus)	Decayed roots and plant base	Preplant treatment: plow cover crops under 8 weeks before planting; treat seeds with 50-percent captan WP.	

[1] No time limit when used as recommended. Remove residues by washing.

Bean mosaic virus and powdery mildew are also frequently encountered on legumes. See the section on general vegetable diseases for information on symptoms and control.

Lettuce Disease

Lettuce, endive.

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Yellows (virus)	Inner leaves curled, twisted, or yellowed.	Control leafhopper vectors. See general pest section.	

Okra Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Fusarium wilt (fungus).	Yellowing and wilting of foliage beginning with lower leaves; browning of woody tissue under green parts of stem.	Sprays are of no value. Plant resistant varieties. Rotate crops but do not rotate with eggplant, potato, or tomato, which are also fusarium susceptible.	

Okra is also subject to the cercospora leaf spot fungus during wet weather. See the section on general vegetable diseases for information on symptoms and control.

Onion Diseases

Onion, leek, garlic.

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Soft rot (bacteria)	Rotting of bulbs	Harvest bulbs promptly and store in a dry airy place. Plant resistant varieties.	
Purple blotch (fungus).	Large purple spots intermixed with white spots on leaves.	Bordeaux mixture 80-percent maneb WP, 1 tbsp./gal. water.	(1) (1)
Leaf anthracnose (fungus).	Whitish spots on leaves	Bordeaux mixture 75-percent zineb WP, 4 level tsp./gal. water.	(1) (1, 2)

[1] No time limit when used as recommended. Remove residues by washing.
[2] Zineb should not be applied to green onions within 7 days of harvest.

Downy mildew also is frequently found on these vegetables. See the section on general vegetable diseases for information on symptoms and control.

NOTE: Because of the waxy nature of onion foliage, it is difficult to obtain adequate foliar coverage with sprays. Early morning spraying when dew is still on the plant aids in proper distribution of chemicals.

Pepper Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Anthracnose (fungus).	Brown sunken spots on fruits	Bordeaux mixture 75-percent zineb WP, 4 level tsp./gal. water.	(1) (1)
Wilt (bacteria)	Wilting beginning at midday and recovering overnight becoming progressively severe; slimy yellowish oozing from plant parts.	Sprays are ineffective. Rotate crops. Plant resistant varieties.	
Fusarium wilt (fungus).	Yellowing and wilting of foliage beginning with lower leaves; browning of woody tissues under green parts of stem.	Same control as for bacterial wilt	

[1] No time limit when used as recommended. Remove residues by washing.

A number of general diseases, including damping-off, bacterial leaf spot, cercospora leaf spot, downy mildew, and mosaic virus, attack pepper plants. Pepper varieties resistant to mosaic virus include Yolo Wonder, Yolo Wonder L, Chato, and Corozal. See the section on general diseases for information on symptoms and control.

Sweetpotato Diseases

Disease and causal organism	*Symptoms*	*Control*	*Minimum days to harvest*
Black rot (fungus).	Round black sunken spots on tubers; black cankers on underground parts of stems.	Destroy diseased plants. Rotate location. Plant clean seed pieces.	----------
Stem rot or wilt (fungus).	Yellowed or wilted plants; stems and roots showing black discoloration or ring when cut across.	Same control as for black rot -----	----------
Internal cork (virus).	Tough and corky tubers ----------	Plant cork-free seed stock --------	----------

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