Production of TOMATOES FOR CANNING AND MANUFACTURING

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THE TOMATO is the first in value of the vegetable canning crops. It also ranks high as a source of vitamins. A large portion of the crop is canned or made into soups, purees, juice, and other products.

In the United States in recent years about two-thirds of the 600,000 acres in tomatoes have been devoted to the crop annually for canning and manufacturing purposes. The total production varies from 1,700,000 to 2,700,000 short tons.

The industry is widely distributed over the United States, but California, Indiana, Maryland, New Jersey, Ohio, and New York produce a large part of the crop for canning and manufacturing.

Careful selection, proper preparation, fertilization, and care of the soil to keep it well supplied with available plant food, high-grade disease-free seed of suitable varieties, strong well-grown plants, careful setting, good care, and control of diseases and insects are essential for the profitable production of tomatoes for canning and manufacturing. Proper picking and handling will result not only in higher total yields but also in an increased proportion of those of No. 1 grade.

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PRODUCTION OF TOMATOES FOR CANNING AND MANUFACTURING

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Contents

IMPORTANCE OF THE CROP

THE TOMATO is one of the few vegetables of American origin that have attained great commercial importance. Introduced into the United States about 1800, it was for a long time looked upon largely as an ornamental plant. Owing to its membership in the nightshade family, it was regarded with suspicion and was said to be poisonous; it was not until after this strong prejudice had been broken down that its cultivation began to attract attention and its use became general.

About the middle of the last century canned tomatoes were introduced as an article of trade, and the tomato-canning industry soon attained considerable importance. In 1887 the total pack of canned tomatoes in the United States was about 3,000,000 cases, each case containing two dozen No. 3 cans, each holding approximately 1 quart.

Production has expanded until the tomato now occupies third place in value among the vegetable crops, being exceeded only by potatoes and sweetpotatoes. In recent years the area devoted to the tomato crop has amounted to about 600,000 acres, approximately two-thirds of which has been grown for canning and manufacturing purposes. The total production of canning and manufacturing

tomatoes varies from 1,700,000 to 2,700,000 short tons, with a value of more than $41,500,000.

The popularity of the tomato, as well as of the canned products made from it, is due to its cheapness, to its attractive appearance, and to its pleasing acid taste, which is retained to a very large extent in the manufactured goods.

Increased knowledge of the food value of tomatoes has added new prestige to their popularity. Although the tomato built up its reputation with the dietitians on the basis of its vitamin C content, that is not all this vegetable has to offer. It almost runs the gamut of the vitamin alphabet. Besides vitamin C, it supplies A, B_1, G, and the pellagra-preventive factor. In the effort to improve the diets of the Nation, tomatoes are receiving major attention.

DISTRIBUTION OF THE TOMATO-PROCESSING INDUSTRY

The tomato is a crop requiring a moderately warm climate and a long growing season for its best development. In the Northern States, where the frost-free season is too short for maturing the crop out of doors, it can be grown by starting the plants indoors, thus prolonging the growing season by several weeks. By following this practice it is possible to grow tomatoes in a commercial way in regions where the industry could not otherwise flourish. In climates where its growth is not interrupted by frost the tomato is a perennial plant, but in the parts of the United States where the tomato-processing industry has attained its greatest importance the tomato is treated as an annual.

Climatic conditions, nearness to market, labor supply, soils, and other factors have all had an influence in the development of the industry. According to the agricultural statistics for 1940 California led in the total production of tomatoes for canning and manufacturing and was followed by Indiana, Maryland, New Jersey, Ohio, New York, Pennsylvania, Virginia, and Utah in the order named.

The geographical distribution of the industry is shown in figure 1, each dot on the map indicating a factory devoted to the canning or the manufacture of tomatoes into soup or some other product. Although many of these factories may be operating under serious economic disadvantages, the map shows that tomatoes for canning and manufacturing are being grown and packed over a considerable part of the United States.

While the high temperatures and hot sun of the lower South are not well suited to the growing of tomatoes for canning and the northern limit of their growth is established by the short growing season of the northern part of the United States, it does not follow that the present distribution of the industry is in all cases economically sound. Within the climatic range to which the tomato is adapted it is not particularly exacting as to soil requirements. Any good soil suitable for general farm crops can readily be adapted to the growing of tomatoes for canning. The plant requires from 80 to 110 days from seed to come into bearing, but about one-third of this period can be spent in the greenhouse, the hotbed, or some other protected place, and the fruiting period of the plant can in this way be considerably lengthened. The plant bears until killed by frost unless injured by drought, insects, or diseases; hence, the longer the

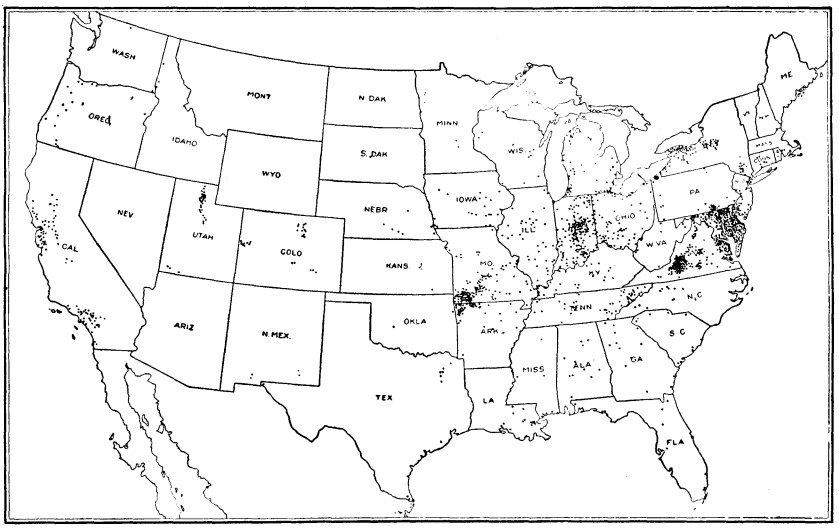

FIGURE 1.—Map of the United States showing the distribution of the tomato-processing industry. Each dot represents one factory for canning or for manufacturing tomatoes into soup, puree, or some other products.

producing season the higher the yields. During the producing period the plant does best when the day temperature is from 80° to 85° F. and the night temperature about 65° to 70°. The crop requires about the same amount of moisture as other farm crops grown in the sections adapted to tomatoes.

From a consideration of these factors it is apparent that large areas lying in a broad belt between the extremely hot lower part of the South and the short-growing-season areas of the North are, as far as the climatic requirements of the plant are concerned, well adapted to the growing of tomatoes for manufacturing purposes. The very fact that the tomato can be so easily produced under a wide variety of conditions has in the past led to the development of the industry in sections where there have been and are few economic reasons for its continuance. In sections where the soil is very light, requiring large quantities of organic material and commercial fertilizers and where the crop is easily injured by drought, and where, as a rule, under such conditions the yields are low, growers are at a serious disadvantage. When the crop is grown for canning only and where nearness to market is not essential, it would be better to center the industry in sections where the soil and climatic conditions are favorable for large yields over a long period.

METHODS FOLLOWED BY CANNERS TO OBTAIN A SUPPLY

Canners obtain their supply of tomatoes either by contracting with growers for a definite acreage, by growing tomatoes themselves, or by buying them in the open market.

It is difficult, however, for the canners to insure a sufficient supply without some form of contract with growers. In some cases a plan has been devised whereby the growers are guaranteed a fixed minimum price for their tomatoes, this price being sufficient to return them the

cost of growing the crop, and the final settlement is made on the basis of the price received for the canned goods. Some such plan as this may obviate many of the difficulties experienced in the past. Canners and growers should realize that they have interests in common and that each is indispensable to the other. The canner must have tomatoes if he is to operate his factory, and he in turn gives the grower a ready market for his crop.

Some of the large canning companies now produce a part of the tomatoes they require on land either owned or leased by them. Such companies maintain a farm department, with the necessary equipment to plant, care for, and handle the crop. This plan has many points in its favor but is hardly practicable for any but the small canner handling the product of his own farm or for the very large concern able to command sufficient resources to produce the crop along the most advanced lines. Where a sufficient supply can be obtained from the farmers, most firms prefer to devote their whole energies to the manufacturing end, leaving the growing of the crop to the farmers.

Few canners depend on buying their entire supply on the open market, preferring as a rule to contract for at least 90 percent of their requirements. Some large manufacturing firms follow the practice of buying the surplus stocks of tomatoes on certain markets available to them when the price drops to a specified point. Part of the surplus is thus taken off the market, and this acts as a safety valve, the growers being guaranteed against the entire loss of this part of their crop.

Whether the farmers have a direct financial interest in the cannery end of the business or not, there should be sufficiently close cooperation between the farmers and the canners to permit the employment of every means that will increase the yields and make the industry a profitable one to both, for unless the business gives both the growers and the canners reasonable returns, they cannot be expected to continue the production and the packing of this crop.

Within the last few years growing and canning tomatoes have not been uniformly profitable to growers and canners. The average yield for the past few years in the Tri-State territory of New Jersey, Delaware, and Maryland has been less than 5 tons per acre and in Indiana less than 6 tons per acre. Some growers in these States have uniformly obtained much higher yields, 10 to 12 tons per acre being rather common. Growers who expect to make a success of tomato growing must obtain good yields; the purpose of this bulletin is to point out some of the practices that have proved successful in increasing the yields of tomatoes.

SELECTION AND PREPARATION OF TOMATO SOILS

SOILS FOR TOMATOES

Tomatoes can be grown on a wide range of soil types. They are successfully produced in commercial quantities on soils ranging from mucks to clays and from clays to comparatively light sands. Light soils, however, are open to the objection that they suffer severely from drought and are hard to keep supplied with organic matter and available plant food. On the other hand, such soils are easier to

work and are usually earlier, and the cost of preparing the ground and planting and caring for the crop is less than for heavier soils.

The tomato is very sensitive to poorly drained soil, and such ground should never be used for the growing of this crop. The land should be in a high state of fertility and in good physical condition as a result of proper treatment during previous seasons and should not have been in tomatoes, potatoes, peppers, or eggplants for at least 3 years. Crops that are closely related to the tomato may serve as host plants for various disease-producing organisms that may later attack the tomato crop.

CROP ROTATION

A crop rotation that will keep the soil in good physical condition and well supplied with organic matter is particularly desirable on farms where tomatoes are grown year after year. A rotation that includes at least one crop of clover or cowpeas is extremely desirable. It is too often the practice to relegate the tomato crop to the poorest part of the farm, using the good ground for other crops. The crop should be placed on good ground if success is expected. For details as to the rotation best suited to local conditions, the county agent should be consulted.

The particular method to be followed must be determined by the conditions found on each farm, but the purpose should be to keep the ground occupied at all times with some crop that is adding vegetable matter to the soil, preferably one that is adding plant food in the form of nitrogen. It should be remembered that even the non-nitrogen-gathering green-manure crops add to the fertility of the soil by making available much of the insoluble plant food found in most soils, as well as by adding organic matter.

PREPARATION OF THE SOIL

Where fall plowing can be done without sacrificing well-established cover crops, it is in many cases desirable. On heavy soils, where it is possible to practice fall plowing without injury to the soil through leaching and washing, it is a good custom, as it promotes more thorough decay of roots and other organic matter in the soil and, owing to the alternate freezing and thawing, puts the soil in better physical condition. Plowing should be done as deeply as the soil will permit, and the depth of plowing should be gradually increased by half an inch each season until the soil is plowed at least 8 inches deep. It is not desirable to increase the depth of plowing suddenly so that large quantities of subsoil are brought to the surface, but through gradually deepening the plowing the surface soil can be increased in depth without affecting the present crop. The final result will greatly improve conditions for the growing of tomatoes and other crops. In case a cover crop or sod is to be plowed under, disking is recommended before plowing, as this will hasten the decay of the material being turned under. The preparation of the land after plowing should be more thorough than for general farm crops. Before setting the plants the topsoil should be well pulverized to a depth of 3 or 4 inches.

Soils having a hardpan or a layer of impervious clay 10 or 12 inches below the surface will be greatly improved for tomato production if

the underlying soil is broken up without being brought to the surface. Deep tillage is accomplished by breaking the soil below ordinary plow depth. Plowing at the same depth year after year produces what is termed a "plow sole," and in time this becomes very hard. This condition can be corrected by an attachment to the plow that works in the bottom of the furrow and breaks the subsoil to a depth of 5 to 8 inches below the regular depth of plowing. The additional power required to operate this attachment is about equal to that required for ordinary plowing.

MANURING

Many growers prefer to apply stable or barn-lot manure to the crop preceding tomatoes rather than to the tomato crop itself. Others follow the practice of applying the manure to a cover crop of rye, wheat, or barley during the winter and then plowing the manure under together with the cover crop in ample time to properly prepare the land for setting the plants. When the manure is well-decayed and of fine texture, 6 to 8 tons per acre may be applied broadcast after plowing and thoroughly disked into the soil. Even 10 or 12 tons may be applied without danger of adverse results, especially where the organic content of the soil is low and available plant food is not abundant. However, the cost of the manure in such large quantities may be a limiting factor. On soils that have been heavily manured during past years or where the organic content of the soil is high, care should be exercised in the application of manure on account of its tendency to produce a heavy vine growth at the expense of the set of fruit. When manure is applied preceding the planting of the tomato crop, the percentage of nitrogen in the commercial fertilizer is frequently reduced, or this element is omitted entirely. Owing to the scarcity and cost of manure in most localities, however, growers are coming to depend more and more upon soil-improving crops as a means of maintaining the proper balance of organic matter in the soil.

USE OF COMMERCIAL FERTILIZERS

Soils on which canning tomatoes are grown differ in their fertilizer requirements, but tests in the leading production sections give conclusive evidence that increased yields are obtained by the judicious use of commercial fertilizers. Although much depends upon the previous treatment of the land, especially as to the use of manure and soil-improvement crops, certain soils are especially in need of phosphorus, whereas others require additional potash. On account of the injurious effect of nitrogen on the setting of the fruit, this element should be used cautiously. A New Jersey grower who stood at the top in the 1939 Ten-Ton Tomato Club, with an average yield of a little over 18 tons to the acre, grew his crop on land that had carried a winter cover crop of rye deeply plowed under, supplemented with two applications of 800 pounds each of a 5–8–7 fertilizer. Another member of the club, with a record of 16½ tons to the acre, grew his crop on land where wheat was used as a winter cover crop, supplemented by an application of 6 tons of manure plowed under with the wheat in the spring. This was further supplemented by the application of 1,000 pounds of a 4–8–10 fertilizer, which was broadcast and disked into the soil 1 week before setting the tomato plants.

In Ohio, fertilizer practices in general consist of an application of 300 pounds per acre of a 0–12–12 fertilizer broadcast previous to plant setting. As the plants are being set, an additional 200 to 250 pounds per acre of the same grade of fertilizer is applied by means of fertilizer attachments on the planter. This latter application is usually distributed in a strip or band on each side of the row. It will be noted that the fertilizer used by the Ohio growers does not contain any nitrogen, but this is fully compensated for by the presence of nitrogen-carrying organic matter in the soil.

In Indiana, fertilizing practices differ considerably according to the type of soil, but an application of 400 to 600 pounds of the proper commercial fertilizer per acre is the rule. As general recommendations, clay soils of light color and acid reaction respond to a 2–16–8 or a 2–12–6 fertilizer; dark sands and white slash soils, to a 2–8–16 fertilizer; sandy loams of light color, to a 2–8–10 or 3–12–12 fertilizer; dark-colored loams, silt loams, and clay loams, to a 0–12–12 or 3–12–12 fertilizer if the previous crop was not a legume. On soils low in nitrogen it is often profitable to side-dress with 100 to 150 pounds of nitrate of soda to the acre just before the last cultivation. In Indiana it has been found that for greatest effectiveness the fertilizer should be applied in bands on each side of the row, about 3 or 4 inches from the plants and at a depth of 4 or 5 inches.

In view of the wide variation in the fertilizer requirements of the different sections in which canning tomatoes are grown on a large scale, growers are urged to consult their county agents and State extension specialists whenever there is any doubt as to the composition or amount of fertilizer to use or the best methods of application.

LIMING

Results obtained by the New Jersey Agricultural Experiment Station [1] show that on acid soils yields of tomatoes may be increased as much as 50 percent by the use of lime. Reports of the members of the Ten-Ton Tomato Club of New Jersey for 1939 mention the use of 1,000 to 1,550 pounds of hydrated lime to the acre to correct the acidity of their soil. Soil acidity is based on the hydrogen-ion concentration, or pH value. A pH value of 3.5 indicates a very strongly acid soil; one of 6.5 to 6.8 indicates a mildly acid soil; 7.0 is the neutral point, neither acid or alkaline; and anything above pH 7.0 is alkaline. Potatoes grown in a soil having a pH of 5.2 or 5.3 are usually free from common scab, and when these soils are used the following year for growing tomatoes an application of lime will be required to bring the soil to a pH of about 6.5 or 6.8, at which point good yields of tomatoes may be expected provided the soil is well supplied with organic matter and contains the necessary plant food elements from manure or commercial fertilizers.

Lime is not used for its fertilizing value but mainly as a corrective of soil acidity, and the amount to apply should be determined by an acidity test in each case and for each part of the field. As in the case of fertilizers, the county agent or the State extension specialist should be consulted, since an overdose of lime has the effect of locking up certain of the plant food elements in the soil, causing reduced yields.

[1] See article entitled "Value of Lime in the Production of Tomatoes," by Emil Truog, professor of soils, University of Wisconsin, in 1939 Report of Ten-Ton Tomato Club of New Jersey.

The form in which the lime is applied often affects results, and the occasional use of dolomitic lime in place of pure calcium lime may prove a safeguard against unfavorable ratios between certain other essential elements in the soil.

VARIETIES

The varieties of tomatoes used for canning and manufacturing purposes have undergone a decided change during the past 12 or 15 years. The old standard varieties, such as Bonny Best, Greater Baltimore, and Stone, have been largely superseded by varieties of the Marglobe type, which are for the most part tolerant to fusarium wilt. Pan America, a recently introduced variety suitable for canning and manufacturing, is highly resistant to wilt.

In New Jersey, the three standard varieties for canning are Marglobe, Rutgers (of which Marglobe is one of the parents), and Pritchard (often referred to as Scarlet Topper). Special strains of these are used for the production of certified seed. The New Jersey cannery acreage is divided mainly between Rutgers and Marglobe, but about 10 percent of Pritchard is grown on account of its earliness.

In New York, varieties of the Bonny Best type, such as John Baer, Landreth, Cobourg, and Scarlet Dawn, have been largely used in the past, but recently the Stokesdale, Rutgers, and Early Baltimore have met with considerable favor.

In Ohio, the Indiana Baltimore (a selection of Greater Baltimore) is used at present for about two-thirds of the planting. Rutgers, Cobourg, and a variety known as J. T. D., make up the remaining one-third of the acreage.

In Indiana, 80 to 90 percent of the present acreage is set with either Indiana Baltimore or a selection of it. Stone is planted to a limited extent in the southern part of the State on account of its greater foliage protection for the fruits.

In Maryland, Rutgers and Marglobe constitute about 85 percent of the canning acreage, the remainder being mainly of the Baltimore variety. About 65 percent of the acreage on the Eastern Shore is of the Rutgers variety.

In California, Santa Clara Canner, Stone, and Marglobe are the commonly planted varieties. The recently introduced varieties, Essar and Riverside, which possess some resistance to verticillium wilt and fusarium wilt, are being planted, but the acreage of these varieties is limited.

In selecting a variety for canning and manufacturing, the matter of earliness and length of picking season, as well as adaptation to climatic conditions, must be given consideration. In addition, resistance to fusarium wilt is extremely important in many sections. The ideal canning tomato is of the slightly flattened globe type, deep red in color, with firm flesh and few seeds, and free from growth cracks. The ideal variety must also have good foliage to protect the fruit from sunscald and be capable of giving high yields and a maximum percentage of No. 1 grade tomatoes.

IMPORTANCE OF GOOD SEED

Two ounces of good tomato seed will produce an abundance of plants with which to set an acre by the transplanting method. In

Ohio and Indiana, where a part of the tomato acreage is being planted by the direct-seeding method described on page 17, 8 to 16 ounces of seed is required per acre; however, this amount is being reduced as improved methods of seeding are developed.

Certified seed is being used almost exclusively for the production of plants with which to grow tomatoes for canning and manufacturing. In New Jersey during the season of 1940 there were 3,580 acres of tomatoes under inspection, producing 117,575 pounds of certified seed, or enough to plant the entire commercial acreage of the United States, if carefully handled. Other States have made provision for the production of tomato seed under inspection and certification, and in addition a number of seed firms are now developing and distributing special strains of high-grade tomato seed. The cost of high-grade seed is a minor item in the total cost of the crop; therefore, the grower cannot afford to take chances on the use of seed of unknown quality, since the use of certified seed furnishes protection against disease-producing organisms that are carried on the seed.

Tomato seed retains its vitality for a number of years under proper storage conditions, and some growers of canning tomatoes are purchasing their seed a year in advance in order to test its quality. With strict enforcement of inspection and certification rules this procedure may not be necessary except that it safeguards the grower against failure to secure sufficient certified seed in any particular season. Tomato seed should be stored in a relatively dry atmosphere (65 percent humidity or lower) and at a uniform temperature of about 65° F. or lower.

GOOD PLANTS AND METHODS OF OBTAINING THEM

THE PLANT SUPPLY

Strong, well-developed plants are essential to the production of profitable crops of tomatoes, and the method to be followed in obtaining these plants must be determined largely by local circumstances. In years past practically all the plants used for setting the canning crop were grown locally; greenhouses, hotbeds, and coldframes were used for early plantings, and the plants for the late or main crop were grown in the open. At present, 75 or 80 percent of the plants used for setting the canning crop in the Northeastern States are obtained from southern plant growers, and the remainder are produced locally. Certain of the canners and manufacturers of tomato juice and purees are still following the practice of starting the plants with which their contract growers plant their entire acreages. This is in order to obtain uniformity of the product and regulate the rate of delivery of tomatoes to the factory over a given period. Tomato growers in Ohio, Indiana, and other tomato-producing States are now seeding a portion of their crop directly in the field, and they are getting yields about equal to those obtained by transplanting and at a reduced planting cost. The results have been fairly satisfactory, and the acreage planted by this method is being somewhat increased.

Southern-grown plants are now being largely produced under State supervision and certification. In Georgia, regulations for the production of certified tomato plants are issued by the State entomologist,

working under the State Department of Entomology. These regulations provide that all certified acreage must be on land that has not been planted during the past 2 years to tomato or related crops. Fields that were planted with certified tomato plants the previous year for the first time and in which no root knot nematode [2] or bacterial wilt was present are excepted, provided that immediately after the plants were pulled, such fields were plowed or disked and planted with crotalaria, velvetbeans, peanuts, or were fallowed. If such land is planted to crotalaria, velvetbeans, or peanuts, sufficient seed must be used to insure a stand; if fallowed, the land must be harrowed or plowed about every 30 days, that is, often enough to keep down all vegetation. All such fields must be approved by an inspector of the Georgia Department of Entomology. Only two successive crops of tomato plants will be certified from any field. The regulations also provide that the land shall not have been planted any time during the preceding 3 years to crops of tobacco, sweetpotatoes, watermelons, beans, carrots, and other truck and garden crops that are extremely susceptible to root knot nematode.

The Georgia regulations for certified tomato plants require that the plants shall be grown entirely from certified seed from a source approved by the State entomologist, that the seed must be treated for the elimination of seed-borne diseases before being planted, and that the plants must be sprayed thoroughly during the period of their growth. Only plants fully meeting the certification requirements may be shipped under certificate, thus guaranteeing the purchaser that the plants had a clean bill of health when shipped.

PREPARATION AND TREATMENT OF SEEDBED SOIL

The character of the soil in which the seed is sown is of importance; in brief, it should be rather light in texture, with good moisture-holding characteristics. It should not be so rich as to produce plants having a soft growth; yet it should contain sufficient quantities of all essential plant nutrients to produce a sturdy growth. Such a soil can best be prepared by composting pieces of sod and a good grade of manure at the rate of 2 or 3 parts of sod or loam and 1 part of manure. This mixture should be prepared the summer before it is to be used, and the pile should be turned over several times to obtain a uniform mixture. If a clay loam is used, a little sand or leafmold may be added to improve its texture. In all cases the soil for the seedbed should be screened or sifted to remove all stones or lumps. It should not be sterilized until about 2 weeks before it is to be used.

Where plants are grown locally in greenhouses, hotbeds, coldframes, and in the open the greatest care should be taken to avoid the use of soil that has been used for growing tomatoes or related crops within the preceding 3 years or on which manure containing tomato refuse has been used. The danger from soil-borne diseases can be greatly reduced or almost eliminated by heat sterilization or by chemical treatment of the plant beds. Changing the soil in the plant beds is advisable but expensive. It is not always convenient to obtain disease-free soil for replacement, and sterilization either by heating or by chemical treatment will usually provide adequate disease con-

[2] *Heterodera marioni* (Cornu) Goodey.

trol in the plant beds. Not only should the soil be treated for disease elimination, but the boxes or trays used for starting the seeds, the greenhouse benches, and the framework of the plant bed should also be treated.

The soil in hotbeds and coldframes may be sterilized by means of a portable steam boiler mounted on wheels. The steam may be applied by means of an inverted metal pan connected to the boiler by means of a section of steam hose, or it may be applied to the soil by means of a steam rake having hollow teeth spaced 6 or 7 inches apart that discharge the steam at a depth of 6 or 7 inches below the surface of the soil in the beds. This rake device is constructed of pipe and connected to the boiler by means of a steam hose and, like the inverted pan, is moved along the bed as rapidly as the soil becomes heated to approximately 210° F. As the soil is heated, it is covered with canvas or other material so as to retain the heat for a considerable period. Although steam sterilization of the soil is preferable, other forms of heat sterilization are effective.

Treatment with formaldehyde, chloropicrin, or other chemicals also is effective if they are available or can be obtained under existing priorities. The chemical treatment of the seedbed soil consists of the application of some chemical that will destroy disease organisms and not interfere with the growth of the plants later. Saturating the soil of the plant bed with a solution consisting of 1 pint of commercial formaldehyde in 30 gallons of water is effective, but this must be applied at least 2 weeks before the seed is sown, and the soil should be turned at least twice to liberate the fumes of the formaldehyde. Chloropicrin, or military tear gas, is now being used rather extensively by plant growers for the control of the root knot nematode and disease organisms in plant beds. Chloropicrin, which is sold under trade names, is injected into the soil by means of a special device, and 2 grams of the liquid is applied at a depth of 7 or 8 inches to each square foot of bed space. The soil is immediately covered with heavy paper in order to retain the fumes for 3 or 4 days; then the paper is removed and the soil is stirred to liberate any remaining fumes. The fumes of chloropicrin are deadly to all plant growth, including the roots of plants. **This material should be used with extreme caution and should be handled only in the open air. Small amounts of the fumes reaching the eyes and nose will cause an intense flow of tears and possibly headache.** After sterilization, the soil should be brought indoors or put in the hotbed and kept at a temperature of 65° to 70° F. for several days before the seed is sown. Tomato seed germinate best at a temperature of about 70°.

Care should be taken that the soil is not kept too wet, as an excess of moisture is likely to favor damping-off and other diseases. Whatever the method followed in producing the plants, particular attention must be paid to the soil and other conditions under which they are grown, as experience has shown that yields are very greatly affected by the start given the plants.

GREENHOUSE-GROWN PLANTS

Earliness is not an important consideration in the growing of tomatoes for canning and manufacturing, except as it contributes to uniform production over a relatively long period. In order to extend the period of operation, growers in certain sections start a part of

their crop very early and then deliver tomatoes to the market until the date that the factory opens. Small, sash greenhouses,[3] heated by means of stoves, flues, or small, hot-water heaters, are being used in a number of the Northeastern States for starting the seedlings, which are transplanted to coldframes and later to the open fields. Seeds are sown in soil in the greenhouse benches or in trays about 12 by 22 inches and 3 inches deep, as shown in figure 2. The seedlings are

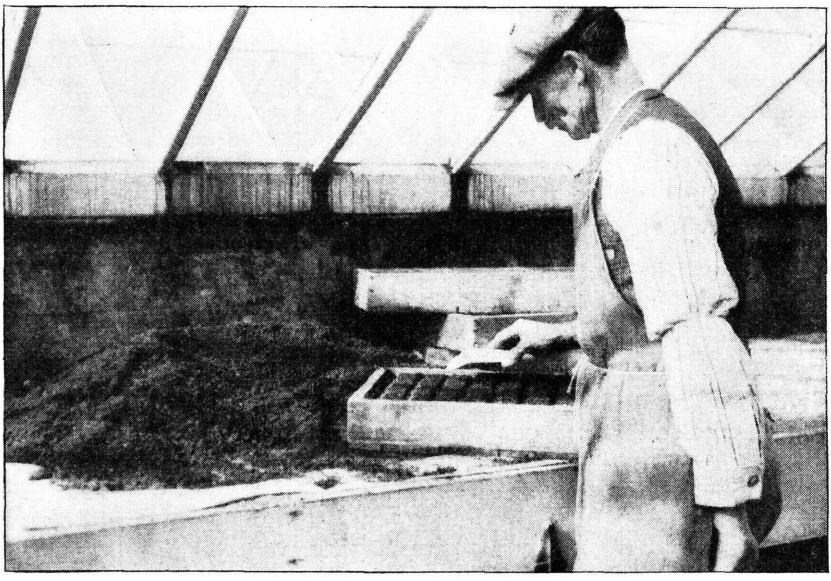

FIGURE 2.—Sowing tomato seed in flats in the greenhouse. The seed is covered with fine sifted soil.

usually ready for transplanting in 12 to 20 days after the seed is sown, and 4 to 5 weeks are required in the transplanting bed. The proper date for sowing the seed can be determined by allowing 6 to 7 weeks from the date of seed sowing to the date of setting the plants in the field, the length of time being dependent upon location and average weather conditions for the locality. Where extra-large plants are desired, especially those grown in pots (fig. 3), 8 or 9 weeks should be allowed. Such plants increase the chances of success, but their cost is too great for use on a large scale. It is apparent that no advantage but earliness is achieved by the use of greenhouses or hotbeds and the transplanting of plants two or three times; therefore, this method has been largely discontinued by growers of canning tomatoes.

HOTBED-COLDFRAME METHOD

Early plants are frequently grown in hotbeds heated by means of fermenting manure, coils of steam or hot-water pipes, or a furnace with a flue extending underneath the bed. Where electric current can be obtained at a low rate, the beds may be warmed by means of special electric heating units buried in the soil and the amount of heat controlled by a thermoregulator.[4] In the case of a manure heated bed

[3] Leaflet No. 124, Sash Greenhouses.
[4] Farmers' Bulletin 1743, Hotbeds and Coldframes.

the seed should not be sown until the bed has passed the peak of heating and the temperature of the soil has fallen to, or slightly below, 85° F. This precaution will not be necessary with the fuel- or electric-heated beds, as the temperature can be controlled from the start. Figure 4 shows a range of tomato plant beds heated by means of electric cables.

In the hotbeds the seed should be sown in drills, usually crosswise the beds and about one-half inch deep. The beds should be covered with sash or with heavy muslin, and careful attention must be given to watering and ventilating. When the

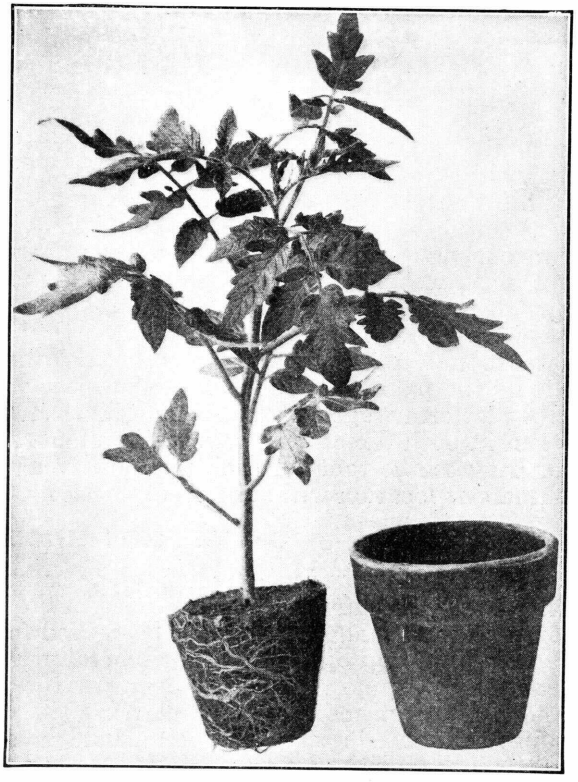

FIGURE 3.—A strong and hardy pot-grown tomato plant produced by two transplantings.

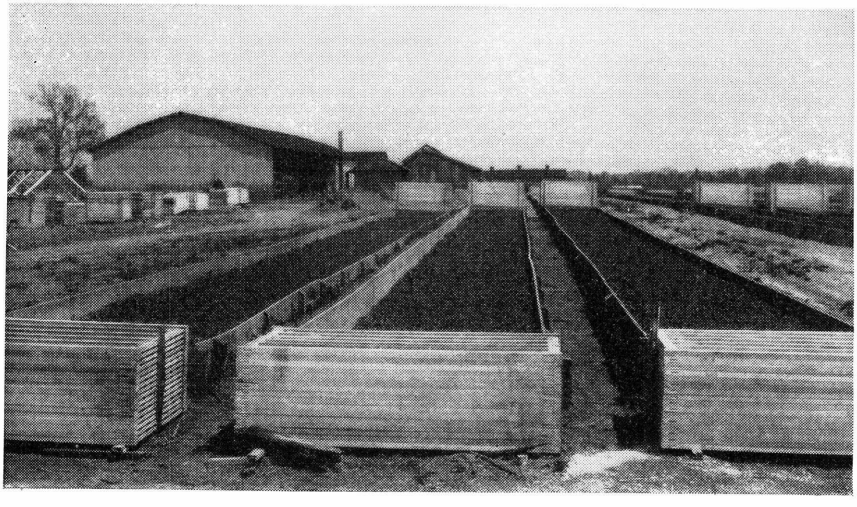

FIGURE 4.—Tomato plant beds heated by means of electric cables. Sash removed to accustom plants to outdoor conditions.

plants have formed two leaves in addition to the seed leaves, they are ready for transplanting to other beds or coldframes, where they should be given a space of at least 3 to 4 inches in each direction. During the time the plants remain in the coldframe they should have plenty of ventilation and the temperature should be kept as low as possible without stunting the growth in order to produce strong, stocky plants that will stand transplanting to the field. When the time comes to set the plants in the field they will have formed a mass of roots, and by cutting the soil in squares the plants may be placed in trays and transferred to the field with a minimum of root disturbance.

A modification of the above-described method consists in transplanting the seedlings to trays of the type shown in figure 2. These trays are placed in the coldframe, where the plants are grown for 3 to 4 weeks with plenty of ventilation. When the proper time arrives for setting the plants in the field the trays are watered and then placed on a platform wagon or truck and transferred to the field. A knife is run in both directions between the plants and, with a block of soil adhering to the roots of each plant, they are lifted and set in their permanent location without serious check in their growth.

OPEN-SEEDBED METHOD

For late plantings in the region where canning tomatoes are grown extensively the plants are often started in the open on a specially prepared piece of land that has not been used for a seedbed or the production of a crop of tomatoes for several years. The use, year after year, of the same seedbed is open to the objection that disease-producing organisms may accumulate in the soil. Where it is necessary to use the same location, the soil should be sterilized either by heat treatment or with chemicals. (See p. 11.) Prior to planting the seed, tomato-plant growers of Delaware, Maryland, New Jersey, and Virginia frequently haul brush from the woods and burn it on the area to be used as a plant bed. This method results in sterilizing the soil to some extent, destroys weed seeds, and at the same time adds a little potash.

Tomato seed may be planted in the open as soon as the danger of frost is past, but germination is slow if the soil remains cold or wet. The seed should be covered not to exceed one-half inch deep in soils of relatively light texture and not more than one-fourth inch deep on soils that are heavy. On heavy soils it is desirable to cover the seeds with a thin layer of leafmold, peat moss, sand, or finely sifted compost to prevent the crusting of the soil. Under very favorable conditions an ounce of high-grade tomato seed will produce an abundance of plants with which to set an acre, but it is usually best to use 2 ounces. Thin seeding will produce the best plants; however, 5 to 8 seeds should be drilled to the inch in order that the seedlings may be numerous enough to push through the surface.

In open seedbeds the seed is generally sown in rows about 12 or 14 inches apart by means of a hand seed drill. Wheel hoes and ordinary garden tools are used for cultivating the plants, and some method of watering the plant beds is provided. Small beds may be watered with sprinkling cans, the water being supplied from barrels hauled to the beds, but where plants are grown on a larger scale overhead irrigation or lines of garden hose are employed for watering whenever rainfall is insufficient. Plants grown in the open with facilities for

watering are generally more sturdy and stand transplanting to the field better than those grown in enclosed beds; moreover, they do not need to be transplanted from the seedbed to the plant bed and again to the field by blocking out. Figure 5 shows good plants

FIGURE 5.—Good tomato plants grown in open seedbeds without transplanting.

produced in the open without transplanting, and figure 6 shows a good plant grown by the method involving transplanting and blocking out.

The open-seedbed method of growing tomato plants has some disadvantages; for example, it does not produce early plants and is therefore adapted only for growing plants to be used for the late plantings. Recently the trend in growing tomatoes for canning and manufacturing has been toward earlier planting, and this is usually attained by the use of southern-grown plants. The cost of growing plants locally by the open-seedbed method is low, but this method cannot be depended on where earliness is desired.

FIGURE 6.—A good tomato plant grown by the transplanting and blocking-out method.

SOUTHERN-GROWN PLANTS

Tomato plants grown in the South for northern planting are produced in the open on specially prepared land, and by the time they reach a suitable size for shipment they are stocky, have good foliage, and are in excellent condition for setting. The fields in which the plants are grown are plowed and fertilized, and the soil is well prepared and leveled. The seed is planted one-half inch deep in rows at least 16 inches apart. Seeding is done by means of tractor-drawn gang-seeder outfits that harrow the ground, place the fertilizer, and sow the seed for four rows, all at one operation. The plants are cultivated by means of cultivators that work the soil between three or four rows of plants at a time, the cutters or sweeps being changed according to the size of the plants. Spraying is done with either horse-drawn or tractor-power sprayers that spray the same number of rows as are planted by the gang-seeder. In some cases the sprayers cover eight rows, or double the number sown by the gang-seeder. As a rule, a space is left between each eight rows of plants.

Pulling the plants begins when they are about 8 inches high. They are bunched in bundles of 50 each as they are pulled and taken to a packing house, where the roots are packed in wet moss and wrapped in paper. The bundles are then packed in crates or hampers and are ready for shipment. Figure 7 shows a field of plants ready for pulling, and figure 8 shows the workers pulling and bunching the plants. In

some cases the plants are pulled and placed in field crates without bunching and are then sorted and bunched in a central packing shed. This method provides greater uniformity and a better pack. Figure 9 shows the packing of plants in bundles of 50 each with peat moss wrapped about the roots, and figure 10 shows the crates of plants loaded in a car for shipment.

FIGURE 7.—A field of southern-grown tomato plants ready for pulling.

DIRECT-SEEDING METHOD

Tomato growers of Ohio, Indiana, and other States are now establishing a part of their acreage by planting the seed directly in the field where the plants are to grow (see p. 9). This method does away with transplanting but is wasteful of seed and often involves considerable hazard to the young plants; moreover, the plants require blocking out and thinning. In one section the cost of planting by this method is reported to be about $8.50 per acre, as compared with $14 per acre by the transplanting method, or a saving of $5.50 per acre. This method has not been sufficiently tested under a variety of commercial conditions to determine whether or not it is likely to be generally superior—or inferior—to the methods involving transplanting. Some tests have given yields as good as those with transplanted plants; others have not.

In a plot test on the Ohio State University farm, where moisture conditions were controlled through irrigation and fertility levels were carefully checked, there were significant increases in yield in favor of

seedlings started in sterilized soil in greenhouses and grown in 4-inch pots (fig. 3) until set in the field; and also in favor of plants grown in sterilized soil in hotbeds and transplanted to the field with the addition of a starter solution in transplanting. No data were given showing costs of establishing the crop.

FIGURE 8.—Workers pulling and bunching southern-grown tomato plants.

Although the direct-seeding method shows possibilities under favorable soil and climatic conditions, it might prove a great mistake for growers of cannery tomatoes to abandon the methods requiring transplanting, before they have thoroughly tried the direct-seeding method and found that the yields justify the change.

SETTING PLANTS IN THE FIELD

Tomato plants should not be set in the field until danger of frost is past, the actual date depending upon the particular section of the country in which they are grown. It should be the aim of the grower to move the plants to the field with as little shock to them as possible. For this reason, just as much as possible of the root system should be saved. Tomato plants grown in such a way that they can be transferred to the field without disturbing the root system have a very great advantage over those whose root systems are more or less injured in being removed from the seedbed to the field.

FIGURE 9.—Packing southern-grown tomato plants in bundles of 50 each with damp moss around their roots.

FIGURE 10.—Crates of southern-grown tomato plants loaded in express car for shipment to northern growers.

Planting distances for cannery tomatoes vary, but experimental work in Missouri indicates that there is little difference in the yields from different spacings. In general, large-growing varieties like the Greater Baltimore need more space. Planting in checkrows 4 by 4 feet is perhaps the most usual practice, but some space the rows wider and set the plants closer in the rows, such as rows spaced 5 feet apart with the plants 3 feet apart in the row. This greatly facilitates spraying and harvesting and gives about the same number of plants per acre. Spacing the plants 4 feet apart each way will require about 2,700 plants per acre. The 5 by 3 foot spacing will require about 2,900 plants per acre.

If set in dry weather, the plants should be watered in, and it is a distinct advantage to set them fairly deep or at an angle so that but a few inches of the tops will be exposed. Hand planting is necessary where the plants have large quantities of earth adhering, such as is secured by blocking, growing in pots, paper bands, etc. The use of transplanting machines is advantageous where plants that have not been previously transplanted are used. The use of water or a transplanting solution in machine setting is advisable.

TRANSPLANTING SOLUTIONS

Recent tests in the several tomato-growing sections have demonstrated that increased yields may be obtained by the use of transplanting solutions.[5] In some sections a large proportion of the growers are using such solutions in connection with the setting of the plants in the field. Not only are yields increased but also the tomatoes begin to ripen approximately a week earlier. It has also been found that the best results from the use of transplanting solutions are obtained where the fertilizers are applied in bands or as side dressings at a little distance from the plants.

Various combinations of plant-food elements have been used in preparing these transplanting solutions. The most common and cheapest combination consists of 4 parts superphosphate, 1 part Cal-Nitro, and 1 part nitrate of potash; it has been used at the rate of 4 to 6 pounds in 50 gallons of water. However, the disadvantage of this solution is that it leaves a sediment that interferes with the proper working of the distributor valve on the transplanter. A more satisfactory but slightly more expensive solution is made with 4 parts monocalcium phosphate, 1 part Ammo-Phos, 1 part magnesium sulfate, and 4 parts nitrate of potash. This combination is much stronger than the first-mentioned, and 2 to 4 pounds is sufficient for use in 50 gallons of water, one-half pint of the solution being used around the roots of each plant. Unless the grower has had previous experience in the preparation of these transplanting solutions, he should consult the county agent or someone who is familiar with their local use.

Tests in New York [6] in 1939 indicated that the highest ultimate yields and earliest ripening were obtained when the transplanting solution was applied at the rate of only one-fourth pint per plant, but at the rate of 8 pounds of the mixture in 50 gallons of water. An appli-

[5] See article entitled "Results with the Transplanting Solution," by Jackson B. Hester, soil technologist, Campbell Soup Co., in 1939 Report of Ten-Ton Tomato Club of New Jersey.
[6] Charles B. Sayre, New York State Experiment Station, Geneva, N. Y.

cation of one-half pint to a plant at the rate of 4 pounds of the mixture in 50 gallons of water gave slightly lower yields. In one test the mixture used consisted of 2 parts Ammo-Phos 11–48 and 1 part nitrate of potash and had an analysis of 11 percent nitrogen, 32 percent phosphoric acid, and 14 percent potash. It contains both nitrate and ammonia nitrogen, and there is evidence that there is an advantage in supplying both forms of nitrogen; furthermore, the phosphate has a high percentage of water solubility, an important point in itself because it is only the soluble phosphate that is available to the plants. The fact that the highest yields were obtained by the application of only one-fourth pint of the highly concentrated solution is difficult to explain, but there is a decided advantage in reducing the amount of water that must be used. In another test the highest early yields were obtained with a mixture of 1½ pounds of monopotassium phosphate and 1½ pounds of diammonium phosphate in 50 gallons of water, having an analysis of 12.5 percent nitrogen, 52 percent phosphoric acid, and 17.5 percent potash. This mixture cost 20 cents a pound in 1939, but was reduced to 11 cents a pound in 1940, or 33 cents for 50 gallons of the transplanting solution, which, at the rate of one-quarter pint per plant, would water 1,600 plants. These tests were made on clay soil; on light or sandy soils it might be better to use one-half of the amount of chemical mixture and to apply at least one-half pint of the solution.

CULTIVATION

Cultivation that will keep down weeds and keep the topsoil loose and mellow is essential to the production of high yields of cannery tomatoes. Certain weeds that are related to the tomato, such as the horsenettle, are carriers of tomato diseases and not only should be kept out of the tomato fields but also should be destroyed on adjacent land. A healthy tomato plant has an enormous spread of feeder roots, and these are found both near the surface and at considerable depth. Rather frequent cultivation by means of riding cultivators, such as are used for corn, will serve to keep the tomato plants in a clean, growing condition; and, where checkrowing permits cultivation in two directions, hand hoeing will be greatly reduced. A certain amount of hand hoeing will be required during the early stages of growth and later, after the size of the vines prevents further horse or tractor cultivation.

Tomatoes should not be cultivated or hoed while the vines are wet with dew or rain, as this tends to spread the spores of the leaf spot fungi. Persons walking through the tomatoes when the plants are wet are likely to spread the leaf spot diseases. In planting the tomato field the width of rows should be governed to some degree by the width of the cultivators and sprayers, in order that the plants may be kept properly worked and sprayed until they practically cover the ground. After the crop reaches the stage where picking of the fruit begins, very little cultivation or spraying will be required.

IRRIGATION

In sections having an abundant rainfall during the growing season, tomatoes for canning and manufacturing are grown as a rule without

irrigation. During seasons of limited rainfall, or for short periods during which the precipitation is below normal, irrigation gives a decided advantage in maintaining growth and obtaining good yields. In the East the overhead or sprinkler system is most commonly employed, although on land that is level or only slightly sloping the furrow or flow method may be used. Recently large-capacity portable irrigation or slip-joint pipes have come into use for the distribution of water. No irrigation is given late in the season after the crop has reached an advanced stage of maturity, for fear of causing fruit rots and cracks. In the regions where crops are grown entirely under irrigation, the preparation of the land for planting, the width of rows, and other factors are made to conform to the approved methods of irrigation.

In California [7] tomato crops can be grown satisfactorily in some parts of the State with little or no irrigation—for example, in the districts having more than 15 inches of winter rainfall and a cool summer, like the San Francisco Bay district. However, in some of these districts increased yields may be obtained by irrigation, and in many other districts growers depend on this practice for maximum yields. The number and frequency of applications are determined by local conditions, chiefly by the amount and distribution of rainfall, the type of soil, the temperature during the growing season, and the plant growth habit. Sufficient water should be used to keep the plants growing steadily without wilting. The requirements of irrigation and soil-moisture maintenance are the same for tomatoes as for many other plants. For adequate irrigation of tomato plants all the dry soil in the root area should be wetted. This is best accomplished by using several small furrows between the rows and by wetting as much of the soil as possible; if it is necessary to irrigate while the plants are small one ditch close to the row of plants may be used. As the plants increase in size it may not be practicable to maintain several furrows between the rows, because of injury to the plants. Instead, a broad shallow ditch may be formed for irrigation. As the lateral penetration of water is slow, this ditch should be maintained as wide as the size of the plants will permit. Keeping the surface soil dry under the plants during the latter part of the season will minimize the loss caused by fruit rots.

Tomato plants, being deeply rooted, draw water from a large volume of the soil. If the soil is filled with water, as after a winter rainfall or a heavy irrigation, the plants may go uninjured without additional water for several months. Recent investigation has shown that growth is retarded by lack of moisture but not completely interrupted until the lack results in wilting. If the supply of soil moisture becomes dangerously low, an irrigation will replenish the water supply without injuring the plant. Where the rate of evaporation is high, as in the interior valleys in California or in the Imperial Valley, water is applied approximately three times during the season with 5 or 6 acre-inches per irrigation for the heavy soils. Lighter soils are irrigated more frequently.

[7] California Agricultural Extension Service Circular 104, The Production of Tomatoes in California, by D. R. Porter and John H. MacGillivray.

INSECT PESTS AND THEIR CONTROL [8]

A number of different kinds of insect pests attack the tomato plant, and some of these are important pests of the tomato every year in some parts of the country and periodically in other tomato-growing areas. The most common and widespread of these insect pests are the cutworm, the potato and tobacco flea beetles,[9] the tomato fruitworm,[10] and the hornworm.[11] The tomato pinworm [12] is destructive in the San Joaquin Valley and in the southern part of California, and it has also been recorded as damaging field-grown tomatoes in Florida. The tomato, or potato, psyllid [13] and the beet leafhopper [14] are prevalent in several States in the West and during some years cause considerable loss to tomato plantings. Feeding by the tomato psyllid causes a physiological disturbance in the plant known as psyllid yellows, and the beet leafhopper, through its feeding, transmits to tomatoes a disease known as curly top, or western yellow blight.

CUTWORMS

Cutworms attack the young tomato plants, both in the plant bed and after they are set in the field, usually during the first few days after they are transplanted. These pests cut the stems near the ground, and the plants are a total loss.

Cutworms may be controlled by applying to the affected areas a bait prepared by thoroughly mixing 1 pound of paris green with 50 pounds of wheat bran moistened with just enough water so that when a handful is pressed together it will fall apart with a crumbly consistency. White arsenic or sodium fluosilicate may be substituted for the paris green. The bait is most effective when applied late in the afternoon. It should be applied on the ground, because if the bait comes in contact with the plants the paris green will cause injury by burning the plant tissue. The bait may be broadcast over the field before planting, at the rate of 15 or 20 pounds per acre, dry weight. If it is applied after the plants are transplanted a small quantity should be dropped near each hill, care being exercised to see that none of the bait particles remain in contact with the plant. **Paris green (an arsenical compound), white arsenic, and sodium fluosilicate are all poisonous to human beings and to animals. For this reason it is essential that the poison and the poisoned bran bait be kept out of the reach of livestock and irresponsible persons.** Experience has indicated that there is little or no likelihood of birds or poultry being poisoned as a result of having access to the poisoned bait in the field.

FLEA BEETLES

The potato flea beetle and the tobacco flea beetle, small black and dark-brown insects about twice the size of a pinhead, are particularly destructive to the young tomato plants in the seedbed and also in the field soon after the plants are set out and before they become well

[8] Prepared by the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine.
[9] *Epitrix cucumeris* (Harr.) and *E. parcula* (F.).
[10] *Heliothis armigera* (Hbn.).
[11] *Protoparce sexta* (Johan.) and *P. quinquemaculata* (Haw.).
[12] *Keiferia lycopersicella* (Busck).
[13] *Paratrioza cockerelli* (Sulc.).
[14] *Eutettix tenellus* (Bak.).

established. They injure the plants by eating numerous small holes in the leaves and are attracted more to the wilted transplants than to those that are in a thrifty, growing condition. For controlling the beetle on tomato plants in the seedbed or on the newly set plants, use a dust mixture containing 1 percent of rotenone, prepared by mixing derris or cube root powder with talc or a similar material. Apply the dust in the plant bed at the rate of about one-half pound to 100 square yards of bed. In the field on small plants use it at the rate of 8 to 10 pounds per acre, applied directly to the plants. The application should be repeated about every 4 days until the infestation is checked.

Where bordeaux mixture is used on tomatoes the beetles may be controlled by adding 1 pound of calcium arsenate to each 50 gallons of the spray mixture. **Calcium arsenate, however, should not be applied to tomatoes after the earliest fruits are about half-grown unless they are to be washed or wiped carefully before they are canned or processed, to remove any poisonous residues remaining at harvest.**

TOMATO FRUITWORM

The tomato fruitworm (fig. 11), also known as the corn earworm and the bollworm, is a robust caterpillar about 1½ inches long when mature that burrows into the fruits and renders them unfit for food. Although present control measures for the fruitworm are not entirely adequate, a fair degree of protection from this pest can be obtained by the use of calcium arsenate, a dust mixture containing cryolite, or a poisoned bait consisting of corn meal and cryolite. The commercial cryolites contain from 83 to 98 percent of sodium fluoaluminate and for dusting should be mixed with talc or some other suitable carrier so as to contain approximately 70 percent of sodium fluoaluminate. The poisoned bait is prepared by thoroughly mixing 1 pound of cryolite and 10 pounds of corn meal. The calcium arsenate is used full strength for dusting. Best control can be obtained by making three applications at intervals of 2 weeks, beginning when the plant spread is about 1 to 2 feet in diameter or when the first fruits are set. It is necessary to cover the plants thoroughly with the insecticide, especially the growing tips and outer leaves, where the insect eggs are laid. This requires that from 20 to 40 pounds of the insecticide be applied, per acre per application, depending upon the size of the plants. The corn meal-cryolite bait should be sprinkled by hand over the plants at the rate of 40, 60, and 80 pounds per acre for the three applications, respectively.

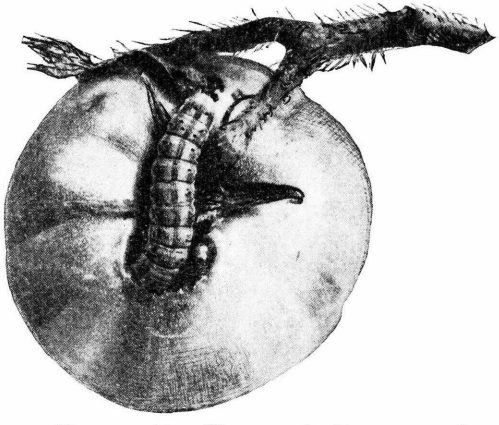

FIGURE 11.—Tomato fruitworm and its characteristic work.

Caution: Cryolite and calcium arsenate are poisons; their use may result in a harmful residue on the tomato fruit at harvest which should be removed by either washing or wiping the fruit carefully before it is marketed or consumed.

HORNWORMS

The hornworms, large caterpillars about 4 inches in length when fully grown and easily recognized by the hornlike structure on the end of the body, blend so effectively with the tomato plant that they are located with difficulty even after considerable foliage has been destroyed. The chief damage is from their feeding on the foliage, but they sometimes feed on the fruit also. Hand-picking of the hornworm is effective in small plantings and when infestations are light, but more effective and economical control in larger plantings is obtained by dusting them with undiluted calcium arsenate. For best results the dust should be applied when the caterpillars are small, at rates of 10 to 30 pounds per acre, depending upon the size of the plants.

TOMATO PINWORM

The tomato pinworm is a small caterpillar that feeds on the foliage of tomatoes and burrows into the fruit around and under the stem, causing small pinholes. It often burrows so deeply that not all the injured portion is removed with the core in the preparation of the fruit for canning or processing. Some control of this pest can be obtained by treating the plants with a dust mixture of cryolite containing 70 percent of sodium fluoaluminate. The most effective degree of control has been achieved by making four applications at intervals of from 10 days to 2 weeks, timed so that the last application will be made soon after the first picking.

Complete destruction of the discarded fruits and tomato vines immediately after harvest, followed by plowing or disking, is an effective aid in controlling this pest. If old tomato vines and the fruit they bear, as well as eggplant and nightshade plants, have not been destroyed, new tomato plantings should not be made near the old fields containing these plants or near places where old plants have been piled.

TOMATO, OR POTATO, PSYLLID

The tomato, or potato, psyllid, a small, jumping plant louse, is frequently very destructive to tomatoes in Colorado, Nebraska, Wyoming, Utah, and other sections of the West. Feeding by the nymphs of this pest on tomatoes causes a physiological disturbance or disease in the plants known as psyllid yellows. The older leaves of the plants attacked thicken and at the basal portions curl upward, often with the petioles twisting. The younger leaves show slight purpling along the veins and outer margins, the rest of the leaf usually becoming a light or yellowish green. The growth of the plant is stunted, and the plant tops acquire a feathery appearance. If the plant is attacked when small, the internodes are shortened and may fail to grow for weeks, and the plant may fail to fruit or will set only a few fruits, which remain small. When the attack is severe on larger plants, the internodes may be lengthened and the leaves narrowed, with many fruits, which remain small, set near the ends of the branches. Further, the fruits on affected plants are inferior in quality. They fail to ripen

properly, having a yellowish cast on the exterior, while the interior central mass and partition walls of the tomato fail to color normally upon ripening, being rough and even rubbery in some instances and having an insipid taste.

To control this pest, dust the plants with 300-mesh dusting sulfur or spray them with a mixture of 1 pound of wettable sulfur in 10 gallons of water. Although the application of a spray consisting of 1 gallon of liquid lime sulfur (32° Baumé) and 4 pounds of wettable sulfur to 80 gallons of water is effective against the insects, this mixture may cause slight injury to the plants. Best results can be obtained by making four applications of the insecticides as follows: The first, 10 days before the plants are pulled from the coldframe; the second, 10 days after they are transplanted to the field; the third, when the plants begin to blossom; and the fourth, just before the plants break over and begin to spread. If the plants are not treated before they are taken from the plant bed, the tops should be dipped, when they are being set out, in a mixture of 1 ounce of wettable sulfur to 1 gallon of water. Before canning or extracting the juices from tomatoes treated with sulfur near harvest the fruits should be carefully washed and peeled.

BEET LEAFHOPPER

In the tomato-growing districts of the Intermountain States and in California, the beet leafhopper is frequently a serious menace to the tomato crop. Moving from its desert breeding areas into the fields soon after transplanting time, it feeds upon the young tomato plants and transmits to them a disease known as curly top or tomato yellows. The disease is recognized by an inward rolling of the leaflets along the midrib. The petiole and midrib frequently curve downward, giving a drooping appearance to the leaves, which become somewhat thickened and crisp. The stems become hollow through the drying of the pith. With the first appearance of these symptoms growth of the plant is arrested, and the plant assumes an erect or rigid habit. If small fruits have formed, they ripen prematurely. Beginning at the tips, the roots of the diseased plants decay, and finally the plant dies, and the leaves and stems turn brown.

Recent experiments in Utah have indicated that a method for reducing losses from curly top is to set two tomato plants about 6 inches apart in each hill. Promising results there have also been obtained in protecting the plants from curly top infection by covering them with cheesecloth protectors during the first month after they are transplanted to the field. The protector consists of 1 square yard of cheesecloth supported by two loops made of lengths of wire 42 inches long, crossing at right angles to each other so that the cloth forms a large "hot cap" over the plant. The cloth is held in place over the loops of wire by covering the lower edge with soil.

WHERE INSECTICIDES MAY BE PURCHASED

Information regarding the purchase of insecticidal materials mentioned herein may be obtained through local dealers in agricultural supplies or through county agents or State agricultural experiment stations.

DISEASES AND THEIR CONTROL

Many of the diseases that cause the greatest injury to canning-crop tomatoes are carried on the seed or live over in seedbed soils. For this reason it is important that new seedbed soil be used each year if it is practical to do so, or the old soil should be sterilized by steam or chemical treatments (p. 11). If, in addition, the seed is treated with chemical disinfectants to free the surface of disease-producing organisms, the losses from disease are likely to be much reduced.

The more common diseases of canning-crop tomatoes are briefly described in the following paragraphs with the most effective methods for their control.

DAMPING-OFF [15]

Damping-off of seedlings is caused by fungi that are common in most soils and frequently cause wilting and collapse of the stems of tomato seedlings at the soil line. The trouble can be prevented by soil sterilization and is also effectively controlled by various chemical treatments. Dusting the seed with cuprous oxide has given very satisfactory results in damping-off control, the dust being used at the rate of 1½ level teaspoonfuls per pound of seed. The seed and dust should be shaken in a tight container and the excess dust screened off. Seed may also be effectively treated by soaking for 1 to 2 hours in a solution composed of 2 ounces of copper sulfate dissolved in a gallon of water. The seed is dried after treatment without rinsing or may be planted at once.[16]

SEPTORIA LEAF SPOT [17]

Septoria leaf spot, which frequently causes serious losses in some of the canning States, is characterized by small, dark, circular spots with gray centers. The centers of these spots commonly show small, dark flecks that are the fruiting bodies in which the spores (seedlike bodies) of the fungus are produced (fig.12). The disease affects the foliage and stems, beginning with the older leaves, and often defoliates the plants with the exception of a few leaves at the tips. Poorly ripened and sun-scalded fruit often result from such injury to the foliage.

As the fungus causing leaf spot overwinters on the remains of the previous crop, diseased vines should be plowed under deeply in the fall. Crop rotation is also important in controlling the disease. As the fungus has a narrow temperature range it does little damage until the weather is warm, and its injury is not serious until early summer.

In seasons when injury from the disease is severe it often proves profitable to spray the plants with bordeaux mixture. It has been found, however, that, in the case of the tomato, bordeaux sprays may cause some reduction in yields; their use is likely to prove of value only in seasons when conditions are particularly favorable to the leaf diseases. Spraying should be started before the disease gains headway, the time of the first application depending on the amount of early-season rainfall. Where dry weather occurs during the first

[15] Caused chiefly by *Pythium* spp. and *Rhizoctonia solani* Kühn.
[16] For other seed treatments, see Farmers' Bulletin 1862, Vegetable Seed Treatments.
[17] Caused by *Septoria lycopersici* Speg.

few weeks after the plants are in the field, the first spraying may be delayed until the plants reach a fair size. Spraying should be repeated every 8 to 10 days when conditions favor infection by the leaf spot fungus; care should be taken to coat both surfaces of the leaves.

An 8–8–100 bordeaux mixture has been commonly used and may be prepared by dissolving 8 pounds of copper sulfate in 50 gallons of water and 8 pounds of fresh hydrated lime in a small amount of water and diluting to 50 gallons. The two solutions are then poured together

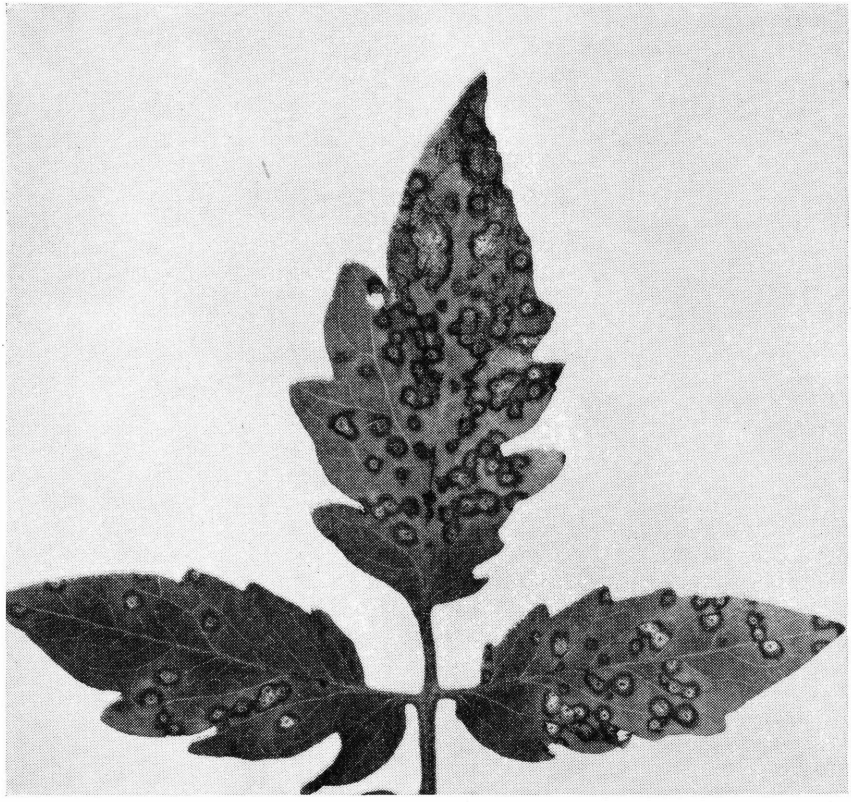

FIGURE 12.—Tomato leaflets showing septoria leaf spot. Note dark flecks in the centers of the spots, which are bodies containing the spores of the fungus.

while being stirred. Various other formulas are recommended for bordeaux mixture in which both the copper sulfate and lime content are varied. It is ordinarily best to use the formula that has seemed to give best results in the grower's own locality. The preparation of large quantities of bordeaux mixture can be hastened by making up separate stock solutions of copper sulfate and lime that contain 1 pound to each gallon of water. In making an 8–8–100 bordeaux mixture, 8 gallons of copper sulfate stock is added to 60 gallons of water, and 8 gallons of lime stock is then added to this while it is being stirred. The mixture is then made up to 100 gallons with water. A finely powdered form of copper sulfate that simplifies mixing is also available.

The sprayer tank is filled about three-fourths full with water and after the agitator has been started the required amount of copper sulfate is added. The necessary lime is made into a thin paste with water and then added to the mixture, which is kept agitated and should be used at once.

Bordeaux mixture may cause gastric disturbances if taken internally and is somewhat irritative to the eyes and skin. All unused portions should be disposed of or covered, in order to be inaccessible to children and animals.

Recent work has indicated that some of the so-called insoluble or fixed copper compounds cause less injury than bordeaux mixture, although they are not superior to it in fungicidal value. They should be used as directed by the manufacturer, the usual rate being one that gives the equivalent of 2 pounds of metallic copper in each 100 gallons of spray. No lime is used, but a sticking agent, such as wheat flour, is commonly added at the rate of 8 pounds to 100 gallons. It is also advisable to use some spreading agent, such as skim-milk powder or calcium caseinate, at the rate of 1 pound to 100 gallons to obtain better coverage of the leaves.

A copper-lime dust made up of 20 pounds of monohydrated copper sulfate thoroughly mixed with 80 pounds of finely ground hydrated lime has also been used to some extent in the control of tomato leaf diseases. The dust is applied when the plants are wet with dew and forms a compound much like bordeaux mixture. It is somewhat easier to apply than the liquid sprays, but generally has seemed somewhat less effective as a fungicide and, like bordeaux mixture, is somewhat injurious to the plants. The time and number of applications of this compound are the same as those recommended for bordeaux mixture.

EARLY BLIGHT [18]

Early blight is caused by a fungus that attacks leaves, stems, and fruit. On the leaves it produces spots that are larger and less numerous than those of septoria leaf spot. These spots frequently are circular and show concentric, targetlike markings. The stems of seedlings are attacked near the soil line, and, when the injury occurs, the dark sunken spots known as collar rot are produced (fig. 13). The fungus also causes large, firm, dark spots that generally occur immediately about the stem end and may extend deeply into the fruit. Early blight is common throughout the Northern and Middle Atlantic States and in the South. The disease develops most rapidly in periods of warm, moist weather and is usually most severe where plants are poorly nourished or carrying a heavy load of fruit.

The fungus, which is also parasitic on the potato and other relatives of the tomato, may live for some time on dead weeds and crop remains in the field, in the soil, or on the seed. Tomato crops should be planted in a long rotation, as this tends to prevent the severe development of various soil-borne diseases. It is also advisable to plow under the plants as soon as possible after the harvest is finished. Seed treatment will free the surface of the seed of this and other disease-producing organisms, and all seed should be treated before planting. Seed may be disinfected by being soaked for 5 minutes in a 1:2,000

[18] Caused by *Alternaria solani* (Ell. and Mart.) Jones and Grout.

solution (1 ounce to 15 gallons) of mercury bichloride (corrosive sublimate), then washed for 15 minutes in running water, and dried. As this treatment is not effective in the control of damping-off, in addition the seed should be dusted with cuprous oxide before it is planted if there is likelihood of damping-off injury. Seed may also be disinfected by being dipped for 5 minutes in a 1:1,200 solution (1 ounce to 9 gallons) of New Improved Ceresan, which contains 5 percent of ethyl mercury phosphate. The seed is not rinsed but is

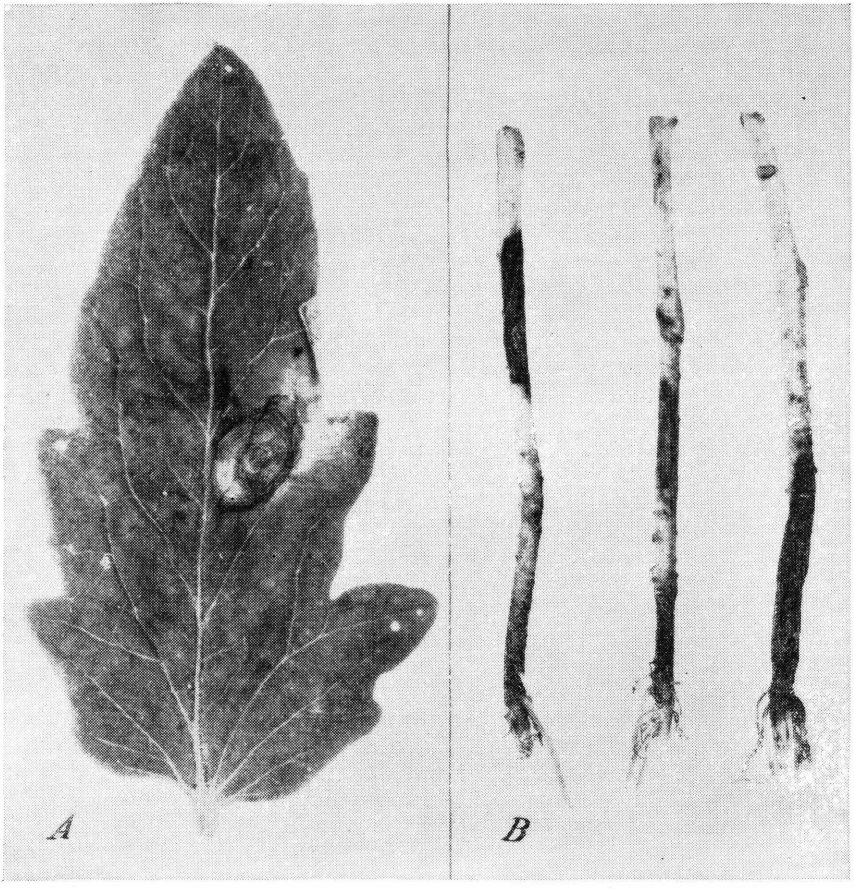

FIGURE 13.—*A*, Tomato leaflet showing typical spot of early blight. *B*, Stems showing collar rot injury caused by the early blight fungus.

dried at once after this treatment. In using the above treatments, 1 gallon of solution is used for each pound of seed. (**Both Ceresan and mercury bichloride are poisonous and care should be exercised in their use. Rubber gloves should be used in handling seed wet with the Ceresan solution or the solution itself. Care should also be taken not to inhale the Ceresan dust or that from the dry, treated seed.**) Spraying or dusting the plants in the field with copper fungicides is fairly effective in the control of early blight, and the same procedure should be followed as for septoria leaf spot.

Fields should not be set with plants showing early blight infection, and plants with stem cankers should be particularly avoided. Where plant beds or plant shipments contain large numbers of infected plants they all should be discarded, as more plants are likely to develop the disease after transplanting. Holding plants in beds after they reach a proper size for transplanting should be avoided, as such plants often develop collar rot infection.

FUSARIUM WILT [19]

Fusarium wilt is one of the most common and destructive diseases of tomatoes and is caused by a fungus that when once introduced will live for long periods in the soil. Plants affected with fusarium wilt show gradual yellowing and wilting of the foliage that begin with the older leaves; it often causes the death of the plant (fig. 14). One of the

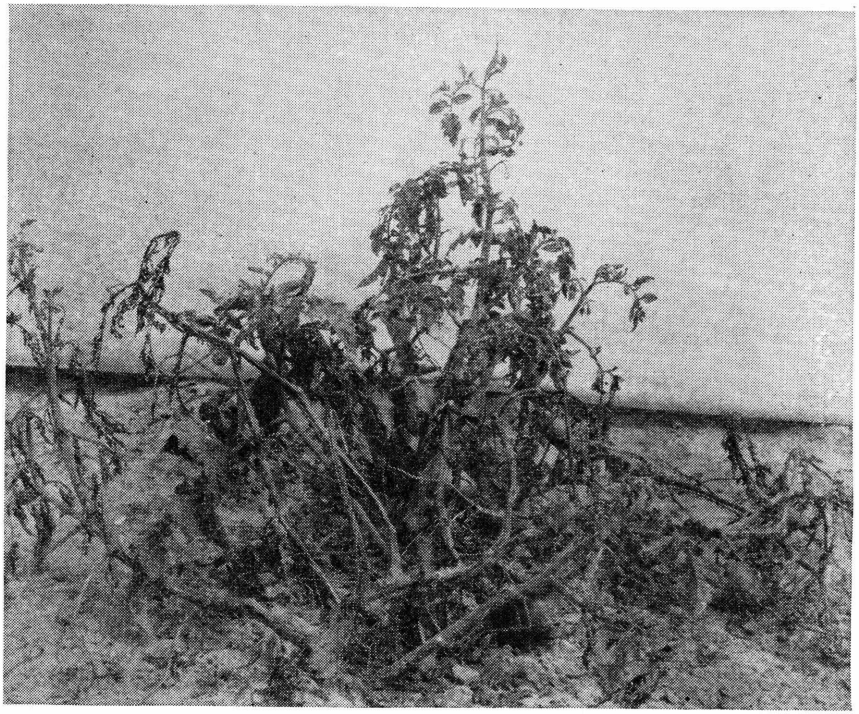

FIGURE 14.—Tomato plant affected with fusarium wilt, showing dead shoots and loss of lower foliage.

chief characteristics of the disease consists of a brown discoloration of the water-conducting tissues of the stem just below the outer green portion of the stem. When it is possible to do so, seedbeds should be located on wilt-free soil, and the crop should be grown on land where the disease has not previously occurred. Rotation is important, as when fields are only slightly infested with the wilt fungus a continuous cropping with tomatoes is likely to increase the amount of the organism in the soil to a point where serious losses will occur.

[19] Caused by *Fusarium bulbigenum* var. *lycopersici* (Brushi) Wr. and R.

The best means of avoiding losses from fusarium wilt is to use varieties resistant to the disease. The most widely planted of these varieties are the Marglobe and Rutgers, which are main-crop canning varieties. Pritchard, a somewhat earlier market tomato of excellent quality, is also used to some extent for canning. Recently the United States Department of Agriculture has introduced a variety, the Pan America, which possesses extremely high resistance to fusarium wilt.

VERTICILLIUM WILT [20]

Another wilt disease known as verticillium wilt produces symptoms somewhat similar to those of fusarium wilt, but it is confined largely to the Northern, Pacific Coast, and Intermountain States. It is less common than fusarium wilt. The fungus causing this disease lives for long periods in the soil and also affects herbaceous plants, such as pepper, eggplant, and potato, and a number of woody hosts. Land where the disease is known to occur should not be used for tomatoes if it can be avoided, and tomatoes should not be planted in close rotation with the other crops mentioned above. The tomato varieties listed as resistant to fusarium wilt are not resistant to verticillium wilt, and their use will not prevent losses from this disease. Two varieties, Riverside and Essar, that show some resistance to both fusarium and verticillium wilts have recently been introduced. These varieties, however, are more particularly adapted for growing under California conditions.

BACTERIAL WILT [21]

Bacterial wilt, or brown rot, is a third kind of wilt that sometimes affects tomatoes. It is characterized by a rather rapid and complete wilting of the plant without any noticeable yellowing of the foliage. When a diseased stem is cut across there is a creamy bacterial exudation from the cut vessels, and the discoloration extends deeply into the pith, which may be almost destroyed. Occasionally the disease is serious in the South, and at times it is found in the Central and Middle Atlantic States. Where bacterial wilt has occurred, the land should not again be used for tomatoes for at least 4 years. During this period the field should not be used for potatoes or peppers, as the disease also is serious on these crops.

BACTERIAL CANKER [22]

Bacterial canker affects leaves, stems, and fruit and often causes serious injury on canning tomatoes. The disease works upward from the lower portion of the plant and is usually first evident in the lower leaves. The stems and petioles of the plant remain turgid, but the leaflets turn brown and die. In many cases the leaves on only one side of the plant appear to be attacked, and the resulting one-sided appearance is very characteristic. In later stages yellowish-white streaks appear on the younger parts of the stem and often crack open

[20] Caused by *Verticillium albo-atrum* Reinke and Berth.
[21] Caused by *Phytomonas solanacearum* (E. F. Smith) Bergey et al.
[22] Caused by *Phytomonas michiganensis* (E. F. Smith) Bergey et al.

to form the longitudinal cankers that give the disease its name. Portions of the pith become soft and yellow and, later, cavities form in the stem. On the fruits, bacterial canker may cause small, snow-white, round spots, which later become raised and have a tan-colored center surrounded by a light halo.

As the bacterial canker organism may be carried on the seed, care should be taken to obtain seed from plants free from the disease. Seed may be freed from the canker organism at the time of harvest by fermenting the seed and fruit pulp for 3 to 4 days at temperatures not exceeding 70° F. or by soaking the freshly extracted seed for 24 hours in an 0.8 percent solution of acetic acid at the same temperature. Dried seed may be treated by soaking for 24 hours in a 0.6 percent acetic acid solution at 70° or may be disinfected by one of the treatments described on page 30. The organism may live over in seedbed soils for at least a year; therefore, if the disease has occurred, new soil should be used or the beds should be sterilized by steam or chemical treatment. (See p. 11.)

BACTERIAL SPOT [23]

Bacterial spot is most serious in its effects on the fruit where it forms small, greenish-white, raised pustules that develop a flat, sunken, brown center. Eventually the green margin disappears; the center becomes dark brown, and the epidermis is torn and curled back.[24] On the leaves the disease appears as small, black, and rather greasy-appearing spots, which often cause considerable injury to the foliage. The causal organism is seed-borne and may be controlled by seed treatment with new Improved Ceresan or mercuric chloride, as described on page 30.

ANTHRACNOSE [25]

Anthracnose is a serious fruit rot of canning tomatoes and frequently causes heavy losses. The disease is caused by a fungus that is present in the soil and affects the fruit as it ripens, causing circular, sunken, water-soaked spots that gradually become darker than the surrounding tissue. The centers of the spots eventually become lighter in color and show small dark specks in which the fungus spores are produced (fig. 15). Frequently these bodies form dark concentric rings in the centers of the spots. Injury to the fruits is not necessary for infection, as the fungus can penetrate the uninjured surface. Proper fertilization and drainage tend to reduce losses from this disease, and spraying with copper fungicides is also of some value in its control.

MOSAIC

Mosaic produces a green and yellow mottling of the foliage and a noticeable stunting of the plant. Mosaic leaves are somewhat curled and may be distorted into the abnormally narrow forms known as "fern leaf." Mosaic is not caused by a fungus or bacterium, but an

[23] Caused by *Phytomonas vesicatoria* (Doidge) Bergey et al.
[24] U. S. Department of Agriculture Circular 282, Three Bacterial Spots of Tomato Fruits. This circular may be purchased from the Superintendent of Documents, Washington, D. C., for 5 cents a copy.
[25] Caused by *Colletotrichum phomoides* (Sacc.) Chester.

infective principle or virus is present in the juices of affected plants, and the virus is transmitted by plant lice and also by pruning and handling diseased plants. It does not appear to be generally carried in the seed but occurs in certain perennial weeds, such as the ground-cherry, whence it may be carried to the tomato by insects that have previously fed on the weed hosts. When mosaic once appears in the field, it is difficult to control, and every care should be taken to prevent infection of the young tomato plants. Weeds should be kept down at the edges of the field, particularly in the vicinity of seed-

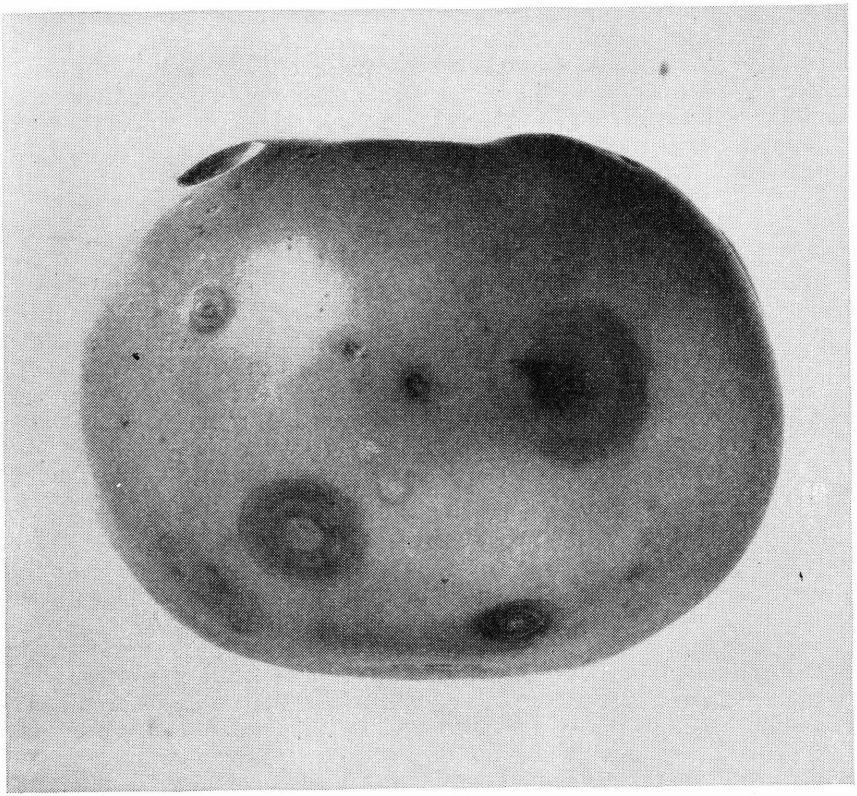

FIGURE 15.—Tomato fruit showing anthracnose spots. These are sunken and show dark, concentric markings.

beds. Plants should never be started in greenhouses where there are older tomato plants affected with mosaic, as the disease is almost sure to be transmitted to some of the younger plants and pass unnoticed until after they have been set in the field. The virus causing the common form of tomato mosaic also affects tobacco and may be present in manufactured tobacco, particularly that used for smoking. It has been shown that plant infection may occur from the hands of workers who smoke, and therefore smoking should be avoided when working with young plants.

BLOSSOM-END ROT

Blossom-end rot (fig. 16) is a nonparasitic disease that causes a decay of the blossom end of the fruit. The disease usually makes its appearance during or after periods of drought when the roots of the plants are unable to supply the necessary moisture to maintain the growth of both the foliage and the fruit. At such times it is believed that the leaves, having a greater demand for moisture, rob the fruits of moisture; this causes a breakdown of the cell structure in the blossom end of the fruit. The disease is most likely to develop on plants that have made a vigorous growth under favorable soil-moisture and temperature conditions and are later exposed to high temperatures and drought. Loss from the disease can be materially reduced, but not entirely prevented, by limiting the applications of nitrogen, especially that contained in animal manures, and by supplying sufficient superphosphate and available calcium. On the other hand, plants that have been starved for lack of fertilizer (nitrogen) and have accumulated large reserves of starch and other carbohydrates are particularly subject to blossom-end rot. It is indicated that the use of calcium nitrate as a source of both calcium and nitrogen will give results in the control of blossom-end rot. The supplying of moisture to the soil during periods of drought has been found rather effective in preventing the development of the disease, but fruits that have become affected cannot be saved.

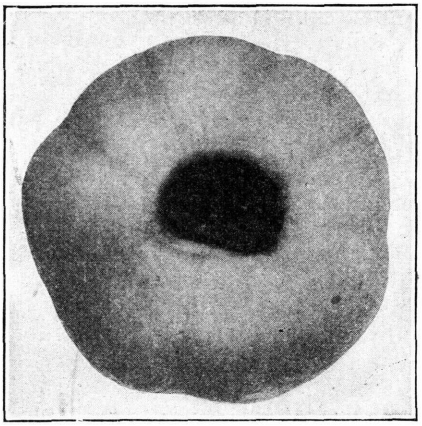

FIGURE 16.—Tomato blossom-end rot.

PICKING AND HANDLING TOMATOES

Tomatoes should be picked at reasonably frequent intervals, but the important consideration is not so much frequency of picking as thoroughness. The periods between pickings will vary with the weather, but usually tomatoes for a cannery should be picked at 4-day intervals in warm weather and at weekly intervals during cooler weather. Temperature affects the rate of ripening; and although proper moisture is essential for plant growth, continued rain is harmful and injures the quality of the crop. Tomatoes that are wet with rain appear to be more highly colored than when dry, and this difference should be taken into consideration while picking during rainy periods. The color of the fruit changes from green to yellowish and finally to the mature red color. These changes in color are associated and directly connected with chemical changes within the fruit, and the highest flavor is found only in mature, well-colored fruit. The richness of the color depends to a considerable degree upon warm temperature, but temperatures above 90° F. for any considerable period are unfavorable, and in cases of insufficient foliage, sunburning

or discoloration of the fruits will result. One of the first essentials in the proper picking of the tomatoes is to train the pickers, so that they will not only recognize the proper color stage but will also avoid picking fruits that have not reached the proper color. Tomatoes continue to increase in size until fully ripened and in doing so give a heavier ultimate yield; however, if left on the vines too long, the fruits become overripe, growth cracks occur, and decay sets in.

Certain persons suffer more or less from color-blindness and are unable to distinguish between green and red. Persons who are so affected should not be employed as pickers, and if it is found that any picker is gathering tomatoes that are too green, a test should be made to determine if he or she can distinguish the colors.

As the tomatoes are picked they should be placed directly on trucks for hauling to the loading point or to the canning factory, and under no circumstances should they be allowed to remain exposed to the hot sun for any length of time after being gathered. Where the haul is long, the loads of tomatoes should be covered so as to be protected from the sun. Tomatoes should not be picked when the vines are wet, with either dew or rain, as the fruit so picked is more subject to spoilage; and, in addition, there is great danger that leaf spot and early blight, two very serious diseases, will be spread by the hands and clothing of the pickers. During periods of continued rain it may be necessary to pick tomatoes while the vines are wet, but in this case they should be rushed to the factory and processed as quickly as possible.

Baskets and crates should be filled only level with the top, as overfilling crushes the fruits. The hampers or baskets should be so stacked and braced in the wagons or trucks that movement of the load in transit will be avoided.

The workers of the department of horticulture of the Agricultural Experiment Station of Purdue University have summed up the matter of quality tomato picking as follows:

(1) The crop must be grown with good farm practices, but it must also be carefully and skillfully picked.

(2) Color-blind people are not successful tomato pickers unless they have knowledge of their condition and pick for brightness rather than redness.

(3) Frequency of picking must be governed by weather conditions, but tomatoes are usually picked too frequently.

(4) On the average 68 percent will become U. S. No. 1's and remain so for an average of 6.2 days.

(5) Bruising or cracking tomatoes by careless picking, overfilling the baskets, or improper loading of the tomatoes in trucks or wagons results in a loss of tonnage and quality to grower and canner.

(6) Tomatoes that are wet from rain or dew appear redder than when dry. The picking of wet tomatoes should be avoided; but when it is necessary, special care should be used.

(7) More decayed tomatoes result from careless picking than from unfavorable weather conditions.

(8) Most tomato pickers must be supervised and paid on a quality and thoroughness basis.

GRADES OF CANNING TOMATOES [26]

U. S. grades have been established for both canning tomatoes and tomatoes to be used for manufacture of strained products. The greater portion of the tomatoes used for these purposes are purchased

[26] Data in first three paragraphs furnished by R. R. Pailthorp, Agricultural Marketing Service.

on the basis of such standards, the grading being done by Federal-State inspectors.

U. S. No. 1 grade for canning tomatoes requires that they shall be firm, ripe, well-colored, well-formed, and free from molds, decay, and damage caused by growth cracks, worm holes, catfaces, sunscald, freezing injury, and mechanical injury. U. S. No. 1 grade for tomatoes for manufacture of strained products requires them to be fairly firm, ripe, well-colored, and free from stems and damage caused by badly discolored cracks, shriveling, molds, decay, sunburn, sunscald, and freezing. U. S. No. 2 grade in both sets of standards specifies that tomatoes, although not meeting the requirements of U. S. No. 1 grade, are ripe, fairly well-colored, and free from serious damage from any cause. These standards may be changed from time to time to conform with needs of the industry or as new insect pests and diseases develop. Copies of these grade standards may be obtained from the Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C.

Seasonal variations, cultural practices, and general soil and climatic adaptation to production account for considerable variation in the average quality of tomatoes delivered to factories within the same State and in different States. For example, in 1939, a year when average quality was relatively good, the average percentage of U. S. No. 1 tomatoes ranged from 45 to 68 percent in the States using the Service, of U. S. No. 2's from 25 to 43 percent, and of culls from 1 to 12 percent. In 1940, when growing conditions were unfavorable in many States, the average percentage of U. S. No. 1's ranged from 27 to 70 percent, of U. S. No. 2's from 25 to 68 percent, and of culls from 1 to 11 percent.

Growers of canning tomatoes in Indiana have worked out a plan whereby the pickers are paid largely on the basis of grade. If the canneries are purchasing tomatoes on a graded basis and the tomatoes are poorly picked, the farmer will naturally receive less for his crop. Under the plan of paying the pickers on the basis of the quantity of No. 1's, the grower will receive more for his crop. No definite figures can be given as to how much difference there should be in the amount paid for the picking of No. 1's and No. 2's. This can be determined by a comparison of the price received for the No. 1's and the No. 2's at the canning factory. The premium for picking No. 1's should be sufficiently high to constitute an inducement to the pickers to use extreme care in the picking.

Data obtained by the workers of the Indiana Extension Service showed an increase from 55 percent No. 1's when the picking was done carelessly to 70 percent No. 1's when the picking was properly done. On the basis of $12 per ton for U. S. No. 1's and $7 for U. S. No. 2's, the average gross returns for the grower under careless methods of picking was $9.75 a ton as compared with $10.50 per ton under proper picking.

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