Integrating Flowering Windbreaks for Insect Management in Cucumbers

Final Report for GNC14-194

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Grant Recipient: Michigan State University
Region: North Central
State: Michigan

Graduate Student:

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Project Information

Summary:

Cucumbers (*Cucumis sativus*) are one of the most widely grown crops of the North Central Region, yet they are also one of the most likely to face pollination and biological control deficits. Natural enemies and pollinators require additional nutritional and habitat resources that are not found in conventional agricultural fields. The addition of flowering cover crops within the field could provide these resources. As of now, information on this topic, especially in cucumbers, remains limited. We hypothesized that pollinator and natural enemy abundance would increase in plots containing flower strips and that the effect would be greatest in the rows closest to the flower strips. Five flower strip treatments were used: 1) cucumbers (control), 2) buckwheat (*Fagopyrum esculentum*), 3) yellow mustard, (*Brassica hirta*), or 4) sweet alyssum (*Lobularia maritima*). Flowers were planted within a commercial cucumber field in a randomized complete block design with six replications in the 2014 growing season. Some floral treatments successfully attracted more beneficial insects than others, but the beneficials did not disperse out to the cucumber plants. Cucumber yield was unaffected. Habitat management for beneficial insects still holds a great deal of potential to improve yield, profitability, and sustainability, but questions as to its application in cucurbit agroecosystems remain.

Introduction:

In 2013, in Michigan alone, cucurbit crops (pumpkin, squash and cucumber) were grown on over 45,400 acres and valued at over $43.2 million (USDA/NASS, 2014). The region accounts for 37% of all U.S. acreage for these crops. In cucurbit crops, including cucumber, the insects causing the greatest economic costs in the NC

Region are cucumber beetles, squash bugs, thrips, spider mites and seed corn maggot. Current insect management practices in cucurbit crops are highly dependent on a relatively narrow range of insecticides, which inadequately control several key pests and are cause for environmental concern. A large-scale conventional commercial cucumber grower's standard insect pest management program in Michigan consists of about 8 broad-spectrum insecticide applications in any given growing season. Expenditures for insect management in these crops can easily exceed $100 per acre for pesticide applications alone (Barnett 2012). Despite these enormous pesticide applications, yield losses due to insects remain high. Alternative management strategies, such as the use of habitat modification with mulches and insectary plants can contribute to pest reduction by enhancing the activity of natural enemies. Winter rye windbreaks are commonly used in cucumber production systems to protect vulnerable seedlings and soils from damaging winds, but they are not particularly attractive to beneficial insects.

One of the many ecosystem services insects provide to growers is biological control. Enhancing the efficacy of natural enemies in controlling pests continues to remain an active field of investigation (Landis *et al*. 2000, Kleijn and Sutherland 2003, Bianchi et al. 2006, van Lenteren 2011, Walton and Isaacs 2011). Despite their desirability, declines in natural enemy populations in agricultural areas have been consistently observed, especially in highly disturbed areas (Sotherton 1998, Biesmeijer et al. 2006). Many studies have explored conditions that maximize ecosystem services, such as the addition of perennial flowering plants and fallow fields adjacent to cultivation, which increase the abundance of natural enemies (Long *et. al* 1998, Rebek *et al.* 2005, Wanner *et al.* 2006, Fiedler et al. 2008). Flowering species are rarely found adjacent to or within agricultural fields due to intensive herbicide use and the perception of revenue loss in from uncultivated space, but there is increasing support for the use of habitat diversification as a means to increase both the number and efficacy of beneficial insects. (Goverde et al. 2002, Carvell et al. 2006, Blaauw et al 2012). The effect of flowering windbreaks on natural enemies in cucumber production is not well-studied, warranting further investigation.

With respect to pollinators, growers in our region typically rent hives at a cost of $20-40/acre. In recent years, growers have observed reductions in fruit set and yield of their cucumber crops, and suspect that inadequate pollination may be contributing to substantial revenue losses. In response to decreasing honeybee populations worldwide, attracting and maximizing the efficacy of native pollinators has become of increasing interest (Isaacs and Kirk 2010, Petersen *et al.* 2013). In cucumbers, pollination is essential for proper fruit set, with inadequate pollination being associated with fruit abortion and low fruit quality (Stanghellini *et al.* 1997). The main pollinators of cucumber are honey bees (*Apis mellifera*) and the common bumblebee (*Bombus impatiens*), though the role of other pollinators is not well-understood (Smith *et al.* 2012). Wild pollinators, such as the common bumblebee, have been shown to pollinate cucumber more effectively than honey bees, even when managed honey bee hives are added to the field (Gajc-Wolska *et al.* 2011). Therefore, attracting wild pollinators to cucumber fields should be a priority. When grown adjacent to wooded or natural areas, the abundance of wild pollinators in cucumber fields has been shown to increase (Lowenstein *et al.* 2012, Smith *et al.* 2013). This may be due to the fact that native pollinators are often sensitive to environmental disturbances and require additional food and habit resources (Tuell *et al.* 2008, Williams *et al.* 2010, Winfree *et al.* 2011). Adding flowering areas within the field itself may provide these resources, thus increasing pollination. Native pollinators have been shown to be attracted to both annual and perennial flowering species in Michigan (Fiedler and Landis 2007a,b). Taken together, the literature suggests that adding flowering areas to cropped areas may enhance pollination in cucumber.

I predicted that the inclusion of flowering windbreaks in cucumber fields would: 1) increase the abundance of natural enemies 2) decrease the abundance of herbivorous insects, and 3)increase pollinator abundance and diversity , and 4) increase cucumber yield and quality. Additionally, we expect the effect of the flowering windbreaks to be the strongest in rows of cucumbers adjacent to the flowers, meaning that the will be greater abundance and diversity of beneficial insects and fewer pests in rows of cucumbers closest to the flowering annuals. Quinn_SARE_LiteratureCited

Project Objectives:

The immediate goal of this project was to evaluate the effect of the inclusion of flowering plant species in commercial cucumber (*Cucumis sativus*) fields on beneficial insect community composition to inform us of which flowering species enhance beneficial insect activity most effectively. Through presentations and other outreach, growers were educated on the value and effective implementation of flowering windbreaks in their own farms. The action outcome was to increase grower acceptance of this strategy, which in turn will lead to an overall increase in beneficial insect activity on their farms, thus increasing cucumber yield and profitability in the North Central Region.

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Research

Materials and methods:

Field plot establishment. The experiment took place in commercial cucumber fields in Benton Harbor, Michigan in 2014. The field was 201 x 402m. Pests were managed according to the grower's standard management practices. A randomized complete block design was implemented. The field was divided into six blocks with five treatments. Slicing cucumbers (*Cucumis sativus*, "Intimidator") were planted at the end of April in 2014 with an application of imidacloprid. For the flower strips, black plastic was removed in 20m long sections that were separated by 40m in rows and 12 rows (46m) between flower-strips. The following flower treatments were seeded at the end of April 2014: 1) *Brassica hirta* (yellow mustard, ('Tilney')), 2) *Lobularia maritima* (sweet alyssum, 'Carpet of Snow') 3) *Fagopyrum esculentum* (buckwheat), or 4) cucumbers (control). Cucumber seeds were hand planted and promptly covered with low tunnels using a transparent plastic cover. Sweet alyssum and clover were hand seeded while buckwheat and mustard was seeded with a Model JP-3 Clean Seeder using a Y24 disk for mustard and a R12 disk for buckwheat (Jang Automation Co., Ltd, South Korea). Oats were used as a nurse crop for the alyssum and seeds. At the end of May 2014, oat nurse crop was killed with a selective herbicide application and low tunnels were removed. A single pyrethroid application occurred in June. All other diseases and pests were managed as needed with conventional chemical management. Managed hives were stocked at 2 hives per acre. In late June and July, the cucumbers were harvested.

Arthropod Sampling.

Foliar arthropod abundance. Sampling transects (0.77 x 20m) were located within the flower strips (Row 0) and 1.5m (Row 1), 5m (Row 3), and 10m (Row 5) away from the flower strips in the cucumber field. In 2014 only, insects were sampled on the cucumber leaves in each treatment plot. Insects on foliage were visually sampled in each transect on 10 randomly selected whole plants during the first two weeks following cucumber emergence. Once the plants had approximately five leaves each, the numbers of insects on 10 randomly selected cucumber leaves in the each transect were recorded. Insects were identified to major taxonomic groups in the field.

Sticky Traps. Yellow sticky traps (12x15 cm) (Great Lakes IPM, Vestaburg, MI) were deployed at the center of each flower strip at canopy height in 2014 and 2015. Traps were collected and redeployed weekly. Traps were frozen at -20C° and identified in the laboratory to the lowest relevant taxonomic unit.

Sweep Net. Flower-strips were sampled weekly via sweep net. When sampled, each 20m flower strip was swept 100 times. Insects were frozen at -20C° and identified in the laboratory to the lowest relevant taxonomic unit.

Pollinator Observation. Sampling for pollinators occurred between 7:30am and 12:30pm on sunny, calm days, at approximately one week intervals. In the cucumbers, pollinators were assessed visually by walking parallel to the floral strip and recording the number and identity of all bees observed over a 10 minute period. Sampling transects (0.77 x 20m) were located within the flower strips (Row 0) and 1.5m (Row 1), 5m (Row 3), and 10m (Row 5) away from the flower strips in the cucumber field. If sight identification was not possible, pollinators were collected for laboratory identification. In the laboratory, pollinators were pinned and identified according to Mitchell's Bees of the Eastern United States (1962).

Yield. Yield data were collected twice during harvest. The diameter and length of the harvested cucumbers was graded in accordance with the United States Standards for Grades of Cucumbers (USDA 1997). The mass of all cucumbers in a 1m section within each transect were used as a measure of yield.

Statistical analysis. Arthropod abundance by taxonomic group, sampling method, treatment, and row were analyzed with Generalized Linear Mixed Models using a Poisson distribution with treatment and row as independent variables and treatment as the main effect. Treatment was nested within block as a random effect. Where main effects were significant ($\alpha=0.05$), pairwise Tukey-Kramer adjusted least-square means tests were performed (PROC GLIMMIX, SAS 9.4, SAS Institute, Cary, NC, USA). Most Diptera were excluded, except for Tachinidae and Syrphidae. The effect on total weight and average grade of the cucumbers harvested within the transects by distance from the flowering strips were analyzed with Generalized Linear Mixed Models using a normal distribution with treatment and row as independent variables and treatment as the main effect. Treatment was nested within block as a random effect. Where main effects were significant ($\alpha=0.05$), pairwise Tukey-Kramer adjusted least-square means tests were performed (PROC GLIMMIX, SAS 9.4, SAS Institute, Cary, NC, USA).

Voucher Specimens. Representative voucher specimens of arthropods that were collected as part of this project are kept at Michigan State University's A.J. Cook Arthropod Collection.

Research results and discussion:

Arthropods across sampling methods were more abundant in floral strips and less abundant in cropped areas. Cucumber rows closest to the floral strips did not have more insects than those further away. Cucumber yield was significantly increased in sweet alyssum treatments in the row located farthest away from the floral strips. Fruit quality was not significantly affected.

Herbivores. Flowering treatment, row, and the interaction between treatment and row did not significantly affect the abundance of natural enemies or herbivores found on cucumber leaves in 2014 ($F_{8,5}$<0.45, P>0.05). No significant treatment or row effects on sticky trap captures were found for any herbivores ($F_{3,206}$ < 0.98, *P*>0.05). Flowering treatment did not significantly affect the abundance of herbivores collected by sweep net from the flower strips pre and during cucumber harvest in 2014 ($F_{4,70}$ <0.21, P>0.05).

Contrary to what was predicted, the abundance of herbivorous insects was not significantly reduced by the presence of flowers, regardless of sampling methods. The herbivore communities within flower strips were also not significantly different from one another. Few arthropods were observed overall on the cucumber plants or sticky traps in either year, a primary contributing factor to this may be the use of the systemic insecticide imidacloprid at planting.

Natural Enemies. Abundances of lady beetles and minute pirate bugs collected by sticky trap in the floral strips were significantly different among treatments ($F_{4,93}$ >3.39, *P*<0.02) (Fig. 1). Significantly more lady beetles were found on the sticky traps in the buckwheat and sweet alyssum treatments than control cucumber only plots (t>1.32, df=93, *P*<0.05) (Fig. 1). Significantly more minute pirate bugs were found on sticky traps placed in mustard and sweet alyssum strips compared to control cucumber-only plots (t>3.32, df=93, *P*<0.05) . All other natural enemy taxa were unaffected by treatment, row, or their interaction ($F_{3,206}$<0.77, *P*>0.05).

Greater numbers of natural enemies were detected in the floral strips compared to the cucumbers in both seasons. Insect abundance tends to be highest where the greatest numbers of suitable resources are located, according to the resource concentration hypothesis (Root 1973). While the cucumber flowers provide little nectar and pollen (Southwick *et* al. 1981, Cook *et al.* 2003, Masierowska 2003, Peng *et al* 2004), the floral species used here are well-established insectary plants (Platt *et al.* 1999, Landis *et al.* 2000, Berndt and Wratten 2005, Fiedler *et al.* 2008). It is likely that the flowers concentrated the available natural enemies in the flower strips rather than increasing the total number of natural enemies available for biological control in the whole field. The effect of insectary plant mixes on the natural enemy community found in cucurbit systems can vary from year to year, with some years having higher abundances of key natural enemies in cropped areas while some demonstrate little effect (Grasswitz 2013). Quinn_SARE_FiguresQuinn_SARE_Figures

Pollinators. In 2014, flowering treatment, row, and the interaction between treatment and row did not significantly affect the abundance of observed honey bees, native bees, or hover flies 1, 3, or 5 rows away from the flower treatments before cucumber harvest ($F_{8,64}$<0.45, P>0.3). Row and the interaction between treatment and row did not significantly affect the abundance of any bees observed ($F_{2,64}$ <1.23, P>0.05).

The distance away from the strips did not appear to significantly affect pollinator foraging on cucumber plants. Native bees occurred at lower levels than honey bees in the cucumber field overall, but showed a similar pattern. Honey bees and many native bees are generalists, but prefer to visit flowers with high-quality resources (Cook *et al.* 2003, Cnaani *et al.* 2006). Honey bees are one of the primary pollinators of cucumbers in North America, yet they do not appear to have been drawn to the cucumbers by the floral resources provided. Rather, they may have concentrated within the flower strips without dispersing into the surrounding cropped areas or being drawn away from the cucumbers. Bees and other highly mobile insects have demonstrated sensitivities to the quality of the landscape as a whole, meaning that local-scale management may be insufficient support for their populations (Shackelford *et al.* 2013, Petersen and Nault 2014, Kremen et al. 2015, Park *et al.* 2015).

Yield. In 2014, there were no significant differences by distance from the flower strips in mass harvested per meter ($F_{2,73}$< 2.66, P>0.05) or the interaction between flower treatment and distance ($F_{8,70}$, F=0.46, P>0.05). The percentage of low-grade cucumbers harvested was not affected by treatment ($F_{4,70}$=1.29, *P*>0.05), distance from flower treatment, ($F_{2,70}$ <1.48, *P*>0.05), or their interaction ($F_{8,70}$= 0.46, *P*>0.05).

Cucumbers tend to be variable in size, weight, and shape and produce fruit for several weeks, during which time cucumbers are harvested daily. Increasing the area of cucumbers harvested for yield could provide a more robust estimate of the amount and quality of cucumber yield. The interaction of these factors in combination with the fact that pollinator visitation to cucumber plants was not increased by the treatments applied likely explains the weak treatment effect on yield.

Participation Summary

Educational & Outreach Activities

PARTICIPATION SUMMARY:

Education/outreach description:

PUBLICATIONS

Thesis:

Published:

N.F. Quinn. 2015. “Habitat management for beneficial insects in Michigan cucurbit agroecosystems.” Master of Science Thesis. Department of Entomology, Michigan State University.

In prep:

N.F. Quinn, D.C. Brainard, Z. Szendrei. "Habitat management for natural enemies and pollinators: the effect of floral intercropping on beneficial insects.”

N.F. Quinn, D.C. Brainard, Z. Szendrei. The effect of reduced tillage and crop residue on natural enemies of weed seeds and insects.”

PRESENTATIONS

Invited talks:

September 2016 N. Quinn and R. Morrison. Oral. “Talking to Swarms Without Borders: Methods for Engaging the Public in the Buzz about Entomology.” XXV

International Congress of Entomology (ICE). Orlando, FL.

June 2016 N. Quinn and Z. Szendrei. Oral. “The effect of floral intercropping on beneficial insects in cucumbers.” Agroecology in Specialty Crops: IPM Strategies to Address Pest Management Challenges. Entomological Society of America, North Central Branch Meeting. Cleveland, OH.

March 2015 N. Quinn, D. Brainard, Z. Szendrei. Oral. “Supporting Our Insect Allies: Habitat Management for Beneficial Insects.” USDA-ARS Appalachian Fruit Research Station. Kearneysville, WV. Attendance: 40 people.

April 2015 N. Quinn, D. Brainard, Z. Szendrei. Oral. “Supporting Our Insect Allies: Habitat Management for Beneficial Insects.” Michigan State University, Department of Entomology Spring Seminar Series. East Lansing, MI. Attendance: 40 people.

Contributed talks:

November 2015 N. Quinn, D. Brainard, Z. Szendrei. Oral. “The effect of floral intercropping on beneficial insects in cucumbers.” Entomological Society of America, Ten Minute Paper Competition. Minneapolis, MN. Attendance: 60 people.

April 2015 N. Quinn, D. Brainard, Z. Szendrei. Poster. “The effect of floral strips on beneficial insects.” Michigan State University, Kellogg Biological Station Long-Term Ecological Research Symposium. East Lansing, MI.

Symposia organized:

September 2016 N. Quinn and R. Morrison. Co-organizer. “Talking to Swarms Without Borders: Methods for Engaging the Public in the Buzz about Entomology.” XXV International Congress of Entomology (ICE). Orlando, FL.

EXTENSION

Invited talks:

December 2015 Z. Szendrei and N. Quinn. Oral. Biological Control . “Habitat Management for Beneficial Insects in Vine Crops.” Great Lakes Fruit, Vegetable and Farm Market EXPO. Grand Rapids, MI. Attendance: 60 people.

December 2014 N. Quinn. B. Blaauw, Z. Szendrei. Oral. Biological Control . “Habitat Management for Beneficial Insects.” Great Lakes Fruit, Vegetable and Farm Market EXPO. Grand Rapids, MI. Attendance: 60 people.

Contributed talks:

September 2015 N. Quinn, Ari Grode, Z. Szendrei. Oral. “An Introduction to Beneficial Insects and Habitat Management.” Beginning Farmer Workshop Series: Pests and Diseases. East Lansing, MI. Attendance: 20 people.

August 2015 N. Quinn, Z. Szendrei. Oral. “An Introduction to Beneficial Insects and Habitat Management.” Women in Agriculture Pest and Disease Workshop. Flint, MI. Attendance: 20 people.

Factsheets:

Bryant, A., W.R. Morrison III, B. Werling, N. Quinn, and Z. Szendrei. 2015. Insect pests in Michigan cucurbits. Michigan State University, East Lansing, MI.

Press:

Weaver, B., and M. Weaver. 2016. Floral strips in cucumber fields. Ctry. Folk. Grow.

OUTREACH

June 2015-- Beepalooza Exhibitor: Habitat Management for Native Bees, MSU, East Lansing, MI

Ran a booth and distributed information on how to conserve native bees at home. Responsible for designing and selecting materials and educating booth visitors. Attendance: 400 people.

June 2014-- Beepalooza Exhibitor: Habitat Management for Native Bees, MSU, East Lansing, MI

Ran a booth and distributed information on how to conserve native bees at home. Responsible for designing and selecting materials and educating booth visitors. Attendance: 500 people.

Project Outcomes

Project outcomes:

This experiment did not detect benefits of within-field floral intercropping extending out to the cucumber field. Planting flowers in larger patches and in unused areas of the field such as the driveways and field margins may improve the effects on beneficial insects at the local scale, similar to the use of insectary hedgerows (Blaauw and Isaacs 2012, Morandin *et al.* 2014). However, for growers to widely adopt a given habitat management strategy, yield and cost-effectiveness would have to be noticeably improved. Yield was not improved by the presence of any of the flowers added, meaning that the justification for removing those areas from cultivation is limited. However, in low-input settings, such as small, organic farms that are not as intensively managed, improvements to the habitat on the arthropod community may become more apparent.

Farmer Adoption

The techniques outlined in this study should not be adopted by cucumber growers due to lack of effectiveness in enhancing beneficial insect activity and yield.

Recommendations:

Areas needing additional study

Habitat management in cucurbits should be explored at the landscape level. Evidence for greater impact of landscape level habitat resources on beneficial insects has been increasing in a variety of cropping systems. Local level effects tend to be much weaker by comparison and limited to edge and spillover effects that do not strongly affect insect communities or yield. Studies that quantify the impact of larger, unmanaged areas on beneficial insect abundance and movement should be pursued.