GREENHOUSE TOMATOES

By
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Ground bed production of "out of season" tomatoes in plastic greenhouses can be profitable. However, it requires exacting knowledge and care. Production is concentrated in a small space under ideal conditions. One mistake can cause serious problems, resulting in reduced profits or even unrecoverable loss. Production should be attempted only if sufficient time and money are available to do a complete job throughout production and marketing. Midwinter production may not be profitable because of low light intensity, poor fruit set, poor fruit quality, or high fuel cost.

Plastic houses are popular because of their low cost. Many commercial greenhouse "packages" can be erected by the supplier or the grower.

Costs and returns. Plastic houses will cost about $3 to $5 per square foot, depending on design, materials and labor. Four thousand (4,000) square feet or two houses (22 feet wide by 96 feet long) are considered a minimum economic unit. This will produce enough greenhouse tomatoes to supply the market for about l0,000 people. Costs for a single house or larger houses may vary. A total of 4 to 6 pounds of fruit (combined spring and fall) can be produced per square foot. Growers' prices have averaged from about $.85 to $1.30 per pound for number 1 grade tomato fruit.

Operating schedule. The schedule of operation below is typical for greenhouse tomato production in Kansas.

Schedule	Spring crop	Fall crop
Plant seeds in flats	Dec. 1–15	Aug. 1–15
Transplant seedlings to pots	Dec. 10–25	Aug. 10–25
Set plants in plastic house	Feb. 1–15	Sep. 10–25
Control diseases and insects (if present)	Every 7–10 days	Every 7–10 days
Start vibrating plants for pollination	March 1–15	Oct. 10–15
Start harvesting tomatoes	Apr. 15–30	Nov. 10–15
End harvesting and clean up house	June 15–July 1	Dec. 25–31
Yield per plant	14–16 lbs	8–10 lbs
Yield per square foot	2–3 lbs	1–2 lbs
Grower's average price per pound	$.85–1.30	$.85–1.30

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Greenhouse. Build the greenhouse on a well-drained site, convenient to get to, in full sunlight, and with an adequate water supply. Frames are usually made of metal pipe or tubing. Greenhouse-grade clear polyethylene is one of the cheaper materials used for covering greenhouse structures. The newer polyethylene coverings will normally last through two and, in some instances, three spring crops. Use two layers of plastic film with a dead air space in between. This will reduce heat costs by about one-third and reduce excessive moisture from condensation. Use 6 mil polyethylene for the outside layer and a 4 mil thickness for the inner layer. A small blower fan is used to keep the two layers separated for better insulation.

For multiple houses, a gutter-connected type of construction will require less heat than a comparable area covered by separate greenhouse units.

Soils. Select a soil that is rich, loamy, well drained, and high in organic matter. Stable manure, peat, sawdust, etc. may be used to build up the organic matter. **Test soil for lime and fertilizer requirements before each crop.** Work the soil as deeply as possible and fumigate, if necessary, to reduce disease and weed problems. Consult your county extension agent for information on fumigant materials that can be used in greenhouses, rates, and the required waiting periods.

Heating. Gas heaters are probably the most practical for greenhouse vegetable operations. Natural gas is more economical than other fuels. The heat should be thermostatically controlled. Size of the heating unit required may be calculated by using this formula:

(Square feet of exposed surface) × (.8 for double layer of plastic) × (minimum required inside temperature minus minimum expected outside temperature) = BTUs required.

Example. Your house has 4,000 square feet of exposed surface and a double layer of polyethylene, minimum required house temperature is 58°F, and the expected outside temperature is as low as –10°F. The calculation would be:

4,000 × .8 × 68 (58–(–10) = 217,000 BTUs required.

If the wind velocity averages more than 15 miles per hour during the heating season, the heat requirement should be increased by 4 percent for each 5 mph above l5 mph.

Example. For 20 miles per hour, 217,000 BTU × .04 = 8,680 BTUs or a total of 225,680 BTUs.

Because heat rises, a circulating or tubulating fan and plastic tube that runs the length of the greenhouse are used. Operating continuously, this fan will stir the air to maintain a more uniform temperature throughout the house, reduce condensation, and reduce heating costs.

Ventilation. Ventilation is necessary to control temperature and humidity, and to replenish carbon dioxide needed by the plants. Without ventilation, temperatures can build up to 100°F and above, even when outside temperatures are much lower. Temperatures above 90°F are detrimental to fruit set and plant growth. Most growers use thermostatically controlled fans with enough capacity to change the volume of air in the house in one minute. High humidity results in condensation, greater disease problems, and less light. Even on cold days or at night, ventilation may be necessary to exhaust "wet air" and bring in "dry air" and carbon dioxide. Ventilators should be located high enough so the cold air comes in above the growing plants. Many growers use polyethylene tubes for ventilation. The tubes, about 3 feet in diameter, extend the entire length of the house, are held up by wire and clips, and have 3-inch holes every 3 to 5 feet on both sides

of the tube. One end of the tube is connected around the ventilating fan; the other end to louvered shutters. This allows fresh air to be brought in gradually without chilling the plants and exhausts the warmest air, which is near the top of the house.

The temperature to maintain will depend on the outside weather — primarily sunlight. The following temperatures are considered ideal:

Sunny weather	**Cloudy weather**
Day: 70°F–80°F	Day: 65°F–75°F
(not over 85°F if possible)	
Night: 58°F–60°F	Night: 57°F–58°F

Lower night temperatures could result in poor fruit set. Higher temperatures often result in rapid vegetative growth, spindly plants, poor fruit set, and lower yields.

Varieties. Size, color, freedom from cracking and blemishes, shape, yield, and flavor are important. Most field varieties do not perform well in the greenhouses. The following varieties have performed well in Kansas greenhouses.

Jumbo: large, red fruit, with dense plant growth. Yields well for spring and fall crop. No disease resistance.

Tropic: medium-size red fruit. Plants resistant to fusarium wilt, verticillium wilt, and gray leafspot; also carries resistance to blossom-end rot, crease-stem, and graywall and tolerance to tobacco mosaic virus.

Laura: large "beefsteak" type semi-greenback; round, slightly ribbed, and very firm fruit. Strong growth and short internode.

Caruso: large "beefsteak" variety, semi-greenback type; round fruit shape, slightly ribbed. Medium to strong growth, open plant habit.

Dombello: beefsteak variety, round and slightly ribbed, very firm fruit of excellent quality; very resistant to fruit cracking. Short and sturdy truss stem and lower number of flowers per truss.

Consult your seed salesperson for other varieties to try on a limited scale. Most "greenhouse" varieties are of European origin, so seed companies dealing in greenhouse cultivars should be used.

Plants. Grow your own plants. Growing transplants in a separate structure permits confinement of temperature control for transplants to a smaller area and encourages good sanitation practices that ensure production of disease-free plants. A plant growing area should be equipped with benches, environmental control equipment, and necessary irrigation-feeding equipment. Start seeds in flats and transplant to 2- or 3-inch peat or plastic pots in 10 to 14 days (when first true leaf appears) or seed directly into the growing flats or containers. One ounce of seed has about 10,000 seeds and will produce about 6,000 plants. A soilless or artificial growing mix is recommended for transplant production. The advantage of a soilless or artificial medium over natural potting soil is its sterile nature, which eliminates the need to sterilize or fumigate the material. Most mixes will have a "nutrient charge" added but supplemental fertilizing will be needed. (Consult K-State Commercial Production Guide, "Vegetable Transplants.")

Fertilization. Greenhouse tomatoes have a high nutrient requirement. Soil should be tested before each crop or at least once a year. A fertilization program is usually planned so the phosphorous is applied at the time of soil preparation. Nitrogen and potassium fertilizer can be applied when needed by the growing plants. During the growing season, you can apply a soluble fertilizer with the irrigation water. Soluble fertilizer is often used by hydroponic and bag culture growers.

Uniformly broadcast the amount of phosphate fertilizer recommended by the soil test report and mix it well into the upper 8 to 10 inches of soil before planting. Lime or sulfur may also be needed to adjust the pH at this time.

Soluble salts tend to build up in greenhouse soil from fertilizers added. To reduce soluble salts build-up, use fertilizers that add less "salt" such as:

Calcium nitrate: 15.5-0-0

Potassium nitrate: 13-0-44

Treble superphosphate: 0-46-0

Diammonium phosphate: 18-48-0

Potassium sulfate: 0-0-48

Sulphate of potash-magnesia: 0-0-22, 11 mg.

Setting plants. Set plants in rows about 3 feet apart with plants 16 to 18 inches apart in the row. Each plant should have 3½ to 4½ square feet of growing space. Run rows along the length of the house. Set plants so the root ball is at least 1 inch below the soil level. Water newly set plants with a "starter solution" of a fertilizer high in phosphorus, such as 10-52-17 or 10-20-10.

Side Dressing. After being transplanted, the plants should be fed small amounts of fertilizer continuously throughout the growing season. High analysis soluble fertilizers can be proportioned into the irrigation water.

The rate and frequency of side dressing should vary depending on the amount of sunlight, color of foliage, size of stems, fruit load, and tissue analysis report. A popular schedule is presented in Table 1.

Training. Train plants to one stem by removing suckers (or side branches) twice a week when they first become noticeable and before they are 4 inches long. Plants are trained up a trellis. The trellis involves installing a 10 or 12 gauge wire 6 to 7 feet above the row. The trellis should be supported by posts and not hung from the greenhouse structure. A piece of plastic twine is tied to the wire above each plant and extends to the bottom of the plant. A loose loop around the stem under the first leaf at the base of the plant will anchor the twine. The twine should have about 1 or 2 inches of slack. As the plants grow, they can be twisted around the twine or fastened to the twine using plastic clips at the same time suckers are removed.

Pest Control. Mulch with plastic, old straw, sawdust, or similar organic materials to help control weeds and reduce moisture loss. Mulches also reduce blossom-end rot and soil crusting or packing. The main disease problems encountered in greenhouse tomato production are fusarium wilt, verticillium wilt, leaf mold, mosaic, and root knot nematode. Common insect pests are mites, aphids, whiteflies, leaf miners, tomato fruitworm, and tomato pinworm. Consult your local extension office for current disease and insect control recommendations.

Watering. Water control is important. Check soil at the 4- to 6-inch depth to determine when watering is necessary. Use of drip irrigation and fertilizer

proportioners/injectors is recommended. Overwatering is as bad as underwatering, so monitor the soil moisture status using tensiometers or similar equipment. Remember— young plants do not require nearly as much water as older plants. (See K-State Research and Extension publications "Tensiometer Use in Scheduling Irrigation," L-796 and "Soil Water Measurement: An Aid to Irrigation Water Management," L-795.)

Pollination. Blossoms of greenhouse tomatoes will not set many fruits unless they are pollinated. When grown outside, the flower is "vibrated" by wind to distribute pollen from the outer to the inner portion of the flower. In the greenhouse, battery-operated vibrators are available to release the pollen. Pollination in greenhouses is done by sharply vibrating each flower cluster that has open blooms. Pollinate at least every other day and every day when blooms are numerous. The best time to pollinate is 10 a.m. to 2 p.m. on sunny days. Pollen does not shed on dark cloudy days, so vibration would be useless. Flowers can be pollinated for about three days when they are fully open (yellow). Blossoms that are not pollinated turn brown and drop off.

Harvesting. Harvest when fruits are pink to red. Handle carefully to avoid bruising. Most greenhouse tomatoes are sold in 8- or 10-pound cartons, labeled "Greenhouse Tomatoes." Misshapen or defective fruits will not be marketable and should be removed from the plants as soon as possible. Ripe greenhouse tomatoes will keep much longer than field-grown tomatoes. Never store harvested fruit below 55°F.

Greenhouse Problems. Following are problems often encountered by greenhouse tomato growers:

- Soluble salt build-up in soils. The soluble salts reading from a Solur Bridge RD-B15 should be about 50 to 150 milimhos/cm. If the reading is above 125 to 150, you may have problems with plant growth, especially in young seedlings, and blossom-end rot of the fruits.

  To keep the salt level low, use fertilizers that don't contribute to salt build-up. Many growers mix their own preplant fertilizer to reduce soluble salt content, because most ready-mixed fertilizers (like 5-10-10) tend to contribute to the soluble salt problem. If salts are high, you can leach most of them out with a heavy irrigation (up to 2 inches of water).

- Blossom-end rot, usually due to a lack of calcium. Most Kansas soils have high levels of calcium, but a soil test will reveal if calcium is needed. Adding 25 to 50 pounds of gypsum (calcium sulfate) per l,000 square feet before planting can help supply calcium. Gypsum will not affect the soil pH and tends to improve the soil structure. Blossom end rot also results from a fluctuation of soil moisture levels. Maintaining a uniform soil moisture supply reduces this problem, so mulches should be used. Excessive fertilization at any one time may also increase blossom-end rot.

- Blossom drop. Blossoms fail to set fruit if: they are not pollinated by vibration; continuous cloudy weather occurs when the blossoms open; the temperature is too high (above 95°F) or too low (below 55°F) on the day the blossom opens; you have applied too much nitrogen (particularly during cloudy weather); or you keep the soil too wet for optimum growth.

- Spindly plants, usually caused by one or more of the following: night temperatures too high; improper soil pH; insufficient fertilizer, especially phosphorous; too much shade or cloudy weather; too much nitrogen during cloudy weather; too much water; or root problems such as nematodes.

- Rough fruit, resulting from cloudy weather and/or temperatures too low during pollination. Some varieties are more subject to rough fruit than others. Many of the early and large-fruited varieties tend to have rougher fruits.

- Fruit cracking. Some varieties are more susceptible than others. Fluctuations in soil moisture result in more cracking. Fruits exposed to full sunlight crack more rapidly, so good foliage cover is essential.

Summary. Do all jobs *completely and correctly.* Timing is important. Make out a schedule for the entire year—*and then follow it!* You can learn a lot by visiting someone who is successfully growing greenhouse tomatoes. If you don't know of a local grower, your agricultural extension agent can help you locate one. Be sure you know where you will sell your produce before you plant.

Additional References

USDA Agr. Handbook No. 382, "Commercial Production of Greenhouse Tomatoes." Supt. of Documents, U.S. Gov't Printing Office, Washington, D.C. 20402.

Ohio Agr. Ext. Bulletin SB-19, "Growing Tomatoes in Ohio." Dept. of Horticulture, 2001 Fyffe Court, The Ohio State University, Columbus, OH 43210.

Ohio Agr. Ext. Bulletin 674, "Greenhouse Tomatoes—Disease and Insect Control." Dept. of Horticulture, 2001 Fyffe Court, The Ohio State University, Columbus, OH 43210.

American Vegetable Grower, Meister Publishing Co., 37841 Euclid Ave., Willoughby, OH 44094 (Monthly publication).

Greenhouse Grower, Meister Publishing Co., 37841 Euclid Ave., Willoughby, OH 44094 (Monthly publication).

American Greenhouse Vegetable Growers Association, P.O. Box 9797, Colorado Springs, CO 80932 (Newsletter).

Greenhouse Vegetable Newsletter. J.C. Fisher, Vegetable Crops Advisor, Research Station, Harrow, Ontario, Canada N0R 1G0.

See table on following page.

Table 1. Amounts of ammonium nitrate and potassium sulfate to side-dress per 1,000 sq. ft. for spring and fall crops. For supplying nitrogen and potassium, one source has been suggested. Other combinations of the materials can be used.

Spring crop. Starting 3 weeks after planting, side-dress at approximately 2-week intervals.

Weeks after planting	Amounts per 1,000 sq. ft.			
	lbs Nitrogen	lbs Ammonium nitrate	lbs K_20	lbs Potassium sulfate
3	.5	1.5	2.3	4.7
5	.75	2.3	2.3	4.7
7	.75	2.3	2.3	4.7
9	1.0	3.3	1.5	3.0
11	1.0	3.3	1.5	3.0
13	1.0	3.3	1.0	2.0
15	1.0	3.3	1.0	2.0

Fall crop. Because the day length and light intensity during fall and winter results in a slower rate of growth, less frequent and smaller amounts of fertilizer are needed than for a spring crop.

Weeks after planting	Amounts per 1,000 sq. ft.			
	lbs Nitrogen	lbs Ammonium nitrate	lbs K_20	lbs Potassium sulfate
4 to 5	.82	2.5	.53	1.1
6 to 8	.5	1.5	1.2	2.5
8 to 10	None	None	1.2	2.5

The amount of sidedressing listed in Table 1 should be considered a minimum. On sandy soils or with a heavy fruit set, the side dressing could be increased up to double the amount indicated.

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