Greenhouse Tomato Production Guide

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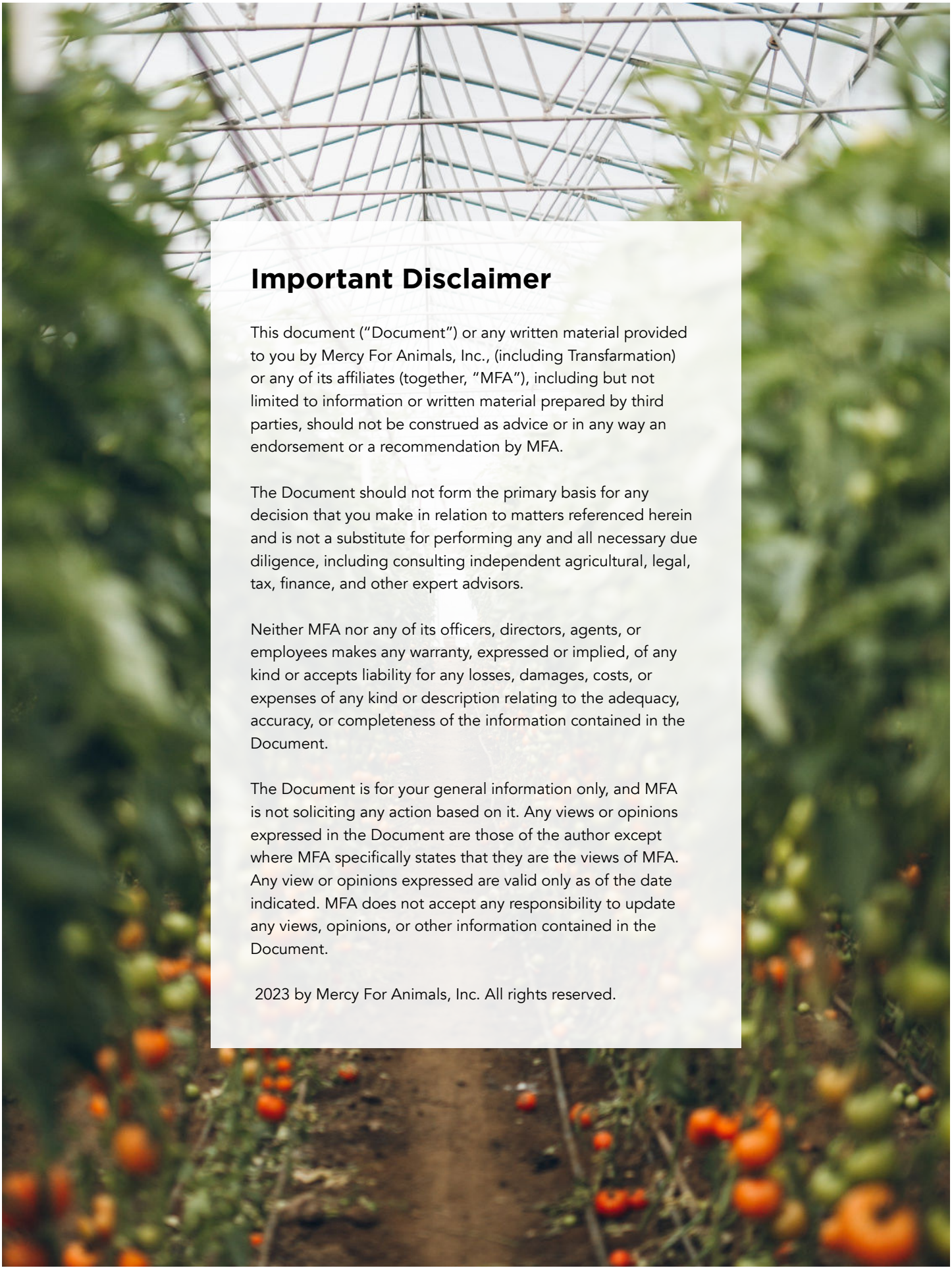

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GREENHOUSE TOMATO PRODUCTION GUIDE

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Tomatoes

The large *Solanaceae* family consists of over 3,000 species. Commonly known as the nightshade family, it comprises diverse plants such as tomato, pepper, potato, tomatillo, eggplant, petunia, and tobacco. All cultivated varieties of tomato belong to a single species, *Solanum lycopersicum*. This species has about 16 wild relatives in regions of South America and on the Galapagos Islands.

Tomato Production

Tomatoes are a monoecious crop, meaning that a single plant has both male and female flowers. But tomato plants are special because they have "perfect" flowers, containing both male and female reproductive parts in the same blossom. Thus, tomato plants are self-pollinating, which is an important factor of yield, fruit set, and successful greenhouse production.

Tomatoes are a very popular crop for commercial greenhouse production, as they have high yields and can be easy to grow, compared with cucumbers or lettuce. Demand for tomatoes is high, and they are widely grown and consumed around the world. Reports from home garden centers show that tomatoes are the most commonly planted garden crop in the United States.

Cultivar Selection

Cultivar selection greatly affects yield and production success. Several tomato cultivars are available for greenhouse production. Many of these are produced in Europe, but some companies have representatives for sales and technical support in North America. Additionally, greenhouse supply companies often distribute seeds. Cultivars are ever-changing, and climate is a factor in cultivar performance, so it is important to talk with a local extension agent or seed-company representative about which cultivars perform best in each region at a given time. Additionally, factors such as disease resistance, plant vigor, early yield, total yield, maturity, fruit size and color, and fruit quality should be considered.

Tomato varieties are one of two types, indeterminate or determinate, which differ in growth pattern and fruit production. Determinate varieties have a shorter, bushier appearance and produce flowers at the ends of their branches. Determinate tomatoes often mature faster and stop growing after terminal flowers appear. Conversely, indeterminate, or "vining," varieties tend to be taller and continue flower and fruit production for the duration of the plant's life, as they produce buds laterally as opposed to at the ends of their stems.

Greenhouse Methods

Environment

Tomatoes favor warm weather and fare best in daytime temperatures between 80 and 85 degrees Fahrenheit and nighttime temperatures between 62 and 72 degrees. Plants can tolerate temperatures just outside the ideal range for short periods, but temperatures above 90 degrees Fahrenheit and below 60 should be avoided if possible, as they can affect pollination, fruit set, yield, and color. Tomato plants are intolerant of frost, and cold temperatures can be detrimental. Humidity is another important environmental factor and should be around 60 to 70 percent. Humidity percentages that are too low or too high can affect pollination, and humidity levels that are too high can encourage disease.

Starting Tomatoes

Tomato plants grown in a greenhouse should be directly seeded into trays or containers, possibly with the help of a Speedy Seeder. After seeding, the trays or containers should be irrigated thoroughly from above with water adjusted to a pH of 6.0 to provide plenty of moisture. Seeds germinate best in warm temperatures between 75 and 80 degrees Fahrenheit. Seedlings should emerge after about seven to 10 days. Plants should be given nutrient solution and grown for about three to four weeks, in appropriate temperature and light conditions, at which point they can be transplanted. The process of starting tomatoes and growing to the transplant stage should take place in a separate area of the greenhouse or even in a separate greenhouse entirely.

Figure 1. Photo of tomato seedlings.

Transplanting Tomatoes

Once plants reach about four to six inches, they are ready to be transplanted. Plants should be transplanted into the greenhouse quickly and efficiently, with plenty of water and nutrients, to avoid stress. They can be transplanted into grow bags in rows about 15 inches apart. Wide grow bags can hold two rows per bag, but any size grow bag can be used for tomato production. Grow bags should be placed uniformly in rows about five feet apart, and each plant grown on a trellis or other support system. Drip-irrigation lines can be set up to run the length of the grow bags, with spray stakes in the bags beside the plants.

Choice of support depends on the type of plant. Indeterminate tomato plants are commonly grown using a trellis system. Plants are trained to grow up vertical wires or strings that are attached to a horizontal cable above, typically about seven to 10 feet high. One end of the string is tied or loosely clipped to the base of the plant, and the other is thrown over the cable and clipped or tied with a slipknot. Strings should be about twice as long as the top cable is tall to enable the plants to be moved—leaned and lowered—along the cable as they grow.

Figure 2. Photo of a trellis system and grow bag transplants.

Spacing and Pruning

The number of plants grown depends on the size of the greenhouse, light conditions, and pruning method. Each plant should be given three to four square feet of greenhouse space, depending on the amount of light. Less space is needed with adequate lighting, but with low lighting, more space may be required to avoid shading from overlapping leaf canopies.

Indeterminate tomato plants must be pruned using a method appropriate to the cultivar and growing conditions. Plants should be pruned to a single stem by removing all lateral shoots, or suckers, which form at each node between the base stem and leaf branches. If left to develop, suckers would generate fruit, but multiple suckers on one plant will cause the fruit to be small and of poor quality. One or two of the smallest suckers can be left at the top of the plant to form a new terminal bud if the original one is damaged or broken off.

Pruning should be done early in the day and ideally in sunny conditions to encourage drying of wounds.

Some tomato cultivars bear fruit in clusters, which may need to be thinned. Most clusters support about 10 flowers, six or eight of which become fruit with good pollination. For optimal growth and fruit quality, clusters should be thinned to about four or five fruits to allow room for adequate growth and coloring. In the winter, clusters of three or four fruits are optimal. Cluster thinning can be done about once a week to allow fruits to set, and thinning can be based on fruit size and quality.

When plants reach the top trellis cable, they must be "leaned and lowered," and bottom leaves should be pruned for air flow and easier management. First, remove four to six of the bottom leaves by clipping or hand-snapping, ensuring a clean cut. Next, unfasten the vertical string or wire from the supporting top cable and reattach it at the point where the vertical string of the adjacent plant meets the top cable. Repeat this to shift each plant one position along the top cable. Each plant is thus leaned and lowered about 18 to 24 inches. Leaning and lowering should be done about every 10 to 14 days. Eventually, stems will rest on the greenhouse floor.

Figure 3. Photo of a pruned tomato plant.

Figure 4. Photo of lowered tomato plants.

Figure 5. Photo of a thinned, uniform cluster.

Figure 6. Photo of a tomato sucker.

Soil Conditions

Tomatoes can tolerate a wide pH range but prefer a pH between 6.5 and 6.9. Outside this range, plants may exhibit poor growth and reduced yield. Tomatoes require a moderate amount of water and nutrient solution, which can be provided by drip irrigation and should be in the 5.5–6.0 pH range. Water and nutrient requirements vary by growth stage. When irrigating, feed solution until there is a 10 percent leachate, or solution running through the bag, to ensure that all parts of the root zone and growing media receive an adequate amount of solution.

Temperature Requirements

Temperature requirements for tomatoes grown in a greenhouse are relatively constant throughout plant growth stages. Optimal temperatures are about 80 to 85 degrees Fahrenheit during the day and between 62 and 72 degrees at night. Nighttime temperatures should not drop below 60 degrees Fahrenheit. Daytime temperatures should not exceed 90 degrees Fahrenheit. Tomatoes are relatively tolerant of temperatures outside the ideal range, which is helpful when growing more than one cycle a year. Temperatures in the greenhouse may fluctuate between seasons, but fans, cool cells, and heaters should be used to keep temperatures within tolerable ranges.

Water and Nutrient Requirements

The amount of water and nutrient solution required varies according to plant size. Using the correct irrigation system is critical in providing the appropriate amount of water to avoid flooding the roots and depriving them of oxygen. In addition, too little moisture affects fruit size and shape, while too much moisture encourages disease. Frequency of irrigation also depends on plant growth stage and size as well as greenhouse temperatures, ranging from once or twice daily after transplanting to multiple times per day during harvest on warm days. Watering in the morning with minimal wetting of foliage by aiming the drip-irrigation stake at the base of the plant will help prevent disease.

Fertigation

Delivering water and nutrient solutions using drip irrigation is known as fertigation. This method has several advantages, including efficient nutrient delivery through precise application, control over application rate and timing, and lower cost. Most often, liquid or water-soluble fertilizers are used in fertigation. A variety of fertilizers can be used in tomato production. Choice is typically based on farmer preference or region. A horticultural company sales representative or local extension agent can help determine the best fertilizing practices for a particular region. Complete fertilizers are commonly used in greenhouse tomato production with nitrogen, phosphorus, and potassium (N-P-K) ratios such as 20-20-20, 20-10-20, 15-11-29, and 5-11-26.

All plants require 17 essential elements, which are split into two groups: macronutrients, required in large amounts, and micronutrients, required in small amounts, often in later growth stages. Plants must receive the appropriate amount of macro- and micronutrients for proper growth and development. Both nutrient deficiencies and nutrient toxicities, caused by excess nutrients, can harm or even kill plants if not properly treated.

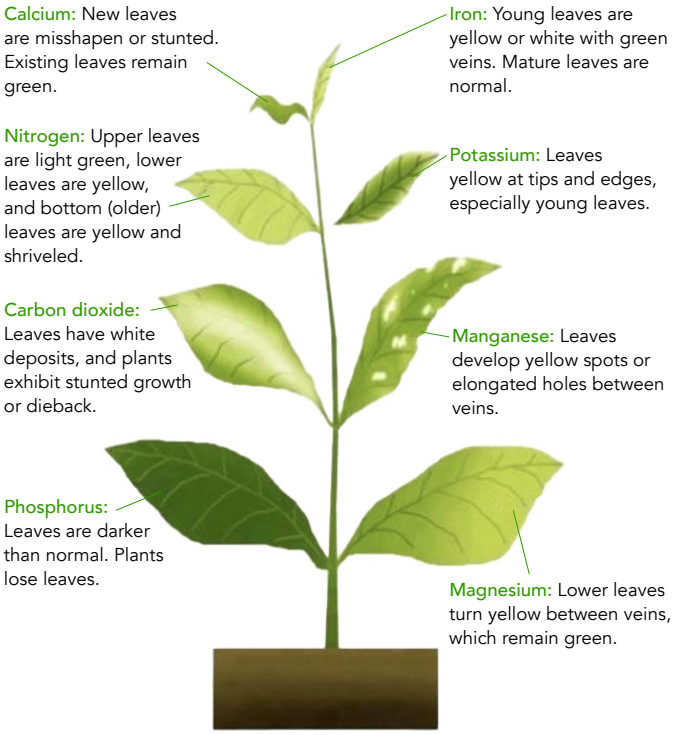

Figure 7. Diagram of nutrient deficiencies.

Figure 8. Photo of leaves with nitrogen deficiency.

Figure 9. Photo of leaves with phosphorus deficiency.

Figure 10. Photo of leaves with magnesium deficiency.

Figure 11. Photo of leaves with potassium deficiency.

Figure 12. Photo of leaves with calcium deficiency.

Figure 13. Photo of tomato fertigation lines.

Pollination

Outdoors, wind is the primary pollinating vector of tomato plants, shaking them and enabling release of pollen, while insects may act as secondary vectors. If grown in a greenhouse, plants need to be manually pollinated using a vibrating device, such as a pollination wand, to gently shake the plant and allow for pollen release. Leaf blowers have also been used to blow and shake plants enough to release pollen. Unsuccessful or inadequate pollination will result in poor fruit set and low yield.

Figure 14. Photo of a pollination wand.

Pest and Disease Control

Pest and disease control are important factors in commercial greenhouse tomato production, as they can severely impact yield and fruit quality. Pesticides can help prevent or reduce damage caused by pathogens and insects. The first step in preventing pest damage is to correctly identify the problem. A wide variety of insects, bacteria, fungi, and viruses can affect tomato plants. A local extension agent can advise on best-performing pesticides and which to use for each type of insect or pathogen. Some tomato varieties have disease resistance, which is an important factor to consider when choosing a cultivar to grow.

Greenhouse environmental conditions can influence the presence of insects and pathogens. High humidity with low ventilation and increased moisture, especially on foliage, will create a favorable environment for pathogens such as bacteria and fungi, which can cause wilt, mold, and mildew. One way to prevent growth of these pathogens is to avoid overhead irrigation, which causes increased wetting of foliage. Increasing ventilation and air flow in the greenhouse with fans will also help.

Viruses are widely spread by insects feeding on weeds outside the greenhouse. Controlling weeds around the greenhouse is important and helps prevent viruses from entering, as no tomato varieties are resistant to any viral diseases. If plants contract viral diseases in the greenhouse, symptomatic plants should be removed to slow the spread. Additionally, a good way to decrease insect pests in the greenhouse is to limit ways for them to get in by covering vents, fans, doorways, and small openings with screens.

Figure 15. Photo of aphids.

Figure 16. Photo of whiteflies.

Figure 17. Photo of powdery mildew.

Pests, Diseases, and Disorders

Tomato plants are susceptible to a wide variety of pests and pathogens. Major insect pests include aphids, flea beetles, fruit worms, whiteflies, mites, leaf miners, and pinworms. Bacteria and fungi cause diseases such as bacterial spots, fusarium wilt, early blight, gray mold, leaf mold, nematodes, southern blight, and verticillium wilt. Lastly, viral pathogens such as tobacco mosaic virus and tomato spotted wilt virus are common.

In addition to diseases caused by pathogens, physiological disorders can occur. These result from stressful environmental or nutritional conditions and include cracking, splitting, blotchy ripening, puffiness, rotting, and scarring. A common physiological disorder in tomatoes is blossom-end rot, which usually appears around the bottom of the fruit but can also occur on the sides or inside. Fruit with blossom-end rot appears leathery, sunken, and dark brown or black. The cause of blossom-end rot is typically calcium deficiency or improper distribution of calcium, with calcium settling in one part of the plant (toxicity). Blossom-end rot can also result from overfertilization (toxicity), particularly of nitrogen, potassium, and magnesium. This disorder usually occurs with the first tomatoes of the growing season. To prevent blossom-end rot, provide steady, unrushed growing conditions and ensure adequate soil moisture, appropriate fertilization, and a continuous supply of calcium.

Figure 18. Photo of leaves affected by tomato spotted wilt virus.

Figure 19. Photo of tomatoes with blossom-end rot

Harvesting

Tomatoes intended for shipment should be harvested when the star on the blossom end turns pink. Fruits at this stage are already red internally and will turn red externally without exposure to ethylene gas. Tomatoes harvested at this stage should be packed and shipped immediately to ensure the best color when displayed for sale. Tomatoes can also be harvested when they reach the mature green stage and later treated with ethylene under appropriate conditions to induce ripening and color change. Green tomatoes are harvested less often than pink ones. Tomatoes to be sold locally may be harvested when they are vine ripe. Harvesting may last for several weeks, depending on plant variety and yield.

Insect pressure can affect harvesting time and frequency, as well as fruit yields if parts of the plant are damaged. Periods of high insect pressure may reduce the overall harvest by requiring earlier harvest and reducing the amount of fruit available. When insect pressure is low, harvests may be more spread out to allow for more plant growth and fruit production.

Harvesting tomatoes is costly and labor intensive, as it is done by walking through and manually picking the fruit and because growing seasons usually have two or three harvests. Additionally, harvesting mature green tomatoes may require more time, energy, and labor, as they can be harder to pick from the vine and will need ethylene treatment to induce ripening.

Bruising during harvesting should be minimized, as it can cause additional losses. Riper tomatoes tend to be more prone to bruising than green ones. Tomatoes should be gently placed in a container or bucket, not dropped in. Research shows that a drop in excess of six inches will result in internal bruising. External bruising is caused by rough handling or dumping fruit into bulk bins. Additionally, overloading bulk bins causes compression, which leads to bruising.

Storage

Storage conditions somewhat depend on color, ripeness, and when the fruit is harvested. Tomatoes that are still green should be kept no colder than 55 degrees Fahrenheit to avoid deactivation of the color-changing enzyme. If tomatoes are harvested after ripening, they can be kept in temperatures as low as 45 degrees Fahrenheit. Regardless of storage temperature, humidity should be high to avoid water loss and shriveling.

Packaging

Tomatoes should be sorted and packaged according to color and size to ensure uniformity for various markets. A box should not contain more than one size and color. Tomatoes being sold in chain stores should be packed in 20- or 25-pound boxes or cartons with the size, color, and brand labeled on the outside. Tomatoes sold locally are normally packed in bushel or half-bushel crates when they are in the early pink stage.

Figure 20. Photo of a tomato carton.

After the Growing Season

After the last harvest, all tomato plants and remnants should be removed from greenhouses. Soil should be discarded and should not be reused for later growing seasons. Most greenhouse tomato producers partially cut open grow bags to allow them to dry out before removal, as they tend to be heavy, especially when wet from fertigation. All parts of the irrigation system, including spray stakes, drip lines, and main irrigation lines, should be flushed and cleaned. Houses should be thoroughly cleaned, sanitized, sterilized, and aired out to ensure they are ready for the next growing season. Cleaning includes removal of plant and soil remnants, debris, and weeds. Any equipment that will be reused in the house, such as irrigation systems, should be sanitized and washed at least with water. Proper sterilization requires the use of a disinfectant throughout the greenhouse and on any equipment that will be used in and around the greenhouse. Many disinfectants are available through commercial dealers. Alcohol and chlorine bleach can also be used. If an alcohol or a chlorine bleach solution is used, the irrigation system and all greenhouse equipment must be thoroughly flushed so that no solution remains. Cleaning and sanitizing should be done immediately after the growing season. If houses are not properly sterilized, pests or pathogens may survive between growing seasons.

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