Assessing the impact of strawberry clipper in annual strawberry production

Final report

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Research proposal

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OBJECTIVES

1. Determine the frequency and distribution of strawberry clipper weevil damage in annual plasticulture strawberries.
2. Assess the impact of simulated strawberry clipper damage on strawberry yield and harvest period.
3. Screen reduced risk insecticides for efficacy against adult strawberry clipper weevils.

JUSTIFICATION

Strawberry clipper weevil (*Anthanomus signatus*) is a widespread pest of strawberries in the eastern United States (listed as an important pest in AR, CT, ME, MA, NC, NH, NY, OH, PA, RI, TN, VA, and WV strawberry), and feeds on a narrow range of spring flowering crop profiles plants, including strawberries, caneberries, and red bud. Female strawberry clippers (2-3mm long beetles) lay their eggs in developing flower buds, and then chew partially through the pedicel, causing the bud to droop or fall from the plant. Beetle larvae develop and pupate within the flower buds. Following pupation, adults emerge and migrate into wooded areas, where they remain inactive (estivate) through the summer. There is only one generation of strawberry clippers per year.

Because strawberry clippers kill developing buds, thus preventing them from developing into fruit, growers are often very conservative in their management practices and routinely apply broad spectrum insecticides both preventatively and in response to damage by strawberry clipper weevils. However, it is unclear as to whether this aggressive response is justified. Research in New York conducting during late 1990s demonstrated that many strawberry plants compensate for flower loss by producing larger fruit and that clippers rarely lay eggs on primary buds, which produce the largest fruit (Pritts et al. 1999, Kovach et al. 1999). Other plant species have also demonstrated the ability to compensate for injury from related weevils (Long and Averill 2003). However, the results from these studies are not generalizable to southeastern strawberry growing conditions for several reasons. Most notably, previous research on strawberry clipper damage and distribution was conducted in matted row strawberry plantings which differ greatly in production practices from the annual plasticulture strawberry systems common in the southeast.

One significant difference between these systems are the varieties grown, and varieties are known to vary widely in their ability to compensate for bud loss (Pritts et al. 1999). An additional concern specific to annual strawberry plantings is that of seasonality. Insect activity periods occur later in the year in northern growing areas, so it is unclear if strawberry clipper damage timing is the same in the southeast as in the northeast. In addition to potential differences in insect activity timing, harvest periods vary between matted row and annual plantings. One means by which strawberry clippers may indirectly damage plants is by shifting harvest intervals, meaning that plants may compensate for lost buds by fruiting heavily either later or earlier than they would have if undamaged. This potential form of damage is of particular concern to southeastern strawberry growers, as they often try to hit specific intervals for direct market customers, e.g. Mother's Day and Easter.

Our project has taken a three phase approach to understanding strawberry clipper significance in southeastern strawberries. First, we have surveyed commercial strawberry fields to determine how common and severe damage from strawberry clipper weevil is. Second, we have simulated different degrees and timing of damage to determine impacts on yield. Finally, we have screened reduced risk insecticides for efficacy against strawberry clipper in our findings from our first and second activities suggest that management is necessary.

METHODOLOGIES

Objective 1: Determine the frequency and distribution of strawberry clipper weevil damage in annual plasticulture strawberries.

To determine how common damage due to strawberry clipper weevil was, we established monitoring sites at ten NC locations and one VA location. Within each location, four transects were established, each moving into a field from adjacent non crop habitat, most often a wooded edge. Transects were spaced 10m apart and observation points within a transect were placed 20m apart. At each observation point, 4 plants were observed and the total of number of buds present and any clipped buds were counted. A yellow sticky trap was also placed at each observation point to determine if trap captures provided either a warning of upcoming damage or were predictive of damage severity. Clipped buds were counted and traps checked weekly. Traps were changed as needed. In 2015, we also screened commercially available pheromone lures for other *Anthanomus* species, specifically *A. eugenii* and *A. grandis,* to see if there was any cross reactivity between species. Cross species attraction to pheromones has been observed in other *Anthanomus* species.

Objective 2: Assess the impact of simulated strawberry clipper damage on strawberry yield and harvest period.

We assessed the impact of bud removal at three developmental points on yield in a single variety, Camarosa, in the first year of our project. We compared plants with all their primary buds removed, all their secondary buds removed, and all their tertiary buds removed to plants for which no buds were removed. During the second year of our project, we expanded our comparisons to include four other commonly grown varieties; Albion (day neutral), Benicia, Chandler, and Sweet Charlie; and repeated our comparisons with Camarosa. We employed the same methods as in 2014.

Objective 3: Screen reduced risk insecticides for efficacy against adult strawberry clipper weevils.
Because none of the materials we compared during 2014 had activity against strawberry clipper weevils, we selected a different set of reduced risk chemicals to screen in 2015: Assail (acetamiprid), Beleaf (flonicamid), and Entrust (spinosad). These were compared to Brigade (bifentrhin), a grower standard broad spectrum material, and an untreated control, following the same methods employed in 2014.

RESULTS
Objective 1: Determine the frequency and distribution of strawberry clipper weevil damage in annual plasticulture strawberries.
Strawberry clipper weevil were detected at 6 of the 7 commercial monitoring sites, and at one NC site and the VA site, between 40 to 50% of buds were damaged during peak activity (Figure 1). Similar to 2014, activity again began in early April (15^{th} week of the year) and typically decreased by the third week of May (22^{nd} week of the year).

We developed a preliminary degree day model for strawberry clipper, using a lower development threshold of 0C and a biofix date of January 1^{st}. This lower threshold and date combination was selected because they produced the least variable results for our monitoring locations. This model suggests that strawberry clipper weevil damage will begin no earlier than 510 degree days after January $1^{st\,(}$Table 1). We will collect data during 2016 to field validate this threshold, but if accurate, it will be useful for growers to time the start of their monitoring activities.

Trap captures did not reliably predated clipper damage and are not an accurate predictor of strawberry clipper damage.

Objective 2: Assess the impact of simulated strawberry clipper damage on strawberry yield and harvest period.
The removal of all the primary, secondary, or tertiary buds on a plant did not significantly impact total yield for any of the verities compared in either year (Table 2), but there was a significant interaction between yield and time for all varieties except Albion. This resulted in differences in weekly yields between some treatments in some varieties (Table 3). Single berry weights were collected in 2015 and did not differ between treatments, suggesting that these varieties increased in number of fruit they produced, rather than berry size, in response to strawberry clipper damage which compensated for bud loss.

Objective 3: Screen reduced risk insecticides for efficacy against adult strawberry clipper weevils.

Both aetamiprid and spinosad produced significantly higher strawberry clipper mortality than no treatment, and mortality in spinoad treatments was comparable to the grower standard bifenrhin after 120 h of exposure (Table 4).

CONCULSIONS

We have demonstrated that strawberry clipper is common throughout NC and VA strawberry growing areas. Damage occurring at a similar time to when clipper populations were present in commercial fields did not significantly impact total strawberry yield but may potential shift harvest peaks by one to two weeks.

IMPACT STATEMENT

Ours is the first project to assess the impact of strawberry clipper weevil in annual strawberry production in the United States. Based on our results, we expect to revise economic thresholds for this pest in this system to at least 10 clipped buds per plant. We also expect to revise control recommendations to include acetamiprid and spinosad as alternatives to bifenthrin.

Tables

Table 1. Two year accumulated degree days for first strawberry clipper weevil damage dates. Lowest value of coefficient of variance selected the model of a base temperature of -0°C with a biofix date of 1 January.

Biofix date	Base Degree C	Year	Mean	95 CI lower	95 CI upper
1-Jan	0	2014	628.8	548.56	705.82
1-Jan	0	2015	579.12	509.47	666.73

Table 2. Total per plant yield ± SE in kilograms. No significant difference occurs at any variety across treatments α=0.05. (F= 1.57, *df*= 12, 48, *p*=0.1344).

Cultivar	Year	UTC	Primary	Secondary	Tertiary
Albion	2015	0.29±0.03	0.21±0.03	0.24±0.01	0.28±0.05
Benicia	2015	0.48±0.04	0.41±0.04	0.43±0.02	0.57±0.05
Camarosa	2014	1.66±0.09	1.58±0.03	1.47±0.10	1.71±0.01
Camarosa	2015	0.53±0.04	0.42±0.06	0.50±0.04	0.58±0.05
Chandler	2015	0.32±0.06	0.43±0.02	0.42±0.06	0.37±0.08
Sweet Charlie	2015	0.53±0.02	0.44±0.01	0.45±0.03	0.42±0.05

Table 3. Summary of weekly yield affects across all varieties compared during 2015. + indicates increased yield relative to the untreated control; - indicates decreased yield.

Variety	Primary buds removed (number of weeks effect	Secondary buds removed (number of weeks effect	Tertiary buds removed (number of weeks effect

	observed)	observed)	observed)
Albion	0	0	0
Benicia	+ (1)	+ (1)	+ (2)
Camarosa	- (2)	0	+ (1)
Chandler	+ (2)	0	0
Sweet Charlie	0	- (2)	- (1)

Table 4 Mean ± SE. proportion dead *A. signatus* in 2015 experiments. Values followed by different letter within a column indicates significant differences, α=0.05. Data are presented as untransformed means proportions.

Material	**Rate**	**24hr**	**120hr**
Acetamiprid	935.41 L/ha	0.275±0.123**b**	0.325±0.043**b**
Flonicamid	935.41 L/ha	0.050±0.050**b**	0.050±0.050**c**
Bifenthrin	935.41 L/ha	0.90±0.058**a**	1.00±0.0**a**
Untreated Control	935.41 L/ha	0.0±0.0**b**	0.0±0.0**c**
Spinosad	935.41 L/ha	0.10±0.058**b**	0.850±0.096**a**
	df	4, 15	4, 15
	F	28.05	77.58
	p	<0.001	<0.001