Wisconsin has a history in the production of fresh market and processing fruits and vegetables including cucurbit crops such as melons, cucumber, squash, and pumpkins. While acreages and crops have changed over the years, growers have adapted and remained leaders in several crops. Additionally, small-acreage fresh market production, particularly organic, continues to expand in Wisconsin. A special focus of this section of the research will emphasize surveys of domestic and native pollinators. To date, we have documented significant reductions in both populations of cucumber beetles and the bacterial pathogen they transmit in susceptible vine crops using these tactics. In addition, we have identified several species of native pollinators which appear to be regularly abundant in fields treated for cucumber beetles. The seasonal abundance and species composition of insect pollinators varied among farm locations with *Apis* and *Bombus* spp occurring most frequently. We have demonstrated the ability to significantly reduce the reliance on broad spectrum insecticides by incorporating IPB-based, cultural practices that prevent damaging beetle feeding.

**Background and Rationale**

Wisconsin Agricultural Statistics report vegetable production on over 112,000 acres in Wisconsin with a total of 2,850 reported processed and fresh market growers. Fresh market vegetables are grown and packaged for direct market sales (road-side stands & farmers markets), produce auctions throughout the state, and for large emerging produce cooperatives emphasizing locally sourced, value-added products (Organic Valley, LaFarge, WI). While acreages and crops continue to evolve in response to market demands and production limitations, growers have adapted and remained leaders in several crops. Although no “official” statistics are collected on fresh market production, the Wis. Fresh Market grower association estimates nearly 1,500 small-acreage producers rowing over 50 crop cultivars in the state. Recent increases in locally grown food has fostered the growth of local produce auctions, expansion of farmers’ markets, and roadside stands in many locations in western Wisconsin. This has provided Amish and some small acreage, non-Amish farmers in the area an opportunity to diversify their farms and enhance farm income by adding vegetable enterprises. Several farms use a significant portion of their land for raising fresh market vegetables. This has presented two primary challenges; first, they have limited experience in growing vegetables commercially, creating the need for training on cultural and pest management practices on a variety of vegetable crops. Secondly, they need to make sure they have enough quality production from their field crops to meet the needs of rapidly emerging markets driven by the regional food sourcing initiatives. These farmers have been seeking information to help with these two concerns from several sources including Agribusinesses, Wis. Cooperative Extension, and other producers.
Among the range of production issues faced by this clientele group, cucumber beetles and the bacterial pathogen *Erwinia tracheiphila*, continue to rank high among limiting factors annually recurring in many areas. The overwintering adult insect causes feeding damage on young, emerging plants as well as blossoms and fruit. In addition to direct damage on plants, cucumber beetles are vectors of the bacterial wilt pathogen. The transmission of bacterial wilt disease is even more serious than direct damage because the disease will kill the plant. Because grower access to IPM strategies for management of this insidious pest complex has been limited, insecticides have been commonly used in conventional cucurbit production for control of cucumber beetles especially in melons and summer squash. Very often, the insecticide options used have been inappropriate formulations applied at inappropriate times leading to direct impacts on native and domestic pollinators and ultimately poor fruit set. IPM practices crucial for successfully improving our management of these beetles and the bacterial wilt pathogen they transmit are the focus of this project.

**Research Objectives / Performance Targets.**

The primary goal of this research project has been focused on the development of a comprehensive set of IPM-based tools to manage the cucumber beetle – bacterial wilt pathosystem and document reductions in total pesticide use and avoidance of risk associated with adoption of IPM.

**Associated Research Goals:**

1. Participating growers will grow a field of highly-vulnerable, cucurbit crops with greater than a 50% reduction in the use of high risk insecticides required to produce a non-resistant variety.
2. Participating growers will achieve a > 75% reduction in disease incidence by layering multiple management tactics with minimal adverse effects on fruit yield or quality.
3. The long-term persistence of cucumber beetle populations and incidence of bacterial wilt inoculum will be reduced by greater than 50% through sanitation and source reduction efforts.
4. Assessing the seasonal host utilization and foraging patterns of native and domestic pollinators in vine crop production with the following sub-goals:
   a. Determine what bee species we find in cucurbit fields in Wisconsin.
   b. Evaluate if field size affects bee visits.
   c. Determine if there are differences in bee visits between field edges and field centers.
   d. Characterize the impact(s) of insecticide inputs that affect pollinator effectiveness.
   e. Determine if different bee species and the number of bee visits affect crop yield.

**Research Approach and Outcomes to Date.**

**Site Selection(s):**

A total of 5 experimental farms were identified on which the proposed research was conducted in 2008. Field locations 1-3 were located approximately 8.8 km southwest of Cashton, WI in both Monroe and Vernon counties. Field Site 1 is operated by Mr. Joseph Kauffman and located at S805 Irish Ridge Rd., Cashton, WI. The principal agricultural outputs of the operation include manufactured wood products, greenhouse bedding plants, and field grown fruiting vegetables and cucurbit vine crops occupying approximately 8.5 acres. Both greenhouse and field grown vegetable produce are sold locally at the Cashton, WI produce auction. Field Site 2 is operated by Mr. Christ Hershberger, S2185 County Highway D, Westby, WI. Here again, agricultural outputs of the farm operation include cucurbit vine crops, fruiting vegetables, and greenhouse bedding plants and hanging baskets produced on approximately 4.5 acres and also retail sold at the Cashton WI produce auction. Field Site 3 is operated by Mr. James Yoder, S3718 County Highway D, Westby, WI and is operated
as a certified organic produce operation occupying approximately 12.5 acres. Similar to the other local farm operations, the range of vegetable offerings are similar in kind but sold as wholesale raw product to Organic Valley’s, Organic Produce Pool, LaFarge, WI. Experimental Site 4 is operated by Mr. Jerry Schneider and Ms. Lisa Riniker, 1103 Habhegger Ave., Sparta, WI and consisted of 12 acres of retail pumpkin. Finally, Field Site 5 is operated by Mr. Grant Murphy, S1028 90 Meter Dr., Westby, WI and consisted of approximately 2.5 acres of cucurbit vine crops as well as a minor component of fruit crops including apples and raspberries. These sites were co-selected to monitor for both native and domestic pollinator species foraging within vine crop production acres.

Briefly, Field Sites 1, 2, and 4 were included as conventional grower locations which adopted the comprehensive program of IPM-based tactics to limit insect and disease pressure, which included reduced-risk insecticides. Experimental Site 3 was included as the ‘organically managed, comparatively standard location which included all non-chemical approaches to management of the insect pathosystem. Field Site 5 was managed by the grower/operator consistent with their past management practices. This site served as the conventional standard location as many broad spectrum insecticides were used for insect and disease control with very little adoption of IPM-based practices.

The methods used for documenting pollinators were designed to be simple, repeatable, and easily incorporated into other concurrent research objectives and were modeled after past research protocols. It provides consistency among locations and years to effectively track population trends and evaluate species richness across different landscapes, and finally to begin to make comparisons across treatments in the total project. To minimize captures of bees from other habitat types, sample plots were located away from the edge of adjacent habitat types and were generally placed centrally in the crop area. Plots were generally no less than 0.75 acre in size and generally consisted of crop that met minimums of 100 m in length and 100 m in width. Detailed records for each plot were kept including surrounding habitat, aspect, slope, latitude, longitude (degrees, minutes, seconds) and elevation. Specifically, vegetation landuse coverage (NASS Landcover Data) was recorded for each site. A list of species that were in bloom for each date is also recorded at each sample site twice through the sample interval.

Plots were sampled on a monthly basis from mid-June to the end of August in 2008. In each plot, pan traps were placed prior to 9:00 am and picked up from the plot after 5:00 pm of the same day by each cooperating grower. As well, two 50-m transects were established in each plot and the pan traps were placed on each transect. Transects were arranged to form an ‘X’ pattern reaching the corners of the plot. Pan trap colors (white, yellow, and blue) were randomly assigned each time the pan traps are placed out at each sample position in the fields. The start and finish of transects were marked to ensure that the same transects were used in subsequent samples.

Pan traps used were small, white Solo brand dishes holding approximately 6 fl oz of liquid. The pans were subdivided into thirds and 1/3 of the pan traps were painted fluorescent blue, 1/3 painted fluorescent yellow and 1/3 left white. Pans were then filled with a solution made up of 1 teaspoon per gallon of dishwashing soap and pans were placed at level ground during the sample interval. After placement in the field for 6-8 hours, we strained all bees in the field and placed these in 75% alcohol. Prior to identifications, the contents of each sample were dumped through a sieve, rinsed with water, and patted dry on a towel to remove excess water. All bees were placed on a paper towel and rubbed gently to remove all excess water and alcohol. We have begun to compile a reference collection through assistance from Ms Hannah Gaines, Department of Entomology, University of Wisconsin, how has greatly assisted with preliminary identifications, pinning and labeling of specimens.
Grower Cooperator Acknowledgements:
- Mr. Jerry Schneider and Ms. Lisa Riniker, 1103 Habhegger Avenue, Sparta, WI 54656
- Michael and David Warzynski, Paradise Farms, 9950 County Road AA South, Almond, WI 54909

First year project accomplishments to be recorded through this interval include:

(A) During monthly field visits, a 10-minute interval of time during the early morning was spent monitoring / recording pollinator services in the main crop and the portion of the crop under row cover. Specifically, the frequency and duration of visits to flowers by domestic honeybees (*Apis mellifera*), wild bumblebees (*Bombus* spp.), and other wild pollinators such as the squash bee (*Peponapis pruinosa*) were evaluated through visual counts.

(B) A total of 11 predominant bee species were recorded from fields:

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apidae</td>
<td><em>Peponapis pruinosa</em></td>
<td>Squash bee</td>
</tr>
<tr>
<td></td>
<td><em>Apis mellifera</em></td>
<td>Honey bee</td>
</tr>
<tr>
<td></td>
<td><em>Bombus impatiens</em></td>
<td>Bumble bee</td>
</tr>
<tr>
<td></td>
<td><em>Melissodes bimaculata</em></td>
<td>Two-spotted miner bee</td>
</tr>
<tr>
<td></td>
<td><em>Doeringiella remigatus</em></td>
<td>Cuckoo bee</td>
</tr>
<tr>
<td>Halictidae</td>
<td><em>Agapostemon sericeus</em></td>
<td>Green sweat bee</td>
</tr>
<tr>
<td></td>
<td><em>Augochloropsis metallica</em></td>
<td>Metallic green sweat bee</td>
</tr>
<tr>
<td></td>
<td><em>Lasioglossum leucozonium</em></td>
<td>Black sweat bee</td>
</tr>
<tr>
<td></td>
<td><em>L. zonulum</em></td>
<td>Black sweat bee</td>
</tr>
<tr>
<td></td>
<td><em>Halictus</em> sp.</td>
<td>Black sweat bee</td>
</tr>
<tr>
<td>Megachilidae</td>
<td><em>Megachile sculpturalis</em></td>
<td>Giant resin bee</td>
</tr>
</tbody>
</table>

(C) We recorded a total of 3,672 total bee visits; 94% of all bee visits were by honey bees, bumble bees, and squash bees. The remaining bees constituted the remaining 6% of total visits to cucurbit flowers over 4 vine crop species (pumpkin, muskmelon, cucumber, and summer squash).

(D) Squash bee and bumble bee visits were higher in smaller fields, but decreased with increasing field size. Honey bee visits increased with increasing field size and were likely supplemented by nearby bee yards.

(E) There were more squash bee visits at field edges than in field centers. No difference between honey bee visits or bumble bee visits and field location.

(F) There were significant differences among pollination treatments in fruit weight. Trends reported in increasing fruit weight with additional bee visits. Honey bees and bumble bees were both effective pollinators of pumpkins, cucumbers, and muskmelons. More than four bee visits required for maximum fruit weight, especially with pumpkin fruit set.

Taken together, the proposed management program continues to enhance the close cooperation that has developed between direct market produce growers, wholesale produce buyers, county agricultural extension agents, and extension specialists at the University of Wisconsin. The collaboration team is very much on course towards the development of sustainable, culturally-based, pest management recommendations to limit the damage caused by cucumber beetles and bacterial wilt.
with an emphasis on reduced pesticide inputs targeted as high risk by FQPA. Field scale trials in the coming year have again been focused on confirming the effectiveness of different strategies within local production systems towards verification that these multiple tactics do not interfere with native and domestic pollinators.