Historical Perspective

The tomato (*Lycopersicon esculentum* Mill.) is a member of the Solanaceae family (Nightshade family), which also contains bell peppers, hot peppers, eggplants, and Irish potatoes. The tomato is the most commonly cultivated vegetable crop in the world.

A native of the tropical regions of South America, the tomato was spread by ancient peoples along trade routes. The tomato was a staple in their diets. In the seventeenth century as the Spanish began exploring the New World, they collected plants; however, the tomato did not become widely used in the diets of most Europeans until the mid-eighteenth century. After the tomato gained in popularity for use in cooking, it quickly found its way to the United States.

Today the United States produces more fresh market tomatoes than any other country in the world produces. In 1998, Alabama ranked twelfth following California and Florida as leaders in fresh market production in the United States.

The production of staked tomatoes is highly specialized (Figures 1a and 1b). It is labor intensive, requires a high initial investment, and demands a high level of management to be profitable. Staked tomato production should only be considered if you plan to do a thorough and conscientious job of managing your operation.

Soil and Fertility

Tomatoes can be successfully grown in most soils in Alabama. A well-drained, sandy loam, loam, or clay loam with a pH of 6.0 to 6.8 is preferred. Using a cover crop plowed in a month or more before transplanting can be beneficial by increasing the organic matter composition of the soil and by providing an additional source of plant nutrients (especially if the cover crop is a legume). Subsoiling may be valuable on soils with plow pans or hardpans.

Avoid continual cropping of tomatoes, peppers, eggplant, Irish potatoes, or any related vegetable crop on the same land area. Rotating tomatoes with nonrelated crops every 2 to 3 years is essential; crop rotation is a basic and effective means of controlling soilborne diseases and nematodes that otherwise may not have an effective chemical control. It is also important to avoid areas with known problems such as southern blight, heavy weed infestations, poor drainage, or steep slopes.

Figure 1a. Spring/early summer production of staked tomatoes on black plastic with drip irrigation

Figure 1b. Summer/fall production of staked tomatoes on white plastic with drip irrigation

Planting Recommendations

**Planting Dates**

Tomatoes are a warm-season crop sensitive to cool weather. This limits the use of direct seeding as a means of production in Alabama. Transplanting is the preferred method of production. When transplanting, it is best to wait until after all threats of frost have passed before planting. Depending on which stage of maturity is desired (mature green or breaker stage), most tomato varieties require 35 to 60 days from transplanting to reaching market maturity. Transplants are generally set around March 10 in southern Alabama, April 1 in central Alabama, and April 15 in northern Alabama.
Tomatoes are heavy feeders. To assure a good response to fertilizers, a detailed soil analysis for each field is important. Planning a fertilizer program based on soil test results helps you to satisfy the nutritional requirements for the tomatoes. Timely and appropriate application of fertilizer will make a critical difference in the quality of the crop as well as the overall yield. Collect soil samples in late winter or early spring. Apply the recommended amount of lime 2 to 3 months before planting. Be sure to thoroughly mix the lime with the soil. Also apply 0.5 to 1 pound of actual boron per acre prior to planting; recent research has shown a definite benefit in maintaining boron levels in tomatoes.

If a soil test is not done, apply enough fertilizer to supply 150 to 180 pounds per acre of nitrogen (N) and 200 to 250 pounds per acre of P₂O₅ and K₂O (potash). In any case, apply 30 to 50 percent of the required N and K₂O and 100 percent of the required P₂O₅ before transplanting. When growing on bare ground, sidedress with 25 percent of the remaining N and K₂O just after the first blooms set fruit and then again 3 weeks after that with the last 25 percent of the required N and K₂O. When using drip irrigation, apply the preplant fertilizers as indicated above. A lower percentage of preplant fertilizer is commonly used (30 percent) with drip irrigation. Sidedressing will involve weekly, biweekly, or possibly daily injections of fertilizer materials (fertigation) through the drip irrigation system. A more complete explanation of fertigation will follow under the “Irrigation” section of this publication.

### Transplants and Spacing

Tomatoes are an easy crop to transplant. Grow your own transplants to maximize your production. It takes about 4 to 6 weeks to produce a tomato transplant, and 3 ounces of seed will produce about 10,000 transplants. The optimal temperature for germination is 85 degrees F. It will take about 5 days at that temperature for the seedlings to emerge. By growing your own transplants, you can be certain of the cultivar, treatment of the transplants, and overall health of the transplants. In addition, the transplants will be ready when you need them because you do the scheduling. You do not need to depend on a transplant operation or on other growers.

If you are unable to produce your own transplants, be sure that the transplants that you purchase are certified and disease free. It is vital to remember that the health of the transplant is a major factor in how well the plants produce later. Poor quality transplants will produce poor quality fruit and lower yields. For optimal growth and establishment in the field, transplants should not be flowering (unless you are using a large 3- to 4-inch container for producing your transplants) or fruiting.

In any case, spacing generally depends on the variety, the training system, and the spray equipment to be used. Place rows 4 to 6 feet apart with plants 18 to 24 inches apart within the row. Use Table 1 to determine the number of plants per acre required at various spacings.

To determine the number of transplants required per acre for any spacings, divide 43,560 (number of square feet in an acre) by the product of the desired spacing between plants and the desired spacing between the rows. For example, an 18-inch between-plant spacing on 48-inch centers would require 7,260 plants per acre: 18 inches x 48 inches or 1.5 feet x 4 feet = 6 feet²; then divide 43,560/6 = 7,260 plants per acre.

### Varieties

Three types of tomatoes are produced for commercial markets: traditional, large-fruited tomatoes; cherry tomatoes; and Roma, or plum, tomatoes. Marketing channels for each of these types can differ a great deal. It is important to market your crop before you plant your first transplant since your market will often determine which variety (or varieties) you need to grow. Be sure to check with your buyer so that you will have a clear understanding of what he or she is expecting.

Not all varieties are suitable for production throughout the growing season. Some varieties are specifically bred for production in the spring and early summer, while others are more suited to late summer and early fall production. Also, many varieties were developed specifically for particular markets, that is, either mature-green harvest or vine-ripe harvest. Picking the correct variety for your market is imperative.

#### Table 1. Number of Plants Per Acre Required at Various Spacings

<table>
<thead>
<tr>
<th>Between-row spacing</th>
<th>Number of plants required per acre at various in-row spacings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 inches</td>
</tr>
<tr>
<td>4 feet</td>
<td>7,260</td>
</tr>
<tr>
<td>5 feet</td>
<td>5,808</td>
</tr>
<tr>
<td>6 feet</td>
<td>4,840</td>
</tr>
</tbody>
</table>
New heat-set or bot-set tomatoes are entering the market. These varieties were developed to produce greater yields of high quality tomatoes under stressful high temperatures common in the summer and early fall in the Southeast. (See the section on “Blossom Drop” for more details.) Conditions such as blossom drop and fruit roughness prevail when day temperatures exceed 85 degrees F and night temperatures exceed 72 degrees F for an extended period of time. It appears that many of these varieties not only produce well under high temperatures, but also under poor growing conditions common in the spring (fluctuating low temperatures, excessive rain). Many growers are switching to these heat-tolerant tomatoes for season-long production.

Contact your county Extension agent for a copy of the vegetable variety trials from the Alabama Agricultural Experiment Station at Auburn University. In the report, you will find information on the performance of selected tomatoes evaluated in several locations throughout Alabama. Although there are a number of commercial varieties available, you should only grow those that are adapted to Alabama. Try growing a small trial plot of several varieties each year to determine which ones are best suited to your particular market and growing conditions.

**Staking and Tying**

Staking tomatoes improves fruit quality by keeping plants and fruits off the ground and by providing better spray coverage. It is also easier to harvest staked tomatoes than ground tomatoes (Figure 2). In the staking process, a series of wooden stakes with twine woven around the stakes is used to train the plants to grow vertically off the ground. Stakes 4- to 5-feet-long by 1-inch square are driven about 8 to 12 inches into the soil between every other plant.

Vigorous cultivars may require larger and longer stakes. A stake placed between every other plant is adequate to support most determinate varieties (Figure 2). Placing an additional stake at an angle and tied to the end stake of each section will strengthen the trellis system (Figure 3). Stakes can be driven by hand with a homemade driving tool (usually a length of 2-inch pipe with an end cap secured in place) or with a commercially available, power-driven stake-driving tool. Drive stakes to a consistent depth so that spray booms can be operated in the field without damaging the trellis system.

Select tomato twine that is resistant to weathering and stretching and that binds well to the wooden stakes. Tomato twine is available in 3- to 4-pound boxes. About 30 pounds per acre are required. To make tying convenient, use a homemade stringing tool. This tool can be made from a length of metal conduit, a broom handle, or a wooden dowel (Figure 4). With a conduit, the string is fed through the pipe. With a broom handle or wooden dowel, drill two small, parallel holes, each about 1 inch from the end to feed the string through one hole along the length of the tool and through the other hole. The tool serves as an extension of the worker’s arm (the length cut to the worker’s preference) and helps to keep the string tight.

Proper stringing consists of tying the twine to an end stake passing the string along one side of the plants, looping the twine around each stake until the end of a row or section (100-foot sections with alleys may be helpful for harvesting) is reached (Figure 4). Continue the same process on the other side of the row. The string tension must be tight enough to hold the plants upright, but harvest can be difficult and strings can scar fruit if they are too tight.

The first string should be strung 8 to 10 inches above the ground when plants are 12 to 15 inches tall before they fall over. Run the next string 6 to 8 inches above the preceding string before plants start to fall over. Most determinate varieties require 3 to 5 stringings. Stringing should be done when the foliage is dry to prevent the spread of any bacterial diseases.

**Pruning**

Pruning helps maintain a balance between vegetative and reproductive growth. If you do not prune or prune very little, your tomato plants will produce excessive vegetative growth with reduced fruit size. Moderate pruning will leave your plants with smaller vines and larger fruit that will mature earlier. Pruning keeps plants and fruit off the ground, helping to control diseases. Although pruning requires a lot of effort, the benefits of doing so are more marketable fruit, easier harvesting, and reduced injury to plants when multiple harvests are being made. This practice is most profitable when a long harvest season is possible and when there is uniform fruit production over the season. The most common method is pruning a two-stemmed plant by pinching off lateral branches, known as suckers, as they appear in the axils of each leaf.

To achieve this balance, remove all the suckers up to the one immediately below the first flower cluster (Figure 5). Single pruning will usually be adequate, although a later pruning may be needed to remove...
suckers growing from the ground at the base of the plant. Suckers should be removed when small, no more than 2 to 4 inches in length. Letting them get large wastes plant energy and provides an entry point for plant pathogens.

Pruning should be done in the early morning after plants have dried. Indeterminate varieties may need to be topped using a knife or machete if the vines grow above the top of the stakes.

**Irrigation and Polyethylene Mulch**

**Background**

Irrigation is a requirement of any successful vegetable operation. It is also critical to the production of quality tomatoes. Tomatoes as well as most vegetables are 85 to 95 percent water, so any loss in water weight is equal to a loss in saleable weight. Whether using overhead or drip irrigation, you

need to provide enough water to the crop to ensure optimal production. Tomatoes need 1 to 1.5 inches of water per week. The tomato is a deep-rooted crop (24 inches plus) meaning that it will be able to exploit a lot of soil area for moisture; however, it is not a drought-tolerant crop. Insufficient water will result in the formation of undersized fruit, fruit with blossom-end rot, and fruit with growth cracks. All of this results in the production of a significant number of culls.

In tomatoes, the most critical time period for irrigation is during fruit sizing. Basically, this means that tomatoes need a continuous supply of moisture from establishment through the final harvest as fruit begins to set and enlarge within 2 to 3 weeks following transplanting. For tomatoes, the best system for supplying continuous moisture is drip irrigation. In most cases, you will need to run your drip irrigation system daily during times of peak water need (heavy fruit load, low relative humidity, high temperatures).
Using polyethylene (plastic) mulch offers growers several advantages. Plastic mulch increases the soil temperature accelerating plant growth and development. It also conserves soil moisture and reduces several common problems: soil compaction and crusting, ground rot of fruit, fertilizer leaching, drowning of crops, evaporation, and competition from weeds. Black plastic (Figure 1a) is commonly used for spring plantings since it hastens maturity and increases yields while white or white-on-black plastic is best used for summer and fall plantings when hastening maturity is not as important as the need to cool soil (Figure 1b). If white or white-on-black plastic is unavailable or too costly, you can spray black plastic with a dilute solution of flat, exterior white latex paint and water (3:2 v/v). A narrow 6- to 8-inch strip down the middle of the black plastic will be enough to cool the soil and prevent any young transplants from being damaged by the high soil temperatures typical under black plastic in the summer.

Although using mulch will increase production costs, those costs are offset by increased profits from earlier and larger yields of high quality produce. Drip irrigation systems must be used with plastic mulch. In addition, growers can plant multiple crops (double cropping) into the plastic mulch provided care is taken to avoid excessive damage (tears, holes, etc.) to mulch. Double cropping will spread your production costs over two crops, decreasing the risk associated with the higher initial setup costs. Tomatoes can be planted on mulch that was used to produce a spring crop such as cabbage, collards, broccoli, or strawberries. Be sure that drip tape is offset 3 to 4 inches from the center of the bed, buried 2 to 4 inches deep.

Drip Irrigation

Drip irrigation can be used on bare ground (Figure 6) or in combination with any organic or synthetic mulching material (Figure 7). Drip irrigation of staked tomatoes using raised beds covered with plastic mulch has resulted in higher yields and better quality fruit. While tomatoes grown using conventional sprinkler irrigation may yield approximately 800 25-pound boxes per acre, drip irrigated tomatoes with plastic mulch may yield from 1,500 to 2,000 boxes per acre. Because water and fertilizer can be precisely controlled, tomato quality is often superior. Thus, the market value for such tomatoes is higher depending on the market in any given year.

Management Requirements

Drip irrigation of staked tomatoes requires added attention to detail and increased management supervision in order to produce the high-quality, predictable crop required for shipment to markets throughout the country. The plastic mulch technique does increase labor and preharvest costs; however, this cost increase is more than offset by the increase in both fruit quality and quantity.

The drip system may need to be chlorinated regularly and should be closely monitored for proper operation. To avoid possible leaching or salinity problems, fertilizer applications through the system should be made on a frequent, often daily basis. Since rainfall will not replenish soil moisture under the plastic mulch, the moisture levels must be carefully monitored and irrigation events scheduled to meet the plants’ water requirements.

Bed Preparation

Staked tomatoes are produced on raised beds that are typically 4 to 6 inches high and 30 to 36 inches wide. Special equipment is used to form the beds and lay the plastic mulch. Careful attention to the soil condition and to the adjustment of equipment is needed to form beds and to place the plastic so that it will stay in place and provide an optimum environment for the tomato root system. Beds are shaped, pressed, fertilized, and fumigated (if necessary) in one operation. After the beds are shaped, the plastic mulch and drip tubing are then laid in a single operation.

Equipment required includes a bed press, equipment for fumigating the soil, and equipment for laying the plastic mulch and drip tubing. An alternative soil fumigation method is to inject the fumigant through the irrigation system after the plastic mulch is laid. With either method caution should be exercised before planting to ensure that the fumigant has dissipated and the beds are suitable for planting. Be sure to read the label for the fumigant since some may require up to 2 weeks to completely dissipate.

Drip Lateral Options

Two types of drip irrigation laterals, drip tape (Figure 8) and in-line tubing, are commonly used for irrigating staked tomatoes on plastic mulch covered beds. Drip tape has emitters formed in the tape as part of the manufacturing process and is a relatively inexpensive, throw-away product used for only one growing season. In-line tubing has drip emitters factory-installed inside the tube and usually is made of heavier gauge material so that it can be used for a number of growing seasons. When used for more than one growing
season, in-line tubing has to be recovered and rolled onto a large spool for storage.

In-line and tape products are manufactured with outlets spaced at uniform intervals, ranging from 4 to 24 inches or more. The spacing selected should be based on the soil type and crop. For tomatoes, 8-inch spacing is commonly used on sandy soils; 12-inch spacing is commonly used on heavier soil types.

The tape or in-line tube is placed to one side of the center of the row, normally 3 to 4 inches from the center and 2 to 4 inches deep in the bed. Stakes and tomato plants can then be placed down the center of the row without damaging the drip irrigation laterals.

Whether using drip tape or in-line tubing, care must be taken to ensure that the outlets do not become plugged during the growing season. Proper filtration and a routine chlorination and flushing maintenance program can accomplish this. For information on chlorination, contact your county Extension agent.

**System Design**

The irrigation system should be able to apply an amount of water equal to 75 percent of the maximum expected daily pan evaporation (PE), based on the total field area (excluding harvest roads). This application amount is the minimum design requirement and should take care of the maximum water needs of the crop. At a PE of .35, the highest normally expected in Alabama, the design peak application amount is .26 inches or .7128 gallons per acre per day. Note that this is the actual water application amount needed. Since the expected application efficiency of drip system is 80 to 90 percent, the design pumping capacity should be 7,920 to 8,910 gallons per acre per day.

Because this water is applied only along rows, bed spacing will affect the amounts to be applied per row foot. For example, assuming 80 percent efficiency, the design pumping capability should be 123 gallons per day per 100 feet of bed for beds spaced 6 feet apart (3-foot bed width) and 102 gallons per day per 100 feet with 5-foot spacing (2-foot bed width).

This design rate would only be applied in the most extreme cases, such as drought with mature plants, high temperature and wind, low humidity, and no clouds. The actual quantity applied each day will depend on the water used by the crop. For example, less water would be applied early in the growing season, when the plants are small, or on days with moderate weather conditions.

The operating time needed to apply a given amount of water will depend on the flow rate of the drip tape or in-line tubing used. For example, if drip tape with a flow rate of 0.45 gpm per 100 feet is used, it will take 3 hours 37 minutes to deliver 123 gallons per 100 bed-feet.

Find the total daily operating time by dividing the amount needed (gallons) per 100 feet by the tape flow rate (gallons per minute) per 100 feet.

**Fertigation**

Fertilization of plastic-mulched tomatoes should be based on soil test recommendations. Around 30 to 50 percent of the nitrogen and potassium needed by the crop is usually incorporated into the bed before planting and the rest applied through the irrigation system throughout the growing season. Phosphorus is not recommended for injection in irrigation systems, and 100 percent of the phosphorus requirement should be applied preplant. Commercial liquid fertilizer materials are much easier to apply through the system than are dry fertilizers, and they are less likely to cause clogging.

Adjustments of the amounts of N and K to be applied preplant or injected are made in accordance with the soil test recommendation and the analysis of the fertilizer material used. The key is that the proportions of N and K injected should match the fertilizer analysis.

| Table 2. Example of Preplant vs Injected Fertilizer Amounts |
|---------------------------------|-----------------|----------------------|---------------------|
| A | B | C | D | E |
|---------------------------------|-----------------|----------------------|---------------------|
| Fertilizer analysis (N:K ratio) | Total fertilization recommendation | Preplant N (30-40%) | Injected N (B - C) and K (N:K ratio to match analysis, Col. A) | Preplant K (B - D) |
| 7-0-7 (1:1 ratio) | 180 lb N | 60 lb N (33%) | 120 lb N | 1:1 ratio | 60 lb K |
| 7-0-7 (1:1 ratio) | 180 lb K | | 120 lb K | | |
| 5-0-10 (1:2 ratio) | 240 lb N | 72 lb N (40%) | 108 lb N | 1:2 ratio | 24 lb K |
| 5-0-10 (1:2 ratio) | 240 lb K | | 216 lb K | | |
Usually, nitrogen is taken as the first element to allocate to pre-plant or injection application. In Table 2 you will see examples of typical choices made for different fertilization recommendations and fertilizer material analyses.

Table 3 shows the recommended percentages to be injected during each week in a typical 12-week tomato-growing season. The idea is to match fertilization amounts with the plant’s requirements at each growth stage. Note that the percentages refer only to the portion of the recommendation to be injected, not to the entire fertilizer requirement. The actual amounts injected (pounds or gallons) will depend on the soil test recommendation and the fertilizer analysis. The breakdown is given on a weekly basis; however, daily injection (or 6 days a week) is preferable to minimize possible leaching and undesirable salinity problems. It is always better to inject smaller amounts of fertilizers more frequently on sandy soils (such as daily or every other day). With soils that contain more clay, less frequent injections such as once or twice per week are common.

Table 3. Percentage of Injected Fertilizer to Apply Per Week (For 12-Week Tomato Crop)

<table>
<thead>
<tr>
<th>Week</th>
<th>1%</th>
<th>3%</th>
<th>4%</th>
<th>6%</th>
<th>8%</th>
<th>9%</th>
<th>11%</th>
<th>15%</th>
<th>11%</th>
<th>11%</th>
<th>11%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>% to inject</td>
<td>1%</td>
<td>3%</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
<td>9%</td>
<td>11%</td>
<td>15%</td>
<td>11%</td>
<td>11%</td>
<td>11%</td>
<td>10%</td>
</tr>
</tbody>
</table>

An example of a tomato fertigation schedule below shows how amounts to be injected can be calculated to make up a detailed fertigation schedule (Table 4). Note that this is an example only. Columns A and B (basic fertigation schedule) would be generally applicable for tomatoes having a 12-week growing season. However, a complete fertigation schedule for a particular variety in a given field can only be developed with all of

Table 4. Example of a Tomato Fertigation Schedule

<table>
<thead>
<tr>
<th>Soil test fertilization recommendation:</th>
<th>180 lb N/acre</th>
<th>240 lb K/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation zone size: 10 acres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertigation schedule: 6 days/wk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer material: 7-0-7 (liquid)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid fertilizer weight: 10.5 lb/gal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basic fertigation schedule for tomatoes</th>
<th>Actual fertilizer amounts needed for injection</th>
<th>Gallons of 7-0-7 to be injected</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>% fert. Inject/ wk</td>
<td>lb N/ wk</td>
<td>lb N/ day</td>
</tr>
<tr>
<td>1</td>
<td>1%</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>3%</td>
<td>3.6</td>
</tr>
<tr>
<td>3</td>
<td>4%</td>
<td>4.8</td>
</tr>
<tr>
<td>4</td>
<td>6%</td>
<td>7.2</td>
</tr>
<tr>
<td>5</td>
<td>8%</td>
<td>9.6</td>
</tr>
<tr>
<td>6</td>
<td>9%</td>
<td>10.8</td>
</tr>
<tr>
<td>7</td>
<td>11%</td>
<td>13.2</td>
</tr>
<tr>
<td>8</td>
<td>15%</td>
<td>18.0</td>
</tr>
<tr>
<td>9</td>
<td>11%</td>
<td>13.2</td>
</tr>
<tr>
<td>10</td>
<td>11%</td>
<td>13.2</td>
</tr>
<tr>
<td>11</td>
<td>11%</td>
<td>13.2</td>
</tr>
<tr>
<td>12</td>
<td>10%</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Explanations:
Column C = B/100 x 120 lb
Column D = C lb/ 6 days/wk
Column E = D lb x 10 acres
Column F = B/100 x 120 lb
Column G = F lb/ 6 days/wk
Column H = G lb x 10 acres
Column I = C lb = 0.735 lb/gal
Column J = I gal = 6 days/wk
Column K = J gal x 10 acres

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the information from the soil test, the zone size, the fertilizer material analysis, etc.

If liquid fertilizer materials are used, the weight (pound/gallon) of the fertilizer material used must be known. In the sample fertigation schedule, for example, week 4 calls for 6 percent of the 120 pounds of actual N (per acre) to be injected, or 7.2 pounds. This figure must be converted to gallons of liquid fertilizer. Using a 7-0-7 fertilizer material that weighs 10.5 pounds per gallon, each gallon contains 0.735 pounds actual N (0.07 x 10.5 lb = 0.735 lb). To get 7.2 pounds actual N then requires 9.8 gallons (7.2 lb ÷ 0.735 lb/gal = 9.8 gal), as shown in Column I. For further details on fertigation, contact your county Extension agent.

**Scheduling**

Scheduling is the process by which decisions of when to irrigate and how much water to apply are made. For tomatoes grown on plastic mulch with drip irrigation, a scheduling plan that maintains nearly optimal soil moisture conditions is recommended. This means that the irrigation system is usually operated daily. On very sandy soils the system may even have to operate more than once per day to maintain the desired level of soil moisture.

Tensiometers are recommended for monitoring soil moisture, placed at both 6-inch and 12-inch depths in the bed and located 4 to 6 inches offset from the drip tape and midway between plants (Figure 9). Tensiometers at 12 inches monitor root development and moisture extraction at and below 12 inches. Tensiometers with tips placed at 6 inches are the primary indicators for scheduling irrigation. Irrigation should be scheduled so tensiometer readings will be maintained in the 10 to 15 centibar range, allowing not more than 20 percent depletion of soil moisture. Close monitoring of soil moisture is needed, especially on sandy soils or where plant root systems are restricted, such as growing tomatoes on plastic mulch.

**Physiological Disorders (Problems Not Caused by Diseases or Insects)**

**Blossom-End Rot**

Blossom-end rot (BER) is a physiological disorder, not a disease. It is easily identified as a brown, leathery rot developing on or near the blossom end of the fruit (Figure 10a). It starts with a dry, brown lesion the size of a dime and generally increases in diameter as the condition worsens. In time, lesions often become covered with a black mold.

BER is caused by calcium deficiency, usually due to fluctuations in water supply. Because calcium is not a highly mobile element in the plant, even brief changes in the water supply can cause BER. Droughty soil or damage to the roots from excessive or improper cultivation, i.e., root pruning, that restricts water intake can prevent plants from getting the calcium they need from the soil. Also, if plants are growing under high relative humidity in highly acidic soil or are getting too much water from either heavy rain or overirrigation, they can develop calcium deficiency and BER. With any of these cases, high temperatures (above 90 degrees F) will make BER worse.

To control BER, take the following steps:

1. **Keep the soil’s pH at 6.0 to 6.8.** Perform a soil test and apply the recommended rate of lime, using dolomitic or high-calcium limestone. Be sure to apply lime and fully incorporate lime 2 to 4 months before planting tomatoes.

2. **Apply the required amount of fertilizer when necessary as based on soil test results for tomato.** Applying too much fertilizer at one time can induce BER. Following soil test recommendations is the surest way to fertilize properly.

3. **Use mulches to conserve moisture.** Use pine straw, straw, decomposed sawdust, plastic, or newspapers. Mulches conserve soil moisture and reduce the incidence of BER.

4. **Give your plants adequate water.** Tomato plants need about 1.5 inches of water per week during fruiting. Extreme fluctuations in soil moisture can result in a greater incidence of BER.

5. **If your plants develop BER, spray them with a calcium solution at the rate of 4 pounds of calcium nitrate or calcium chloride per 100 gallons of water (or 4 level tablespoons per gallon of water).** Be careful with calcium chloride. If day temperatures are higher than 85 to 90 degrees F, calcium chloride can burn plants. Under high temperatures, use calcium nitrate. You should spray two or three times each week, beginning when the second fruit clusters are blooming. Spraying calcium is not a substitute for proper irrigation and fertility management.

6. **Try growing several varieties and keep notes of their performance under your growing conditions.** Some tomato varieties tend to be more sensitive to conditions that cause BER.

7. **Remove fruits with BER.** Once a fruit develops BER, it will not regrow or repair the infected area. Remove the fruit; otherwise, these damaged areas...
could serve as entry points for disease-causing bacteria, fungi, and insects.

Blossom Drop

This condition is NOT related to any nutritional disorder, disease, or insect damage. It is related to temperature. Despite the fact that tomatoes evolved in the tropics, flowering in tomatoes is sensitive to temperature. When day temperatures exceed 85 degrees F and night temperatures exceed 72 degrees F, tomato flowers often abort. An important temperature factor is time of exposure. The longer the plants are exposed to those high temperatures, the longer the condition will last and the more serious the effect will be on flowering. Short exposures of only 2 to 3 days may not cause much of a problem. It is interesting to note that although the combination of high day and night temperatures causes blossom drop, high night temperatures alone can be detrimental to flowering even if day temperatures are not over 85 degrees F.

Heirloom and older home garden varieties are more sensitive to high temperatures than are many of the newer hybrids that are presently available. When the fruit does not set and all other conditions are otherwise favorable (sufficient water and fertilizer, good pest control, appropriate pH), plants generally become vigorous and dark green. Even new hybrids, however, can be susceptible to blossom drop especially under prolonged adverse conditions.

Commercial growers in the Southeastern United States have suffered with this problem for many years until the recent advent of “heat set” tomato varieties. These varieties have been bred for tolerance to high day and night temperatures common in the summer and early fall. In fact, many of these varieties set fruit under poor growing conditions—extended cool, rainy periods as well as during extended periods of hot weather.

If this condition has developed in your planting, keep the plants healthy and watered. Maintain fertility levels and control any pest problems since any additional stress will make the condition worse. The plants will produce flowers and set fruit when temperatures become more favorable.

For your next crop, try growing a “heat set” variety. Many seed catalogs carry a wide range of tomatoes. Read the descriptions carefully looking for phrases such as “heat set,” “hot set,” or “heat tolerant.” Often those varieties have references to their heat tolerance in their names. Varieties such as ‘Sunbeam,’ ‘Sunmaster,’ ‘Suncrest,’ and ‘Sun Leaper’ have performed well in Alabama even during extended periods of hot weather and have become a mainstay for many of our commercial tomato growers.

Puffiness

This problem is worse under conditions of high nitrogen and low light (short days or cloudy weather) and when the nitrogen-to-potassium ratio is not in balance. It occurs more frequently after rainfall, particularly when accompanied by low temperatures. Anything that interferes with pollination (low light, excessive nitrogen, temperatures below 58 degrees F, or temperatures above 95 degrees F during the day and above 70 degrees F at night) leads to a greater incidence of puffiness.

Catfacing and Rough Blossom Scars

These problems are more serious with large-fruited varieties than they are with cherry or Roma tomatoes (Figure 10b). They are more prevalent if the weather is cool and cloudy at the time of bloom. Some publications list “open locule” as a form of catfacing. Open locule has been found more frequently when boron is deficient.

Fruit Cracks

There are two distinct types of fruit cracking: radial and concentric. Radial cracking is the most common and results in the most fruit damage (Figure 11). It occurs more often during rainy periods when the temperature is relatively high, especially when rains follow a long, dry period. Radial cracking is more severe on ripening fruits, especially if they are exposed to the sun. Concentric cracking begins on green fruits that are fully exposed to the sun (Figure 11). Maintaining a uniform water supply throughout the growing season with drip irrigation, mulches, or both, and maintaining good foliage cover will help reduce fruit cracks.

Sunscald

Sunscald can be a problem on both large-fruited and Roma tomatoes. The condition is commonly a problem with green-shouldered varieties or varieties that do not produce sufficient foliage to cover developing fruit. Producing poor foliage cover can be a function of the variety (low vigor variety) or it can be induced by insufficient nitrogen levels. The condition is characterized by the development of very dark green shoulders when the fruit is still immature. As the fruit develops, the shoulders begin to turn yellow (Figure 11) and remain so making the fruit unmarketable. Also, sudden exposure of the fruit to sunlight can cause sunscald. Avoid any unnecessary damage to the plant’s canopy during harvest.
that would result in exposing developing fruit to sunlight.

**Gray Wall**

Also called blotchy ripening, gray wall is more severe when the nitrogen level is excessive, the soil is poorly drained, the nitrogen-to-potassium ratio is not in balance, and the soil pH is low. Selecting well-drained soils and fertilizing according to the soil test recommendations will reduce this problem.

**Harvesting Tomatoes**

There is no money in growing tomatoes—just in selling them. Therefore, it is essential that you harvest your tomatoes at the stage of maturity that your market desires. Every grower should plan ahead and spend the necessary time training your workers to recognize the different stages of maturity of the tomato.

**Mature Green**

For shipping to distant markets, fruits generally are harvested at the mature green stage, which is when the fruit will ripen normally when removed from the plant (Figure 12). The best way to determine if the fruit has reached the mature green stage is to collect a sample of fruits and cut each crosswise. If the knife passes through the fruit without cutting any seeds, then the fruit is mature green. Otherwise, the fruit is immature green and will not color up and ripen properly when picked. For some varieties, a light or whitish color develops on the blossom end of the fruit. For the first harvest, growers will wait until about 10 percent of the fruit on the first flower cluster is at the breaker stage of maturity, which is when a flush of pink color develops on the blossom end of the fruit. All fruit on the first two flower clusters is removed. At the second harvest, which is usually 10 to 14 days after the first, mature fruit from the middle of the plant is removed. Maturity for the second harvest is based primarily on size; only fruit that is 2 inches in diameter and larger is removed. At the third harvest, 10 to 14 days after the second, fruit is removed from the upper portion of the plant.

**Vine Ripe**

Fruit for vine ripe production should be harvested at the breaker stage of maturity (the point at which a flush of pink color develops on the blossom end of the fruit). At this stage, fruit can be harvested, handled, and shipped with less damage than fruit with more color. It will also bring a higher price. Plan on harvesting every other day during the peak of the season. Vine ripe fruit tend to bring a higher price in the fresh market compared to mature green fruit.

**Pinks/Light Reds (60 to 90 Percent Red)**

For local markets, allow fruits to develop more color—pink to red stage. For the pink market, harvesting should be done daily or at least every other day according to the pinkness desired. Since these fruits are more mature than mature green or breakers are, their shelf life will be reduced and they will be easier to bruise.

For any local or distant market, always pack in the size container your market wants. This usually is a 20-, 25-, or 30-pound cardboard carton. Pack to assure uniform size, color, and quality. With proper cultural practices, tomatoes can produce 1,500 to 2,000 25-pound boxes of fruit per acre when using plastic mulch and drip irrigation. On bare ground with irrigation, expect yields to be around 800 25-pound boxes per acre.

**Cooling and Storage of Tomatoes**

The following recommendations are adapted from *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stock*, 1986, USDA, Agricultural Handbook No. 66. Be sure that all harvest bins are clean of any debris or soil. Placing padding in bulk bins can reduce damage to fruit. When emptying bins or containers, never drop fruit from any higher than necessary (Figure 13).

Table 5. Storage Temperatures and Shelf Life

<table>
<thead>
<tr>
<th>Stage of Maturity</th>
<th>Storage Temperatures</th>
<th>Length of Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature green</td>
<td>55 to 70 degrees F w/ 85 to 95 percent relative humidity</td>
<td>1 to 3 weeks</td>
</tr>
<tr>
<td>Pink</td>
<td>50 to 60 degrees F w/ 85 to 95 percent relative humidity</td>
<td>5 to 10 days</td>
</tr>
<tr>
<td>Ripe</td>
<td>45 to 50 degrees F w/ 85 to 95 percent relative humidity</td>
<td>4 to 7 days</td>
</tr>
</tbody>
</table>
for tomatoes. Never use ice or chilled water to cool fruit. If you are using a tank to wash fruit, the temperature of the water in the tank should be close to the internal temperature of the fruit, the pulp temperature. Placing hot fruit in cold water will significantly reduce the post-harvest life of the fruit.

Ripening of tomatoes is initiated by ethylene that they produce. It can also be induced by exposing mature green fruit to ethylene using a device that produces it. Mature green fruit is commonly treated with ethylene to hasten ripening and provide more uniform ripening within a particular lot. For treatment, tomatoes are exposed to 100 to 150 ppm ethylene for 24 to 48 hours at 68 to 78 degrees F with 85 to 90 percent relative humidity. Treating fruit that is beyond the breaker stage of maturity with ethylene will not provide any benefit since these fruits are already producing their own ethylene.

Precise temperature control is critical to maintaining acceptable quality in tomatoes. Use Table 5 to determine the optimal storage temperature for the particular fruit stage that you are concerned with. Note that as fruit becomes more mature, its optimal storage temperature decreases and its shelf life decreases. Tomatoes are very sensitive to chilling. Never store tomatoes below the low temperatures recommended in Table 5.

References

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