Tomatoes:
Organic Production in Virginia

Mark Schonbeck with Keith Damian, Pam Dawling and Charlie Maloney
Virginia Association for Biological Farming Information Sheet

Number 5-06 11/01/06 http://www.vabf.org/pubs.php

The tomato is one of the most popular market vegetables, with the US population consuming 4.8 billion pounds of fresh market tomatoes and several times that many tomatoes in processed foods each year. Many diversified farms in Virginia grow tomatoes as one of their major crops. While tomato production can be labor intensive and challenging, soaring demand for fresh organic tomatoes of all sizes, shapes, colors and flavors, as well as organic value-added tomato products, make for potentially high net returns from this crop.

Tomatoes grow vigorously in Virginia's warm-temperate climates, and generally respond well to good organic soil management. Yields average 10-13 tons per acre (180-250 lb for 100 ft of row), and can go as high as 40 tons per acre (750 lb in 100 ft row) under good organic management. However, a long list of fungal, bacterial and viral diseases can attack tomato crops, and this presents the greatest single hurdle to successful organic tomato production. Growers in Virginia and elsewhere have come up with many cultural practices and strategies to prevent and manage tomato diseases, improve fruit flavor and quality, and extend the tomato harvest season for early and late markets.

Contents:

Variety Selection

Deciding what varieties to grow is perhaps more complex for tomato than for any other crop. Tomato varieties are classified as determinate (limited vegetative growth and fruit production period) or indeterminate (large plants with a long season of vegetative growth and fruit production), and as early maturing (for cool or short growing seasons), mid-season or late. The fruits come in all sizes, shapes, and culinary uses: fresh salad, slicing and cherry tomatoes, paste (processing) varieties, and tomatoes for drying. Many of the heirloom varieties are best suited for direct marketing venues: they are rich in flavor but rather soft and don't keep or ship well. Most modern varieties are firmer and better suited for wholesale markets: flavor ranges from disappointing to quite good.

In addition to the traditional red tomato, the recent resurgence of interest in heirloom varieties has brought pink, purple, yellow, orange and even green, black (well, sort of) and bi-colored tomatoes to seed catalogues and farmers' markets. The dizzying choice also includes subtle variations in flavor (sweet, tangy, fruity, "complex" and even "smoky"). One of the more useful flavor categories is *low-acid*, which includes most yellow and orange varieties. Customers who are sensitive to the high acidity of red tomatoes can tolerate and enjoy the low-acid varieties, and will seek them out at farmers' markets.

Growers should consider the following factors in selecting tomato varieties:

- Market needs and demands
- Suitability to the grower's production system
- Regional adaptation – climate, soil, etc.
- Resistance or tolerance to prevailing diseases and pests

Table of Good Varieties for Areas of Virginia

Variety Type	Appalachia	Piedmont	Tidewater
Early	Daybreak	Glacier Stupice	First Lady II
Cherries	Sweet 100 Peacevine	Sun Gold Amy's Sugar Gem (saladette)	Sun Gold Juliet (Saladette) Red Pear
Maincrop Red		Celebrity Tropic Big Bite	Goliath Red Sun Amelia (TSWV Resistant)
Low Acid/Yellow or Orange		Golden Boy Jubilee	
Heirloom/Specialty	Brandywine Pineapple Mortgage Lifter	Striped German Garden Peach	Brandywine German Johnson Eva's Purple Ball
Paste/Processing	Polish Linguisa Grandma Mary Pittman Valley Plum Blue Beech Bellstar	Roma	Viva Italia

Crop Growth Requirements: Soil Fertility and Nutrients

Tomatoes thrive on well drained, mildly acid soils (pH 6.0-6.8), require moderate amounts of nitrogen (N) and fairly large amounts of phosphorus (P), potassium (K) and calcium (Ca). Micronutrients are important, especially boron (B) iron (Fe), zinc (Zn) and molybdenum (Mb). The tomato's deep, extensive root system absorbs these nutrients quite efficiently during the crop's long growing season. Well-managed, biologically active soils that receive regular organic inputs (cover crops, organic mulch, compost and/or aged manure), can provide most or all of a tomato crop's nutrient needs, and usually require no concentrated organic NPK fertilizers. In fact, numerous studies have shown that tomatoes grown after legume green manures and/or fed with aged manures applied the previous fall can outyield tomatoes grown on recommended rates of NPK fertilizers.

On soils lower in organic matter and soil life, provide NPK and micronutrients with composted manure or organic fertilizers until soil quality has been built up. Avoid overfeeding tomatoes with N, which can result in lots of foliage but few fruit. If supplemental N seems necessary, incorporate about 50 lb N per acre at planting, and sidedress at first fruit set with another 25-50 lb/acre, using readily available N from organic sources, such as feather meal. To build up soil P levels, use rock or colloidal phosphate and/or manure compost; use natural potassium sulfate or hay mulches to add K.

Soil nutrient *balance* is important for tomatoes, so conduct a soil test initially and every few years thereafter to guide your fertility program. Note that excessive K can contribute to blossom end rot and other physiological disorders, especially where Ca is below optimum. Some soils with a history of

intensive conventional agriculture that show very low organic matter and appear "dead," may actually have very high or excessive P and K levels. In this case, use *no* manure, old hay or mineral P and K amendments, and rely on high biomass cover crops and *light* applications of high quality compost to build up soil life and organic matter. Soils under intensive *organic* management can also build up excess P and K: when this happens, use legume cover crops to replenish N and organic matter without adding more P and K. If the soil requires liming, use a high-calcium (calcitic) lime unless magnesium (Mg) is also low, in which case use dolomitic lime. If soil pH is over 6.0 and K is excessive, apply gypsum (broadcast, or smaller amounts in planting holes) to bring it back in balance.

Many Virginia soils are quite low in boron (B). If soil test shows low B, apply boron supplements or borax at 10-20 lb/acre (= 1-2 lb elemental B/acre) – *no more*, as too much is phytotoxic. A boron-deficient tomato plant can suddenly develop alarming "virus" symptoms with small, distorted leaves at growing points. A light foliar application of borax solution (1-2 lb borax/acre) can relieve visible deficiency and allow the plant to resume normal growth.

Temperature and Moisture Requirements

Tomatoes like it warm but not hot. They are frost-tender, and grow best at temperatures of 65-85°F. In particular, tomatoes take up nutrients and grow most efficiently when their root zone is between 70-80°F, and slow down markedly when the soil gets much hotter than this. Very hot summer weather, wide day/night temperature swings, and chilly nights (below 55°F) can reduce fruit set or fruit quality.

Tomatoes use a lot of moisture, yet their large, efficient root systems make them fairly drought tolerant. Try to keep soil moisture levels fairly consistent over time, as sudden wet/dry fluctuations can lead to fruit cracking or blossom end rot. If soil moisture levels are quite high, fruit size may increase, but flavor, percent soluble solids and shelf life may decline. In the cooler weather and medium-to-heavy texture soils of the Appalachian region, *moderate* drought years often produce the best tomatoes, with medium fruit size, superior flavor, minimal disease, and a longer harvest. However, *severe* drought, especially on sandy soils or in warmer regions, will curtail yield, so be prepared to irrigate if needed.

Two important water management tools for tomato growers are *drip irrigation* and *mulch*. Drip irrigation allows for precise application of moisture to the root zone, without wetting the foliage (important for disease prevention). A good organic mulch (straw or seed-free hay, spread loosely, about 3-4 inches deep) should be applied when the crop is well established and the soil has warmed to 70-75°F. The mulch will conserve soil moisture, reduce moisture fluctuations, curb weed growth, and help maintain optimal root zone temperatures. A black plastic film mulch laid before planting will block weeds more completely, but will also exclude rainfall – so drip irrigation tape *must* be laid under plastic, or the root zone will overheat and dry out, causing production to slow or stop after an early start.

Planting and plant spacing

Tomatoes can be direct-seeded at the frost-free date, but they are usually started in the greenhouse about six weeks earlier. To grow starts, sow seeds in a flat with a good organic starting mix, placing seeds about ½ inch deep and ½ inch apart in rows about two inches apart. When the seedlings have their first true leaf, spot them out two to three inches apart in flats of growing mix, or individually in 3-inch pots. At six weeks after sowing, seedlings should be six to eight inches tall and ready to set out. In the event of delay, they may get somewhat leggy and crowded, but will remain viable for several weeks longer if provided with some foliar organic fertilizer.

Use a commercially-available greenhouse mix that is formulated for organic growers, or make your own. Mixes that contain a substantial proportion of high quality compost (at least 10% - some growers have grown great starts in up to 80% compost) give more robust starts and need less additional fertilizer than sterile, soilless mixes. *Vermicompost* (worm castings) included at 10-20 percent of mix volume (not higher) has been shown to enhance seedling vigor and sometimes crop yield in tomato and other vegetables. Avoid low-quality, poorly decomposed or anaerobic compost in starting mixes, as these can promote

diseases.

When transplanting tomatoes into the field, set them an inch or two deeper than they were in the flat. If plants are tall and leggy, you can bury more of the stem. Lay the root ball and lower half of the stem in a shallow (4-inch) furrow and cover with topsoil, rather than planting the root ball really deep where the soil may be too cold or airless for good root growth.

Tomatoes are large plants, so be sure to give them plenty of room! Most sources recommend spacing rows five to six feet apart, with plants two to three feet apart within the row (18-24 inches for smaller determinate varieties). At least one Virginia grower has had much better results with wider within-row spacing (see sidebar).

Season Extension

The price for fresh tomatoes is much higher early and late in the year than in the "months of glut" August and September. More and more farmers are producing tomatoes in *high tunnels* – unheated greenhouse structures that can extend the season at least a month at both ends through solar gain and frost protection. (see sidebar – Hoophouse Tomato Culture). A second important advantage of high tunnels is that
they keep rain off the crop foliage and greatly reduce the risk of fungal diseases. Tomatoes can be started

Sidebar:
Hoophouse Tomato Culture:

Charlie Maloney, Dayspring Farm, Tidewater region.

Alison and Paul Weidiger suggest using the bush varieties of *Celebrity* and *Early Girl,* but I find that the regular determinates give better production. For trellising I use T posts and a Florida weave system.

I am going to grow more beneficial plants in the hoophouse to attract beneficial insects. This year I had a bad outbreak of aphids and whiteflies. I sprayed with Safer Insecticidal Soap and released ladybugs.

Anthony Flaccavento, Appalachian Region.

Seasonal Field Hoophouses 100' x 14' using 1oz or 1.2oz (per square yard) rowcover fabric can give protection down to 28F or 26F. these hoophouses hold 3 100' long beds, accommodating 3 rows of tomatoes – about 180-200 plants. The plants are set out around March 20-25 (about 6 weeks before our last frost date), and fruit is harvested from mid-June, about 3 weeks ahead of field crops. The covers are removed in mid-May. Plasnting dates are similar for plastic covered high tunnels, which give better overall production.

Sowing/Transplanting Dates for Succession Crops

Planting	Appalachia	Piedmont	Tidewater (inland). (10-14 days earlier on coast)
Hoophouse Earlies	30 Jan/25 Mar	17 Jan/15 Mar	15 Jan/10 Mar
Outdoor Earlies	15 Mar/5 May (with rowcover) 1 Apr/15 May	27 Feb/15 May	15 Feb/20 Apr
Outdoor Maincrop	15 Apr/25 May-1 Jun	15 Mar/15 May 17 Apr/30 May	1 Mar/30 Apr
Outdoor Lates	10 May/25 Jun	14 May/16 Jun	25 May/1 Jul
Hoophouse Lates		18 Jun/8 Aug	

in the late winter to obtain first fruit before the end of May, or in early summer for late fall harvests.

Some season extension is also possible in the field. For early tomatoes, set them out under row covers (supported on hoops) a week or two before the spring frost date, and leave row covers in place until the crop is well established and the weather is warm. For late production, start tomatoes in May or early June, and transplant in July at some distance from earlier plantings, to minimize migration of pests and pathogens. Late plantings can provide harvests in early fall (until frost) when the main crop has given out due to disease or senescence.

Prevention and Control of Tomato Diseases

Tomatoes suffer from an amazing diversity of diseases caused by fungi, protozoa, bacteria, viruses and nematodes. The most widespread and costly fungal disease in Virginia is *early blight,* which first appears on lower leaves as brownish lesions, perhaps a half inch across, with a distinct concentric ring pattern and a yellow halo. When warm, humid conditions favor disease development, the fungus progressively defoliates the plants, reducing yield potential, exposing fruit to sunscald and sometimes attacking the fruit itself, causing a black, sunken lesion at the *stem* end. Other common fungal diseases of warm, moist weather include *septoria leaf spot* (small brown-black dots on lower leaves, spreading up the plant and reducing yield by defoliation -see sidebar), *gray leaf mold,* and *anthracnose* (which attacks primarily the fruit itself (sunken, watersoaked spots, especially on fruit lying on the ground). In the Appalachian region, cool, moist summer weather can lead to *late blight,* a fast-moving and devastating disease caused by a species of water mold (a group of organisms long considered fungi, but recently moved to the phylum Protozoa!) Late blight starts as gray-black spots on the leaves, sometimes with a distinct white fuzzy mold growth. Fruit develop brown, firm, shiny or greasy-looking lesions. The disease spreads rapidly and can consume an entire field in ten days, unless stopped by a spell of hot, dry weather. Soil-borne fungal diseases include fusarium wilt and several races of verticillium wilt. These fungi clog the plant's vascular system, causing whole branches or entire plants to wilt suddenly.

Sidebar:
Tomato Spotted Wilt Virus

Charlie Maloney, Dayspring Farm, Tidewater region

Tomato Spotted Wilt Virus arrived in the Tidewater region in 2002. The virus is known to be spread by adult thrips. The foliage of infected plants will show numerous small dark spots and turn bronze in color. Dark streaks appear on the main stems, and the tops of plants often yellow and wilt. Some plants may survive, but will be stunted, and the ripening tomatoes will have slightly raised, yellow bulls-eye rings on the skin, and be deformed in shape. Yield is greatly reduced. The greatest loss is among the heirloom varieties. *Amish Paste* is very susceptible. Cherry and small tomatoes fare better, especially *Sun Gold.* Among main crop varieties, *First Lady* and *Rutgers* have done better than most. Among resistant varieties, the Johnny's *BHN-444* produces nice size fruits without blemishes, but the shoulders are green and the taste is on the flat side. *Amelia* from Park's has better production and flavor.

Unfortunately, once a plant is infected, the disease cannot be controlled for that plant. Good sanitation is the best prevention. Some weeds such as chickweed and bindweed are hosts for the virus, so these should be controlled in areas adjacent to the tomatoes. Many ornamentals, especially dahlias and lilies, are also hosts and should be planted away from the tomato patch. It is unclear whether removing infected tomato plants will reduce the spread of the disease, or flush out the thrips that then move to other plants. The virus is very difficult to control and does over-winter. Careful rotation of crops helps reduce the incidence and severity of the disease. Reflective mulches might also be helpful.

TSWV was severe in 2002, following an unusually mild winter. This was alarming as TSWV has surged to epidemic proportions in some areas of the world, and there are now parts of California and Hawaii where tomatoes can no longer be grown. Fortunately, over the last several years, there has been very little TSWV at Dayspring Farm.

Bacterial diseases include bacterial canker (leaves develop brown edges and wilt), bacterial spot and bacterial speck (brown, rough spots on fruit, small spots on leaves). The most serious viral diseases include tobacco mosaic virus (TMV - small, distorted leaves and plant), and tomato spotted wilt virus (TSWV – small dark spots on leaves and stems, plants yellow and wilt, fruit blemished). Wet weather is not the culprit for viral diseases. Rather, TMV is vectored (carried) by aphids and humans who smoke tobacco, while thrips (another small insect pest) is the vector for TSWV. (See sidebar -Tomato Spotted Wilt Virus)

Plant-pathogenic nematodes (near-microscopic worms), such as the root knot nematode (RKN) can attack tomatoes, reducing crop vigor and yield. These nematodes are most problematic in warmer climates and in soils low in organic matter and soil life. As the soil becomes healthier under good organic management, harmless nematodes that live on soil fungi and bacteria gradually supplant the root-feeding (plant pathogenic) species.

Several physiological disorders that are *not* caused by pathogens, but can make tomato fruit unmarketable include: blossom end rot (black sunken lesion at blossom end, related to localized Ca deficiency in the fruit, aggravated by drought, wet-dry fluctuations, and possibly excess soil K); catfacing (distortion at blossom end, aggravated by cool temperatures), cracking (aggravated by heavy rain or overwatering after dry spell), and sunscald (bleaching and decay of fruit, caused by direct exposure to the sun due to defoliation). Nutrient deficiency symptoms that can look like a microbial disease include yellowing of older leaves (N), reddish-purple leaves (P), bronze spots between leaf veins (K), and small, twisted leaves (B).

Maintaining healthy soil and balanced crop nutrition can minimize deficiencies and physiological disorders, and *partially* protect the crop from pathogens. Prolonged leaf wetness is a key factor in the onset and spread of fungal and some bacterial diseases; thus many disease-prevention strategies are focused on keeping the aboveground parts of the plant as dry as possible – a real challenge in our rainy climates! In particularly wet seasons or climates, "calendar spraying" with copper-based or other organic-allowed fungicides every 7-10 days may be necessary to prevent severe outbreaks of early blight, late blight or septoria. Good sanitation and crop rotation are essential. For insect-vectored viral diseases, controlling the vector insects and the weeds that act as alternate hosts are the main strategies.

Specific disease reduction practices include:

- Select locally adapted and/or disease resistant varieties. Varieties marked "VFN" are resistant to verticillium and fusarium wilts and pest nematodes. Some early blight resistant varieties have been released, notably the "Mountain" series developed in North Carolina. If you save your own seed, select for disease resistance.
- Practice good crop rotation. Plant solanaceous vegetables (tomatoes, potatoes, peppers, eggplant, tomatillo, ground cherry, tobacco) in a particular plot no more than once every three to four years to control foliar blights, or every six years for fusarium and verticillium wilts.
- Practice good sanitation. Avoid smoking near tomatoes, have smokers wash hands with soap and/or milk before working with tomatoes. Avoid handling plants or entering the field while tomato foliage is wet. Eliminate solanaceous weeds (such as horsenettle, jimsonweed and black nightshade), which can serve as reservoirs for viral and fungal pathogens. Remove and destroy infected plants, especially for TMV and TSWV.
- After tomato harvest is finished, remove and compost or burn crop residues, or till them into the soil to speed decomposition.
- Ensure good soil drainage and aeration. Subsoil or chisel plow to break hardpan, grow tomatoes in raised beds, mound soil around stem so excess moisture drains away from plants.
- Maximize air circulation around plants. Choose a sunny, breezy upland location (avoid "frost pockets" – they also get more fog and dew), orient rows parallel to prevailing wind, and give plants plenty of room between and within rows so that they are not crowded. Remove lower leaves that touch the ground.
- Provide support for plants – stake and weave, trellis or cage – so that they do not sprawl on the ground (See drawing of stake and weave system).
- Use a mulch to prevent soil splash onto foliage. Soil splash can touch off outbreaks of early blight and some other foliar diseases.
- Avoid overhead irrigation – use drip irrigation to minimize leaf wetness.
- Consider investing in a high tunnel for tomato

Sidebar:
Septoria Leaf Spot;
Pam Dawling, Twin Oaks Community, central Virginia.

Septoria plagues us every year. Initially I mis-diagnosed the problem as Early Blight, and tried growing blight-resistant varieties, to no avail! The disease starts to appear in July, after fruit set. To improve our chances against the disease, we rotate crops to give the soil 2 or 3 years away frim nightshades. Four would be better. Because compost is a disease-suppressant we add a small amount of compost in each planting hole when using the no-till method. We use drip irrigation rather than overhead sprinklers, and organic mulch to absorb rain drops. We use the stake and weave system to get plants up off the ground. We try to avoid working or harvesting while the foliage is wet, and generally avoid touching the spotty leaves as much as possible. We collect and compost rotten fruit, rather than leave it on the ground.

At the end of the season we scrub the stakes, and disk the plants into the soil. We save our own seeds for our paste variety, and are selecting for resistance. (As yet, there are no Septoria resistant paste varieties on the market. Randy Gardner and Brett Grosghal are working on it.) We use a fermentation process when saving seed, which kills some diseases, though I'm not sure if Septoria is one of them.

My list of ideas to try next includes: Hot water treatment or bleach treatment before sowing, to kill diseases on the seed; Orienting rows so the prevailing wind blows down the rows; Trying wider in-row spacing; Pruning the suckers below the first flower cluster; Removing lower leaves that touch the ground; Removing affected leaves at the first sign of the disease; Removing nightshade weeds from as much of the garden as possible; Planting a succession to reduce the impact of disease, by providing fresh, healthy plants.

Copper fungicides (which accumulate in the soil, and are toxic), are allowed by organic certifiers. They are somewhat effective against Septoria. Treatment involves spraying every 7-10 days. Formulations allowable in organic certification include bordeaux, basic sulfates, hydroxides, oxychlorides, and oxides.

So far, my research has not shown up any beneficial organisms or bio-rational controls that are proven effective against Septoria. Possibilities to investigate include Compost Tea, Kelp foliar spray, Milk, Soap Shield, Hydrogen Peroxide, Sodium Bicarbonate, Sulfur, AQ10™, Antitranspirants, Biological fungicides (Mycostop™, F-Stop™, T-22G Biological Plant Protectant Granules™ or other forms of Trichoderma).

In 2006 we tried more plantings of tomatoes, in succession, but the later ones just got diseased more quickly, and had short lifespans. The challenge continues!

production. It can eliminate foliage wetting and greatly reduce disease inoculum and spread.

• During moist seasons, apply foliar protectants every 7-10 days – *before* you first see disease symptoms. Organic standards allow copper fungicides on a regulated basis; these help prevent most of the fungal and bacterial foliar and fruit diseases. There are now bio-fungicides commercially available that show promise against some of the tomato diseases. Somegrowers have reported success with foliar treatments with seaweed extract, compost tea or other "pro-biotic" microbial inoculants designed to enhance general disease resistance (See sidebar).

• A few tomato diseases are seed-borne. If you save your own seed, disinfect seeds either by dipping them in a 1:10 bleach:water solution, or into hot water (122°F) for 25 minutes. Do hot water treatment *immediately* before planting, as this starts the germination process.

Staking and Pruning

Most small to medium scale tomato producers provide support for their tomato plants, which greatly reduces fruit rotting and helps prevent some diseases.

There are many different systems, each with advantages and disadvantages. Indeterminate varieties need tall, sturdy support, while smaller determinates may do fine with relatively small cages, or allowed to sprawl on a *clean* straw mulch over well drained raised beds. Marlin Burkholder in central Virginia, and Anthony Flaccavento in the Appalachian region of southwest Virginia have used a semicircular woven-wire tunnel about 18 inches high and centered over the row as a support for determinate paste tomatoes. The tunnel can also serve as support for a row cover to protect early-planted tomatoes from spring frost.

Some growers use the "Florida stake-and-weave" system for large indeterminate varieties. Set sturdy stakes (e.g. t-posts) between plants, one every two to three plants within the row. Add horizontal wires or twine every six to eight inches up the stake as the plants grow, weaving to alternate sides to support plants from both sides. On a smaller scale, tall cages or trellises can be used.

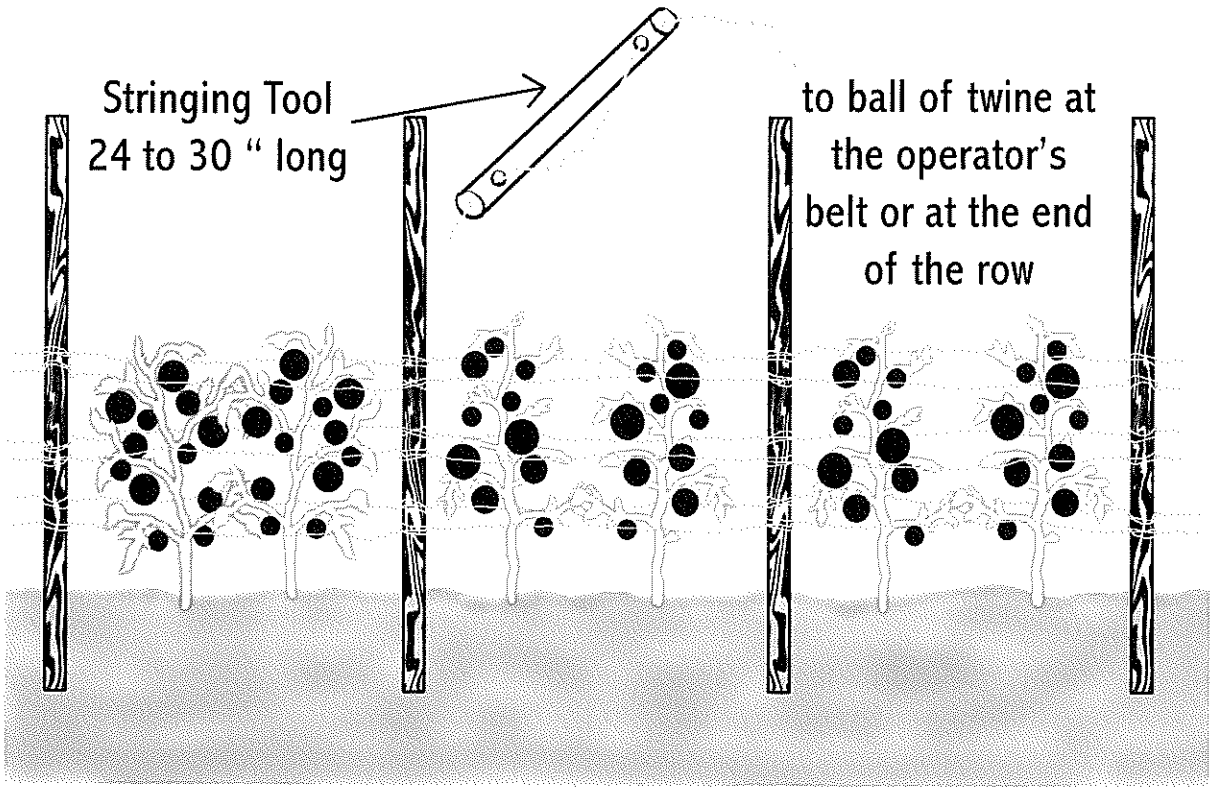
Some growers prune indeterminate varieties using various systems. In greenhouse production, it is common practice to prune each plant to just one or two stems, and train each stem up a vertical wire supported from above. Studies have shown that in the field, stringent pruning results in earlier and larger fruit, but lower total yields and greater risk of sunscald because there is much less foliage. At the opposite extreme, plants can be left entirely unpruned – in which case *wide* spacing is strongly advised.

Pest Management

Because tomato grows so vigorously, it can tolerate some defoliation by insects, and has relatively few really serious insect pests. The biggest threats come from viral diseases carried by aphids (TMV) or thrips (TSWV). If the viral diseases are present in your area, protect tomatoes from them with row covers (early season) and/or insecticidal soap or botanical pesticides if necessary.

Encourage beneficial insects through diverse habitat plantings near the tomato crop ("farmscaping" – include buckwheat, legumes, and flowering plants in the carrot, mint and sunflower families). This can go far toward keeping tomato pests down. Protect

Stake and weave support system



your insect allies by using soap or botanicals only when really necessary, and *never* spray habitat plantings.

Caterpillars that eat the foliage and/or fruit include tomato and tobacco hornworms, tomato fruitworm (= corn earworm), fall armyworm, and pinworm. Hornworms are dramatic in their size and their ability to strip entire branches, but they often fall prey to a braconid parasitic wasp before they get out of hand. If you see these large caterpillars covered with little white cocoons, don't spray – the problem is already under control. Otherwise, Bt is quite effective. For fruitworm and armyworm, Bt works only during the first few days after they hatch, before they burrow into fruit.

Flea beetles, Colorado potato beetles and blister beetles sometimes feed on foliage, but will probably not affect yield unless defoliation is severe or the plant is still small when pests arrive. Stink bugs can damage fruit and make it unmarketable. Whitefly can be a problem, especially on young plants in the greenhouse. Severe infestations of any of these insects may require a botanical insecticide spray.

No discussion of pests is complete without mentioning deer. Tomato foliage is fairly poisonous to humans, but deer can and will eat it without ill effect, and they *love* the ripe fruit. In areas with high deer populations, a good high fence to exclude deer is essential for tomato production – and for most other vegetables as well. Groundhogs (woodchucks) are also capable of eating young tomato plants down to nubbins, and will remove ripe fruit. Because they dig, they are hard to fence out, but they may be trapped and removed.

Weed Management, Mulching and No-till Cover Crop Management

Tomatoes are fairly vigorous and competitive against weeds. It is important to control weeds by cultivation, hoeing and/or mulching for the first four to five weeks after transplanting. Later-emerging weeds will have little direct effect on tomato yield. However, remove or cut weeds before they go to seed, cut back weeds that threaten to reduce air circulation to the plants, and *diligently* remove solanaceous weeds that can harbor disease organisms.

More and more growers are using high biomass winter cover crops, managed without tillage, for tomato production. Winter rye, combined with hairy vetch, crimson clover or Austrian winter field peas, planted in the fall, can be grown until they flower in May, then killed by mowing, undercutting or flattening with a roller-crimper. This forms an *in situ* mulch, through which tomato seedlings can be transplanted. Some people report that Austrian winter peas as a winter cover crop will reduce the incidence of Septoria leaf spot. Rye is quite allelopathic, releasing natural substances that inhibit weed seed germination and early seedling growth for at least several weeks after the cover crop is mowed or rolled. Tomato transplants are quite tolerant to this allelopathy; in fact several different studies have shown superior yields in tomato planted no-till into a killed rye + vetch cover crop (3 parts winter rye: 1 part hairy vetch). The high cover crop biomass and reduced tillage of these systems also benefit soil quality as well as reducing weed pressure and providing slow-release nitrogen to the crop. Its one drawback is that the cover crop mulch will keep the soil a little cooler during tomato crop establishment, so this system is *not* recommended if you are growing tomatoes for an early market.

Harvest and Post-harvest Handling and Storage

For direct marketing, fresh tomatoes are picked every two to four days, at the "firm-ripe" stage when they are at peak flavor and have several days' shelf life. They can be cooled to 55°F (not lower) to prolong shelf life to a week or so.

For wholesale markets, tomatoes are often picked at a "mature green" stage. The test for maturity is to slice a tomato in half. If the knife slices right through some seeds, the tomato is not mature enough, but if the seeds slip out of the path of the knife so that they remain intact, the tomato is mature enough to ripen off the vine and develop some flavor. Ripening and flavor development is better if tomatoes are picked at "breaker" stage (some red blush at blossom end), and better yet if allowed to get fairly close to ripe color on the vine – which is feasible for some *regional* wholesale markets where the tomato has a shorter trip to its final market. Mature green and half-ripe tomatoes must not be refrigerated, as this will "kill" the ripening enzyme and prevent flavor development.

Processing tomatoes are harvested at the red ripe

stage, either several times manually at five to seven day intervals, or once over mechanically. In these varieties, ripe fruit can stay on the vine for at least several days without becoming overripe.

Other Resources

Steve Diver, George Kuepper and Holly Born, 1999. *Organic Tomato Production.* National Sustainable Agriculture Information Service (= ATTRA). 21pp Excellent information sheet with more research references, though not specifically tailored to our region.
http://www.attra.ncat.org/attra-pub/tomato.htm

Southern Exposure Seed Exchange (P.O. Box 460, Mineral, VA 23117; 540-894-9481) carries a wide diversity of tomato varieties for our region, including some organic seed. Catalogue provides valuable cultural information for many of the varieties listed. Good information about seed saving is available. *www.southernexposure.com.*

Fedco Seeds (P.O. Box 520, Waterville, ME 04903; 207-873-7333) also carries a large number of tomato varieties, specializing in those adapted for cooler regions such as the higher Appalachians in Virginia. Catalogue provides cultural information. *www.fedcoseeds.com.*

Saving Our Seed (a project of Carolina Farm Stewardship Association) has developed a network of organic seed growers. Tomato is one of their priority crops, and the network has saved seeds of several regional varieties. Cricket Rakita, Project Coordinator, tel. (540) 894-8865, cell (706) 614-1451, fax (540) 894-8060
e-mail *cricket@savingourseed.org.*
Web site *http://www.savingourseed.org.*

Virginia Tech's publications on commercial tomato production are at:
http://www.ext.vt.edu/cgi-bin/WebObjects/Docs.woa/wa/getcat?cat=ir-fv-vegc-tom

other ATTRA publications:
Soil-borne Diseases:
http://www.attra.org/attra-pub/soilborne.html

Tomato Weblinks:
http://ww.attra.ncat.org/attra-pub/tomatoweb.html

Biointensive Integrated Pest Management:
http://attra.ncat.org/attra-pub/ipm.html

USDA: "Commercial Biocontrol Products for Use Against Soilborne Crop Diseases:
http://ww.barc.usda.gov/psi/bpdl/bioprod.htm
http://www.ars.usda.gov/is/tom/
http://www.ars.usda.gov/is/np/tomatoes.html
* Also see their publication on diseases at
http://www.ext.vt.edu/pubs/plantdiseasesefs/450-711/450-711.html.

Insect and Disease problems:
http://aggie-horticulture.tamu.edu/imagemap/mgmaps/mgprob.html
http://leviathan.tamu.edu:70/oh/mg/vegetable/tomato.html

Contact Information:

Virginia Association for Biological Farming
Post Office Box 1003
Lexington, Virginia 24450

www.vabf.org