Mesotunnels for Organic Management of Cucurbit Pests and Diseases

Tips for Growers

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CURRENT CUCURBIT

University of Kentucky

IOWA STATE UNIVERSITY

Cornell AgriTech
New York State Agricultural Experiment Station

USDA National Institute of Food and Agriculture
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Purpose of this Guide

Organic growers of cucurbit crops in the Midwest and East face many challenges to effectively manage insect pests and diseases. Our OREI project's 3-year field research project in Iowa, Kentucky, and New York is evaluating mesotunnels (mid-size, breathable row cover structures; **FIGURES 1 & 2**) as a physical barrier to keep pest insects like cucumber beetles and squash bugs away from the crop. We've found that mesotunnels make effective barriers against these pests, but that some tweaks are needed to assure adequate pollination and weed control.

This growers' guide summarizes the practical take-home messages from our USDA-NIFA-OREI project. The project was led by a group of researchers at Iowa State University, University of Kentucky, and Cornell University, and advised by a group of organic cucurbit growers from each state. Although future research may further optimize mesotunnel use, this guide provides growers with our current advice for effectively using mesotunnels in organic cucurbit production.

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Mesotunnels

Mesotunnels (**FIGURES 1 & 2**) use a nylon-mesh fabric that resembles window screen. This is different from the spunbonded polypropylene fabric used to cover low tunnels. The nylon-mesh fabric is much more breathable, so plants don't overheat even in midsummer (**FIGURE 3**). Also, it is much stronger and more durable. Mesotunnel designs vary from farm to farm, but they are usually supported by hoops formed from 10-ft-long sections of steel conduit. At the ground level, nets can be held down by nylon bags filled with sand or rocks (**FIGURE 4**), pavers, layflat filled with water or gravel, or by soil piled on the fabric edges to hold them down. The optimal choice for holding down mesotunnel nets may depend on cost (including labor) and availability of materials.

FIGURE 1. ***A three-row mesotunnel plot at Iowa State University.***
Photo: Jose Gonzalez

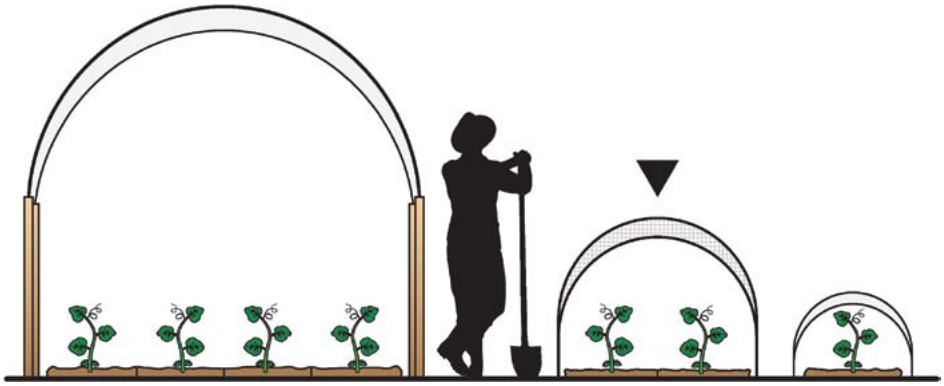

FIGURE 2. ***Size comparison of a 9-ft-tall caterpillar tunnel (left), mesotunnel (center) and low tunnel (right).***

Cucurbit crops need pollinators (mainly bees) to produce fruit. As a result, mesotunnels must allow bees to have access to the flowers during bloom.

In mesotunnels on cucurbit crops in Iowa, Kentucky, and New York, the nylon-mesh fabric covers raised plastic beds with drip tape underneath. But the alleys between the plastic-mulch strips are bare soil, so weed control is a concern.

So far, mesotunnels have been tested mainly on organic muskmelon and winter squash. However, some growers have tried them on other crops such as cucumbers and celery.

Installation

Mesotunnel supports need to be stable to keep the nets from sagging. This stability requires the conduit hoops at the ends to be pushed 6 to 12 inches into the soil. This depth makes them resistant to tugging from the wind. The hoops are much easier to insert deeply when the conduit ends are flattened and pushed into moist rather than dry soil. We have also found that mesotunnels are stable when sandbags are placed at intervals of 6 to 8 feet, with six evenly spaced sandbags at each end of the tunnels for extra stability. Experience has shown us that tension on the nets is strongest when one of the long sides is secured first, then the other long side, and finally the ends. Minimizing sag and ripples makes the tunnel much more resistant to wind. You can also go back and retighten the nets as needed throughout the season. *IMPORTANT: Mesotunnels must be set up on the same day that transplants are*

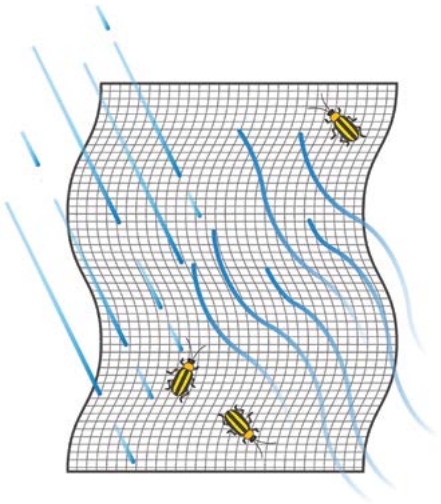

FIGURE 3. ***The nylon-mesh fabric covering mesotunnels keeps out pest insects while providing excellent ventilation.***

FIGURE 4. ***Sandbags used between two triple-row mesotunnels to hold down the nets.*** *Photo: Jose Gonzalez*

FIGURE 5. ***Hoop placement in a zig-zag pattern with ends pushed into the plastic mulch.*** *Photo: Kellie Damann*

planted to keep cucumber beetles and other pest insects from pouncing on the seedlings before the barrier goes up.

Hoop details

We manually bent 10-ft-long sections of steel electrical conduit into hoops using an inexpensive hoop bender from Johnny's Selected Seeds. Flattening the ends of the hoops makes them easier to push into the ground. Grower feedback inspired us to adopt a zig-zag pattern for hoop placement (FIGURE 5). This allows enough space to mow between the planting rows to control weeds and provides a more stable structure than hoops that are aligned perpendicular to the rows. Additionally, the zig-zag pattern facilitates driving the hoop ends into the plastic mulch-covered raised beds; the soil there is softer and damper, which makes hoops easier to insert, especially during dry periods. Note that hoops at the ends of the tunnels should be aligned perpendicular and diagonal to the planting row in order to maintain tension on the nets.

Cost, maintenance, and durability of the materials

The 60-gram nylon-mesh fabric we used is about 2.5 times more expensive than spunbond polypropylene, but it is also considerably more durable. Nevertheless, holes can appear in the fabric if it is poked with sharp objects, chewed by rodents, or exposed to high winds. Weeds can grow through the net at the edges of the tunnel and tear the fabric. Weights for holding down the nets can cause damage to the fabric but sandbags are less abrasive than rock bags for holding down the nets. Holes can be mended with 50-lb-test fishing line. Depending on how much wear the nets incur, they can be reused for 2 to 3 years or more; however, repair of large holes is required to keep excluding pest insects. Conduit hoops should last for 10 years or longer. Sandbags can last from 1 to 3+ years

depending on the strength of the material; ultraviolet-resistant bags are likely to survive the longest without splitting.

> *"[The nylon-mesh fabric is] much better than anything I bought . . . not going to rip as easily [as spunbonded row cover]"*
>
> —Grower testimonial

Storage and re-use of the tunnel fabric

The nylon-mesh fabric can get damaged by rodents and UV light if left unprotected during the winter. We recommend storing it in a dry and rodent-safe space, such as in barrels or hung from rafters in a shed. Alternatively, organic repellants like peppermint oil may deter rodents from nesting in the nets. Regardless of storage conditions, a few weeks before installation of mesotunnels, the nets should be unfolded, checked for holes larger than a quarter, and mended. Alternatively, mending can be done soon after mesotunnel establishment.

Insect pest and disease control

Scouting for insect pests and diseases is a key part of a successful integrated pest management (IPM) plan. Monitoring through the nets of a mesotunnel can be challenging, especially with dense-foliage crops like squash, which tends to form a tight canopy inside the tunnel within a few weeks after planting. When scouting, shading (for example, with a piece of cardboard) and squatting down help to improve the view of crops and pests inside the tunnel. Alternatively, scouting can be done by entering the tunnel.

FIGURE 6. ***Squash bees, bumble bees, honey bees, native bees and other pollinators can pollinate cucurbits.*** *Infographic: Lexi Gauger*

Mesotunnels will keep out many species of pest insects, but not the much smaller spores of disease-causing microbes. The most common diseases we found inside mesotunnels were Alternaria leaf spot, downy mildew, powdery mildew, and other minor leaf spots. Bacterial wilt and cucurbit yellow vine disease (CYVD) were generally avoided due to exclusion of the pest insects (cucumber beetles and squash bugs, respectively) that spread the bacteria that cause these diseases. Aphid outbreaks can occur when the nets keep out the aphids' natural enemies; however, a newer netting mesh size (marketed by Teknit as 85-gram weight) can keep out some aphid species. In addition, natural enemies of aphids, such as lacewings, can be introduced under the nets to keep the aphid numbers down.

There is no need to remove mesotunnel nets to apply pesticide sprays, as the sprays pass easily through the mesh. If you anticipate rodent issues on your farm, it's a good idea to place traps around your

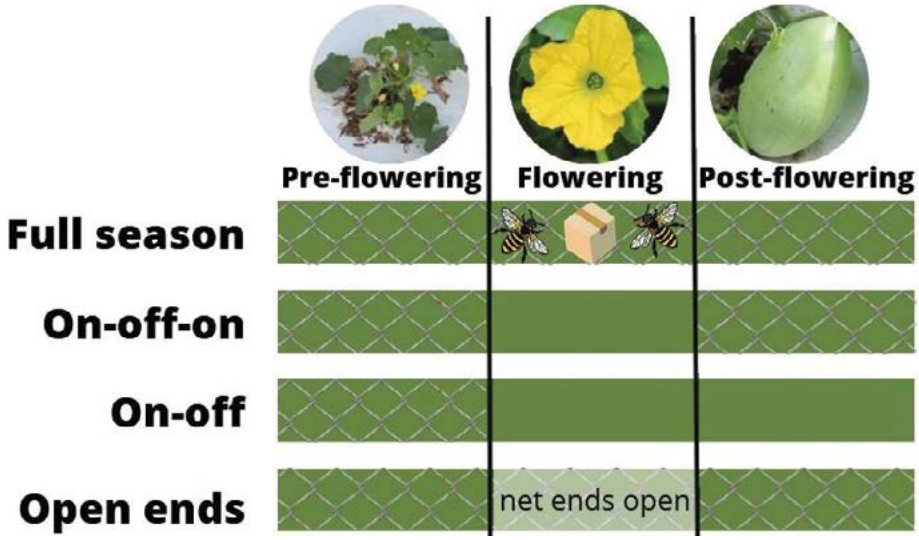

FIGURE 7. ***Schematic of mesotunnel pollination treatments showing sequence of opening and closing the tunnels.*** *Infographic: Lexi Gauger*

mesotunnels, beginning at least 2 weeks before harvest starts, to avoid chewing damage to the nets and fruit.

Pollination

Most cucurbit crops require insects (usually bees) for pollination. Bumble bees and squash bees are the most effective pollinators for these crops (**FIGURE 6**). When using a row cover like mesotunnels, ensuring good pollination during bloom is key for a successful crop. We've tried four alternative strategies to ensure pollination in mesotunnels: on-off-on, open ends, on-off, and full-season coverage (**FIGURE 7**). The **on-off-on** strategy relies on pollinators that already inhabit the farm. It involves uncovering the tunnels when female flowers appear, followed by re-covering 2 to 3 weeks later. The **open ends** strategy means that only the ends of the tunnels are opened when the female flowers appear, and the ends are re-covered 2 to 3 weeks later. We have used fishing line or large binder clips to hold the ends open. As with the on-off-on strategy, the farm's natural pollinator population is relied upon. The **on-off** strategy is like the on-off-on strategy except that the tunnels remain uncovered once the nets are removed at bloom. This strategy may be useful in situations where the tunnels are then moved to protect another crop in the same growing season, or where there is concern about trapping pest insects inside nets once they are replaced. The **full-season** strategy keeps the tunnels closed all season until harvest. Pollination services are provided by a commercial bumble bee hive (available from Koppert, BioBest, or other suppliers) placed in the center of the tunnel when female flowers start to appear. Place the box on a cinder block or similar item to keep it off the ground, and cover the box with an upside-down plastic laundry basket or similar item to prevent water damage and overheating of the bees. You can either leave the hives in the tunnel all season or remove them after flowering and reuse them in another crop field.

Alternatively, growing cucurbit varieties (mainly cucumber) that are marketed as "parthenocarpic" (meaning that they don't need pollination) could avoid the need for the introduction of purchased bees.

Weed management

Managing weeds in the furrows between plastic-mulched beds requires careful planning. In the on-off-on, on-off, and open-ends pollination strategies, weed management can be done when covers are removed temporarily to allow for pollination. However, in full-season mesotunnels a season-long mulch (living mulch, crop debris, or landscape fabric) that covers the ground and suppresses weeds is preferable. We have tested three different weed management strategies on university farms and commercial organic farms.

- **LANDSCAPE FABRIC.** Using landscape fabric to cover the soil alleys between the plastic-mulched crop rows provided nearly 100% weed control. However landscape fabric is laborious to install, remove, and reuse in later growing seasons, and it can be costly to replace every year. Also, staples are needed to hold down the landscape fabric, and if some of the staples remain in the field after cleanup, they can cause problems for mower blades and tractor tires. Furthermore, after the landscape fabric is removed, the ground is left bare, vulnerable to erosion, and with no added organic matter.

FIGURE 8. ***Mowing teff on an acorn squash plot, Ames, Iowa.***
Photo: Jose Gonzalez

- **LIVING MULCHES.** Sowing cover crops in the furrows between planting rows can effectively control weeds if the living mulch seed is sown adequately and soil moisture is favorable for germination and establishment. A living mulch can enrich the soil with organic matter, potentially improving soil health, suppressing weed growth, and eventually reducing weed seed bank. We used teff (*Eragrostis tef*), a drought-tolerant grass from Africa, in our Iowa and Kentucky field experiments, but other living mulch options include red clover, white clover, buckwheat, and ryegrass. We advise checking with an extension adviser for local recommendations.

- **MOWING TEFF.** In Iowa trials, teff provided effective weed control in moist years but in dry years its massive root system competed with the crop and created a yield drag. However, mowing the teff (**FIGURE 8**) minimized or eliminated this yield drag. The timing of mowing is important. In Iowa, we had the best results by seeding the teff at the same time as transplanting the crop and mowing about 3 weeks later when the nets were removed for pollination. A mowing height of 2 to 4 inches above ground level is recommended. A flail mower attachment on a BCS walk-behind tractor does a good job; a rotary-type lawn mower didn't perform well on teff. When using a flail mower in the full-season pollination treatment, the nets can either be removed briefly or left in place. *NOTE: if you uncover the full season tunnels briefly while mowing, bumblebee boxes should be closed at dusk the previous night to ensure the bees are back in their box and you don't lose them, then re-opened once the covers are replaced.*

- **MOWING-ONLY APPROACH.** Another option is to not plant a living mulch and just let weeds grow in the furrows between crop rows. In this low-cost option, growers could decide to mow the weeds at some point—for example, when female flowers appear in the crop and before vines run into the alleys—to achieve adequate weed control but avoid a yield penalty. It is important to mow weeds

Glossary

- **Mesotunnel:** A temporary tunnel constructed of nylon-mesh fabric over 3.5-ft-tall hoops, used to exclude pest insects and the disease-causing bacteria they carry.
- **Nylon-mesh fabric:** Porous screen-like fabric, of varying mesh sizes, used as a barrier to exclude certain insect pests from crop plants.
- **Spunbond polypropylene:** A type of plastic, created by bonding spun filaments of fibers to create a uniform web of material, used for season extension and pest-insect management in certain specialty crops.
- **Sandbag:** A plastic bag filled with sand or rocks, used for securing mesotunnel fabric to the ground.
- **Living mulch:** A cover crop interplanted with a main crop, used to suppress weeds, protect soil from water and wind erosion, and enhance soil quality through addition of organic matter.
- **Caterpillar tunnel:** A temporary tunnel for season extension of vegetable crops, usually covered with impermeable polyethylene.

before they produce any seed in order to avoid enriching the weed seed bank in the soil.

Performance of mesotunnels in organic cucurbit production

For region-specific advice, growers should consult with the extension leaders listed for each state in the project (starred in the author list below) to learn which strategies are best suited for their own region and cucurbit crop selection.

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