Warm-Season Vegetable Production in High Tunnels

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This project was developed in response to the growing interest in the use of high tunnels. High tunnels are solar-heated structures (i.e., a cold frame) used to extend the traditional growing season of horticultural crops. Typically, no electricity is used in high tunnels to operate fans, vents, heaters, etc. Manual ventilation is instead provided through roll-up sidewalls or through the end walls. Other typical components of high tunnels are that they are irrigated via drip irrigation system with crops grown in "ground culture" in comparison to crops grown hydroponically in a soil-less type of growing system. High tunnels are basically what the greenhouse or nursery industry has for years called hoop-houses. High tunnels have recently been classified as such to distinguish them from low tunnels common in many areas for fruit and vegetable production. High tunnels typically range from fourteen to twenty feet wide and are ninety-six feet long. They consist of a series of evenly spaced bows covered with a single layer of six-mil greenhouse-grade polyethylene.

High tunnels, while developed in the United States, have been used in other parts of the world to a larger degree. High tunnels have been used extensively in Japan, southern Europe, and China for the last several decades (Romanowski 1981; Jenson 2000). These countries with limited land and abundant population have acknowledged the benefits of high-tunnel production systems. In the U.S., an increase in interest in these production systems is likely to continue as the dynamics of our own country changes over time.

States involved in this project are Kansas, Nebraska, and Missouri. Each state is investigating different aspects of high-tunnel production for the Central Great Plains. Double-cropping annual strawberry and vegetable production systems research is being conducted in Wichita, Kansas. Organic and conventional production systems for leafy vegetables are being investigated in Olathe, Kansas. Nebraska is taking the lead on research for cut flower production, and in Missouri, we are looking at extended season production of warm-season crops.

Missouri Focus

In Missouri, our primary focus crop has been high-tunnel production of tomatoes because of the higher, out-of-season prices available to growers for this crop. As previously mentioned, the primary advantage to high-tunnel structures is that of crop extension. Tomato plants in high tunnels produce crops three to four weeks earlier than plasticulture field tomatoes (Wells 1996). Earliness is the combination of planting about two weeks earlier than field planting, and faster maturity. Season extension may not be limited to the spring season. Tomatoes can also be extended an additional three weeks at the end of the growing season in the fall. Earlier harvest of high-tunnel crops is due largely to the increase in soil temperatures that expand root growth and hasten harvest. This increase in soil temperature partly offsets the detrimental effect of low night air temperatures (Gosselin and Trudel 1983).

In our research in Columbia, Missouri, we have found that the addition of row covers within the high tunnels is a vital component of warm-season vegetable production. Row covers are a spun-bonded fabric permeable to sunlight, water, and air, while at the same time able to warm the microenvironment around the plant by retaining the warmth of the soil heated through solar radiation in the high tunnel. It is generally considered that row covers will give an additional two to eight degrees of frost protection. We used row covers early in the season to protect the young tomato plants from the extreme cold. Plants that are properly hardened off were able to withstand temperatures as low as 20˚ F when covered with row covers in the high tunnels.

An additional advantage of high tunnels is wind pro-

About Jay Chism

At the University of Missouri currently, Chism is conducting research on the effects of high tunnels on the production of tomatoes in the Midwest. However, for 17 years, he owned and operated a twelve-acre retail farm where he grew strawberries and blueberries, a variety of vegetables, and managed over 12,000 sq. feet of bedding-plant producing greenhouses.

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tection. Protection against the whipping of the wind reduces evapotranspiration (loss of water from the soil) both by evaporation from the surface and by transpiration from the plants growing in the high tunnel. Windbreaks enhance early maturity and improve growth, increase production, and result in a better-quality product (Wittwer and Castilla 1995; Cavins, et. al 2000).

Disease control and prevention is another primary function of high tunnels. The plastic covering protects the crops from rainfall, thereby reducing the amount of foliar diseases common in field production tomatoes. For example, early blight on tomatoes is a serious foliage and fruit disease on field-grown tomatoes. Early blight typically is not a problem in high tunnels if they are ventilated properly (Lamont and Orzolek 2001).

Tomato Variety Trial
University of Missouri-Columbia

Each experiment was conducted in 20'x 36' high tunnels in early spring 2002.

Several varieties of tomatoes were tested to determine their productivity, both early in the season and through mid-July. The highest producer throughout the harvest period was Merced. Mountain Spring and BHN 543, however, were more productive than Merced before July 4. Production before or just after July 4 is important for a grower to capture higher prices for a tomato crop. The following table gives the results for all varieties tested.

HIGH TUNNEL VARIETY TRIAL

Variety Planting Date: 3/14	Lbs/ Plant of #1 Grade Harvested Before July 4	Total Lbs/ Plant of #1 Grade Harvested Through July 20
BHN 543	5.43	7.55
Brandywine	2.43	4.40
Carolina Gold	2.84	7.15
Floralina	2.71	7.13
Florida 47	2.85	7.91
Florida 91	2.69	7.44
Merced	4.45	9.74
Mountain Fresh	2.34	6.90
Mountain Spring	5.38	6.44

This variety trial will be repeated in 2003.

Early Plant Date Trial 2002
Variety Tested: Mountain Spring

An earliness trial was developed to push the envelope for early planting dates of tomatoes in central Missouri. This trial was also developed to determine if early planting actually resulted in significant earlier yields. March 14 was the earliest planting date, and higher earlier yields per plant were the result. Total yield, however, for the tomatoes planted earlier was down compared to the later planting dates. Depending on the type of market available to growers, the planting date in high tunnels will be important. The following table gives the results from the early plant date trial.

Planting Date:	Lbs/ Plant of #1 Grade Harvested Before July 4	Total Lbs/ Plant of #1 Grade Harvested Through July 20
March 14	5.38	6.44
March 24	3.60	8.01
April 5	3.51	8.46

This earliness trial will be repeated in 2003.

Plastic Mulch Trial 2002
Variety Tested: Mountain Fresh

We also conducted research comparing different types of plastic mulch inside high tunnels. The planting date for this experiment was March 14. Black plastic is the standard recommendation for tomato production in high tunnels. In our research this season, however, clear plastic outperformed both black plastic and bare ground. The following table lists the results for our research.

Mulch Treatment	Lbs/ Plant of #1 Grade Harvested Before July 4	Total Lbs/ Plant of #1 Grade Harvested Through July 20
Bare Ground	2.32	5.82
Black Plastic 1-mil	2.43	6.64
Clear Plastic 1-mil	3.09	9.96

The plastic mulch trial will be repeated in 2003.

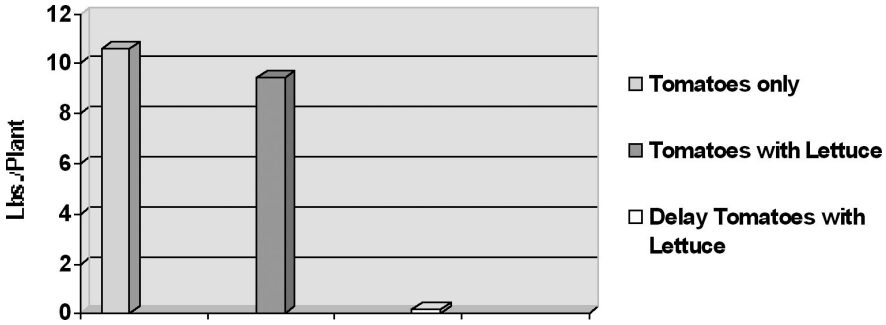
Intercropping Within High Tunnels

In a broad sense, intercropping is defined as the growing of more than one crop in the same row or field at the same time (McClure 1994). China has practiced for years what has been described as "rational close spacing." Rational close spacing is the growing of crops in patterns as intensive as feasible and at plant densities that will give maximum yields. This intensive crop system is highly productive when one considers limited land and water resources (Hardwood and Plucknett 1981). When intercropping systems are applied to high tunnels, the expected results are that a grower is able to increase revenue per square foot when compared to monoculture systems. The data presented is from two replications from the tomato/lettuce intercropping experiment. Two rows of lettuce seed were direct-seeded alongside newly transplanted tomato plants. Tomatoes were also planted thirty days after the lettuce was direct-seeded. The delayed planting was developed to evaluate the growth of tomatoes when transplanted into an existing stand of lettuce.

Intercropping Tomato/Lettuce 2002 Trial
Tomato Yields #1 and #2

Merced Tomatoes and Salad Bowl Red Lettuce were used in this trial.

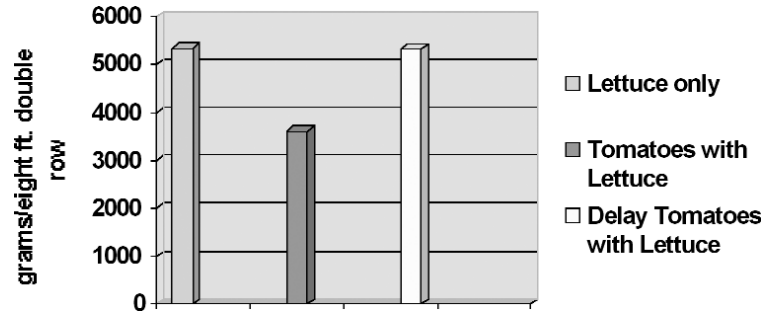
Note: The delayed planted tomatoes were removed from this trial before they came into production.



Intercropping Tomato/Lettuce 2002 Trial
Lettuce Yields

Merced Tomatoes and Salad Bowl Red Lettuce were used in this trial.

All the above research represents one season's data and does not constitute recommendations.



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