GROWING TOMATOES SUCCESSFULLY ON THE TEXAS HIGH PLAINS

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Introduction

Tomatoes (*Lycopersicon lycopersicum*) are sub-tropical plants. In spite of this, tomatoes can be grown successfully even on the hot, windy, dry Texas High Plains. The High Plains has naturally fertile, well-drained loamy sand, sandy loam, and clay loam soils that provide a very productive environment for tomato growth. Research has shown that both commercial growers and homeowners who utilize cages or trellis cultures can significantly improve tomato yield and quality. Cage or trellis cultures combined with wrapping the plants with floating row covers (e.g. spun-bonded polypropylene or perforated polyethylene) will protect the developing transplants from virus-bearing insects, as well as wind and dust storms, and tomatoes will have greater success than those not covered. Cages/trellises will support tomato stems and fruit from contacting the soil surface, aiding in producing higher quality fruit, and gardeners will have more fun watching plants develop.

The purpose of this informational guide is to offer growing suggestions based on scientific research and personal experiences of the authors. Growing tomatoes can be very enjoyable, but may also be frustrating when individual efforts do not equal the reward of higher yield and quality fruit. The instructions contained herein are suggested "guidelines" to improve your chances for success; however, your results may vary depending on localized environmental, moisture and nutritional conditions, as well as efforts taken in pest management. It is best to remember that every good thing takes time, and that sincere efforts will be rewarded.

Backyard or alleyway home garden (left) with tomato cages wrapped in white plastic and soil amended with compost and sphagnum peat; and (right) tomatoes caged with spun-web polypropylene row cover cloth plus drip irrigation.

Soil preparation

Every few years, and several weeks before planting it is wise to take soil samples from the garden area and have it tested at a reliable private laboratory. Contact the local county Texas AgriLife Extension office for a recommendation. In recent housing developments, some homes are built on the former shores of playa lakes. These areas may have highly alkaline materials in the lake floor that were mixed with the surrounding soils during building and landscaping. Urban garden soils near these new homes may have also been mixed with construction leftovers (concrete, brick mortar and caliche (hard rock-like soils of calcium sulfate) during grading of the soil surface. Soil test results will determine how best to treat the soil before planting.

All garden soils may be enhanced by adding additional organic matter (dead or decomposed plant materials), which may be applied as compost and composted manures. Compost may be applied safely to the garden at a rate of 50 lbs per 100 square feet. Knowing the type of compost to be

added is important as the chemical makeup can vary widely (see section below). Too much highly fertile compost can actually hurt tomato roots by raising the soil's soluble salt concentration to a toxic level. Sphagnum peat is a great source organic matter, and though it adds little or no available nutrients, it will be a storehouse for plant-available essential elements applied prior to or during the gardening season. Use no more than 50 – 60 lbs of sphagnum peat per 100 square feet to make its use economical.

When adding compost or sphagnum peat, work (using a rototiller or spade fork) it into the soil to a depth of 12" or more. Break up any clods in order to provide a more granular structure to the soil. Also, work in approximately 5 lbs of agricultural sulfur per 100 square feet of garden area if the soil test indicates it is needed. If the soil in the garden area is tight (a heavy, compacted sandy loam or a clay loam) with a high pH (7.8 or higher) and/or if a local city water source is used, it may be beneficial to work in 5 – 6 lbs of gypsum per 100 square feet which will assist in lowering the sodium salt concentration. Make sure to work the soil when it is properly moist (when it breaks apart easily), but not when it is so wet that it sticks to the garden tools.

Compost

Compost is defined as organic residues (plant material) which have been piled, mixed, moistened and potentially supplemented with fertilizer and lime, which then goes through the biological process of decomposition, producing a humus-like material. If adequately produced, pathogens (disease organisms) will be killed and organic carbon stabilized.

Composted organic amendments can improve soil nitrogen management, increase soil organic matter, soil microbial activity, and soil water holding capacity, as well as decrease erosion by water and wind. Composts can be tilled and incorporated into soil. Compost should be mixed so that the soil structure is not affected, which might interfere with overall root growth and water movement.

Using compost also improves the chemical, physical and biological properties of soil. Compost may increase the cation exchange capacity (CEC) in soils, improving nutrient uptake, and modify or stabilize the pH. In terms of physical properties, compost improves soil structure and soil moisture content. Biologically, compost increases soil microbial populations and can be used to suppress plant disease.

Local-source compost created from cattle and chicken manure.

Plant disease suppression can be general, where soil microbes compete against the plant pathogens. Other times, specific suppression involves select microbes targeting the pathogen. A plant pathogen suppressive soil is one where: 1) a pathogen finds it difficult to establish; 2) a pathogen establishes but causes little or no damage; or 3) a pathogen causes disease but the disease becomes less significant with time. Disease suppression can involve production of antibiotics, parasitism of plant pathogens by microorganisms, activation of induced systemic resistance, production of toxic compounds, competition for nutrients, changes ins soil physical properties, and changes in soil conductivity and pH.

Compost can vary in terms of age or maturity. Mature compost is very stable and has undergone a long period of decomposition. This compost should be either brown to black in color. If the temperature of the compost is increased to greater than 68 °F above ambient temperature, no thermophilic (breakdown by high temperature bacteria) activity will be observed. This compost can be placed in direct contact with plant roots. Semi-mature compost is light to dark brown in color, may still heat up and thus direct contact with plant roots is not recommended. Fresh compost has gone through the thermophilic stage but is only partially decomposed. This material may reheat and undergo further thermophilic decomposition. This material will be similar in color to the initial material used in making the compost. Further decomposition and stabilization must take place. Composted materials can come from municipal solid waste, yard trimmings, and biosolid waste from municipal wastewater treatment facilities. Components of municipal waste include uneaten food, cardboard, paper, wooden crates, yard waste, and biodegradable clothing. Yard trimmings include leaves, branches, pine needles, grass clippings, roots, and shrubs. The solid portion of biosolid waste from municipal wastewater is often mixed with the other two composts since its nitrogen can accelerate the raw organic decomposition process. For more information on composting or for local sources, contact a nearby Extension office or visit http://aggie-horticulture.tamu.edu/.

Fertilizing

Once again, knowing the garden's soil fertility is very important to successful tomato production, so make sure to take a soil sample and have it tested! Soil sampling kits with forms, instructions and sampling bags may be available at local county extension offices, or they may have a reliable source where they can be purchased. If specific fertilizer recommendations have not been made from the results of the soil sample, then (before transplanting) apply a complete fertilizer, and work it in to a depth of at least 6 inches. Fertilize at least 25 square feet of garden area for each individual tomato plant to get the best results. Water the newly-set transplants with a water-soluble fertilizer at the base of each tomato plant, and continue to do this until the plants have begun to set fruit.

When the first fruit are noticed, begin to apply a nitrogen-based fertilizer (e.g. one level tablespoon of urea [45-0-0] nitrogen per tomato plant). Sprinkle the urea uniformly over a 6-foot diameter circle on the soil area surrounding each plant and immediately irrigate with approximately one inch of water. One inch of water over a circle with a 3-foot radius is 16 gallons. One inch of water over a circle with a 4-foot radius is 31 gallons. Be careful when feeding tomato plants, as over-fertilizing (too much nitrogen) may cause excessive foliar and stem growth, and possibly reduce tomato yields.

Sunlight

Tomatoes will grow best in full sunlight and will require at least 6 hours of full sunlight each day. They are likely to get this when grown on the east side of a north/south-running fence, or on the south side of an east/west running fence in an alleyway or home. It is critical to prune back any overhanging tree limbs or remove anything that will cause excessive shading on the tomato plants.

If sunlight is inadequate, tomatoes will likely survive but will become leggy and do very poorly and yield less. When caging tomatoes, make sure that the plastic or the spun-web cloth used allows for maximum sunlight penetration (75% or higher is best). Do not wrap cages in colored plastics as they may alter plant growth.

Spacing

The actual space required to grow tomatoes will vary depending on selected varieties as well as the growing methods. Trellised plants should be spaced approximately 24" apart within the row, and 4 – 6 feet between rows.

Proper spacing of tomato plants, both in the row (left) and between the rows (right) will maximize space and allow for improved yield and fruit quality, as well as allow for better crop management and growth.

The appropriate spacing allows for workers or gardeners to walk in-between the rows for weeding, spraying or harvesting, and may also allow for use of rototillers or other equipment during garden maintenance. Caged tomatoes should be spaced at least 6 feet apart both in-row and between-rows. Dwarf varieties may be spaced closer (12 – 18" apart). The roots of healthy tomato plants radiate out at least 3 feet from the plant base and if too close together, they may start to compete with one another, reducing overall plant health and yields.

Cages

Remember, tomatoes are sub-tropical and will benefit from protection against environmental extremes found on the Texas High Plains including low temperatures, wind, hail, insects and diseases. Grow- or spun-web materials will give limited protection against these elements when cages are wrapped. Cages should be 18" – 24" in diameter and 3 – 5 feet high (use higher cages when planting indeterminate tomatoes [see figure on right]). To improve support, use buried concrete rebar tied to the inside of the cages. Following transplanting, wrap the cages with perforated plastic or spun-bonded polypropylene cloth and clamp/tie the material to the wire cages with clothes pins, etc. to keep it in place. The wrapped material can be used once or for multiple years depending on care. The wrapped cage will reduce winds, and keep the air and soil environments surrounding the tomato plants warmer. In addition, tomatoes wrapped in cages will be protected from virus-bearing insects (leafhoppers, aphids, thrips, etc.) and will allow for plenty of light. Cloth or row-covers will

allow rainfall to penetrate inside the cage. When leaves of the plant inside touch the wrapping, remove the cloth and/or drape the wrap over and around the cage to continue repelling insects while liberating the plant to grow and set more fruit. The wrapping can also be removed entirely if desired.

Wind-damaged tomato plant (left) that had no windbreak or cages to protect it. Note that top half of the leaves are wind-torn and shredded; it will likely fall off later. A caged and wrapped tomato plant (right) showing excellent signs of growth and will be better protected from winds.

Soil rot will likely occur if the tomato fruit are allowed to touch the ground. An organic or plastic mulch will offer some protection (see section on mulches), but caging or trellising is preferable and worth the effort. Wire cages made of reinforced wire (hog fencing, etc.) can provide excellent support systems for tomato plants. These cages can be made into various heights, but should be at least 18" in diameter. Cages of 24" diameter may be too wide to allow easy access to early setting fruit. Caution should be taken during the growing season for wasp's nests built on or inside the cages, and for the black widow spiders that love to build their webs inside plant canopies!

Begin to unwrap (roll down or cut) the covering off the cages as soon as the leaves begin to push through the top, and remove the entire wrap once the leaves and fruit push outward. The longer the wrapping can remain in place the better will be the protection against wind, insects and diseases.

Place the cages over each tomato plant immediately following transplanting for best protection. Anchor each cage firmly into the ground with wooden stakes or concrete rebar, and tie to the cages for support. This will prevent cages from blowing over in the wind, and will support the cages when the plants are loaded with fruit. Each cage should support just one tomato plant. Suckering or

pruning the plants is not necessary when cages are used, especially with determinate varieties. If you plant them on trellises, support them with twine woven around wooden stakes.

Anchor each cage for support. Pruning is not necessary, though leaves can be removed from the center. However, keep plenty of leaves on the outside of the plant to avoid sunburn of the tomato fruit.

Wrap the cages immediately for best protection against wind and insects. Don't try to keep foliage inside the cage, but encourage the branches to grow outward starting at the second rung of the cage. Branches will grow out of the top eventually. Encourage good foliar growth around the fruit to help prevent sunburn of the tomato fruit.

Plastic mulches

Plastic (polyethylene) mulches are beneficial for increasing soil temperatures, reducing soil evaporation, controlling weeds, and keeping the leaves and tomato fruit from touching the garden soil. Black plastic mulches raise soil temperatures quickly so that plants can increase growth resulting in earlier and higher yields (possibly up to 15% or more) compared to bareground production. Silver reflective mulches can also increase tomato growth and yield (20% or more), and may have the added benefit of deterring certain flying insects. Red plastic mulch has been suggested for tomatoes in other regions of the US, however, in West Texas, tests showed that tomatoes may do poorly on red-colored plastic mulch.

It is best to ensure that all edges of the plastic mulch are placed in the soil at least 6" deep to prevent high winds from pulling up the plastic mulch and damaging plants. Setting the plastic mulch in a moist soil is preferable so that the edges can seal and have weight. Following placement, it is best to seal the edges with water. In addition, after transplanting tomatoes into the holes of the plastic, fill them with soil and seal the edges to prevent wind from getting under and lifting the plastic. It is best not to use the plastic for more than one year. If that is planned, plant a different crop (different family) into the same holes the next year to reduce potential for increasing root diseases. A significant problem with leaving plastic for more than one year is soil compaction. If the soil is too compacted and tough to plant in, it may result in reduced root zone penetration by the tomato plant. If that is the case, it must be removed and the soil rototilled or worked with a spade. Several commercial seed catalogs sell plastic mulches in small quantities for home gardeners.

Tomatoes may be grown under different types of production including: silver plastic mulch (front, left); bare soil (front, second from left); and red plastic mulch (front, third from left). In the back row: black plastic mulch (left) and caged tomatoes (second from left) which had a spun-bonded cloth removed after 5 weeks. Note the differences in growth between the different colored plastics as well as with the caged tomatoes.

Windbreaks

Tomato plants are not very wind tolerant. To reach their maximum yield and quality potential, the tomato plant must be protected from excessive environmental stresses imposed by the West Texas climate. Living, killed, disposable or permanent windbreaks can be grown (taller plants) or constructed by hand. Elbon rye, triticale, or tall-growing wheat started the previous fall will work very well. Tall-growing sorghum and sunflowers also make excellent windbreaks and even offer some hail protection. Small, newly transplanted tomatoes can be protected from the wind with shingles, old PVC pipes, boards, fencing, hotcaps or anything that will block the wind and not shade out the plant. Windbreaks are also valuable protection for cages to prevent them from blowing over and breaking the plants inside. For every foot taller that windbreak plants are compared to the tomato plant, there will be protection outward for at least 10 feet from the windbreak row.

High temperatures (heat)

Tomato plants are very sensitive to the high temperatures found in West Texas. Flowers may abort or blossoms drop when daytime temperatures are above 90 ^{o}F and night time temperatures remain above 75 ^{o}F. Much of this is due to a lack of pollination during high daytime and night temperatures. When this happens, fruit development may be delayed, even if the plants appear to be healthy. It is a good idea to use heat tolerant varieties if available, or allow for some afternoon shade on the tomato plants. Keeping the soil moist with uniform irrigations may also help, but there really is very little that one can do when extremely high temperatures occur for extended periods.

Hail damage

Tomato plants that are protected by windbreaks and cages will likely have less damage from the hail that almost always occurs on the Texas High Plains. Newly transplanted tomato seedlings can best be protected by using wire cages wrapped with spun-bonded polypropylene row cloth or perforated polyethylene plastic. If not and there is the risk of hail or frost, quickly cover the cages with a blanket until the threat is over. If non-caged or unprotected plants are hit with hail, there is still the possibility that they could continue to survive (though their growth may be reduced and fruit set delayed). If the main stem is broken, replace the tomato plant as it will not survive. If the main stem is fine, but lateral branches and leaves are damaged, prune the broken branches and leaves off to the point where no damage is observed. There should be some new growth of undamaged buds (leaves and branches) within a week or so. If no new growth is observed, remove the entire plant and start with new seedlings. It is fine to replant tomato seedlings until at least 120 days before the expected first fall frost. All damaged plants should be sprayed with a broad-spectrum fungicide to reduce the potential for diseases.

Variety selection

All tomatoes are warm-season annuals that require plenty of sunlight and uniform soil moisture. Tomatoes generally are heavy feeders of nitrogen; however, too much nitrogen will cause the plants to produce more leaves and stems and less fruit. Tomatoes are probably grown by more gardeners than any other vegetable and selecting the right variety can be confusing. Whether growing for enjoyment or for winning first prize at the county fair, selecting the right variety amongst hundreds is critical, and also a matter of pride.

There are many tomato varieties available to home gardeners and commercial growers, and they can be classified into several categories. First, tomatoes are generally classified as *determinate* or *indeterminate* types. *Determinate* varieties are those that have a set "determined" growth based on their genetics, and they have vines that will produce very little growth once their fruit load is set. They generally have a set harvest period and most fruit will ripen within a matter of weeks. *Indeterminate* varieties are just the opposite; they continue to put on new stems, leaves and blossoms even after initial fruit set. They will continue to have fruit of all stages of ripening on the vine at the same time and harvest is extended for a longer period.

Other important characteristics for tomatoes include the following terminology:

Early-, mid- or late-season – Varieties are classified by how soon they have ripe fruit ready to pick. Those that can be harvested within 54 – 65 days are considered "early-season", while those that are not picked until after 80 days are generally considered "late-season" varieties.

Round or globe shaped varieties – Typical looking tomatoes that have small- to medium-sized fruit and can be either determinate or indeterminate types.

Paste or Roma types – Can be either determinate or indeterminate varieties, fruit is smaller and oval shaped, and the skin (or peel) is generally tougher than round varieties. Fruit also contains less juice and is considered meatier.

Different shapes and sizes of tomatoes: Round or globe-shaped (left); oval-shaped paste or Roma type (middle) and small-fruited pear-shaped fruit (right).

Beefsteak varieties – Generally produce large fruit that can weigh up to a pound or more. These varieties are typically indeterminate and because of the heavy fruit load, it is best to have the plants supported by stakes, cages or trellises.

Small-fruited types – These tomatoes are usually indeterminate, though some determinate varieties are available. Small-fruited types can have shapes like grapes, cherries and pear, are often higher in sugar content, and thus are very sweet.

Coloration – There are many variations in fruit color amongst tomato varieties. Tomato fruit can be red, pink, yellow, orange, green, bi-color, dark-red (black) with many variations and striations in between.

Cold or heat tolerance – While tomatoes are generally considered to be warm-season plants, some varieties are more tolerant of cooler temperatures, and thus able to produce fruit under those conditions. These varieties would be best for planting early in the spring. In contrast, heat tolerant varieties are those that will do best under high heat (90 ^{o}F or better), and are able to set or continue to set fruit under hot conditions.

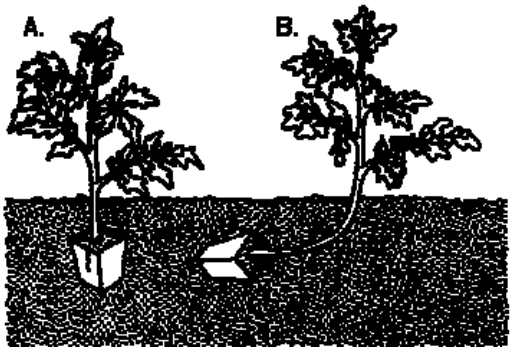
Disease resistance – Many tomato varieties have been found or are bred to have resistance or tolerance to specific diseases (see listing under disease section). If a variety has disease resistance, it usually will have its varietal name followed by a series of letters such as V, F, N or a variation of those letters. These letters indicate what resistances this specific variety has including V = *Verticillium* wilt, F (races 1, 2, 3) = *Fusarium* wilt (races 1, 2 or 3), N = Rootknot nematodes, T = Tobacco mosaic virus, A = *Alternaria*, TYLCV = tomato yellow leaf curl virus, and TSWV = tomato spotted wilt virus.

Heirloom varieties – Heirloom varieties are those that have been around for many years (possibly even more than a century!). Most heirloom varieties are indeterminate types and have no or very little resistance to diseases.

Which variety is best? That depends on how much effort a gardener is willing to put into the tomatoes after planting. If tomatoes are wanted for just a part of the summer and there is no desire to spend time pruning stems or supporting vines, a determinate type is best. However, pick varieties that have plenty of disease resistance and that are heat tolerant. If preserving tomatoes and the plan is to do most of them at once, also pick a determinate variety. If spending time in the garden is not a problem, and tomatoes are wanted over an extended period, select indeterminate varieties. A good idea is to plant a mixture of varieties, including both determinate and indeterminate types in order to ensure season-long harvesting. Remember though, indeterminate types may require more attention and care. For unique characteristics, select heirloom varieties that can offer different colors and shapes, but again, these are likely indeterminate types with little to no disease resistance.

On the Texas High Plains, it is best to pick varieties that have some heat tolerance due to the high temperatures in mid-summer. Varieties tend to come and go quickly, so check with local extension offices for any up-to-date varieties that do well in the area. If specific varieties are not available at your local garden center, you may be able to request that they grow them for you. However, it is very unlikely that national chain stores will do that. For up-to-date information on tomato variety trials that are conducted yearly at the Texas AgriLife Research & Extension Center go to the following website: http://lubbock.tamu.edu/horticulture/.

Transplanting



In most cases, it is best to purchase or grow your own tomato transplants. Seeding tomatoes directly into the soil is very difficult, and may result in poor growth. When transplanting tomatoes into clay loam soils, it is best to use raised beds in order to simplify watering and improve soil aeration. In sandy-loam soils where drip or sprinkler irrigation will be used, tomatoes can be transplanted flat within a circular berm of 18 – 24" diameter. The berm (or dam) is formed around the plant to prevent water from flowing away from the roots. Set the tomato plants in the spring as soon as there is no danger of a frost (generally mid-April), or if using cages, this could be a bit earlier. For best root growth, wait until the soil temperatures at a 6" depth are at least 60 – 65 ^{o}F. Watch your local weather reports for updated information.

Plant potted tomatoes at least 1 – 2" deeper than the surface of the rootball. Covering the stem of the plant to just above the point of attachment of the two cotyledons (seed leaves) is a good guide (see plant "A" in figure above). For fall transplanting, it is best to plant about 120 days before the typical first frost (generally around early to mid-November).

When purchasing tomato plants, it is best to select those that are dark green, medium-height, heavy-stemmed, and that have no flowers or fruit. If growing your own tomatoes for transplanting, seed tomatoes in trays approximately 5 weeks before the anticipated date of transplanting. Be careful not to injure or tear any roots of the plants when removing them from the seedling trays as this may lead to increased root diseases. Set the plants slightly deeper in the garden soil than the original soil level from the tray. Make sure to cover the entire root ball with fresh soil in order to avoid root wicking (loss of moisture) which may increase plant stress or cause death. If the plant is spindly or leggy, its stem can be planted deeper in the soil to prevent breakage (see plant "B" in figure above). It is best to transplant in the late afternoon or early evening to reduce transplant shock from heat, or drying and wind damage. Following transplanting, erect any windbreaks or wrap the cages, and apply a starter fertilizer after each plant is set in the soil; then water each plant immediately. After several more days, move any portable windbreaks far enough away to reduce shadows that block direct sunlight onto the plants.

Maintain a deep layer of organic mulch

If not using plastic mulch, then organic mulches (clean, weed-free dry wheat or rye straw, alfalfa, vetch, crimson clover, sorghum, haygrazer, and grass clippings [must be heat sterilized to 140 ^{o}F or higher for over 24 hours in black or clear plastic bags]) can be used to conserve soil moisture, or to help maintain optimum soil temperatures, encourage expansion of the root system, and prevent potential weed competition. The optimum root zone temperature for tomatoes is 75 ^{o}F. The organic

mulch should be maintained at a depth of 4 – 6". Organic mulches can be applied as soon as soil temperatures reach 70 ^{o}F. Place the mulch outward at least 4 – 6 feet from the center of each tomato plant. Under the mulch, the roots may grow right up to the surface. Mulched plants should be more productive than non-mulched plants, and fruit that touches the mulch will not likely rot as much as those that rest directly on moist soils.

Irrigation during crop growth

The tomato plant is a "water spender" in that it can not be conditioned to thrive on limited soil moisture. Consequences of low soil moisture will include aborted flowers or blossoms, blossom end rot (a physiological disorder caused by calcium deficiency), radial fruit cracking (a physiological disorder caused by uneven watering), smaller fruit and lower yields. Drought stress will restrict leaf growth leading to higher incidence of sunburned fruit when exposed to high-intensity sunlight.

Physiological disorders of tomato fruits from non-uniform watering; blossom end rot (left) derived from a calcium deficiency and radial fruit cracking (right) due to uneven watering and plant heat stress.

Tomato roots will not grow in dry soils to seek out moisture. It is best to maintain optimum soil moisture from the center of the plant outward at least 3 – 4 feet to encourage maximum root development. This will optimize plant health and increase fruit and yield quality and reduce the potential for physiological fruit disorders. The area of soil surrounding the tomato is inhabited by roots, and plants will require irrigation or watering every 3 – 5 days depending on environmental conditions (temperature, sunlight and wind). As plant growth and fruit load increases, the volume of water required will also increase. In the spring to mid-summer, water every 3 days to maintain adequate soil moisture. A deep mulch layer over the soil surface from the base of the tomato plant outward at least 4 feet from the stem will increase water use efficiency (see section on mulching).

Drip irrigation offers an easy way to provide regular, uniform watering which will improve the overall performance of tomato plants. Regular intervals of uniform watering will decrease flower abortion, blossom end rot and radial fruit cracking.

Pest control

It is essential to inspect tomato plants often (at least weekly) for common insect and disease pests. Approximately 12 insects and 7 diseases have the potential to attack tomatoes when grown on the Texas High Plains. Insects and diseases may attack all or selected parts of the tomato plant including the leaves, stems, fruits and roots. Failure to inspect and subsequently control these pests throughout their entire crop cycle may result in a complete defoliation (loss of leaves) of the plant, or a total loss of the fruit. If assistance is needed in identifying tomato insect or disease symptoms, or for controlling pests, contact the local county extension office or garden center.

Many insects can be prevented from attacking tomatoes by using cages wrapped in spun-web cloth in the early part of the season before the summer heat sets in. Diseases may be a serious problem, especially when preventative measures are not taken. Over-watering will increase the potential of root and foliar diseases; therefore, prevent water-logged soils by using raised beds or drip-irrigation. Tomato foliage is susceptible to diseases when it remains wet for extended periods, and this may cause disease during fruit set or later stages of development. Some varieties are labeled as "resistant" or "tolerant" to selected diseases and it would be wise to check these out before purchasing any new varieties. Many "heirloom" varieties will not have any built-in disease resistances associated with them.

If chemicals are to be used for controlling pests, there are several important steps to ensure good control. First, make sure the pest is correctly identified. If the wrong pest is identified, the method of control or chemical used may not be adequate. Second, if using chemicals, choose the proper pesticide for specific pest. Third, use the recommended concentration (or rate) of the pesticide to ensure that control is sufficient and that there is no under- or over-dosing of the plants. Fourth, make sure that spray coverage is adequate and that all plant parts to be sprayed are thoroughly covered.

The new version of Managing Insect and Mite Pests in Vegetable Gardens (E-194) includes a discussion of non-chemical, least toxic and conventional control options for tomatoes. The publication can be found at http://agrilifebookstore.org/. Before applying any pesticide, be sure to **READ THE ENTIRE LABEL** and follow all instructions carefully. For up-to-date pesticide information, please consult control guides available from local extension offices and garden centers.

Insects

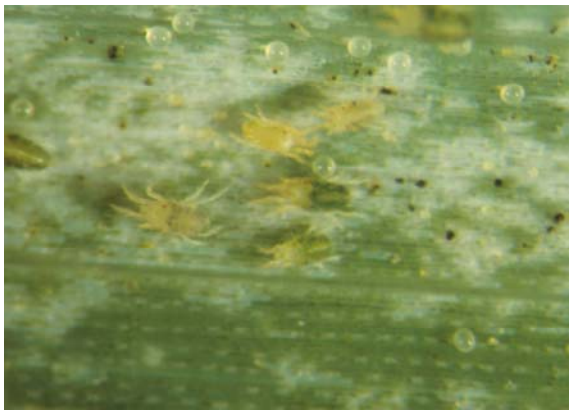
Cutworms – These are early season pests that attack seedlings or small transplants by cutting them off at or slightly below the soil surface. Just a few cutworms may destroy an entire stand of plants. Cutworms are the larval stages of several species of moths. Eggs are often laid on plant residue, other plants or weeds in or near the garden. Cutworm larvae can be difficult to detect because several species stay in the soil during the day and feed at night. Paper or metal collars placed around the plants offer some protection, but for best results, use a thorough application of liquid insecticide around the lower part of the plant.

Aphids – Small, soft-bodied insects that attack tomatoes at any stage of development by sucking the juices (sap) from plants. Aphids can easily transmit diseases (especially viruses) to tomatoes. Populations will build up rapidly and should be treated when the colonies first appear on the plant. The primary threat from aphids is the diseases they transmit, not the leaf feeding itself. While biological control of aphids works well in many other crops, it often takes too much time in tomatoes to prevent a significant amount of disease transmission.


Cutworm damage on seedling corn plant (above left, courtesy of Mike Blanton) and a colony of aphids (above right, by Noel Troxclair).

Leaf miners – Leaf miners are immature, small flies. The adults lay eggs between the upper and lower surfaces of the leaves and when hatched, the small larvae tunnel (leaving visible "mines") throughout the leaf, destroying tissue where the mines occur. Leaf miners attack tomatoes in all stages of growth; however, they do more damage to young seedlings. Consider controlling leaf miners in seedlings by applying insecticides as soon as tunneling is visible. Two or three applications at weekly intervals may be needed. Larger plants can withstand more leaf miner damage, and insecticide applications may not be warranted. Leaf miners do not attack the fruit and cause mostly cosmetic damage on older plants.

Spider mites – Mites are one of the most serious tomato pests on the High Plains. They are green or reddish in color and are very small. Spider mites will rasp leaf cells and suck the sap that exudes from tomato leaves. Heavy infestations will cause leaves to turn yellow and eventually drop off. As a practical matter, control should begin when mites and damaged leaves are first observed. Control may be difficult, and applications may be required at 5-day intervals for 3 – 4 weeks. If left uncontrolled, colonies usually grow rapidly during hot weather. Spider mites do have natural enemies, but at a garden scale these are usually ineffective at reducing populations. Plants should be kept well watered as spider mites increase more rapidly on drought stressed plants.

Leaf miner damage or tunnels (left, courtesy of Entomology Dept, Texas A & M) and right, spider mites, eggs and rasping damage on a leaf surface (courtesy of Frank Peairs).

Leafhoppers – Small, wedge-shaped insects that suck the sap from tomato leaves. Leafhoppers may cause leaf discoloration, curling and stunting. These insects also transmit certain plant diseases such as Curly Yellow Top virus of tomatoes. Because they can carry diseases, consider treating for leafhoppers as soon as they are visible on plants.

Flea beetles – These insects are very small, black or brown in color, though some may be metallic blue or green, or even striped. Flea beetles eat tiny holes in the tomato foliage and heavy populations may defoliate a small plant. There are often large flea beetle infestations in May and early June. Consider control when there is significant damage on young plants and flea beetles are present. Older plants can withstand more damage, and control may not be warranted.

A typical leafhopper (left, courtesy of Charles Barr) and right, flea beetles and damage on a leaf surface (courtesy of Pat Porter).

Whiteflies – Very small, white, aphid-like insects that suck the sap from the underside of tomato leaves. Immature whiteflies appear scale-like and are attached to the leaf bottom. Heavy populations can cause small fruit and blossoms to drop off, and may defoliate plants if left untreated. An easy way to find adult whiteflies is to gently shake plants on a windless day and watch for the tiny white adults as they fly off the plant. Treat for whiteflies before populations build up and become established. Control of established populations may be difficult.

Stinkbugs – Stinkbugs suck the sap from tomato leaves, but may also attack the stems and fruit. Heavy infestations can cause blossoms to drop off. Punctured fruit will show hard, light colored spots beneath the peel. Because they do damage to the fruit, control should be considered when stinkbugs are first noticed.

An adult whitefly and hatched egg (left, courtesy of Bart Drees), and right, a stink bug (courtesy of Pat Porter).

Tomato fruitworms – More commonly known as cotton bollworms and corn earworms, and this pest is often very abundant on the High Plains. Larvae feed on tomato leaves and fruit; only one worm may damage several small fruit. Damaged fruit may fall off or ripen prematurely. Best time to control this pest is when very small; larger larvae are more difficult to kill. There are three or four generations of tomato fruitworms on the High Plains, and tomatoes are at risk from the seedling stage onward.

Tomato hornworms – Larvae are about 3 inches long when fully grown, and are identified by green, slanted bars on the sides and a horn-like projection on the posterior end. Hornworms feed on tomato foliage and fruit, and large larvae can defoliate a plant very quickly. The larvae can be difficult to see on tomato foliage. Look for missing leaf tissue and the characteristic black frass (excrement) pellets that this larva produces. "Hand pick and squish" is an effective control measure when there are only a few plants. If many are noticed, apply appropriate chemical treatment as soon as possible. Hornworms are very susceptible to the organic and very safe insecticide, *Bacillus thuringiensis* that is sold for caterpillar control in garden supply stores.

A tomato fruitworm (left, courtesy of Clemson University, Dept. of Entomology) and tomato hornworm larvae (right, courtesy of Texas AgriLife Extension Service).

Tomato pinworms – Small, dark, banded worms that are about 0.25 inches long when fully grown. Young larvae are leaf miners and large ones may tie leaves together, feed on the leaves and bore into the tomato fruit. Begin a treatment as soon as any larvae are detected. Several treatments at weekly intervals may be necessary for control.

Thrips – Small, agile insects with rasping, sucking mouth parts, and are approximately 1/16 to 1/8 inch long with four feathery-like, hair-fringed wings. They are difficult to see and mostly live in the flowers and vegetative tips of the plant where they can feed on new growth of tender young plants. A good way to sample for thrips is to slap the terminal part of the plant onto a white sheet of paper and then look for the tiny, brownish or tan thrips. Consider chemical treatment as soon as they are detected. Most gardens experience a large influx of thrips when the local wheat begins to dry down in June, and this influx can continue for many weeks.

A tomato pinworm larvae (left, courtesy of Bart Drees), and right; thrips shaken off the plant and onto the hand (courtesy of Pat Porter).

Diseases

Early blight (*Alternaria solani*) – Early blight is a fungus that affects a wide range of plants and could be present in and on the seed as well as on crop residues. It is first observed on plants as small, brownish to black lesions, mostly on the older leaves. Spots will enlarge up to ½ inch, but by the time they are ¼ inch in diameter or larger, concentric rings can be seen in the center of the diseased area. Tissues surrounding the spots may turn yellow. If high temperature and humidity occurs at this time, much of the foliage may be killed or the plant may become defoliated. Early blight is greatest when leaves remains wet due from dew or fog, and if daytime temperatures remain under 95 °F. Infection of young seedlings usually results from fungi in soil, and it occurs principally during the periods of high humidity and warm temperature. Stem lesions are similar to those on leaves, and sometimes girdle the plant if occurring near the soil line. This girdling is known as collar rot. The fungus also infects the fruit, generally through the calyx or stem. Lesions may attain considerable size, and involve the entire fruit. Concentric rings can also be observed on the fruit. Control practices include the use of disease-free transplants and regular preventative fungicide applications during the growing season. For control, apply a labeled fungicide every 7-10 days once the disease is detected or as recommended. If applied preventively, use a contact fungicide that can provide a moderate level of control. It is also best to alternate registered fungicides to reduce potential disease resistance.

Symptoms of early blight on tomato leaf. Enlarged spots show the typical concentric rings that can be seen in the center of the diseased area.

Late blight (*Phytophthora infestans*) – Late blight is a fungus that appears on the leaves, with irregular, large, dark green lesions with a water-soaked appearance. These lesions enlarge rapidly and turn brown. Under humid conditions, the lesions will develop a white moldy growth near the margins of the diseased area on the lower leaf surface or on stems. Disease development is favored by cool nights (50-60 °F) and days with mild temperatures (70-80 °F). Late blight may spread rapidly and large areas of leaves can be affected. Infected fruit may have large, green to dark brown lesions that appear mostly on the upper half of the fruit; but they may also occur on other parts. White moldy growth may also appear on fruits under humid conditions. The fungus produces abundant spores called sporangia, which may be spread by splashing rain or wind. These spores can easily infect healthy leaves, stems and fruit if climatic conditions are optimum. Hot and dry weather reduces disease development. Control practices include crop rotation so as not to follow potato or tomato, avoiding planting tomatoes near potatoes, and using disease-free seed and/or healthy transplants. Crops should be sprayed regularly with a registered fungicide. Spraying should begin whenever weather conditions are favorable for disease development. Applications should continue on a 7 to 10 day schedule until harvest.

Water soaked lesion caused by *Phytophthora infestans* on a tomato leaf (left). Fruit lesions on a tomato fruit can develop a moldy growth under humid conditions that also promote fungal sporulation (right).

Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) – Tomato seedlings will become stunted and develop poorly when infected with this fungus. In older plants, symptoms on older leaves include chlorosis, leaf drooping with a downward curve, and wilting. Plant wilting, collapse, and death are further consequences of disease progression. If stem vascular tissue is observed, infected tissue is dark brown and the base of the stems is enlarged. Vascular discoloration can be observed on upper stems as well. To manage this disease, resistant cultivars should be used. Avoid fields with heavy infestations of root knot nematodes since they could facilitate the fungus in overcoming plant resistance.

Verticillium wilt (*Verticillium dahliae*) – Initial symptoms of this fungus are yellowing of the leaf margins and tips of the lower, older leaves. Yellowing may follow an angular pattern. Wilting of leaves and shoot tips is noticeable, especially during the warmest times during the day. Plants may completely collapse but usually this wilt develops more slowly than with Fusarium wilt. If vascular tissue is observed, discoloration is usually a light brown color, unlike that of Fusarium wilt which is darker in appearance. Resistant or tolerant cultivars should be planted to avoid this disease. Crop rotations with non-host crops such as grains are an option to reduce fungal population levels.

Fusarium crown and root rot (*Fusarium oxysporum* f. sp. *radicis-lycopersici*) – The first symptom of infection by this fungus is lower leaf yellowing usually along the margins. Leaves may later turn necrotic (dry) and die. Chlorosis will spread to younger leaves until only the top of the plant looks healthy. Stunting, plant decline, and plant collapse are further symptoms of disease progression. If vascular tissue is observed, a brown discoloration appears in the lower stem and roots. Stem discoloration is usually limited to the lower stem, unlike that of Fusarium wilt. Necrotic cankers may be observed around the crown area and orange fungal spores may be observed. For management of this disease, crop rotations with non-host crops are a good option.

Gray leaf spot (*Stemphylium solani*) – Gray leaf spot (a fungus) appears as small, shiny brownish-black spots or specks on the lower leaves that extend through to the undersurface of the leaf. Spots usually remain small, but may enlarge until they are about 1/8" in diameter. These spots can become glazed and the centers may crack and tear. Infected leaves usually turn yellow and as the disease progresses, then usually die and drop off. Spots may also form on the stems. The fungus over-winters primarily on diseased refuse and can be spread by airborne spores from diseased to healthy plants. Control measures include resistant varieties, crop rotation, seedbed sanitation and preventative fungicide applications similar to the control of early blight.

Leaf mold (*Cladosporium fulvum*) – Leaf mold is a fungus that is usually observed on older leaves near the soil where air movement is poor and humidity is high. At first, diffuse whitish spots or blotches appear on the upper surfaces of older leaves and can rapidly enlarge and become yellow. Under humid conditions, the lower surfaces of these spots become covered with a gray or olive velvety growth due to fungal spore production. Tomato stems and fruits can also be infected. When conditions are ideal for fungal development, large areas of the field may be infected, and plants become weakened, and yield is greatly reduced. Disease pressure is enhanced when foliage remains wet and if daytime temperatures remain under 95 °F. This environment is also conducive for abundant production of fungal spores. Fungicides can be used as chemical controls.

Soil rot (several fungi) – This type of rot may occur when the fruit touches, grows near, or when soil splashes onto the fruit. Damaged fruit decays rapidly, and affected areas are cracked and watery. To prevent soil rot, make sure that fruit does not touch the ground by using mulches, supporting the plant with cages or trellises, using well-drained soil, or by applying the appropriate fungicides. Fungi responsible for this rot may be secondary pathogens that are abundant in soil. Fungicides may be used to manage soil rot.

Bacterial spot (*Xanthomonas spp.*) – Symptoms of bacterial spot include small, brown, circular spots less than 1/8 inch on leaves, stems, and fruit. Spots may appear water-soaked and eventually blighting may occur. On the green fruit, spots first appear as tiny, raised blisters and expand to ¼ inch. The centers of a lesion can become irregular, light brown and somewhat sunken and may exhibit a rough, scabby surface. Ripe fruits tend not to be susceptible to this disease. It is not uncommon for spots to develop a halo appearance that will disappear with time, and in tomato leaves, spots could exhibit a shot-hole appearance.

Bacterial spot is favored by splashing rains and weather that is moist and high in temperature (85-95 °F). Bacterial spot is difficult to control once it appears. Disease-free seed and seedlings should always be used. Crops should be rotated to avoid any previous season's tomato residue. Dry, hot weather usually does not favor disease development. Control options include copper bactericides, plant inducers and bacteriophages that target specific strains.

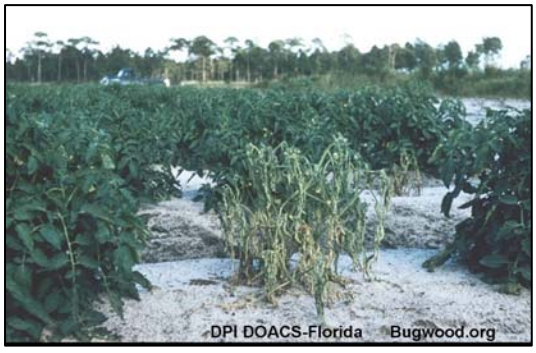
Tomato leaves exhibiting a shot-hole appearance caused by bacterial spot (left). On young fruit, spots appear as tiny, raised blisters that expand with time (right).

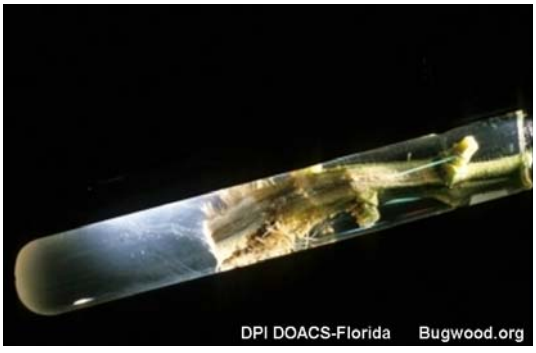
Bacterial speck (*Pseudomonas syringae* pv. *Tomato*) – Lesions tend to be round and dark brown to black in appearance. With time, a halo will develop and lesions will spread throughout the leaf, coalesce, and kill large tissue areas. Lesions on pedicels, stems, and petioles appear oval to elongate. On fruit, pinhead-size tiny specks or lesions develop, expand, and are dark in appearance.

The bacterium is seed borne but can potentially survive for six months in crop residue. Weed species can also serve as alternative hosts for this bacterium. High humidity and low temperatures (64-75 °F) favor disease development. Seed treatments should be employed and disease-free transplants should be used. Copper bactericides or copper bactericides or other combinations are an option for disease management.

Bacterial speck on fruit. Lesions will continue to expand.

Bacterial wilt (*Ralstonia solanacearum*) – First symptom is wilting of the upper leaves during the warmest time of day, though plants may recover at night. Plants will become stunted or completely wilted and die. In the lower stem, vascular tissue exhibits a dark brown discoloration. If a cut in the lower stem is placed in water, bacterial ooze is an indication that this pathogen is present. Disease is favored by high temperatures (85-95 °F) and soil with high moisture content. Control of bacterial wilt is difficult. Avoid fields with a history of *R. solanacearum*, rotate crops with a non-susceptible crop, and raise the soil pH to 7.5 or liming are some cultural practices to manage this disease. Moderately resistant cultivars are available but might not be suitable to the area or must first be tested for adaptability to a specific location. Soil fumigation has only achieved limited success.





Wilting of a tomato plant as a result of infection by *Ralstonia solanacearum*, the causal of bacterial wilt on tomato (left). A sign of bacterial wilt is bacterial oozing from a cut stem piece after being placed in a clear container with water.

Root Knot Nematodes (*Meloidogyne spp.*) – Nematodes are small, microscopic worms that are present in many soils. Root knot nematodes are possibly the greatest overall threat to tomato production. Affected plants often appear to be stunted, yellow and low in fertility. Leaves will wilt, especially during the hottest time during the day. In susceptible varieties, infected roots generally have knots or galls which prevent normal uptake of nutrients. An infected root can predispose the plant to infection by *Fusarium* and increase disease levels by the bacterial pathogen *Ralstonia solanacearum*. Once present it becomes necessary to use a resistant variety or to apply nematicide.

Prevent a buildup of nematodes by maintaining high organic matter in the soil. Since these nematodes have a wide host range, weeds and volunteer crops should be controlled. Use of resistant varieties is the most effective method of reducing losses caused by nematodes. Nematicides and soil fumigation are other alternatives in managing root knot nematode populations.

Tomato plant infected with root knot nematodes that form galling on the roots.

Viruses – Tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), and (beet) curly top virus (BCTV) are three of the most common viruses which attack tomato plants on the Texas High Plains. Tomato mosaic virus (ToMV), tomato spotted wilt virus (TSWV) and Tomato yellow leaf curl virus (TYLCV) are three other important viruses that could be of major concern to the region. TMV is mechanically transmitted. CMV, BCTV, TSWV, and TYLCV are transmitted or vectored by aphids, beet leafhoppers, thrips, and whiteflies, respectively. In young plants, TYLCV may cause severe stunting and later on, plants may not produce any fruit. In addition, leaves will curl upward, plant growth may also be upward, and leaves will exhibit interveinal chlorosis. With TSWV, light brown specks first appear on leaves and then turn brown. Whole leaves may turn brown and die, giving the plant a wilted appearance. Plants can be stunted and fruit may develop concentric rings. BCTV will cause death or at least stunting, especially on young tissue. With TMV and CMV, it is common to see light and dark green mottling on the leaves. In TMV, leaflets may be deformed and narrow, while in CMV and some strains of TMV, the plant ends up having shoestring leaf blades. Plants will show chlorotic tissues and leaves become thick with purple veins and curl upwards. To control viruses, buy only healthy plants, avoid excessive handling, and follow a good insect control program. Remove all virus-infected plants as soon as possible to avoid infecting other plants. Infected plants should be removed when small. Also, eliminate weeds around the field since many viruses may have alternative hosts that over-winter as a survival mechanism. For viruses that are potentially seed borne, such as ToMV, dry heat treatments at 158 °F for 2 - 4 days are an option. If using plastic mulches, metallic (shiny) mulches that are highly UV reflective can be used.

Typical orange and red discoloration can be observed (left), followed by rings that turn brown. On leaves, tomato spotted wilt virus (TSWV) will show small, dark brown spots (right).

Weeds

Weeds are not only unsightly in the garden but they also interfere with tomato productivity. Weeds compete for space, light, nutrients and soil moisture. Proper spacing of plants within the garden area will assist with control by shading out small weeds. In small gardens use a hand-held hoe or other tool to remove weeds. Identification and understanding the biology of weeds is important to improving their control in any garden. Weeds can be classified into categories such as grasses (bermudagrass, crabgrass, sandbur, etc.), broadleaves (dandelion, khaki weed, nightshade, etc.) and sedges (yellow or purple nutsedge, sometimes incorrectly called nutgrass). In addition, these weeds have life cycles that are either annual (live only for one year) or perennial (live for multiple years).

A simple knowledge of biology can improve the chances for successful weed control. For example, a deep-rooted perennial weed will respond differently to either weed removal or chemical sprays than will annual weeds. Pulling out a perennial weed will likely leave many reproductive parts below ground which eventually emerge and continue to compete with the tomatoes. Therefore, herbicides would be a good choice to use under those conditions.

When spraying commonly-used broad-spectrum herbicides like Roundup (glyphosate) around tomato plants, be careful not to drift any on the leaves as this may kill or severely stunt tomato plants. A carefully placed paintbrush or Q-Tip dipped in the concentrated herbicide can be used to wipe any weed leaves around and within the tomato canopy. Avoid using any broadleaf weed killers that contain active ingredients like 2,4-D, dicamba or other products containing Trimec as these may volatilize and be taken up by the tomato plant. Don't use the same sprayer for applying fungicides after using it with herbicides as the used sprayer may cause injury to the plants. Most injury can be seen as deformed leaves and/or twisted plants. Once these plants have been affected, there is usually nothing that can be done to alleviate the problem. Use extreme caution with herbicides around tomato plants and always **READ AND FOLLOW THE LABEL INSTRUCTIONS FOR ANY HERBICIDE**. For commercial growers, there are more herbicide choices available for use.

Two weeds, silverleaf nightshade (left) and black nightshade (right) are related to tomatoes and may be difficult to control with herbicides. Silverleaf nightshade is a perennial with an extremely deep tap root, thorny stems and leaves; black nightshade is an annual weed with a fibrous root (easily pulled out).

Fruit Set & Harvesting

Conditions that may cause tomatoes to have low set fruit are multiple and include the following: application of too much nitrogen fertilizer (this will cause plants to produce more stems and leaves than fruit); when day time temperatures are too low (50 ^{o}F) or too high (95 ^{o}F), or when night

temperatures remain over 75 ^{o}F. Non-uniform, irregular or fluctuations in watering will reduce pollination and cause physiological disorders of the fruit. Too much shade, too much rainfall, fog or not enough sunlight, and even planting the wrong variety may cause lower yields. All of these conditions can cause reduced fruit set, but a mixture of one or more may lead to complete crop failure. Tomato fruit set can be increased by gently beating the plants with a broom (don't do it too hard or damage to the leaves and fruit may occur) to induce the pollen within the flowers to fertilize. Tomato flowers have both male and female parts and will easily fertilize under ideal conditions. It is best to follow the recommended varieties from Texas AgriLife Extension Service; however, it doesn't hurt to experiment with other varieties as well. Make sure to take good notes when experimenting with newer varieties.

Tomato fruit do not necessarily ripen on the plant any better than when they are off the plant if picked when a pink color is visible on the blossom end (the side facing the soil), and when held at room temperature in the light or dark. This reality is hard to believe, but harvesting tomatoes when they are just beginning to turn pink will maximize both quality and yield by reducing the potential for disease and insect attack. After picking the fruit, remove the calyx (stem) to prevent puncturing other fruit. Excellent tomato growers will continue to harvest from the same plants all summer long and into the fall, even up to the first frost. Pick tomatoes at full color for the best quality and taste. When temperatures are above 85 ^{o}F, fruits allowed to ripen on the vine may become yellowish-orange rather than red. At this time, it is best to pick at the pink stage and allow fruit to ripen indoors at temperatures between 55 and 70 ^{o}F for improved color development. Exposure of immature fruit to temperatures below 55 ^{o}F will prevent ripening. Tomato fruit will suffer chilling injury when stored in refrigerators.

Maintaining plant health

By mid-season, the older leaves at the base of the plants often become infected with early blight or pinworms. These leaves are shaded by those above and are no longer of benefit to the overall plant or fruit growth. All nonproductive plant tissues (fruiting trusses, yellowed or diseased leaves, or spindly non-fruiting stems) should be removed from the older (or lower) regions of the plant to allow for more sunlight and air movement. If possible, a long rotation (generally 4 years or more) in gardens is best to prevent soil borne diseases and nematodes from becoming serious issues. Do not plant an area to tomatoes or any relatives of the nightshade family (potatoes, peppers, and eggplant) or okra any more often than once every 4 years. Continue to keep the areas around the tomato plants mulched during the season. In West Texas, this can not be over-emphasized for both commercial and home gardening. Mulching has been strongly emphasized in horticulture for generations as an important technique for promoting plant health.

Greenhouse production

Tomatoes can be grown very successfully in large or small greenhouses on the Texas High Plains (even in backyard greenhouses), but they will likely require much more work and effort. Researchers at Mississippi State University have stated that greenhouse tomatoes will "have unique cultural requirements" and because of these "specific production requirements, greenhouse tomatoes can not be termed an easy crop to grow." In addition, "the time necessary to grow greenhouse tomatoes is much greater on a per unit basis than any field vegetable crop." When growing greenhouse tomatoes, it is important to understand the environment is "not a sterile one", and insect and disease pressure will likely increase. For expert information on greenhouse tomato growing, or to obtain the *Greenhouse Tomato Handbook*, contact Dr. Rick Snyder at the address listed on page 26. There is also the *Texas Greenhouse Management Handbook* found at: http://aggie-horticulture.tamu.edu; however, this is not a specific resource for greenhouse tomato production in Texas.

Greenhouse-grown tomatoes on the Texas High Plains showing determinate varieties (left) and taller indeterminate varieties on the right. During periods of excessively high temperatures, the sides of the greenhouse can be rolled up to allow air movement to cool the inside.

On the Texas High Plains, care should be taken to reinforce all structures to prevent wind damage (often winds will reach in excess of 60 – 70 miles per hour), not only to the greenhouse but the tomato crop inside as well. It is best to provide some large windbreaks (nearby trees, etc.) to reduce the effects of winds. Greenhouses whether large or small, should have plenty of ventilation to allow for cooling when high temperatures and sunlight overheat the house. Tomato plants can be grown directly in the soil, or in pots, bags, or using hydroponic techniques. Expect to spend more time assisting with flower pollination (lightly beating or with bees) to improve fruit set. Insect and disease populations will likely be greater greenhouses as well, so expect to spend more time scouting and monitoring for those pests. Fertilization will be critical, and the water pH, soil nutrients and soluble salts will need to be monitored closely. Finally, specific varieties are known to be excellent for greenhouse production, and those will likely increase the success of this type of production on the High Plains.

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Useful websites:

High Plains Vegetable Program:
http://lubbock.tamu.edu/horticulture/

Aggie Horticulture:
http://aggie-horticulture.tamu.edu/

Tomato Problem Solver:
http://aggie-horticulture.tamu.edu/tomatoproblemsolver/index.html

Greenhouse Tomato Handbook:
Dr. Rick Snyder, Extension Vegetable Specialist, Mississippi State University Extension Service, Truck Crops Branch Experiment Station, PO Box 231, Crystal Springs, MS 39059. Publication No. 1828 (28 pages). Email: ricks@ext.msstate.edu.