High Tunnel Melon and Watermelon Production
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High tunnels are low-cost, passive, solar greenhouses that use no fossil fuels for heating or venting (Figure 1). High tunnels can provide many benefits to horticulture crop producers:

- High tunnels are used to lengthen the growing season of crops.
- High tunnels protect the growing crop from environmental stress such as drought, driving rain, wind and temperature extremes.
- High tunnels protect crops from insect and disease invasion.
- High tunnels are well suited for producing heirloom and specialty vegetables that require a specific growing environment.
- High tunnels permit intensive crop production on a small area of land.

Many warm-season (frost-sensitive) vegetable crops can be grown in a high tunnel. Cucurbits are a large, diverse group of warm-season plants in the Cucurbitaceae family. Cucurbits include many popular vegetables such as cucumber, gourd, cantaloupe (muskmelon), squash, pumpkin and watermelon and are an important dietary source of fiber, minerals, beta-carotene and vitamin C.

Botany

Cantaloupe or muskmelon (*Cucumis melo* L.) and watermelon (*Citrullus lanatus* var. *lanatus*) are annual plants with a trailing vine growth. *Cucumis melo* has several botanical subgroups (Table 1). In the United States, *reticulatus* and *inodorus* are commercially grown, while the remaining groups are grown for niche or local markets.

The cantaloupe fruit that most Americans are familiar with is not actually a true cantaloupe. A true cantaloupe has no netting on the rind, is often warty, and many will not abscise or slip from the vine when mature (Figure 2). True cantaloupes are widely grown in Europe and include varieties such as *Charentais*, *Prescott*, *D’Alger* and *Petit gris de Rennes*.

A muskmelon (*Cucumis melo* var. *reticulatus*) has a pronounced netting on the fruit, is aromatic, and slips from the vine when mature (Table 1). Most wholesale markets prefer an oval to round muskmelon with medium to heavy netting and slight ribbing, while some local markets prefer lightly netted, deep-ribbed types. The terms *muskmelon* and *cantaloupe* are often used interchangeably in U.S. markets.

Galia melons are green-fleshed, aromatic muskmelons with a golden-yellow, netted rind (Figure 2). Galia melons are adapted to warm, dry climates and are often called desert melons. Rainfall during flowering and fruit formation significantly lowers the quality of Galia melons.

Watermelons are classified as seeded diploids or seedless triploids. Seedless watermelons have higher production costs but may be profitable as an early-season crop in a high tunnel. A seedless watermelon is a cross between a diploid (two sets of chromosomes), seeded variety and a tetraploid (four sets of chromosomes) line. The resulting

![Figure 1. High tunnels are plastic-covered, solar greenhouses that can be used for early-season cucurbit production.](image)

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plant is sterile with three sets of chromosomes. Seedless cultivars must have pollen from a seeded, diploid cultivar to set fruit. Mini seedless watermelons (less than 6 pounds) are becoming popular with consumers as single-serving melons. Melons and watermelons are second only to bananas in total U.S. per capita consumption of fresh fruit. Melons are low in fat and sodium, have no cholesterol, and provide many essential nutrients such as potassium. Watermelons are an excellent source of lycopene, which is credited with reducing many forms of cancer.

Both melons and watermelon are native to Africa and thrive in a warm, dry climate with a long growing season. The optimal growing temperature for melons and watermelons is 70–85 degrees F.

Cucurbits have palm-shaped leaves that are lobed (watermelon) or nonlobed (cantaloupe). Leaves are arranged in an alternate pattern on the vine. The vines are angular and hairy with several lateral branches that in turn have many secondary branches. Vines can reach a length of 30 feet for some cucurbit varieties.

Melons and watermelons have modified, threadlike leaves called tendrils, which the vine uses for anchoring or climbing (Figure 3). Tendrils can be branched (watermelon) or simple (muskmelon). Both cucurbit crops have strong taproots that can be deep on nonirrigated melons but generally are shallow but horizontally extensive when the crop is adequately irrigated.

Cucurbit flowers are diverse in color, shape and size (Figure 4). Cucurbits have a monoecious flowering pattern, which means male and female flowers are separate on each plant. Melons have male (staminate) flowers and a mix of female (pistillate) and perfect (both male and female organs) flowers. Watermelons typically have staminate and pistillate flowers. Staminate flowers appear

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Table 1. Groups of *Cucumis melo*

<table>
<thead>
<tr>
<th><strong>Cucumis melo</strong> subgroup</th>
<th><strong>Cultivar examples</strong></th>
<th><strong>Fruit characteristics</strong></th>
</tr>
</thead>
</table>
| Cantaloupeens (true cantaloupe) | Prescott melon  
D’Alger  
Charentais | Smooth to warty fruit surface. Very aromatic. No netting. Fruits do not slip from vine when mature. Widely grown in Europe |
| Inodorus | Canary melon  
Casaba melon  
Crenshaw melon  
Honeydew melon | Not aromatic. Fruit does not slip from vine when mature. Flesh is usually green or white. |
| Reticulatus | Muskmelons  
Persian melon  
Galia melon | Netted and aromatic fruit slips from the vine when mature. |
| Conomon | Makuwa uri  
Chinese melon  
Sakata’s sweet | No aroma. Fruit has crisp, white flesh. Widely grown in Asia. |
| Flexuosus | Armenian cucumber  
Snake melon | Elongated fruit with no aroma. |
| Chito | Mango, Lemon melon | Fruit is not sweet or aromatic. |
| Dudaism | Queen Anne’s Pocket Melon | Very aromatic fruit. |
first and are followed by emergence of more staminate and pistillate flowers. Generally, 12 to 15 staminate flowers are produced for each pistillate flower.

**Cultivar selection**

There are many productive cantaloupe and watermelon cultivars that can be grown in a high tunnel (Figure 5, Table 3). Choose a suitable cultivar for your market outlet. Purchase high-quality, vigorous seed for transplant production. (See Appendix for a list of seed suppliers). High-quality seed means faster germination and vigorous growth. One ounce of muskmelon seeds contains 950 to 1,200 seeds while one ounce of watermelon seeds contains 300 (large-seeded cultivars) to 650 (small-seeded cultivars) seeds (Table 2).

Table 2. Seeds required for transplant production

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Plants/oz of seed*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantaloupe</td>
<td>500–600</td>
</tr>
<tr>
<td>Cucumber</td>
<td>500–600</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>200</td>
</tr>
<tr>
<td>Summer squash</td>
<td>200–300</td>
</tr>
<tr>
<td>Watermelon</td>
<td>200–400</td>
</tr>
</tbody>
</table>

*Graded transplants.

Table 3 includes suggested varieties of muskmelons, cantaloupes, honeydews and mini seedless watermelons for high tunnel production.

**Figure 3.** Watermelon leaves (left) are lobed with branched tendrils while muskmelon leaves (center) are nonlobed with simple tendrils at each leaf axis. Tendrils are used by the vines for climbing and anchoring (right).

**Figure 4.** Melon flowers (left) are brighter yellow and yield more nectar than watermelon flowers, (center and right).

**Figure 5.** Mini seedless watermelons are similar in size to muskmelons (3–6 pounds).
For early production in a high tunnel, melons and watermelons should be established as transplants. Transplants increase uniformity and earliness of the crop while reducing seed costs (Figure 6). Quality transplants begin with quality seed. Choose a suitable cultivar and melon type that has consumer demand in your market outlet (Table 3).

Various containers can be used to germinate and grow cucurbit plants. Generally a transplant container or cell 1 to 2 inches in diameter is optimal for melon and watermelon. However, using a larger cell size may increase earliness. One seed can be placed in each container cell, one-half inch deep using a standard potting or germination mix. Seedless watermelon seeds are planted with the radicle tip pointed up or flat, which helps the seed shed the seed coat. After seeding, water the seeds and place in a warm room (85–90 degrees F) for about three days to accelerate ger-

Table 3. Potential melon and mini watermelon cultivars for high tunnel production.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Cucurbit type</th>
<th>Days to maturity</th>
<th>Fruit description</th>
<th>Disease tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athena</td>
<td>Muskmelon</td>
<td>80</td>
<td>Oval/round fruit with minor netting and no sutures.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Aphrodite</td>
<td>Muskmelon</td>
<td>75</td>
<td>Oval, large fruit. Light sutures.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Ambrosia</td>
<td>Muskmelon</td>
<td>86</td>
<td>Round fruit. Coarse netting. Good garden cultivar.</td>
<td>PM</td>
</tr>
<tr>
<td>Crescent Moon</td>
<td>Muskmelon</td>
<td>73</td>
<td>Large, eastern-type melon.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Jenny Lind</td>
<td>Muskmelon</td>
<td>70</td>
<td>Round fruit with heavy netting. Green or orange flesh. Large blossom scar. Heirloom melon.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Odyssey</td>
<td>Muskmelon</td>
<td>80</td>
<td>Round, large fruit with coarse netting and shallow sutures</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Primo</td>
<td>Muskmelon</td>
<td>78</td>
<td>Small, western-type shipping melon. Heavy netting</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Arava</td>
<td>Galia</td>
<td>77</td>
<td>Round fruit with green flesh. Light netting.</td>
<td>PM</td>
</tr>
<tr>
<td>Galia 152</td>
<td>Galia</td>
<td>80</td>
<td>Round fruit with green flesh. Very aromatic. No sutures.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Galileo</td>
<td>Galia</td>
<td>83</td>
<td>Round fruit with green flesh. Light netting.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Gallicum</td>
<td>Galia</td>
<td>80</td>
<td>Round fruit with green flesh. Small fruit.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Lavigal</td>
<td>Galia</td>
<td>80</td>
<td>Round fruit with green flesh. Very aromatic. Light netting.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Early Dew</td>
<td>Honeydew</td>
<td>80</td>
<td>Round fruit. Very early, 2.5–3 lb fruit which slips at maturity.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Honey Orange</td>
<td>Honeydew</td>
<td>74</td>
<td>Oval fruit with orange flesh.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Honey Star</td>
<td>Honeydew</td>
<td>85</td>
<td>Round fruit with light-green flesh.</td>
<td>PM0,1,2</td>
</tr>
<tr>
<td>Savor</td>
<td>Cantaloupe</td>
<td>78</td>
<td>Round, small fruit with dark orange flesh. Produces a vigorous vine that may need pruning</td>
<td>PM0,1,2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Watermelon (mini size)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Beauty</td>
<td>Mini seeded</td>
<td>77</td>
<td>Small, oblong, seeded watermelon</td>
<td>—</td>
</tr>
<tr>
<td>Extazy</td>
<td>Mini seedless</td>
<td>85</td>
<td>Small, round</td>
<td>—</td>
</tr>
<tr>
<td>Hazera 5130</td>
<td>Mini seedless</td>
<td>85</td>
<td>Small, round</td>
<td>—</td>
</tr>
<tr>
<td>Mohican</td>
<td>Mini seedless</td>
<td>85</td>
<td>Medium, green rind</td>
<td>—</td>
</tr>
<tr>
<td>Solitaire</td>
<td>Mini seedless</td>
<td>85</td>
<td>Small, round</td>
<td>—</td>
</tr>
<tr>
<td>Vanessa</td>
<td>Mini seedless</td>
<td>80</td>
<td>Solid, dark rind</td>
<td>—</td>
</tr>
</tbody>
</table>

PM = Powdery mildew race 0, 1, 2.  F = Fusarium race 0, 1, 2.
Note: This list is not intended to include every cultivar that may perform well in a high tunnel.
Do not overwater seedless triploids. Seedless watermelons should be germinated at 90 degrees for 48 hours. After 10 percent of the seeds have emerged, the temperature can be lowered to 70–80 degrees (day) and 65–70 degrees (night) for growth and development. Depending on prevailing weather, transplants should be regularly watered. Watering should be done in the morning allowing leaves to dry before evening, which reduces the risk of disease. Three times a week, a 200 ppm nitrogen solution can be applied to the growing transplants (Table 4). Four to six weeks are required for growth of melon and watermelon transplants. One week before transplanting, reduce fertilization and watering to harden or condition the plants for transplanting within the high tunnel. A good melon or watermelon transplant should have two to four true leaves, short, thick stems and a healthy root system (Figure 7).

**Planting in the high tunnel**

The soil within the high tunnel should be tilled, fertilized and formed into a raised bed before transplanting (Figure 8). Raised beds (4–6 inches high by 20–32 inches wide) increase the average soil temperature and improve root zone aeration and drainage while providing a larger volume of soil for root growth. For early melon production, plastic mulch is more effective in warming the soil than organic mulches. Plastic mulch and drip irrigation should be applied to the raised beds at least two weeks before transplanting. There are several plastic mulches to choose from. Black plastic is the preferred plastic mulch for cucurbits because it warms the root zone and both reduces weed germination and soil moisture evaporation. The soil temperature during the daytime is about 5 degrees F warmer at the 2-inch depth under black plastic than in nonmulched, bare soil. Clear plastic mulch warms the soil more than black plastic but does not suppress weed germination. Infrared (IRT) mulch is intermediate between clear and black with the added benefit of reducing most weed emergence. Reflective or metallic mulches repel insects such as aphids but generally keep the soil cooler. White or white-on-black mulch is used to cool the soil and can be used for summer or fall cucurbit plantings within the high tunnel. All plastic mulch should fit tightly over the raised bed to maximize heat transfer from the mulch to the soil. Embossed plastic (embossed with a diamond-shape pattern) mulch fits tightly over the raised bed and expands and contracts without losing tautness. Transplants can be lost from heat necrosis that occurs when heat funnels out through the planting hole when the plastic

![Figure 7. Use healthy, vigorous transplants for early melon and watermelon production in a high tunnel.](image)

![Figure 8. Plastic mulch on raised beds accelerates melon growth in a high tunnel.](image)

<table>
<thead>
<tr>
<th>Nitrogen (ppm)</th>
<th>Fertilizer analysis</th>
<th>20-20-20 (oz)</th>
<th>9-45-15 (oz)</th>
<th>15-5-0-0 (oz)</th>
<th>15-30-15 (oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>6.7</td>
<td>14.8</td>
<td>8.6</td>
<td>8.9</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>13.3</td>
<td>29.6</td>
<td>17.2</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>20.1</td>
<td>44.4</td>
<td>25.8</td>
<td>26.7</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>26.6</td>
<td>59.2</td>
<td>34.4</td>
<td>35.6</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>33.5</td>
<td>74.0</td>
<td>43.0</td>
<td>44.5</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>40.2</td>
<td>88.8</td>
<td>51.6</td>
<td>53.4</td>
<td></td>
</tr>
</tbody>
</table>

$^2$ Ounces of fertilizer dissolved in 100 gallons of water.
Mulch is not tightly fitted over the raised bed.

In a high tunnel, melons and watermelons are spaced 24 to 36 inches between plants within each row, and the rows are spaced 40 to 48 inches on center. On a square foot basis, this is nearly double the plant density of field-grown melons and watermelons. The ability to grow the plants vertically by trellising and the dry (no rain) environment make higher plant populations feasible within a high tunnel. Thus a commercial high tunnel (2,500 ft²) can accommodate 200 to 300 cantaloupe or watermelon plants.

Each transplant is planted about 1 to 2 inches deeper than the surface of the transplant root ball. The planting hole on the plastic mulch can be perforated by hand or using a bulb planter. Immediately after transplanting, a starter fertilizer solution containing nitrogen (200–400 ppm) and phosphorus should be applied to each transplant to reduce transplant shock.

Planting date varies with geographical region. Soil temperature is a reliable index for determining when to plant within a high tunnel. Melons and watermelons can be transplanted when the soil temperature at the 2-inch depth is at least 60 degrees F.

**Row covers**

Row covers are used to increase the average minimum temperature within the crop canopy. There are two types of row covers. One type is polyethylene plastic with perforated holes for ventilation, and the other type is a spunbonded fabric. Spunbonded row covers (0.5–1.25 oz/yd²) are recommended for high tunnel Cucurbit production (Figure 9). Unlike polyethylene row covers, spun bond row covers do not produce extremely high air temperatures during the daytime and are more effective at retaining heat for frost protection during the night. In addition, spunbonded row covers are lightweight, which makes them easy to place on or remove from the crop canopy.

Row covers should be applied immediately after transplanting in the spring and can be kept over the crop for several weeks depending on temperature within the high tunnel. In Missouri, row covers are left on the plants for about three weeks and are removed when the melons and watermelons begin to flower in mid-April. They are not completely removed from the high tunnel but held in reserve if a frost or freeze threatens the crop.

**Soil management and fertilization**

Before planting cucurbits within a high tunnel, the soil should be sampled and analyzed to determine pH, organic matter content and nutrient levels. The optimal pH range for cantaloupes and watermelons is 6.0 to 6.8. If the soil pH is below optimum, liming may be performed. If necessary, lime should be applied as far in advance of transplanting as possible.

Before transplanting, 7 to 11 ounces of nitrogen per 1,000 ft² should be applied to the raised beds. Based on a soil test, all the required phosphorus and half of the required potassium should be applied before transplanting and mulch application. If the soil within the high tunnel is high in organic matter (at least 3 percent), a lower rate of preplant nitrogen can be applied. Thoroughly incorporate the fertilizer in the top 4 to 6 inches of the soil. Applying water-soluble fertilizer through the irrigation system is referred to as fertigation. If no fertilizer is applied before planting, fertigation should begin immediately after transplanting in the high tunnel. However, if preplant fertilizer is applied, fertigation can be delayed for two weeks. Fertilizer can be applied through the drip irrigation system over the remaining 10- to 12-week growing season. Table 5 gives a suggested fertigation program for high tunnel melons and watermelons. If preplant potassium is applied, potassium fertigation commences three weeks after transplanting. Adequate potassium fertilization is crucial for melon crops because potassium is correlated with melon sweetness. Fertilization rates should be based on the total effective mulched area. Measure the width of the raised bed covered with plastic, and multiply by the row length. This product is multiplied by the number of rows within the high tunnel, which equals the total effective mulched area per high tunnel.

**Figure 9. Row covers protect melons from frost damage and chilling injury.**
Table 5. Suggested nitrogen and potassium fertigation schedule for high tunnel melons and watermelons.

<table>
<thead>
<tr>
<th>Days after transplanting</th>
<th>Weekly nitrogen (oz/1,000 ft²)</th>
<th>Weekly potassium (K₂O) (oz/1,000 ft²)</th>
<th>Cumulative nitrogen (oz/1,000 ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preplant</td>
<td>9.2</td>
<td>18.4</td>
<td>9.2</td>
</tr>
<tr>
<td>14–21</td>
<td>2.3</td>
<td>0</td>
<td>11.5</td>
</tr>
<tr>
<td>22–49</td>
<td>3.3</td>
<td>6.7</td>
<td>24.7</td>
</tr>
<tr>
<td>50–77</td>
<td>3.9</td>
<td>7.7</td>
<td>40.3</td>
</tr>
<tr>
<td>77–84</td>
<td>1.8</td>
<td>3.6</td>
<td>42.1</td>
</tr>
</tbody>
</table>

Assumes a low soil potassium level.

Irrigation

Because high tunnels exclude natural rainfall, the water requirements of the crop must be supplied by drip irrigation. Drip irrigation is a method of applying water slowly to the root zone of the growing crop by using small, collapsible tubes called drip tape (Figure 10). Drip irrigation has many advantages, including less water use and the ability to supply nutrients to the crop over the course of the growing season. Drip irrigation also helps the crop to grow evenly, reduces weed emergence and keeps the foliage dry, which prevents many diseases.

One drip line (8–10 mil thickness; 4–12 inch dripper spacing) is placed 3 inches from the center of the bed. The drip line should be buried 1 inch to prevent damage by mice and expansion and contraction of the tube during the growing season. Lateral movement of water from the drip tube may be about 10 to 12 inches on either side of the tube in heavy soils and 8 to 10 inches in light soils.

Irrigation can be scheduled based on using a soil moisture sensor (tensiometer or moisture blocks) or systematically applying an even quantity of water each week. Tensiometers work effectively in sandy soils, while gypsum blocks are effective in heavy soils.

Generally one inch of water (per acre equivalent) is applied to melons and watermelons each week. During periods of hot weather and a heavy fruit load, 1.5 inches/week can be applied. For example, if a grower is using a medium-flow drip tape with a flow rate of 0.40 gpm/100 ft, and the mulched row width is 30 inches, the crop should be irrigated 6.5 hours per week to deliver one inch of water to the crop (Table 6). Because plastic mulch reduces soil moisture evaporation, it is important not to overwater the crops. Excessive irrigation during the latter stages of fruit ripening can lower sugar levels and cause fruit cracking.

Table 6. Hours required to apply 1 inch of water to a mulched, raised bed.

<table>
<thead>
<tr>
<th>Drip tube flow rate</th>
<th>Width of mulched bed (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Gph/100 ft</td>
<td>2Gpm/100 ft</td>
</tr>
<tr>
<td>Width</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td>8</td>
<td>0.13</td>
</tr>
<tr>
<td>10</td>
<td>0.17</td>
</tr>
<tr>
<td>12</td>
<td>0.20</td>
</tr>
<tr>
<td>16</td>
<td>0.27</td>
</tr>
<tr>
<td>18</td>
<td>0.30</td>
</tr>
<tr>
<td>20</td>
<td>0.33</td>
</tr>
<tr>
<td>24</td>
<td>0.40</td>
</tr>
<tr>
<td>30</td>
<td>0.50</td>
</tr>
<tr>
<td>36</td>
<td>0.60</td>
</tr>
<tr>
<td>40</td>
<td>0.67</td>
</tr>
<tr>
<td>42</td>
<td>0.70</td>
</tr>
<tr>
<td>48</td>
<td>0.80</td>
</tr>
</tbody>
</table>

1 Gallons of water per hour per 100 ft run of drip tape.
2 Gallons of water per minute per 100 ft run of drip tape.

Pollination

Melons and watermelons have separate male and female flowers on each vine. Male flowers appear at least a week earlier than female flowers. Female flowers are easy to distinguish from male flowers by the presence of a swollen base below the flower petals (Figure 11A). Flowers open after sunrise and remain open for only one day. Since melon and watermelon pollen is heavy and sticky, it does not move with wind currents. Thus, physical movement of pollen is necessary before a fruit is set on the vine. Pollination of the first flush of female flowers is crucial because these flowers can develop into large, early fruit.

Nectar-collecting bees (honey bees, bumble bees, solitary bees and mason bees) are common vectors of cucurbit pollen. Research has
High Tunnel Melon and Watermelon Production

revealed that each female melon flower must receive at least eight bee visits to set a marketable fruit. Research at the University of Missouri has revealed that having sufficient bees for pollination will increase average fruit weight of muskmelons within a high tunnel. Bumble bees (Bombus impatiens) can be purchased and placed within each high tunnel two to three weeks after transplanting. Use insect screen to retain the bees within the high tunnel. Honey bee colonies can be placed close to the high tunnel to encourage entry. Planting high nectar yielding plants such as Brassica sp. (mustards) close to the high tunnel may increase native bee density within a high tunnel. Melons that are poorly pollinated are smaller while improperly pollinated watermelons are often lopsided or bottlenecked.

If feasible, hand pollination of cucurbits may be performed. In midmorning select a recently opened male flower. Carefully remove the petals surrounding the male stamens (pollen-producing organs). Identify a recently opened female flower, and gently brush the stamens against the flower 10 to 15 times. Research indicates that hand pollination is most effective between 6:00 and 9:00 a.m. Hand pollination requires patience and may be effective only 50 percent of the time.

Seedless watermelons produce sterile pollen and thus require pollen from a seeded cultivar before setting fruit. A seeded cultivar can be planted as a single row parallel to the baseboards of the high tunnel. Also, the seeded cultivar can be interplanted with the seedless cultivar with every third plant within the row a seeded cultivar.

Trellising

Training melons and watermelons to grow vertically is referred to as trellising and is one of the advantages of growing melons in a high tunnel. Most melon cultivars and personal size (less than 7 pounds) watermelon cultivars are amenable to trellising. Trellising improves light interception by the crop canopy, makes harvest easier, improves pollination and reduces damage to the vines during harvest. Trellising is necessary if the high tunnel is used to grow crops in addition to melons, since melon vines will overrun other plants if not trained.

Various types of trellises can be used for high tunnel melons and watermelons (Figure 12). Using a trellis with a plastic (nylon) net (6-inch by 7-inch openings) that is about 72 inches...
high is a suitable trellis for pruned and unpruned vines. The trellis must be supported by a tensile wire, which runs parallel to the row and slightly higher than the trellis. This wire can be secured to the frame of the high tunnel or attached to posts at each end of the row. The mesh trellis is in turn secured to the wire. The vines gradually grow up the trellis, using their tendrils to cling to the mesh trellis, but they will require training to keep the growth vertical. Assume the static load on the wire will be about 10 to 12 pounds per linear foot.

Another form of trellis is an option when each vine has been pruned to one or two stems. Tie a length of nylon twine to a tensile wire 6 to 7 feet off the ground and secure it to the ground using anchor pins. The primary stem of the muskmelon plant is secured to the twine using plastic vine clips. As the vine continues to grow, it is clipped to the vertical twine. If the vine grows taller than the height of the trellis, it can be trimmed from the top down on another length of twine. Woven wire fence or livestock panels can also be used as a trellis for cucurbits.

Fruit may require support as it grows on the trellis. Some muskmelon cultivars have fruit with rigid peduncles (fruit stems) and may not need support. Small, mesh bags (onion sacks), cheesecloth or nylons can be used as slings to support the fruit (Figure 13). The bags can be tied to the trellis or the support wire. The bag should allow light penetration and not hold moisture. When the fruit is ripe, the bag can be cut from the trellis.

Mini seedless (or seeded) watermelons can be trellised in a high tunnel. If so, the fruit must be supported. Other types of watermelons (large, seeded or seedless) can be grown without a trellis and left to vine throughout the high tunnel.

### Harvest and yield

Melons have several yield flushes requiring harvest three to four times a week during peak production, while watermelons tend to ripen evenly and the bulk of the fruit can be harvested in relatively few harvests (Figure 14). Melon and watermelon fruit are ready to harvest 45 to 60 days after flowering. Research at the University of Missouri has shown that Galia muskmelons are very high yielding when grown in a high tunnel (Table 7). Muskmelons yield more fruit per plant than watermelons in a high tunnel. Melon harvest in a high tunnel is four to five weeks earlier than field-grown melons and watermelons in Missouri.

![Figure 12. Trellising increases marketable yields of high tunnel melons.](image1)

![Figure 13. Mesh bags tied to a trellis protect and support melons as they ripen.](image2)

<table>
<thead>
<tr>
<th>Melon type</th>
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<th>Average market yield/high tunnel (no.)</th>
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<tr>
<td>Galia</td>
<td>3–5</td>
<td>900–1,500</td>
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<tr>
<td>Charentais</td>
<td>3–4</td>
<td>900–1,200</td>
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<td>Athena</td>
<td>2–3</td>
<td>600–900</td>
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<tr>
<td>Micro seedless watermelon</td>
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<td>600</td>
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</table>

1 Assumes a high tunnel with 300 melon or watermelon plants.
Muskmelons develop a distinct abscission zone between the fruit stem and the fruit (Figure 15). As muskmelon fruit ripens, the color changes from green to yellow, and the fruit produces an aromatic odor on the blossom end. On some cultivars, the netting becomes more pronounced at maturity. High tunnel muskmelons for local markets should be harvested vine ripe or "full slip," the stage at which the fruit detaches from the vine with slight pressure. To prevent overripening, Galia melons should be harvested when the fruit changes color to a bright yellow. Galia melons produce a strong floral odor and easily detach from the stem. Muskmelons will ripen after harvest, but the sugar content does not increase. The sweetness should be at least 11 degrees Brix, and the fruit should weigh 3 pounds or more. Specialty melons can be sold at a smaller weight (1–2 pounds).

Charentais melons and honeydew melons do not slip from the vine at maturity, and honeydews do not produce an aroma as they ripen. Charentais fruit will change color from a gray/green to creamy white. The leaves closest to the fruit stem will also begin to develop a pale color. The fruit must be harvested before it begins to split. Ripe melons can be stored for almost two weeks at 34 degrees F and 95 percent relative humidity. Honeydew melons and other specialty melons should be stored at 45 degrees and 90 percent relative humidity.

Watermelons do not slip from the vine or emit an odor when ripening. Other indicators of maturity include increased “waxiness” of the rind, drying of the tendril closest to the fruit and a dull, muffled sound when the watermelon is thumped, depending on the variety. Watermelons should be cut from the vine rather than pulled, leaving about an inch of stem. The stem can be trimmed on the day of sale, giving the melons a fresh harvest appearance. Harvest early in the morning when field heat is low and the fruits are most turgid. Watermelon sweetness should be at least 11 degrees Brix. Watermelons should be stored at 50 to 60 degrees F and 90 percent relative humidity.

Marketing
Demand for melons and watermelons is increasing. Muskmelons are sold individually in farmers’ markets (Figure 16). Most wholesale markets sell melons in corrugated bins or 1¾-bushel boxes that contain 15 to 18 melons per box and weigh about 60 pounds. Muskmelons weighing more than 6 pounds are considered large; medium-size melons weigh 4 to 6 pounds and small melons weigh less than 4 pounds. Watermelons are sold individually or in bins containing about 60 watermelons. Use only clean bins or boxes for packing melons and watermelons.

Pest management
High tunnels are effective in reducing pest outbreaks that routinely occur in the open field environment. Growing crops earlier in the season avoids many pests, which normally become
established later in the season. However, insects and diseases can enter and spread within the high tunnel. Maintaining healthy, nonstressed plants, managing the high tunnel environment properly, preserving beneficial insects and early pest detection will prevent many pests from becoming a problem within the high tunnel. The following are some pests detected on high tunnel melons and watermelons in the central Midwest.

**Aphids**

Aphids are small (1/10 inch long), pear-shaped insects with soft bodies. In the sheltered, humid environment of a high tunnel, aphids are prolific. The melon aphid (*Aphis gossypii*) is the most common aphid that feeds on cantaloupes and watermelons. Melon aphids are typically pale green in the wingless stage and dark black as winged adults (Figure 17). Aphids suck sap or photosynthates from the growing plant, causing it to weaken. Aphids also excrete tremendous volumes of waste material called honeydew, which becomes a black sooty mold on leaf and fruit surfaces. Aphids can transmit many serious cucurbit virus diseases.

Early detection of aphid invasion is crucial in a high tunnel. Scout rows closest to the baseboards or end walls for aphid infection. Generally, aphids can be found on the underside of leaves and at the growing tips of the vines. However, melon aphid can also be observed on lower leaves of the vines as well as the growing tips. Often the growing tips become curled, looking like virus symptoms. Melon aphids can overwinter within a high tunnel. Remove all crop debris from winter production, and destroy any weeds before establishing melons and watermelons in a high tunnel. Carefully inspect transplants to detect any aphids that may have invaded transplants in the greenhouse.

Aphids have many natural enemies, including ladybird beetles (*Hippodamia convergens*), lacewings (*Chrysoperia rufilabris*) and predatory midges (*Aphidoletes aphidimyza*). Natural enemies can be released to clean up hot spots in the high tunnel and should not be used as a rescue treatment when aphid numbers are high. Systemic, targeted insecticides (those that translocate within the plant) can be applied at transplanting to provide 30 to 36 days of aphid control. Avoid using harsh, foliar insecticides that may kill beneficial insects in a high tunnel. There are several “soft” insecticides that target only aphids and preserve beneficial insects. Always use a labeled surfactant with each pesticide to increase distribution over the foliage.

**Thrips**

Thrips (Thysanoptera: Thripidae) are small (1/16 inch long) elongated insects that can be a serious insect pest of high tunnel melons and watermelons. Thrips are usually found clustered in flowers and on the underside of leaves, especially near the terminal growth of the vines. Damage to the plants is caused by adult and nymph thrips scraping the surface of the leaves with their mouthparts and feeding on the exuding sap. The damaged plants will have small, silver streaks on the leaves, and the plant looks as though it has been sandblasted (Figure 18). Fruit can have surface scars from early-season thrips feeding. Thrips, like aphids, can be imported into the high tunnel on transplants.

Always isolate vegetable transplants from ornamental plants in the greenhouse. Early detection of thrips is important. Inspect plants regularly, looking in blossoms or on the underside of terminal leaves. Use blue sticky traps to detect winged adult thrips.

Minute pirate bugs (*Orius insidiosus*), green lacewings and predatory mites are natural enemies of thrips and may be effective in the early stages of a thrips invasion.

However, using beneficial insects and mites will not be effective as a rescue treatment for
widespread thrips invasion within the high tunnel. Systemic, targeted insecticides applied at transplanting will be effective in controlling thrips for about 35 days.

Several soft pesticides may be used to control thrips within a high tunnel. Insect exclusion screen can be used to cover the high tunnel vents and prevent invasion of thrips.

Cucumber beetles

Spotted cucumber beetle (*Diabrotica undecimpunctata howardii* (Barber)) and striped cucumber beetle (*Acalymma vittata* (Fabricius)) are serious insect pests of field-grown cucurbits in the central Midwest. Cucumber beetles are ¼-inch-long beetles with either 12 spots (spotted cucumber beetle) or three black stripes (striped cucumber beetle) on their abdomens (Figure 19). Both species can overwinter in Missouri and become active in April when daytime temperatures exceed 55 degrees F.

Adult beetles begin feeding on cotyledons (seed leaves) of transplants and continue to feed on the emerging leaves, stems, flowers and eventually the fruit surface (watermelon). Both species can transmit bacterial wilt (*Erwinia tracheiphila*) to cantaloupes and muskmelons (see Figure 23). Watermelons are not susceptible to bacterial wilt.

Within two weeks after transplanting, begin scouting for cucumber beetles in the high tunnel. Use yellow sticky traps to detect cucumber beetles.

Cucumber beetles are very mobile. Insect exclusion screens can be used to control cucumber beetles entry into the high tunnel. Systemic insecticides applied as a post transplant drench will provide about 35 days of control, which is long enough to reduce bacterial wilt infection. Further control through the growing season can be accomplished by applying foliar insecticides. Avoid using insecticides that may be toxic to pollinating insects. There are no effective biological control techniques for cucumber beetle.

Whiteflies

Greenhouse whitefly (*Trialeurodes vaporariorum* (Westwood)) is the most common whitefly species that can infest high tunnel melons and watermelons. Whiteflies are small (1/16 inch long), soft-bodied insects with wings covered with white, powdery wax. Whiteflies damage plants by sucking the sap and transmitting harmful viruses. Much like aphids, they excrete honeydew, which develops into sooty mold on the vines and fruit. In the central Midwest, whiteflies can appear within the high tunnel in late summer. Scout plants regularly, and check the underside of the
leaves of new foliage for whitefly adults (Figure 20). Yellow sticky traps are useful in detecting whitefly population levels in the high tunnel. Natural enemies of whitefly include a parasitic wasp (Encarsio formosa), and Delphastus beetles (Delphastus catalinae). Several biological and soft pesticides are labeled for control of whitefly.

**Spider mites**

Spider mites are small (1/50 inch long), oval-shaped arthropods related to spiders. The most common spider mite on high tunnel melons and watermelons is the twospotted spider mite (Tetanychus urticae) with two dark spots on the abdomen (Figure 21). Mites can be found on the underside of leaves where they congregate and suck sap from the plant. The leaf surface develops a scratchlike appearance and interveinal yellowing or bronzing develops (Figure 21). Eventually the leaves die, and the plant becomes progressively weakened. As the population of mites increases, they develop a webbing around the area where they feed and lay eggs. Mites thrive in hot, dry climates (at least 80 degrees F and less than 50 percent relative humidity) and thus become a problem on high tunnel melons and watermelons from midseason onward in the Midwest.

The twospotted spider mite overwinters in the Midwest and will infest early-season melons in a high tunnel if all weeds and other residue are not removed before establishing the melon or watermelon crop. Clean mowing of vegetation around the high tunnel will reduce the risk of spider mite movement into the high tunnel. Exclusion screening will prevent or reduce spider mite invasion. Spider mites have several natural enemies. Miticides can be used to control the twospotted spider mite. Most miticides will not kill mite eggs, so the first and second spray application should be relatively close together to kill nymphs and adults, which hatch from eggs laid earlier. Always read the label of the pesticide before application. Surfactants should be used to improve miticide distribution over the crop canopy.

**Powdery mildew**

The dry, humid and dense plant growth within a high tunnel is optimal for development of powdery mildew. Powdery mildew (Podosphaera xanthii) is a fungus that looks like a white mold on leaves (Figure 22). The disease appears on the lower leaves of the vine and gradually spreads through the canopy. The vines become weakened from leaf loss, and fruit size can be significantly reduced. Plants should be regularly inspected, starting at fruit set for powdery mildew. Choose resistant cultivars (Table 3). The high tunnel should be properly vented to reduce relative humidity. Many effective fungicides are labeled for powdery mildew control.

**Bacterial wilt**

Bacterial wilt (Erwinia tracheiphila) is a serious disease of melons. Watermelons are resistant to this disease. Bacterial wilt is transmitted by spotted and striped cucumber beetles that feed on melon foliage. Infected plants exhibit leaf wilting followed by vine collapse (Figure 23). Plants are most often infected at early stages of growth.

Control of bacterial wilt in a high tunnel begins with control of cucumber beetles. Scout regularly for cucumber beetles. Use a systemic insecticide that provides 36 days of cucumber beetle control. Row covers will protect the plants from early-season feeding by cucumber beetles. There are currently no melon cultivars resistant to bacterial wilt.
Useful references

Midwest Vegetable Production Guide for Commercial Growers, University of Missouri Extension Publication MX384, University of Missouri-Columbia.


High tunnel information: http://hightunnels.org

Melon price information: www.ams.usda.gov/mnreports/HX_FV010.txt
Melon and watermelon seed sources

Abbott & Cobb, Inc.
P.O. Box 307
Trevose, PA 19083-0307
(267) 525-7037
http://acseed.com

Abundant Life Seed Foundation
P.O. Box 772
1029 Lawrence St.
Port Townsend, WA 98368
(360) 385-5660
http://www.abundantlifeseed.org

Baker Creek Heirlooms
2278 Baker Creek Rd.
Mansfield, MO 65704
(417) 924-8917
http://rareseeds.com

Bountiful Gardens
18001 Schaefer Ranch Rd.
Wilton, CA 95693
(707) 385-5660
http://www.bountifulgardens.org

Burgess Seed
905 Four Seasons Rd.
Bloomington, IL 61701
http://eburgess.com

Burrell Seeds
P.O. Box 150
Rocky Ford, CO 81067
(719) 254-3319

Chesmore Seeds
5030 E. Hwy. 36
St. Joseph, MO 64507
(800) 383-0865
http://chesmore.com

Clifton Seed Co.
2586 NC 403 W
P.O. Box 206
Faison, NC 28430
(910) 267-2690

Cook Garden
P.O. Box 535
Londonberry, VT 05148
(802) 457-9703
http://cooksgarden.com

Fedco Seeds
P.O. Box 520
Waterville, ME 04993
(207) 873-7333
http://fedcoseeds.com

Golden Valley Seed
P.O. Box 1600
El Centro, CA 92244
(760) 397-3100

Harris Moran Seed Co.
555 Codoni Ave.
Modest, CA 95357
(209) 549-5208
http://harrismoran.com

Harris Seeds
355 Paul Rd.
Rochester, NY 14624
(800) 544-7938
http://harrisseeds.com

Hazera Seeds
2255 Glades Rd.
Suite 123A
Boca Raton, FL 33431
(561) 988-1315
http://www.hazera.com

Holmes Seeds
2125 46th St. NW
Canton, OH 44709
(800) 435-6077

Johnnys Selected Seeds
955 Benton Ave.
Winslow, ME 04901
(800) 854-2580
http://johnnysseeds.com

Jordan Seeds
6400 Upper Alton Rd.
Woodbury, MN 55125
(612) 738-3422

Morgan County Seeds
18761 Kelsay Rd.
Barrett, MO 65011-3009
(573) 378-2655

Nunhems USA, Inc.
1200 Anderson Corner Rd.
Parma, ID 83660
(208) 674-4146
http://www.nunhemsusa.com

Osetti Seeds
P.O. Box 2350
Hollister, CA 95024-2350
(831) 636-4822
http://osettiseeds.com

Park Seeds
1 Parkton Ave.
Greenwood, SC 29647-0001
(800) 845-3369
http://www.parks.com

Peaceful Valley Farm Supply
P.O. Box 2209
Grass Valley, CA 95945
(888) 784-1722
http://groworganic.com

Rupp Seeds
17919 Co. Rd. B
Wauseon, OH 43567
(800) 700-1199
http://www.ruppseeds.com

Sakata Seed
18095 Serene Dr.
Morgan Hill, CA 95037
(408) 778-7758
http://www.sakata.com

Seedway
1225 Zeager Rd.
Elizabethtown, PA 17022
(800) 952-7333
http://seedway.com

Seminis Seeds
2700 Camino del Sol
Oxnard, CA 93030
(866) 334-1056
http://seminis.com

Shamrock Seed Co.
3 Harris Pl.
Salinas, CA 93901
(831) 771-1522
http://www.shamrockseed.com

Siegers Seed
13031 Reflections Dr.
Holland, MI 49424
(800) 962-4999
http://www.siegers.com

Southwestern Seed Co.
P.O. Box 11449
Casa Grande, AZ 85230
(520) 836-7595
http://southwesternseed.com

Stokes Seeds
P.O. Box 548
Buffalo, NY 14240
(800) 263-2733
http://stokesseeds.com

Sugar Creek Seed
P.O. Box 508
Hinton, OK 73047
(405) 542-3920
http://sugarcreekeed.com

Sun Seeds
2210 Stephanie Brooks Rd.
Wenatchee, WA 98801

Syngenta Seeds, Rogers Brand
600 N. Armstrong Pl.
Boise, ID 83704
(208) 327-7252
http://rogersadvantage.com

Wilhite Seed Co.
P.O. Box 23
Poolville, TX 76487
(817) 599-8656
http://wilhiteseed.com

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Sources of high tunnels (hoophouses)

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Contact Person</th>
<th>Address</th>
<th>Phone</th>
<th>Website</th>
<th>Email</th>
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<tbody>
<tr>
<td>A. M. Leonard</td>
<td></td>
<td>P.O. Box 816, Piqua, OH 45356</td>
<td>800-543-8955</td>
<td><a href="http://www.amleo.com">www.amleo.com</a></td>
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<tr>
<td>Atlas Greenhouse Systems, Inc.</td>
<td></td>
<td>P.O. Box 558, Alapaha, GA 31622</td>
<td>800-346-9902</td>
<td><a href="http://www.atlasgreenhouse.com">www.atlasgreenhouse.com</a></td>
<td>e-mail: <a href="mailto:service@atlasgreenhouse.com">service@atlasgreenhouse.com</a></td>
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<tr>
<td>Conley’s Greenhouse Mfg.</td>
<td></td>
<td>4344 Mission Blvd., Montclair, CA 91763</td>
<td>800-377-8441</td>
<td><a href="http://www.conleys.com">www.conleys.com</a></td>
<td>e-mail: <a href="mailto:info@conleys.com">info@conleys.com</a></td>
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<tr>
<td>CropKing, Inc.,</td>
<td></td>
<td>5050 Greenwich Rd., Seville, OH 44273</td>
<td>(330) 769-2616</td>
<td><a href="http://www.cropring.com">www.cropring.com</a></td>
<td>e-mail: <a href="mailto:cropring@cropring.com">cropring@cropring.com</a></td>
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<tr>
<td>FarmTek</td>
<td></td>
<td>1440 Field of Dreams Way, Dyersville, IA 52040</td>
<td>800-327-6835</td>
<td><a href="http://www.farmtek.com">www.farmtek.com</a></td>
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<tr>
<td>Grow-It Greenhouse</td>
<td></td>
<td>P.O. Box 26037, West Haven, CT 06516</td>
<td>800-932-9344</td>
<td><a href="http://www.growitgreenhouses.com">www.growitgreenhouses.com</a></td>
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<td>Harnois Greenhouses</td>
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<td>US Distributors include:</td>
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<tr>
<td>Syngenta Inc./S&amp;G Flowers (D)</td>
<td></td>
<td>5300 Katrine Ave., Downers Grove, IL 60515</td>
<td>(630) 969-0889</td>
<td><a href="http://www.syngenta.com">www.syngenta.com</a></td>
<td><a href="mailto:dennis.meisch@syngenta.com">dennis.meisch@syngenta.com</a></td>
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<tr>
<td>Rimol Greenhouse Systems</td>
<td></td>
<td>40 Londonderry Turnpike, Hooksett, NH 03106</td>
<td>(877) 746-6544</td>
<td><a href="http://www.rimol.com">www.rimol.com</a></td>
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<tr>
<td>Speedling Inc.</td>
<td></td>
<td>P.O. Box 7238, Sun City, FL 33586</td>
<td>800-881-4769</td>
<td><a href="http://www.speedling.com">www.speedling.com</a></td>
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<td>Stuppy Greenhouse Mfg.</td>
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<td>1212 Clay St., North Kansas City, MO 64116</td>
<td>800-733-5025</td>
<td><a href="http://www.stuppyg.com">www.stuppyg.com</a></td>
<td>e-mail: <a href="mailto:greenhouse@stuppy.com">greenhouse@stuppy.com</a></td>
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<td>Turner Greenhouses</td>
<td></td>
<td>P.O. Box 1260, Goldsboro, NC 27530</td>
<td>800-672-4770</td>
<td><a href="http://www.turnergreenhouses.com">www.turnergreenhouses.com</a></td>
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<tr>
<td>Zimmerman’s Welding</td>
<td></td>
<td>Jacob L. Zimmerman, 16645 Ridgewood Rd., Versailles, MO 65084</td>
<td>(573) 378-4770</td>
<td><a href="http://www.zimmberns.com">www.zimmberns.com</a></td>
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