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TOMATO PRODUCTION IN KANSAS

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TOMATO PRODUCTION IN KANSAS[1]

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INTRODUCTION

The tomato is one of the more popular and important vegetable crops grown in the home and truck gardens of Kansas. It is used in an almost unlimited number of combinations in cooking, salads, relishes, desserts, and drinks. Tomato juice is highly regarded for its mineral and vitamin C content and is used extensively in children's and adults' diets.

The value of the tomato crop is exceeded only by the potato and sweet potato which are generally considered field crops and not commonly recommended for the smaller home gardens. Potatoes and sweet potatoes are grown commercially in large acreages to a much greater extent than are tomatoes. Tomatoes in Kansas are grown primarily for local trade and home use. Tomatoes are recommended as a major crop in all gardens of the farm, suburban areas, and cities.

There are a few major problems in the growing of tomatoes which threaten their production in Kansas, the most important of which is the production of strong vigorous plants which fail to set fruit. This is commonly referred to as "blossom drop".

A second problem is the production of fruits free of injury. Sunscald during July and August, when temperatures are high with a prevailing southwest wind and a low rainfall frequently, causes heavy losses. Varieties which carry their fruit well under the foliage suffer heavy losses during periods of wet weather as the fruits commonly come in contact with the soil under such conditions.

Other problems arise due to the presence of injurious insects and diseases which cause a loss of foliage or weaken plant growth to a dangerous extent.

Still other problems are created by the type of plant set, especially the age of plant set and the weather conditions under which plants are set. The tomato is a warm weather plant which fails to set fruit in cool and damp weather so common in late April and during May.

An understanding of the climatic factors as affecting growth of the plants, cultural requirements of the crop and selection of varieties should aid greatly in the production of tomatoes under adverse conditions.

CLIMATIC FACTORS AFFECTING TOMATO CULTURE

The tomato is a tender, short-lived perennial of tropical American origin. In Kansas gardens, however, it is treated as an annual. The tomato requires warm weather and ample sun-

[1] Contribution No. 193, Department of Horticulture.

shine for its best development. A medium amount of rainfall well distributed throughout the growing season is essential for high yields and a frost free period of 120 to 160 days is favorable to low cost production.

In the Great Plains region rainfall and drought periods, wind, temperature, and humidity are major climatic factors affecting tomato production.

In Kansas, first attention is directed toward the protection of the crop in drought conditions. High temperatures and strong winds frequently accompany a drought period causing severe tomato losses. The market gardener has defined a drought period as the occurrence of a period of ten consecutive days or more without one-fourth inch of rainfall in 24 hours in April and May or one-half inch in 24 hours during the balance of the growing season; the tenth day would be considered without effective moisture and would be the start of a drought period, the eleventh day would be the second day of a drought period, etc. Experience has shown that, under average conditions, well cared for crops need rain at ten-day intervals. When temperatures become high and humidity low a larger amount is required.

Since 120 to 160 days, depending upon the variety, are required to grow a crop of tomatoes in the field to a complete harvest, several methods are used in an attempt to reduce the loss due to adverse conditions. The plant breeder is working for an adapted variety, the home gardener uses windbreaks and irrigation and practices early planting in the spring.

Rainfall and Drought Periods. —Kansas soils generally are well supplied with available moisture during the spring of the year; however, moisture may not be stored deeply in the subsoil. Conditions are favorable for vigorous plant growth so long as rainfall is frequent enough and sufficient to prevent drought periods. In drought years, the rainfall usually is below normal, temperatures are high, wind is stronger than normal and humidity is low. The average number of days without effective moisture from April 1 to October 1, during the 20-year period, 1914 to 1934, is shown in Fig. 1. Eastern Kansas has, on an average, 55 to 65 days without effective moisture while western Kansas has 95 to 103 days out of a total of 183 considered in the growing season April 1 to October 1. Plants with the moisture requirement of the tomato need protection when one-third to more than one-half of the days of the growing season are without effective moisture. Means of conserving moisture, wind protection, use of irrigation and selection of varieties are important considerations in successful tomato culture under such adverse conditions.

In eastern Kansas, a period of 33 to 38 consecutive days without effective rainfall may be expected, in central Kansas 38 to 44 days and in western Kansas 44 to 54 days. During these pe-

riods few, if any, fruit will set unless additional water is added and the plants protected from other elements mentioned above.

When the drought picture for the state is superimposed upon that of the annual rainfall, the seriousness of the problem becomes more clear. Southeastern Kansas, with an annual rainfall of 40 inches. has a better possibility of growing tomatoes

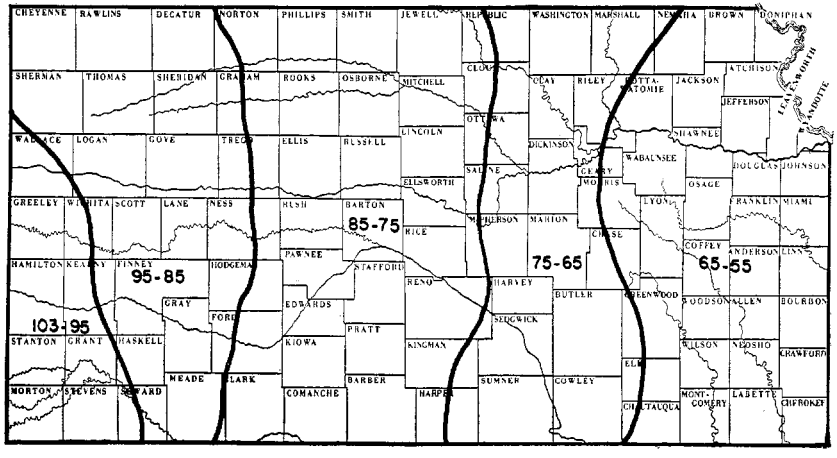

Fig. 1. Average number of days without effective moisture in Kansas during the 183-day period, April to September inclusive, for the period of 1914 to 1933, inclusive.

than western Kansas with an annual rainfall of 18 inches. Tomatoes of the market garden varieties can be grown with fairly good success in eastern Kansas where the annual rainfall is 30 inches or more. Special home garden varieties have been developed which aid greatly in the culture of tomatoes for the balance of the state.

Wind. —The effect of wind on plants is both physical and physiological. Storms and strong winds which tumble the vines and break the branches are familiar examples of the physical effect of wind, and this factor is frequently more important than is generally believed as the tomato roots freely from the stems which come in contact with the soil. Diseases may gain entrance through the wounds and greatly reduce productivity of the plant, often causing early death.

The tomato flower is self-pollinated and wind is a favorable factor in pollination. The blossom which develops normally has stamens arranged about the pistil which are slightly longer than the pistil. The pollen borne upon the stamens ripens and is shaken loose into the air by the wind. The pollen is light and tends to float in the air about the pistil, some alighting upon the terminal end.

The physiological effect of wind consists almost entirely in

increasing transpiration, that is, the rate at which plants give off moisture. This may be serious, especially when rainfall is a limiting factor. The importance of wind in increasing transpiration becomes greater as the temperature increases and humidity decreases. The southwest wind so common in Kansas during July and August is especially severe on exposed tomato plants resulting in poor set of fruits, often leading to severe wilting of the plants, and sun burning of the fruits already set, Wind movement in eastern Kansas does not differ greatly from that of more eastern states, but it is noticeably higher for the western two-thirds. The air movement is generally greater during the early spring months, April and May, than during the balance of the growing season.

When air movement is considered along with annual rainfall, the western two-thirds of Kansas might well be the more difficult part in which to grow tomatoes: at least the data indicate the importance of windbreaks for this area.

Temperature. — Tomatoes do best at monthly mean temperatures of 70 to 75° F. while a mean temperature of 80° F. or above becomes a limiting factor. Under Kansas conditions the high daily maximum temperatures and the low humidity frequently damage the flowers, keeping the plants barren for weeks at a time. The newer varieties recommended for western Kansas show more tolerance to high temperature and low humidity than the popular market garden varieties of eastern Kansas.

Mean temperatures of 80° F. or above prevent desirable color development in the ripened fruits of varieties commonly grown commercially.

Relative Humidity. — The moisture of the air which is in the form of vapor is termed humidity. Relative humidity is the ratio, expressed as a percentage, of the water vapor present in the air (unit of space) at a certain temperature and pressure to the amount necessary to saturate the same unit of space under those conditions. The lower the relative humidity, the more rapidly the air will take up water from the transpiring leaf or from a moist surface. Moisture of the air thus becomes one of the chief factors influencing plants by its direct effect upon the rate of transpiration.

Humidity is affected by temperature, wind, altitude, and exposure. A high temperature increases the capacity of the air for moisture and consequently lowers the relative humidity or additional moisture must be supplied by plants, soil, etc. Air completely saturated at 80° F. will carry about twice as much moisture as air at 60° F.

The relative humidity falls during the day as the temperature increases and rises in the evening as the air becomes cooler. Each change of 1° F. in temperature usually produces a corresponding variation, but in the opposite direction of 1.5 to 2 percent relative humidity. The air may become saturated and

moisture may be precipitated out as dew even during dry weather if the night temperatures are sufficiently low.

A dry wind has a great effect upon plants by removing the moist air from around the plants and mixing it with dry air, keeping the relative humidity near the leaves low thus promoting transpiration. The position of sloping ground with respect to the sun and wind affects humidity. Slopes longest exposed to the sun's rays receive the most heat; consequently, air over south slopes regularly shows a lower humidity than over north slopes. The effect of wind is most pronounced upon those slopes exposed to prevailing dry winds, thus a south or southwest slope is to be avoided for tomato culture. A valley protected by a hill to the south and west with a tree growth on the top of the hill which lifts the prevailing wind up over the valley makes an ideal location for tomatoes, all other factors being favorable.

CULTURAL PRACTICES

Soils Adapted to Tomato Growing. —The tomato is among the least exacting of the vegetable crops as to soil type and is comparatively tolerant of soil reaction. The extensive and vigorous root system and its thorough occupancy of a large volume of soil helps to explain why tomatoes are successfully grown on a wide variety of soils. The essential requirements of a soil are that it be well drained and yet capable of retaining moisture, making sandy and clay soils least desirable under Kansas conditions.

Attention is here directed to the relation of the roots to soil from the standpoint of plant nutrients, water and air relations. In areas of deficient rainfall major consideration is given to retaining soil moisture without interfering with aeration.

A soil well supplied with humus, having a fairly open structure, moderately rich in nutrients, well drained, which warms readily and yet retains sufficient water to insure against severe injury during drought, would seem ideal for the best root development.

The setting of tomato fruits is relatively sensitive to the ratio of the nitrogen supply to the phosphorous supply. In areas of high annual rainfall and where tile drainage is beneficial or the subsoil is open, permitting subsoil drainage, manure can be applied liberally. Under Kansas conditions where leaching of the subsoil is uncommon, liberal use of manure is likely to cause an accumulation of available nitrates which will prove injurious to tomato production. For this reason frequent heavy applications of manure to garden soil are not recommended for tomatoes in Kansas.

Use of Phosphate Fertilizers. — Phosphorus is especially important for both earliness and large yields. This element is deficient in most Kansas soils and is relatively ineffective when

applied as a top-dressing because it penetrates slowly. In the garden an application of 400 to 500 pounds of 16 to 20 percent superphosphate per acre or 200 pounds of treble superphosphate may be broadcast and plowed under and will be sufficient for three or more years. Smaller amounts, 60 to 100 pounds of treble superphosphate, may be mixed with the soil at the time of transplanting. In some cases one pound of treble superphosphate dissolved in five gallons of water is applied at a rate of ½ pint to the plants at the time they are set into the field. Phosphorus is not readily leached from the soil and plants are not easily injured by a liberal application of phosphorus, therefore large applications are frequently applied. That portion not used by the growing crop remains in the soil for succeeding crops. Phosphorus has a beneficial effect upon the root system as well as checking vegetative growth and hastening fruiting. Phosphorus, therefore, tends to overcome the injurious effect of a liberal supply of nitrogen.

Nitrogenous Fertilizers. — Tomato plants respond quickly and profitably to a proper use of fertilizers. Nitrogenous fertilizers should be used sparingly because tomato plants growing in a soil high in nitrogen may be affected adversely if the first flower cluster fails to set fruit.

Soil Preparation. — No amount of food nutrients will compensate for a soil in poor physical condition due to a lack of humus or poor preparation of the soil. Getting the soil in excellent condition before transplanting greatly insures the prompt reestablishment of the plant and less disturbance of the root system during later cultivation. Well tilled soils are more retentive of water than those in poor physical condition.

Deep plowing aids in securing a more deeply penetrating root system which assures the plants of a more adequate moisture supply. Under irrigation, deeply rooted plants require less frequent watering and suffer less from sharp fluctuations of alternately having too little and too much water.

It is believed that poorly developed or shallow root systems are responsible for many troubles which express themselves as physiological diseases, such as blossom-end rot, the loss of foliage because of deficient moisture, or blossom drop. These ailments are due to improper conditions for growth and not to disease organisms.

A typical tomato root system is composed of 15 to 20 strong growing horizontal roots with many short laterals. The strong growing horizontal root may extend three feet outward and then turn downward. Many of the horizontal roots are within six inches of the surface of the soil. Deep cultivation may destroy one-half of the root system. Cultivation serves two purposes, to keep weeds under control and to keep the soil retentive of moisture. Soils that have been properly prepared can be kept

in good tilth by shallow cultivation which will not interfere with tomato root development while deep cultivation may cause much damage.

Mulching Tomatoes. —Mulching of tomatoes is frequently practiced to conserve moisture and to keep the fruit from coming in contact with the ground. In general it is not advisable to mulch tomatoes unless irrigation is available. Mulch should not be applied until the root system has developed deeply and the mulch applied should not be one which will require large amounts of soil nitrogen to break it down.

It is important for tomato production that the soil be well prepared, high in organic matter, retentive of moisture, liberally supplied with phosphorus and not too liberally supplied with nitrogen.

SELECTION OF A GARDEN SITE

The selection of a suitable site is one of the most important factors in successful tomato production in Kansas. The ideal location is a fertile, well drained soil located in a valley with a hill to the south and west upon which trees are growing causing the southwest winds to be forced up and over the site and ample water for irrigation. Few farm families are so located that such a site is available, therefore artificial protection must be resorted to. In the selection of a site more importance should be given to protection from wind than to irrigation, however a combination of the two is to be much desired.

Windbreaks.—In so far as possible every garden site should take advantage of natural windbreaks, in other cases mature tree plantings may serve to give the needed protection. Frequently, however, it will be necessary to construct temporary windbreaks. One of the requirements of a good windbreak is that some air filter through the structure so as to serve as a buffer and prevent rapid return of the air to the ground after passing over the barrier. Solid board fences have been found unsatisfactory because the air quickly returns to the ground.

Where the area is not a limiting factor, "strip cropping" may be a convenient answer for a windbreak. Here tall-growing crops are planted to the south of low-growing crops. A few rows of corn, then tomatoes, then more corn followed by more tomatoes is one "strip cropping" arrangement that may be used. Castor beans, sorghums or similar crops may replace corn.

Fences of various kinds may serve as windbreaks. Snow fencing, burlap covered fences, bundles of corn or sorghum stover set against a fence or Russian thistles stacked between two fences have proved satisfactory. They have the advantage of not competing with the tomato plants for soil moisture and

they require little space. Such windbreaks are recommended where space is at a premium. The fences or windbreaks should be four to five feet in height.

A tall crop such as corn may be planted to the south and west of the tomato field and then corn planted throughout the tomato field to provide protection by checking wind movement and to provide shade. About one-third of the area planted to corn is recommended.

Tomatoes for table use should be grown near the house but for canning purposes they may be planted in a corn field where it is possible to obtain wind protection from all directions and where they can be cared for with the minimum of labor. There is also a possible wider selection of soils.

Some growers complain about damage from corn ear worm in tomato fruits when corn, especially sweet corn, is grown with tomatoes. For means of control see Fruit Worm, page 29.

Further details on establishment of windbreaks may be obtained from Kansas State College Extension Service Circular 140.

IRRIGATION

The amount of rainfall and number of drought periods, together with their various lengths during the growing seasons, are of prime importance when determining the need for irrigation. In eastern Kansas, with 55 to 65 days without effective moisture, five or six irrigations would be required. Western Kansas, with 95 to 103 days without effective moisture, would need nine or 10 irrigations.

The users of irrigation are much concerned as to the efficiency of water application. The quantity of water available for garden irrigation is often limited and pumping and distributing costs appear prohibitive.

The home gardener who is considering irrigation should explore the possibilities of three methods of applying water; surface irrigation, subsurface irrigation, and overhead. Surface irrigation may consist either of flooding the area or opening furrows through which water is carried across the garden at frequent intervals. Subsurface or subirrigation consists of laying lines of porous tile across the garden below plow level at intervals of three to four feet.

Surface and subsurface irrigation do not require that the water be under pressure. These types are not well adapted to areas with an open subsoil. The garden area for both surface and subsurface irrigation needs to be nearly level. A slope of more than six inches to 100 feet is objectionable. In surface irrigation the surface must have a uniform slope since high and low spots will cause irregular application of water. Some method of storing water or a pump of large capacity is desirable.

Overhead irrigation consists of placing water under pressure and applying it as a spray to the area to be irrigated. There

are many systems available. The water used in such systems must be free from sand and dirt particles and be placed under pressure of 15 to 30 pounds per square inch. Comparatively few farms have water under pressure so that the system has limited use. This method of irrigation is well adapted to a wide variety of soils and the garden area need not be level.

More complete information on garden irrigation is available in publications prepared by the Division of Extension, Kansas State College.

SELECTION OF VARIETIES

It is desirable that two or more varieties of tomatoes be grown. One variety may be superior under normal conditions for a locality. Occasionally abnormal climatic conditions for tomato culture are experienced and it is suggested that a variety be included which does well in the off-season years.

Tomato plants are of three distinct types of growth designated as determinate, semi-determinate and terminal growing varieties.

Plants described as determinate or self-pruning are of recent origin among the recommended varieties (Fig. 3). The plants are of short, bushy habit, of weak vegetative growth, produce flowers freely and set fruit under adverse conditions. The leaves are small, giving little protection to the fruits. The varieties are generally early and the cropping season is short. The fruits of some varieties are small, of other varieties rough and of others the fruits ripen poorly. Such varieties leave much to be desired from the standpoint of the commercial crop, yet they have extended the area of tomato production. Bison is a determinate variety recommended for the western two-thirds of Kansas.

During recent years varieties intermediate between the strong terminal habit and the determinate habit have been introduced and are commonly referred to as semi-determinate. They produce plants of good size yet there are no strong terminal growing shoots. Semi-determinate varieties, as a rule, are intermediate between the determinate and terminal varieties in ability to set fruit under adverse conditions.

Terminal growing varieties produce strong vegetative branches. When grown on fertile soil and when conditions are unfavorable to fruit setting on the first flower cluster the plant may become so strongly vegetative that few fruits are set though flowers are freely produced.

Some terminal growing varieties produce large fleshy leaves while others have much smaller leaves. Among the small leaved varieties are found those which are early and which set fruit most freely, as Earliana.

Kansas gardeners may improve tomatoes for their own sites through selection. Through study of individual plants one may

find a plant that is superior to all others in earliness, in setting fruit freely, in foliage that provides shade for the fruit, in holding the fruit off the ground, in that the center of the plant remains closed providing protection for the early set fruits. A superior plant is worthy of special attention and seed from it should be saved.

Fruits saved for seed should be allowed to develop to full ripeness upon the vine. Remove the seed from the fruits, add a little water to the seed and allow to ferment for two to four days. Then wash the pulp from the seed and dry, stirring occasionally while drying so seeds do not dry together. Seed allowed to ferment for too long a time becomes dark in color and may be injured.

VARIETIES FOR EASTERN KANSAS

Rutgers, developed at the New Jersey Agricultural Experiment Station, is a cross between Marglobe and J. T. D. It requires about the same length season as Marglobe. The plant is medium large with a spreading upright habit, of the semi-determinate type, but does not set fruit as freely as is desired under many Kansas conditions. Foliage is abundant, tending to be coarse and is dark green in color. The fruit is medium large, borne in clusters of three to six. The fruit is slightly flattened and rich red throughout. The fruits may produce deep radial cracks. The outer wall and partition wall are thick and the central mass is fleshy and firm. Plants are wilt resistant.

Stokesdale was introduced by Francis C. Stokes Company, Vincentown, N. J. It is a free-setting variety of the terminal type growth. Its fruit is large of brilliant, smooth, uniform appearance and matures in the same length season of Bonny Best. The Francis C. Stokes Company also introduced Bonny Best but have discontinued it in preference to Stokesdale. For eastern Kansas Stokesdale has many desirable characteristics. It is not a heavy foliaged plant so that under adverse conditions sunburning of the fruit is a matter of concern.

Bonny Best is an old variety and represents the standard of excellence among early red varieties. One of its shortcomings is that the fruits fail to reach good size after the first two or three clusters. Many named selections of Bonny Best have been made in an attempt to improve and adapt it to environmental conditions. The plants possess the terminal growth habit but are not as vigorous, semi-upright and spreading as others of that type. Growth varies widely, depending upon soil and climatic factors. The leaves are inclined to be fine of texture, medium green.

The immature fruits are dark green at the stem end, pale green over the balance of the fruit. The fruit is of medium size early in the season, becoming small as the season progresses.

It is slightly flattened globe shape, red to scarlet when ripe. Radial cracking is common. Fruits borne in clusters, outer and partition walls thick, central mass fleshy and firm. The plants are not resistant to wilt and therefore the variety is recommended only where wilt is not a factor. John Baer and Chalks Early Jewel are varieties that are similar to Bonny Best and are commonly grown for home garden use.

Earliana is an old and popular variety of the terminal type of growth. Many selections have been made from the variety, perhaps due to the fact that the variety is somewhat variable. Seed of the variety offered by seedsmen may vary widely in both plant growth and fruit type. It is an early variety and it is believed that the name Earliana has played an important part in maintaining the popularity of the variety for home garden use. The plants are not wilt resistant so are recommended only for wilt-free soils.

Firesteel is the result of a Bison X Pritchard X Bison cross and is a semi-determinate type plant possessing more nearly than other varieties the foliage protection of the strong growing terminal type varieties and the free fruit-setting quality of the determinate type varieties. The fruits are large, smooth, of good color and texture so that it competes well with other varieties upon competitive markets. The full extent of the adaptability of the variety to Kansas conditions is still unknown.

Pritchard, Break O'Day and **Marglobe** are among the first Fusarium wilt resistant varieties adapted to Kansas conditions. They are still grown to some extent in eastern and southeastern Kansas. Varieties described above have largely replaced them in areas where growing conditions are more trying.

VARIETIES FOR CENTRAL AND WESTERN KANSAS

Conditions found in central and western Kansas are such that successful tomato culture is difficult. Most of the tomatoes grown in this area are for home use and here production is more essential than market quality, especially from the standpoint of size. There are comparatively few varieties adapted to adverse conditions, therefore, the varieties recommended may leave much to be desired, but are the best available.

There are two types available to the home gardener when selecting plants that will set fruit under adverse conditions. As a rule, small fruiting varieties will set fruit under more adverse conditions than large fruited varieties. Dwarf growing plants also frequently set fruit under adverse conditions more freely than strong growing plants.

Bison is a dwarf plant producing medium size to small fruits, and was originated by the North Dakota Agricultural Experi-

ment Station. It is an early variety of the determinate or self-pruning habit of growth. The leaves are inclined to be small and are not produced in sufficient numbers to protect the fruits when conditions become unfavorable. The fruits, in addition to being small, frequently ripen irregularly and are generally inferior to the varieties recommended for eastern Kansas. The ability of the variety to set fruit under adverse conditions has caused it to become popular in central and western Kansas even though much fruit is injured by heat.

The determinate type growth of Bison does not permit pruning and training. However, the plant may be tied to a stake to hold the fruits up off the ground, especially when surface irrigation is used. The plants are not resistant to Fusarium wilt.

Danmark is an early variety with plant growth resembling Bison. Danmark is a European variety introduced by the Cheyenne Horticultural Field Station. The fruits are smaller, smoother and ripen more uniformly than Bison. The fruits are borne in clusters, frequently six or more. The plants may be set 2 x 3 feet apart under conditions where moisture is not a major factor. The plants are not resistant to Fusarium wilt.

Firesteel possesses qualities which may make for it a place in the more favorable garden sites of central and western Kansas. See page 15 for description.

Porter, a variety producing somewhat pear-shaped small fruits has been tested extensively in Oklahoma and southwest Kansas in cooperation with the Southern Plains Station of Woodward, Okla., and the variety is receiving much favorable comment from growers in that area. A selection from Porter known as New Porter or Porter's New Tom produces fruit about twice the size of Porter and in tests at Manhattan set fruit freely. Though small-fruited, it gives promise of being a good home variety.

Victor and **Bounty** are recent introductions somewhat similar to Bison that are being tested in central and western Kansas gardens. They were introduced as being superior to Bison in quality of fruit and in foliage. They should be tested generally as results to date have been promising.

Red River, Ruby, Mandon, Earliana, Earliosa and **Redhead** are varieties that possess free fruit-setting qualities, but are sparse of foliage or produce coarse, rough fruits and have been found generally inferior to above varieties.

SELECTION OF PLANTS

A well grown tomato plant is short and stalky with well developed leaves of good size with a correspondingly good root system. Sufficient space, a minimum of 2 x 2 inches per plant,

is necessary for the development of strong plants, (Fig. 2). Temperature, soil moisture, and light must be carefully regulated. A night temperature of 60° F. with a day temperature of 70° F. on cloudy days is ideal for tomato plant growth. A high moisture content in soil and air tends to cause a rapid soft plant

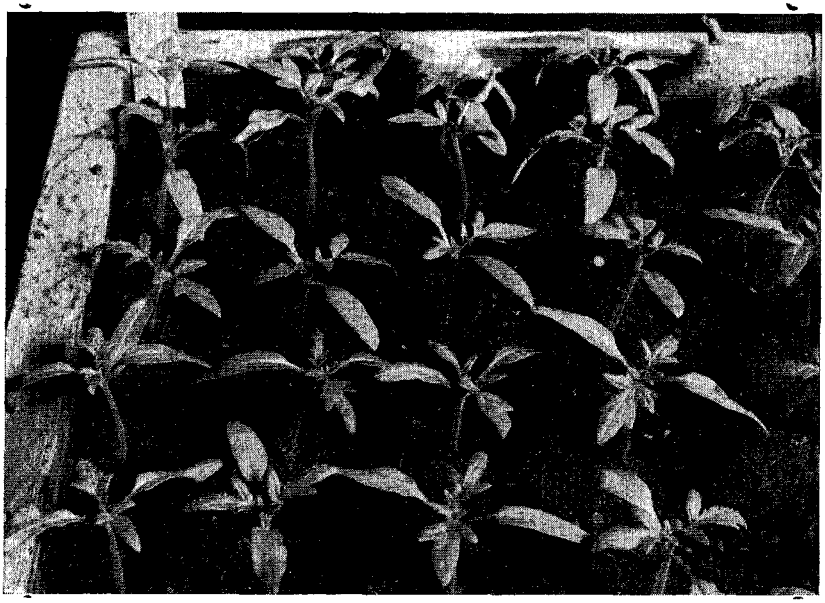

Fig. 2. Tomato seedlings transplanted into a flat two inches on the square to allow sufficient space to develop good strong plants.

growth and is favorable to development of damping-off (see diseases). Such plants must have their growth checked and be somewhat hardened before they are suitable for planting into the field where they are exposed to fluctuating temperature, wind, and direct sun. The process of preparing plants for adverse conditions is spoken of as "hardening-off" and is accomplished either by gradually withholding water until growth is checked without seriously wilting the plants or by gradually reducing the temperature to harden the growth. It requires eight weeks to grow and to properly prepare plants for transplanting into the garden early in the spring. Six to seven weeks is sufficient time for producing plants to be set in the garden when the soil is warm.

Plants are judged as good or poor by examining the top growth, however, for successful transplanting much care should be given to the root system. An injury to the root system tends to increase the shock from transplanting, therefore, root injury should be kept to the minimum. Plants should be lifted carefully

rather than to be pulled from the seed bed, leaving as much of the soil as possible on the roots.

Plants that have been properly grown, sufficiently hardened-off and carefully handled during transplanting should show practically no wilting or checking of growth when transplanted.

Fig. 3. Three tomato plants of the same variety and of the same age. Plant No. 3 has had ample water. Plant No. 1 has been checked by withholding water over a period of time. Plant No. 2 has also been checked by withholding water but for a shorter time than for No. 1. Plant No. 1 is hardened-off to withstand severe transplanting conditions. Plant No. 2 is hardened-off moderately for transplanting into the field when conditions are favorable. Plant No. 3 is a soft plant suitable for transplanting only under the most favorable conditions. Note the flower bud near the top. If this plant suffers much from transplanting fruit will likely fail to set on this flower cluster.

The hardening-off process may be carried to an extreme and so harden the plant that rapid growth is not resumed and total yield is reduced accordingly (Fig. 3).

Plants are best transplanted before flower buds have set as the shock of transplanting is most injurious to the developing fruit buds and may prevent a subsequent set of fruit. In cases of failure to set fruit upon the first fruit cluster, plants growing in a fertile garden soil frequently become so strongly vegetative that fruit is never borne though flowers are produced freely. Plants established in individual containers so that they can be transplanted without injury to the root systems can be further developed than plants not so established. Plants of a determi-

nate type of growth are not as easily encouraged to produce excessive vegetative growth as are terminal growing varieties such as Marglobe.

TIME OF SETTING

The tomato is a warm weather crop, is easily injured by cold, and is tender to frost, therefore plants set before the frost free date are in danger of severe damage.

The home gardener who desires fruits as early as possible for table use can be justified in setting a few well grown properly hardened-off plants early. In case of danger of frost they can be covered. Such plants should be watched carefully as they develop and if the first flowers open during a damp cool period hand pollination may be resorted to so as to hold the balance between vegetative growth and fruiting.

The main crop of tomatoes should be planted into the field as soon as danger of frost has passed. Under Kansas conditions spring and early summer afford nearly ideal growing conditions so the earlier the plants can be set and escape injury from cold the better for the crop.

Direct seeding of tomatoes for the main or late crop may well be considered by home gardeners. Tomato seed of selected varieties are planted where the plant is to mature, any time after oats or garden beet seed is planted. Three to four seeds are planted at each place, later they are thinned to one plant. As a general rule direct seeded plants are late producers but indications are that such plants produce stronger and deeper root systems than transplanted plants of the same variety and therefore should be better able to withstand adverse conditions. Should transplanted plants encounter adverse conditions before becoming established, their development and production is delayed so that direct-seeded plants produce fruit as soon as the transplanted plants of the same variety.

PLANTING TOMATOES

Planting Distance. —The spacing of plants in the field is dependent upon the variety, fertility of the soil and method of training.

Plants allowed to grow normally require more space than those that are trained. Tomatoes produce larger plants and require more space when grown on a fertile soil than when grown on a soil low in plant nutrients or when the soil is in poor physical condition. Some varieties produce small bushy plants while other varieties are strong, vigorous growers and require spacing accordingly.

In the home garden where culture is intensive, plants may be set closer than is recommended for field culture where all labor possible is done with power tools and harvesting must be

done economically. When tomatoes are grown as a cash crop, labor becomes a major factor and hand labor is kept to the minimum.

PLANTING DISTANCE FOR TOMATO VARIETIES UNDER AVERAGE CONDITIONS (FEET).

Variety	No training	Staked		
		Not pruned	Pruned to 3 stems	Pruned to 1 stem
Rutgers	3.5x3.5	3x3.5	2.5x3	1.5x3
Stokesdale	3.5x3.5	3x3.5	2.5x3	1.5x3
Bonny Best	3.5x3.5	3x3.5	2.5x3	1.5x3
Earliana	3.5x3.5	3x3.5	2.5x3	1.5x3
Firesteel	3x3.5	2x3.5		
Pritchard	3.5x4	3.5x3.5	2.5x3	1.5x3
Break O'Day	3.5x4	3.5x3.5	2.5x3	1.5x3
Marglobe	3.5x4	3.5x3.5	2.5x3	1.5x3
Bison	3x3	2x3		
Danmark	3x3.5	2x3		
Porter	3x3.5	3x3		
Victor	3x3	2x3		

Spacing of plants to be trained will be discussed under the heading of staking and pruning.

Setting Plants. —Well selected plants with ample roots may fail to become established because of faulty practices in transplanting. The plant depends upon the root system to supply water and those food nutrients not obtained from the air. The root to function properly must have direct contact with the soil.

The ideal moisture content of a soil when transplanting a plant is sufficient that finely pulverized soil will hold the mold of the hand when pressed, and will return to its original form when broken up. This proves that there is sufficient moisture so that the soil will pack yet not sufficiently moist to cause puddling.

In transplanting, a hole should be dug large enough to accommodate the roots without crowding and deep enough that the plant is set deeper than it originally grew.

The soil should be firmed about the roots to exclude large air spaces, leaving the soil loose at the surface. Watering at time of transplanting drives out the excess air and brings the soil into direct contact with the roots.

Staking, Pruning, etc. —There are various systems of pruning and staking tomatoes. The extreme system of pruning is found in universal favor in greenhouse culture where the plant is pruned to a single stem and all side shoots are removed from the leaf axils. If the shoots are removed when young they can be broken out without serious injury to the plant. Shoots that have made considerable growth should be removed with the aid of a sharp knife. The single stem is supported by means of a stake or a string suspended from a wire overhead. This system allows plants to be set closely; the fruiting season is shortened so that a maximum yield is obtained in a short period of time.

The individual fruits are kept off the soil, ripen uniformly and are of good color, provided they are not injured by the sun. The plants are commonly spaced in the field 18 x 36 inches. The method requires much labor and can be justified only where space is limited or a premium is placed upon high quality tomatoes. The system can be recommended for Kansas only when the plants are grown under ideal conditions and even then a

Fig. 4. These tomatoes have been sun-scalded because of a lack of protective foliage on the plant.

slight modification of the system is recommended to provide more shade for the fruits. This is accomplished by allowing the shoot arising from the leaf axil above a flower cluster to develop until two or three leaves have formed and then removing the terminal end of the shoot, the additional foliage provides the shade needed to keep the fruit from scalding when the temperatures are high and the humidity is low, (Fig. 5). The yellowish red color commonly found upon the side of the ripened fruit is caused by heat from the sun.

A plant may be pruned to two or three shoots rather than to one (Fig. 6). In this case the plants require more space, the harvest season is extended but the damage from sun is not greatly reduced.

In any of these systems the plants are topped when they reach the height of the trellis or support to throw all energy in to the fruits and to prevent the vine growth from interfering with the harvest.

Market gardeners frequently stake tomatoes that are not pruned. They use a short stake 30 to 36 inches long, drive it beside the plant and tie all branches loosely to the stake. This system holds the first 3 to 5 clusters of fruits off the ground, which are the fruits most likely to be injured by wet weather

Fig. 5. To provide more shade for fruits, allow the branches B directly above the flower clusters to develop until two leaves are formed and then pinch terminal bud. All other branches are removed from the leaf axils.

and they are the most valuable fruits to the market gardener. This system can be widely recommended to the home gardeners. Under Kansas conditions the method has the added advantage of serving to place a tent over the fruits as their weight causes them to hang below the foliage.

In tying the branches to the stake, use a coarse soft twine or strips of cloth. The string is first tied tightly around the stake to prevent slipping and then passed around the stem so as to hold it loosely, allowing for free movement and growth. Bunching of the branches when tying may lead to serious loss of foliage by disease.

Plants so supported can be set somewhat closer than plants

not supported in any way. When plants are irrigated by the flood, furrow or overhead systems supports of some kind are highly desirable.

Fig. 6. When plants are to be pruned to three stems select three strong shoots and support each separately by means of string or stake. All branches should be nearly equal in vigor and selected from near the base of the plant. In garden culture, branches should be selected from the lower leaf axils. (The plant shown in the illustration above is for demonstrative purposes.) With some varieties it will be necessary to pinch the leader so that branches with equal vigor can be selected.

PROTECTION FROM DISEASES AND INSECTS

DISEASES

Tomatoes are commonly attacked by a variety of diseases causing heavy losses. Frequently the disease has made considerable headway before being observed at which time control becomes difficult if not impossible. Most diseases are more easily prevented than cured, so treatment should become a part of the cultural practice. Cleaning up of the vegetable plants in the

garden area and destroying insect harbors around the garden in the fall is to be recommended.

Root Knot. —Root knot is caused by a microscopic eelworm (nematode) which produces swellings evenly distributed on the root system and greatly deforms it. The small roots and root hairs, so essential in absorbing the food nutrients and moisture from the soil, are lacking (Fig. 7). Root knot is common in southern soils though not so serious in northern gardens as the nematodes cannot endure low temperatures. It is a serious dis-

Fig. 7. Root Knot of Tomato. The old roots become enlarged, knotted with few side branches. Notice the white normal sized roots arising high on the stem. Some of the side branches on these roots show enlargements caused by nematode infection.

ease of vegetables in southern Kansas and may become important elsewhere. The disease attacks most all vegetable crops, therefore, great care should be taken to guard against contaminating the garden soil.

Root knot is commonly brought into the garden by the purchase of plants infested with the nematodes, therefore, one

should take special precautions to see that plants purchased are healthy.

Garden soils infected with nematodes may be treated in one of the following ways or a combination of them: By plowing the area in the fall to expose roots and allowing it to remain rough to encourage deep frost penetration; by abandoning the area as a garden for two or more years. (Corn, kafir, grasses and a few beans are resistant to nematode attack and may be grown.) A number of weeds are subject to attack and may serve to keep the disease alive. Treating the soil with chemicals or heat will kill the nematodes. The chemical and heat treatments are expensive and are therefore recommended only as a last resort.

The following crops commonly grown in the vegetable garden are subject to injury from root knot: tomatoes, asparagus, beans, carrots, celery, cucumbers, eggplant, beets, peas, potatoes, lettuce, muskmelon, okra, onion, pepper, salsify, spinach, and strawberries. The following trees are subject to attack: cherry, mulberry, peach, catalpa, weeping willow, and European elm.

Cabbage and onion plants as well as tomatoes are common carriers of the disease and the source of such plants should be carefully watched.

Wilt, Fusarium.—This disease is very widespread and may be seed or soil borne. When soil borne the causal organism gains entrance to the plant through wounds on roots or stems which come in contact with the ground. As a rule the disease attacks one side of the plant and progresses up that side in advance of injury on other sides. The disease is characterized in its early stage by a wilting of the leaves and an upward and inward rolling of the leaves. The leaves turn yellow and slowly die. The dead leaves cling to the plant. A cross section of a diseased stem shows a dark brown discoloration between the pith and bark.

The fungus causing wilt can live in the soil for several years. Soil treatment is not practical so the use of wilt resistant varieties when available among the recommended varieties is desirable. (See Recommended Varieties, page 14.) The tomato varieties recommended for western Kansas are not wilt resistant. When disease is present and resistant varieties are not available, a three- to five-year crop rotation is recommended.

Damping-off is caused by any one of a group of organisms that may be carried on the seed coat or they may be living in the soil in which the seed is planted. Plants are subject to the attack of this group of organisms at any time during growth, however, when attacked in the seedling stage the young plants decay or rot near the surface of the ground and this behavior is familiarly known as damping-off.

Damping-off losses under house and hotbed conditions can be kept to the minimum by seed and soil treatment supplemented by proper cultural practices. Watering should be held at a minimum after the seeds are planted. Free aeration without draft and a low humidity should be provided. A temperature of 60° F. at night, 70° F. during cloudy days, and higher than 70° F. on bright days should be maintained with a maximum of light.

Seed should be treated with one of the following chemicals: Yellow copper oxide (cuprous oxide), zinc oxide or Semesan, following directions of the manufacturer. When seeds are planted under house or hotbed conditions the soil in which the seed is planted should be sterilized by heating the soil to 160° F. using hot water or steam or by placing soil in the oven, or by means of formaldehyde 1 part to 49 parts water, using one gallon to a cubic foot of soil 10 days before soil is used.

When seed is planted in the garden where plants are to mature, seed treatment is recommended but only under known disease conditions is soil treatment advised.

Septoria Leaf Spot. —The disease appears on the leaves as watersoaked spots which later turn brown with grayish centers and the leaf finally dries and drops off. The older leaves die first but the disease works upward to new leaves until the plants are often almost completely defoliated before half of the crop is matured. Leaf spot is more serious during wet weather than in dry. The disease in Kansas frequently attacks the plants during the moist cool weather of May and June but is unnoticed until the leaves drop and expose the fruits to the sun.

Control methods include fall clean-up of all plant refuse, destruction of horse nettle, ground cherry, jimson weed, and nightshade. The newly planted tomatoes should be sprayed with copper spray mixtures or Bordeaux.

Nailhead Spot. —Reddish-brown spots with concentric rings appearing on the leaves and black-rot spots on the fruit are characteristic of this disease. The spots on the fruits are small, circular, slightly depressed, grayish brown to black. Most serious infection takes place on the smaller fruits. The control measures are the same as for septoria leaf spot.

Bacterial Spot. —This disease attacks the leaves and fruits, the greatest damage being caused by the spots on the fruit. The spots on the leaves appear as watersoaked areas which enlarge and the centers become black and sunken on the lower side. Infection of the young leaves may cause them to turn yellow and drop. Lesions (spots) also appear on the leaf petiole and stem. The lesions resemble those of the septoria leaf spot. The lesions on the fruits appear as small, black, raised spots surrounded by a narrow watersoaked area. As the diseased area disintegrates, the raised spots sink until they become cavities bordered by the broken epidermis.

Control measures should include the use of clean seed or seed treated with a solution of 1 part corrosive sublimate to 3,000 parts water for 5 minutes and then washed in running water for 10 to 15 minutes. Practice a three-year rotation in the garden and field.

Bacterial Canker or Grand Rapids Disease. —The canker spots make their first appearance as round snowy white areas which may be removed by a rub of the thumb. The margin of the diseased area remains snowy white while the center becomes tan-colored. Control measures are the same as for bacterial spot.

Mosaic. —There are several kinds of mosaic which may attack tomatoes. Some are much more serious than others. The more serious types of mosaic cause tomato leaves to become deformed until they appear as fern leaves or as a shoe string, thus the name fern leaf or shoe string mosaic. Plants affected

DISEASE CONTROL CALENDAR

Stage of Development	Control of	Treatment
Seed treatment	Bacterial spot Bacterial canker	Place seed in cloth bag, submerge for five minutes in a solution of one gram of corrosive sublimate to three quarts of water or two large tablets (7.3 grains each) of corrosive sublimate to three quarts of water. After treatment, wash thoroughly in fresh water and dry.
Seed treatment	Damping-off	Treat dry seed with yellow copper oxide, zinc oxide or Semesan according to manufacturer's recommendations.
Seed	Wilt	Use certified seed of resistant varieties and plant in disease-free soil.
Seedlings	Septoria leaf spot	Spray plants before being set in field with 2-4-50 Bordeaux mixture.
In the field	Septoria leaf spot Nailhead spot Bacterial diseases	Spray with yellow copper oxide or 4-8-50 Bordeaux mixture. Destroy all weeds closely related to tomatoes.
	Mosaic	Control insects, destroy young diseased plants as soon as observed.
	Root knot	Purchase healthy vegetable plants of all kinds.
General	Preventive measures	Practice three to five year crop rotation and practice fall clean-up.

with this type of mosaic produce very few if any fruits and should be destroyed as soon as noted.

Other mosaics are characterized by variegated mottling of dark and light green areas. This is characteristic of the tobacco mosaic. The yields are only slightly reduced by this disease. The disease is readily transmitted from one plant to another by

bruising plants during planting, cultivation, through pruning operations or by insects feeding. All closely related weeds, horse nettles, ground cherries, nightshades should be destroyed as the disease may be carried over winter on these plants. There is no recommended control for diseased plants, therefore, every effort should be taken to prevent infection.

Blossom-end Rot. —This is caused by severe wilting of the plant when the fruit is developing rapidly, causing the cells at the blossom end of the fruit to be killed. Shallow soil, small or diseased root systems and water-logged soil are factors which may attribute to more severe losses by blossom-end rot if present when rapid prolonged wilting results. A deep, well distributed root system and uniform moisture tend to prevent development of the disease.

INSECTS

There are a number of insects which may cause injury to tomatoes. Some are more or less specific enemies of the tomato, while in other cases the insect has a wide range of hosts.

Red Spider is a very small mite which increases rapidly in dry warm weather. It feeds largely on the lower side of the leaves, frequently going unnoticed until severe damage is done. A slight yellow mottling or russeting of the leaves is typical of red spider injury. Treating plants with dusting sulfur is the most commonly recommended control measure.

Aphids, commonly called plant lice and green bugs, may cause injury to tomatoes in one of two ways. The aphids feed by sucking the juices from the plant and when numerous may become serious. The aphids may also be a carrier of mosaic, a serious disease of tomatoes. Because of the fact that they may serve as a carrier of mosaic, it is advisable that they be controlled even though they are present in small numbers.

"Black Leaf 40" or nicotine sulphate used as a spray or dust is the recommended control measure. The spray is more commonly recommended.

Cutworms. —The cutworm does its major damage shortly after the plants are set into the field by cutting the plants off near the ground level. The cutworms are active at night and hide during daylight, usually in the ground.

The tomatoes are set into the field when nights are likely to be cool. During such periods cutworms are rather inactive. The recommended control measure is to scatter poison bran mash near the plants late in the afternoon. Since cutworms are more active following a warm afternoon, a larger kill can be expected if the poison is spread on warm days.

Some growers start plants in wooden or paper bands. When the plants are set into the field the band is lifted above soil-

level about one-half inch to serve as a barrier to the worm, Home gardeners may use bands from tin cans, while others wrap paper about the stem.

Fruit Worm. —Frequently the tomato fruits are attacked by a worm. As a rule this worm is a major enemy of some other crop. The corn ear worm may cause serious injury to tomato fruits. The egg of the moth may be laid near the stem and under the calyx and the larvae frequently enter the fruit under the calyx. In other cases the larvae feed on leaves or elsewhere before attacking the fruit. The larger larvae may attack the fruit at any point.

Corn used as a windbreak or planted in among tomatoes to provide shade as well as to check wind may increase the loss from ear worm. However, the worm prefers sweet corn to tomatoes and if several plantings of sweet corn are made the worms will likely cause little damage to the tomatoes.

A stomach poison such as lead arsenate is recommended for control of the worms, however, it is difficult to control successfully those which attack the fruit at the calyx.

The Tomato Hornworm. —The tomato hornworm is a large green worm with a slender horn-like growth at the tip of the body. The worm is also commonly called tomato worm and tobacco worm, The worm is the larva of either of two sphinx moths of very similar habits. The larvae are heavy feeders and a single worm may strip a large tomato plant. Hand picking and spraying or dusting the plants with arsenate of lead are the recommended control measures.

Flea Beetle. —The flea beetle is so named because it is flighty and therefore rather difficult to see other than on the wing. It is a tiny black beetle which eats small round holes (shot-holes) in the leaves. The flea beetle attacks a variety of crops, such as eggplant, beans and potatoes. Spraying with a Bordeaux mixture is the recommended control.

Blister Beetle. — The common blister beetle sometimes becomes a pest of the tomato. Some are successful in driving the insects from the garden by use of a brush. Spray with Bordeaux mixture to which has been added arsenate of lead or calcium arsenate is recommended. For those varieties of strong growing habit dusting with sodium or barium fluosilicate should replace the spray treatment as Bordeaux mixture may stimulate vegetative growth.

Grasshoppers are frequently present in sufficient numbers to cause serious damage. Poisoned mash may be used effectively. Some gardeners recommend allowing the poultry to pasture the garden and especially the area surrounding the garden.

PRODUCTION SUGGESTIONS

1. In selection of a site a windbreak is considered essential and irrigation desirable.

2. A soil high in phosphorus tends to develop a strong root system and encourages high fruit production while a soil high in nitrogen tends to induce excessive vegetative growth at the expense of fruiting.

3. Shallow cultivation to control weeds and keep soil retentive of moisture is recommended.

4. Select varieties that will produce good yields under favorable conditions for the area: In central and western Kansas Bison, Danmark and similar varieties: in eastern Kansas Rutgers, Stokesdale and Firesteel.

5. Select strong vigorous plants that have not set bud and that have been hardened-off so as to endure adverse conditions.

6. Save as much of the root system as possible when transplanting the plants.

7. Firm the soil about the roots in transplanting. Watering at time of transplanting brings the soil in direct contact with the roots so that water and nutrients are available.

8. When strong growing varieties are grown on fertile soil hand pollination should be resorted to if necessary to cause fruit to set upon the first cluster of flowers, so as to maintain a balance between fruiting and vegetative growth.

9. Varieties of terminal growth habit should be selected when plants are to be pruned to one or three stems.

10. Spray to control leaf diseases. Loss of foliage causes weakened plants and increased loss of fruit due to sun injury.