A. Grant Data

Title: Perimeter trap cropping in butternut squash: a systems approach to control striped cucumber beetle and enhance pollination and yield

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State(s) involved: Massachusetts

Years funded: 2005-2007

Funding amount: $59,179.56

B. Nontechnical Summary.

Pollination services are required for yield in many fruit and vegetable crops. However, conventional management practices generally focus on pest control. The extent to which yield is reduced by pests compared to insufficient pollination is unknown, and recent bee declines due to pesticide use, disease and parasites suggest that management of pollinator as well as pest populations may be essential to maintain crop yield.

Our proposal combines research and extension to evaluate perimeter trap crops for reducing pesticide use and increasing yield via resistance to cucumber beetles and attraction of pollinators in butternut squash. Northeastern stakeholders rank cucumber beetles and associated diseases they vector as a region-wide problem that causes significant reduction in yield and results in high pesticide use. Perimeter trap crops (PTC), or the use of an attractive crop to surround and protect main crops from herbivores, have proven effective in reducing pesticide use by 95% compared to conventional management practices. Here we propose to (1) screen 20 cultivars for potential as effective PTCs via interactions with pests and pollinators, (2) test 5 PTC cultivars in experimental plots for potential to increase yield through reduced damage and

increased pollination, (3) select 3 PTC cultivars to compare with conventional management practices on growers' farms. Results of these studies will be communicated to growers through electronic and printed publications and educational programs. This research will further the goals of integrated pest management by providing growers with several options to reduce pesticide use and increase pollination services.

C. Introduction.

The value of vegetable crops sold in the United States was $12.7 billion in 2002. Northeastern states have a high proportion of their vegetable crop industry invested in cucurbit crops including squash, melons, cucumbers and pumpkins; in Massachusetts alone, 40% of the vegetable crop acreage is devoted to cucurbit crops. Yields of winter squash, one of the major cucurbit crops, exceed 20,000 lb/acre with a wholesale value estimated at $3400/acre, or greater than $5 million for the state. Butternut squash is a key winter crop, in part because of strong market demand and excellent storage capability.

Cucumber beetles (*Diabrotica* spp, *Acalymma vittatum*) constitute some of most serious pests of cucurbit crops in the world. These beetles are ranked as the most important insect pest in cucurbit crops in the Northeast, and are the primary target of insecticide applications used by growers. The Northeast Vegetable IPM Commodity Working Group, comprised of growers, crop consultants, processors, departments of agriculture, university researchers, extension specialists, and environmentalists from nine northeastern states, ranked the cucumber beetle and bacterial wilt complex as a region-wide problem that causes significant reduction in yield and results in high pesticide use. Conventional pest management for many cucurbit crops requires 2- 8 applications of pesticides, with an estimated cost of $40-160 per crop. Because beetle colonization of fields can occur within a day, proper timing of foliar sprays according to thresholds can be difficult for growers to achieve. Recently, growers in the Northeast have adopted use of systemic insecticides (e.g., imidcloprid) in the furrow at planting to target early feeding damage; however, the per-acre cost is higher than foliar applications, and adoption in New England remains at <10%.

Pollinators are essential for production of many vegetables, fruits, nuts, cotton and canola. The value of pollination services in agriculture and rangelands has been estimated as $117 billion per year in the United States; the value of honey bees alone to U.S. crop production has been estimated between $5-14 billion per year. Nearly all cucurbit crops require pollination to produce fruit, but the role of pollination on yield is poorly understood. A recent survey revealed that there is a strong perception among Massachusetts growers and agricultural specialists that managed honeybee colonies are declining in quality, and farmers have expressed concerns about pollination and the need for information that affects their production. Declines in beekeeping due to pesticide poisoning, disease, parasites, and the spread of Africanized honey bees are all reducing the availability of honey bee pollination services. The development of management strategies that reduce pesticide use and foster pollination are essential to insure future crop yield in the face of declining bee populations.

Perimeter trap cropping ('PTC' hereafter) is a systems approach to pest control that designs the crop layout to take advantage of pest colonization behavior and host preference. Border defenses are established by planting a more attractive trap crop to completely encircle the main crop, resulting in reduced infestation and reduced need for insecticides in the main crop). While this method has been effective in controlling pest populations and reducing pesticide applications to the main crop, we have little information on how effective different crops function as effective perimeter traps, and what mechanisms (attraction of beetles vs. pollinators) are most important for yield.

D. Objectives.

Objective 1. (Year 1) Correlate pollination and beetle damage, including bacterial wilt, with floral and vegetative traits across 20 cucurbit species and cultivars to identify traits involved in attraction and resistance, and to predict likely cultivars for PTC.

Status: This objective has been largely achieved. We are repeating the field portion this summer to get more data; this will be complete in 2 weeks. Two cultivars were dropped from the analysis because they never flowered in the field or greenhouse. Also, chemical analysis for cucurbitacins was conducted by a collaborator instead of in Adler's lab.

Objective 2a. (Year 1) Compare yield of butternut squash (*Cucurbita moschata*) using 5 different perimeter trap crops in an experimental farm setting.
Objective 2b. (Year 1) Determine how these 5 PTC affect yield via attraction or resistance to cucumber beetles and pollinating bees.

Status: Objective 2 is complete as planned. Data are being analyzed for publication.

Objective 3a. (Year 2) Select 3 cultivars based on data from Objectives 1 and 2, implement PTC using these crops in commercial fields of butternut squash, and evaluate effects on yield compared to fields with conventional pest management practices.
Objective 3b. (Year 2) Determine how these 3 PTC affect yield via attraction or resistance to cucumber beetles and pollinating bees.

Status: This Objective is being addressed this summer and should be complete by mid-September. We used 2 PTC instead of 3, and increased our farms to 21 instead of 20, to increase our statistical power to detect treatment effects.

E. Approach.

Each objective constituted a separate experiment. For Objective 1, we grew 20 squash and related cultivars in a randomized block design at South Deerfield Farm in summer 2005. We measured herbivory and pollinator preference on each plant. In fall 2005, we grew the same cultivars in the greenhouse and assessed several traits thought to be important for herbivore and pollinator attraction. We are repeated the field portion this summer to get more data, and we will then correlate the traits with herbivory and

pollination to find out which traits are most important for attracting pollinators and deterring pests.

Objective 2 was conducted in summer 2005 at the South Deerfield Farm. Five blocks of butternut squash were grown. Each block had 5 plots that were surrounded with a different PTC. Each plot was divided into 4 subplots in which we manipulated herbivory and pollination in a 2 x 2 factorial design. We measured pest damage, pollination, and yield for each subplot to determine how PTC affected yield via herbivory and pollination. Based on these data, we selected 2 PTC for use in Objective 3 this summer, which is ongoing. Twenty-one farms were used, with 7 assigned to each PTC and to a control treatment (no border). We are measuring pest damage, pollination, yield, and pesticide use to determine how PTC affects pesticide use and yield via interactions with herbivores and pollinators.

F. Progress.
We are nearly done collecting data for this project and are completely on target with our proposed timeline. Objective 2 was completed in Year 1. Objective 1 was conducted, but we decided to repeat the field portion this summer to collect more data, which will be complete by the first week of September. We are also still waiting for chemical analysis of cucurbitacins by a collaborator, but all other greenhouse data has been collected. Objective 3 is being conducted this summer, and should be complete by the end of September. We have already presented results from Objective 2 at a grower's meeting, and from Objective 1 at an international symposium. We should have no trouble submitting at least 2, and hopefully all 3, planned papers for publication by the grant's termination in April.