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Improving and Testing Methods of Securing Row Cover for Organic Cucurbit Production

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ABSTRACT. ***Cucumber beetles feed on leaves of cucurbit crops (i.e. squash and cucumbers) and can transmit bacterial wilt disease, stunt plant growth, and reduce fruit marketability. Several pesticides are available to deter pests, but options are limited for organic growers. As an alternative, row covers can be used to physically block insects contact with the plants. Comparisons between different methods of utilizing row covers to test their effectiveness are limited. Experiments were designed to compare methods of perimeter sealing, material anchoring, and structural support. The success of perimeter sealing was judged by the number of insects found under row covers. The anchoring and structure trials tested the duration of success and damage caused to the covers by each method.***

The perimeter experiment indicated that sandbags at 5-ft intervals was the least effective and burying the cover edges was the most effective method with 79% confidence in statistical difference (Pr > F of .21) at flowering and 75% confidence (Pr > F of .25) over 15 weeks of entire trial. While each method provided different levels of protection, most treatments kept beetle populations under integrated pest management thresholds. The anchoring trial showed that both burying and rock bags were very effective and indicated promising results for PVC clips. In the structure trial, conduit hoops did not damage the material or allow it to sag.

Keywords. Disease, horticulture, insects, perimeter, squash, structure

Introduction

Both striped and spotted cucumber beetles feed on leaves of cucurbits (i.e. squash, melons, and cucumbers). The largest problem with this pest is that it is a vector for the bacterial wilt disease (Erwina tracheiphila). Beetles can also cause considerable feeding damage to the plants, which can stunt plant growth as well as reduce the marketability of the fruit. A number of pesticides are available to combat this pest, but options are limited for organic growers. As an alternative, row covers can be used to act as a physical barrier between the plants and the insects.

Existing cover systems add significant expense (Hanna et al., 2016). Questions include which material, supporting structure, and methods of anchoring the row covers are best. One solution is a semi-mechanized hoop tunnel layer that inserts wire low tunnels and subsequently covers them with spunbond polypropylene row cover (Agribon) and buries the edges. This method is limited by its ability to only cover single rows. This system does not allow adequate room for the covered plants to spread out and grow, meaning that the row covers need to be removed early in the growing season. Early removal of the row covers leaves young plants vulnerable to predation from cucumber beetles. This issue has resulted in a shift towards meso-tunnels, which support the cover approximately three feet above the soil surface. Keeping row covers on longer, using a meso-tunnel method, into the growing season significantly increases marketable fruit production and weight (Nelson and Gleason, 2017).

Although meso-tunnels are more effective than low tunnels (Nelson and Gleason, 2017), there is still uncertainty in how to efficiently and economically create the tunnels. Various methods of anchoring row cover fabric and support structures have been utilized, but they have not been directly compared with one-another.

Three experiments were carried out to determine the effectiveness of row cover support and sealing methods. The first experiment compared the effectiveness of different perimeter sealing methods to block cucumber beetles from crawling under the row cover. The second evaluated the difficulty and practicality of various methods of anchoring row cover as well as observing row cover fabric wear due to anchoring. The third trial assessed the effectiveness and practicality of several structures to support the row cover and suspend it above the plants. These trials helped determine the best practices for utilizing row covers.

Methods and Materials

Two different materials were investigated as possible row covers for this project. One material was spunbond polypropylene, (Agribon AG-30; Johnny's Selected Seeds, Fairfield, ME). Agribon can be used as a row cover and frost blanket. It is relatively easy to tear and allows some airflow and 70% of sunlight to reach the plants (Figure 1). Agribon is about 35% of the cost of the second material used, polyethylene mesh (ProtekNet; Dubois Agrinovation, Saint-Rémi, Québec). The ProtekNet material is a mesh netting, often used to protect fruit trees from birds. Its mesh structure is similar to screened wire. This option allows airflow and sunlight to reach the plant and is also transparent, which allows the grower to easily monitor their plants (Figure 1). Although it is more expensive than Agribon, ProtekNet is more durable and can be mended by sewing up holes with fishing line.

Meso tunnels created from ½ inch electrical conduit were used over the course of the project as they have proven successful for small scale test plots in related row cover studies (Nelson and Gleason, 2017).

Beetle Exclusion Experiment

This experiment compared four different methods of sealing row cover perimeters. Three test locations were used near Ames, IA: Iowa State University (ISU) Johnson Farm near Ames, ISU Horticulture Research Station near Gilbert, and ISU Field Extension Education Lab (FEEL) near Boone. Four rows, one for each perimeter sealing method, were set up at each location. Four sealing methods were used: sandbags spaced 10-ft apart and sandbags spaced 5-ft apart, PVC clips, and burying the excess perimeter material with soil. The sandbags were made with filling plastic storage bags with 5-lbs of sand and were rolled into the perimeter material to prevent the cover from slipping under the bag and becoming unsecured (Figure 1). The PVC clips (#10 Snap Clamp; Circo Innovations Inc, Grass Valley, CA) were snapped over the cover at the base of the hoops, creating a barrier of bunched up row cover against the ground (Figure 2). The ends of the PVC clip rows were buried to accommodate the excess cover material. The final method involved completely burying the cover perimeter using shovels.

Figure 1. Rows sealed with both 5-ft (left) and 10-ft (right) spaced sandbags.

Figure 2. PVC clips were used to secure row covers to hoop structure and create a barrier of bunched up material at the base of the structure.

The rows were created using conduit meso-tunnels covered with ProtekNet. Underneath each row, six acorn squash plants and a sticky pheromone trap and lure (Harris Seeds, Rochester, NY). An additional pheromone trap was set up uncovered at each location to help determine when a population of cucumber beetles was drawn. After construction, the plants and traps were monitored 2-3 times a week for cucumber beetles.

Anchoring Trial

The trials were tested using Agribon AG-30 row covers because they are more easily damaged and show wear faster than ProtekNet. Failure for the anchoring trials was defined as a length of five feet or more of perimeter row cover not held securely to the ground.

Experiment 1

This initial round of testing looked at five different methods of anchoring the row cover: sandbags placed at 5-ft intervals, 1.5-in diameter PVC lay-flat hose, rock bags spaced 5-ft apart, homemade PVC clips, and burying the edges with soil. The sandbag and buried rows follow the same procedure as in the beetle exclusion experiment, and the PVC clips are very similar although those used in this trial were constructed from cutting sections of ½-in diameter PVC pipe. PVC lay-flat hose is commonly used for irrigation in produce gardens. It was stretched around the row perimeter and filled with water in the field (Figure 3). The rock bags were created by filling tied off sections of plastic mesh with approximately 10-lbs of gravel and rocks.

Figure 3. Row cover was pinned under the filled lay-flat hose.

Experiment 2

The second phase of the anchoring trial tested three additional methods of securing the row cover: four purchased PVC clips per hoop, a combination of two PVC clips per hoop and 5-ft spaced rock bags, and a combination of two PVC clips per hoop and tap clips anchored with metal stakes spaced 5-ft apart. The PVC clips used in this phase were the same as those used in the beetle exclusion experiment. The tarp clips were attached to the point where the row cover met the ground. The ends of the clips were anchored to the ground using 7-in metal stakes (Figure 4).

Figure 4. Tarp clips were secured to the perimeter material and held to the ground with metal stakes.

Structure Experiment

Four different structures were tested in the structure experiment: PVC hoops, conduit hoops, electric fence posts and steel T-posts (Figure 5). Each row covered a 12-ft wide by 20-ft long are and was covered using Agribon AG-30 row cover and the perimeters were buried in the soil. PVC hoops are a compromise between meso-tunnels and high tunnels. This method is tall enough for workers to stand under the rows, while also being a seasonal and less expensive alternative to the classical high tunnel. The conduit hoops were used due to their popularity with researchers on similar projects. The steel T-post method comes from trials testing multi-row covers and column supports (Hanna et al., 2015). The electric fence post approach is a cheaper and a less labor-intensive adaptation of the steel T-post trial. A method was considered to have failed if it was allowed to sag within 3-ft of the ground.

Figure 5. Steel T-Post (1), conduit hoop (2), electric fence post (3), and PVC hoop (4) treatments of structure trial.

PVC pipes, 20-ft long 1-in diameter schedule 40, were set up with each end of the pipe fit over rebar pounded into opposite ends of the row. The conduit hoops used were the same as those used in the previous trial, but the covered plot included two side by side rows of hoops. Four-foot-long electric fence posts were spaced at 10-ft intervals and were topped with golf balls to prevent the post from puncturing the material. Sections of 3 ½-ft steel t-posts were also spaced 10-ft apart and were topped with tennis balls. This method was later altered by placing two 6-ft tall posts in the center of the row to tent up the cover material and prevent it from sagging.

Results and Discussion

Beetle Exclusion Experiment

The number of cucumber beetles gained access to the rows before the flowers had reached anthesis (flowering) varied across different locations and treatments (Figure 6). Rows where rows were sealed with sandbags placed at 5-ft intervals showed the highest levels of cucumber beetles with a maximum of 7 beetles at the Johnson location. There were no beetles recorded under rows with a buried perimeter. Using an ANOVA table to test for significant difference, the results showed that there is a statistical difference between the buried and 5-ft sandbag treatments with 79% confidence (Pr > F of .21). To increase the duration of the trial as well as to observe how the treatments withstand under increased beetle pressure, row covers remained over rows for five more weeks after anthesis.

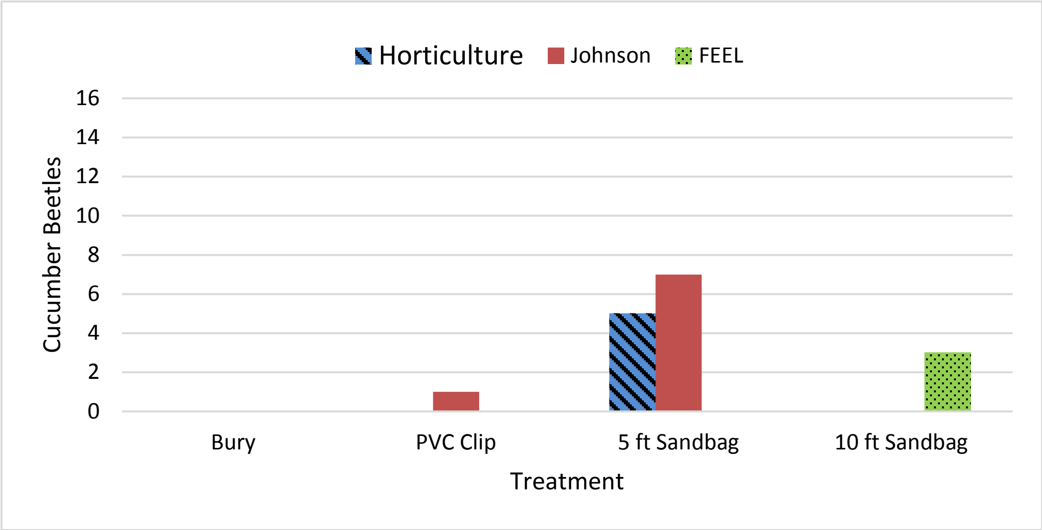

Figure 6. Cucumber beetle count under row covers before anthesis

Figure 7 shows the final cucumber beetle counts at the end of the experiment. The maximum number of beetles counted under rows was 14, which was found under the 5-ft spaced sandbag treatment at the Horticulture farm. The treatment with the least number of beetles was the buried perimeter, with only one beetle recorded among all three locations. The treatments were statistically different with a 75% confidence (Pr > F of .25). Though several rows had considerably larger populations of cucumber beetles, none of the plants showed symptoms of bacterial wilt, the disease vectored by cucumber beetles.

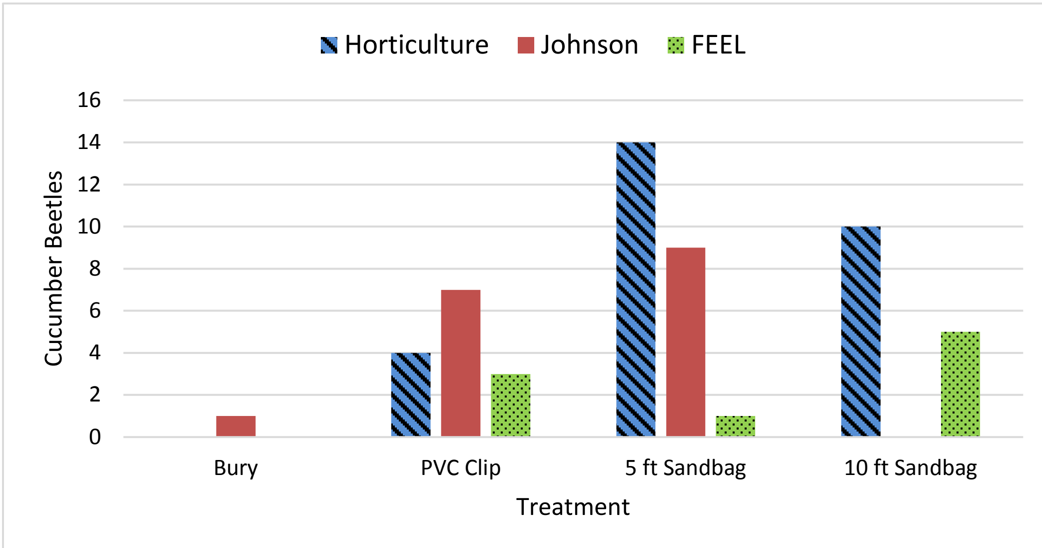

Figure 7. Total cucumber beetle count under row covers throughout entire study

Brust and Foster (1999) suggest an economic threshold for controlling cucumber beetle populations with insecticides of one beetle per plant. Using a threshold of one beetle per plant and the six plants per row, all rows with the buried perimeter are under the threshold, as well as two-thirds of both the 10-ft spaced sandbag row and PVC clip row locations. Considering the beetle pressure before anthesis, the primary time when row covers are present, all but the 5-ft sandbag row at Johnson farm were successful.

Anchoring Trial

Experiment 1

On the first run of Experiment 1, all trials failed after a storm with wind speeds up to 32 mph (Figure 8). After this, all the trials were set back up for a second run. Again, all the trials failed within 3 days except the buried row, which remained standing until finally taken down at the end of Experiment 2 trials. The PVC-clip row sustained the most damage from these runs, while the rock bag treatment did not cause any damage to the row cover (Figure 9).

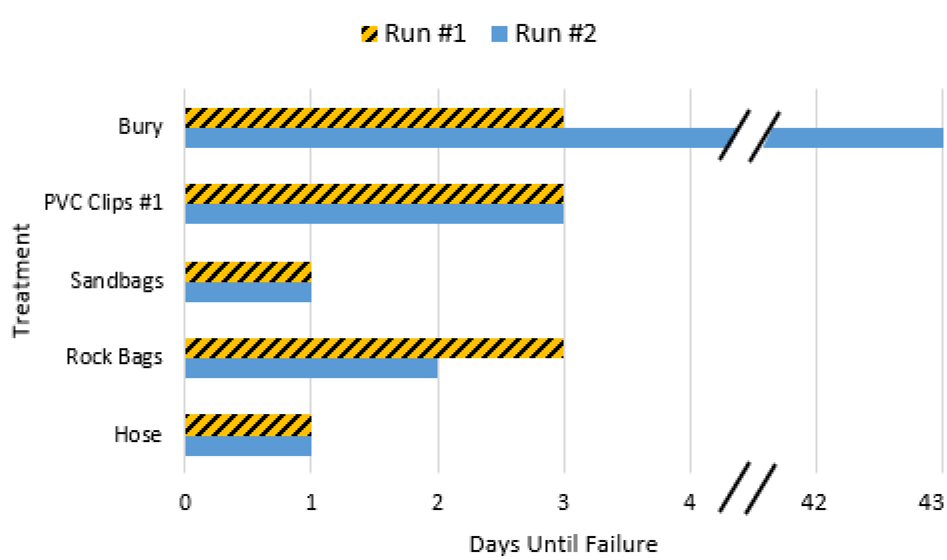

Figure 8. Days until failure for Anchoring Experiment 1 treatments

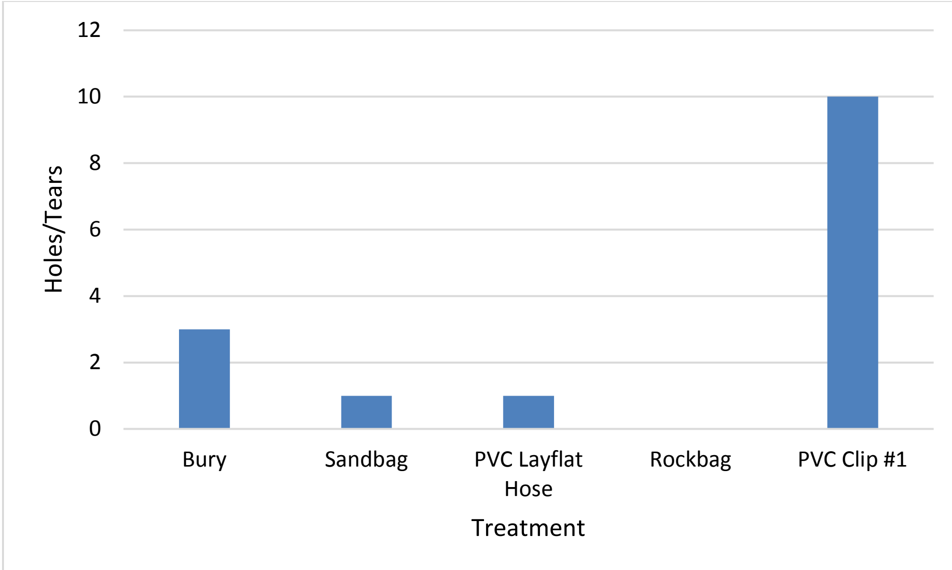

Figure 9. Row cover damage for treatments in Experiment #1

Experiment 2

The row covers sustained higher damage during in Experiment 2 (Table 1). This is likely due to the increased number of PVC clips used. These trials were all successful with regards to maintaining perimeter integrity with exception of the tarp clip row. The rows withstood wind speeds up to 31 mph.

Table 1. Damage to Experiment 2 treatments

Treatment	Holes/Tears
4 PVC Clips	19
Rockbags + PVC Clips	8
Tarp Clips + PVC Clips	13
Reinforced 4 PVC Clips	13

Structure Experiment

Of the four initial structure trial setups, only the conduit hoop trial was successful in supporting the cover without excessive sagging. The conduit hoop system may be improved by investigating methods to increase spacing between hoops, and thereby decreasing the number of hoops needed for each row.

A large storm occurred shortly after the trials were set up. All methods failed except the conduit hoop trial. The posts in the electric fence and t-post trials punctured through the row cover. The PVC hoops collapsed and efforts to re-anchor them proved fruitless.

The tented t-post trial remained standing for 22 days until it finally failed under 25 mph winds and 1.85 inches of rainfall with one of the 6-ft posts poking through the fabric. This method may prove to be an alternative to conduit hoops with further testing by adding additional material at support points to reinforce the row cover.

Conclusions

Beetle Exclusion Experiment

Methods of sealing row cover perimeter varied in their effectiveness of keeping cucumber beetles out of rows at statistically significant difference between treatments of 79% confidence before anthesis and 75% confidence over a 15-week season. The most effective was buried perimeter, which provided almost complete exclusion, but is very labor intensive. This method is recommended for areas that routinely face devastating damage due to bacterial wilt and cucumber beetle feeding. The other three methods are less effective at excluding beetles but are less labor intensive. All methods but

5-ft sandbag spacing were below economic threshold during the 15-week season. A decision on method must be made by the farmer, balancing the need to completely exclude the beetle and the time and effort required to seal the perimeter.

Anchoring Trial

Buried perimeter succeeded the longest for anchoring but was very labor intensive. The anchoring approach that caused the least amount of damage to the row cover was the rock bags, which can potentially increase the life of the row cover used. Additional testing with more reinforcement at attachment points for the PVC clips, which are relatively inexpensive, may be beneficial as their addition greatly improves the ability to hold cover to supports and the duration that the row is successfully covered.

Structure Experiment

The commonly used conduit hoop method remained intact as compared to other systems.

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