

*A Plain Language Guide*

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# Growing Fresh Market Tomatoes

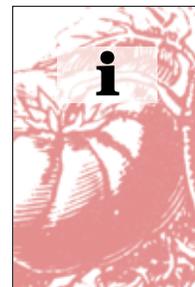


A. C. Newenhouse



The Wisconsin Farm Center has more information about services to help beginning farmers. To find this information on the internet look under the heading Farming and Agriculture at <http://datcp.state.wi.us/>.

Your local county Extension office also has more information for fresh market farmers. Go to <http://www.csrees.usda.gov/Extension/>. Click on your state and then your county to find the Extension office near you.



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# Plant Description

Tomatoes are a good crop to grow for local market because fresh tomatoes taste better and are better quality than tomatoes shipped from far away. Many people want to buy tomatoes. They are the second most popular vegetable in the United States and the most popular vegetable grown in American gardens. If you want to make more money from tomatoes you can also make and sell salsa. Salsa is very popular in the United States. Tomatoes have a lot of vitamin A and vitamin C. Tomatoes grow well in an unheated plastic greenhouse or hoophouse.

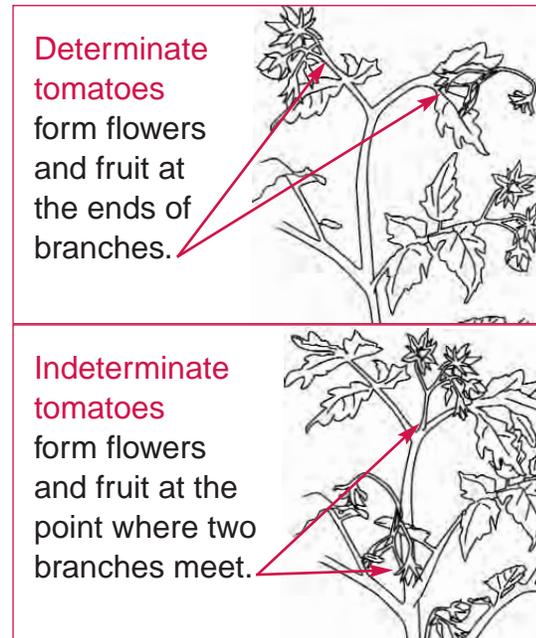
## Plant Description

The tomato (*Lycopersicon esculentum*) is native to the Andes mountains in South America. People thought tomatoes were poisonous until the 1700's. They are related to other plants such as the weed nightshade that contain a chemical poison. There is a small amount of the chemical in the leaves and other green parts of tomatoes and in unripe tomato fruit but it is not enough to harm people.

Tomatoes can not withstand cold temperature. Although they are perennial in the tropics they are annual in the cold climate of the Midwest.

Tomatoes have two types of growth pattern. One is called determinate. Another type is called indeterminate.

Determinate tomatoes form flowers and fruit at the ends of branches. Determinate plants are usually smaller. These types of tomatoes ripen earlier and usually ripen all their fruit at once.



Indeterminate tomatoes form flowers and fruit at the point where two branches meet. The branches keep growing and these plants are usually larger and form vines. Indeterminate tomatoes yield tomatoes over a long time. Some tomato plants share habits between the two forms.

Tomato plants have a deep taproot and many smaller side roots. The roots can grow down to 10 feet.

Tomato flowers are most often self fertile and are pollinated by wind. Flowers grow in clusters and one plant can have 20 or more clusters.



There are many different varieties of tomatoes. They may be red, yellow, orange, pink, purple, or striped, and their shape may be round, oblong, or pear shaped.

Tomatoes grow best when temperatures are around 75°F during the day and 68°F at night. Plants will produce the most fruit when there is a 10°F difference between day and night temperatures. If the temperature is below 60°F or above 80°F then tomatoes have less growth and fruit set, although some varieties of determinate plants can set fruit in cool temperatures.

### *Site selection*

Tomatoes need full sun. They like soil that is light, warm, well drained, and fertile. If soil has too much organic matter then the plant grows more leaves and less fruit. Soil pH should be between 5.5 and 7.5.

## Variety Selection

There are many varieties of tomatoes. Choose varieties that suit your farm and your market. When you try a new variety plant it near the old so you can compare them. Look for varieties that resist disease and will ripen during your growing season. Choose varieties that other growers like and also varieties that you like. If you like a variety you can describe it well and it will be easier for you to sell. Some tomato varieties are called “early crop” or “main crop”. “Paste” tomatoes are used to make tomato paste. Other tomato varieties are called “cherry” tomatoes or “grape” tomatoes because they are small and look like those fruits.

Tomato varieties can be open pollinated or hybrid. You can collect seed from an open-pollinated variety and grow a new plant like the parent. Hybrid plants are bred from two pure parent plants that have been crossed together. If your plant is a hybrid you cannot collect the seed and grow a new plant like the parent. “Heirloom” tomato varieties are older open-pollinated varieties.

Two diseases that are caused by fungi in the soil affect tomatoes. These are Verticillium wilt and Fusarium wilt. If you know your soil has this problem, choose tomato varieties that resist these diseases. Some tomato varieties also resist nematodes, which are small worm-like animals that live in soil.



# Variety Selection



<b>Tomato Varieties</b>	
<b>Variety</b>	<b>Days to first harvest</b>
<b>Indeterminate (climbing)</b>	
New Girl	62
Early Girl	64
Big Beef	70
Estiva	70
Better Boy	72
Wisconsin 55	75
<b>Determinate (bush)</b>	
Orange Blossom	60
Valley Girl	65
Celebrity	72
BHN-826	72
Paragon	78
<b>Heirloom</b>	
Green Zebra	72
Black Prince	74
Valencia	76
<b>Cherry</b>	
Favorita	58
Red Pearl (grape type)	58
Sun Gold	57
Sweet Million	65
<b>Paste</b>	
Roma VF	76
Viva Italia	76
San Marzano	78
Amish Paste	80
<b>Hoophouse</b>	
Estiva	70
Geronimo	78



## Planting and Care

Tomatoes need a long, warm growing season. Farmers usually start tomato plants inside under lights or in a greenhouse and transplant them outside after the last frost in spring. Start tomatoes 4-6 weeks before you transplant them to the field. Plants will transplant best if they are 4-6 inches tall and do not have flower buds. You can buy or mix your own sterile potting mix. The mix should include compost, peat, or sphagnum to hold moisture; vermiculite or perlite for aeration; and mineral and nutrient sources to feed the new plants after the first roots form.



- ❖ Sterilize plastic or styrofoam cell trays in a 10% bleach solution before you plant. You can make a 10% solution with one part bleach and 9 parts water.
- ❖ Fill the transplant trays with potting soil, or make individual blocks with a soil blocker. Cells that are 2" diameter are a good size.
- ❖ Plant seeds ¼ inch deep.
- ❖ Label the trays with variety and planting date.
- ❖ Keep soil moist but not wet.
- ❖ The soil temperature should be warmer than the air temperature until the seeds sprout. Use a heating mat or a cable under the trays to keep soil temperature at 80-90 °F.
- ❖ Air temperature during the day should be 70-75 °F and at night should be 60-62 °F. After the seeds sprout you can keep the soil temperature at 70 °F, or the same as the air temperature.
- ❖ Thin seedlings to one plant per cell or plug, or one plant every 2 ½ inches.
- ❖ Ten days before transplanting out to the field, harden off the plants by putting them outside for a few hours each day during the warmest time of the day, or move plants into a cold frame. The section on season extension describes a cold frame.

While you harden off the tomato plants, be very careful to keep them



warm. Tomato plants cannot tolerate any frost or cool temperature. Bring plants inside if the temperature starts to dip below 40-45°F. Give the plants less water and no fertilizer during this time because it helps prepare them to be planted in the field. Tomato plants can become “over-hardened”, which happens when they spend too much time in between greenhouse growing and field planting. If this happens, the

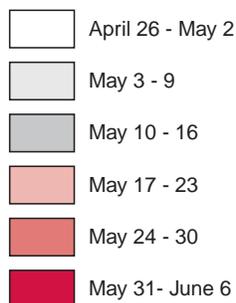
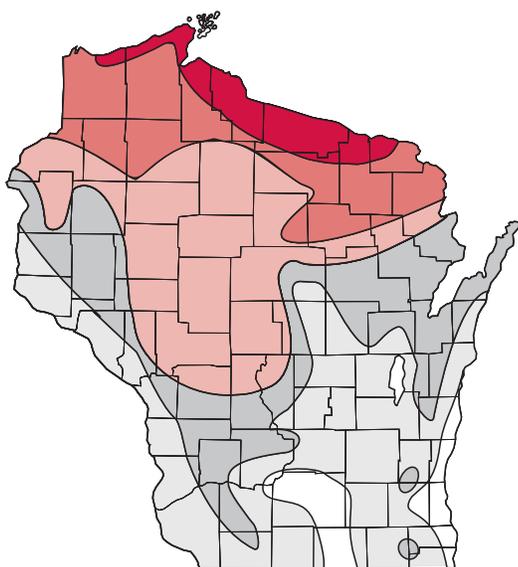
plants will take a long time to grow after they are planted in the field.

### Seed storage

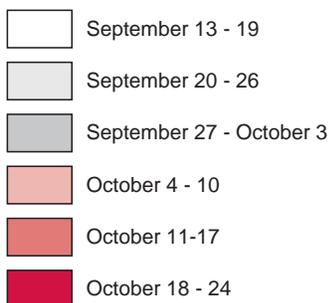
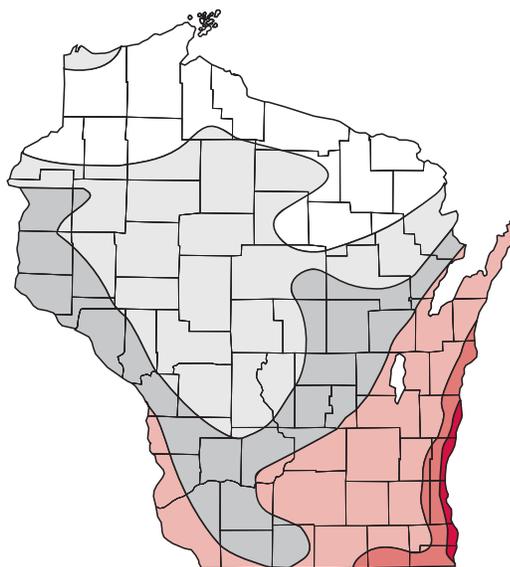
If you have seeds left at the end of the year, store them in an airtight glass jar in a cool, dark, dry place such as a cellar. You can sprout the seeds to test germination next year. In the best storage these seeds could keep for 4 years.

## Frost dates maps

Last spring killing frost



First fall killing frost





## Planting and Care

### *Soil preparation*

Work beds 7-8 inches deep to promote deep rooting. Never work wet soil because this can cause soil compaction. Compacted soils are hard and do not hold enough air. Compacted soils prevent oxygen and water from reaching roots, and plants do not grow as well or produce as much.

### *Raised beds*

You can use raised beds to help soil drainage and prevent compaction. Raised beds are usually 4-5 feet wide and 100 feet long. Leave a 1-foot aisle on either side of each bed for a foot path.

### *Plant spacing*

Before you plant into the field, decide what type of field equipment you will use and how you will support the tomato plants. This will determine how far apart your rows should be. You can plant tomatoes 18-24 inches apart in rows 3-4 feet apart.

### *Supports for tomatoes*

Tomatoes grow best if plants are staked or grown on a trellis. If you give the plants support then the fruit is larger, cleaner, earlier, and easier to harvest. Also you can prevent some diseases this way and you can fit more plants in a small area. Farmers who grow indeterminate varieties (which tend to be tall) usually use a “basket weave” trellis system. Farmers who grow determinate varieties can either use the “basket weave” trellis system or tie the plants to one stake.





## *Basket weave trellis system*

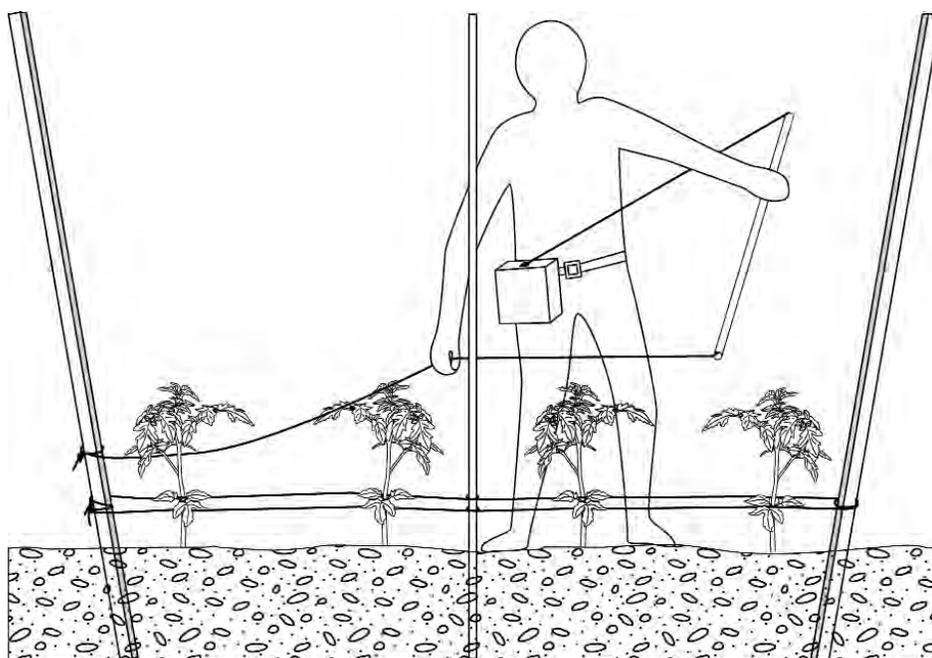
### Set up the trellis

- ❖ Choose stakes that are 1 inch square and 5-7 feet long (length depends on the height of the tomato variety).
- ❖ Drive stakes 1 foot into the ground between every other plant in the row.
- ❖ On each end of the row, either use a heavier stake or drive two stakes into the ground with one at an angle and tied to the first so it can take more weight.
- ❖ If your rows are long, leave a section open in the middle so you can walk between rows at harvest time.

### Weave the trellis

- ❖ When the plants are about 12 inches tall, before they fall over, begin the basket weave at 8-10 inches above the ground.

- ❖ Use strong, durable “tomato twine” which comes in a box that attaches to your belt.
- ❖ Tie the twine to an end stake and pass it along one side of the plants and around each stake.
- ❖ Pull the twine tight as you go.
- ❖ At the end of the row, go to the other side of the plants and loop twine around each stake until you are back where you started.
- ❖ Tie the twine to the first stake.
- ❖ It is easier to weave the twine if you thread the end through a 12-36 inch piece of plastic pipe.
- ❖ As the plants grow, add twine 6-8 inches above the previous twine until you have a trellis of 4 strings.
- ❖ If the plants grow taller than the stakes, guide branches back down into the trellis.
- ❖ At the end of the season, you can pull up the stakes and plants and compost the plants and twine.

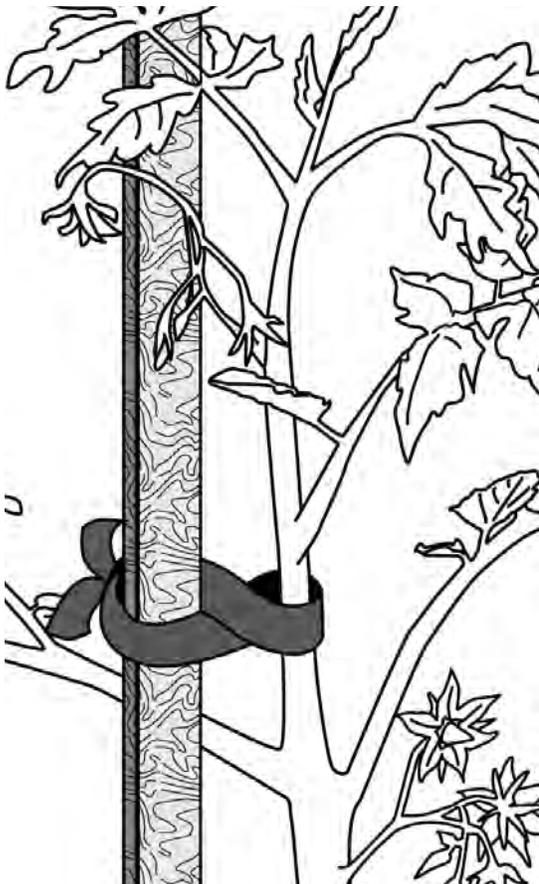




# Planting and Care

## *Staking tomato plants*

- ❖ Use wooden or metal stakes 4-6 feet long.
- ❖ Drive a stake into the ground next to each tomato plant at the same time as you transplant into the field.
- ❖ If the soil is too hard to insert the stake, soak the soil to make your work easier. If you wait to stake plants until they have started to grow in the field you can hurt the root system.
- ❖ As the plant grows, tie the plant loosely to the stake with a piece of cloth or twine. (see drawing, like a figure 8).



## *Tomato cages*

You can make cages for each tomato plant.

- ❖ Use the type of wire mesh that is sold as “concrete reinforcing wire”. This is very strong and the ends can be sharp.
- ❖ Wear gloves when you work with this wire.
- ❖ Use bolt cutters to cut sections 5 feet tall and 6 feet wide.
- ❖ Form each section into a circle and use pliers to form hooks on one side to fasten the sides together (see photo below).
- ❖ Cut and remove the bottom horizontal wire to leave wire legs to stick in the ground.
- ❖ Put the tomato cage around the plant soon after transplanting.
- ❖ Guide branches back into the cages as the plants grow.





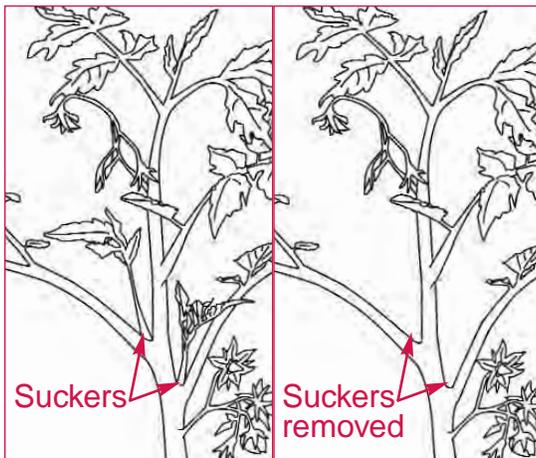
### *Pruning tomatoes*

You don't need to prune tomatoes unless you want to create slightly larger fruit or keep your plants neat. If your plants are determinate you should not prune them because they will not produce as much fruit. Do not prune plants growing in tomato cages.

If your plants are indeterminate and you want to prune them:

- ❖ Let two or three branches grow from the base of the plant. They will become the main stems.
- ❖ When a new shoot starts to form at the base of a branch, snap it off when it is about 3-4 inches long (see drawing). These side shoots are sometimes called suckers.

Some tomatoes are a type between determinate and indeterminate. If you want to prune these types, only remove the lower side shoots up to the one below the first flower cluster.



### *Preventing plant diseases while working*

- ❖ Do not smoke cigarettes or use chewing tobacco while you work with tomato plants because diseases caused by viruses can spread from tobacco to tomato.
- ❖ Do not use scissors to prune tomatoes because disease organisms can spread from plant to plant on the scissors.

### *Season extenders*

You can make the growing season longer and harvest tomatoes earlier in spring and later in fall. Protect plants from late spring frosts and early fall frosts using these methods:

- ❖ plant on a south-facing slope
- ❖ cover the soil with black plastic
- ❖ use floating row covers
- ❖ place clear plastic tunnels over the rows of young plants
- ❖ plant windbreaks
- ❖ place young plants in a cold frame
- ❖ grow tomatoes in a greenhouse or plastic hoop house



### *Black plastic mulch*

If you cover the soil with black plastic ("plastic mulch") you can raise the soil temperature 4-5°F and harvest tomatoes 1-3 weeks earlier. The plastic prevents weeds. It also keeps the crop clean and prevents fungus and bacteria spores in the soil from splashing onto the plant, which prevents diseases. Farmers who use black plastic mulch often use drip irrigation under the plastic. If moist soil is covered with plastic the water stays in the soil and does not evaporate.

If you decide to use black plastic mulch you must apply it correctly.

- ❖ Lay wide strips of 1.25-1.5 mil black plastic by hand or with a machine attached to a tractor.

- ❖ Work the soil and hill it up to make a long raised bed that is slightly higher in the center so water runs off to either side.
- ❖ The bed should be firm.
- ❖ Lay the plastic tightly over the bed and bury it half way up the sides.
- ❖ When you plant into the plastic, you can cut holes for the plants with a scissors or burn holes with a propane torch.
- ❖ Do not leave a flap of plastic at the hole because when it is windy it can scrape the plant stem.

Black plastic mulch is expensive, difficult to re-use, and difficult to recycle. Farmers who use black plastic do so because in their situation they can grow better quality tomatoes earlier with fewer weeds.





### *Floating row covers*

Floating row covers are special sheets of white fabric made of spun-bonded polypropylene which lets sunlight and water through the fabric but stops insects. You can use row covers in spring on young tomato plants to keep them warm.

- ❖ Row covers protect plants from frost and wind.
- ❖ Row covers come in different weights and the thicker ones can warm plants by 4-8°F.
- ❖ You can plant tomatoes 3-4 weeks earlier in the spring.
- ❖ You can wash and re-use fabric for two to three seasons.

Put the row cover on top of the crop or hold it up with wire hoops. If you use wire hoops to hold up the row cover, use 9-gauge wire 6 feet apart and buried 1 foot deep on each side of the row.

If you gather the edges and loosely bury them along the crop row, then as the crop grows it will push up enough fabric to form a “floating” cover. You can also use rocks or heavy posts to hold down the edges.

In early spring, take the row covers off when the air is warm enough for the tomatoes to grow. Before this, let the plants harden off for a few days to prevent heat and sun from burning the crops. Do this by removing covers on cloudy days or for a few hours on sunny days. On very hot days, be

sure to lift the row cover to give plants some air.

### *Tunnels and cold frames*

Tunnels are large, unheated plastic covers that make a greenhouse over a row of plants. They can also be used to lengthen the growing season for young plants in spring. Use metal or plastic hoops to hold up clear plastic over young tomato plants. Cut slits in the plastic for air flow. Tunnels made of clear plastic with slits increase daytime temperatures by 10-30°F and give 1-4°F of frost protection.

Cold frames are a type of planting bed made by building wooden sides on each side of a bed on the ground. The back is higher than the front and the frame holds up a glass top at an angle to the sun facing south. You can use an old window to make a cold frame. Cold frames also warm the soil. You can use a cold frame to put your tomato transplants outside earlier in the spring before you transplant them to the field.





### *Windbreaks*

If the area where you want to grow tomatoes is windy you might want to make a windbreak. Wind blows dust and sand which can make a small wound in the leaf or fruit. Fungus and bacteria can enter the plant through the wounds. A windbreak will help prevent these diseases. A windbreak will also help warm the area.

Put the windbreak in a row on the side of the field where most of the wind is coming from. You can plant fast growing trees or shrubs, or put up a fence made of plastic mesh.

A windbreak will help stop wind in an area 2 ½ times as far as it is tall. For example, if the windbreak is 10 feet tall then it will help stop wind in an area up to 25 feet away from the windbreak. Some farmers plant a tall cover crop such as rye grain between rows to act as a windbreak.

### *Greenhouse and hoop house production*

Tomatoes grow well in greenhouses, plastic hoop houses, or plastic tunnels, where you can plant 4-6 weeks earlier than outside. You can also harvest through November before sunlight is too weak. You can use floating row covers on top of tomatoes to give them extra warmth when they are growing in a greenhouse or hoop house.



## Soils and Nutrient Management

Get a soil test before you plant a field for the first time and then at least once every 3 years. For information on how to collect samples and where to send them for analysis, see UW Extension publication *Sampling Soils for Testing* (A2100).

Most soil tests include pH, organic matter, phosphorus, and potassium. You can also ask to test for nitrate-nitrogen, calcium, magnesium, sulfur, boron, manganese, and zinc. You will receive the results of your soil test along with fertilizer recommendations based on how you will use your field. You can also test your potting soil and the soil inside your hoop house or greenhouse.

### Soil pH

Soil pH measures acidity. Soil pH should be between 6.8 - 7.0 for tomatoes so they can take up the most nutrients from the soil and have enough minerals. If the pH is below 6.0, apply aglime to raise the pH.

### Fertilizer needs

Tomatoes need nitrogen, phosphorus, and potassium in large amounts and many other nutrients in small amounts. Choose fertilizer from organic or inorganic sources. Healthy soil has tiny organisms (microbes) that break down organic matter into nutrients that plants need to grow. Over time, organic fertilizer can build your soil and make the soil more healthy and fluffy which lets plants grow more easily. Inorganic fertilizers give plants nutrients quickly but do not build the soil. Some inorganic

**Table A. - Soils and Nutrients**

Annual nitrogen, phosphate, and potash for tomatoes								
Vegetable	Nitrogen			Phosphate and potash				
	Organic matter	Amount to apply <sup>a</sup>		Soil test categories	Amount to apply <sup>a</sup>			
		lb/acre	oz/100 sq ft		Phosphate (P <sub>2</sub> O <sub>5</sub> )		Potash (K <sub>2</sub> O)	
%	lb/acre	oz/100 sq ft	lb/a	oz/100 sq ft	lb/a	oz/100 sq ft	lb/a	oz/100 sq ft
Tomato	<2.0	140	5.25	20 -25	40	1.5	180	6.75
	2.0 - 4.9	120	4.4					
	5-10	100	3.75					
	>10	80	3.0					

<sup>a</sup> Amounts of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O are for soils that have correct levels for tomatoes.

If soil test shows higher P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O than needed, do not apply at all or apply at half this amount.

If soil test shows low P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, add more according to the test results.



fertilizers have a lot of salt which is bad for soil organisms.

Organic fertilizers can come from manure, compost, fish meal, bone meal, and live compost tea that includes oxygen. Recent studies show that live compost tea helps prevent plant diseases and also gives nutrients to plants. Live compost tea is made by carefully mixing fungi, bacteria, sugars, water, and a steady stream of air to grow active soil micro organisms.

Table A gives the amount of fertilizer tomatoes need. Look at your soil test results to learn how much phosphorus and potassium you will need. Work this into the soil before planting. If your soil is mostly clay it has small particles and the soil particle size is called "fine textured". If your soil is mostly sand it has large particles and the soil particle size is called "coarse textured". For fields with mostly clay, add nitrogen fertilizer to the soil and work it in before planting.

For fields with mostly sand, add part of the nitrogen fertilizer to the soil before planting and add the rest later. Work in 20-40 lbs nitrogen/acre (0.75-1.5 oz /100 square feet) nitrogen per acre before planting. Later, either once or twice after the fruit sets, add the rest in a strip near the plant roots.



### *Irrigation*

Tomatoes need water regularly because when they do not have enough water they do not produce as much fruit. If leaves begin to wilt in the middle of the day, plants do not have enough water. Plants that wilt for a short time will not produce as big a yield. Plants that wilt often or for a long time might die.

Calcium needs water to travel through the plant. If tomatoes do not get enough calcium they can develop blossom end rot. Prevent blossom end rot by giving tomato plants enough water.

Tomatoes need one inch of water every week.

- ❖ Irrigate every 5-10 days depending on the soil type and rain.

- ❖ Soak the soil so roots grow deep.
- ❖ Use either drip irrigation or sprinkler.
- ❖ Drip irrigation saves water and helps prevent leaf diseases.
- ❖ If you use a sprinkler, water early in the day so leaves dry quickly.
- ❖ Keep the leaves dry to prevent diseases.

Mulch is important for tomato plants.

- ❖ Mulch can help keep moisture in the soil.
- ❖ Mulch also prevents disease because fungus and bacteria spores from soil cannot splash up onto leaves.
- ❖ Use straw, shredded leaves, or black plastic for mulch.





## Harvest, Handling, and Storage

Pick tomatoes by hand when they are sweet and ripe. Taste your own crop to learn the best time to harvest from your field. If you know your own crop well you can talk about the high quality of your produce with customers. People who buy local tomatoes want fresh, vine ripened fruit with the best possible flavor. Tomatoes that are picked when mature but not ripe will still ripen off the vine, but their flavor will not be as good.

It takes a tomato ten days to go from the mature green stage to be table ripe. You can use Table B to estimate when your tomatoes will be ripe and to plan for when you will need help to harvest them. This table is from the USDA and helps create standards to describe the fruit.

Many farmers wipe tomatoes clean with a cloth before sale. Some farmers put tomatoes in a water bath to remove field heat after harvest. If you use a water bath, do not let tomatoes chill. Once a tomato is chilled it will not ripen further.

*Table B. - Tomato Ripening Stages*

USDA Classification	Description	Days to full color
Green fruit	skin is whitish green, gelatin formed around seeds	9-13
Breaker	some color on blossom end	8
Turning	10-30% pink starting at blossom end	7
Pink	30-60% pink or red	6
Light red	60-90% pink or red	3
Red/firm ripe	>90% red	1
Table ripe	ready to eat, fruit somewhat soft	0



## Harvest, Handling, and Storage

Handle tomatoes gently since they bruise easily.

- ❖ Do not stack tomatoes higher than two layers.
- ❖ Pack them in shallow cardboard boxes or trays.

Tomatoes are sensitive to cold.

- ❖ Do not store tomatoes below 55° F.
- ❖ Never let ice touch tomatoes.

If tomatoes become too cold or touch ice, they can develop poor flavor and irregular ripening. Tomatoes continue to ripen in temperature above 55° F. Tell your customers to store tomatoes on the kitchen counter and not in the refrigerator.

Sell tomatoes within 2-3 days for best flavor and quality. You can store tomatoes for up to 2 weeks and keep good quality if you have the right conditions. The storage area should be cool and humid.

- ❖ Store tomatoes above 55° F.
- ❖ Store tomatoes at 85-90% humidity.
- ❖ If tomatoes are mature and green you can store them for up to 6 weeks in these conditions.



## Preventing Stress on Your Body

Try to prevent stress on your body when you grow tomatoes.

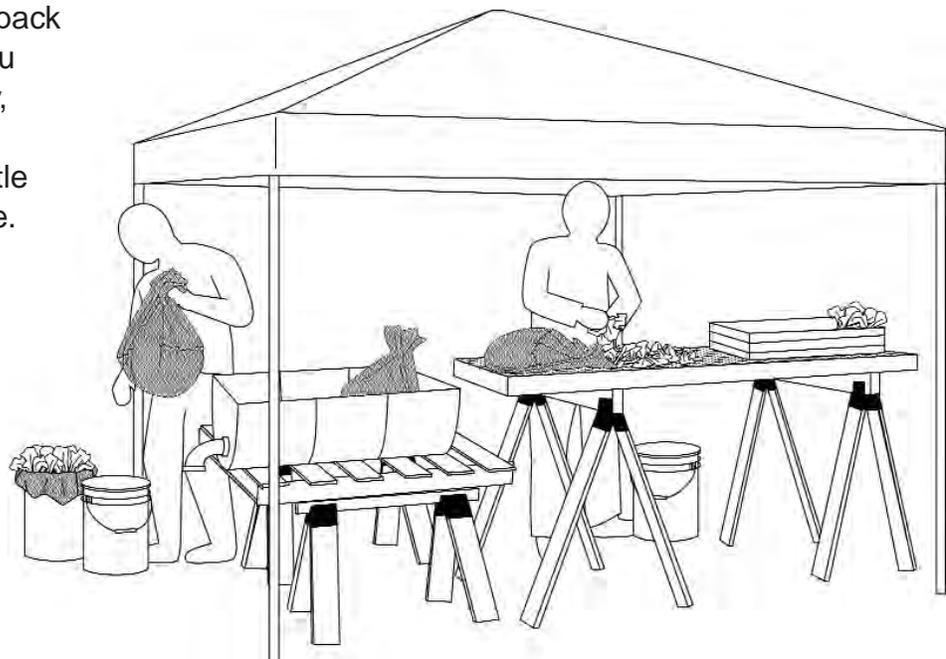
- ❖ Try to prevent stooping or bending.
- ❖ Change your position often.
- ❖ Sit on a stool or a pail. You can use a stool that you wear as a belt, or a stool on wheels that rolls along the row like a cart.
- ❖ Use garden carts and wagons as often as you can so you do not lift and carry so much.
- ❖ If you use a standard plastic container that stacks and is easy to load, unload, and clean, you will save time.

In the place where you pack your crops, try to have a smooth level floor so it is easier to work with carts and wagons.

- ❖ Set up your wash and pack area so you walk, carry, stoop, and bend as little as possible.

- ❖ Set up work areas the same height as a table.
- ❖ Short people might want to stand on a stool to reach the tables more comfortably.
- ❖ To move boxes of produce, there are systems you can use with small pallets and hand pallet trucks.
- ❖ You can also buy roller table to move heavy boxes of produce.

There are examples of tools that make work easier from the University of Wisconsin-Madison Department of Biological Systems Engineering. Go to the department website <http://bse.wisc.edu/> and look under 'Department Links' for the Healthy Farmers, Healthy Profits Project. Click on Tip Sheets and go to the category for vegetable growers.





## Weed Management

You must control weeds to grow a good crop of tomatoes. Weeds take water, nutrients, space, and light away from your crop. Also, weeds left in the field might have diseases or insects that can harm tomato plants.

Before you plant, remove perennial and annual weeds.

- ❖ Do this by hand,
- ❖ by smothering with a cover crop (such as buckwheat),
- ❖ by covering the soil with black plastic to heat it and keep out light,
- ❖ by using herbicide sprays.

During the growing season, remove perennial and annual weeds.

- ❖ Cultivate or hoe regularly to remove annual weeds.
- ❖ If you cultivate early in the season you prevent most weed problems.
- ❖ If you use weed killers (herbicides), check and follow the rules on the label.
- ❖ Certified organic growers can only use approved organic weed killers.

If you use chemical weed killers, be sure you check the label and understand that the one you choose is legal for the crops you sell. Chemicals legal for a home garden might not be legal to use if you sell the crops.

Mulch helps keep weeds down and also helps prevent diseases and keeps the soil moist. You can use

black plastic mulch to prevent weeds. Black plastic also helps warm the soil in the spring.

You can also use straw as a mulch. A thick layer of straw blocks sunlight from reaching the soil. Weed seeds won't sprout.

Some growers use red plastic mulch to grow an earlier crop. We do not yet fully understand whether red plastic helps grow earlier tomatoes or helps warm the soil for earlier tomatoes.



**A thick layer of mulch like this straw on strawberries works well for tomatoes also.**



## Pest and Disease Management

Many insects and diseases affect tomato plants. The best way to control these problems are to prevent them. Choose varieties that resist diseases. Plant clean seed that does not carry diseases. Keep weeds out of the field. Put mulch on the ground so plants and fruit stay clean. Give the plants enough water and fertilizer so they grow well.

### *Tomato problems caused by weather and water*

Some problems with tomatoes are caused by weather or soil moisture. These are:

- ❖ Sun scald
- ❖ Growth cracks
- ❖ Blotchy ripening
- ❖ Green shoulder
- ❖ Catfacing
- ❖ Large core
- ❖ Leaf roll

**Sun scald** looks like white or pale sunken tissue on the fruit. If fruit is in direct sunlight sun scald can occur. Sometimes rot-causing organisms enter the fruit at the place where sun scald occurred, and the fruit rots. Tomato plants with fewer leaves are more likely to get sun scald. If a plant loses leaves from a disease then the tomatoes are more likely to get sunscald.

**Growth cracks** occur on the stem end of the fruit. They can be circular cracks around the stem end or they can be lines that spread out from the stem. Cracks appear as the fruit matures. Growth cracks happen when weather and moisture changes quickly. If the weather suddenly warms up, or if you have dry weather and then heavy rains you are likely to see growth cracks. Some tomato varieties are more likely to get growth cracks. You can prevent growth cracks by giving the plants enough water on a regular schedule and also the right amount of fertilizer on a regular schedule.

**Green shoulder** looks like the shoulder area of the tomato does not ripen and that part stays green. Some



**Sun scald**



varieties get green shoulder and others do not. If you see this in your field for several years, choose a variety that resists green shoulder.

**Blotchy ripening** happens when parts of the tomato do not ripen because of poor fertilization. Yellow or orange blotches appear on the skin and the tissue inside the fruit is hard and white. The blotches usually appear on the upper part of the fruit near the stem end. Blotchy ripening happens in cool years and is worse if the plants get too much or too little water. Sometimes plants that have a virus show blotchy ripening. Some varieties get blotchy ripening and others do not. It happens more often on older varieties.

**Catfacing** looks like the blossom end of the fruit has areas with deep grooves. Catfacing happens when the temperature drops below 50°F during flowering and fruit set. Sometimes too much heat, injury from the weedkiller 2,4-D, and uneven soil moisture can cause catfacing. Some varieties get catfacing and others do not. Tomatoes with large fruit are more likely to get it. Tomatoes from older varieties are more likely to get it.

**Large core.** Tomatoes that are not fully round might have “large core”. Cut open the fruit and look for parts that did not ripen and are filled with gel. The fruit will look flat near that part. These three things can cause large core: poor pollination, too much nitrogen, and poor seed development.

Large core can be worse in cold weather.

**Leaf roll** looks like the leaves curl upward. Leaf roll does not affect fruit production. It is worse in years that are very cold and wet. The leaves curl up because of high water pressure in the plant. Sometimes leaf roll can look like damage from leafhopper insects, but with leaf roll the edges of the leaves do not turn brown.

### *Tomatoes and Black Walnut trees*

Do not grow tomatoes near black walnut or butternut trees. These trees make a chemical called juglone that will kill tomato plants. The tree gives off this chemical from the roots, leaves, wood, and nuts.



**Black Walnut**

Robert Vidéki, Doronicum Kft., 5396389, Bugwood.org



## Tomato Diseases

Many tomato diseases are caused by fungus or bacteria spores that infect the plant. The spores live in the soil or on plants or weeds related to the tomato. Splashes from raindrops or irrigation carry spores up from the soil to the plant. You can prevent most infection with these steps:

- ❖ plant resistant varieties
- ❖ cover the soil with mulch
- ❖ control weeds, especially weeds of plants related to tomato such as nightshade and jimsonweed
- ❖ use drip irrigation instead of sprinkler
- ❖ rotate your crops at least every 3-4 years
  - ~ do not plant any plants in the tomato family
  - ~ tomato family includes potatoes, eggplants, peppers, tomatillo, ground cherry

### *Early blight*

**Description:** A fungus (*Alternaria solani*) invades the leaves, stems, and fruit. You see brown and black spots on older leaves first. These spots spread out in rings. Spots can be ¼-1/2 inches in diameter. A yellow halo may surround the spots. When the infection is really bad, the whole leaf may turn yellow and fall off. Green fruit gets dark, leathery, sunken spots near the stem end. Plants that get early blight often also get septoria leaf spot and sun scald.



Yuan-Min Shen, Taichung District Agricultural Research and Extension Station, 5393411, Bugwood.org

**Disease cycle:** The fungus lives over winter on infected parts of plants, seed, or in the soil. It can live for 1 year on infected parts of plants. If the spring is warm and wet you get more early blight. Tomatoes that ripen early are more likely to get early blight.

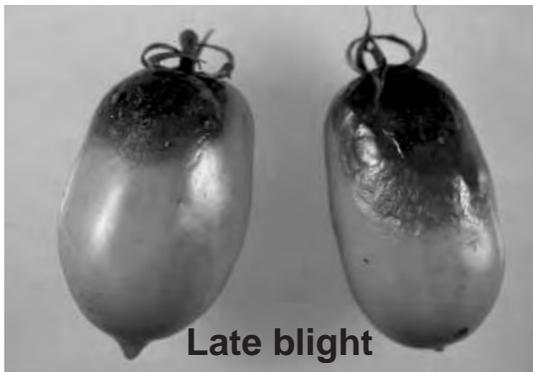
**Management:** Rotate your crops every 3-4 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other crops in the Solanaceae family. Use seed that is sold as “free of early blight pathogen”. Choose tomato varieties that resist early blight. If you want to use chemicals you can spray a fungicide every 7-10 days to prevent early blight. Certified organic growers can only use approved organic fungicides.

### *Late blight*

**Description:** A fungus (*Phytophthora infestans*) invades the leaves, stems, and fruit. Early after the disease strikes you see water soaked spots that grow to cover the whole leaf. Later, leaves turn brown and dry up. These water soaked spots also occur



on the stem. In wet weather you might see a white fuzzy growth on the underneath side of leaves. On the fruit, you see dark olive green greasy spots that can cover the whole fruit. Other fruit rots come and infect the fruit after late blight starts. As vines die, the disease makes vines smell very bad.



**Late blight**

Robert Wick, University of Massachusetts, 5333060, Bugwood.org

**Disease cycle:** The fungus lives over winter on infected parts of plants. In cool, wet weather the disease starts. Storms can carry late blight fungus spores very far. In this way the disease travels over great distances.

**Management:** Rotate your crops every 2-3 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other crops in the Solanaceae family. Destroy infected plants immediately. Destroy other infected plants in the Solanaceae family, such as potatoes and their tubers. Choose tomato varieties that resist late blight. If you buy tomato transplants, buy them

from a place where there is no late blight. If you want to use chemicals you can spray a copper fungicide to prevent early blight. Certified organic growers can only use approved organic fungicides.

### ***Septoria leaf spot***

**Description:** A fungus (*Septoria lycopersici*) invades the leaves. You see small round spots on the upper side of older leaves and water-soaked areas on the lower side of the leaves. The infection starts on the lower part of the plant and spreads upwards. Spores from infected leaves splash onto clean leaves with rain or irrigation water. Infection does not start until after fruit set. As the spots get bigger the edge of the spot turns dark brown and the center becomes sunken and gray. In the middle of these areas, you might see tiny black fungus with spores. Infected leaves fall off.



**Septoria leaf spot**

William M. Brown Jr., 5357038, Bugwood.org

**Disease cycle:** The fungus lives over winter on infected parts of plants or on infected weeds for up to 3 years. Weeds that sometimes get septoria



leaf spot are nightshade and jimsonweed. Ground cherries can also get the disease. Plants get more infection in wet weather. If you work in fields when the plants are wet you can spread spores and disease from plant to plant. Plants that have late blight often get septoria leaf spot also.

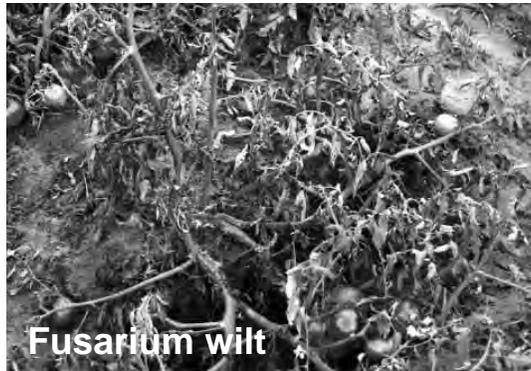
**Management:** Rotate your crops every 3-4 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other crops in the Solanaceae family. Destroy infected plants immediately after harvest in fall and plow them under. Do not compost infected plants. Destroy any other infected plants in the Solanaceae family, such as ground cherries. Remove weeds, especially the weeds in the Solanaceae family that can be infected with septoria leaf blight. Examples of these weeds are nightshade and jimsonweed.

Drip irrigation is better than overhead sprinkler irrigation because less water touches the leaves. This prevents spores from traveling on splashes of water. If you want to use chemicals you can spray a copper fungicide on the developing fruit to prevent septoria leaf spot. Certified organic growers can only use approved organic fungicides. There are no varieties of tomato that resist septoria leaf spot.

### *Fusarium wilt and Verticillium wilt*

Two other diseases caused by fungus are **fusarium wilt** and **verticillium wilt**.

**Description:** A fungus invades the tissue inside the stem. Water cannot reach the leaves. Older leaves start to turn yellow. Often the leaves on one side of the plant start to turn yellow. The infection starts on the lower part of the plant and spreads upwards until much or all of the plant dies. If you cut open a stem where the leaf is attached you see dark brown inside the stem. If you think you have fusarium or Verticillium wilt, bring a sample of the plant to your county Extension office for diagnosis.



**Fusarium wilt**  
Clemson University - USDA Cooperative Extension Slide Series, 1436102, Bugwood.org

**Disease cycle:** Fusarium and Verticillium fungi live in the soil for many years. Infection is worse when the soil stays wet and the air temperature is high.

**Management:** Rotate your crops every 3-4 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other



crops in the Solanaceae family. If you have had Fusarium or Verticillium wilt disease before, choose tomato varieties that resist the disease.

### ***Bacterial speck and Bacterial spot***

These two diseases often strike the same plant. They are caused by two different bacteria.

#### ***Bacterial speck***

**Description:** A bacteria (*Pseudomonas syringae*) invades the leaves. You see small (less than 1/8 inch diameter), dark round spots on the leaves. At first there is a yellow halo around the spots. Later, the spots spread to stems, leaf stems, and flowers. You may also see tiny dark spots on the fruit. The spots on fruit are often sunken with a darker green halo around the center.



**Bacterial speck**

Howard F. Schwartz, Colorado State University,  
5360972, Bugwood.org

**Disease cycle:** Bacterial speck is often carried on infected seed. Spores from infected leaves splash onto clean leaves with rain or irrigation water. If you work in fields when the plants are wet you can spread spores and disease from plant to plant. Plants get more infection in cool weather.

**Management:** Rotate your crops at least every 2 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other crops in the Solanaceae family. Use treated seed that does not carry the bacteria. Drip irrigation is better than overhead sprinkler irrigation because less water touches the leaves. This prevents spores from traveling on splashes of water. If you want to use chemicals you can use a spray that contains copper on the developing fruit to prevent bacterial speck. Certified organic growers can only use approved organic fungicides.

#### ***Bacterial spot***

**Description:** A bacteria (*Xanthomonas campestris*) invades the leaves. You see water-soaked brown spots or areas on leaves, stems, and fruit. There is a yellow halo around the spots. As the disease gets worse, leaves might start to turn yellow.

**Disease cycle:** Bacterial spot lives over winter on infected parts of plants. Spores from infected parts of the plant splash onto clean parts with rain or irrigation water. If you work in fields



when the plants are wet you can spread spores and disease from plant to plant. Plants get more infection in warm weather.

**Management:** Rotate your crops at least every 2 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other crops in the Solanaceae family. Remove weeds, especially weeds in the Solanaceae family that can be infected with bacterial spot. Mulch and stake the plants so fruit does not touch the soil. Drip irrigation is better than overhead sprinkler irrigation because less water touches the leaves. This prevents spores from traveling on splashes of water. If you want to use chemicals you can use a spray that contains copper on the developing fruit to prevent bacterial spot. Certified organic growers can only use approved organic fungicides.

### ***Anthracnose***

**Description:** A fungus (*Colletotrichum coccodes*) invades the fruit, leaves, and stems. You see small round water-soaked sunken brown spots on fruit. As the spots get



Clemson University - USDA Cooperative Extension Slide Series, 1436107, Bugwood.org

bigger they can combine into larger areas. The fungus can also invade leaves and stems. The spots are darker in the middle and have lighter rings around them.

**Disease cycle:** Anthracnose lives over winter on infected parts of plants and in the soil. The first point of infection is often fruit that touches the ground. Fruit can be infected when it is still green but you don't see spots until the fruit starts to ripen. Spores from infected parts of the plant splash onto clean parts with rain or irrigation water. If you work in fields when the plants are wet you can spread spores and disease from plant to plant. Plants get more infection in warm weather.

**Management:** Rotate your crops at least every 2 years and in that year do not plant any tomatoes, eggplants, peppers, potatoes, tomatillos, or other crops in the Solanaceae family. Remove weeds, especially weeds in the Solanaceae family that can be infected with anthracnose. Drip irrigation is better than overhead sprinkler irrigation because less water touches the leaves. This prevents spores from traveling on splashes of water. If you want to use chemicals you can spray a copper fungicide to prevent anthracnose. Certified organic growers can only use approved organic fungicides.

### ***Viruses***

Three different viruses attack tomato plants. If your plants are infected by a



virus they will produce less fruit, the fruit will be poor quality, and the plants will be weak. If you think a plant has a virus, remove it from the field quickly and destroy it. Milk, soap, and trisodium phosphate (TSP) are all solutions you can use to clean your hands and tools against viruses. You can use skim milk mixed with water or powdered milk mixed with water. Use a solution of 3% TSP (trisodium phosphate).

Virus diseases can travel easily from seedling to seedling in the greenhouse. When you work with seedlings, dip your hands into a milk solution often. You can also prevent the virus infection if you wash your hands with soap often. Clean under your nails. If you use tools or stakes on plants that are infected you should wash them with milk or soap and soak them for 30 minutes in 3% TSP (trisodium phosphate).

### ***Tobacco mosaic virus***

Tobacco mosaic virus causes mottled areas on leaves and fruit. These areas can be light green, dark green, or bright yellow. Leaves can also curl, twist, and become narrow and strap-like. These symptoms look like what you see on leaves that have been injured by 2,4 D herbicide or similar herbicides. Fruit that is infected with tobacco mosaic virus can have brown areas inside. Fruit from plants with tobacco mosaic virus usually ripens unevenly and is small. A plant with the virus will have fewer fruit.

**Disease cycle:** Tobacco mosaic virus spreads from infected seed and from other infected plants including weeds. Since tobacco mosaic virus also affects tobacco, farmers and workers who use tobacco can spread the virus to tomato plants.

**Management:** Plant varieties that resist the virus and use clean virus-free seed. Control weeds since they might carry and spread the disease. Do not smoke or chew tobacco while you work with tobacco plants since you can spread the virus from tobacco on your hands. Wash your hands and tools regularly.

### ***Cucumber mosaic virus***

A tomato plant with cucumber mosaic virus has yellow leaves which are smaller than normal. Leaves can become narrow and look like a strap, a string, or a shoelace. These symptoms look like what you see on leaves that have been injured by 2,4 D herbicide or similar herbicides. The plant can look bushy. The oldest and youngest leaves might show symptoms and the middle part of the plant might look normal.

**Disease cycle:** Cucumber mosaic virus spreads by aphids from other infected plants including weeds. Many other crops can be infected such as cucumbers, carrots, celery, eggplants, legumes, lettuce, pepper, spinach, and squash.

**Management:** Control weeds since they might carry and spread the



disease, and since aphids might live in them. Wash your hands and tools often. In a greenhouse, use screen to help keep out aphids.

### ***Tomato spotted wilt virus***

Plants with tomato spotted wilt virus have many small dark spots and leaves can be lighter green or yellowish. The young leaves can have areas that look metallic or bronzed. Shoots can wilt and die. Stems might have streaks. Fruit can have spots that look like a target.

**Disease cycle:** Tomato spotted wilt virus spreads by small flying insects called thrips. They carry the virus from other infected plants including weeds.

**Management:** Control weeds since they might carry and spread the disease, and since thrips might live in them. In a greenhouse, use screen to help keep out thrips. In a greenhouse, use yellow sticky cards to look for and count thrips and check whether they are multiplying. Many ornamental flowers such as impatiens and begonias can become infected with tomato spotted wilt virus. If these plants are near your tomatoes in a greenhouse or field, check the impatiens or begonias for thrips and virus symptoms.

## **Insect Management**

### ***Aphids***

**Description:** Aphids are very small pear-shaped insects with soft bodies. They come in many different colors. They have two “tailpipes” that stick out on the top of their back end. Aphids pierce plant tissue and suck on plant juices. Aphids secrete a sticky sap called honeydew. Look for aphids and honeydew on the undersides of leaves.



**Aphids**

Whitney Cranshaw, Colorado State University, 1243127, Bugwood.org

**Management:** Usually aphids do not cause problems for tomatoes unless they carry the cucumber mosaic virus. Beneficial insects and sprays of insecticidal soap control aphids.

### ***Flea beetles***

**Description:** Flea beetles are small (1/10 inch) dark beetles with large back legs. Flea beetles jump. You will



see tiny holes on the leaves where flea beetles have eaten. If many holes are next to each other they can cover a small area. These areas where flea beetles eat can be scattered throughout the leaves.

**Life cycle:** Flea beetles spend the winter as adults in plants or plant debris. When the temperature reaches 50°F the beetles emerge. This usually happens in late April. Adults begin to lay eggs in the soil at the base of tomatoes in May. They also lay eggs at the base of other plants which are related to tomatoes: peppers, eggplant, and potatoes. The eggs hatch 7-14 days later. Larvae feed on plants until they are fully grown. The larvae move below ground to pupate. Then, 11-13 days later, the adult flea beetles emerge from the ground.

**Management:** Damage from flea beetles is worse on small tomato seedlings. When tomato plants are larger the plants are usually strong enough to tolerate flea beetle damage. If you have a lot of flea beetle damage, remove tomato plants from the field at the end of the growing season. You can also use deep cultivation to bury plants. The number of flea beetles will go down because they will not have a place to overwinter.

### ***Worms or caterpillars***

Two different worms or caterpillars sometimes eat tomato plants and fruit. They are the tomato fruitworm

and the tomato hornworm. Both worms are larva of different types of moth.

The tomato fruitworm is also called the corn earworm. It is light green to brown-black with splotches of pink, maroon, green, brown, or tan. There are stripes along the body. Tomato fruitworms are 1  $\frac{3}{4}$  inches long. They eat green fruit. They make deep, watery holes in fruit. Fungus and bacteria can enter these holes and cause rot.

**Life cycle:** Pupa of the tomato fruitworm spends the winter in southern US. The adult moths emerge in spring and fly north. They usually arrive in the Midwest in late July. The moth lays eggs on sweet corn. If there is no sweet corn the moth lays eggs on tomato fruit. Larva, or worms, start to hatch a day later. They eat for two weeks. Then they fall to the ground and pupate. Tomato fruitworms have one generation a year.

**Management:** Tomato fruitworm problems are worse when you plant tomatoes late in the season. Listen to farm pest reports for sweet corn. When you hear that corn earworms are eating sweet corn, look for young larvae on your tomatoes. When you see many young larva (young worms) on the fruit, you can use a Bt spray of *Bacillus thuringiensis* to control young worms.

***Hornworms***

Tomato and tobacco hornworms are large (3-4 inches) blue-green caterpillars with a horn on their tail end. They eat tomato leaves and sometimes tomato fruit.



Hornworm  
Whitney Cranshaw, Colorado State University, 5304010, Bugwood.org

**Life cycle:** Pupa of the tomato hornworm spends the winter in the soil. The adult moths emerge in late June and mate. The moth lays eggs in a row on the lower surface of tomato leaves. Larva, or worms, start to hatch and eat. In a month they can be full grown. In late summer, full grown larva fall to the ground and pupate. Tomato hornworms have one generation a year.

**Management:** Look at your plants often. If you find more than one or two caterpillars per two plants it is time for control. You can use a Bt spray of

*Bacillus thuringiensis*. You can also release a wasp that is a natural parasite of the hornworm eggs. This type of wasp is called trichogrammid.





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