Tomato pollination and how to increase it in high tunnels

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EXTENSION
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I have been growing HT tomatoes for the last 10 or so years in the mid-Atlantic and have always thought my tomatoes did pretty well. Until I saw a report about the average yield per plant......
Research in the eastern United States has demonstrated that the yield per plant from a HT tomato should be between 20 and 30 lbs per plant.

My yields averaged 19.6 lbs/plant
A great number of my studies looked at the fertilization of tomato plants in HTs so I kept a close eye on the plants with soil and tissue tests like the one you see here. All the tests showed my fertilization program was good.
So what else could be causing a reduction in my yields? One thing I noticed in my HT was about 50-60% of my flowers-potential fruit-did not make it to fruit. As you see here on 3 clusters of tomato only 6 out of a possible 15 flowers turned into fruit. The flowers you still see on these clusters will abort.
These clusters had all their flowers abort - this is due to poor pollination, poor fertilization or both.
Tomato flowers are unusual among vegetable flowers. They have yellow petals and a yellow funnel-like structure coming out of the center of the flower. Most think this structure is made up of petals, but it is not—these are anthers.
This is an idealized picture of a flower, the anthers are the pollen producing part of the flower. The pollen is moved by pollinators or wind onto the stigma. Once this happens the flower is considered pollinated.
In tomato flowers the anthers surround the female part of the flower and just about any pollen that falls on the stigma comes from the same flower (and therefore plant—there is no or little cross-pollination in tomatoes). Tomato pollen is sticky and fairly heavy as pollen grains go and it takes a good breeze or a vibration of the flower to dislodge the pollen from the anthers onto the stigma.
Once pollinated, pollen must produce a pollen tube that delivers sperm to an ovule (seed). Each seed must be fertilized by a grain of pollen.
The final size and weight of fruit are largely determined by the number of seeds set, which is ultimately due to the quality of pollination and fertilization.
Temperatures above 88°F may cause abnormal style elongation. High rain fall will cause pollen to clump and be less available for pollination.

The optimum temperature for pollen tube growth is 70°F. Above or below this temperature reduces the germination and growth of the pollen tube. Temperatures above 90°F negatively affect the viability of ovules and pollen.
Bumble bees are good at pollinating tomato flowers. When they grab onto the flower with their mouth parts and vibrate the flower they remove some of the pollen from the flower. By doing this they also vibrate loose pollen that falls onto the stigma and helps pollinate the flower very efficaciously.
This flower has not been visited by any bumble bees as it has no markings from where the bee hung onto the flower with its mouthparts.

This flower has been visited by several bumble bees. The brown marks on the flower show where the bees grabbed onto the flower anthers.
After many visits and grabbing of flowers the flowers become pollinated and fertilized and the petals start to fall off. The brown ends of the tips of the anthers signal that the flowers were heavily visited by bumble bees. This can be looked for in a HT or out in the field to see how well your flowers may be visited and pollinated. Bumble bees are the best at doing this type of pollination—called ‘buzz pollination’. In greenhouse tomato production they use tiny vibrators to pollinate tomato flowers and this is called sonication.
Enhanced Pollination Study

The study was conducted for 2 years. The first year of the study only one HT was used while in the 2nds year 2 HTs were used. One HT was on the eastern shore while the other was on the western shore.

Four different cultivars of tomatoes were used in both HTs, 2 hybrids (Mt Fresh+ and Crista) and 2 heirlooms (Cherokee Purple and Brandywine).

I used a Craftsman 235/150 mph electric blower to sonicate (buzz pollinate).
Leaf blower used in enhanced pollination study
An ‘enhanced pollination treatment’ consisted of taking the leaf blower and placing it on low (150 mph) with the end of the blower 2-3 ft from a plant moving it back and forth and up and down concentrating the movement in the area of the flowers.

Plants were treated either 0, 2, or 4+ times a week and for either 0, 5, 10, or 20 seconds per plant with the blower. Treatments started 5-days after the first flower cluster appeared and were treated for 4 weeks. There were 4 replications of each treatment, 5 plants per rep.
One concern I had about the technique is that if fruit set was increased and plants were supporting more fruit:

1. Would plants be able to size those tomatoes and
2. Would the tomatoes have good quality?
Results
Typical untreated area with only half of flowers pollinated.
Two clusters of tomato flowers with a potential 12 flowers, had a total of 10 fruit produced. Only 1 fruit (arrow) did not size correctly on these two clusters—treated for 5 seconds 4 days a week.
Yield (lbs)  
1st harvest/plot

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (lbs)</th>
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<tbody>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Four +</td>
<td>5</td>
</tr>
<tr>
<td>Two</td>
<td>5</td>
</tr>
<tr>
<td>Two</td>
<td>10</td>
</tr>
<tr>
<td>Four+</td>
<td>10</td>
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Legend: a, b, c
Length of time pollination enhancement occurred

Yield (lbs)
1st harvest/plot

<table>
<thead>
<tr>
<th></th>
<th>None (a)</th>
<th>Five (b)</th>
<th>Ten (b)</th>
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<tbody>
<tr>
<td>Length of time</td>
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The graph shows the yield (in lbs) for different levels of pollination enhancement. The highest yield is achieved with the Five treatment, followed by the Ten treatment. The None treatment has the lowest yield. The bars labeled 'a' and 'b' indicate statistical significance.
Yield (lbs) of total harvest
Per plant

None  Five  Ten

None  23  29  29
Five  21  31  31
Ten   15  17  17
Frequency of pollination enhancement per week

Yield (lbs) per plant

Total harvest, HT-A

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<thead>
<tr>
<th>Frequency of pollination enhancement per week</th>
<th>Yield (lbs) per plant</th>
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<tbody>
<tr>
<td>Four +</td>
<td>a</td>
</tr>
<tr>
<td>Two</td>
<td>ab</td>
</tr>
<tr>
<td>None</td>
<td>b</td>
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Wt (lbs) per plant

total harvest, HT-B

none  two  four+

a      b      c
Mean Weight (oz.) of 1 fruit

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Two</th>
<th>Four+</th>
<th>Four+</th>
<th>Two</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>10</td>
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Treated for 5 seconds 4 times per week—5 plants

Not treated—5 control plants
Overall yields were good in these two HTs compared with previous seasons. Normally I would have expected 19.6 lbs/plant in these HTs, but instead got 21.8 lbs per control plant.
The average yield per plant increased to as much as 33.7 lbs with the pollination enhancement technique.

By enhancing pollination I was able to increase my overall yields by as much as 55%.

The pollination enhancement technique also improved fruit quality by reducing the percentage of culls and increasing the average size of fruit.
One concern I had about the technique is that if fruit set was increased and plants were supporting more fruit:

1. Would plants be able to size those tomatoes and
2. Would the tomatoes have good quality?

The answer appears to be yes to both questions. We did not add any extra nutrients to either HT compared with how we normally fertilize.

This technique did appear to work better on the first 6-8 fruit clusters the plant produced vs using the technique on later fruit clusters.
This technique is not for everyone, but it could be utilized very easily in a HT and be carried out by just about anyone who can hold and point a leaf blower.

The plants would need to be treated for 5-10 seconds at least 4 times a week for there to be a good possibility of yield and quality enhancement.
Treating the plants longer than 20 seconds ended up decreasing yields compared with doing nothing (data from year 1).

Plants could undergo this enhancement technique in the early part of the season when the HT sides are often down.
CAUTION

This technique should not be used if your HT tomatoes are usually low in any nutrient at the first harvest or you have fruit ripening problems with later harvests. Heirloom cultivars responded less consistently than hybrid cultivars.
Questions

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http://extension.umd.edu/mdvegetables