Horticulture

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High Tunnel Tomato Production

Britney Hunter, Graduate Student, ***Dan Drost***, Extension Vegetable Specialist and
Brent Black, Extension Fruit Specialist

Introduction

Tomato is a commonly grown high value vegetable crop that can add diversity to small scale and part time farming operations. Growing tomatoes in high tunnels makes it possible to produce the crop approximately 1 month earlier and 6 weeks later than field grown tomatoes. High tunnels increase marketing opportunities, improve early cash flow, and yields are often higher than outdoor grown tomatoes. High tunnels are relatively inexpensive to build, are passively heated and cooled, and allow planting as early as March in many locations in Utah. Tomatoes begin to ripen in June and can be harvested as late as November.

High tunnels are temporary structures covered with a single layer of greenhouse grade plastic which is supported by a galvanized steel or PVC frame. Frequent sunny days make growing in high tunnels logical in Utah because tunnels are passively heated using solar radiation. High tunnels help protect plants from cold injury at night and maintain optimal growing temperatures during the day. Daily ventilation may be necessary to prevent temperatures from exceeding the optimal range. A full list of construction details and photographs for a low-cost PVC-frame high tunnel can be found at: extension.usu.edu/files/publications/publication/HG_High_Tunnels_2008-01photos.pdf.

Variety Selection

Select tomato varieties based on fruit size, earliness, soluble solids (sweetness), growth habit (determinate or indeterminate), and disease resistance. Determinate varieties are a good choice for high tunnel production in Utah because they allow for early production in the tunnel with most fruits ripening prior to field-grown tomatoes. Vine growth is limited for determinate varieties making it easier to trellis the plants. Indeterminate varieties continue to grow, flower, and fruit throughout the season, so more robust trellising and a taller tunnel are required. Heirloom varieties, while popular at farmers markets, generally lack disease resistance, are more prone to cosmetic defects. High tunnels help protect plants from diseases and the weather that can cause cosmetic defects. All tomato varieties tend to perform better and have higher quality when grown in a high tunnel. Consult with your local nursery or garden center, seed salesman or any seed catalog for detailed information on tomato growth characteristics. While we have not conducted any tomato variety trials for high tunnels at Utah State University, some of the recommended varieties for high tunnels based on other universities variety trials can be found at: http://www.hightunnels.org/ForGrowers/WarmSeasonVegetables/warmseasonvegtomprod.htm

Site Selection

Deep sandy to loamy soil with a pH of 6.5 to 7.5 is ideal for tomato production. Most Utah soils are good for tomato production as long as the soil is well drained, fertile, and there is no salt build up. Tomato plants are sensitive to herbicides in soil, so pay special attention to tunnel site selection if residual herbicides have been used in the past. The high tunnel should be located near a year-round water source in order to facilitate irrigation in the early spring and late fall when seasonal irrigation water is not available.

Site Preparation and Fertility Management

Prior to planting, have the soil tested to determine nutrient needs and deficiencies. It is a good idea to incorporate composted organic matter before

planting to sustain soil fertility. An initial application of 5 tons per acre of high quality compost of known nutrient analysis is recommended. Specific fertilizer rates recommended for tomato production based on soil tests are listed in Tables 1 and 2. A common practice is to add half of the required nitrogen fertilizer and all the phosphorous and potassium prior to planting. The additional nitrogen is then added after fruit set. Table 2 describes an appropriate nitrogen fertility schedule if fertilizer is injected with drip irrigation. Spreading out the nitrogen fertilizer applications allows for less leaching and improves plant growth and yield.

Table 1. Fertilizer rates based on pre-plant soil test results for tomato grown in bare soil [5]

Nitrogen (lb/acre)	P_2O_5 (lb/acre)[1] Soil Phosphorous level			Potassium (lb/acre)[1] Soil Potassium level			Application Time
	Low[2]	Medium	High	Low[3]	Medium	High	
50	150	100	50	180	120	60	Incorporate prior to planting
50	0	0	0	0	0	0	When 1st fruits 1″ in diameter
100	150	100	60	180	120	60	Total recommended

[1]A 14′ x 96′ high tunnel is 1,344 square feet (.03 acres). One acre equals 43,560 square feet.
[2] <15 ppm is considered low, and >25 ppm is considered high phosphorous for soil test results.
[3] <130 ppm is considered low, and >250 ppm is considered high potassium for soil test results.

Table 2. Fertilizer rates based on pre-plant soil test results for transplants in plastic mulch [5]

Nitrogen (lb/acre)	P_2O_5 (lb/acre) [1] Soil Phosphorous level			K_2O (lb/acre) [1] Soil Potassium level			Application Time
	Low[2]	Medium	High	Low[3]	Medium	High	
40	90	40	0	120	60	0	Incorporate prior to planting
20	20	20	20	20	20	20	2 weeks after transplanting
20	20	20	20	20	20	20	When 1st fruits 1″ in diameter
20	20	20	20	20	20	20	When 1st fruits turns color
100	150	100	60	180	120	60	Total recommended

[1]A 14′ x 96′ high tunnel is 1,344 square feet (.03 acres). One acre equals 43,560 square feet.
[2] <15 ppm is considered low, and >25 ppm is considered high phosphorous for soil test results.
[3] <130 ppm is considered low, and >250 ppm is considered high potassium for soil test results.

High tunnel tomatoes can be grown with organic fertilizers which promote soil fertility, and yields are often equal to tomatoes grown using conventional fertilizers. Organically grown tomatoes tend to have a higher market value. Composted chicken manure has been used for tomato production due to its high mineralization capacity. The high tunnel study at Utah State found tomato yields were similar between composted chicken manure and conventional fertilizers, but fruit quality was higher when grown with compost. The organic-managed tomatoes produced 79% #1 quality fruits while the conventionally fertilized tomatoes yielded only 60% #1 quality fruits primarily due to potassium deficiency. The initial rate of compost application is quite high (15 tons per acre) and amounts are reduced as soil fertility increases in later years. It is advised that regular soil tests be conducted to ensure that nutrient balances in the soil are maintained, and salt accumulation is avoided, when growing tomatoes using organic methods. More detailed information about organic tomato production can be found at attra.ncat.org/attra-pub/tomato.html.

After enriching the soil with nutrients, incorporate the fertilizers to a depth of 4 to 6 inches with a tractor mounted or hand operated tiller. High tunnels can be designed to accommodate small machinery for soil tillage and other operations.

Drip irrigation is well suited for tomato production in high tunnels and should be used in combination with black plastic mulch. Plastic mulches reduce water evaporation from the soil, blocks weeds, and warm the soil to promote early growth and fruiting (Images 2 & 3). Lay plastics at least 1 week prior to planting to help increase soil temperature. Bury 6 inches of the plastic edges in the soil to secure the mulch. This can be done by making small trench on both sides of the planting bed and filling in the trench after the plastic mulch is laid down. Be sure to place the drip tape under the plastic mulch and water the beds after installation.

Irrigation Management

Tomatoes require regular, uniform watering during the growing season. Inconsistent watering can cause blossom end rot, and during fruit sizing can cause cracking. A small decrease in water after fruits reach mature size can trigger plants to begin ripening. Soil water status should be monitored regularly to maintain consistent soil water. This is easily done with a resistance block such as the Irrometer® Watermark

sensor. Place sensors at various locations and depths in the soil profile to get a more accurate measure of soil water content. Soil texture (clay, loam, sand) influences the soils ability to hold water (Table 3). Other low cost tools and methods to monitor soil water can be found at attra.ncat.org/attra-pub/soil_moisture.html

Table 3. Soil Tension Values for Different Soil Textures for Use in Scheduling Drip Irrigation as listed by the Midwest Vegetable Production Guide [6]

	0% Depletion of Available Water Holding Capacity (Field Capacity)[1]	20-25% Depletion of Available Water Holding Capacity[2]
Soil Texture	Soil Tension Values (in centibars)	
Sand, loamy sand	5-10	17-22
Sandy loam	10-20	22-27
Loam, silt loam	15-25	25-30
Clay loam, clay	20-40	35-45

[1] At field capacity a soil contains 100 percent of available water holding capacity; any excess water in the root zone has drained away.
[2] Start trickle irrigation for shallow-rooted crops at this point.
Adapted from New Jersey Commercial Vegetable Production Guide, New Jersey Ag Expt. Station, Rutgers; and Water Management in Drip-irrigated Vegetable Production by T.K. Hartz, UC-Davis, Calif., Vegetable Research and Information Center.

Transplant Production

Transplanting is recommended for most growing areas of Utah. Many growers produce their own transplants, but plants can also be purchased from a local greenhouse supplier. Sow seeds into plastic plug trays with 50-72 cells per tray filled with a good soilless mix. Adequate light is essential to produce a quality plant. Cool white fluorescent lights positioned to stay 2 to 3 inches above the plants, lit for 14–16 hours per day will ensure plants grow big and healthy. Growth temperatures should be approximately 75°F during the day and 65°F at night. Water regularly and feed weekly with a soluble complete fertilizer diluted to 100 ppm. Gently brushing the plants each day or exposing them to wind helps make the plants stocky and strong. Condition or "hardened off" transplants for a short time each day by exposing them to cool temperatures (50-60°F) one week before transplanting to adapt the tomato for cold temperatures found in the tunnels. Allow 6-8 weeks for growing transplants depending on greenhouse growing temperatures. Transplants should have 5-7 mature leaves and a well developed root system. It is advised that transplants be covered with floating row cover or low tunnels during the first 4-6 weeks after establishment in the spring.

Planting, Pruning and Training

Tomato planting dates vary depending on location and climate conditions in Utah. Tomatoes in tunnels are often spaced 18 to 24 inches apart in row depending on the variety with rows spaced 36-48 inches apart (Image 2). A 14′ x 96′ high tunnel would accommodate 186 plants if there are three rows (48″ apart) with plants spaced 18 inches apart. Once planted water well and cover with floating or low tunnel row covers (Image 2 and 3). Ventilate tunnels whenever temperatures inside exceed 90°F.

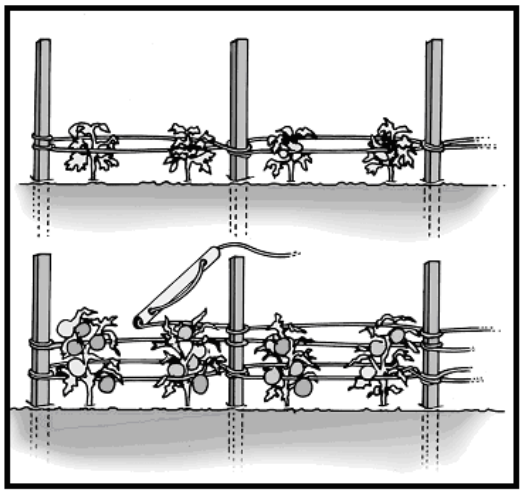

Image 1. Tomato trellis system [1]

High tunnel tomatoes are commonly trellised using a stake and weave system (Image 1). Staking helps reduce sunscald and ground staining thus producing higher yields of #1 quality fruits. It involves driving 4 foot long wooden stakes 18 inches deep every other plant and weaving string horizontally between the stakes. Prior to applying the first string, the plants are pruned of secondary shoots (suckers). Suckers are the vigorous new growth found at the base of the leaves. Remove suckers from the bottom three leaves on determinate varieties when the suckers are 3-4 inches long. Suckering reduces vine growth, but promotes earlier and larger fruit. After suckering attach the first string one foot above the ground and additional strings


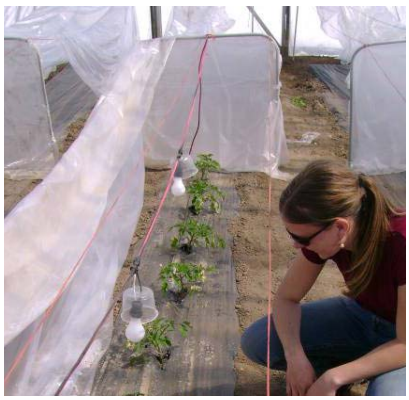


Image 2 (left) Row cover cloth over tomato plants inside a high tunnel in early spring. **Image 3** (center) Opened low tunnels over tomato plants inside a high tunnel with experimental lights for frost protection. **Image 4** (right) Staked tomatoes inside a ventilated high tunnel in summer.

after every 8 inches of new growth. Generally plants are only suckered once and trellised three to four times. The most common method of trellising indeterminate varieties is a vertical wire system. Six foot tall support posts are placed every 5 to 10 feet with a 12-guage wire running between them. Plants are then tied to a vertical piece of twine attached to the overhead wire. Additional ties and/or clips are used to keep the vine attached to the twine.

High Tunnel Temperature Management

Tomatoes grow best at temperatures between 75 and 85°F and when night temperatures stay above 50°F. At temperatures between 50 and 60°F, 'rough', irregular fruit growth (cat-facing) occurs. Temperatures above 95°F can damage tomato blossoms causing flowers to fall off or develop misshapen fruit. High tunnels can mitigate some of these temperature variations thus resulting in higher yields and more #1 quality fruits.

Utah has limited frost free days. Local freeze-free dates can be found at the Utah Climate Center website under climate reports (climate.usurf.usu.edu). Use the website to find the earliest, average, and latest recorded spring freeze dates for your production area. With this information, tomatoes can be planted from 4-6 weeks earlier which allows for earlier flowering and fruiting. Some frost protection is still needed when planting in high tunnels. When outside temperatures are between 20 and 35°F in early spring, the temperature will be 1-4°F warmer inside a high tunnel. Row cover cloth or Reemay® is a thin spun bonded fabric that can be laid directly on the plants and left on during establishment (Image 2). The cloth helps keep the temperatures around the plants 2 – 4°F warmer than the surrounding air and limits heat lost during cold nights. Low tunnels inside high tunnels (Image 3) will keep night temperatures slightly warmer than cloth covers, but plastic must be vented during the day to avoid excessive heat. The total cold temperature protection provided by different row covers within high tunnels is 3-10°F when outside temperatures are near freezing. Plants are further protected by the windbreak that the tunnel provides. Another strategy for avoiding frost inside the high tunnel early in the season is to have a back up heat source such as a propane heater. This can be very effective, but also costly when used on a large scale. Root zone heating is more energy efficient and has been shown to offset the negative effects of low air temperatures [2]. Results from the Utah State University high tunnel tomato trial, including an assessment of back up heat sources, can be found near the end of the bulletin.

Daily ventilation may be required to ensure temperatures inside do not exceed 90°F. Ventilation may entail opening a single door in April, or both sides and doors in May when day temperatures are warm (Image 4). When night temperatures stay above 50°F, the plastic on the high tunnel should be removed and replaced with a 30-50% shade cloth. This is important to avoid excessive heat buildup in the tunnel and to prevent sunscald on the fruits.

Pest Management

Pests can reduce yield and threaten fruit quality. Healthy plants grown in a clean environment are less likely to have pest outbreaks that require chemical treatments. Application of chemicals in tunnels is more hazardous than in the open field due to the closed environment. Chemicals used inside a closed high tunnel should be labeled for greenhouse use. If using chemicals in tunnels, follow the directions on the label closely and always wear appropriate personal protective equipment. If you are having trouble diagnosing a pest problem, contact your county Extension agent or other knowledgeable individual. Some of the common insects found in high tunnels include aphids, various worms, beetles and grasshoppers.

Aphids

Aphids are tiny insects that feed on plants by sucking sap out of stems and leaves. Aphids can also transmit viruses and diseases. Symptoms include stunting and distortion of plant growth and sticky sap on the leaves. Prevent aphids from becoming a problem by making sure transplants are free of aphids before planting, and controlling weeds in and around the tunnels. Insecticidal soaps and horticultural oils are effective at controlling aphids, are safe to use inside a tunnel, and often come in organic formulations.

Hornworms and Fruitworms

Hornworms are large green caterpillars with white v-shaped or dashed markings on their sides and a black or red hook/horn on the back end of the worm. The worms develop into moths which emerge in the late spring to lay eggs. Worms devour foliage quickly and also feed on the fruit. Hand removal is the recommended control for light infestations. Biological (naturally occurring) insecticide is available for hornworm control, and hornworms may also be controlled with other common chemical insecticides. Fruitworms (also called corn earworms) are foliage feeding caterpillars that often bore into green or ripening fruits. The same control methods can be used for fruitworms as hornworms.

Flea Beetles

Flea beetles are small black or brown beetles that jump when disturbed. Adult flea beetles chew holes in leaves which can make plants more susceptible to disease. Seedlings and transplants are particularly susceptible. Most plants eventually outgrow flea beetle damage. For heavy infestations a chemical insecticide may be required.

Grasshoppers

Grasshoppers emerge in spring with an appetite for foliage and fruit that lasts all summer. Eliminating weeds near the high tunnel will deter grasshoppers from feeding there and finding a way into the tunnel. It is a good idea to scout regularly for grasshoppers before they become a problem. Removing tomato plants promptly after the harvest and controlling weeds in the fall will discourage female grasshoppers from laying eggs near the tunnels. Biological baits are available for grasshopper control as well as baits containing chemical insecticide for fast control in severe infestations.

Disease Control

High tunnels trap warm humid air which can promote disease. Disease resistant varieties, proper soil drainage, good ventilation, and crop rotation aid in disease prevention. Most hybrid varieties are disease resistant or tolerant. Specific resistances are abbreviated on the seed packet or plant label and may include *Verticillium* wilt (V), *Fusarium* wilt races 1 & 2 (F or FW), Nematodes (N), *Alternaria* stem canker (A), and/or Tobacco mosaic virus (T). Common diseases noted in high tunnels include mold and mildews, various wilts and viruses.

Mold and Mildew

Grey mold is a common disease of tunnel house tomatoes caused by the fungus *Botrytis cinerea.* Grey mold looks like light grey colored fuzzy growth on the stems and leaves. White fuzzy patches on leaves are powdery mildew. Fungal diseases also cause leaf spots that can be yellow, brown, or black. Common leaf spot diseases include early blight and *Septoria* leaf spot. These diseases reduce leaf cover which can decrease yield and cause sunscald. Good ventilation and air circulation will help reduce excess moisture in the tunnels thus preventing most diseases. Placing drip irrigation below plastic mulch will also help to maintain dry foliage. Fungicide can be applied when diseases are first noticed.

Wilts

Fusarium wilt is a common tomato disease. Plants with *fusarium* wilt appear to be under water stress (wilting) because the disease attacks tissue responsible for water transport to the leaves. The stem will appear brown inside if cut open. Infected plants should be destroyed and no susceptible tomato varieties should be planted in the area. *Verticillium* wilt attacks many species of plants including potato, pepper, watermelon, strawberry, and radish. Symptoms are similar to *fusarium* wilt but lower leaves have yellow blotches on them that progress upward as the disease progresses. Plants are stunted and yield is greatly reduced. No varieties susceptible to *verticillium* wilt should be planted in the area.

Viruses

Viruses can be spread by insects, contact with other infected plants, and from tobacco products through human contact. Tobacco mosaic virus, cucumber mosaic virus, and spotted wilt are common viruses that affect tomato. Plants infected with a virus tend to have dwarfed light green leaves that may be twisted or cupped. Yellow ring spots can be seen on the fruits of plants infected with a spotted wilt virus. Plants should be removed and destroyed immediately to prevent the spread of virus.

Physiological Disorders

Tomatoes are susceptible to several physiological and environmental disorders that limit production or affect fruit quality. Most of the disorders are poorly understood and can be induced by many

conditions related to nutrition, environments, or cultural practices.

Blossom end rot and fruit cracking are two disorders associated with irregular watering. Blossom end rot (Image 5) looks like a sunken brown to black spot on the bottom of the fruit and is caused by a localized calcium deficiency. Fruit cracking takes place when rapid changes occur in the movement of water or solutes into the fruit during fruit growth or ripening. Cracks may be radiating outward from the stem scar (radial cracks) or encircling (concentric cracks) the fruit. "Russetting" are minute, hair-line cracks which give the fruit a rough feel but are not always visible. Most hybrid varieties are more resistant to cracking while heirloom types are quite susceptible.

Cat-facing is misshapen fruits with leathery protruding tissue at the blossom end of the fruit. Cat-facing (Image 5) is caused by cold temperatures and low light conditions during flowering and early fruit growth. Sunscald (Image 5) occurs when green fruits are exposed to intense sun light which bleaches the flesh of the tomato and cause them to ripen unevenly. The affected tissue may be leathery, have yellow skin and white flesh extending into the core, and is firmer than surrounding tissues. Plants grown with low nitrogen levels are more likely to experience sunscald as leaf growth does not shade the fruits. Use shade cloth over the tunnel to reduce sunscald. Blotchy ripening (Image 5) can be caused by sunscald or nutrient deficiency. While the cause of blotchy ripening is not completely understood, soils with potassium and nitrogen deficiency are more likely to express the symptoms. The symptoms cannot be seen on immature fruits and generally show as greenish, yellowish or white areas near the calyx of otherwise normal red tomato fruits. Large fruited varieties are more susceptible. Management strategies include maintaining high soil potassium levels, keeping air temperatures below 90°F, and minimizing soil water stress.

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Image 5. Common tomato disorders include blossom end rot (left), cat-facing (center-left), sunscald (center-right), and blotchy ripening (right).

Weed Management

Weeds promote pests and compete with tomatoes for water, nutrients, and light, especially when tomato plants are small. Weeding is simplified in a high tunnel with the use of plastic mulch. The edges of the high tunnel (inside and out) are the only problem weed areas since foot traffic keeps weeds down in the walkways and water is only being applied under plastic mulch. Weeding should be shallow near the plants to avoid damaging the roots. Chemical weed control should be avoided at all costs. Herbicides labeled for field tomatoes may not be appropriate for use in tunnels due to the risk of accumulating fumes in the closed environment.

Harvesting and Handling

Fruits can be picked when they are light green to pink but picking when tomatoes are approaching full ripeness will result in better flavor and market appeal. Harvesting should take place frequently (2-3 times per week) if tomatoes are vine ripened. Some growers remove the calyx (Image 8) which can puncture other fruits and thus reduce fruit quality. If the calyx is left on the fruit, more care is needed during picking and packaging to minimize damage to other fruits. Before marketing, tomatoes should be graded into U.S. size (small, medium, large or extra large) and grade categories (#1, #2 or culls). Specific tomato grading guidelines can be found at http://www.ams.usda.gov under a search for tomato grades. Fruits graded as #1 are mature, well shaped, firm, and free of decay, injuries or sunscald. Fruits graded as #2 may have some minor defects such as russetting or radial cracks, but must be mature, firm and free of broken skin. Mature red tomatoes are best when stored at approximately 50°F.

Utah State High Tunnel Tomato Trials

Sunbrite (determinate) tomatoes have been used for all tomato trials conducted at Utah State University. From 2005-2008, we compared the production of tomatoes when grown using organic or conventional based fertilizers. In 2009, tomatoes were planted on three dates (March 17 and 30, April 7) and additional low tunnels made of 2-mil construction grade plastic

were used inside the tunnels for added plant protection early in the season. Electric soil heat cables (Image 7) and 40 Watt incandescent light bulbs (Image 3) were evaluated in the early season to provide supplemental heat. In all studies, tomatoes were transplanted through black plastic mulch and drip irrigation was used for watering. The plastic covering the high tunnel was removed in early to mid-June and replaced with 40% shade cloth (Image 6) during the 2008-2009 studies to prevent sunscald. Replicated, randomized experimental design was used for all trials, and yield relationships were derived through statistical analysis.

Image 6. Shade cloth

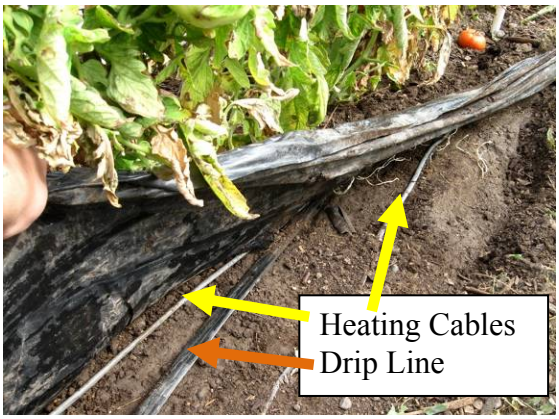

Image 7. Soil heated cables under plastic mulch

Image 8. Harvested tomatoes before grading

Yield Assessment

Red ripe tomatoes were harvested two times per week starting in early July and ending in early to mid-August and graded according to U.S. standards (Image 8). In most years, harvest was completed before the onset of full production of locally grown field tomatoes. Cull fruits were affected by potassium deficiencies, sunscald, grasshopper feeding, and cat-facing. The overall yield suggests that it is possible to produce more than 2,000 lbs (11 lbs per plant) of tomatoes per 14'x 96'high tunnel. An enterprise budget for high tunnel tomato production will be available on the Utah State University Extension website in summer 2010.

Organic vs. Conventional Fertility Case Study

Marketable yield of organically grown tomatoes was lower than those grown with conventional fertilizers in 2005 during the first year of the nutrient study. However, by 2006, marketable yield was only slightly lower when grown organically compared to conventional approaches. By 2007 and 2008, marketable tomato fruit yields were higher when using organic production approaches than if conventional fertilizers were used (Table 4). The addition of shade cloth in 2008 increased the quality of all the tomatoes by protecting the fruit from sunscald.

Table 4. Effect of organic and conventional fertility on tomato yield in 2007 and 2008.

	Yield (lbs/plant)			
Grade	Organic '07	Organic '08	Conventional '07	Conventional '08
Marketable	8.9	7.5	8.1	6.9
#1	5.4	5.6	4.7	5.2
#2	3.5	1.9	3.4	1.7
Culls	3.2*	0.2	3.1*	0.3

*excessive sunscald damage
Harvest Periods: 2007 – 3 July to 10 August; 2008 – 21 July to 28 August
#1 and #2 grades are considered marketable

Supplemental Heating Case Study

The combination of soil and air heating (incandescent lights) resulted in significantly higher early season yield, but was similar to the other treatments in overall yield (Table 5). There was no difference in yield between unheated plots and those heated with cables only. The effect of the lighted treatment was only significant for plants from the March 17th planting date. The results indicate that light bulbs offer some cold protection in the very early season, and that root zone heating does not increase cold protection for high tunnel tomatoes.

Table 5. The effect of supplemental heat on tomato yields in 2009.

Grade	Yield (lbs/plant)		
	Unheated	Soil Heat Cables	Soil Heat and Lights
Marketable	9.6	9.9	10.7
#1	7.8	8.3	8.7
#2	1.8	1.6	2.0
Culls	1.5	1.9	1.8

Planting Date Case Study

Fruits began to ripen in late June for all plantings and picking commenced on July 7. Early season (Image 9) and overall marketable yield was significantly lower for the April 7th planting date (Table 6). The results indicate that planting in late March leads to earlier and greater yields for high tunnel tomatoes compared to planting in early April. On March 28 the outside low temperature was recorded at 16°F while the low temperature recorded inside the tunnels was 25°F. 4% of plants from the first planting date were lost to cold during this time regardless of heating treatment. Excellent plant survival implies that low tunnels within high tunnels are adequate to help tomato plants survive early season frost events.

Table 6. Effect of planting date on tomato yield in 2009.

Grade	Yield (lbs/plant)		
	March 17	March 30	April 7
Marketable	10.8	10.6	8.8
#1	8.6	8.9	7.4
#2	2.2	1.7	1.4
Culls	2.0	1.8	1.4

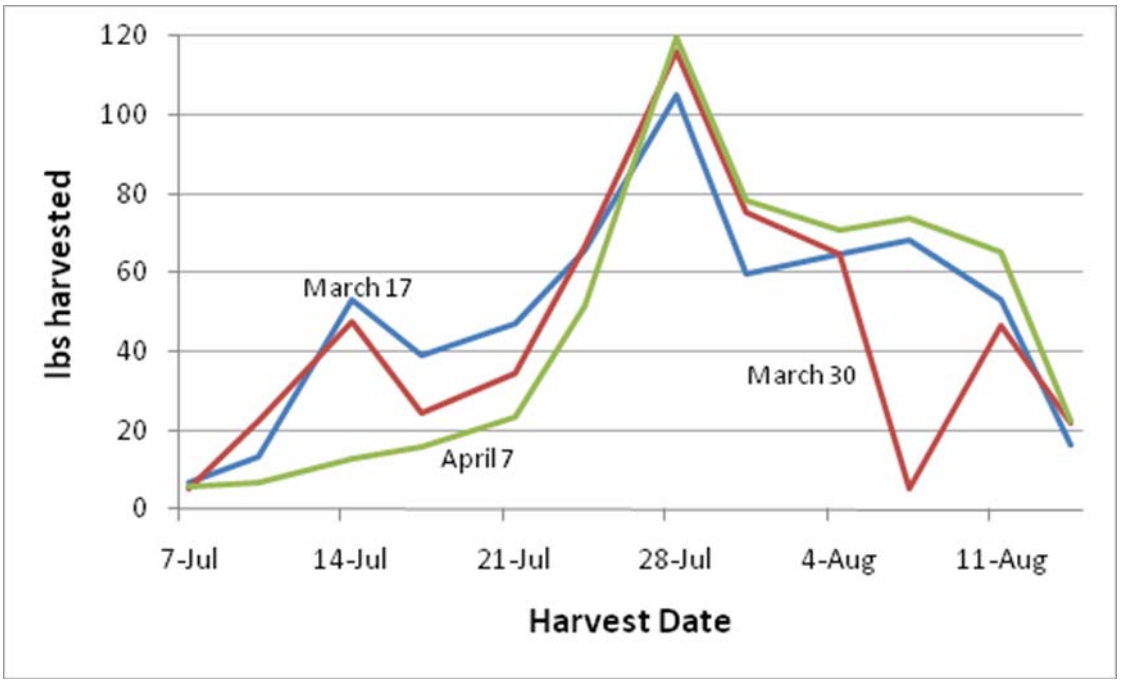

Image 9. 2009 tomato yield by planting date for a 14′ by 96′ high tunnel.

Summary

Early tomatoes can provide local farmers additional product to sell at farmers' markets and other local retail outlets at a time when outdoor production is not yet available. High tunnels allow 4-6 week earlier production, high yields, and better quality and thus are an economically attractive product in marginal production areas of Utah. High tunnel tomatoes should not be thought of as an alternative to outdoor production. Rather they are an early season compliment to other products, thus allowing farmers to supply local tomatoes to the public for a longer period of time, and during a time when local tomatoes command a price premium.

Disclaimer: Mention of trademark names does not constitute a guarantee, warranty, or endorsement of the named products nor does it imply criticism of similar products not named.

Precautionary Statement: All pesticides have benefits and risks, however following the label will maximize the benefits and reduce risks. Pay attention to the directions for use and follow precautionary statements. Pesticide labels are considered legal documents containing instructions and limitations. Inconsistent use of the product or disregarding the label is a violation of both federal and state laws. The pesticide applicator is legally responsible for proper use.

Other Useful Websites:

Resource Guide to Organic and Sustainable Vegetable Production
http://attra.ncat.org/attra-pub/vegetable-guide.html

High tunnel Resource Collection
http://www.hightunnels.org
http://plasticulture.cas.psu.edu/
http://www.extension.umn.edu/distribution/horticulture/M1218.html

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