

# High Tunnel Melon and Watermelon Production



## Author:

Lewis W. Jett  
State Vegetable Crops Specialist  
Department of Horticulture  
University of Missouri  
Columbia, MO 65211-7140



UNIVERSITY OF MISSOURI  
 Extension

## High Tunnel Melon and Watermelon Production

High tunnels are low-cost, passive, solar greenhouses which use no fossil fuels for heating or venting. High tunnels can provide many benefits to horticulture crop producers:

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

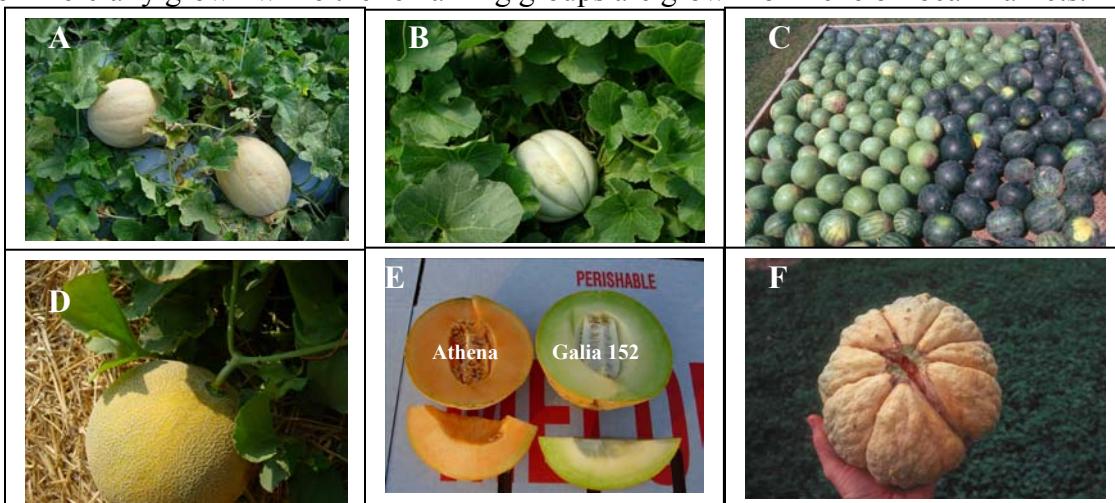


**Figure 1.** High tunnels are plastic-covered, solar greenhouses.

Many warm season (frost sensitive) vegetable crops can be grown within a high tunnel. Cucurbits are a large, diverse group of warm season plants within the Cucurbitaceae family. Cucurbits include many popular vegetables such as cucumber, gourd, cantaloupe (muskmelon), squash, pumpkin and watermelon. Cucurbits 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.



**Figure 2.** Muskmelons and watermelons vary in shape, size and color. **A.** ‘Athena’ muskmelon. **B.** Charentais cantaloupe. **C.** Personal-size (mini) seedless watermelons. **D.** Galia muskmelon. **E.** Galia 152 & Athena muskmelon flesh. **F.** Prescott cantaloupe.

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 term 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 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 within a high tunnel. A seedless watermelon is a cross between a diploid (2 sets of chromosomes), seeded variety and a tetraploid (4 sets of chromosomes) line. The resulting plant is sterile with three sets of chromosomes. Seedless cultivars must have pollen from a seeded, diploid cultivar in order to set fruit. Mini seedless watermelons ( $\leq$  6 lbs) are becoming popular with consumers as single-serving melons. Melons and watermelon 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 correlated with reducing many forms of cancer.



**Figure 3.** Watermelon leaves (A) are lobed with branched tendrils while muskmelon leaves (B) are non lobed with simple tendrils at each leaf axis. Tendrils are used by the vines for climbing and anchoring (C).

**Table 1.** Groups of *Cucumis melo*.

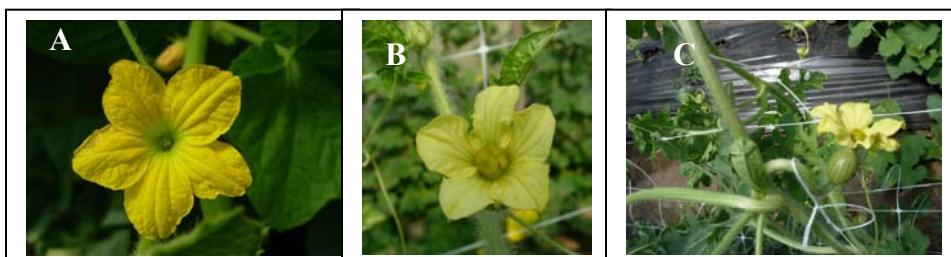
<b><i>Cucumis melo</i> subgroup</b>	<b>Cultivar examples</b>	<b>Fruit characteristics</b>
<i>Cantaloupe</i> nsis (true cantaloupe)	<i>Prescott melon</i> <i>D'Alger</i> <i>Charentais</i>	Smooth to warty fruit surface. Very aromatic. No netting. Fruits do not slip from vine when mature. Widely grown in Europe
<i>Inodorus</i>	<i>Canary melon</i> <i>Casaba melon</i> <i>Crenshaw melon</i> <i>Honeydew melon</i>	Not aromatic. Fruit does not slip from vine when mature. Flesh is usually green or white.
<i>Reticulatus</i>	<i>Muskmelons</i> <i>Persian melon</i> <i>Galia melon</i>	Netted and aromatic fruit slips from the vine when mature.
<i>Conomon</i>	<i>Makuwa uri</i> <i>Chinese melon</i> <i>Sakata's sweet</i>	No aroma. Fruit has crisp, white flesh. Widely grown in Asia.
<i>Flexuosus</i>	<i>Armenian cucumber</i> <i>Snake melon</i>	Elongated fruit with no aroma.
<i>Chito</i>	<i>Mango, Lemon melon</i>	Fruit is not sweet or aromatic.
<i>Dudaim</i>	<i>Queen Anne's Pocket Melon</i>	Very aromatic fruit.

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°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 which in turn have many secondary branches. Vines can reach a length of 30 feet for some Cucurbit varieties.

Melons and watermelons have modified, thread-like leaves called tendrils which the vine uses for anchoring or climbing. Tendrils can be branched (watermelon) or simple (muskmelon). Both Cucurbit crops have strong tap roots which 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. 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 first and are followed by emergence of more staminate and pistillate flowers. Generally, 15 staminate flowers are produced for each pistillate flower.



**Figure 4.** Melon flowers (A) are brighter yellow and yield more nectar relative to watermelon flowers (B, C).

### **Cultivar selection.**

There are many productive cantaloupe and watermelon cultivars which can be grown within a high tunnel. Choose a suitable cultivar for your market outlet. Purchase high quality, vigorous seed for transplant production. (See list of seed suppliers). High quality seed means faster germination and vigorous growth. One ounce of muskmelon seeds contains 950 to 1200 seeds while one ounce of watermelon seeds contains 300 (large seeded cultivars) to 650 (small seed cultivars) seeds. The following table includes suggested varieties of muskmelons, cantaloupes, honeydews and mini seedless watermelons for high tunnel production.



**Table 2.** Potential melon and mini watermelon cultivars for high tunnel production.

Cultivar	Cucurbit type	Days to maturity	Fruit description	Disease tolerance
Athena	Muskmelon	80	Oval/round fruit with minor netting and no sutures.	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Aphrodite	Muskmelon	75	Oval, large fruit. Light sutures.	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Ambrosia	Muskmelon	86	Round fruit. Coarse netting. Good garden cultivar.	PM
Crescent Moon	Muskmelon	73	Large, eastern-type melon.	PM <sub>12</sub>
Odyssey	Muskmelon	80	Round, large fruit with coarse netting and shallow sutures	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Primo	Muskmelon	78	Small, western-type shipping melon. Heavy netting	PM <sub>12</sub>
Jenny Lind	Muskmelon	70	Round fruit with heavy netting. Green flesh. Large blossom scar. Heirloom melon.	-
Galia 152	Galia	80	Round fruit with green flesh. Very aromatic. No sutures.	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Galileo	Galia	83	Round fruit with green flesh. Light netting.	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Arava	Galia	77	Round fruit with green flesh. Light netting.	PM
Gallicum	Galia	80	Round fruit with green flesh. Small fruit.	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Lavigal	Galia	80	Round fruit with green flesh. Very aromatic. Light netting.	PM <sub>1,2</sub> F <sub>0,1,2</sub>
Early Dew	Honeydew	80	Round fruit. Very early, 2.5-3 lb fruit which slips at maturity.	PM <sub>1,2</sub> F <sub>0,1,</sub>
Honey Star	Honeydew	85	Round fruit with light-green flesh.	PM <sub>1,2</sub> F <sub>0,1,</sub>
Honey Orange	Honeydew	74	Oval fruit with orange flesh.	PM <sub>1,2</sub> F <sub>0,1,</sub>
Savor	Charentais Cantaloupe	78	Round, small fruit with dark orange flesh. Produces a vigorous vine which may need pruning	PM F <sub>0,1,2</sub>
<b>Watermelon (personal size)</b>				
Sweet Beauty	Mini Seeded	77	Small, oblong, seeded watermelon	-
Extazy	Mini Seedless	85	Small; round	-
Hazera 5130	Mini Seedless	85	Small, round	-
Solitaire	Mini Seedless	85	Small; round	-
Vanessa	Mini Seedless	80	Solid, dark rind.	-

PM=Powdery Mildew race 0, 1, 2. F=Fusarium race 0, 1,2

**This list is not intended to include every cultivar that may perform well in a high tunnel.**

## Transplant production.

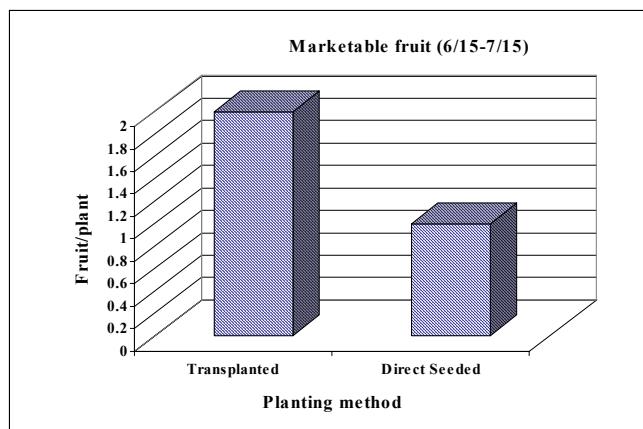
For early production within a high tunnel, melons and watermelons should be established as transplants. Transplants increase uniformity and earliness of the crop while reducing seed costs (Figure 6). Quality transplants begin with quality seed. Choose a suitable cultivar and melon type which has consumer demand in your market outlet (Table 2).

Various containers can be used to germinate and grow cucurbit plants. Generally a 1-2" diameter transplant container or cell 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 seedcoat. After seeding, water the seeds and place in a warm room (85-90°F) for approximately 3 days to accelerate germination. Do not over water seedless triploids. Seedless watermelons should be germinated at 90°F for 48 hours. After 10% of the seeds have emerged, the temperature can be lowered to 70-80°F (day) and 65-70°F (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 per week, a 200-ppm nitrogen solution can be applied to the growing transplants (Table 3). Four to six weeks are required for growth of melon and watermelon transplants. One week prior to 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 2-4 true leaves, short, thick stems and a healthy root system (Figure 5).



**Figure 5.** Use healthy, vigorous transplants for early melon and watermelon production within a high tunnel.



**Figure 6.** Transplants increase early yield of melons within a high tunnel.

**Table 3.** Ounces of fertilizer/100 gallons of water.

Nitrogen ppm	Fertilizer analysis			
	20-20-20 (oz.) <sup>z</sup>	9-45-15 (oz.)	15.5-0-0 (oz.)	15-30-15 (oz.)
100	6.7	14.8	8.6	8.9
200	13.3	29.6	17.2	17.8
300	20.1	44.4	25.8	26.7
400	26.6	59.2	34.4	35.6
500	33.5	74.0	43.0	44.5
600	40.2	88.8	51.6	53.4

<sup>z</sup>Ounces of fertilizer dissolved in 100 gallons of water.

### Planting within the high tunnel.

The soil within the high tunnel should be tilled, fertilized and formed into a raised bed prior to transplanting (Figure 7). Raised beds (4-6" height x 20-32" width) increase the average soil temperature, 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 2 weeks before transplanting. There are several plastic mulches to choose from.

Black plastic is the preferred plastic mulch for Cucurbits since it warms the root zone, and both reduces weed germination and soil moisture evaporation. The soil temperature during the daytime is approximately 5°F warmer at the 2-inch depth under black plastic relative to non-mulched, 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 mulch is not tightly fitted over the raised bed.

In a high tunnel, melons and watermelons are spaced 24-36" between plants within each row, and the rows are spaced 40-48" apart 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 (2500 ft<sup>2</sup>) can accommodate 200-300 cantaloupe or watermelon plants.

Each transplant is planted approximately 1-2 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. A reliable index for determining when to plant within a high tunnel is soil temperature. Melons and watermelons can be transplanted when the soil temperature at the 2" depth is ≥ 60°F.



**Figure 7.** Plastic mulch on raised beds accelerates melon growth within a high tunnel.

### 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 spun bonded fabric. Spun bonded row covers ( $0.5\text{-}1.25 \text{ oz/yd}^2$ ) are recommended for high tunnel Cucurbit production (Figure 8). Unlike polyethylene row covers, spun bonded 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, spun bonded row covers are very 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 approximately 3 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.



**Figure 8.** Row covers protect melons from frost damage.

### 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 6.0-6.8. 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.

Prior to transplanting, 7-11 oz of actual nitrogen/1000 ft<sup>2</sup> should be applied to the raised beds. Based on a soil test, all the required phosphorus and one half of the required potassium should be applied prior to transplanting and mulch application. If the soil within the high tunnel is high in organic matter (>3%), a lower rate of preplant nitrogen can be applied. Thoroughly incorporate the fertilizer in the top 4-6 inches of the soil.

Applying water-soluble fertilizer through the irrigation system is referred to as fertigation. If no fertilizer is applied preplant, fertigation should begin immediately after transplanting within 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 10-12 week growing season. A suggested fertigation program for high tunnel melons and watermelons is given below (Table 4). If preplant potassium is

applied, potassium fertigation commences 3 weeks after transplanting. Adequate potassium fertilization is crucial for melon crops since 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.

**Table 4.** Suggested nitrogen and potassium fertigation schedule for high tunnel melons and watermelons.

Days after transplanting	Weekly nitrogen (oz./1000 ft <sup>2</sup> )	Weekly potassium <sup>z</sup> (K <sub>2</sub> O) (oz./1000 ft <sup>2</sup> )	Cumulative nitrogen (oz./1000 ft <sup>2</sup> )
Preplant	9.2	18.4	9.2
14-21	2.3	0	13.8
22-49	3.3	6.7	27.0
50-77	3.9	7.7	42.6
77-84	1.8	3.6	44.4

<sup>z</sup>Assumes a low soil potassium level.

### Irrigation.

Since high tunnels exclude natural rainfall, the water requirements of the crop must be supplied by drip irrigation. Drip irrigation is a method in which water is applied slowly to the root zone of the growing crop by using small, collapsible tubes called drip tape (Figure 8). Drip irrigation has many advantages including less water usage 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" dripper spacing) is placed 3" from the center of the bed. The drip line should be buried 1" 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 approximately 10-12 inches on either side of the tube in heavy soils and 8-10 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 5). Since plastic mulch reduces soil moisture evaporation, it is important not to over water the crops. Excessive irrigation during the latter stages of fruit ripening can lower sugar levels and cause fruit cracking.



**Figure 9.** Drip irrigation and black plastic mulch improve melon and watermelon yield and quality.

**Table 5.** Hours required to apply 1 inch of water to a mulched, raised bed.

Drip tube flow rate		Width of mulched bed (ft.)		
<sup>1</sup> Gph/100 ft.	<sup>2</sup> Gpm/100 ft.	2.0	2.5	3.0
8	0.13	15.5	19.5	23.5
10	0.17	12.5	16.5	18.5
12	0.20	10.5	13.0	15.5
16	0.27	8.0	10.0	11.5
18	0.30	7.0	8.5	10.5
20	0.33	6.0	8.0	9.5
24	0.40	5.0	6.5	8.0
30	0.50	4.0	5.0	6.0
36	0.60	3.5	4.5	5.0
40	0.67	3.0	4.0	4.5
42	0.70	3.0	4.0	4.5
48	0.80	2.5	3.0	4.0

<sup>1</sup>Gallons of water per hour per 100 ft. run of drip tape..

<sup>2</sup>Gallons of water per minute per 100 ft. run of drip tape.

### Pollination.

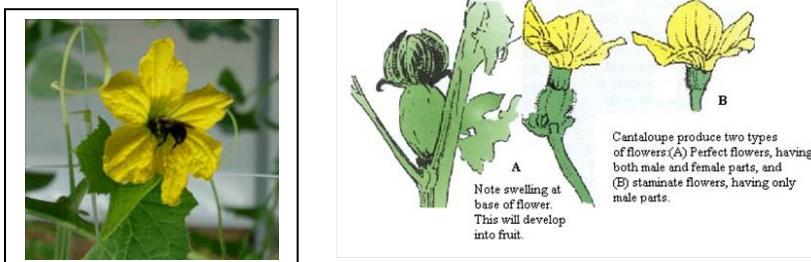
Melons and watermelons have separate male and female flowers on each vine. Male flowers appear at least a week earlier than female flowers. Female flowers are easy to distinguish from male flowers by the presence of a swollen base below the flower petals. Flowers open after sunrise and remain open for 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 since these flowers can develop into large, early fruit.

Nectar collecting bees (honeybees, bumble bees, solitary bees and mason bees) are common vectors of Cucurbit pollen. Research has 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 2-3 weeks after transplanting. If bumble bees are used within the high tunnel, insect screen should be used to retain the bees within the high tunnel. Honeybee colonies can be placed close to the high tunnel to encourage entry. Planting high nectar yielding plants close to the high tunnel such as *Brassica* sp. (mustards) may increase native bee density within a high tunnel. Melons which are poorly pollinated are smaller while improperly pollinated watermelons are often lopsided or bottlenecked.

If feasible, hand pollination of Cucurbits may be performed. In mid-morning 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 10-15 times. Research indicates that hand pollination is

most effective between 6-9 AM. Hand pollination requires patience and may only be effective 50% 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. Icebox watermelon cultivars (7-10 lb fruit) are very effective pollinizers for early yield of seedless watermelons. It is very important to synchronize appearance of male flowers on the pollinator cultivar with female flower opening on the seedless cultivar. The icebox pollinator should be seeded 7-10 days later than the seedless watermelon cultivar, since they flower earlier than most watermelon cultivars. If a standard sized seeded melon is used as a pollinator, it should be seeded 3-4 days before the seedless watermelons are seeded. Watermelons and melons will not cross-pollinate when grown within the same high tunnel.



**Figure 10.** Melons and watermelons require cross-pollination in order to set fruit. *Source: Auburn Univ.*

### **Pruning.**

Many melon cultivars produce extensive vine growth. Pruning the vines may be necessary if the melons are trellised. Pruning is performed to achieve a balance between vine growth and fruit set. Pruning increases average fruit weight while reducing the number of unmarketable (cull) fruit.

Each melon vine produces a primary stem or leader with many secondary branches or laterals. A suitable pruning treatment for high tunnel muskmelons is retaining the primary stem and one of the first laterals while pruning all additional laterals up to and including the eighth leaf node. All secondary branches after the eighth node can be left unpruned on the plant. This method of pruning permits the vine to be easily trellised either by a nylon net trellis or using strings and vine clips as in greenhouse tomato production. Prune off any misshapen fruit.

### **Trellising.**

Training melons and watermelons to grow vertically is referred to as trellising and is one of the advantages of growing melons within a high tunnel. Most melon cultivars and personal size (< 7 lbs.) 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 10). Using a trellis with a plastic (nylon) net (6" x 7" openings) that is approximately 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 will require some training to keep the growth vertical. Assume the static load on the wire will be approximately 10-12 lbs per linear foot.

Another form of trellis is an option when each vine has been pruned to one or two stems. Using a nylon string tied to a tensile wire 6-7 ft off the ground, the string is secured 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 trained from the top down on another twine. Woven wire fence or livestock panels can also be used as a trellis for Cucurbits.

Fruit requires 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 12). 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.

Micro seedless (or seeded) watermelons can be trellised within 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.



**Figure 11.** Trellising increases marketable yields of high tunnel melons.

### **Harvest and yield.**

Melons have several yield flushes requiring harvest 3-4 times per week during peak production while watermelons tend to ripen evenly and the bulk of the fruit can be harvested in relatively few harvests (Figure 13). Melon and watermelon fruit are ready to harvest 45-60 days after flowering. Research at the University of Missouri has revealed that Galia muskmelons are very high yielding when grown within a high tunnel (Table 6). Muskmelons yield more fruit per plant than watermelons within a high tunnel. Melon harvest within a high tunnel is 4-5 weeks earlier than field-grown melons and watermelons in Missouri.

Muskmelons develop a distinct abscission zone between the fruit stem and the fruit (Figure 11). As muskmelon fruit ripens, the color changes from green to yellow, and the fruit produces a very 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”. Full slip is the stage of harvest when the fruit detaches from the vine with slight pressure. Galia melons should be harvested when the fruit changes color to a bright yellow to prevent them from over ripening. 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  $\geq 11^{\circ}$  Brix, and the fruit should be 3 lbs or greater. Specialty melons can be sold at a smaller weight (1-2 lbs).

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 2 weeks at 34°F and 95% relative humidity. Honeydew melons and other specialty melons should be stored at 45F and 90% relative humidity.

Watermelons do not slip from the vine or emit an odor when ripening. Other indicators of maturity are change in “waxiness” of the rind, drying of the tendril closest to the fruit and thumping the fruit for a dull, muffled sound. Watermelons should be cut from the vine rather than pulled leaving about 1” 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  $\geq 11^{\circ}$  brix. Watermelons should be stored at 50-60°F and 90% relative humidity.

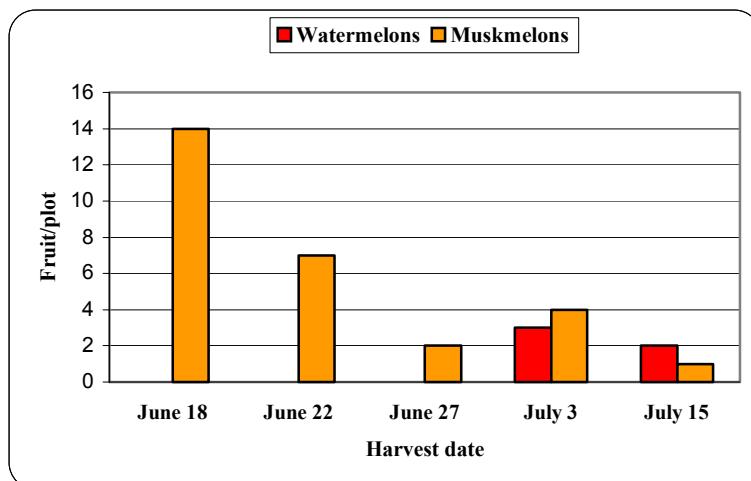


**Figure 12.** Muskmelons slip from the vine when mature. Watermelons, however, do not slip and are harvested when the tendril closest to the fruit dries.

**Table 6.** Average yields of cantaloupes and mini seedless watermelons within a high tunnel. Columbia, MO.

Melon type	Average mkt. yield/plant (No.)	<sup>1</sup> Average mkt. yield/high tunnel (No.)
Galia	3-6	900-1800
Charentais	3-4	900-1200
Athena	2-3	600-900
Micro seedless watermelon	2	600

<sup>1</sup> Assumes a high tunnel with 300 melon or watermelon plants.



**Figure 13.** Marketable yield of Galia muskmelon and mini seedless watermelon- 2005 Columbia, MO  
Each plot contained 4 plants.

## Pest management.

High tunnels are very 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, non-stressed 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" length), 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 14). Aphid sucks 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 within 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 over winter within a high tunnel. Remove all crop debris from winter production and destroy any weeds before establishing melons and watermelons within a high tunnel. Carefully inspect transplants to detect any aphids which may have invaded transplants in the greenhouse. Aphids have many natural enemies including ladybird beetles (*Hippodamia convergens*), lacewings (*Chrysoperla rufilabris*), and predatory midges (*Aphidoletes aphidimyza*). Natural enemies can be released to clean up hot spots within the high tunnel and should not be used for a rescue treatment when aphid numbers are high. Systemic<sup>1</sup>, targeted insecticides can be applied at transplanting to provide 30-36 days of aphid control. Avoid using harsh, foliar insecticides which may kill beneficial insects within a high tunnel. There are several "soft" insecticides which target only aphids and preserve beneficial insects. Always use a labeled surfactant with each pesticide to increase distribution over the foliage.



**Figure 14.** Melon aphids congregate on lower leaf surfaces and cause "cupping" of the leaves.

<sup>1</sup>Translocated within the plant.

### **Thrips.**

Thrips (*Thysanoptera: Thripidae*) are very small (1/16" length) elongated insects which 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. 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 very 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 approximately 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.



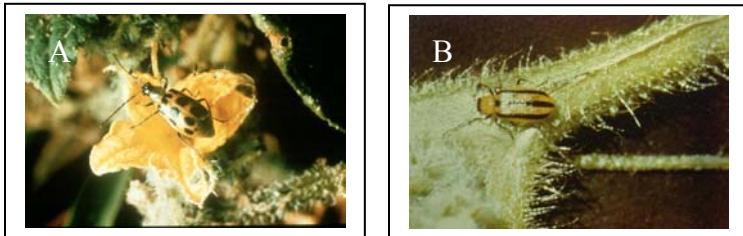
**Figure 15.** Thrips cause significant foliar damage to cucurbits (A, B). Adult thrip (C)

### **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 1/4" long beetles with either 12 spots (spotted cucumber beetle) or 3 black stripes (striped cucumber beetle) on their abdomens. Both species can over winter in Missouri and become active in April when daytime temperatures exceed 55°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 tracheiphilia*) to cantaloupes and muskmelons. 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 approximately 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 which may be toxic to pollinating insects. There are no effective biological control techniques for cucumber beetle.



**Figure 16.** Spotted (A) and striped (B) cucumber beetle are serious pests of melons and watermelons.

### Whiteflies.

Greenhouse whitefly (*Trialeurodes vaporariorum* (Westwood)) is the most common whitefly species which can infest high tunnel melons and watermelons. Whiteflies are small (1/16" length), 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 17). 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.



**Figure 17.** Whiteflies are late season pests of high tunnel melons.

### Spider mites.

Spider mites are small (1/50" length), oval-shaped arthropods related to spiders. The most common spider mite on high tunnel melons and watermelons is the two-spotted spider mite (*Tetranychus urticae*) with two dark spots on the abdomen (Figure 18). Mites can be found on the underside of leaves where they congregate and suck sap from the plant. The leaf surface develops a scratch-like appearance and interveinal yellowing or bronzing develops (Figure 18). Eventually the leaves die, and the plant becomes progressively weakened. As the population of mites increase, they develop a webbing around the area where they feed and lay eggs. Mites thrive in hot ( $\geq 80^{\circ}\text{F}$ ), dry ( $\leq 50\%$  RH) climates and thus become a problem on high tunnel melons and watermelons from midseason onward in the Midwest.

Two spotted spider mite over winters in the Midwest and will infest early-season melons within a high tunnel if all residue (including weeds) 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 two-spotted spider mite. Most miticides will not kill mite eggs, so the first and second spray application should be relatively close together in order 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.



**Figure 18.** Spider mite damage to Cucurbit leaves. *Source:* F. Lam

#### **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 which looks like a white mold on leaves (Figure 19). 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 2). The high tunnel should be properly vented to reduce relative humidity. Many effective fungicides are labeled for powdery mildew control.



**Figure 19.** Powdery mildew on Cucurbits leaves.

#### **Bacterial wilt.**

Bacterial wilt (*Erwinia tracheiphila*) is a very serious disease of melons. Watermelons are resistant to this disease. Bacterial wilt is transmitted by spotted and striped cucumber beetles which feed on melon foliage. Infected plants exhibit leaf wilting followed by vine collapse (Figure 20). Plants are most often infected at early stages of growth. Control of bacterial wilt within a high tunnel begins with control of cucumber beetles. Scout regularly for cucumber beetles. Use a systemic insecticide which provides 36 days of cucumber beetle control. Row covers will protect the plants from early season feeding by cucumber beetles. There are currently no bacterial wilt resistant melon cultivars.



**Figure 20.** Bacterial wilt causes vine collapse of melons. *Source:* D. Egel

### **Useful References:**

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Zitter, T. A., D. Hopkins and C. Thomas (eds.). 1996. *Compendium of cucurbit diseases*. APS Press, St. Paul, MN.

Melon price information: [www.ams.usda.gov/mnreports/HX\\_FV010.txt](http://www.ams.usda.gov/mnreports/HX_FV010.txt)

## Melon and Watermelon Seed Sources

<b>Abundant Life Seed Foundation</b> P. O. Box 772 1029 Lawrence St., Port Townsend, WA 98368 360-385-5660 <a href="http://www.abundantlifeseed.org">www.abundantlifeseed.org</a>	<b>Cook Garden</b> P. O. Box 535 Londonberry, VT 05148 800-457-9703 <a href="http://www.cooksgarden.com">www.cooksgarden.com</a>	<b>Morgan County Seeds</b> 18761 Kelsay Rd., Barnett, MO 65011-3009 573-378-2655
<b>Abbott &amp; Cobb, Inc.</b> , P. O. Box 307 Trevose, PA 19053-0307 267-525-7037 <a href="http://www.acseed.com">www.acseed.com</a>	<b>Golden Valley Seed</b> P. O. Box 1600 El Centro, CA 92244 760-337-3100	<b>Nunhems USA, Inc.</b> , 1200 Anderson Corner Rd., Parma, ID 83660 208-674-4146 <a href="http://www.nunhemsusa.com">www.nunhemsusa.com</a>
<b>Baker Creek Heirlooms</b> 2278 Baker Creek Rd., Mansfield, MO 65704 417-924-8917 <a href="http://www.rareseeds.com">www.rareseeds.com</a>	<b>Fedco Seeds</b> P. O. Box 520 Waterville, ME 04903	<b>Orsetti Seeds</b> P. O. 2350 Hollister, CA 95024-2350 831-636-4822 <a href="http://www.orsettiseeds.com">www.orsettiseeds.com</a>
<b>Berlin Seeds</b> 5371 Co. Rd. 77 Millersburg, OH 44654	<b>Harris Moran Seed Co.</b> , 555 Codoni Ave., Modest, CA 95357 209-549-5208 <a href="http://www.harrismoran.com">www.harrismoran.com</a>	<b>Park Seeds</b> 1 Parkton Ave., Greenwood, SC 29647-0001 800-845-3369 <a href="http://www.parkseed.com">www.parkseed.com</a>
<b>Bountiful Gardens</b> 18001 Schaefer Ranch Rd., Wilton, CA 95490 707-459-6410 <a href="http://www.bountifulgardens.org">www.bountifulgardens.org</a>	<b>Harris Seeds</b> 355 Paul Rd., Rochester, NY 14624 800-544-7938 <a href="http://www.harrisseeds.com">www.harrisseeds.com</a>	<b>Peaceful Valley Farm Supply</b> P. O. Box 2209 Grass, Valley, CA 95945 888-784-1722 <a href="http://www.groworganic.com">www.groworganic.com</a>
<b>Burgess Seed</b> 905 Four Seasons Rd., Bloomington, IL 61701	<b>Hazera Seeds</b> 2255 Glades Rd., Suite 123A Boca Raton, FL 33431 561-988-1315 <a href="http://www.hazera.com">www.hazera.com</a>	<b>Rupp Seeds</b> 17919 Co. Rd. B Wauseon, OH 43567 800-700-1199 <a href="http://www.ruppsseeds.com">www.ruppsseeds.com</a>
<b>Burrell Seeds</b> P. O. Box 150 Rocky Ford, CO 81067 719-254-3319	<b>Holmes Seeds</b> 2125 46 <sup>th</sup> St. NW Canton, OH 44709 800-435-6077	<b>Sakata Seed</b> 18095 Serene Dr., Morgan Hill, CA 95037 408-778-7758 <a href="http://www.sakata.com">www.sakata.com</a>
<b>Chesmore Seeds, Co.</b> 5030 E. Hwy. 36 St. Joseph, MO 64507 800-383-0865 <a href="http://www.chesmore.com">www.chesmore.com</a>	<b>Johnnys Selected Seeds</b> 955 Benton Ave., Winslow, ME 04901 800-854-2580 <a href="http://www.johnnyseeds.com">www.johnnyseeds.com</a>	<b>Seedway</b> 1225 Zeager Rd., Elizabethtown, PA 17022 800-952-7333 <a href="http://www.seedway.com">www.seedway.com</a>
<b>Clifton Seed Co.</b> , 2586 NC 403 W P. O. Box 206 Faison, NC 28430 910-267-2690	<b>Jordan Seeds</b> 6400 Upper Afton Rd., Woodbury, MN 55125 612-738-3422	<b>Seminis Seeds</b> 2700 Camino del Sol Oxnard, CA 93030 866-334-1056 <a href="http://www.seminis.com">www.seminis.com</a>
<b>Siegers Seed</b> 13031 Reflections Dr., Holland, MI 49424 800-962-4999 <a href="http://www.siegers.com">www.siegers.com</a>	<b>Stokes Seeds</b> P. O. Box 548 Buffalo, NY 14240 800-263-7233 <a href="http://www.stokesseeds.com">www.stokesseeds.com</a>	<b>Shamrock Seed Co.</b> , 3 Harris Pl., Salinas, CA 93901 831-771-1522 <a href="http://www.shamrockseed.com">www.shamrockseed.com</a>

<b>Sugar Creek Seeds</b> P. O. Box 508 Hinton, OK 73047 405-542-3920 <a href="http://www.sugarcreekseeds.com">www.sugarcreekseeds.com</a>	<b>Wilhite Seed Co.,</b> P. O. Box 23 Poolville, TX 76487 817-599-8656 <a href="http://www.wilhiteseed.com">www.wilhiteseed.com</a>
<b>Sun Seeds</b> 2210 Stephanie Brooks Rd., Wenatchee, WA 98801	
<b>Syngenta Seeds, Rogers Brand</b> 600 N. Armstrong Pl. Boise, ID 83704 208-327-7252 <a href="http://www.rogersadvantage.com">www.rogersadvantage.com</a>	