43 Hoop House

Where: Ballroom D
MI Recertification Credits: 2 (COMM CORE, PRIV CORE)
CCA Credits: CM (1)
Moderator: Katie Heflick, Michigan State University

9:00 AM **Tomato Support and Pruning Systems**
- Liz Maynard, Purdue University

9:40 AM **Winter Scheduling for Hoophouse Production**
- Kate Heflick, Michigan State University

10:20 AM **Structural Considerations for Michigan Hoophouses**
- Phil Irwin, Nifty Hoops

11:00 AM **Session Ends**

Tomato Support and Pruning Systems

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Tomatoes grown in high tunnels are usually supported and often pruned. This presentation begins with a review of how tomato plants grow, surveys common techniques for supporting tomatoes, describes types of pruning and reasons to prune, and presents results from recent trials in high tunnels.

The growth habit of a tomato influences which support and pruning techniques will bring the highest quality, yield, and economic return. Genetics determine whether a tomato plant is 'indeterminate', 'determinate', or 'semi-determinate'. Tomato plants produce 7-11 leaves before the first flower cluster, or truss, forms on the main stem. After the first cluster, indeterminate plants produce a flower cluster after every three leaves, and continue doing so indefinitely. In contrast, determinate plants produce a flower cluster after every leaf; after a certain number of clusters, a final cluster forms and the stem stops growing. Semi-determinate plants produce a flower cluster every two leaves; after a certain number of clusters, a final cluster forms and the stem stops growing. In all three growth habits, suckers or branches can grow from the main stem in the axil of each leaf. If allowed to grow, the suckers or branches follow the same growth habit as the main stem: on indeterminate plants they grow indefinitely and on determinate or semi-determinate plants they eventually terminate in a flower cluster.

Indeterminate plants in a high tunnel can easily grow to over 10 feet tall and semi-determinate varieties may grow 4-5 ft. tall; determinate varieties will be a little shorter than that. Except for the very shortest determinate varieties, plants are usually supported for ease of management, to make better use of space in the high tunnel, and reduce fruit contact with the soil. The high wire system of support used in greenhouse tomato production is also found in high tunnels, along with modifications. In this system each tomato stem is supported by a string that hangs from a wire (or other overhead structure) to the ground. The string is attached to the stem when the plant is small and as the plant grows the string is wrapped around the stem, and/or special clips are used to attach the string to the stem. This system is commonly used for indeterminate plants when suckers are removed to leave only one or two main stems per plant, each supported by a string. When the plants reach the top of the string, or have grown to the maximum desired height, they can be lowered by releasing string held in a spool at the wire. A string support system can also be used for semi-determinate plants; but since they usually have more than two stems, several strings for each plant are needed.

The stake and weave system supports plants between horizontal rows of string attached to stakes placed between every or every other plants. Wooden or metal stakes tall enough to be within a foot of the final plant height are pounded into the soil in line with the tomato row. The first horizontal row of twine is placed when plants are about 12 inches tall by wrapping it around a stake about 8 inches above the ground, passing it down one side of the plant row, wrapping it around the next stake, and continuing on to the end of the row, then repeating down the other side. This process is repeated through the season, with rows of twice about 6 to 8 inches apart, or whatever is needed to keep plants supported between the rows of twine. The stake and weave system is common for semi-determinate varieties and determinate varieties when support is

needed. It can also be used for indeterminate varieties. When stakes are not long enough, the top of tomato plants flop over for the final weeks of growth.

Other support systems in use for tomatoes include cages for each tomato plant, fence panels or mesh crop support along each side of the row, and individual stakes for each plant.

Four types of pruning are used on tomatoes: sucker or branch pruning, leaf pruning, fruit or cluster pruning, and main stem topping. Depending on the tomato variety and cropping system, all or none may be appropriate in a particular situation.

Sucker or branch pruning can 1) ease management; 2) promote earlier harvest; 3) increase average fruit weight; 4) possibly reduce disease. Break suckers off while they are small but big enough to distinguish from the main growing point–a few inches long. They usually snap off cleanly with gentle pressure from a thumb. How many and which suckers to remove depends on the plant growth habit, production and support system, and farm-specific factors.

For indeterminate varieties grown in a one-stem system, remove all suckers. For indeterminate varieties in a two-stem system, leave 1 sucker at the leaf just below the first flower cluster on the main stem. This sucker tends to be much more vigorous than others and will become the second stem. Remove all other suckers on both stems. Indeterminate varieties pruned to one or two stems are usually supported with a string (or stake) for each stem. Indeterminate varieties can also be grown successfully without pruning suckers. There will be many stems and a lot of foliage to manage. Without pruning stake and weave is commonly used for support.

For semi-determinate or determinate varieties sucker pruning is usually limited to suckers below the first flower cluster. Above the flower cluster suckers are allowed to grow. The amount of pruning can be described four categories: 1) heavy, 2) moderate, 3) light, or 4) none. With heavy pruning, one sucker is left at the leaf just below the first flower cluster on the main stem. Suckers are removed between the ground and the 'fork' or 'Y' formed by the main stem and that vigorous sucker just below the flower cluster. With moderate pruning, two or three suckers are left just below the first flower cluster, and suckers closer to the ground are removed. With light pruning, four or more suckers are left just below the first flower flower, and only the lowest suckers close to the ground are removed. With experience, growers can tailor the amount of pruning for particular varieties to obtain the best combination of yield, fruit size, and fruit quality.

Leaf pruning in greenhouse production has been used to make plants easier to manage, hasten fruit development, and reduce disease. Diseases can be reduced because older, dying leaves that are more susceptible to attack by weak pathogens are eliminated and so those diseases don't get established as readily. Also, removing leaves can improved air circulation, reducing relative humidity and so making conditions less favorable for many diseases. Leaf pruning is common for indeterminate tomatoes pruned to one or two stems. Breaking off leaves by hand, close to the stem is recommended. If a blade is used, cut close to the stem. If leaf stubs are left, greenhouse studies show they are more likely to get infected with botrytis (grey mold), and the infection can spread to the stem and kill the plant. Leaves below the lowest developing cluster are removed regularly throughout the season as they begin to senesce, or die back.

Fruit pruning, or cluster pruning, has been used in greenhouse production to increase fruit size and quality, and increase uniformity of fruit size. Flowers or young fruit are pinched off each truss to leave the desired number remaining that will develop into fruit. The number of fruit to leave depends on the variety and desired fruit size and growing conditions. Fruit pruning can also be used to remove deformed flowers or small fruit that won't produce a marketable tomato.

Topping is probably not a common practice in high tunnels but still worth mentioning. The purpose is to terminate growth of the stem and thereby speed development of fruit. It is easier to do when plants are pruned to one or two stems. The growing point is removed about 5 or more weeks before the crop will finish and a week later flowers are removed. If conditions are sunny, leaving a few leaves above the top flower cluster will provide some protective shade for the fruit. When done towards the end of the season, this practice directs the plant to put energy into the fruit instead of into new growth that won't produce yield in any case. If done early in the season it could probably be used to increase early yield at the expense of total yield. Whether topping is a useful practice for current high tunnel production remains to be determined.

Results from a two-year trial evaluating combinations of sucker pruning and support systems for three tomato varieties in high tunnels provide information on how these practices can affect yield, fruit size, and quality. At the Pinney Purdue Ag Center in Wanatah, Indiana, 'Mountain Fresh', 'Cherokee Purple', and 'Big Beef' tomatoes were grown in two high tunnels, one managed organically and one managed conventionally. Two support/pruning systems were compared. The stake and weave system (W) supported tomatoes as described above and the plants were not pruned. In the vertical string (S) system 'Big Beef' and 'Cherokee Purple' were pruned to two stems and 'Mountain Fresh' was pruned to leave 1 sucker below the first flower cluster. Strings attached to the high tunnel structure supported each stem of 'Big Beef' and 'Cherokee Purple' and about four stems on each 'Mountain Fresh' plant. Seedlings were transplanted into high tunnels the end of April or May and harvested through mid-September.

Over the two years of the trial, yield of USDA No. 1 and No. 2 fruit was greater with W (stake and weave with unpruned plants) than with S (string support and pruned plants). For 'Big Beef' yield was more than double with W; for 'Cherokee Purple' yield increased 4.3 times with W; and for 'Mountain Fresh' yield increased by 15% with W compared to S. Early (first 3 weeks) marketable yield was greater with W by about 30% for 'Cherokee Purple'; greater with S by about 50%-60% for 'Mountain Fresh'; and showed no difference for 'Big Beef'. Early total yield (marketable plus cull) was 30%-50% greater with S than W for all three varieties. Fruit quality tended to be better with W. The percentage of cull fruit was higher with S than with W. For 'Big Beef' the percent of culls due to cracks was six times higher with S than with W, and for 'Cherokee Purple' the percent of cracks was twice as high with S. For 'Mountain Fresh' there were few cracked fruit and the percent was similar with S and W. For 'Big Beef' and 'Mountain Fresh' the size of individual marketable tomatoes (measured as weight) was larger with S than with W. For 'Cherokee Purple' W and S produced similar-sized marketable tomatoes.

In summary, the S system produced lower marketable yield, a higher percentage of cull fruit, higher early marketable yield for 'Mountain Fresh', and larger marketable fruit for 'Big Beef' and 'Mountain Fresh'. The effects on yield and fruit size are similar to what has been reported in a number of studies that have evaluated pruning effects on field grown tomatoes.

If yields from this study are translated into sales, and assuming the price for early tomatoes is 4 times higher than the price for later tomatoes, income from W is double the income from S for the variety Big Beef. For 'Cherokee Purple', income from W is 2.75 times the income from S. For 'Mountain Fresh' income from W is only 10% higher than from S. If the price difference between early and late tomato prices is not that big, the increase in income from the W system would be even greater.

It should be evident that the pruning and support system for high tunnel tomatoes best suited to a particular farm will depend on numerous factors, including the tomato variety, disease pressure, importance of early yield, and market requirements for fruit size and quality. Other factors not specifically discussed in this presentation include the high tunnel structure itself and availability and cost of labor.