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Project Title: Squash vine borer management by trap cropping and insecticides.

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Introduction:

Squash vine borer (SVB) is a serious pest in summer squash, winter squash and pumpkins, especially on diversified truck farms and small organic farms. One SVB can burrow into a cucurbit stem and kill the entire plant. Control by insecticide is possible but dependent on good timing to kill the larvae before they are safely inside the stem. Growers have been asking how they can control this pest without heavy use of insecticide. A preliminary study done in 2008 found that there were significantly higher infestation rates in unharvested zucchini compared to those that were harvested on a regular basis, which gives the idea that the presence of some unharvested plants could serve as a trap crop for the main crop of squash. For growers who prefer to use insecticide, it has not been clear how many applications are needed, and how a general-use insecticide product compares with the more common restricted-use products.

Objectives of research trial:

Objective 1: Determine if unharvested zucchini can act as a trap crop for SVB, and whether it is more effective if planted early or late, and with or without a row cover to promote early growth.

Objective 2: Determine the best timing and number of insecticide sprays needed to control SVB.

Materials and Methods:

Objective 1: For the trap crop trial, we had eight treatments
1. Early planting, no row cover, unharvested
2. Early planting, no row cover, harvested regularly
3. Early planting, row cover, unharvested
4. Early planting, row cover, harvested regularly
5. Late planting, no row cover, unharvested
6. Late planting, no row cover, harvested regularly
7. Late planting, row cover, unharvested
8. Late planting, row cover, harvested regularly

The early-planted zucchini was transplanted in mid May, while the late-planted zucchini was transplanted four weeks later, in the middle of June. Each plot consisted of four zucchini plants and there were four replicates, each containing eight treatments. All of the zucchini were planted into plastic mulch. We used a transplant soil drench of Admire (imidacloprid), which does not affect SVB, to control for other pests such as cucumber beetle. Row covers were installed immediately after transplanting, and removed once the first female flowers were present. Yield data was taken three times per week from each treatment that was harvested. There was a destructive evaluation at the end of the season in which stems were cut open to check which plants are infested with SVB. Data were subjected to analysis of variance and logistic regression using R studio.

Objective 2: A goal was to compare a typical commercial spray program of two applications of a conventional restricted-use insecticide with two applications of a conventional but general-use insecticide and with a variable number of applications of a less harsh botanical insecticide. The less harsh product was Evergreen, which contains the natural product pyrethrins plus the synergist piperonyl butoxide (PBO). A trial in 2012 found that Evergreen provided excellent control of SVB when applied six times, but we wanted to know if it would provide adequate control if it was used less often. We evaluated Evergreen applied twice (weeks 1 and 3), four times (weeks 1-4), six times (weeks 1-6), and compared it with a restricted-use pyrethroid, zeta-cypermethrin (Gladiator, weeks 1 and 3) and a general-use product, acetamiprid (Assail, weeks 1-3). These six treatments each had four replicate plots, each plot with 20 plants. To determine when to begin spraying for SVB, we used pheromone traps, which were checked three times per week for SVB adults. The first application was done ten days after the first SVB moths were consistently detected in traps. Zucchini was transplanted into plastic mulch in mid-May. A soil drench of Admire was used to control cucumber beetles in all treatments, including the control. Yields were taken for each treatment as weight and as the number of zucchini fruit over 6 inches long. The infestation by SVB was evaluated at the end of the growing season by dissecting each plant stem. Data were subjected to analysis of variance and logistic regression using R Studio.

Results and Discussion

Objective 1:
Our results showed that zucchini planted earlier had significantly higher infestation rates compared to zucchini planted later (Figure 1). The zucchini that started with row covers over them had significantly higher infestation rates than zucchini without row covers (Figure 2), which was likely due to larger size of plants that developed while under row covers. Unharvested zucchini had a significantly higher infestation rate than plants that were harvested regularly in the north field (Figure 3), while in the south field the higher infestation rates were in the harvested zucchini but the differences were not significant (Figure 3). However it is important to note that despite the higher infestation, the zucchini planted earlier had higher yields, as both the number of fruit produced (Table 3) and weight (Table 4). These results support the concept of using early planted zucchini as a trap crop for a later-planted cash crop of zucchini. To reduce yield loss from planting later, the main crop could be deployed less than 4 weeks after the trap crop, or the trap crop

should be planted earlier in the year such as the first of May. The trap crop could also be protected by a row cover to increase its effectiveness due to faster growth and larger size as well as frost protection, but whether row covers are effective enough to justify their cost is not known. In our study, the various treatment plots were small and intercropped. It is likely that a trap crop would be more effective when deployed in a more concentrated arrangement. In a follow-up study, it would be interesting to compare deployment of unharvested early zucchini as a perimeter trap crop versus as strips within a field to evaluate whether or not either arrangement is effective at reducing infestation within the main cash crop. Based on our data, planting early and using row covers and leaving the trap crop plants unharvested would increase the effectiveness of using zucchini as a trap crop, compared to the main cash crop that is planted later, without row covers, and with fruit harvested regularly.

Objective 2:
Due to low infestation by SVB in the untreated plots and due to variability among plots, there were no statistically significant differences among treatments in infestation by SVB (Table 1) or in yield (Table 2). It is possible that the low infestation in this trial was due to the presence of this trial on the same farm as the trap crop trial although the fields were about 800 meters apart. Based on our data, the impact of the number of sprays needed to control squash vine borer by pyrethrins + PBO was inconclusive. Future research on this topic could try using multiple sites to be sure to find sites at which the pest pressure is high enough to cause economic damage. The zucchini treated with Gladiator had the lowest infestation rates even though it was not significantly lower than other treatments. We expect that the number of applications for effective control would vary, based on the type of insecticide used. In the case of Gladiator, which is in the pyrethroid group of insecticides, the longer persistence compared to pyrethrins likely led to the better control even with fewer applications.

Objective 1: Trap crop trial

Figure 1: The average infestation rate of squash vine borer (SVB) for 'Spineless Perfection' zucchini planted early (5/18) and late (6/15) in two fields ($P < 0.001$ for both fields). Within each field, values with the same letter are not statistically significant.

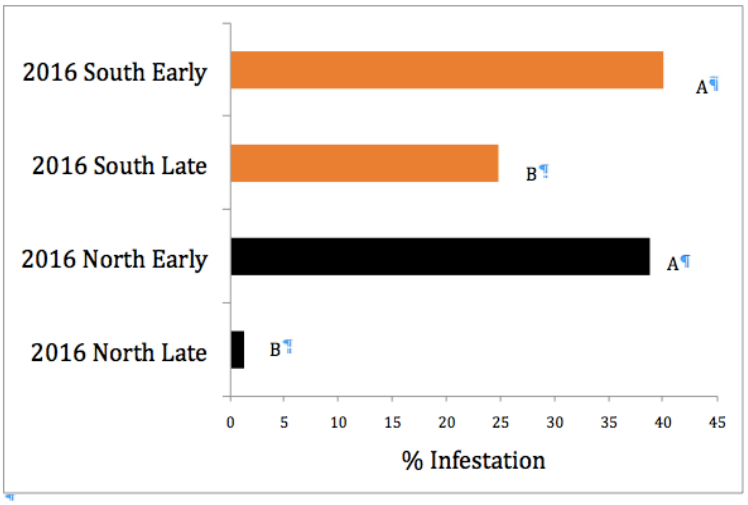

Figure 2: The average infestation rates of SVB in 'Spineless Perfection' zucchini grown with and without row covers (South: $P = 0.0033$; North: $P = 0.0032$), NoNC= no row cover, RC= row cover. Within each field, values with the same letter are not statistically significant.

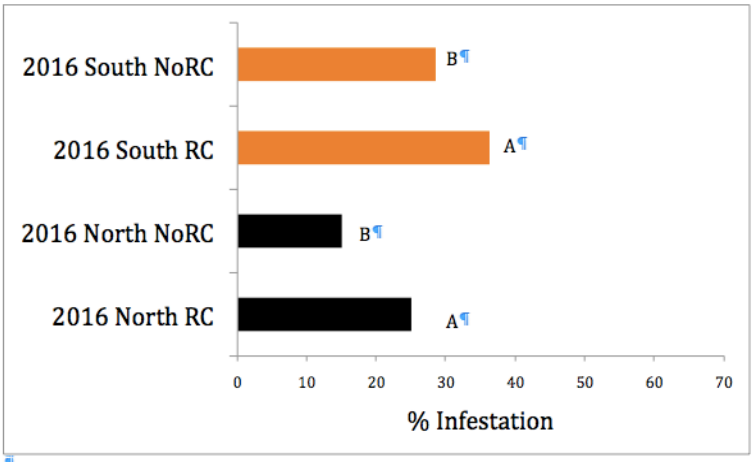

Figure 3: The average infestation rates of SVB for unharvested and harvested 'Spineless Perfection' zucchini (South: $P = 0.3643$; North: $P = 0.0004$). Within each field, values with the same letter are not statistically significant.

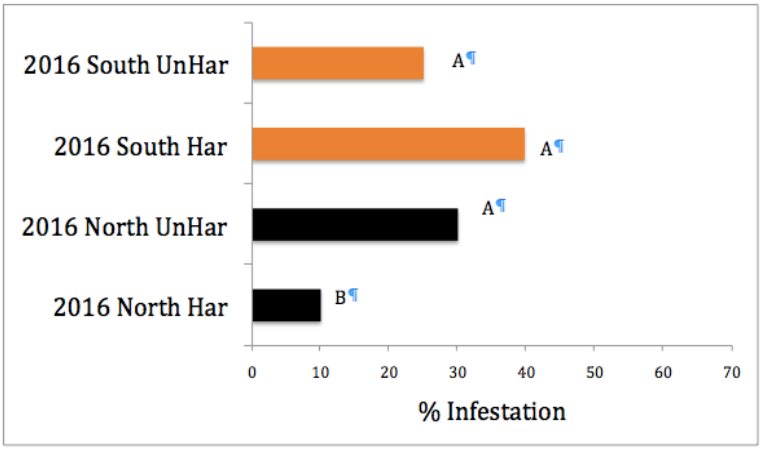

Table 3: The average yield of each plant in number of zucchini fruit ($P < 0.05$). Within each row, numbers with the same letter are not statistically significant.

Field	Early planting		Late planting		P value
	No row cover	With row cover	No row cover	With row cover	
North	4.9 A	5.4 AB	3.6 B	3.8 B	$P < 0.05$
South	4.2 A	3.2 B	2.4 B	3.0 B	$P < 0.05$

Table 4: The average yield of each plant in weight (kg) of zucchini fruit ($P < 0.05$). Within each row, numbers with the same letter are not statistically significant.

Field	Early planting		Late planting		P value
	No row cover	With row cover	No row cover	With row cover	
North	2.4 AB	2.7 A	1.8 B	1.9 B	$P < 0.05$
South	2.0 A	1.5 AB	1.1 B	1.4 B	$P < 0.05$

Objective 2: Insecticide trial

Products and rates tested:

Assail 30SG (acetamiprid): 5.3 oz/acre
Gladiator (zeta-cypermethrin + avermectin B1): 19 fl oz/acre
Evergreen EC 60-6 (pyrethrins + piperonyl butoxide): 16 fl oz/acre

Table 1. The percentage of 'Spineless Perfection' zucchini plants infested by squash vine borer after treatment with insecticides, Columbus, Ohio, 2016. Treatments followed by the same letter in each column are not significantly different than each other. Numbers with the same letter are not statistically significant.

Treatment: insecticide and number of applications	Infestation block 1	Infestation block 2	Infestation block 3	Infestation block 4	Mean infestation
Untreated	0%	13%	0%	20%	8% a
Evergreen, 2 applications	0%	7%	0%	20%	7% a
Evergreen, 4 applications	13%	47%	33%	0%	23% a
Evergreen, 6 applications	20%	0%	7%	0%	7% a
Assail, 2 applications	0%	7%	7%	0%	3% a
Gladiator, 2 applications	0%	0%	7%	13%	5% a
P value					0.256

Table 2. The yield of 'Spineless Perfection' zucchini fruit harvested per plant in each treatment for 26 harvests, Columbus, Ohio, 2016. Within each column, numbers with the same letter are not statistically significant.

Treatments: insecticide and number of applications	Zucchini yield as number of fruit per plant, 2016	Zucchini yield in kg of fruit per plant, 2016
Untreated	19.7 a	9.0 a
Evergreen, 2 applications	20.5 a	10.2 a
Evergreen, 4 applications	20.0 a	9.9 a
Evergreen, 6 applications	19.0 a	9.0 a
Assail, 2 applications	20.9 a	10.5 a
Gladiator, 2 applications	21.3 a	10.5 a
P value	0.489	0.208