Growing Tomatoes in Kentucky

By J. Edward Klinker

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CONTENTS

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The soils and climate of Kentucky are generally favorable to the production of tomatoes. Since they and tobacco belong to the Solanaceae, or nightshade family, it is not surprising that good tobacco soils are ideal for growing this crop.

Whether you grow a few plants or several acres, a yield of 10 pounds per plant per season is not an unreasonable goal. From six plants you could therefore hope for one bushel of red-ripe tomatoes—or 500 bushels (15 tons) from 3,000 tomato plants on one acre. While 10 pounds per plant may be more easily achieved in a small garden, yields of 15 tons per acre by commercial growers are not uncommon in many states.

There is no secret or magic in attaining good yields of tomatoes. Successful production, as with most other food crops, depends on following a number of rather simple but sound cultural practices which have grown out of the combined experience of generations of gardeners, and the patient research of many plant scientists. The purpose of this circular, therefore, is to list and discuss the various practices considered essential to growing tomatoes for the home garden, for early market, and for commercial canning.

Varieties

There are literally hundreds of different tomato varieties. They may be red, pink or yellow, and range in size from the tiny red, currant-type varieties to the very large red Beefsteak and pink Ponderosa types. Although home gardeners usually have personal preferences as to color or type, the ordinary red ones are by far the most widely grown.

EARLY CROP: Valiant and Early Giant Hybrid for home gar-

den and early fresh market. Pritchard,* though somewhat later-maturing than the first two varieties, is still considered an excellent, old-standby variety.

MAIN CROP: Garden State, Marglobe,* Longred, and Rutgers.* Rutgers is probably the most outstanding variety for all purposes. It is especially suitable for commercial and home canning. Pearson, although tested only one year, has shown outstanding quality and yields under severe drouth conditions.

LARGE-FRUITED PINK VARIETIES: Winsall and Ponderosa.

YELLOW OR ORANGE VARIETIES: Jubilee (or Golden Jubilee) and Sunray.

To Grow or Buy Plants

Should I grow or buy plants, is a question often asked. If you grow a few plants to several dozen, it will probably be more convenient and less expensive to purchase the plants from a reliable local plant grower or garden supply store. If you grow several acres of canning tomatoes, it will probably be more practical to buy certified, disease-free, southern-grown plants. The risk of bringing in diseased, off-type varieties from other states has been greatly reduced in the past few years, since most southern plant-growers are now producing moderately priced, excellent plants, according to the standards and supervision of their state agricultural experiment stations. Many prospective growers of canning-tomatoes will find a very fair and convenient arrangement for buying southern-grown plants through their local canning factory. It cannot be too strongly emphasized that these plants must be certified, disease-free.

What of the market gardener and the home gardener, who wish to grow their own plants? There are tomato growers in the market-garden areas of Kentucky who produce extremely fine plants in accordance with the methods of their fathers and grandfathers. To them little additional information can be offered. To the inexperienced, however, detailed instructions for growing tomato plants would seem appropriate.

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* Resistant or partially resistant to Fusarium Wilt.

Steps in Growing Plants

1. Buy certified seed from a reputable seedsman to insure good germination and trueness to varietal type. Many seedsmen now offer seed treated with hot-water or bichloride of mercury (corrosive sublimate). These seed treatments are helpful in preventing seed-borne diseases, such as early blight and Septoria leaf spot.

2. Treat seed with red copper oxide (cuprocide), Arasan, or Semesan to aid in preventing damping-off. This simple treatment is performed by shaking a pinch of cuprocide with the tomato seed in a glass jar until seeds are evenly coated with a layer of red dust. Diseases mentioned in paragraphs 1 and 2 will be discussed under the headings "Diseases" or "Insects."

3. Although sand or vermiculite may be used with good results in starting seedlings, a soil mixture of one-third each of rich top soil, sand, and compost or well-rotted manure is probably the most popular and successful medium for starting seedlings. These materials should be thoroughly mixed before using.

This special soil mixture should be sterilized with heat or chemical gas to control disease-producing soil organisms, nematodes (see description under "Diseases"), and weeds. If only a few plants are needed, mound up the soil mixture in a flat, burying a fairly large potato in the center of the mound; place in a 400°F-oven until the potato is done. Remove flat from oven and allow soil to cool before sowing seed.

Where several thousand plants are needed, treating seed beds with methyl bromide (containing 2 percent chloropicrin) gives excellent results. Directions are given on the container. To treat soil for pots or flats, mound the soil mixture (which should be fairly moist) in a pile on a concrete floor. Since a pound-can of gas treats 50 cubic feet of soil, the mixture might be piled in a mound 4 feet wide, 12 feet long and 1 foot deep. This would be 48 cubic feet. These dimensions may be changed, but do not pile more than 1 foot deep. Cover the pile with a piece of polyethlene film (the same as used in fumigating tobacco beds) and thoroughly seal by covering the edges of the film with soil. Under the cover, release a pound-can of methyl bromide (according to directions on container) and keep sealed at least 24 hours. Re-

Fig. 1.— Sowing tomato seed in a well-prepared seedling flat of soil.

move cover, being very careful not to mix any unsterilized soil with that just treated; let the pile stand in the open air 72 hours before using. Soil temperature should be over 60°F at the time of fumigation with methyl bromide to insure proper sterilization. Unless handled properly, methyl bromide is EXTREMELY HAZARDOUS; therefore, be sure to observe all precautions given in the directions on the package.

4. Six to 8 weeks before time for setting in the field, prepare a seedling flat of convenient size, such as 12x18x3 inches deep, fill with sand or vermiculite or the special sterilized soil mixture mentioned in Step 3 above. Sow seed in this flat at the rate of 6 to 8 seeds per inch of row with rows 2 inches apart (Fig. 1). Cover ½ inch deep with vermiculite, or ¼ to ⅜ inch with sand or soil. After seeding, soak flats with water from a sprinkling can, being careful not to wash seed from the soil. Keep the flat in a well-lighted room at an air temperature of 65°-70°F. After seed germinates, avoid keeping seedlings too wet. Soil surfaces should be allowed to become dry between waterings. Water on mornings of clear, bright days, soaking thoroughly, rather than sprinkling. If germination is reasonably good, each flat should yield 400 to 600 seedlings for the first transplanting.

Some growers prefer to use the space under one or two sash of their hotbeds to sow seed in rows from 4 to 6 inches apart, rather than using seedling flats. If this method is used, give careful attention to ventilation on sunshiny days after the seedlings have come up. Use the same precautions for watering as recommended for flats. For further information concerning hotbeds

and cold frames, see Kentucky Agricultural Extension Service Circular 276.

5. Whether flats or hotbeds are used, seedlings should be transplanted ("pricked off") the first time after they are about 2 inches high and the first true leaf appears (Fig. 2). Seedlings may be transplanted into flats, bands, or pots in 3x3-inch spacings in the hotbed or greenhouse, but much stockier plants can be obtained in spacings 4x4 inches. Tar-paper plant bands impregnated with fertilizer usually give a more satisfactory plant than plain paper or wooden bands of the same size, or clay pots of the same diameter. If possible, use sterilized soil in these containers at pricking-off time.

In experiments at the Kentucky Agricultural Experiment Station, plants grown in the special soil mixture mentioned above, in hotbeds maintained at a soil temperature of 60°-65°F by means of electric heating cables were of a quality equal or superior to greenhouse-grown potted plants.

6. Approximately one week before transplanting to the field, start hardening plants by removing sash to expose them to outdoor conditions, and water only sparingly. Prolonging conditions suitable for hardening much beyond one week may actually reduce early yields. The purpose of hardening (often called hardening-off) plants before transplanting to the field is to firm or harden the tissues to help the plants withstand insect injury, whipping, and hot, drying winds.

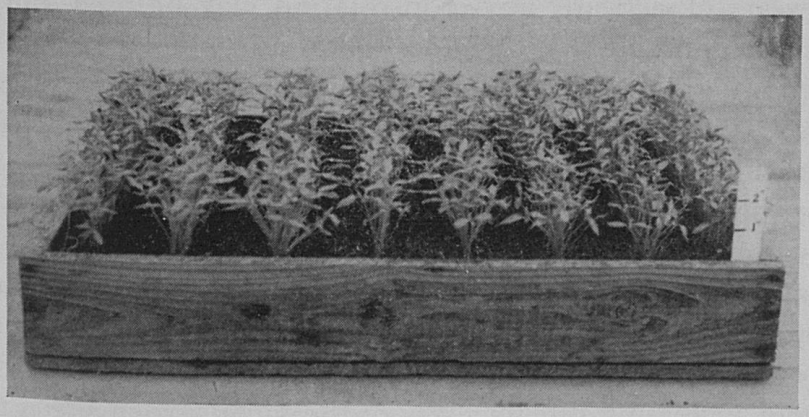

Fig. 2.— Tomato seedlings with first true leaves developed and at a height of 2 inches. This is the proper stage for "pricking off."

Soil Management

It is absolutely essential that soil for tomatoes be well drained. This means that an extra early crop should be planted on a sandy loam rather than silt or clayloam, since sandy loam soils can be worked in the spring much earlier than those which are heavier. A sandy soil can be used for an early crop, but requires the use of more commercial fertilizer. For a mid-season and late crop, heavier silt loams or clay loams, provided they are well drained, should be used since they hold moisture better and usually are more fertile than light soils.

Soil reaction (pH) is of utmost importance in growing tomatoes. A pH of 6.0 to 6.5 (slightly acid) is an ideal range, although good growth is usually obtained from a pH of 5.5 to 6.8. In general, one will seldom find Kentucky soils too alkaline (unless previously over-limed) for growing tomatoes, but those which are too acid are frequently encountered, especially on rolling land and on the lighter soils. The surest method of insuring proper soil reaction is to have the soil tested. If lime is needed, it should be applied in the fall previous to spring planting.

Rotation

Since tomato diseases (in spite of spraying or dusting) and nematode infestations become more and more severe when tomatoes are grown year after year on the same land, it is best that tomatoes be grown no more often on the same land than once in four years. Practically any crop rotation may be used, but it is especially desirable that tomatoes follow a legume or pasture crop turned under the previous fall. Planting tomatoes on early spring-plowed land, on which tobacco was grown the year before, is the next best to following a legume. The home gardener with limited space cannot follow this program, but planting the garden to a winter cover crop, such as barley and vetch, in the late summer and turning under about February will benefit not only the tomatoes but other vegetables as well. The location of tomatoes in the garden should be changed each year, even if only a few feet, to avoid increasing disease. Where the same garden site is to be used year after year, digging up the roots of the old vines at the

end of harvest should aid in preventing the build-up of nematodes in the garden.

Organic matter

The importance of organic matter cannot be overemphasized. The action of decaying organic matter which results from plowing under crop residues, manure, winter cover and green manure crops, leaves and compost is much the same as that of a sponge. Soils high in organic matter absorb more water from spring rains than do soils with a lower organic matter content. Later in the season, this natural reservoir of water in the soil furnishes much needed moisture to tomato roots, thus enabling good growth to be maintained even during the hot, dry days of summer. On the other hand, plants growing on soils low in organic matter show drouth symptoms rather quickly with the declining rainfall of summer, and yields are reduced. Tomatoes growing on "drouthy" soils (those low in organic matter) generally show much more blossom-end rot than those grown on soils high in organic matter. Organic matter also must be continually added to the soil so that it can be kept in good tilth.

Once organic matter has been added to the soil it immediately starts decomposing, due to the action of the soil microorganisms. Finally, only a dark residue of the original organic matter remains. This residue, called humus, is more or less resistant to further microbial breakdown. It has a dissolving power, which can react with the minerals occurring naturally in the soil to release important essential plant nutrients, such as liming materials (calcium and magnesium) and potassium. These important nutrients are then held rather loosely to the surface of humus particles, and hence are very easily available to the roots. Soil nitrogen also is increased by the decomposition of organic matter in the form of a manure or legume green-manure crop.

Animal manures, at the rate of 10 to 15 tons per acre, and legume green-manure crops are probably the most important sources of organic matter for the commercial grower. For home gardeners, manure, leaf mold, compost, and peat all constitute good sources of organic matter. They should be spread out uniformly, 2 to 4 inches deep, over the garden, depending on the past

productivity of the soil. In no case should fresh manure (particularly chicken manure) be applied later than the fall before spring transplanting of tomatoes. Well-rotted manure can be applied at any time until spring plowing, but even where well-rotted manure is used, applications should not be made later than two months before transplanting the tomatoes. It cannot be emphasized too strongly that the plowing under of manure, fresh manure in particular, just before transplanting, will almost always delay maturity of tomatoes from several days to several weeks. The excess nitrogen from the manure causes the tomato plants to produce heavy vines but little fruit.

It is to be remembered that manure furnishes considerable plant food. Ten tons of manure has, in addition to organic matter, a plant food value equal to 1,000 pounds of a 10-5-10 fertilizer, or 100 pounds of manure is equal to 5 pounds of 10-5-10. If manure is to be used as the sole source of plant food, add at least 50 pounds of 20-percent superphosphate for each ton of manure applied, or 2½ pounds superphosphate per 100 pounds of manure. Where large quantities of manure fortified with superphosphate can be used, not so much commercial fertilizer need be applied.

Commercial fertilizer

Tomatoes require a high level of fertility, particularly of phosphorus, to produce high yields. The analysis (also known as grade) and quantity of commercial fertilizer to be applied depends on the state of fertility and physical condition of the soil. An estimate of the phosphate and potash needs of the soil can be obtained by having the soil tested, but such tests do not measure the nitrogen needs of the soil. Information regarding the way to take a soil sample and the place it can be tested may be obtained from your county agricultural agent. If a soil is not tested, there is danger that too little fertilizer will be applied to meet the needs of the soil for producing a good crop.

If the soil tests over 300 pounds of available phosphoric acid and over 400 pounds of available potash per acre, little or no commercial fertilizer need be added except some form of nitrogen. In this case, the nitrogen needs can be met by plowing down 200

to 300 pounds of calcium cyanamid or sulphate of ammonia per acre (or ½ to ¾ pound per 100 square feet). If a heavy application (10 tons or more per acre) of strawy-manure was turned under the previous fall, use only one-half this amount of additional nitrogen. If the manure contained but little straw or other absorptive materials, no further nitrogen may be needed.

More soils are likely to test from 100 to 200 pounds of available phosphoric acid and 200 to 300 pounds of potash per acre, than those that test higher. In this case, it is recommended that 500 pounds per acre (or 1¼ pounds per 100 square feet) of 5-10-10 or 6-12-12 fertilizer be broadcast on top of the ground just before plowing. At plant setting apply on each side of the row an additional 500 pounds of 5-10-10 or 6-12-12 per acre in a band approximately 3 to 4 inches to the side and 3 to 4 inches deep. This application can be made by the fertilizer attachment on some kinds of setters, or by the side-dressing attachment on a cultivator. If the latter method is used, apply the side-dressing within a week after transplanting, so that it may be immediately available for plant use. For a small number of plants, place 2½ ounces of this fertilizer in a trench 3 to 4 inches away from the plant and 3 to 4 inches deep.

In many areas of the state, soils may test considerably below 100 pounds of phosphoric acid and 200 pounds of potash per acre. Such soils will require relatively heavy applications of commercial fertilizer to produce the goal of 10 pounds per plant. One method of meeting these needs is merely to increase the quantities of fertilizer recommended above where the soil test showed 100 to 200 pounds of phosphoric acid and 200 to 300 pounds of potash per acre. Thus, plow down 1,000 pounds (2½ pounds per 100 square feet) of 5-10-10 or 6-12-12 per acre and apply an additional 500 to 750 pounds per acre (2½ to 4 ounces per plant in a trench as described above for a small garden) in the row at plant setting. Less fertilizer would be handled by broadcasting and plowing down 300 pounds of calcium cyanamid or sulphate of ammonia, plus 500 pounds of 0-20-20, and applying an additional 300 pounds of 0-20-20 in the row at setting time, than if a straight 5-10-10 or 6-12-12 analysis were used.

Occasionally, more phosphoric acid will be needed than potash, or vice versa. Where the soil tests higher in phosphoric acid than in potash, one could substitute a greater quantity of 4-8-12 than the 5-10-10 recommended and in that way furnish relatively more potash than phosphoric acid. If potash tested high and phosphoric acid low, a greater quantity of 4-12-8 could be substituted for the 5-10-10 recommended. Additional quantities of these elements can also be added separately, such as sulphate of potash or superphosphate. A more complete discussion of kinds, rates, and analysis of commercial fertilizers may be found in Kentucky Agricultural Experiment Station Circular 70.

In addition to the recommended rates of fertilizer applications described above, a side-dressing of 200 to 300 pounds of 20 percent superphosphate per acre should be made when the first blossoms appear.[1] This special phosphate side dressing should be made at blossoming, even if the soil test showed phosphoric acid to be 300 pounds per acre or more. For a small number of plants, apply ¼ pound (4 heaping tablespoons) of superphosphate per plant in a trench around each plant, 6 to 8 inches from it and 2 inches deep; cover with soil without mixing the fertilizer with it. This practice will be particularly valuable if the vines are large and vigorous with a deep green color. Such plants show they are receiving more nitrogen than they need. Unless extra phosphate is applied to balance the nitrogen, blossoms from the first one or two clusters may drop, with a resulting delay in harvest and a decrease in yield.

Under some conditions tomato plants may develop a pale green color as the first clusters of fruit begin to set. This is a sign that they don't have enough nitrogen. This condition is unlikely to develop if the foregoing fertilizer recommendations have been followed, although it may develop on sandy or sandy-loam soils if the season is wet, due to leaching away of available nitrogen. To overcome such a nitrogen deficiency, scatter by hand on the soil 150 to 200 pounds of ammonium nitrate per acre (after two to three clusters have set), taking care not to cover any foliage with the fertilizer. If rows are 5 to 6 feet apart, it may be possible

[1] E. M. Emmert—*How to Prevent Blossom Drop of Tomatoes.* Ky. Ext. Leaflet H-4, July, 1942.

to make this application by means of the fertilizer attachment on the cultivator. If so, keep the sweeps as far as possible from plants and barely scratch the surface of the soil. For a few plants, sift 1 ounce (4 tablespoons) of ammonium nitrate on top of the ground around each plant and water it with a garden hose.

Transplanting (Setting)

Tomatoes should be transplanted into the field as soon as all danger of frost is past (probably from April 25 for southern Kentucky to May 20 for northern Kentucky) because the tomato is a warm-season vegetable and is easily injured by frost. For very early market, some risk may be taken and plants put out in the field 2 to 3 weeks earlier. This risk is considerably reduced if some kind of plant protector is used. (Discussed under "Plant Protectors.")

Whether plants have been bought or raised at home, make every effort to transfer plants from flats, pots, or hotbeds to the field with the least possible disturbance of the roots by keeping a ball of dirt around them (Fig. 3). This is very easily accomplished if plants are growing in pots or plant bands. Where plants are grown in the hotbed or flats without pots or bands, cross-cut squares of soil around each plant (as though cutting candy into squares) with a sharp butcher knife. Do this approximately one week before transplanting. This procedure cuts some roots, but encourages root branching,

Fig. 3.— An excellent tomato plant ready for setting in the field. Large ball of dirt around roots aids in a quick recovery from transplanting.

which, in turn holds the soil more firmly around the roots at transplanting. In all cases, water the soil in beds, flats, pots or bands thoroughly just before transplanting as an additional aid to holding soil around the roots, and to prevent wilting after setting.

Immediately before transplanting, work the garden or field thoroughly by raking or double-disking and harrowing to give a fine, level seedbed, free of clods. Set plants, by hand or with a tobacco setter, in holes or in a furrow, several inches deeper than they stood in the flat, usually so the first true leaves are level with the surface of the soil. With plants which are spindling or "leggy," lay a large portion of the stem and leaves in a furrow and cover with soil, leaving only the top leaves above the ground. Roots will form all along the buried stem, and will enable the plant to become "stocky" again. If "leggy" plants are not planted deep, they probably will remain weak, and may readily be broken off by the wind or in cultivation. Be especially careful to control fleabeetles, which will almost certainly attack tomato plants after transplanting in the field. (See section on "Insects.")

Starter solutions

Starter solutions are highly soluble fertilizers dissolved in water. Part of this solution should be poured around the roots of the tomato plant when it is transplanted to the field and before it is covered with soil. Being highly soluble and applied in liquid form, this fertilizer can be very readily absorbed by the new transplant. If the soil is warm and moist after transplanting, starter solutions will probably be of little value, but if the soil remains cold starter solutions will give the new transplant a big boost in growth, hastening ripening of fruits as much as a week or more.

Early-planted tomatoes often take on a deep purple color if the soil remains cold after transplanting. Usually this is called "cold injury," but actually it is caused by failure of the young transplant with its limited root system to get enough phosphorus. The highly soluble phosphorus supplied by a starter solution will generally prevent this deficiency from developing.

There are a number of commercial preparations which can be used to make up a starter solution. Some of these are mar-

keted as a dry powder, while others are sold as liquid starter solutions. All are in a concentrated form. Liquid forms are particularly easy to use because they do not "cake" and they mix very readily with water. All must first be diluted with water, before they are applied to the roots. Directions for use in making 1 or 50 gallons of starter solution are stated on the package and should be strictly followed. From ¼ to ½ pint of this starter solution is poured around the roots of each plant before the roots are covered with soil.

Ordinary commercial fertilizers can be used for making a starter solution by dissolving 10 pounds of a 5-10-5, 6-12-6, or 6-12-12 in 50 gallons of water (3 to 3½ ounces per gallon). Stir this solution vigorously and let it stand until the solution is clear. Pour off the clear solution into another container, being careful that none of the undissolved material is mixed with it. Throw away the undissolved fertilizer. Apply ¼ to ½ pint of the clear solution per plant. Use the higher rate unless the soil is known to be unusually fertile.

Spacing

An exact recommendation for spacing cannot be given, since such factors as fertility, type of mechanical equipment for cultivating and spraying, and whether or not plants are to be staked, must all be considered.

In general, early tomatoes which are to be staked should have 8 to 10 square feet each. Plants in this case could be spaced 2 to 2½ feet apart in the row, with rows 4 feet apart.

Tomatoes for later maturity, or early tomatoes not staked, should be spaced to have 15 to 20 square feet per plant. Several combinations are possible to secure this approximate area, such as 5x3 ft, 5x4 ft, 6x2½ ft, 4x4 ft, or 6x3 ft. (The first number in these spacings refers to distance between rows, while the second number is spacing within the row.) If the soil is unusually fertile, use the wider spacing for these later-maturing tomatoes. With a large field of canning tomatoes, mechanical spraying or dusting should be anticipated. Rows in this case should be at least 5 feet apart. Rows 6 feet apart will allow spray equipment to be used

later in the season, when vines are heavy, with less damage. A spacing of 6x3 ft is very satisfactory for the production of canning-tomatoes.

For the small backyard garden, space plants 2 feet apart in the row with rows at least 3 feet apart. This is probably the absolute minimum spacing for tomatoes in the garden. Staking is necessary at so close a spacing. Yields per plant are usually so heavy in a small garden that spacing in most cases can be increased to allow for 10 square feet per plant. Even though this wider spacing means fewer plants, there probably will be little or no sacrifice in yield.

The number of plants required to plant an acre can be calculated by dividing 43,560 square feet (square feet in one acre) by the number of square feet allowed for each plant. For example, a spacing of 5x3 feet equals 15 square feet per plant; 43,560 divided by 15 equals 2,904, or 2,900 plants per acre.

Plant protectors

Extra early market tomatoes may be set in the field two to three weeks ahead of the first frost-free date with considerably less risk from frost injury if some type of plant protector is used. Hotkaps and Hotents are two common types of protectors. Both are individual plant covers made of strong waxed paper. They are effective in giving plants protection against light frosts. However, if any of the leaves should be touching the waxed paper at the time of a frost, plants may actually be injured more than if unprotected.

Because of their larger size and greater height, Hotents seem better suited than Hotkaps for protecting tomatoes. Careful attention must be paid to ventilating plants under these structures to prevent too succulent or spindling growth under some conditions. If cool weather prevails, little ventilation will be necessary until danger of frost is past. Should the weather be mild before the last frost, make a slit with a sharp knife in the plant protector away from the windward side. This slit will reduce moisture condensation and inside temperature, and favor the growth of a more stocky plant. After danger of frost is past, enlarge the slit,

gradually exposing the plant to outside conditions. When weather becomes warm, remove the protector.

Cost of the plant protectors vary from 3 to 5 cents each, depending on the quantities purchased. Promising experimental results have been obtained at the Kentucky Agricultural Experiment Station with polyethylene film plant protectors. This material is obtained in rolls 3 feet wide and is used as a continuous cover over the entire length of the row. There is some indication that these film covers will be an even more effective protector against frost than Hotkaps or Hotents, although somewhat more expensive.

Cultivation

The main purpose of cultivation is to control weeds. Before the plant has become well established in the field (not later than 10 days after transplanting) one deep cultivation (3 to 4 inches) may be made to thoroughly loosen the soil surrounding the plant, but all subsequent cultivations should be shallow (not to exceed 1 to 2 inches) and no more frequent than is necessary to control the weeds. In the garden this would mean a deep hoeing soon after transplanting, then very shallow hoeings thereafter. A rake may also be used for all cultivations after the first, where one has only a few plants. For larger fields of market or canning tomatoes, tractor cultivation is almost a necessity. Sweep-type cultivators are much to be preferred to the shovel-type, because they do not go as deep in the soil and yet are very effective in controlling weeds. After tomato vines cover the ground, all cultivation should cease. Large weeds appearing after the last cultivation should be pulled or hoed out.

It cannot be too strongly emphasized that all cultivations after the first one should be shallow. Deep cultivations after the tomato plant is well established in the field will serve only to destroy that part of the root system in the upper, most fertile layers of the soil. This destruction decreases the uptake not only of essential fertilizer elements, but of water as well. Tomatoes cultivated too deeply will show drouth injury much sooner than those receiving shallow cultivation, and in addition, will likely have much more blossom-end rot. (See blossom-end rot under "Diseases.")

Irrigation and Mulching

Irrigation

Almost every year in Kentucky there is a water shortage during some part of the growing season, severe enough to reduce the growth and yield of tomatoes. Blossom-end rot and blossom-dropping may become much more serious during these periods. Prolonged drouth, followed by rains during ripening, greatly increases tomato cracking. Many of these adverse effects from drouth can be at least partly overcome by timely irrigation.

Irrigating systems to cover several acres of tomatoes are expensive to purchase, but increases in yields may be sufficient to pay for the system in two or three seasons, sometimes even in one. During a temporary drouth, it will probably pay the home gardener to soak the soil thoroughly around the tomato plants with a garden hose.

A few thorough soakings of the soil with water are more beneficial and more efficient than frequent light waterings. The rate and quantity of water applied in one irrigation should be equal to at least 1 inch of rainfall without run-off. Avoid irrigating during harvesting if possible, since it may increase fruit cracking. If necessary to irrigate during this period, apply water immediately after a picking. Avoid irrigating in the morning until foliage has dried from the dew, and stop irrigating in afternoon early enough to allow foliage to dry before nightfall. These precautions aid in preventing the spread of leaf diseases.

Mulching

When irrigation is not available, and the area planted to tomatoes is small, an application of a heavy mulch (4 to 6 inches deep) of straw, old hay, grass clippings, harwood sawdust, or similar materials, is very effective in conserving soil moisture. Apply mulch after the plants are at least 12 inches high. If leaves show any lightening of color after mulching, scatter a small handful of nitrate of soda (about 2 ounces) over the soil around each plant, being careful not to cover any of the leaves with the fertilizer. Somewhat cleaner fruit may be expected if they are protected from the soil by a clean mulch. If the mulching material

is free of weed seed, it will have the additional advantage of controlling weeds. When turning under mulch the next year, be sure to add extra nitrogen to bring about decay of this added material.

Pruning and Staking

If tomatoes are to be pruned, they must be staked. The usual practice is to prune the tomato plant to one stem and tie it to a stake. Pruning to one stem is accomplished by pinching out all shoots (suckers) which arise in the axils of the leaves. They should be pinched out while small (less than 4 to 5 inches long) to prevent stunting of the main plant. The stake (1 by 1 inch, or 1 by 2 inches) should be about 6 feet long and strong enough to support a full-sized vine. Drive the stake in at least 12 inches deep, 3 or 4 inches to the side of the entrance of the main stem into the soil. Loop a soft twine or piece of raffia over the stake and tie the ends in a loose knot around the main stem just below a large leaf stem. Tying the string in a tight knot will constrict the stem and interfere with the conduction of water and nutrients in the plant.

The principal advantages of pruning and staking tomato plants are: (1) more plants can be grown on a given area than where the plants grow free; (2) harvesting is easier; (3) fruits are kept cleaner and usually freer from "ground spots" and soil rot; (4) it is easier to obtain a complete coverage of foliage with sprays and dusts, and (5) there is less tendency for fruit to sunburn in hot weather.

There are some serious disadvantages: (1) Pruning and staking increase the cost of production, for they require extra labor, twine, and stakes, and more plants to produce a given yield; and (2) staked and pruned tomatoes often show more blossom-end rot and cracking than do free-growing tomatoes. In general, pruning and staking will be found profitable only by home gardeners with a very limited garden area, and by market gardeners when land values are very high or when they receive a special premium price for high quality, extra-early, field-grown tomatoes.

All-Purpose Dust for Diseases and Insects

The prospective tomato grower has by now put in much work towards producing his goal of 10 pounds of tomatoes per plant,

and it would seem only fair that picking would be the final step in the procedure. Unfortunately, both the home gardener and commercial grower must next reckon with the ever-present problems of diseases and insects if a successful harvest is to be assured.

Although diseases and insects generally require different materials for their control, an all-purpose dust is available to home gardeners. If applied at weekly intervals, it should give reasonably good control of most of the insects and the leaf diseases of tomatoes. This dust is composed of 3 percent methoxychlor, 5 percent malathion and 3.9 percent actual Zineb. Thorough coverage of the foliage with dust is very essential to obtaining an effective control of these pests.

The following detailed description of the more important diseases and insects of tomatoes and their control is given for the prospective commercial grower who probably will have to contend with these pests on a rather large scale.

Diseases

A great variety of tomato diseases and their control is described in "Tomato Diseases," Farmers' Bulletin No. 1934, U. S. Department of Agriculture. It may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price, 25 cents.

Probably the two most important diseases of tomatoes in Kentucky are early blight and late blight. Both of these diseases are caused by very small parasitic plants called fungi. While early blight causes serious losses in yields year after year, late blight occurs less frequently, being most prevalent during cool, moist seasons.

Early blight

Early blight is recognized within a few weeks after transplanting tomato plants by small, irregular, brown, dead spots on the lower, older leaves. The spots enlarge until they are ¼ to ½ inch in diameter; as they enlarge they commonly show ridged concentric rings in a "target" pattern (Fig. 4A). Eventually, these leaves turn yellow and drop off. This condition moves upward from the base of the plant as the season advances, and in

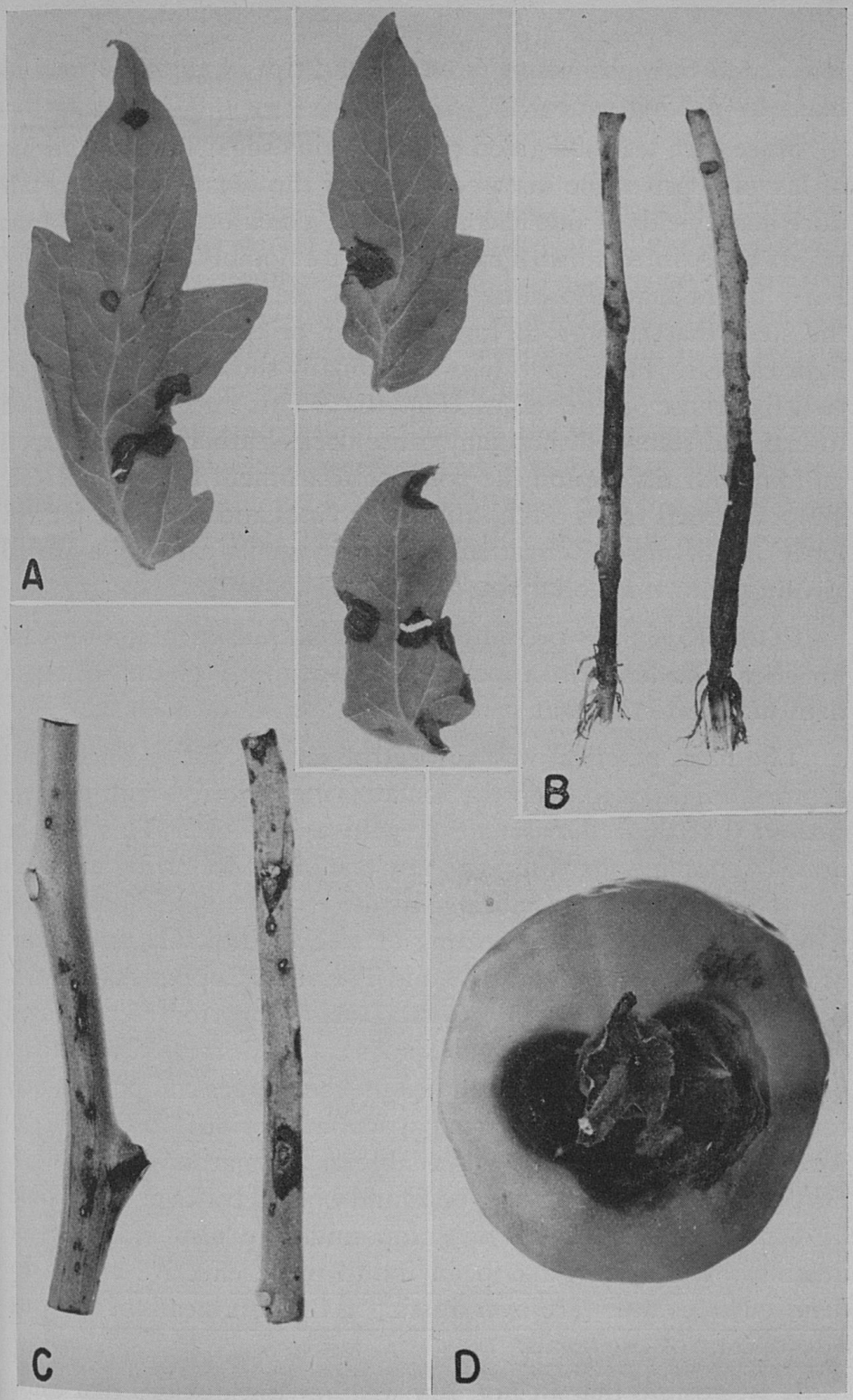

Fig. 4.— Early blight infection of tomato: *A*, characteristic target pattern on leaflets; *B*, seedling stems showing collar rot; *C*, older stems showing cankers; *D*, dark, sunken lesions around stem of tomato fruit.

some cases only the young leaves at the tips of the vine may remain by picking time.

Since each leaf of a green plant is a tiny sugar factory, this loss of leaves deprives the diseased plants of the sugar needed to produce good yields of fine-flavored fruit. Tomatoes harvested from plants badly infected with early blight are notably poor in quality. Early blight may also cause small dark, slightly sunken areas on the stem that enlarge to form circular or elongated spots with light centers. These spots also occasionally show the "target" pattern like those on the leaves (Fig. 4C). This disease, in addition to leaf and stem spotting, may cause dark, leathery, sunken spots on tomato fruits around the point of attachment to the stem (Fig 4D). Diseased fruits often fall off the vines and are unfit for use. Early blight also often attacks seedling stems causing a partial girdling known as collar rot (Fig. 4B).

CONTROL: At present, there are no known blight-resistant varieties. Garden State appears somewhat more tolerant of blight than most varieties, but it is not blight-resistant.

The most practical way to control early and late blights and Septoria blight is to keep the tomato vines covered with a fungicide so that these diseases never gain a foothold. This may be done by spraying the vines with any one of the following materials two to three weeks after the plants are set in the field (sooner, if weather is moist) and repeating at weekly intervals until frost: Manzate, Zineb (Dithane Z-78 and Parzate), Copper A, C-O-C-S, or any other of the fixed coppers. During a period of prolonged dry weather, the time between sprays can be increased to 10 days or 2 weeks. Under certain conditions, the copper compounds may cause some injury, though not particularly serious, to the foliage. These materials are usually available at any garden-supply store. Directions for their use may be found on the package and should be carefully followed. The compounds are also available for dusting, but spraying has been found more effective and is definitely recommended over dusting as the best means of applying disease-control chemicals.

It is possible that in hot, dry weather the diseases that cause spotting or loss of leaves may not become serious, even without

spraying with a fungicide, but disease prevention by spraying or dusting is certainly an excellent form of insurance.

Late blight

Late blight is a spectacularly destructive disease of tomatoes. It is caused by the same fungus that causes late blight of potatoes. Some growers have suffered a complete loss of their crop from this disease. Cool (below 60°F), moist weather, occurring in late summer or early fall, creates very favorable conditions for the infection and rapid spread of tomato late blight.

The first symptoms usually show on the lower, heavily shaded leaves as greenish-black, water-soaked patches (Fig. 5A). These patches enlarge rapidly; soon they become dark brown and the affected leaves wither. In damp weather the dark patches often

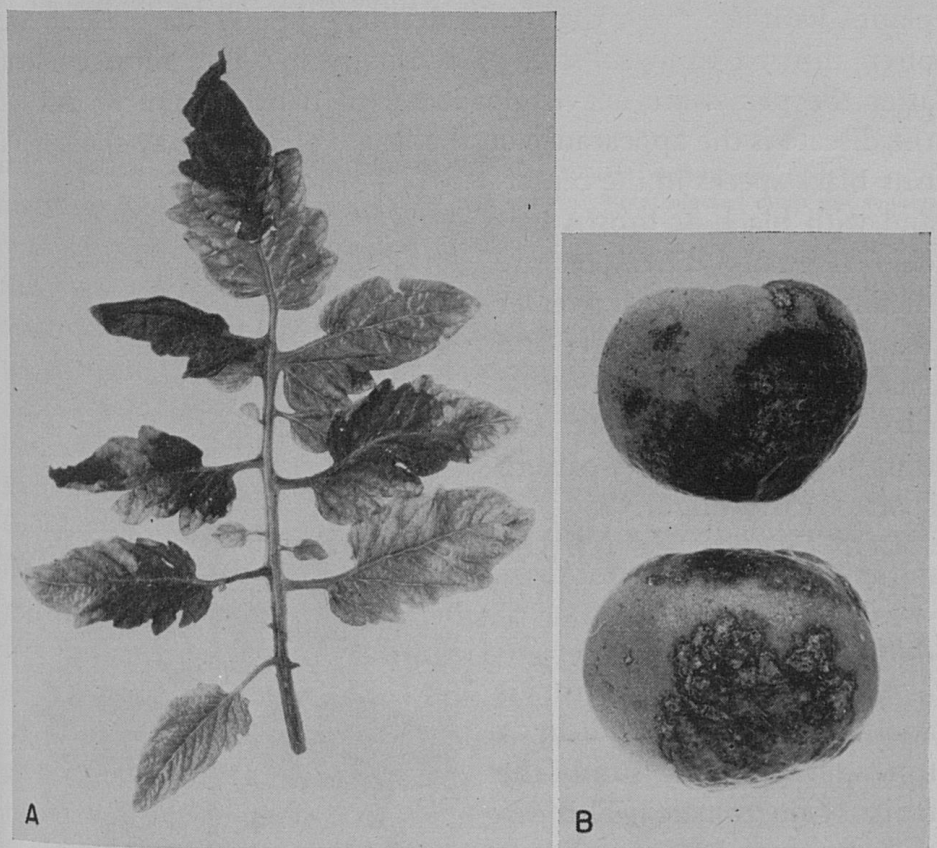

Fig. 5.— Symptoms of late blight on tomato leaf and fruit: A, tomato leaf showing greenish-black infected areas which appear water-soaked; B, infected blotches on fruit are dark brown with a leathery appearance.

have a white fungus growth on their undersides. Its presence will help to distinguish late blight from other leaf spots of tomatoes. As the disease becomes more severe, fruits usually show water-soaked patches, which eventually turn from brown to black, and the fruit finally rots (Fig. 5B). Under conditions ideal for this disease, plants can be destroyed in a few days. Once late blight has attacked the tomatoes, it is practically useless to start spraying to control this disease. Prevention rather than cure is the means of control.

CONTROL: See under Early blight.

Septoria leaf spot

Septoria leaf spot (or Septoria blight) also occurs in Kentucky, but not so frequently as early blight. However, in seasons when temperatures are moderate and showers are frequent, this leaf disease may become so serious as to completely defoliate plants, with the result that fruits do not properly mature and are often injured from sunscald. It usually becomes most evident after the plants are heavily loaded with fruit. Characteristic of the disease is the appearance on the leaves of small gray spots with tiny black specks in the center, and with black or brown borders (Fig. 6). The spots are smaller (usually not greater than 1/8 inch in diameter) and more numerous than those of early blight. (Note the contrast with the target-pattern spots of early blight.)

CONTROL: See under Early blight.

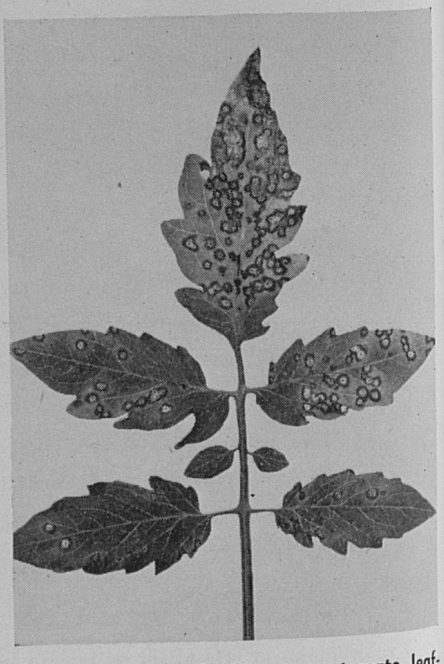

Fig. 6.— Septoria leaf spot on tomato leaflets, showing characteristic tiny black specks in center of gray spots.

Anthracnose

Anthracnose, or ripe-rot, is another disease caused by a fungus which attacks only the fruits of the tomato. This disease does not become evident until fruits are nearly ripe or ripe. It then appears as

numerous small, slightly sunken, circular, water-soaked spots which enlarge rapidly in warm weather. The center of each spot becomes darkened and may turn pink in moist weather. Generally, these spots show a marking of concentric rings, or a "target" pattern (Fig. 7). Fruits affected by this disease are unfit for use. Anthracnose is most serious on poorly drained and infertile soils. Zineb and Manzate sprays and dusts mentioned for the control of blights are fairly effective for controlling this disease.

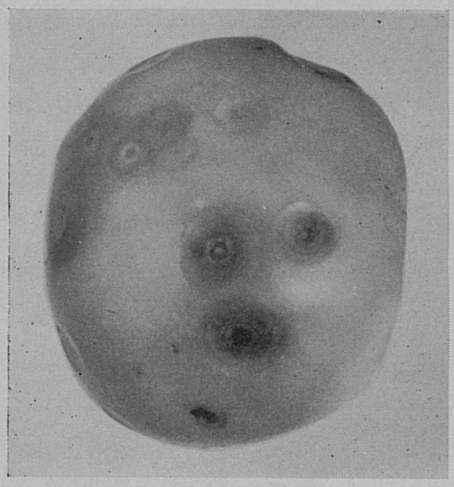

Fig. 7.— Typical anthracnose spotting on a ripe tomato. Note infected areas are sunken and show a target pattern.

Fusarium wilt

Fusarium wilt probably is not as widespread in Kentucky as in states farther south, but it may be found in many areas of the state, especially in gardens which have been in use many years. This is a fungus disease which enters the roots of tomato plants from the soil and develops in the conducting tissues, causing wilting and death of the plant. First symptoms of the disease are the yellowing of a single leaf, or a slight wilting and drooping of the lower leaves on only one side of the main stem. The yellowed leaves gradually wilt and die and, as the disease spreads the yellowing and wilting progress up the stem until the whole plant finally dies. Some growers refer to this disease as "tomato yellows" because of the characteristic yellowing of infected plants. Usually, plants infected with fusarium wilt do not show symptoms of wilting until the beginning of fruit setting. If an infected leaf stem, or the main stem near the soil line, is cut lengthwise, the presence of a dark brown discoloration of the woody tissues next to the green outer covering of the stem (cortex) almost certainly confirms that the disease is fusarium wilt (Fig. 8). Infection of tomato plants by this wilt is generally not serious unless soil and air temperatures are high due to prolonged periods of hot weather.

Do not confuse this disease with the wilt of tomatoes which occurs when their roots come in contact with the roots of black walnut trees, or with the diseases, early, late, and Septoria blights.

Once the soil becomes infected with the fusarium wilt fungus, it lasts for many years. Probably the most satisfactory control of this disease is to grow the varieties Rutgers or Pritchard, or one of the new, highly-wilt resistant varieties, such as Pan American, Jefferson, and Kopiah.

Fig. 8.— Split stems of tomato plants showing typical discoloration of conducting tissues resulting from infection by fusarium wilt.

Damping-off

Damping-off is a serious disease of tomato seedlings. There are two types: pre-emergence and post-emergence. The former type either causes the seed to rot in the soil or destroys the seedling before it comes up. This type is very common and frequently is the cause of poor stands.

Post-emergence type of damping-off occurs after the seedlings have come up but are still small and tender. Affected seedlings show a decay at the soil line which entirely girdles the stem. These

stems shrivel and the seedling falls over and dies. This type of injury is generally associated with the term "damping-off."

Damping-off is generally most severe during cloudy, damp weather, or if seedlings are over-watered or crowded. Steam and chemical sterilization will rid the soil of these organisms, but recontamination can occur. Probably the most practical control is to treat seed with Cuprocide, to water only on bright days, and to ventilate seedlings during periods of high humidity. These precautions have all been described under, "To Grow or Buy Plants." Should post-emergence damping-off occur, allow the flats to become dry enough to cause wilting of the seedlings during the middle of the day. When watering thereafter, add thiram (Arasan, etc.) to the water, according to the instructions on the package, and sprinkle seedlings lightly.

Blossom-end rot

Blossom-end rot has been previously mentioned as a physiological disease. This is a non-parasitic disease which is generally believed due to certain conditions not favorable to normal growth of the plant. It occurs most commonly when plants have grown under favorable conditions during the early part of the season, and are then subject to a long drouth at the time the first fruits are developing. There is also evidence that it is associated with a deficiency of calcium (lime).

This disorder is recognized by a small brownish spot occurring around the blossom scar of the tomato fruit. In some cases, this spot may at first have the appearance of human skin which has received a superficial burn from a hot iron. Later, the spot turns brown, then finally black, and the tissues underneath become sunken (Fig. 9). Other disease organisms then enter, and the whole end be-

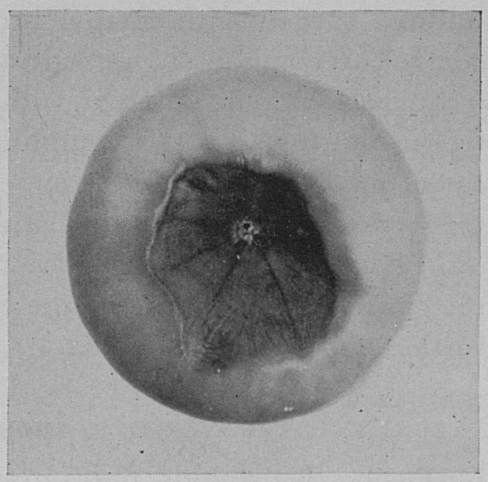

Fig. 9.— Blossom-end rot of tomato.

gins to decay. Generally, even fruits only slightly affected have a bitter taste and are unfit to eat. During a severe drouth, it is not uncommon to find a majority of the fruits affected.

Any cultural practice that helps to conserve soil moisture and promotes the growth of a large root system aids in the control of blossom-end rot. The maintenance of soil-organic matter, proper fertilization, shallow cultivation, and mulching or irrigation are all effective in reducing blossom-end rot.

Nematodes (eelworms)

Nematodes of several different forms attack tomato roots, but the root-knot nematode seems to cause the most damage. This parasite is a true worm of microscopic size, which causes the formation of galls, knots, or swellings on the roots of plants which they attack. As a result, affected plants make poor growth and become stunted; often the foliage turns yellow. If the root-knot nematode is suspected of causing poor growth of a plant, pull it up by the roots; the presence of swellings or knots on the roots indicates nematodes. If swellings or knots are completely absent, the poor growth is probably due to some disease or a fertility factor.

The root-knot nematode does not appear widespread in the open field in Kentucky, except in some gardens which have been in use many years. Probably the simplest control in this case is to change the garden to some other location. Fumigating the infested garden with methyl bromide would also give effective control. Greenhouses, hotbeds and old seedbeds, however, may frequently become infested with the root-knot nematode. Control in this case is best accomplished by sterilizing the soil as outlined under Step 2, "To Grow or to Buy Plants." If shipped-in plants are used, discard all plants showing any swellings or galls on the roots. If only an occasional affected plant is observed in the garden or field, pull up the entire plant and burn to prevent further spread of nematodes.

Insects

Fleabeetles, aphids, mites, tomato fruitworm (corn earworm) and hornworms (tobacco worms) are the insects which will be

most commonly encountered in growing tomatoes in Kentucky. (See also Kentucky Extension Circular 479.)

Fleabeetles

After tomatoes are transplanted, they are usually attacked by tiny, black, fleabeetles which literally "pepper" the leaves with holes and, as a result, the leaves often become pale or yellow and may drop off. Little significance has been attached to this injury in the past, but it is now known that it stunts the plant, delays maturity and may seriously decrease yields.

Fleabeetles can be controlled by dusting plants with a 5-percent dust of methoxychlor (or Marlate) immediately after transplanting, or dusting plants in the seedbed just before transplanting. These dustings should be repeated once or twice at one-week intervals. Once the young transplant is well established and starts rapid growth, little further trouble may be expected from this insect.

Aphids (plant lice)

Aphids are small, soft-bodied insects which may be green, pink, or brownish in color. They feed on the underside of tomato leaves and often are not noticed until the margins of the leaves start curling downward. Unless control measures are used promptly, the plant may become greatly stunted and the yield much reduced.

One part of 40-percent nicotine sulphate to 500 parts water, plus laundry soap (½ tablespoon per gallon of water plus a 1-inch cube of soap) makes a spray that is fairly effective in controlling this insect. Direct the spray against the undersides of the leaves on a warm day (above 70°F). More effective controls are a 1-percent dust of parathion or a 5-percent dust of malathion. For larger fields, sprays of these materials may be used: 1 pound of parathion, 15-percent wettable powder, per 100 gallons of water. Malathion is a relatively safe material to handle, but parathion must be considered as a DEADLY POISON. When applying, observe the directions on the label. Do not apply parathion within 14 days, or malathion within 7 days, of harvest.

Mites

Mites, or more properly, the two-spotted spider mite, have become a serious menace to many fruit and vegetable crops, including tomatoes, in recent years. (This parasite is not a true insect since it belongs to the spider family.) Mites are extremely hard to detect on the underside of tomato leaves except under a magnifying glass. However, the leaf injury produced by them is fairly easy to identify. Areas between the veins show a gradual loss of green color with some yellowing or "bronzing" of the leaves. To control mites, use either dusts or sprays of malathion or parathion, as recommended above for the control of aphids.

Tomato hornworms

Tomato hornworm or tobacco worm is probably the best known of the tomato insects. When fully grown, it is 3 to 4 inches long and usually green, although it may also be brownish. Along the sides of the body, are very pronounced white, diagonal stripes, with a prominent, sharply-pointed horn at the rear end of the body. This insect can be controlled by a 1-percent dust of parathion. Parathion may also be added to the regular fungicide sprays at the rate of 1 pound of 15-percent wettable powder per 100 gallons of spray solution. Don't spray or dust with parathion within 14 days of harvest. TDE may be used as on tobacco: 2 quarts of 25-percent emulsion concentrate per 100 gallons of water per acre. Do not use TDE within 30 days of harvest.

Tomato fruit worm

Tomato fruit worm is generally the ordinary corn earworm which feeds mainly on tomato fruit, attacking all sizes (Fig. 10). There is a considerable variation in the color of the corn earworm, from

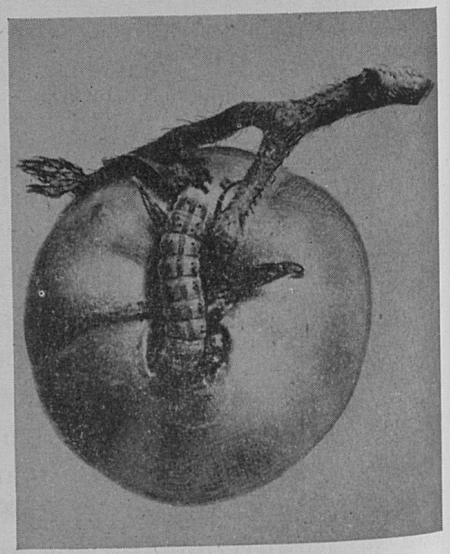

Fig. 10.— Tomato fruit worm (corn ear worm) feeding on a green tomato fruit.

flesh pink to green or dark brown, with darker stripes running in parallel bands the length of the body. Fully-mature worms are usually about 1½ inches long. A 1-percent dust of parathion may be used up to 14 days before harvest; thereafter, a dust of 5-percent Methoxychlor (relatively nontoxic to man) should be used. If sprays of these materials are desired, use either 1 pound of parathion, 15-percent wettable powder, or 2 pounds of methoxychlor, 50-percent wettable powder per 100 gallons of water.

Colorado potato beetles

Colorado potato beetles will occasionally feed on tomato foliage to the extent of literally stripping the plant of all its leaves. The adult beetle is approximately ⅜-inch long, oval, hard-shelled, with alternate black and yellow stripes. The young are red, soft-bodied grubs which have two rows of black spots on each side of the body. A 1-percent dust of parathion or 3 percent purified DDT will control these beetles.

Blister beetles

Blister beetles may literally strip the entire foliage of tomatoes in some areas in Kentucky. They have elongated bodies, usually gray to black. Some may be striped or spotted. Control is the same as for the Colorado potato beetle.

Blossom-Dropping

One of the most commonly reported troubles in tomato growing is blossom-dropping or failure of blossom clusters to set fruit. A number of different factors may be the cause, but extremes in temperature are probably the most important factor.

Low temperature

Early, spring-planted tomatoes generally start blossoming sometime in May, depending on size of plants and time when transplanted to the field. When night temperatures range below 59 degrees Fahrenheit at the time of this early blossoming, the first one or two clusters generally fail to set fruit. Hormone sprays have been found effective in improving fruit setting if applied when these cool temperatures prevail. There are several com-

mercial hormones, such as Tomato Tone and Sure Set, which contain the chemical para-chloro-phenoxyacetic acid, and Blossom Set which contains beta-napthoxyacetic acid. These materials are all highly concentrated plant-growth regulators, which must be diluted before using. Directions for using these hormones are given on the package and should be carefully followed. These sprays should be directed at the open blossoms because they may cause leaf abnormalities such as curling if sprayed on the foliage. Such effects seem to be less severe from beta-napthoxyacetic acid than from para-chlorophenoxyacetic when sprayed on the foliage.

High temperature

High temperatures, especially a hot, drying wind, will often cause blossom-dropping of later maturing tomatoes. If practices have been followed to encourage the growth of an extensive root system and the conserving of soil moisture, such as maintaining plenty of organic matter, proper fertilization, light cultivations, and irrigating or mulching where possible, blossom-dropping from hot, drying winds should be less severe. Completely normal fruit setting, however, will not occur until temperatures return to normal.

Variety

Certain large-fruited varieties, such as Ponderosa and Winsall, appear much more susceptible to blossom-dropping than most other varieties, especially if hot, drying winds prevail.

Nutrition or fertility levels

The unfavorable effects of too much nitrogen on maturity and yield have been explained in foregoing sections where the use of manure and commercial fertilizer were discussed. Should the effects of too much nitrogen be noted, remember that additional phosphate must be applied (as recommended under "Commercial Fertilizer") at blossom time to balance the nitrogen; otherwise, a delay in maturity and a reduction in yield will result.

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