Vine Crops

Wednesday morning 9:00 am

Where: Grand Gallery (main level) Room A & B
MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
CCA Credits: PM(1.0) CM(1.0)
Moderator: Lina Rodriguez-Salamanca, Plant, Soil and Microbial Sciences Dept., MSU

9:00 am Non-Traditional Vine Crops: Beyond Cucumbers and Squash
- Evan Elford, New Crop Development Specialist, OMAF and MRA, Simcoe, Ontario, Canada

9:30 am Abilities of Wild Bees to Provide Pollination Services to Pumpkin
- Jessica Petersen, Entomology Dept., Cornell Univ., NYSAES, Geneva, NY

10:00 am Managing Phytophtora and Powdery Mildew in Vine Crops
- Mary Hausbeck, Plant, Soil and Microbial Sciences Dept., MSU

10:30 am The Impacts of Managed Flowering Areas on Pollination and Biocontrol in Ohio Pumpkin Crops
- Ben Phillips, Vegetable Educator, MSU Extension, Saginaw, MI

11:00 am Session Ends

Non-Traditional Vine Crops: Beyond Cucumbers and Squash

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Non-traditional cucurbits are used for a variety of culinary applications and some species are used for other purposes such as personal care products (e.g. sponges). This session will provide an introduction to non-traditional cucurbits that have been successfully grown in Ontario field trials as well as general agronomic requirements and possible markets opportunities. Further information on each species is available on the OMAF and MRA 'Speciality Cropportunities' website: http://www.omafra.gov.on.ca/CropOp/en/index.html.

Wild Bees Provide Sufficient Pollination Services to Pumpkin

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Vine crops such as pumpkin, squash, cucumber and watermelon are some of the Great Lakes region's most valuable vegetable crops. These crops require pollination by bees, the most well-known of which is the honey bee, *Apis mellifera*. Honey bee hives are placed in vine crops during the time they need to be pollinated. Unfortunately, Colony Collapse Disorder (CCD), parasitic mites, viruses, and pesticides continue to cause significant losses in populations of honey bees throughout the US. Fewer honey bee hives are now available for vine crop growers and the cost of renting hives has increased from approximately \$30 per hive to ≥\$75 per hive. Consequently, growers will continue to pay more for renting hives, unless alternative pollinators are identified to service their vine crops. Previous research has shown that on an individual basis, the common eastern bumble bee, *Bombus impatiens*, was the most efficient pollinator of pumpkin compared with other common species including the honey bee and squash bee, *Peponapis pruinosa*. The common eastern bumble bee is an efficient pollinator, naturally abundant and available commercially, making it a perfect candidate as an alternative pollinator to the honey bee in pumpkin fields.

Our previous research has indicated that pumpkin fields supplemented with bumble bee hives or honey bee hives did not produce greater pumpkin yield (i.e., fruit weight per plant). Also, there were no more visits to pumpkin flowers by bumble bees in fields supplemented with bumble bees than in fields that were not supplemented. Likewise, there were no more honey bee visits to flowers in fields supplemented with honey bees than in fields that were not supplemented. These results could be explained by not supplementing these fields with enough bees. In our studies, we followed the recommended stocking density at which commercial bumble bee hives should be supplemented (one Quad per 2 acres) and what our local vine crop growers follow for honey bees (1 hive per 3 acres). To explore how increasing the stocking density of bees might impact yield and visits to flowers, we compared pumpkin production in fields supplemented with bumble bees at the recommended stocking density with those that had three times the recommended stocking density. We also wanted to produce guidelines that growers could use to decide whether or not to supplement their pumpkin fields with bees.

Does fruit yield or bumble bee visits increase if the density of bumble bees hives is increased? In the Finger Lakes Region of New York in 2012 and 2013, we explored the potential of increasing pumpkin fruit yield and bumble bee visits to pumpkin flowers by increasing the density by three-times the recommended stocking density. Commercial pumpkin fields were supplemented at the recommended density (1 QUAD per 2 acres; *n*=10), 3 times the recommended density (3 QUADs per 2 acres; *n*=10) or not supplemented with bees (*n*=10). Fields ranged in size from 1 to 10 acres; fields of similar size were grouped and randomly assigned one of the three supplementation treatments. The jack-o-lantern variety, 'Gladiator', was planted in all fields. Ten seedlings were transplanted into each of three locations in the field (=30 plants per field). In September, when the crop was mature, all marketable fruit were counted and weighed. Data were analyzed using ANOVA and treatment means were compared (P<0.05). Increasing the density of bumble bee hives in pumpkin fields did not increase pumpkin fruit weight per plant or bumble bee visits to pumpkin flowers **(Fig. 1)**.

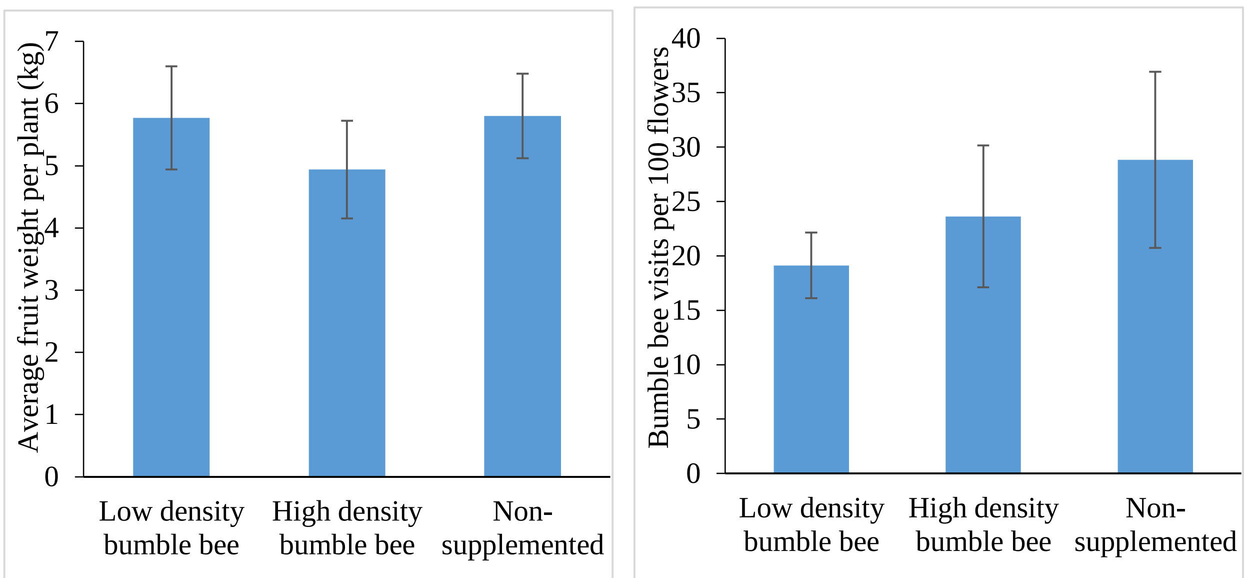

Fig. 1. Mean (± SEM) pumpkin, *Cucurbita pepo*, var. 'Gladiator', fruit yield and bumble bee visits from fields supplemented with commercial bumble bee colonies at a low density of 1 QUAD per 2 acres (n=10), bumble bee colonies at a high density of 3 QUADs per 2 acres (n=10) or were not supplemented (n=10) in New York in 2012 and 2013.

Are there any situations where supplementation with bees could be important? The landscape surrounding pumpkin fields and the population levels of wild bees are likely important in deciding whether to supplement fields with managed bees. While we have shown that supplementing pumpkin fields with bees does not increase fruit yield on average, there might be circumstances where the landscape surrounding pumpkin fields may not support wild bees and this could this result in lower fruit yield if supplementation with commercial bees is not done. To answer this question, we investigated whether features in the landscape impact bee visits to pumpkin flowers and fruit yield. Through a series of statistical analyses, we identified two features in the landscape that impact wild bumble bee and honey bee visits to pumpkin flowers and led to greater fruit yield. The first feature is the level of diversity in land-use types across the landscape. High diversity landscapes (many different land-use types and approximately even parcel sizes as shown in **Fig. 2**) have more bumble bees and greater pumpkin yield compared with landscapes that have low diversity. The second feature is the amount of grassland in the landscape (i.e., semi-natural, open-canopy habitats such as fallows, shrubland, weedy ditches and nature preserves). A landscape with greater than 20% grassland is considered sufficient to sustain an adequate population of bees for pumpkin pollination.

Guidelines for deciding whether or not to supplement pumpkin fields with bees. To assess whether supplementation with bees might be necessary for a particular pumpkin field, the first step is to estimate the number of bees in the field as either high or low. When pumpkin flowers are in bloom, count the total number of honey bees and bumble bees in 60 flowers (male and female), spending 5 seconds counting bees at each flower you watch and then moving on to the next flower. Sample three different locations of 60 flowers each to get an average of the number of each bee species per 60 flowers. A high bumble bee density would be greater than 3 bumble bees per 60 flowers. High honey bee density would be anything greater than 10 honey bees per 60 flowers. It is important to note that this approach will only be useful for future growing seasons, unless a beekeeper is willing to supplement the field with short notice.

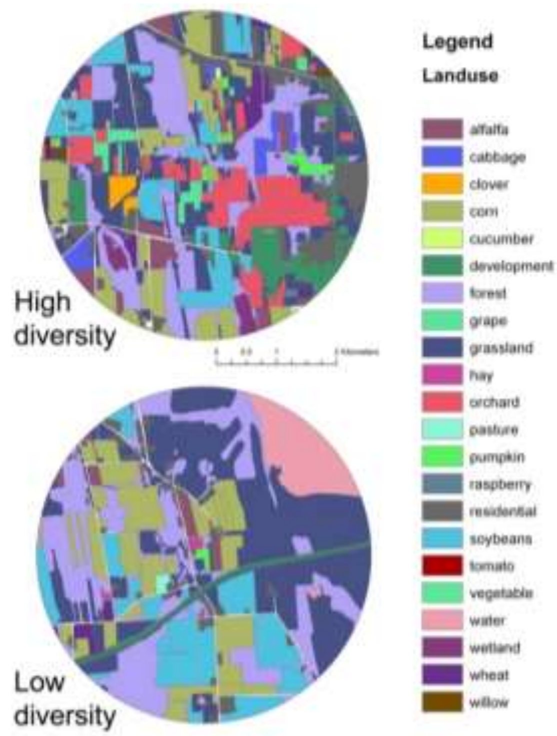

Fig. 2. Examples of high and low landscape diversity surrounding a pumpkin field in the center of each circle.

The next step is to identify the diversity of habitats in the landscape and the percent of the landscape that is undisturbed grassland (within a 2 km [~1.25 miles] radius of the center of the field). These two landscape features could be estimated through direct knowledge of the land-use features surrounding the field or by consulting the Cropland Data Layer produced yearly by the USDA – National Agricultural Statistics Service (http://nassgeodata.gmu.edu/CropScape/).

Combining knowledge of these factors (bumble bee and honey bee density, landscape diversity and percent grassland) will help inform what pumpkin fields should benefit from supplementation with managed bees (**Table 1).**

Table 1. Guidelines for making decisions on whether or not to supplement pumpkin fields with bees and the bee species that is of interest

	Bumble bee density			Honey bee density	
Landscape diversity	High	Low	% Grassland	High	Low
High	Supplementing not necessary	Consider supplementing	High	Supplementing not necessary	Consider supplementing
Low	Supplementing recommended	Consider supplementing	Low	Supplementing recommended	Consider supplementing

Managing *Phytophthora* and Powdery Mildew in Vine Crops

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POWDERY MILDEW is a major foliar disease of cucurbits, easy to identify because of the whitish, talcum-like, powdery growth. It develops first on close-set plants on the shaded lower leaves and can infect leaf surfaces, petioles, and stems. Infected leaves usually wither and die. Premature loss of foliage often reduces the size or number of fruit and the length of the harvest period. The fungus can multiply and spread quickly under favorable conditions, because the length of time between infection and appearance of symptoms is usually only three to seven days. A large number of spores that can infect healthy tissue can be produced in a relatively short time. Spores may be transported rapidly over long distances by air currents.

Market quality of the fruit can be reduced because of sunburn and premature or incomplete ripening, resulting in poor flavor or rind color (pumpkin). In addition, powdery mildew infection predisposes plants to other diseases that may impact the pumpkin handle making it weak and brittle. Resistant cultivars represent an important step forward in managing powdery mildew and are commercially available only for cucumber, cantaloupe, and some pumpkins (Table 1). Currently, fungicides (Table 2) in combination with resistant cultivars are the primary control practice for this disease. Registered products vary widely in their ability to limit the powdery mildew pathogen. Some fungicides could be suitable for use in organic growing systems but may need to be applied early in the production cycle to ensure that the pathogen doesn't become established prior to beginning a protection program; control products will need to be reapplied frequently. Other products suitable for sustainable or conventional production are fairly new to the market and offer a high level of control that will be very useful since the powdery mildew pathogen is well-known for developing resistance to older control products that have been used over the years. When choosing fungicides, it is especially important to alternate among products that attack the pathogen in different ways. In the table below, the FRAC code can be used as a guide to know whether the products act similarly (FRAC numbers are the same) or differently (FRAC numbers are different). Another point to consider is that there are no "magic bullet" products that can halt a well-established problem or a powdery mildew epidemic.

Many years ago, it seemed that the first occurrence of powdery mildew on pumpkins did not occur until early August. However, in more recent years, the first powdery mildew reports on Michigan vine crops are usually made around the July 4th holiday. That can mean that growers are faced with a relatively long period where control products may be needed. Scouting fields beginning in June and carefully looking at older leaves that may be shaded and remembering to check the undersides of the leaves, also, for powdery mildew colonies is important. Knowing when the pathogen first comes into a production field is important so that a management strategy can be put into place before the problem is out of control. Regardless of the type of product that fits into your specific operation, managing the disease early will be more successful than waiting until a crisis and then trying to protect the crop. Even if only a specific number of sprays fit within the control budget, it is best to spend those spray dollars earlier when they can do the most good rather than waiting until the powdery mildew pathogen is past the point of control because the sprays are unlikely to offer much help at that point.

Table 1. Pumpkin cultivars described as being resistant/tolerant to powdery mildew.

Aladdin	Denali	Hobbit	Prankster	Super Herc
Apogee	Dynasty	Holligan	Progress	Superior
Blue Delight	Everest	Iron Man	Prudence	Sweet Lightning
Bumpkin	Gemini	Magician	Racer Plus	Touch Of Autumn
Bunch O'Warts	Gladiator	Magic Lantern	Rascal	Treasure
Cannon Ball	Gold Dust	Millionaire	Rival	Trophy
Capital	Golden Condor	Mystic Plus	Rockafellow	Tycoon
Captain Jack	Gooligan	One Too Many	Spartan	Warts Galore
Casperita	Growers Giant	Packer	Stripes And Warts	Warts Plethora
Charisma	Harvest Princess	Pegasus	Summit	White Delight

Note: *Control products may still be needed in conjunction with using these cultivars to ensure a high level of powdery mildew management. However, the number of applications required will likely be reduced when growing a powdery mildew resistant/tolerant cultivar compared with growing a more susceptible cultivar.*

Table 2. Products registered for use on powdery mildew of vine crops. *NOTE: This information is a guide only and is not intended to replace the specific product labels. Always read the label and follow all instructions closely. Inclusion of a product in this table does not mean that it is recommended for use, but rather indicates that it could be used according to current label interpretations. Also be advised that states may differ in their registration of these products so do your homework* ***before*** *putting together a fungicide strategy.*

Product	**Active ingredient**	**FRAC**
Amicarb[1]	potassium bicarbonate	NC[2]
Badge SC	copper hydroxide/copper oxychloride	M1
Bravo Ultrex, Bravo WeatherStik, Echo 720, Echo 90DF, Equus 720 SST, Equus DF	chlorothalonil	M5
Cabrio	pyraclostrobin	11
Champ DF, Champ Formula 2F, Champion WP, Kocide 2000, Kocide 3000, Nu-Cop 50DF, Nu-Cop 3L	copper hydroxide	M1
Copper Count N	copper ammonium carbonate	M1
Cuprofix Ultra Disperss	copper sulfate	M1
Endura	boscalid	7
Flint	trifloxystrobin	11
Folicur 3.6F	tebuconazole	3
Fontelis	penthiopyrad	7
Inspire Super	difenoconazole/cyprodinil	3/9
Kumulus DF[3], Microthiol Disperss, Thiolux Jet	sulfur	M2
Luna Sensation[4]	flluopyram/trifloxystrobin	7/11
Pristine	pyraclostrobin/boscalid	11/7
Procure 480SC	triflumizole	3
Quadris	azoxystrobin	11
Quadris Opti	azoxystrobin/chlorothalonil	11/M5
Quadris Top	azoxystrobin/difenoconazole	11/3
Quintec	quinoxyfen	13
Rally 40WSP	myclobutanil	3
Serenade, Serenade Max	*Bacillus subtilis*	NC[2]
Sovran	kresoxim-methyl	11
Tenn-Cop 5E	copper resinate	M1
Topsin 4.5FL, Topsin M 70WSB	thiophanate-methyl	1

Product	Active ingredient	FRAC
Torino	cyflufenamid	U6
Trilogy	neem oil	NC[2]

[1]Not labeled for squash or pumpkin.
[2]NC=Not classified.
[3]Not labeled for pumpkin.
[4]Labeled for watermelon only.

PHYTOPHTHORA causes a rot or blight of the roots, crowns, stems, leaves, and/or fruit of summer squash, zucchini, hard squash, melons, and pumpkins. Plants may appear wilted initially and recover in the evenings but eventually the plants will die. Also, following a rainstorm or overhead irrigation, soil containing the pathogen can splash onto the plant's petioles causing a blighting near or just above the plant's crown. Sometimes, the infected plant surfaces can be coated with white *Phytophthora* spores that can look similar to powdered sugar. It can be especially easy to find the powdered sugar symptoms on the infected fruit. Once the fruit become infected with *Phytophthora*, it becomes compromised and can become infected by other pathogens that may be secondary such as *Pythium*. When this happens, there will be a fluffy white appearance to the fruit that will grow over the white powdered sugar symptom that occurred first, making it hard to tell which pathogen is really at fault. Eventually the infected fruit will rot but the pathogen structures that developed inside the diseased fruit will remain viable and serve to further infest the field soil causing increased problems in future years. It is possible to harvest fruit that looks healthy with symptoms of *Phytophthora* rot appearing days later while the crop is in transit or on grocer's shelves. A good way to avoid *Phytophthora* in a field (Table 3) is to take preventive measures before there is an outbreak. If there is a history of *Phytophthora* in a field, do not plant susceptible crops.

Water management is an important component of managing *Phytophthora*. Hard squashes, pumpkins, and other types of vine crops can be planted into raised beds which allow for excess water to move away from the susceptible root and crown area. This strategy has proven to be very helpful for pepper production but becomes more challenging to produce vine crops in this manner. Choosing varieties with more of a bush-like habit versus a trailing vine habit may be helpful for use in conjunction with the raised plant bed system. Because the disease can spread through water, it is essential that fields are well-drained and that low-lying areas of the field are left unplanted. Overhead irrigation should be sparse and drip irrigation is recommended. Irrigation water should not be drawn from a surface water source as it may be infested with *Phytophthora* spores. Widespread studies conducted in Michigan have clearly shown that many sources of surface water are contaminated with this long-lasting, devastating pathogen. As a result, progressive growers have moved away from using surface water for irrigation and use only well water to irrigate their crops. While drilling wells is expensive, spreading *Phytophthora capsici* over susceptible crops and introducing it to clean fields also has very expensive ramifications.

If *Phytophthora* is recognized and diagnosed in the field during production, remove the diseased plants and the surrounding healthy-looking border plants immediately. Growers who have successfully managed this disease have seen benefits to plowing under the portions of their fields with *Phytophthora* including a buffer of healthy plants, to create a "firewall" between the problem area and the rest of their healthy crop. Make sure to clean any equipment used in the field to prevent spread to other areas, and discard the infected fruits in an area where crops are not going to be grown. Power washing equipment to remove soil particles and plant debris will be helpful in limiting the movement of *Phytophthora* from problem fields to clean fields. If you do not have a history of *Phytophthora capsici* in your fields, do everything you can to prevent it from occurring. If *Phytophthora capsici* is present in a field, scout often for disease, rotate only with nonsusceptible crop hosts, and irrigate conservatively from a well. Alternate among fungicides to decrease the likelihood of the pathogen from becoming resistant.

Table 3. Summany of recommended management strategies for *Phytophthora capsici* on pumpkins and vine crops.

- Plant into well-drained, tiled fields.
- Avoid using surface water for irrigation.
- Keep fruit off of the ground.
- Scout fields regularly for *Phytophthora*.
- Apply fungicides preventively and at short intervals when needed.
- Powerwash equipment after it has been in infested fields.
- Use raised beds and drip irrigation.
- Irrigate sparingly from a well.
- Rotate crops.
- Do not dump diseased culls in production fields.
- Remove fruits from the field as quickly as possible and store in a warm, dry place.
- Remove any diseased plants and adjacent healthy plants.

Table 4. Products tested for control of *Phytophthora capsici* in 2013 MSU research field studies.

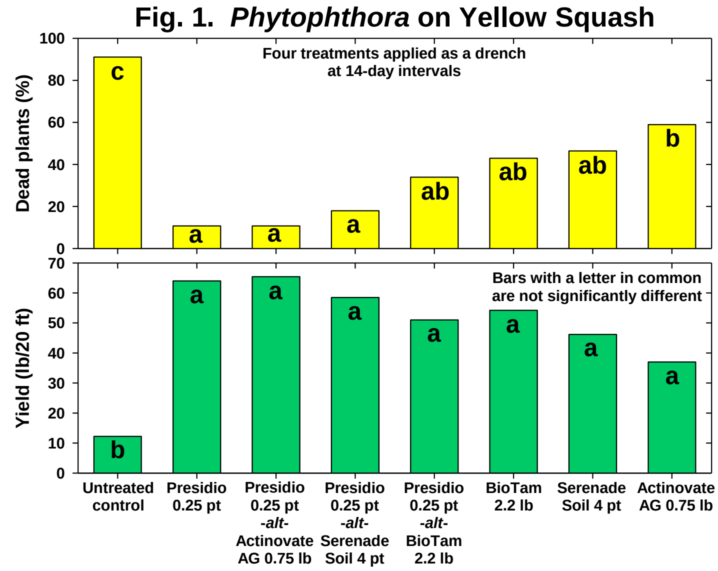
Product	**Active ingredient**	**Labeled**	**FRAC**[1]
Actinovate AG	*Streptomyces lydicus*	yes	NC
Bio-Tam	*Trichoderma asperellum, T. gamsii*	yes	NC
DPX-QGU42	experimental	no	NC
Presidio 4SC	fluopicolide	yes	43
Revus 2.09SC	mandipropamid	yes	40
Serenade Soil	*Bacillus subtilis*	yes	NC

[1]NC=not classified.

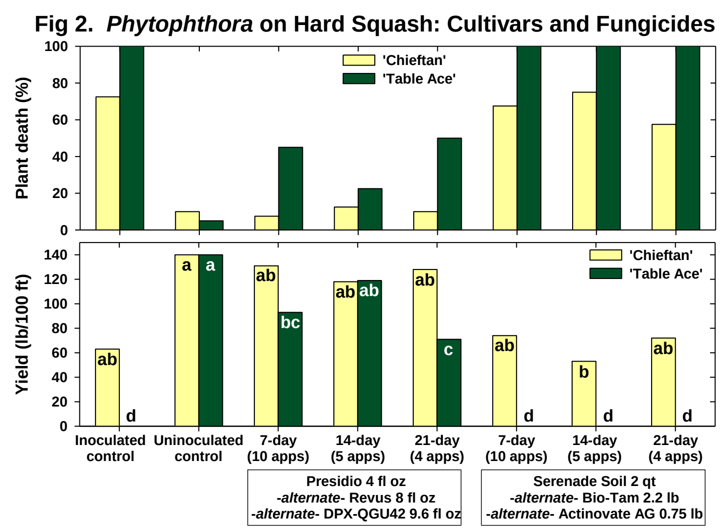
For most crops, applying fungicides for control of *Phytophthora* through trickle irrigation (if allowed per product label) is helpful to protect the plants but foliar applications will be needed later as the fruit develop, especially if the fruit lay on the soil surface in possible contact with the pathogen. Many hard squash and pumpkin plants produce large, dense canopies and proper application equipment is usually required to achieve adequate protection of the fruit. Air-assisted nozzles can help to push the fungicide through the canopy more effectively than conventional nozzles. Several fungicides are registered for use on hard squash and pumpkin. In Michigan, some growing areas have fields with *Phytophthora capsici* isolates that are insensitive to the fungicide mefenoxam (Ridomil Gold, Ultra Flourish).

Evaluation of biopesticides for control of ***Phytophthora*** **crown, fruit and root rot of squash, alone or in combination with Presidio.** This study was conducted at the Southwest Michigan Research and Extension Center located in Berrien County, MI on a sandy soil. Raised plant beds were constructed on 10 June using a RainFlo 2600 plastic-mulch layer. The beds were 6 inches tall and 24 inches wide at the top and were spaced 5½ feet apart on row centers. The beds were covered with 1.25-mil LDPE (low density polyethylene) mulch and a single drip tape (0.65 gpm/100 ft) was installed for plot irrigation. The treatments were arranged in a randomized complete block design with four replicates across eight rows that were 100 feet long. Each treatment replicate was a single row 20 feet long with a 5-feet buffer zone between replicates. Planting holes were made every 18 inches (14 holes per plot) and 'Cougar' squash seeds were sown on 9 July. Treatments were applied as a drench at the time of sowing on 9 July, and repeated at 14-day intervals on 26 July, 6 and 20 August to the emerged seedlings. Product drenches were made by applying the treatment solution to the planting hole after transplanting at a rate of 3 fl oz per hole using a single-nozzle boom equipped with an 8010LP nozzle operated at 13 psi at the boom. Plants in each replicate were inoculated by placing 2 g of *Phytophthora capsici*-infested millet in the soil 1 inch from the plant stem on 9 July. Data were analyzed using Sigma Stat version 3.1 (Systat Software Inc.) and treatments were compared using the Fisher LSD multiple comparison test.

All treatments significantly reduced plant death and increased yield compared to the untreated inoculated control plants (Fig. 1). Actinovate alone did not limit plant death as effectively as other biopesticide treatments of Bio-Tam and Serenade Soil, although yield was not affected. Alternating the biopesticides with Presidio improved the level of disease control for all the biopesticides and increased the total yields of Actinovate and Serenade Soil based programs.



Evaluation of application interval for fungicides applied through the drip irrigation system to manage Phytophthora crown and root rot of two cultivars of fresh market winter squash. The experiment was conducted at the Michigan State University, Southwest Michigan Research and Extension Center in Benton Harbor, MI. On 17 June, fresh market squash cultivars Table Ace (acorn, *Cucurbita pepo*) and Chieftain (butternut, *C. moschata*) were transplanted into 6-inch raised beds covered with black polyethylene mulch. Beds were spaced 5½ feet on center, and rows were 25 feet in length. The field was organized in a split-plot design, with cultivar as the main effect. The trial was arranged with 6 treatments, consisting of three biological (Serenade Soil alternate Bio-Tam alternate Actinovate AG) or three conventional fungicide (Presidio alternate Revus alternate DPXQGU42) programs applied on a 7- (10 applications), 14- (5 applications), or 21-day (4 applications) schedule. After transplanting, the first fungicide in the drip alternation sequence was applied using a backpack sprayer equipped with a TeeJet 8002 flat fan nozzled hand wand and calibrated to 30 GPA. The application was made as a soil drench directed to the crown-soil interface on 19 June. All other applications were made with CO_2 pressurized canisters applied using labeled rates via drip irrigation on 27 June; 1, 8, 15, 22 and 29 July; 4, 12, 19 and 26 August. Five days after the first treatment application, the plants were inoculated with *P. capsici*-infested millet (100 g sterilized millet, 72 ml distilled water, 0.08 g asparagine). Data were analyzed using SAS Proc Mixed and statistical differences were compared using the Student-Newman-Keuls procedure.



'Table Ace' and 'Chieftain' treated with the three Presidio fungicide programs had lower plant death at harvest than the inoculated control (Fig. 2). Yield differences among treatments were not statistically significant for 'Chieftain,' except the uninoculated control compared with the Serenade 14-day treatment. The conventional fungicide programs resulted in lower disease incidence than the biological programs, and higher yields. However, in our study it appeared that 'Chieftain' is less susceptible to *P. capsici* than 'Table Ace' and may be useful in an organic production system that relies on biological control products.

This research was supported by funding provided by the Michigan Vegetable Council.

The Impacts of Managed Flowering Areas on Pollination and Biocontrol in Ohio Pumpkin Crops

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My study system was Ohio pumpkin fields with diverse surrounding landscapes. Ohio pumpkins host three main economically important pests; spotted cucumber beetle (*Diabrotica undecimpunctata*), striped cucumber beetle (*Acalymma vittatum*), and squash bugs (*Anasa tristis/armigera*). They also depend on three main pollinators; generalist honey bees (*Apis mellifera*) and bumble bees (*Bombus spp.*), and the specialist squash bee (*Peponapis pruinosa*). I tested the hypothesis that when floral strips are planted adjacent to a crop, populations of beneficial insects enter the crop from the edges (Platt et al., 1999; Pontin et al., 2005).

OBJECTIVES

Given the importance of pollination by bees, predation, and parasitism of pumpkin pests by natural enemies, and the hypothesis above, I examined the following objectives, organized by ecosystem service:

Predation and Parasitism Objective

2.1) Determine if local addition of floral strips influenced predation of cucumber beetle and squash bug eggs; and parasitism of adult cucumber beetles, and both squash bug adults and eggs.

2.2) Determine if local addition of floral strips influenced the visitation frequency, duration, and pollen deposition of honey bees, bumble bees, and squash bees to male and female pumpkin flowers across the pollination window 6 AM– 12 PM.

METHODS

Study sites

In 2012, a plot consisting of four rows of jack-o-lantern pumpkins (var. “Gladiator”) were established between 10 June and 8 July within each site. No insecticides were applied to these sites. Each plot was divided into 4 sub-plots where all data were collected. Sites were chosen based on grower interest in participating, and by their surrounding landscape. In pumpkin-growing regions of Ohio, 14 sites were included; six in Wayne, Stark, Ashland, and Medina counties in northern Ohio, and six in Jackson, Pike, Highland, Ross, Clinton, and Warren counties in southern Ohio. The visit frequency and duration of bees, and pollen deposition on flowers were investigated only on control and alyssum treatment farms in 2012 because unrelated farmer practices had resulted in high weed competition that reduced pumpkin blooms at those sites.

Habitat management

In October 2010, six sites were selected to establish a 6 x 60 m perennial floral strip treatment of 23 native forbs and 2 grasses. Each grower cleared the area with field cultivators and herbicide, and rolled the soil flat. I mixed the perennial seeds with sawdust at a ratio of 1:2 and spread 1.3 kgs of that mixture at each site to overwinter. The perennial floral strip plots were mowed by the growers once per month to enhance root mass growth during the 2011 growing season.

In 2012, I planted one row of sweet alyssum on either side of pumpkin plots as the annual floral strip treatment adjacent to pumpkins at six sites in northern and southern Ohio. The sweet alyssum was started from seed in 72-cell plug trays in a greenhouse in early May and fertilized twice per week for two weeks. The plants were hardened off outside for an additional two weeks before being between 7-14 June 2012. Plants were watered and Preen Garden Weed Preventer was applied. The transplants were watered via drip irrigation and hand containers (~190 L) twice per week in the field through July.

Six additional sites served as controls, whose growers planted pumpkins adjacent to a mowed grass alley, 6 x 60 m in area.

Measuring predation, parasitism, and pollination

In order to measure predation on spotted cucumber beetle and squash bug eggs, I glued a predetermined number of lab-reared eggs to paper cards and placed 4 sets of them in each field for 48 hours, twice in July. Each card that was open to predation was paired with a card that was covered with a mesh predator excluder for comparison. The proportion of eggs removed from the cards was measured upon retrieval. I videotaped exposed egg masses for 24 hours to identify predator activity.

Parasitism was determined by hand collecting at least 10 striped cucumber beetles, and 10 squash bugs from each site twice in July, and rearing them in growth chambers for 8 days. I then froze them, and dissected them to determine the proportion that had been parasitized. Squash bug eggs were also reared in the growth chamber to determine if any egg parasitoids were present. No parasitoids emerged from squash bug eggs.

Pollination activity was measured by videotaping male and female pumpkin flowers in the field between 6 AM and 12 PM, and by collecting pollen from female flowers exposed to pollinators from 6-8 AM, 8-10 AM, 10-12P M, and 6-12 PM. This occurred once at each site during peak bloom, between July and August, and only sites with a control grass strip or sweet alyssum rows were measured.

RESULTS

Predation and parasitism

In 2012, I found that numerically greater egg predation occurred in pumpkins planted adjacent to the perennial treatments for both species, but there were no significant differences between the numbers of eggs removed from cards across the three types of site treatments. I observed 72.22%, 72.1%, and 80.43% of eggs removed from open spotted cucumber beetle egg cards in pumpkins adjacent to the control, alyssum, and perennial insectaries, respectively (Figure 1). I also observed 8.78%, 7.46%, and 18.43% of eggs removed from open squash bug egg cards in pumpkins adjacent to the control, alyssum, and perennial insectary treatments, respectively (Figure 1).

Similar to predation, in 2012 there was numerically greater parasitism of striped cucumber beetles in pumpkins adjacent to the perennials, but I found no significant difference between parasitism occurring in pumpkins adjacent to a control, and a perennial floral strip treatment. I observed 11.65%, 22.96%, and 24.81% of collected beetles were parasitized in pumpkins adjacent to control, alyssum, and perennial insectaries, respectively (Figure 2). The sample size of squash bug was not large enough to analyze.

I found a large guild of insect and non-insect predators attacking the eggs, and most of the activity occurred between 9 PM and 4 AM. By far, the dominant predators of spotted cucumber beetle eggs were ants and springtails.

Pollination

In 2012, the floral strips had no effect on the visit frequency or duration when each taxa was compared between treatments. For visit frequency, bumble bees were more frequent visitors than honey bees and squash bees to pumpkins adjacent to the control strips (Figure 3). At pumpkins adjacent to the alyssum strips, honey bees had a higher visit frequency than squash bees, but bumble bees still showed a higher frequency than both honey bees and squash bees (Figure 3). For duration of visits, honey bees spent more time in flowers than bumble bees and squash bees in pumpkin plots planted adjacent to both floral strip treatments (Figure 3).

In 2012, there were numerically more pollen grains found in female flowers in pumpkin plots adjacent to the grassy control strip (22407), than the alyssum strip (17855). However, this was not statistically significant (Figure 4).