

CUCURBIT GROWERS' PERCEPTIONS OF MESOTUNNEL PRODUCTION SYSTEMS

GROWER INTERVIEW DATA 2020 TECHNICAL REPORT

By Dr. Lois Wright Morton, Ph.D. Rural Sociology;
Nieyan Cheng, Ph.D. Student Economics
Kaitlin Diggins, George Washington Carver Scholar, Environmental Science & Horticulture
With special assist from Jose Gonzalez-Acuna, OREI Project Coordinator
Iowa State University, Ames Iowa

Resilient Systems for Sustainable Management of Cucurbit Crops. Award number 2019-51300-30248. USDA Organic Agriculture Research & Extension Initiative (OREI).

ORGANIC CUCURBIT MESOTUNNEL PRODUCTION TECHNOLOGIES

The cucurbit family has over 900 species, including cucumber, squash, melon, pumpkins, and gourds. Pumpkins and squash are significant income sources for specialty crop growers in the United States (U.S.). These two cucurbits make up 18% of the top 10 vegetables being marketed in the U.S., according to the United States Department of Agriculture (USDA) 2020 National Retail Special Crop report (USDA 2020).

Consumer demand for fresh, locally grown organic produce, including cucurbits, is rising. However, cucurbit growers in the eastern U.S. struggle to capitalize on this opportunity because of severe damage caused by pests and disease complexes.¹ These pest and disease complexes collectively cost growers more than \$100 million per year. The most critical threats include cucumber beetles, squash bugs, squash vine borer, bacterial wilt, cucurbit yellow vine disease, and powdery and downy mildews. Organic pesticides often fail to stop these insects and diseases and may harm pollinators. The organic options for these pathogens are quite limited. Alternative management options for the pest/disease complex on cucurbits – perimeter trap crops, late planting, crop rotation, biochemical lures, and plant resistance activators– often fail to provide adequate control.

Organic cucurbit growers lose income not only from pest and disease damage but also when they miss key marketing opportunities. Inconsistent yield and quality threaten producer-to-consumer distribution. Row tunnels provide a promising solution for managing major pests and pathogens of cucurbits and are highly amenable to integrating biologicals for further pathogen control. Row tunnels are structures deployed

¹ Resilient Systems for Sustainable Management of Cucurbit Crops, 2019 Project Narrative. Dr. Mark Gleason, Project Director. Award number 2019-51300-30248. USDA Organic Agriculture Research & Extension Initiative (OREI). Iowa State University, University of Kentucky, and Cornell University.

above the crop that protect against pest insects, the pathogens they carry, and weather extremes (heavy rain, hail, and wind) while increasing profitable early-season harvests.

In this three-year USDA organic agriculture project, three universities (University of Kentucky, Iowa State University, and Cornell University) and cucurbit growers from three distinct geographic growing regions (New York, Iowa, and Kentucky) are collaborating in experimental field trials to scale up mesotunnel production systems. The goal is to develop commercial-scale systems utilizing mesotunnel and other biological strategies to control major cucurbit insects and diseases. Mesotunnels (Figure 1 below) deploy a tough, breathable, light-permeable, nylon-mesh fabric covering 3 to 5 ft support hoops. This fabric acts as a season-long barrier to keep out cucumber beetles, squash bugs, and squash vine borers and limit the diseases they spread.



Figure 1: Mesotunnel production system with nylon-mesh netting to exclude insects in an experimental field trial.

In Year 1 of the project (2020), project grower-collaborators, in partnership with the university project team, constructed on-farm mesotunnels using various technologies. Throughout the growing season, each grower monitored their production system, collected harvest data, and participated in one-on-one interviews about their 2020

experiences, observations, and preliminary assessments of the mesotunnel production system. This technical report summarizes project growers' self-reported 2020 experiences and perceptions.

GROWER INTERVIEWS

The project's social and economic aspects are intended to accelerate stakeholder-scientist collaboration and knowledge exchanges to produce useable science and technologies for cucurbit growers. This collaborative effort among grower cooperators and the science and extension team utilizes grower interviews as feed-back in the experimental development of organic production systems. These interviews are an opportunity for growers to share their views on mesotunnel production systems and their potential to reduce pest/disease complex threats to cucurbit production while being profitable.

Grower interviews will be conducted at season end in each of the three years of the project. Their purpose is four-fold:

- 1. Multi-directional feedback loops among growers, cooperators, and the horticultural research team.* This exchange encompasses research questions asked, hypotheses proposed and tested, field trial design, modifications and innovations, and commercial scale-up implications.
- 2. Improve social science understanding of how growers make decisions to adopt (or not) new technologies* such as mesotunnels and ways they modify and reinvent technologies to meet their unique situations.
- 3. Develop Extension and outreach processes and content for other cucurbit growers,* thereby extending what the project science team and grower cooperators learned in their experimental trials to other growers.
- 4. Media information for non-growers.* Increase public awareness of the complexity of food systems, what it takes to produce high yields and excellent quality cucurbit vegetables, and the costs involved in producing different types of cucurbits.

METHODOLOGY

To obtain information about project cucurbit growers' perceptions about the mesotunnel production system, individual interviews with growers at the end of the 2020 growing season were conducted through an online Zoom meeting in November 2020 with Institutional Review Board (IRB) approval through Iowa State University. Seven grower cooperators from Iowa, Kentucky, and New York were recorded in eight open-ended interviews, including one mid-of-season interview, one end-of-season interview, and six

end-of-season interviews that encompassed mid-season production activities. Interviews generally lasted from 30 minutes to one hour. The interview's contents primarily focused on the growers' experience, including disease, pests, the effectiveness of mesotunnels, plant growth and health, and weather conditions (see Appendix A for interview questions). The questions about the mesotunnel asked growers to describe the production process, including mesotunnel installation process, specifically hoops heights, single row or multiple row crops inside the tunnel, construction time, labor and materials; transplanting, pollination, and netting removal and putting back timing. The interviews also asked questions of the post-season observations such as crop yields, market price, and grower thoughts about this year's success and challenges.

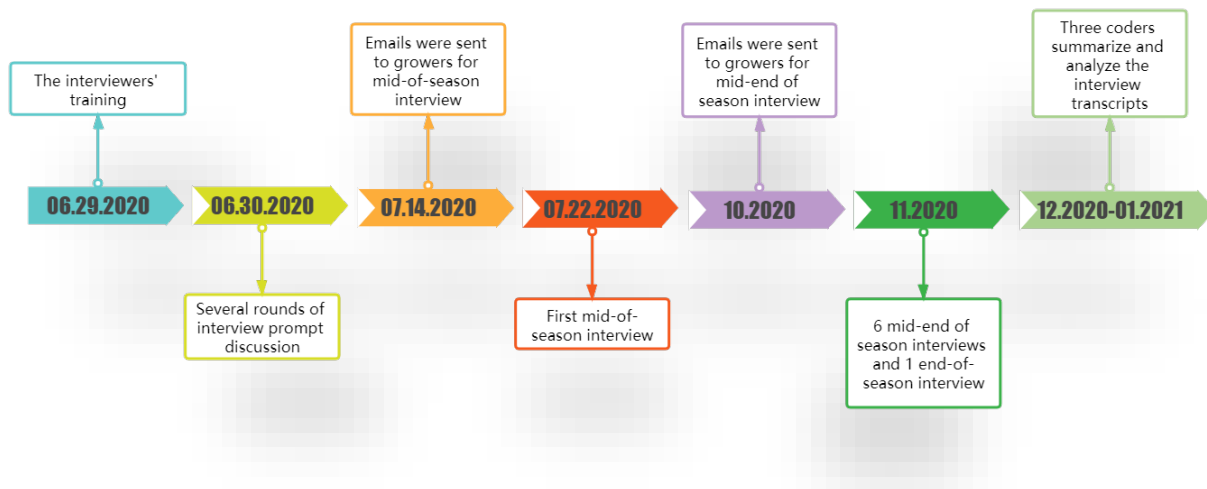


Figure 2: Human subjects Institutional Review Board (IRB) approved methodology and protocols; and 2020 interview timeline.

The Iowa State University Institutional Review Board (IRB) granted the research protocol exempt status because it was assessed to be low-risk to participants. Figure 2 above delineates the 2020 process and interview timeline. The interview instrument and question prompts were discussed and modified by the OREI project team from June to July 2020, and the interviewers were trained before interviewing the growers. The grower was interviewed alone online through Zoom software by two interviewers, including the project coordinator and one graduate student. Several rounds of emails for nine growers were sent to ask the growers the most convenient time, and seven growers responded. Originally, mid-of-season and end-of-season interviews were arranged. However, because mid-July is the busy time for the growers, the team decided to remove the mid-of-season interview and combined the questions into the end-of-season interview. In the end, only one grower was interviewed for the mid-of-season questions in mid-July. In November 2020, the team conducted seven interviews. The grower who participated in

the mid-of-season interview and responded to the end-of-season questions was not able to complete their trials, so these data are not included in this report.

Interviews were digitally recorded, transcribed verbatim, coded, and analyzed by three coders. Transcripts were summarized and aggregated by themes and responses to the questions. All names of growers were removed, and each was assigned a case number to preserve the anonymity of the respondents.

ON-FARM TRIAL LOCATIONS & GROWER CHARACTERISTICS



Figure 3: Locations of project grower cooperators farms.

The on-farm trials were located in upstate New York, Kentucky, and Iowa (Figure 3). In New York, there were two farms total, one near Rochester, NY, south of Lake Ontario, and the second in eastern NY near Albany. The Iowa trials were positioned around the Ames and Cedar Rapids areas. There was only one Kentucky participant, and this farm was situated outside of Lexington. The ratio of males to females was four to two. The grower age range was 30-50 years, with an outlier on each side of that age span.



Figure 4: Mesotunnel with one net covering three rows.

Each grower had a different plot size, ranging from about 50 linear feet to more than 900 linear feet, and varied in mesotunnel arrangement with one net covering multiple (Figure 4) or single rows. The average hoop height was slightly over three feet, with a minimum of two and a half feet and a maximum of about four feet high (Table 1). Variable hoop height was caused by the depth each hoop was pushed into the ground. Hoops deeper in the earth reduced instability or movement of the mesotunnel, especially on plots exposed to high winds or animal pressure.

Table 1: Descriptive statistics on plot size, number of rows under one net and average height of the tunnel at grower-collaborators' on-farm trials.

<u>area/linear ft</u>	<u>arrangement</u>	<u>height of tunnel</u>
50 linear ft	multiple	3 ft
90 linear ft	single row	3 ft
240 linear ft	single	2.5 ft
900 linear ft	multiple	4 ft
1000 sq ft	single row	4 ft
2000 sq ft	multiple	3-4 ft

Four of the six growers had previous experience using a technology similar to a mesotunnel such as high tunnels, low tunnels, or a row cover. One grower elaborated on past experience, “but as far as, you know, setting up the hoops, it’s comparable to setting up low tunnels” (002). This exposure lessened the learning curve with mesotunnel technology for several of the growers,

“We’ve done this before. Tunnels are not new to us...You have to anchor the hoops to each other with what is called a ridge pole. So, you have all the hoops in the ground, and then you have a piece of conduit or some kind of a board... You tie the tops of the hoops together so they can’t go left or right...” (001).

Insight into how to properly secure the mesotunnels proved useful for 001, who reported having no hoop instability issues through the entire growing season.

All of the growers grew at least one variety of winter squash, and one grower (007) raised watermelon in addition to the squash. The winter squash varieties consisted of Honey Bear, Table Ace, Delicata, Honey Nut, Spaghetti, and Butterscotch. The watermelon variety planted by one grower (007) was called Petite Yellow. Five out of six growers positively commented on their satisfaction with the overall quality of these crops, and the other grower (001) did not comment.

“Quality overall was quite good. They [Feed Iowa First] seemed very happy with the quality as well...” (003).

Three out of the six growers noted that the new varieties they grew in the mesotunnel were smaller than others. However, only two of these three growers recognized the potential consumer preferences for smaller fruits.

“I’m getting a fairly good price for the watermelon probably because they are small, and I charge a premium for that. So, I’m getting over \$1 a pound” (007).

The micro-climates and Hardiness Zone (Figure 5) varied for the trial farmers and influenced their production practices and harvest outcomes. Cooperators reported on conditions observed from planting to harvest in each location. The interviews with these growers indicated that drought was present for the entirety for all growers during this growing season.

“We’ve never had a drought like this in my time here” (001) was a comment made by a farmer who had been active in production for just short of fifty years. The grower added, “...our crops did pretty well [this year], but the management of that drought physically and psychologically was very, very difficult...”

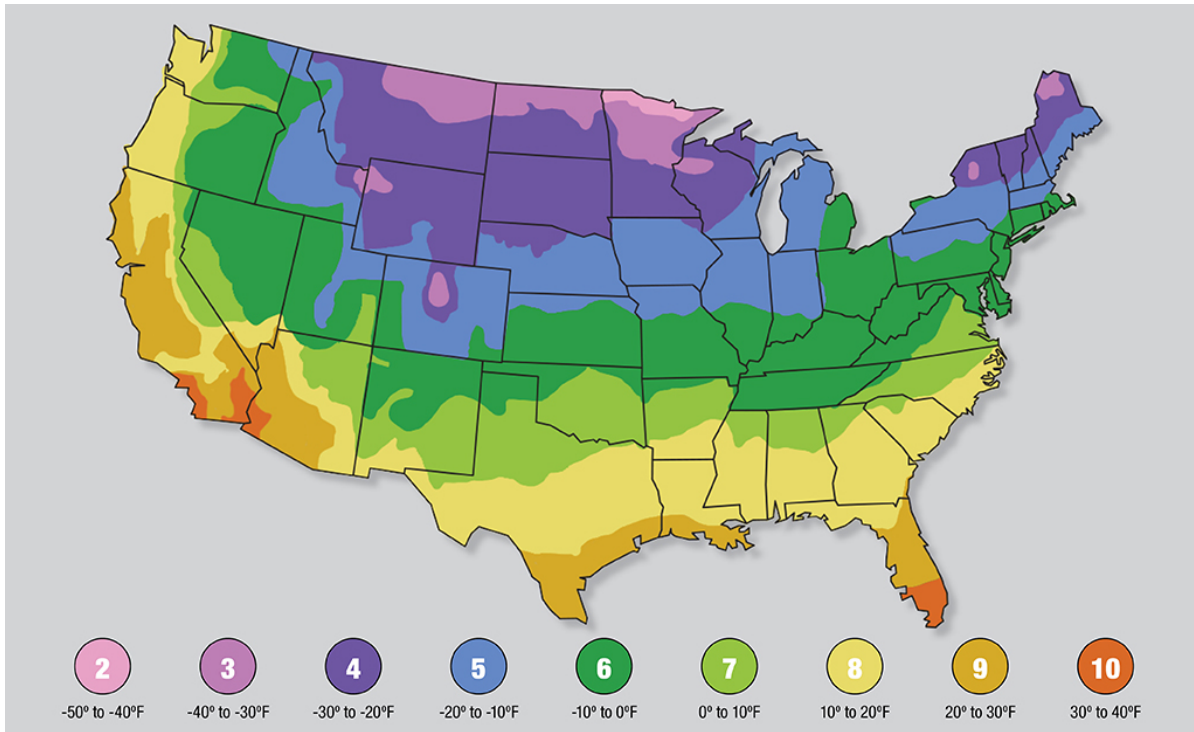


Figure 5: US Hardiness Zone map depicting climate and season differences among growers' locations.

Another grower mentioned, "...Water was a constraint for us... There were drought conditions in the middle of summer, so I was [hand] watering on a weekly basis" (003). Water as a constraining factor caused ongoing issues for 003. However, the inability to properly install the mesotunnel hoops until a significant rain occurred was a unique complication because the ground was hard. This setback caused the installation process to extend further into the season and required additional labor to reposition the mesotunnel.

On August 10, all three Iowa growers experienced the impacts of a derecho (figure 6). This derecho had straight-line winds with speeds up to 140 miles per hour and moved from west to east across much of the Midwest. These winds caused a string of repercussions, ranging from crop damage to pollination and trial management challenges.

Most of the grower feedback concerned the netting of the mesotunnel. One grower said, "We had some issues...When we had that derecho storm, the Pro Tek got blown off" (006).



Figure 6: Aftermath of the 2020 August 10 derecho in an Iowa cucurbit plot.

On-farm trial implications included grower 003, who said,

“...I left my crops uncovered [after pollination], and Ajay [university horticulturalist] was going to visit me, and we were going to recover everything and get everything closed back up, but that was when the derecho hit...Everything was flopped over and blown from west to east” (003).

Another grower commented,

“I did find I was somewhat disappointed with the yield this year with watermelon, and it’s not surprising because that planting did go through the derecho, so that was pretty significant stress on the plant. The vines were blown around quite a bit and also damaged by the wind and rain, so they had to recover from that” (007).

However, direct damage occurred that growers attributed to the winds and rain, but plant health and fruit degradation dipped also, causing another slew of problems.

“The thing is, there was a decent amount of sunscald [on the acorn squash] because of the exposure of the fruit with the moving of the canopy” (003).

The derecho also impacted spraying regimes and pest control for grower 003, who stated,

“...The two things I wanted to spray for were the squash bugs and the powdery mildew because the squash bugs were present in early August, but the derecho negated - it just didn't make sense” (003).

And finally, direct damage to fruits was a source of yield decline.

“There was a lot more variation in size, you know, compared to last year, and there was more damage. More fruit that was rotting or damaged so...and when I looked at them after the storm...I trust that plants can recover from things, but it was still hard” (007).

MESOTUNNEL PRODUCTION SYSTEM



Figure 7: Growers reported plants under the mesotunnel were vigorous with healthy leaves and good color prior to the pollination period. Control row in picture foreground.

Most of the growers were familiar with some type of row covers. Some used them as early-season extenders, and other growers had used row covers in caterpillar and high tunnels. Many sowed only a single row under the mesotunnel, and one grower (007) thought multi-row under the mesotunnel would help scale up the production system.

One grower described well the process of setting up the mesotunnel system:

“...there's two phases to this [using a mesotunnel production system], one is the soil phase, and one is a tunnel phase. So, we'd had all the soil stuff done...the

plastic and the ground cover was all down, ... and we transplanted [the cucurbit plants] into it and then put the tunnel on top of it” (001).

“...we did the complete layout with where the plastic was going, where the irrigation tape was going, and where the ground cover strips [would be located]... We did all that with flags. We put down the compost- chicken manure. We use a rotor tiller, just a garden type rotor tiller, and work that chicken manure in [to the soil]” (001).

One grower (007) pointed out the advantage of the mesotunnel production system: 1) ability to front-load labor into the installation, 2) minimal weeding, 3) only irrigation until harvest, and 4) no spraying. The grower concluded this was a real advantage and indicated that the mesotunnel could add efficiency to the farm production system.

On the other hand, several growers commented that visual cues were missing for decision-making. They noted they could not tell what was happening inside the mesotunnel, so it was hard to decide whether and when to spray for pests and disease, whether pollination was happening, and when the crop was ready for harvest.

MESOTUNNEL INFRASTRUCTURE

There were several installation innovations/challenges. First time users and experienced row cover users in general thought the installation was relatively easy.

“...this is my only first time using it [the mesotunnel system], but it seemed to go pretty smooth” (006).



Figure 8: Mesotunnel installation process. Pushing the hoops into the ground and transplanting cucurbits into black plastic.

The hoops are the structure that holds up the net and requires bending ahead of time (figure 8). Several growers commented that ground compaction was a problem for some sites. It was hard to push the ends of the hoops in very deep, and once it rained, some growers had to go back and push the hoops in deeper to ensure stability,

“...the hoop shape is okay as long as the tunnel is wider... the most important thing is to have the mesotunnel be wide enough to allow the vines to run” (007).

“We had three or four of us, like two people on each side, trying to push those hoops in... a lot of them were quite unstable after planting. “ ...after a deep rain over three days the soil was “very moist and very soft and then I was able to go along and push those hoops in and secure them and then read tighten the Pro Tek net” (003).

“...soil compaction was the main issue as far as getting the hoops in place” (003).

Hoops were often unstable due to the inability to install them deep enough into the earth. One grower suggested a ridge pole between hoops would help, and another recommended criss-crossing the ends.

“...when you have a free-standing group [of hoops] ... There's no trouble. But as soon as you put the tension and weight of the mesh on the hoop it's unstable unless the legs of the hoop are in the ground, you know, more than a couple of inches.

Another grower recommended offsetting the hoops in side-by-side rows so it would be easier to mow and not get wheels caught in the hoop and net structure.

Sandbags. Most growers used sandbags to hold the net down (figure 9). Some growers reused bags from previous operations. Growers, in general, thought the sandbags worked well.

“I've used rock bags before, and I definitely prefer the sandbags (003).



Figure 9: Mesotunnel net secured with sandbags.

Net. Some growers compared Pro Tek to Agrabon and polyspun row covers and said they found the Pro Tek easier to manage in windy conditions. Further, it easily let in precipitation and sunshine and doesn't tear or rip like the polyspun covers, making it reusable in future seasons; however, it was much more expensive. One grower (007) sprayed a foliar spray through the mesotunnel net for additional nutrients. Other growers didn't have the net on when they sprayed because it was during the pollination period or post pollination. Grower observations:

"it's [Pro Tek] stronger than row covers [polyspun], so handling it on a installation-opening-closing basis is just more durable and stronger doesn't rip as easily. It's just tougher and easier to handle... has plenty of airflow, but yet it plenty of sunshine through it... there's no stretching or discoloration or sun burning" (005).

"None of the netting [Pro Tek] was like, caught in the windstorm or blew away because it was all kind of compressed on the ground" (003).

Wind management. The mesotunnel was in a "really windy location. So, we were very careful and set the netting up as tight as possible...so it wouldn't flap" (002).

"...the hardest thing for me was not being able to keep the netting on [after the derecho] ... when to make that decision to take it off... [then] making the decision not to put it back on [after the Derecho because the vines had filled out beyond the net and couldn't get it back on] . Now that was...that was difficult (007).

Varieties, transplant vs. direct seeding. While most growers used transplants (figure 10), one grower direct-seeded three varieties of squash. The grower didn't have 100% germination, so they went back and did a second seeding to fill in empty holes. All three varieties were under the mesotunnel. This staggered germination resulted in different flowering times for pollination inside the mesotunnel, which meant the grower had to leave the net off for an extended period of time. The grower concluded:

“it's best to have one planting date and one variety under the netting; I had three different varieties ...with two planting dates. Therefore, I didn't have a ... distinct pollination period to open up the tunnel. Therefore, my period that the tunnel is uncovered for pollination was way longer than it should have been” (005).



Figure 10: Grower transplanting cucurbits dipped in kaolin clay into the soil.

Another grower observed that it would be best to select a variety that would be ready for harvest all at once.

“[I] think it would ... be pretty much the crops that are just kind of a one-time harvest and then it's done... tomatoes or peppers are a plant that you're harvesting two or three times a week, you have to remove those tunnels [to harvest and put it back on]... [best to plant crops that you can] harvest the whole block at once” (006).

WEED MANAGEMENT

Primary weed management strategies consisted of crop transplants planted into the plastic. Inter-row weed management ranged from landscape fabric, shredded straw, pine mulch, or oats/annual ryegrass periodically mowed. Growers viewed landscape fabric as functional and labor-efficient, but they noted that the staples were time-consuming to install and remove. One grower was interested in trying living mulches, perhaps Teff or cover crops, to avoid the increased labor associated with ground plastic. Straw suppressed the bulk of the weed growth, but the rows were not weed-free. Some observations about the **landscape fabric** from growers:

Installing the landscape fabric was, "... a bit of a slow process with...spreading the fabric and making sure it's lined up and getting all of the landscape staples secured" (003).

The landscape fabric was "very effective in terms of...having a nice clean field and not having to worry about weed management the rest of the season" (003).

"...getting those staples out [was hard]. I'm sure we ended up with a few left in the soil [when we pulled the fabric at the end of the season] (003).

"the landscape fabric ...takes a lot of time to put down and take back up because we hold it down with landscaping staples. I'm really interested in going forward about trying to use a living mulch" (006).

"I crawled under there and into the tunnels, you know, which I did once every 10 days, something like that to check it out. I noticed that the honey bear plants had totally filled the whole we had made. And there was absolutely no weeds (001)"

"Honestly having to cut slits through the ground cloth is not very practical" (002).

One grower used newspapers around the slits in the plastic to manage weeds next to the transplant (001).

Reusability of ground fabric. "...long term use ... you want the ground cover [to] last as long as possible and as soon as you start poking holes in it [you've limited reusability next year] (002).

"straw marginally ...[held] down the worst weed growth, but it also resulted in a lot of voles coming through. So it's not something I would use again, but it certainly was better than bare soil" (007).

"planning to actually put the hoops through shredded straw instead of through the ground cover (002).

POLLINATION

Growers used three pollination strategies: 1) beehives inside the mesotunnel (figure 11), 2) native pollination with row cover off during flowering period, and 3) native pollination for their control group outside the mesotunnel. A fourth option used in university trials, open-ends of the mesotunnel during the flowering period (~two weeks), was not used by any of the grower cooperators.



Figure 11: Beehive placed inside the mesotunnel to ensure pollination of cucurbit crops.

Beehives inside. Three growers used beehive pollination inside the mesotunnel, and one controlled pollination with native bees in the squash field outside the mesotunnel. One grower was very disturbed that the bees were “trapped” inside the net and would rather move to a cucurbit crop that didn’t need pollination (i.e., parthenocarpic). Grower comments about using a beehive inside the mesotunnel:

“...had a place where I could lift up the end and crawl in. It's how I checked the bees. And so from time to time, I would do that. I just caught my head under it, and it was a jungle” (001)

“..squash beetles ..couldn't get in there. So we had bumblebees, but no squash beetles and I just don't think that the pollination was as good [as using native bees outside]” (002).

“.. as a grower and as a human being, I really did not like having these [bees] trapped in the mesotunnel. [it was] upsetting because they were... obviously very

unhappy. They spent [energy] just banging up against it (the net)... I really want to use this [mesotunnel] in places where I don't have to trap pollinators" (002).

Open net for native pollination. Three growers opened the tunnel net when the first female flower was observed. They took the entire net off to the side rather than opening the ends (figure 12). The timing of taking the net off for pollination was a little easier than deciding when to put it back on.

"We didn't open ends. We just pulled the cover... completely off." (005).

'Flowering was coming to an end, and I maybe should have put it back a little sooner. I'll admit that. But I kept I kept seeing a few more flowers along the vines. So I was hesitant [to put the net back on]... I didn't want to like negatively impact the yield." (003)



Figure 12: Mesotunnel with open ends to allow native pollinators inside.

"...opening and closing [the net] again and you don't know how many insects, you're trapping underneath the netting and creating a worse problem" (003).

EQUIPMENT

Equipment (sprayers/irrigation). Growers did not talk very much about their spray regime or irrigation system. Most growers irrigated the crop inside the mesotunnel, but they never irrigated the control field crop. One grower commented that their farm did not have spray equipment and did not spray their crops. Crop spray timing was uneven across growers; some commented that pest pressure was light this year, so they didn't

spray in the late season. Two growers mentioned using an IPM threshold. However, they did not spray, as it was not met.

PEST & DISEASE

Cucumber beetle pressure was low or non-existent in the 2020 season for most growers. Some growers mentioned aphid presence in a couple of fields. However, almost all growers talked about mildew-downy and powdery as major crop disease problems. Several growers perceived wind and precipitation affected mildew presence. One thought the mesotunnel would not protect cucurbits from mildew. Another grower mentioned the need to put ladybugs or other beneficials inside the tunnels to control the insects since some insects can hatch after the net is put in place and closed up.

Not all growers sprayed for pests. One grower that did spray thought the pesticide spray's effectiveness was moderate to marginal. By the time the pest pressure increased, the grower had realized it was too late, and it would not be effective. Another grower thought it was too late in the season to spray.

"...while I did see striped and spot and cucumber beetle. We never hit the threshold for a spray application as advised by the Midwest vegetable grower guide" [I]...did see striped and spotted cucumber beetles, but it was only like one per plant or one per every other plant. I think the threshold was five per plant for acorn squash. So there were no spray applications on this trial." (003).

"..squash bug pressure there were a lot of egg clusters, but I ended up using mechanical control [by hand] and just trying to remove clusters from the underside of the leaves" (003).

One grower noted that cucumber beetles and squash bugs had infested an open field on the opposite side of the farm. They didn't seem to move, so there was little to no pest pressure; thus, "...the mesotunnel didn't really provide any protection because the other planting was acting as a trap crop" (007).

"... I did start to see typical diseases of bacterial wilt and cucumber mosaic virus and things like that... after the mesotunnels were removed "at three weeks" (007).

"I think probably the biggest difference was last year. I was a little bit more regular about the spraying. I was regular and early, and I think this year I was not as on top of the of the pest issues. Squash bugs [are] easier to control in their next stage; and I feel that in 2019 I was able to do some effective spraying during the mid-stage and I sort of cut off the ... the growth cycle. And then this year ... I kind of missed that [mid-stage] and then I maybe even sprayed a week late and I just didn't see the same control" (007).

One grower had an outbreak of aphids inside the net and was concerned that the net kept out the beneficial insects as well as the pests, "There's no beneficial in

there to fight [pests]...[in addition to] releasing bees under the netting we might have to release some ladybugs or [some other beneficials]" (005).

One grower elaborated on potential beneficials that might be helpful inside the mesotunnel.

"Release nematodes through the drip tape or irrigation of the same crops. So we're protecting [the crops with]...the netting from outside [pests] but also releasing the nematodes and toads, we might be protecting any soil-borne insects from coming up underneath and getting [onto the crop] ...I'm not sure that they control them [pests], but I think they can control the larvae" (005).

PLANT GROWTH

Most of the growers thought the plants inside the net looked healthy early in the season and seemed to have adequate biomass. One grower (002) liked the Honey Bear variety because it is determinate, meaning the crop was ripe and could be harvested all at once (compared to indeterminate varieties, which bloom sequentially, and fruit ripens over a period of time). Some growers observed that plants under the mesotunnel seemed to grow bigger and lusher:

Early in the season, the mesotunnel seemed to have "a little bit of a protected culture kind of effects like what I see in the high tunnel where my crops ... look kind of more healthy and ... because they're not being subject to wind and as much direct sunlight. [I] did notice that a little bit in the tunnel that the growth was a little bit more lush... like greenhouse growth" (007).

Inside the mesotunnel,"... it seems like that there is in terms of the crop ... maybe there's just the right amount of shade but not too much but crops seem to ... grow even a little more vigorously than they do without a cover on at all" (005).

"...I thought it looked really good. Just one thing I did kind of notice, was it seemed under the Pro Tek netting the plant seem to grow bigger. They looked a little, I guess, happier to me" (006).

HARVEST

Most growers harvested all of their cucurbits simultaneously, both mesotunnel and open field, in one day. However, growers reported that not all fruits were ready for harvest, and some were still immature. One grower harvested over a two to four week period based on fruit maturity. This prolonged harvest and took more time and labor.

One grower estimated that after the net was removed “about 15% [fruit] was immature...[and]...25% fruit lost [was] due to sun scald” (003).

Growers commented on the net’s opacity, noting the inability to see if the fruit was ripe inside. Instead, they based their harvest decisions on the readiness of the open field fruit for maturity indication. “Honestly, I wasn't checking the ones (fruit maturity) inside [the net]. I couldn't see them” (002). Most growers thought their open field yields of squash were as productive and high quality as those grown in the mesotunnel. Only one grower commented that the mesotunnel seemed to increase the fruit quality (006). In Iowa, growers commented that yields were affected by the derecho on August 10th.



Figure 13: Acorn squash and yellow watermelon, two of the 2020 cucurbit varieties.

GROWER EXPERIENCE & SATISFACTION WITH MESOTUNNEL PRODUCTION SYSTEM

Experimental trials and control. Growers recognized the importance of having a control group concurrent with their experimental plot (figure 14). This control allowed them to compare two production systems (mesotunnel and open field) throughout the season. The growers control field was their current cucurbit production system with weed management and pollination based on “what I’ve been doing.”

Several growers recommended that a higher value crop like brassicas, peppers, eggplant, and Brussel sprouts would be profitable inside the mesotunnel. Some growers were concerned that the cost of the mesotunnel exceeded the prices they were getting for squash.



Figure 14: Mesotunnel production system side-by-side with open field control production system.

Uncertainties the growers expressed: 1) the cost of infrastructure for the cucurbit crop selected, 2) the need to use a fungicide and would a spray through the mesotunnel be effective? and 3) 2020 was a dry growing season with low weed pressure throughout the farm. Growers wondered what would happen in a wetter year? They expected weed management inside/around the tunnels could be problematic in wet years.

“I haven't seen the final data set that I don't know that there was enough of a yield difference that it would have justified the cost of installing the row covers and buying the materials. So that's, that's my speculation is it probably didn't pay off.” (003).

PROFITABILITY, MARKETS, LABOR, TIME, NET LONGEVITY

Labor/Time. Most of the growers perceived that the mesotunnel installation process was relatively easy and smooth if the soil was not compacted (003). The time to install the mesotunnel ranged from 2 hours to 16 hours if accounting for total person-hours.

This varied by plot size and prior experience. Mostly, growers reported that it took 3-4 persons working for 2-3 hours to install the mesotunnel (figure 15). Some growers only counted the hours for the hoop installation and putting the net on time (005), while others counted all the time, including preparation time, loading the materials, and travel to the field time (007). Other growers received help from the university staff and students, so accurate labor costs couldn't be estimated. Variations in hourly wage rates ranged from \$40 to \$90 and influenced grower perceptions of labor costs.



Figure 15: Growers installing conduit hoops for their mesotunnel production system.

“it was Dr. Ajay and one of his grad students [that] came down and did most of the setup work. We just draped the net over at the end” (006).

“...and the person with him [university personnel] ...did the installation of the hoops and the sensors and then they asked me and my coworker ... to help them with putting the netting over” (007).

“...three hours to do [put up the mesotunnel]. But that doesn't include like prep time or loading or going to the field and stuff because we were already doing other stuff on the same day. So, we just did it all at once” (005).

Net Longevity. Not all the growers mentioned the net's longevity, but the growers who did were impressed with the durability of the netting. Even in the Derecho storm, it wasn't ripped or damaged.

“...we had some wind, and it didn't damage the netting or like a blow anything away” (007).

“As long as it lasts as durable and last enough years it's way better to handle than the row cover... it's stronger than row covers so handling it on a installation opening closing basis it is just more durable and stronger, doesn't rip is easily. It's just tougher and easier to handle” (005).

Market/Price. Wholesale, retail, donation, and Community Supported Agriculture are the primary channels where the growers sell their products. Most of them were satisfied with the markets they sold in. However, one grower sold wholesale and had to transport the crop to a distant city. Another grower referenced the increased distribution system difficulty due to the COVID-19 pandemic. Several growers expressed satisfaction with their product price, but one grower commented that the price was too low to offset the high cost of mesotunnel if growing a low-value crop.

“...We're never satisfied with the prices we get.... We live in a community here in rural New York where good food is cheap food, and that's why we have to sell our food in New York City, which we hate to travel food like that” (001).

“...distribution methods and sales methods change on the fly, of all that has been pretty exhausting this year” (005).

Profitability. Most growers observed that the cost of the mesotunnel was expensive and that only growing high-value crops with high pest pressure like Brassicas would make the mesotunnel worth it (003). The materials for constructing the mesotunnel were paid for and provided by the research project. Thus, the growers didn't pay the cost and were uneasy about what it would cost them if they were to pay out-of-pocket. They were aware that the Pro Tek net is expensive. Several growers estimated that if the netting could be reused for three years or more, it would become profitable (005, 007). Only one grower thought the cost of the mesotunnel could be covered from one season sales (006).

“...winter squash isn't a benefit, but other cucurbits that have more [pest] pressure and more damage per actual fruit like cucumbers [could benefit from being grown in a mesotunnel...]” (002).

“...because those are higher-value crops as well....[could] potentially pay for the mesotunnels netting more quickly” (007).

“If I can use the mesotunnel over three years, there's definitely a benefit. If it's an annual, then I would have to say, no” (005).

Overall, the growers didn't think the cost of mesotunnels could be paid off quickly, but they thought there was potential in the long term. The primary cost comes from the

netting. If the nylon-mesh is quite durable and isn't ripped even in a derecho, it might be reused for many years, which would lower the average annual cost. On the other hand, the growers thought if high-value crops with high pest pressure like Brassicas (figure 16) were grown under a mesotunnel, the cost for pesticide spray could be saved, and a higher market price could be charged for quality fruit. Thus, the net cost could be recovered more quickly.

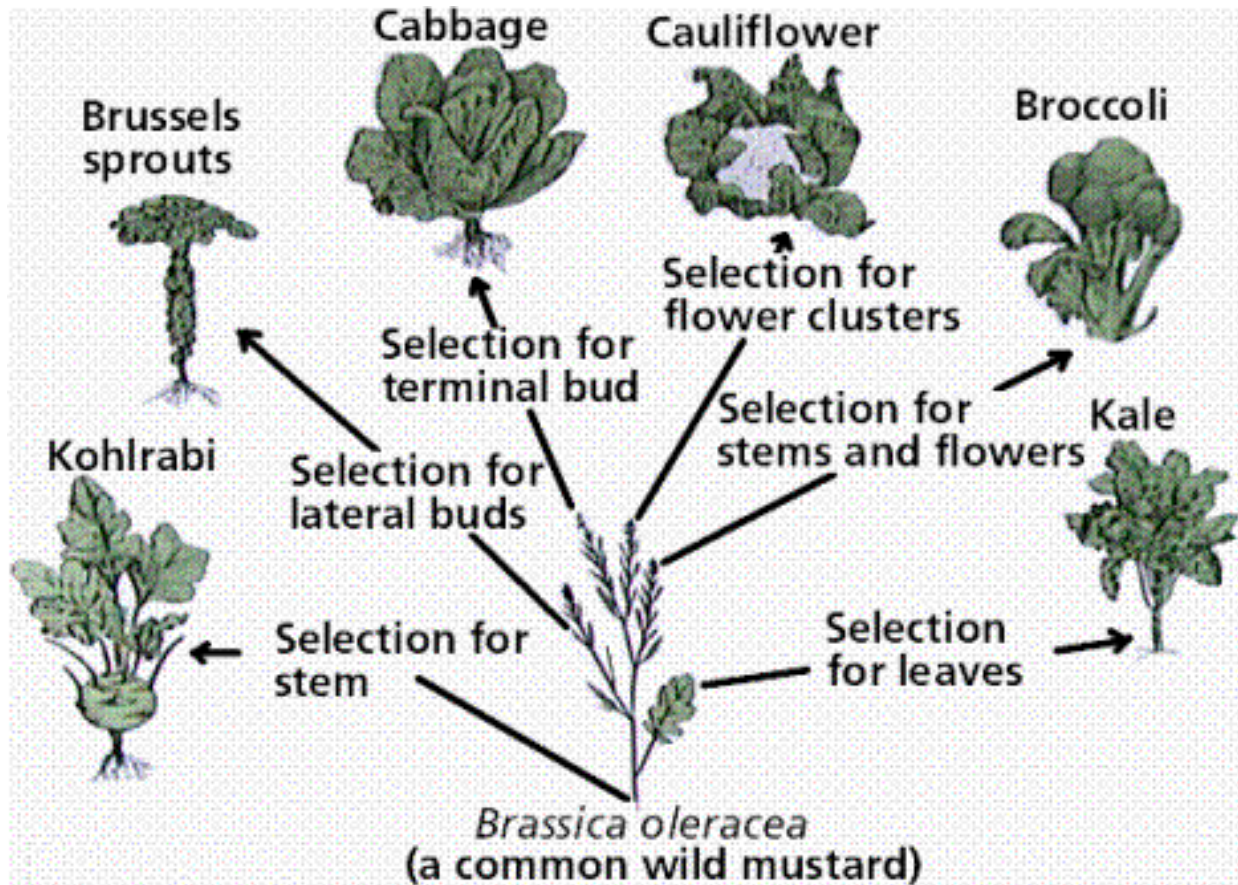


Figure 16: Examples of Brassica crops used for food.

INFORMATION & INFLUENCERS

Growers named several advisors and trusted information sources. One of the primary information sources was their university horticulturalists, who give good advice. Growers noted they are highly responsive to email and texts when they have specific questions, and they are trusted sources of research findings. Practical Farmers of Iowa and other growers were additional sources of useful and trusted growing information.

Growers obtain information from many sources ranging from print, Facebook, Instagram, e-mail, telephone, and direct outreach from peers and university horticulture faculty/staff. Growers tended to have specific questions they want answers to and often reported using a search engine on the Internet. They didn't think they had the patience to watch videos, podcasts, or webinars, as these methods can be time-consuming and challenging to navigate. They perceived that University websites were particularly useful. Different universities specialize in different crops, and they liked the capacity to print off university fact sheets with the click of a button.

"I tend to be someone that needs to hold it in their hands and read things. It's a better way for my brain to connect with the information than listening to it or, or, you know, fancy charts. I am I'm interested in seeing the results" (001).

"[I] prefer websites. I like to be able to scan and pull the information that I need quickly..." don't like videos and podcasts, "I do not have the patience" to watch them (002).

"I'll be honest. Not very often [don't use university blogs, podcast, vides or webinars to get information], I'll call or text [the university horticulturalist] "(006).

"[I'm] not a huge user of videos and webinars and podcasts. I'm more of a fact sheets or farm reports or vegetable production guide. So I think I'm more of a I prefer to read answers than watch videos and webinars, perhaps because you can just like hone in on the answer versus having to like watch a whole video so I'm maybe not patient enough to watch (003).

University and other websites are used to find relevant answers "...to whatever I'm searching. So I utilize a lot of them on as needed basis...so I don't just kind of regularly peruse them. It's when I'm searching for something specific" (005).

"I usually try to find some type of university replicated trial or research. I feel better trying something if it's been University vetted somewhere... some of the most time I spend is new organic certified OMRI listed pesticides come out... I look for university FTC trials" (005).

"[I] find value ...[in] seeing what other growers were doing" (007).

"...my preferred method is that I do Internet searches and then I look at multiple resources and sort of compare them and try to see if there's a consensus ... If not, I will ask specific questions to people either on the PFA listserv or to growers. I know I'll text or email them or call them to actually ask specific questions" (007).

Project communication. All growers expressed satisfaction with the project; and really liked the project updates and opportunity to learn from other growers.

“[I] really appreciated the last meeting where you provided the project update for the research farm trials, it was really insightful. So, I think communication and support has been really clear up until this point, so I was really grateful for all of that.” (003).

“The one meeting, I was able to attend in July with the entire group.... I was interested in some of the other setups, which included the landscape fabric between the plastic mulch and then doing multi mesotunnels tunnels. I recall writing down that in my notes because I thought that that looked like a better, superior setup” (007).

“I'm excited to try this [on-farm cucurbit trials] again next year with some modifications. I really would like to see if we can do something that improves on last year” (007).

REFERENCES

USDA National Retail Report Specialty Crops Vol XIV-No 42 October 16, 2020

APPENDIX A: CUCURBIT GROWER COOPERATIVE INTERVIEW QUESTIONS



Cornell University

**USDA-OREI: Resilient Systems for Sustainable Management of Cucurbit Crops
(2020-2022) Award number 2019-51300-30248;**

FORM B. Interview with Cooperators in On-Farm Trials

Interviews with cooperators in on-farm trials, conducted by the social science team via Zoom, are recorded, transcribed, and stored in a secure location at Iowa State University. This interview should last about 45 minutes. Questions focus on this season's experiences, including disease, pests, effectiveness of mesotunnels, plant growth and health, and weather conditions; harvest and crop yields; and post-season observations.

ID NUMBER of the field trial experiment _____ **Cucurbit crop(s)** _____

Date of interview _____ **Name of Interviewer** _____

Q1. What cucurbit crops did you grow under mesotunnel row covers this year?

- a. How many linear feet (or acres) did you plant of this cucurbit crop?
- b. What percent were grown in the mesotunnel?
- c. Overall, how do you think your crops did in the mesotunnels?

Q2. Let's talk about your mesotunnel.

- a. When did you construct the mesotunnel? [Date]
Were the mesotunnels set up when transplanting occurred? If not, indicate when.
- b. Was the nylon-mesh netting supported by hoops? If so, how tall were the hoops?
- c. Was the mesotunnel plot set up as single rows, or in a multiple-row arrangement covered by single pieces of the netting?
- d. How was pollination of the mesotunnel-covered plot ensured?
- e. Was the nylon-mesh netting removed to allow pollination to occur? If so, how long was the netting removed until it was placed back over the hoops?
- f. Was the netting removed immediately before harvest began, or at some other time?
- g. How did the installation process go? [how many people did you need to build it? How long did it take?]
- h. What do you estimate was the cost of installing the mesotunnel? Time. Materials. Labor.
- i. What did you like about the process and what would you do differently next time?
- j. To what extent did you see any animal, or weather damage to the mesotunnel or the crop? If so, what did it look like and what did you do? What repairs or modifications were needed?

Q3. How did the crop look throughout the season? In what ways do you think the mesotunnel affected plant growth and development?

Q4. What kind of insect damage and disease pressure did you see this season? How do you think the mesotunnel affected insect and disease problems?

Q5. What kind of weed management did you use with your mesotunnel? How well did it work?

Q6. What biological controls and other OMRI-approved products did you use? How well did they work this season?

Q7. To what extent do you think the mesotunnel affected your crop harvest date? Earlier than usual? Delayed? Why?

Harvest and post-harvest observations

Q8. When did you begin your cucurbit harvest? [Approximate date]
Are you still harvesting? [if no, when did you finish harvest?]

Q9. What were your crop yields? _____ (per plant/per acre/per foot/)
If you raised this crop before, how did this year's yields compare to past years?

Q10. How satisfied are with your crop yields? Product quality? Market prices you're getting?

Q11. What do you consider your greatest management success this year?

Q12. What has been the most difficult management challenge this year?

Q13. For what other crops do you think mesotunnel/protection row covers and nets could be a useful management tool?

Q14. Based on the cost (time, labor, materials, etc.) of the mesotunnel, do you think there was a payoff this season in having your crop protected under nets?

Q15. What other information would you like the project scientists to know about your field trial?

Q16. Are there resources or additional support you'd like from the project science team?

Q17. How often do you visit university-related websites, blog posts, podcasts, videos, or webinars to get information that could be useful for crops management? If so, what is your preferred source of information?

Thanks for your time! If you think of additional information you'd like us to know, please drop us an email (see email address list at bottom of the page).