

Fresh Market Tomatoes

The demand for locally-grown, vine-ripened tomatoes remains strong in Missouri. If you can produce high yields of good-quality tomatoes, the opportunity exists for you to make a reasonable return on your investment.

The resources essential for profitable tomato production are relatively fertile land, sufficient water for irrigation, and an adequate labor supply.

Establishing a crop of tomatoes requires a significant investment of time and money. Therefore, you should identify potential markets before entering into tomato production. Producing tomatoes without first identifying where they can be sold is often a money-losing venture. Marketing possibilities for fresh market tomatoes include roadside stands, farmers markets, community supported agriculture (CSA) subscriptions, local supermarkets, restaurants and wholesale produce auctions.

Tomatoes are a demanding crop. Timely and thorough implementation of cultural practices is required through all stages of production. Additionally, tomato production is complex. However, growers with intensive production, management and marketing skills can realize substantial income from a relatively limited amount of land.

Site selection

Deep, fertile upland soils that warm early in the spring and medium-textured bottomland soils are most suitable for tomato production. If possible, select recently cultivated land. Otherwise, allow for a year of preparation to eliminate perennial grasses, weeds and woody vegetation. Avoid land on which herbicides not labeled for tomatoes have been applied in the recent past, and land that lies next to fields likely to be treated with herbicides during the growing season.

Upland sites provide some frost protection for the earliest plantings. Delay bottomland plantings until the danger of frost is past. Cold spring winds are hard on newly transplanted tomatoes. Plant protection devices such as waxed hot caps or floating row covers can be used to protect young plants. However, you must weigh the labor and costs of using these devices against anticipated increases in yields or advancement of expected harvest date.

To lessen disease infestation, never plant tomatoes in a location where they or related species — such as pepper, eggplant and potato — had been planted within the past three years.

Soil improvement

Tomatoes are “heavy feeders” and use many soil nutrients. Many Missouri soils are naturally low in one or more of the essential elements. Previous cropping or soil erosion also may have depleted these elements. A soil test is the only reliable method of determining soil nutrient levels. MU Extension centers offer soil testing services. The test results will indicate nutrient levels and fertilizer recommendations for growing the crop. For tomatoes, soil nutrient levels should be in the ranges shown in Table 1.

Table 1. Desirable soil nutrient levels for tomatoes.

Soil type	Phosphorus	Exchangeable potassium	Exchangeable magnesium	Exchangeable calcium
	Pounds per acre			
Sandy loam	100–125	225–325	150–300	2,000–3,000
Medium silt loam	125–150	325–425	300–450	3,000–4,500
Heavy loam and clays	150–175	425–500	450–600	4,500–7,000

Note: Amounts are based on a University of Missouri test.

Additionally, soil for growing tomatoes should contain at least 2.5 percent organic matter. Organic matter serves as a storehouse of plant nutrients, promotes good soil structure, and enhances soil air-moisture relationships. As a general rule, there are 20 pounds of residual nitrogen per acre for each 1 percent of organic matter. Preplant nitrogen application usually is not necessary on soils having more than 3 percent organic matter. On soils with less than 2.5 percent organic matter, you will need to incorporate some form of organic matter into the soil. Growing and tilling green manure crops into the soil is an inexpensive way to do so.

Sorghum-sudangrass hybrids, such as Sudax, can be grown as a green manure crop during the summer. These hybrids are heat- and drought-tolerant and, after being turned under, can add significant amounts of organic matter to the soil under conditions that are less than satisfactory

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for other green manure crops. Alternatively, either rye grain or perennial ryegrass can be grown as a fall, winter and early spring green manure crop. Before planting tomatoes, allow at least three weeks for the rye grain or ryegrass to decay after turning it under. Up to 30 pounds of nitrogen per acre can be plowed under with the green manure to help break down the organic material.

If the soil test shows deficiencies in phosphorus, potassium, calcium or magnesium, apply the corrective treatments before planting the green manure crop. Doing so will ensure the nutrients will be worked into the soil well.

Soil pH also is important in growing tomatoes. Tomatoes grown in soils with a pH of 6.0 to 7.0 are less likely to show blossom end rot symptoms on the fruit and to be deficient in certain nutrients. An ideal pH for most vegetables, including tomatoes, is 6.4 to 6.8.

Variety selection

Variety selection is one of the most important management decisions for tomato producers. When selecting varieties for fresh market production, traits such as fruit size, vine type, maturity, disease resistance, flavor, productivity and market acceptability must be considered. Contact potential buyers of your crop to determine what they look for when purchasing fresh market tomatoes.

There are hundreds of tomato varieties from which to choose. First-time growers should consider planting several varieties, chosen based on personal research and recommendations from others. Then, select the top-performing one or two to plant as the main crop, but continue to trial new varieties on a limited basis.

Vine type, or growth habit, is an important trait to consider when selecting varieties, because it affects labor requirements. Determinate and semideterminate varieties produce plants that terminate their growth with a flower bud. Such plants are called “self-topping” or “self-pruning.” They do not vine out and can be grown using the stake-and-weave system described in the *Plant training and pruning* section. These varieties require only light pruning, but they only produce fruit for a limited time and must be replanted for you to continue to have tomatoes through the growing season.

In comparison, most greenhouse tomatoes and heirloom varieties are indeterminate. An indeterminate plant produces flowers and fruit throughout its life, never terminating in a flower bud, and keeps growing until frost. Indeterminate tomato varieties have vines that end with a growing point. Thus, blossoms and fruit develop progressively as the vine grows, so tomatoes in all stages of development may be on the vine at one time. The harvest may last for several months if high summer temperatures do not prevent fruit set. Indeterminate varieties require some means of support — such as staking, caging or trellising — and usually are pruned.

An important aspect of variety selection is the so-called “disease package” the variety contains. Disease package

refers to the diseases to which a variety is resistant.

Tomatoes are susceptible to many troublesome diseases. The easiest way, by far, to control a disease is to plant a variety that is resistant to it. Disease resistance associated with a tomato variety is identified by letters, or letters and numbers, in promotional material describing the variety.

As a general rule, avoid tomato varieties with very large fruits, green shoulders, the tendency to crack, late maturity, and little or no disease resistance. Table 2 gives examples of several tomato varieties likely to perform fairly well in Missouri. For a more complete list, refer to MU Extension publication G6201, *Vegetable Planting Calendar*.

Transplant production

If possible, it is usually best to grow your own tomato plants. However, if you lack either growing experience or facilities, consider buying plants from a reliable, established plant grower. In either case, use stocky transplants that are container-grown. A good tomato plant is 6 to 8 inches tall, has a stocky stem about the thickness of a pencil, and has foliage of good color and condition.

Avoid the temptation to save money by using bare-rooted transplants. They experience more transplant shock than do container-grown transplants. The extra money spent for container-grown plants is usually more than offset by their earlier production of marketable tomatoes.

Preferably, buy plants locally. Often, plants bought from distant sources arrive in poor condition and are available in fewer varieties. They also may potentially introduce diseases and nematodes into your fields.

Spacing

Tomatoes should be planted in rows 4 to 5 feet apart, depending upon the tillage equipment to be used. Plants should be spaced 18 to 36 inches apart within the row, depending upon vine type and training system used. Therefore, the number of plants required per acre varies from 2,500 to more than 5,000. A typical spacing of 24 inches between plants within rows spaced 4 feet apart will result in 5,445 plants per acre.

Transplanting

To decrease the possibilities of plant damage or loss caused by transplant shock, follow these practices:

- Water plants an hour or so before transplanting.
- Protect plants from direct sun and wind exposure before setting.
- Water plants in with a starter solution. Use a high-phosphate water-soluble fertilizer such as 9-45-15 at a rate of 3 pounds per 50 gallons of water. Apply about a half pint of solution per plant.
- If a mechanical transplanter is used, check to make sure the soil is firm around the plant's roots and the plant is set at the proper depth.

Table 2. Examples of hybrid tomato varieties for Missouri.

Variety	Maturity	Resistance*	Comments
Semideterminate vine type			
BHN 589	72	V,F	Midseason early; excellent size, shape and quality
Carolina Gold	77	V,F	Yellow-gold fruit; vigorous vine; excellent quality
Florida 91	72	V,F	Very productive; large, firm fruit; sets in heat
Mountain Fresh Plus	77	V,F,N	Very popular; vigorous vine; excellent quality
Red Bounty	76	V,F,N,T	Good yields; large fruit; great interior color/flavor
Red Deuce	72	V,F,T,ST	Good yields; large fruit with outstanding quality
Scarlet Red	75	V,F,ST	Extra-large fruit; outstanding interior quality
Indeterminate vine type			
Better Boy	75	V,F,N,A,ST	Old but still popular; high yields; good quality
Big Beef	73	V,F,N,T	Large-X-large fruit; good yields; great quality
Big Dena	75	V,F,T, Ff	Greenhouse type; good yields; large-X-large fruit
Sweet 100	70	V,F	Very productive cherry tomato; excellent quality

Note: All varieties listed are crack-resistant under normal growing conditions.

* A = alternaria; F = fusarium wilt (race 1); Ff = fusarium wilt (races 1 and 2); N = nematodes; ST = stemphylium; T = tobacco mosaic virus; V = verticillium wilt.

Plant training and pruning

Tomato plants require training and pruning. When tomatoes are supported and pruned, plants receive more sunlight, are more able to resist disease, and are more likely to set early fruit. Pruning involves the removal of suckers, or side shoots, that grow between the leaf and the main stem. This practice will accelerate early harvest and improve disease tolerance by enhancing air circulation around the plant, but will not increase total yield.

Fresh market tomatoes usually are trained to one of three systems depending on vine type: wood or steel stakes, overhead wire trellis, or stake-and-weave.

Stake system. For the stake system, use 1½-inch square or 1-by-2-inch wood stakes or ¾- to ½-inch steel stakes that are about 6 feet long. Drive the stakes about 10 inches into the ground. Each stake should be about 4 inches to the side of a plant but still in the row. Stake plants within two or three weeks of transplanting.

Tie the vines to the stakes with jute or sisal twine, or another soft cord. Arrange the stem of the plant so the blossom clusters face away from the stake. Allow about an inch of free space between the stake and the vine to permit future stem expansion.

Train staked tomatoes to a single stem. To establish a single stem, remove all side shoots, or suckers, on the main stem as soon as they are large enough to handle. A sucker is a shoot that grows where a leaf attaches to the main stem. Remove suckers every five to seven days early in the growth of the plant. Later, after fruit development is well under way, suckers grow more slowly, and the interval may be lengthened.

Overhead wire trellis. To create an overhead wire trellis system, drive 3- to 4-inch posts into the ground so that they extend about 5 feet above the ground. Space the posts 12 to 14 feet apart within the row. Tightly stretch a 12-gauge wire across the top of the posts. If you place 6-inch end posts

deeply and firmly in the soil, bracing posts are not likely to be needed. Tie a string, of a sturdy type that will last the season, to the tomato stem below the first leaf using a loose square knot. Then tie the string to the overhead wire using a slip knot. Periodically loop this string around the tomato stem as it grows taller. Remove suckers as described in the stake system description.

The overhead wire trellis system can be used to train two stems from one root system. To do this, allow the sucker just below the first flower cluster to grow and form a second stem. Hormonal action of the plant causes this particular sucker to grow rapidly and become a second stem. Tie a second string around the stem of the plant just below this sucker and again to the overhead wire. Periodically, wrap the plant stems around the string for support. Remove all other suckers as they develop on each stem. If you use this system, space plants at least 28 inches apart within rows.

Stake-and-weave. The stake-and-weave system most often is used for tomatoes with determinate or semideterminate growth habit. Drive a 5-foot-long stake between every other plant within a row. Tie string to the bottom of the first stake, “weave” it between the two intervening plants, and secure it to the base of the second stake. Repeat this procedure down the length of the row. As plants grow, weave strings every 8 to 12 inches until total support is achieved (Figure 1).

There is debate among growers about whether suckers should be removed using this system. Those that advocate removing suckers remove only the bottom five and allow the remainder to develop.

Cage system. In addition to the three training systems described, of which many adaptations exist, one more method of plant support bears mentioning: the cage system. The cage system consists of a cage made of 6-inch concrete-reinforcing wire mesh. The inside diameter of the cage is usually 12 to 16 inches and the height is 60 inches. Support

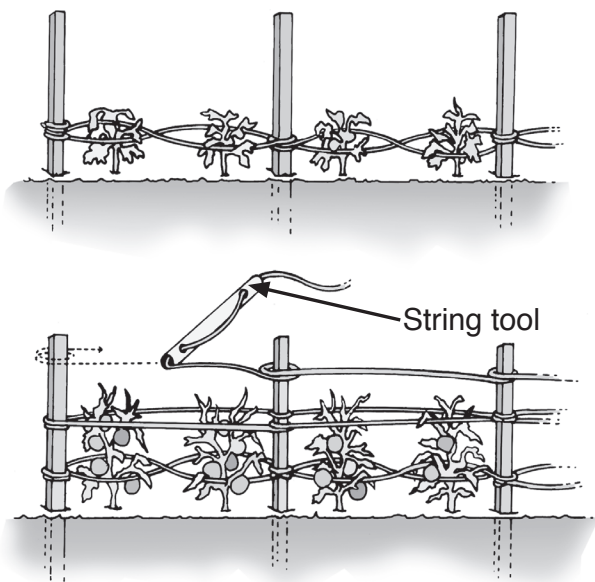


Figure 1. Stake-and-weave trellising system.

the cage with a metal or wood stake. Using this system, you can allow the tomato plant to grow up through the cage with essentially no pruning. Tomatoes can be harvested through the wire mesh with little difficulty.

Mulching

For early tomato production, apply black, clear or infrared-transmitting (IRT) plastic mulch before setting plants. These mulches increase soil temperatures and reduce weed emergence and soil evaporation. For maximum effectiveness, black plastic mulch should be in close contact with the surface of soil for effective transfer of heat. Clear plastic mulch will increase soil temperatures much more than black plastic, but weeds can germinate under the clear plastic.

Organic mulches such as straw or hay can be used but involve considerably more labor and expense to apply. Plus, they tend to delay soil warming in the spring. Before you use straw or hay, check its production history and do not use any from pastures on which herbicides with long residual effects, such as picloram, were applied.

Cultivation and weed control

The main reason for cultivation is to eliminate weeds. Weeds not only compete with tomatoes for light, moisture and plant nutrients, but they also harbor pests and diseases. Cultivate the crop as needed unless or until herbicides have been applied. Any cultivation should be shallow to avoid root damage.

As plants grow and support systems are established, cultivation within the row becomes more difficult. At that point, preemergence herbicides can be used in the row to supplement or replace cultivation and reduce hand labor. Preemergence herbicides labeled for tomatoes can be

applied in a band up to 2 feet wide within the row. Middles may be left untreated to be cultivated.

Another method of weed control is to use a preplant herbicide. These herbicides can be safely added into the soil a certain amount of time before planting.

Herbicides offer two advantages: they help control weeds within the row, reducing the need for hand cultivation, and they reduce weed invasion on soils too wet for cultivation.

Several herbicides are approved for use on tomatoes, but recommendations are subject to change from year to year. Consult the current edition of the *Midwest Vegetable Production Guide for Commercial Growers* for recommended compounds registered for use on tomato plants.

Fertilization

Before planting tomatoes, fertilize the soil by applying 20 pounds of nitrogen, 40 pounds of phosphorus and 40 pounds of potassium (20-40-40) per acre. Apply fertilizers about 6 inches deep in the row ahead of row bedding or ridging. When planting on level soil, place the fertilizer about 4 inches to the side of the row and about 4 inches deep, preferably a week or two before transplanting.

Sidedress at the rate of 30 pounds of actual nitrogen per acre when the first fruits are about 2 inches in diameter. A fertilizer source high in nitrate nitrogen is preferable; calcium nitrate is an excellent choice. Make repeated sidedressing applications every three or four weeks as long as the foliage and vines are healthy and productive. Apply the nitrogen sidedressing in a band just outside the foliage canopy. Be sure to keep the dry fertilizer off of the foliage.

Fertilizer also can be applied through the irrigation system if drip irrigation is used. This technique is often referred to as “fertigation.” It allows nutrients and water to be applied as the crop grows, rather than all of the nutrients being applied at once, either during or before planting. Fertigation saves both water and fertilizer.

Fertigation of nitrogen can be applied based on the volume of water applied by irrigation or based on area. Most tomato roots will be concentrated in a 24- to 30-inch-wide section of the bed or row. Multiply the root zone width by the length of each row and the total number of rows to determine the effective bed width. Additional nitrogen can be applied through the drip irrigation system at a rate of 8 to 10 pounds per acre per week, or 2.9 to 3.7 ounces per 1,000 square feet per week (Table 3).

Many commercial tomato growers fertilize with calcium nitrate and alternate weekly with a high-potassium fertilizer, such as 4-18-38, particularly during ripening. Calcium reduces the incidence of blossom end rot, and recent research suggests potassium helps to improve fruit quality.

Plant tissue testing is the best way to determine if tomato nutrient levels are sufficient. Randomly select plants beginning at flowering or early fruit set. For determinate tomatoes, break the fifth or sixth limb from the top of 10 to 12 plants. For indeterminate tomatoes, choose a leaf above a fruit that is about 2 inches in diameter from 12 to 20 plants.

Table 3. Amount of water-soluble fertilizers used to fertigate fresh market tomatoes.

Nitrogen required		Equivalent rate of commercial nitrogen fertilizers (ounces per 1,000 square feet)			
Pounds per acre equivalent	Ounces per 1,000 square feet	15-0-0	20-20-20	4-18-38	9-45-15
4	0.7	5	4	18	8
6	2.2	15	11	55	24
8	2.9	19	15	73	32
10	3.7	25	19	93	41

Place all limbs or leaves in one paper bag. Dry the sample before sending it to a laboratory for analysis. If necessary, adjust your fertilizer program based on the test results.

Irrigation

Tomato plants should never be allowed to suffer from a water shortage. Good yields and high-quality fruit are the result of steady, even plant growth, which is the result of a continual supply of adequate moisture. Erratic soil moisture encourages fruit cracking and blossom end rot, described in the *Physiological disorders* sections.

Tomatoes tend to require more water as they grow older (Figure 2). Critical growth periods for adequate watering of tomatoes are during flowering, fruit set and fruit development. Because tomatoes are nearly 90 percent water, the greatest need for water occurs during fruit development.

An average of between 2 and 2½ quarts of water per plant per day is needed when water demand is at its greatest. This equates to more than 300 gallons of water per week per 100 tomato plants.

Drip irrigation may be the most effective method of irrigation for tomatoes. Frequent, often daily, application of a measured amount of water directly to the root system nearly eliminates moisture stress. The main disadvantage of drip irrigation is the initial cost of the equipment.

Insects

Several damaging insects are likely to be present every year on tomatoes. The use of integrated pest management (IPM) tactics is recommended for their control. IPM is defined as “the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified.” IPM does not preclude the use of pesticides but

attempts to use them as one of a series of possible control measures. When pesticide use is warranted for insect control, refer to the current edition of the *Midwest Vegetable Production Guide for Commercial Growers* for recommended compounds registered for use on tomato.

Aphids. Aphids are soft-bodied insects that thrive on tomato plants during the cool months of spring and fall. In addition to carrying and transmitting viral diseases, aphids damage tomato plants by extracting sap from the leaves and stems and excreting a sugary mixture called honeydew that covers and discolors the fruit and leaves. Aphids typically move from concentrated areas, or “hot spots,” to the remainder of the crop. Early detection and control are crucial.

Cutworms. Cutworms may be gray, brown or mottled in appearance and up to 1½ inches long. In general, they hide in the soil during the day and come out at night to feed on the tomato stems. Cutworms usually cut off the entire plant about an inch above the soil line. Avoid planting tomatoes on recent pasture or sod land or near cultivated farmland where cutworm populations may be high.

Flea beetles. Flea beetles are small, black jumping insects that eat small, round holes in tomato leaves early in the season. This damage is the best indication of a flea beetle infestation because the insects themselves tend to be elusive.

Spider mites. Two-spotted spider mites are small insectlike pests about the size of a grain of salt. They are light tannish and wingless. They feed by extracting the contents of leaf cells, most often favoring the undersides of leaves as feeding sites. Spider mites can become abundant, especially during hot weather. When populations build, they spin very fine webs that are caught by a breeze to transfer them to neighboring plants. They are a challenge to control because of their tendency to build resistance to pesticides. Early detection is a must for effective spider mite management.

Stink bugs. Stink bugs can be a serious problem. The adults are brown or green shield-shaped insects that

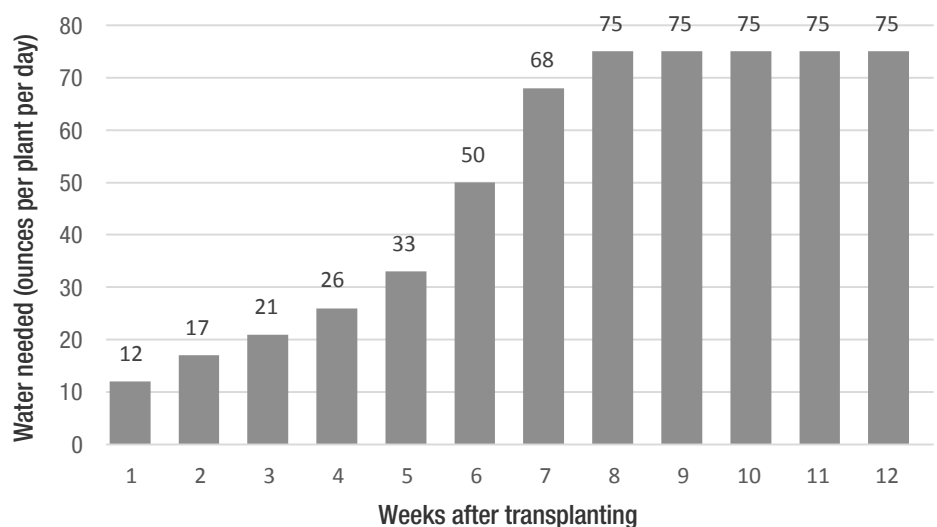


Figure 2. Water requirements of tomato plants at various stages of growth.

produce a foul odor when handled. They suck juices from the plant and cause hard whitish spots to form just under the skin of the tomato fruit. Although the symptoms are superficial, they make tomatoes unattractive and, thus, less salable.

Thrips. Thrips are small, slender insects that feed on tomato flowers, leaves and developing fruit. Although less common than other insect pests on tomatoes, thrips can become a problem when populations grow. Feeding on leaves results in silvery, streaked tissue caused by the thrips rupturing plant cells. Feeding on flowers can result in pollination problems and blossom drop. Fruit damage appears as small yellow flecks on the skin.

Tomato fruit worm. The tomato fruit worm and corn earworm are the same insect. It is the larva of a nocturnal moth that, as the name implies, is attracted to tomatoes when they are flowering. The larvae feed primarily on tomato fruits, resulting in tomatoes that are of inferior quality or totally unsalable. The injury caused by fruit worm feeding makes tomatoes more susceptible to secondary damage caused by certain diseases.

Tomato hornworm. The hornworm is the larva of a large nocturnal insect known as the sphinx moth. These large green worms have a hornlike tail. Hornworms can eat a large amount of foliage in just a day or two. Fortunately, they rarely build large populations in field tomatoes.

Diseases

Tomato diseases can be devastating. Some, such as fusarium and verticillium wilt, are soilborne and are systemic, that is, they affect the entire plant. Others are primarily foliage diseases that reduce the photosynthetic capacity of the plant, thus reducing productivity. A few diseases attack the fruit, often making it unsalable.

Disease management should begin with use of resistant varieties, selection of a good site, and proper handling of plants when transplanting and training. Sanitation is extremely important because most plant diseases must be prevented and cannot be cured. Although disease inoculum (that is, the stage of the pathogen that causes infection) cannot be totally eliminated, rotating planting sites from year to year will help decrease disease severity. Preventive spray programs are necessary for the control of certain problematic diseases, such as *Alternaria* and *Septoria*. Start such a program about a week after transplanting and continue at about weekly intervals at least until harvest begins. The current edition of the *Midwest Vegetable Production Guide for Commercial Growers* is a good source of information for recommended compounds registered for disease control on tomato.

Fusarium wilt. A soilborne fungus that persists for a long time once established in the soil, fusarium wilt invades the roots, grows in the water-conducting tissues of the stem, and blocks the flow of water within the plant. The fungus grows best in soil temperatures of 80 degrees F or higher. Plants wilt slightly, begin showing progressively yellowish leaves from the bottom of the plant upwards, and within

a few weeks may become severely stunted. The water-conducting tissue in the stem usually appears dark brown if infection is severe or if the variety is very susceptible. Use resistant varieties or plant disease-free plants on noninfected soils. Grafting susceptible varieties, such as heirloom types, onto resistant rootstocks is another control strategy.

Verticillium wilt. Verticillium wilt is another soilborne fungus disease that persists for a long time in the soil once it becomes established. Fortunately, it is not as prevalent in Missouri as fusarium wilt. This fungus is most active at soil temperatures between 70 and 75 degrees F. Symptoms of verticillium wilt include yellowing, withering and dropping of older leaves. Younger leaves have a dull finish, and leaflets curl upward at the margins. The disease affects the plant uniformly with a general stunting and loss of foliage as the season progresses. The water-conducting tissues at the base of the plant show a dark color when cut. Use resistant varieties or plant disease-free plants on noninfected soils.

Early blight. Early blight is a troublesome foliage disease of tomato caused by the fungus *Alternaria solani*. It is very prevalent from late May through June. Infection is favored by wet foliage and temperatures between 66 and 73 degrees F. Symptoms appear first on the lower leaves of tomato plants as dark targetlike spots. The disease progresses up the plant canopy, eventually infecting the fruit. Stem lesions can form at the soil line, causing the plant to wilt. As the disease develops, the plant loses its leaves and eventually dies. Early blight inoculum survives on decayed plant material in the soil, therefore rotating planting sites is an important first step in control.

Septoria leaf spot. Septoria leaf spot is caused by the fungus *Septoria lycopersici*. Infection can occur at any time during plant development if conditions are favorable. Symptoms appear on the lower leaves as circular spots about 1/8 inch in diameter with a grayish-black center. Heavily infected leaves usually turn yellow and drop off, thus defoliating the plant. It is not unusual for tomatoes to be infected with *Alternaria* and *Septoria* at the same time. Fortunately, the control measures for both are similar.

Gray leaf spot. Gray leaf spot is caused by several species of fungi in the genus *Stemphylium*. Symptoms are very similar to those of Septoria leaf spot except the spots do not have grayish-black centers. Gray leaf spot is favored by warm, wet conditions.

Anthracnose. Anthracnose is fungus disease found mainly on ripening tomato fruit. It may lead to severe fruit rot, especially on unsupported tomato plants. Early symptoms appear as small, slightly sunken water-soaked spots on the fruit. As the fungus spreads, the fruit begins to decay and soften. As lesions grow, they tend to merge, leading to the decay of the entire fruit. Infection is favored by wet weather and relatively warm temperatures.

Tobacco mosaic virus. There are several strains of tobacco mosaic virus (TMV). TMV can infect tomatoes, tobacco, peppers, eggplants, petunias and such weeds as poke, groundcherry and horsenettle. Some strains of TMV produce only yellowish, mottled areas on the young

leaves. Other strains can cause severe symptoms on the fruit. This blotchy ripening is characterized by white to yellow patches radiating from the stem end of the tomato fruit and penetrating most of the outer wall. It is believed that blotchy ripening is caused by a direct infection of the tomato blossom by TMV. This form of mosaic can degrade the appearance and quality of tomatoes.

Prevention of TMV currently includes these practices:

- Use of resistant varieties, when available
- Controlling insect vectors, particularly aphids
- Eliminating weed carriers of TMV
- Avoiding the use of tobacco in any form when working with tomatoes
- Dipping hands in a powdered milk solution at frequent intervals before tying and pruning (this is done to deactivate the virus and prevent mechanical transmission).

Sclerotinia (timber) rot. Sclerotinia stem rot is a disease favored by cool, moist weather. Infection usually occurs at the time of flowering, and lesions are observed in stem joints and at the soil line. Eventually, large sections of the stem become invaded and the stem develops a dry rot. Within rotted stems are small, black sclerotia that serve as the source of inoculum for the disease. The plant wilt and loses foliage. Remove infected plants. Avoid using manure as a soil amendment unless it has been properly composted.

Bacterial speck and bacterial spot. Bacterial speck and bacterial spot are two potentially serious diseases of tomatoes. Bacterial spot occurs as dark angular spots on the leaves and scabs on the fruit. Bacterial speck produces similar leaf lesions but small, black specks on developing fruit. Bacterial spot is favored by warm, wet weather, whereas bacterial speck occurs most often during cool, wet weather. Sanitation is extremely important in the management of bacterial diseases. Use clean seed. Do not use wooden tomato stakes from field plots that have had bacterial spot or speck unless the stakes have been sterilized.

Nematodes. Nematodes are common and very damaging in the light sandy soils and sandy loam soils of southeast Missouri. The root knot nematode is the most damaging to tomatoes. Plants with nematodes attacking the roots exhibit various degrees of poor growth and moisture stress. Roots damaged by the root knot nematode are abnormally enlarged, warty or knotty, and incapable of sustaining the plant.

To reduce the potential for build-up of root knot nematodes, rotate tomatoes with nonsusceptible crops, or plant on soils where nonsusceptible crops have been grown for the past several years.

Use nematode-resistant varieties (Table 2) or use a soil fumigant before planting the tomato crop.

Physiological disorders

Physiological disorders are disturbances of the normal physiology — the organic processes or functions — of an organism or any of its parts. In the case of tomato plants,

these disorders usually are the result of nutrition, water or environmental stresses.

Blossom end rot. Blossom end rot appears first as a depressed, brown, rather dry rot the size of a dime to a half-dollar on the blossom end of the fruit. Secondary infections may occur and cause the whole fruit to rot. Blossom end rot is caused by a combination of calcium deficiency and wide fluctuations in available moisture. Excessive pruning, overuse of ammonium fertilizer, and genetics also have been implicated. Where possible, use calcium nitrate as the source of nitrogen and maintain an even moisture level.

Yellow shoulder. Yellow shoulder disorder can develop on tomato fruits in a high tunnel. Affected fruit will not develop red color when temperatures exceed 92 degrees F. The apical portion, or shoulder, of the fruit develops a yellow color with internal white tissue. The exact cause of yellow shoulder disorder is unknown; however, this disorder has been associated with inadequate foliage cover and poor fruit shading. Temperatures of fruit exposed directly to the sun can be extremely high, preventing full color development. Proper fertilization, selection of good cultivars, and the use of shade cloth can prevent this problem

Blotchy ripening (graywall). Blotchy ripening develops on mature green fruit before harvest. When the tomato changes color, gray, discolored areas of the fruit are present. Graywall can be caused by several continuous days of cloudy weather, excessive nitrogen, high soil moisture and, possibly, low potassium. Some cultivars appear to be more resistant to graywall than others.

Fruit cracking. Both radial and concentric fruit cracking are the result of irregular water supply. Older heirloom varieties are especially prone to fruit cracking. Using resistant varieties and providing them with a constant supply of soil moisture is the best way to prevent this troublesome disorder.

Catfacing. Catfacing is an extreme deformity that occurs mainly on the blossom end of a tomato. Cold weather at time of pollination seems to intensify the deformities. Large beefsteak types are most severely affected by catfacing. The disorder rarely is a problem after the weather warms.

White (green) core. Fruits affected by white core usually show no outward symptoms. When ripe fruits are cut, white hard areas, especially in the vascular region, are present in the outer walls. Under severe conditions, fruit may also show white tissue in cross-walls and the center of fruit. High temperatures and poor foliage cover during the ripening period seem to trigger the symptoms. Adequate potassium fertilization has shown to reduce white core, but may not eliminate it. Some varieties appear to be more susceptible to the disorder than others.

Physiological leaf roll. Older, lower leaves may roll upward and become stiff and leathery. The disorder is more common on trained and pruned plants. Leaf roll generally is triggered by extreme temperatures and conditions conducive to rapid water loss by the plant. In spite of its appearance, leaf roll does not appear to affect yield significantly.

Flower drop. Failure of tomato flowers to set can occur when temperatures are lower than 55 degrees F or higher than 90 degrees F. Varieties differ in their ability to set fruit at these temperature extremes.

Herbicide damage. Drift from 2,4-D and related herbicides can cause distorted leaves, twisted stems, dropping of flowers, and abnormal fruit shape. Tomatoes are extremely sensitive to 2,4-D and have been known to suffer damage even when the chemical was applied quite some distance away. When spraying tomatoes, do not use sprayers previously used with 2,4-D or any other herbicide.

Harvesting

Locally-grown tomatoes are highly sought after by consumers because of their flavor. Flavor is enhanced by allowing tomatoes to ripen on the vine as long as practical. For local sales, harvesting tomatoes at a stage where they are fully red, yet firm, is desirable. This timing equates to harvesting at least twice per week.

Many of today's hybrid tomatoes were bred for fruit firmness and hold up well even when fully ripe. However, for more distant markets, harvesting fruits at earlier stages of maturity might be necessary for the tomatoes to withstand the rigors of shipment.

When harvesting tomatoes, remove picking containers from the field as soon as possible. Grade and pack tomatoes using practices approved by the Food Safety Modernization Act. Tomatoes can be packed immediately after harvest without washing, or the fruit can be washed with chlorinated water at a concentration of 125 parts per million (ppm).

Use containers dictated by the market. Cardboard cartons are very popular and used by many commercial growers. When holding tomatoes for market, store at temperatures between 50 and 75 degrees F at a relative humidity of around 80 percent. Never refrigerate tomatoes or let storage temperatures rise above 85 degrees F.

Original authors: Arthur E. Gaus, Henry F. DiCarlo and John B. Lower

Economic considerations

Tomatoes are probably the most labor-intensive vegetable crop grown in Missouri. Tomatoes require hand-labor for operations such as staking, trellising, pruning, cultivation and harvesting. Preharvest labor requirements alone may exceed 300 hours per acre. Harvesting and packing requires substantial additional labor, especially for large harvests.

When assessing the feasibility of a new enterprise, it is important to consider the overall profitability. In 2013, the University of Missouri completed an analysis of the profit potential of producing field-grown, fresh market tomatoes. The returns are what producers could expect after paying all expenses of production, land and labor. This budget study suggested that field-grown, fresh market tomatoes have potential returns of around \$2,500 to \$5,000 per acre (Table 4).

Table 4 . Cost-return budget for fresh market tomatoes.

	Yield (20 pound boxes per acre)		
	1,100	1,300	1,500
Income	\$12,650*	\$14,950*	\$17,250*
Variable costs	\$9,652	\$10,322	\$10,992
Fixed costs	\$508	\$508	\$508
Total costs	\$10,160	\$10,830	\$11,499
Return over total costs	\$2,490	\$4,120	\$5,751
Total costs per box	\$9.24	\$8.33	\$7.67
Return per box	\$2.26	\$3.17	\$3.83

*Assumes \$11.50 selling price per box. No marketing costs included in figures.

Resources

Food Safety Modernization Act: <http://www.fda.gov/Food/GuidanceRegulation/FSMA>

Midwest Vegetable Production Guide for Commercial Growers: <https://ag.purdue.edu/btny/midwest-vegetable-guide>

University of Missouri Extension Soil and Plant Testing Laboratory: <http://soilplantlab.missouri.edu/soil>

ALSO FROM MU EXTENSION PUBLICATIONS

- G6201 *Vegetable Planting Calendar*
- G6220 *Organic Vegetable Gardening Techniques*
- G6461 *Growing Home Garden Tomatoes*
- G6462 *Watering and Fertilizing Tomatoes in a High Tunnel*
- GH1456 *Quality for Keeps: Tantalizing Tomatoes — How to Can Fresh Tomato Products*
- M170 *High Tunnel Tomato Production*

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