Graduate Student CERES Grant Final Report

1. Project Title: Evaluation of Apple Flea Weevil Dispersal and the Potential of Kaolin Clay-Based Management in Organic Apples

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4. Accomplishments

These studies were conducted at commercial organic apple orchards in Eaton and Genesee County, MI and an agricultural research station in Ionia County, Michigan. All orchards consisted of mature trees bearing mixed varieties and planted in a variety of soil types.

Objective 1*.Determine the dispersal capability of Apple Flea Weevil (AFW) within orchard landscapes*

Objective one was addressed through a large-scale mark-release-recapture experiment, performed at Clarksville Horticulture Experiment Station (CHES) in Clarksville, MI. Mature apple flea weevil (AFW) were collected from various organic orchards across Mid-Michigan and marked with fluorescent powder. Once marked, the weevils were released in the center of four 12-row plots, each measuring 165' x 130' in area. Two releases of roughly 300 weevils per plot occurred on 6/28/11 and 7/1/11**.** To measure the dispersal ability of AFW, yellow sticky cards were deployed in a 5 by 6 grid centered around the point of release. These traps were checked every two weeks and changed after one month. In an attempt to recapture marked weevils after over-wintering, yellow sticky cards were deployed again in the late spring of 2012. Weevils were determined as having been marked by exposure to a blacklight hand lamp which caused the marking powder to fluoresce brightly.

Of the thousands of released weevils at all four plots, only five marked weevils were recaptured: three from the Spring of 2012 and two from Summer 2011 (Fig. 1). No marked weevils were recovered from the cards deployed in the Spring of 2011. The longest distance traveled by any marked weevil was 81 ft, recaptured in the Spring of 2012 and the longest distance traveled by a marked weevil captured in 2011 was 62 ft. The average distance traveled by recaptured weevils was 64.5 ft (Table 1).

Given the low number of recaptured weevils, it is difficult to infer useful information from this data. However, it was shown that weevils are capable of moving at least 81 ft. and that, on average, the may move significantly farther than previously expected, given the observed aggregate nature of AFW damage. It is possible that few weevils travel very far but the vast majority remain so long as conditions are favorable. If this experiment is to be repeated, a larger quantity of weevils will need to be released to obtain more tangible results.

Objective 2. *Determine the efficacy of Surround on AFW in lab and field trials*

Significant Revisions: Due to the unforeseen and sporadic weather of the Spring of 2012, AFW adults were not present in the field in large enough quantities to allow for lab testing to occur. In lieu of this,

we modified the focus of Objective two to include more extensive field insecticide testing including exploration of Entrust (Spinosad), a compound shown to be promising in other studies, as well as an assessment of the effect of various insecticides (including Surround and Entrust) on the AFW parasitoid community.

Single Tree Insecticide Trial

To test the ability of Entrust and Surround to control AFW populations, 3 rows were selected in the organic plots at CHES. Each row was made up of at least 20 consecutive trees of similar age and with similar history of moderate AFW infestation. To ensure large-scale oviposition, apple flea weevil were collected from CHES and other organic orchards across Mid-Michigan and isolated with 1-gallon pollinator exclusion bags. The bags were secured on twenty terminals within each of the three experimental rows (20 weevils per bag, 1 bag per tree, 20 consecutive trees per row). Weevils remained isolated on terminals for two weeks, timed around the peak of natural apple flea weevil mating and oviposition, after which they were uncaged and released into the orchard. Entrust and Surround were applied at the recommended grower timings and at the recommended rates (3 oz/acre and 50 lb/acre, respectively).

Insecticide efficacy was measured by beat sampling each of the treated trees prior to application as well as twice following. Due to temperatures near freezing, weevils were absent from the orchard canopy following treatment application which delayed post-spray beat sampling 1 and 2 until warmer conditions availed (9 days and 19 days after treatment application, respectively).

Number of collected weevils was significantly affected by treatment during both collection dates. Weevil populations were significantly different between Surround treated trees and Entrust treated trees at both timings (Fig. 2). Populations were lower in Entrust treated rows than in Surround treated rows 9 days after application but were higher in Entrust rows 19 days after treatment (Fig. 2). Additionally, trees treated with Entrust yielded significantly higher numbers of apple flea weevil than untreated trees on the second collection date (Fig. 2).

Parasitoid Study

Treatment effect on the apple flea weevil parasitoid community was measured through repeated collection of leaves infested with apple flea weevil larvae. Leaves with visible apple flea weevil mines were collected from terminals on which weevils had been isolated (1 per tree, 20 trees per row) starting the day of application and repeated ten times throughout the six weeks following application. Infested leaves were transported to the lab and stored in sealed petri dishes for 2-3 months. Dishes were checked weekly for emergence of either adult apple flea weevil or parasitoids.

Average parasitism rate (total parasitoids/total samples) across all treatments was 16%. The untreated control had the highest parasitism rate of any individual treatment at 18% (Fig. 3). Parasitism ratio is an indicator of the percentage of total emerged organisms represented by parasitoids [calculated as # parasitoids/(# parasitoids + # AFW)]. Average parasitism ratio was .63 across all treatments. The untreated control had the highest parasitism ratio of any treatment at .68 (Fig. 4). None of the treatments significantly affected the quantity of parasitoids or apple flea weevil that emerged from the collected leaf mines.

Entrust Timing Study

In the Spring of 2012, the effectiveness of of Entrust applications at various phenological stages of apple bud development was tested at two Mid-Michigan organic orchards [AlMar Orchards, Flushing, MI (Farm 1) and The Country Mill, Potterville, MI (Farm 2)]. Entrust (80% Spinosad, DowAgro) was applied at the label rate (3oz./ acre) at Pink stage or at Tight Cluster stage. Efficacy of each timing was measured in two ways: 1) ten weevils were bagged on bud bearing terminals immediately following treatment applications. Weevils were removed from the terminals 48 hours later. The number of surviving weevils was observed and recorded at 48 and 72 hours. 2) Beat sampling was performed on trees within treatment rows prior to and immediately following treatment. The number of AFW captured during sampling were counted and recorded.

Entrust application timing was shown to significantly affect natural populations of apple flea weevil collected via beat sampling. Both application timings caused significantly higher mortality than the respective untreated controls (Fig. 5). The application timings did not cause significantly different mortality of natural populations (Fig. 5)**.**

Entrust application timing was shown to significantly alter mortality of bagged AFW. Both application timings caused significantly higher mortality than the respective untreated controls (Fig. 6). Entrust application at Pink caused significantly higher mortality than application at Tight Cluster (Fig. 6).

Entrust Rate Study

In the Summer of 2012, the effectiveness of Entrust applications at full label rate (3oz./ acre) and half the label rate (1.5oz./ acre) was tested at the same Mid-Michigan organic orchards as the Entrust Timing Study. Entrust was applied at the peak emergence for the Summer generation of apple flea weevil. Efficacy of each timing was measured in two ways: 1.) ten were bagged on bud bearing terminals immediately following treatment applications. Weevils were removed from the terminals 48 hours later. The number of surviving weevils was observed and recorded at 48 and 72 hours. 2.) Beat sampling was performed on trees within treatment rows prior to and immediately following treatment. The number of AFW captured during sampling were counted and recorded.

Rate of Entrust application was shown to significantly alter mortality of bagged weevils. Both application rates caused significantly higher mortality than the untreated control (Fig. 7). Although the full label rate application caused 7% higher mortality than the half label rate, this effect was not statistically significant.

Entrust application rate was not shown to significantly affect natural populations of apple flea weevil collected via beat sampling. Neither application rate caused a significant change in mortality compared to the untreated control (Fig. 8). The application timings did not cause significantly different mortality of natural populations.

Objective 3. *Disseminate project results to the organic apple-growing community*

Project results have been shared with growers of organic apples through a number of channels. Preliminary results and concept were shared through a pamphlet released at an Organic Tree Fruit Grower Association Field Day in Flushing, MI on August 06, 2011. Information regarding this project was also presented at the 2011 Great Lakes Fruit, Vegetable and Farm Market Expo (Grand Rapids, MI, December 05-08, 2011) in the form of a presentation entitled “Seasonality and Management of Apple

Flea Weevil in Organic Apples," and again in a poster at the 2012 Midwest Organic and Sustainable Education Service (MOSES) Organic Farming Conference in LaCrosse, WI from February 24 to 25, 2012 entitled "Biology Based Management of the Apple Flea Weevil". Final results will be shared by poster at the 2013 Entomological Society of America: North Central Branch Annual Meeting (June 2013). Additionally, all posters and presentations are available online at the Organic Pest Management Laboratory's website (www.opm.msu.edu)

5. Impacts

This research has helped add to our understanding of the biology and management of AFW. The results of these experiments are some of the first data about this pest that have been conducted in over half a century. Growers experiencing pest pressure from apple flea weevil will be able to directly and immediately benefit from the results of the insecticide trials. Some of our grower-collaborators had expressed concern that without practical solutions to AFW damage, they may have explored conventional growing practices. With the information collected in this study we hope to assuage their fears and allow them to continue growing apples organically and sustainably. Beyond that, the basic biological information discovered about the dispersal ability and parasitoid community of this pest will help to build a foundation of knowledge that can be added to by further experiments within and outside of our lab. The fundamental parasitoid research here will also help growers understand the impact of various chemical pest management regimes on an important class of natural enemies of apple flea weevil.

6. Figures

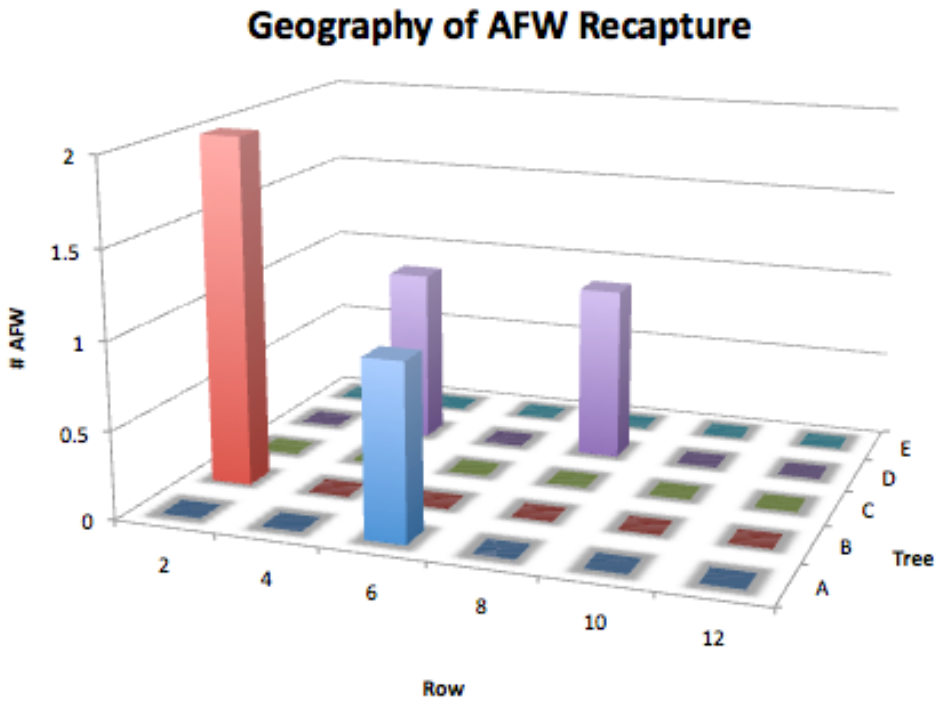

Fig. 1 (Note: Weevils were released from Row 7, Tree C)

Table 1. Distance From Release Point to Recapture Traps (in ft.)

	Row 2	Row 4	Row 6	Row 8	Row 10	Row 12
Tree A	96	75	62	62	75	96
Tree B	81	54	45	45	54	81
Tree C	75	45	15	15	45	75
Tree D	81	54	45	45	54	81
Tree E	96	75	62	62	75	96

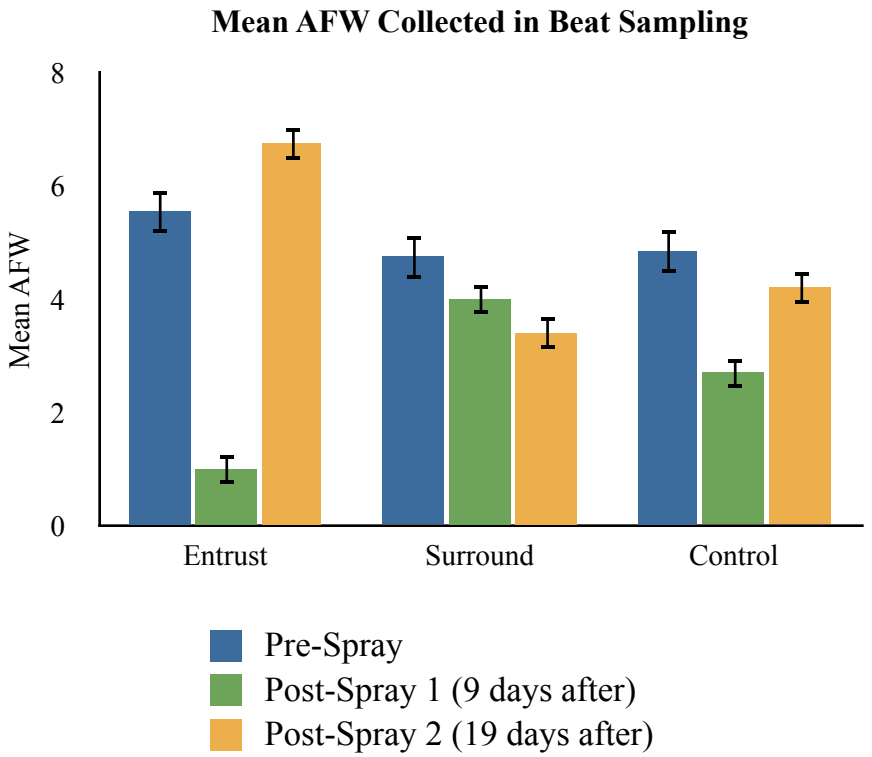

Fig. 2

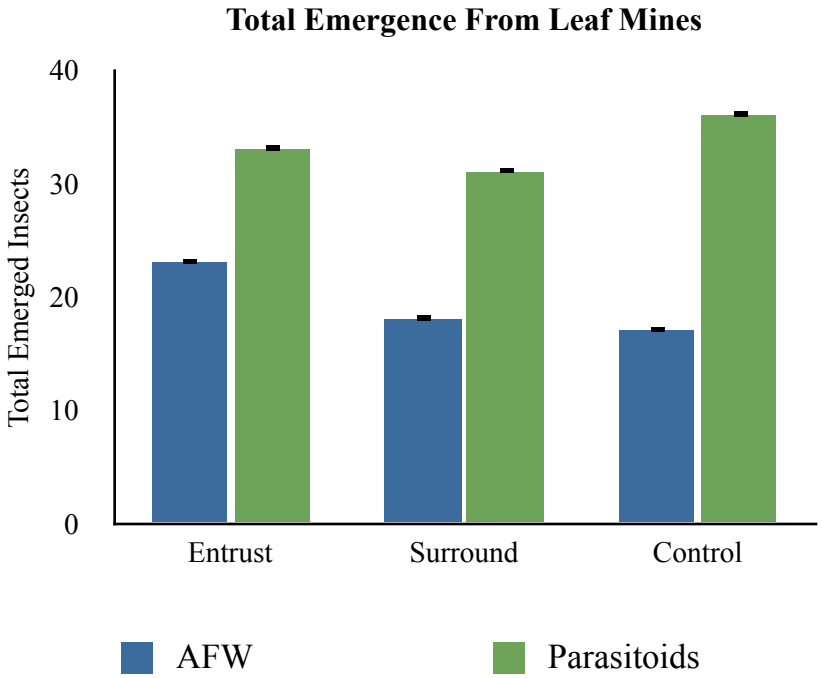
Total Emergence From Leaf Mines
40
30
20
10
0
Total Emerged Insects
Entrust
Surround
Control
AFW
Parasitoids

Fig. 3

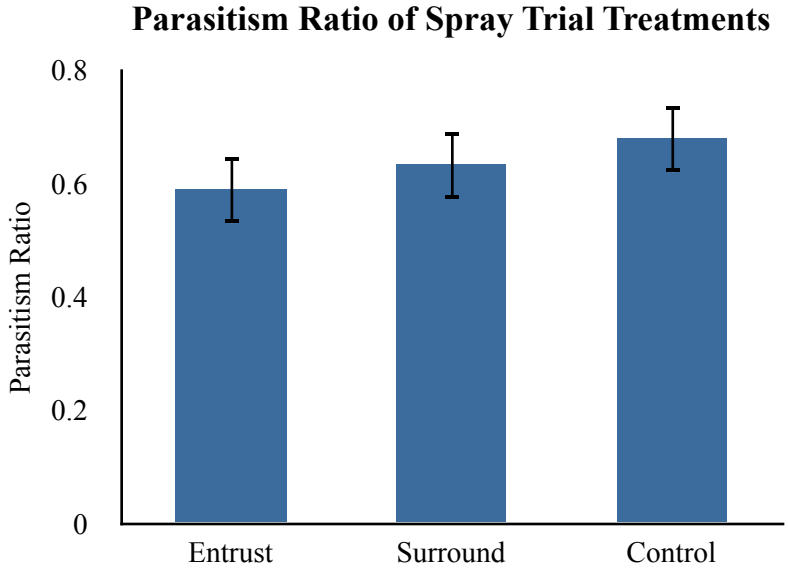
Parasitism Ratio of Spray Trial Treatments
0.8
0.6
0.4
0.2
0
Parasitism Ratio
Entrust
Surround
Control

Fig. 4

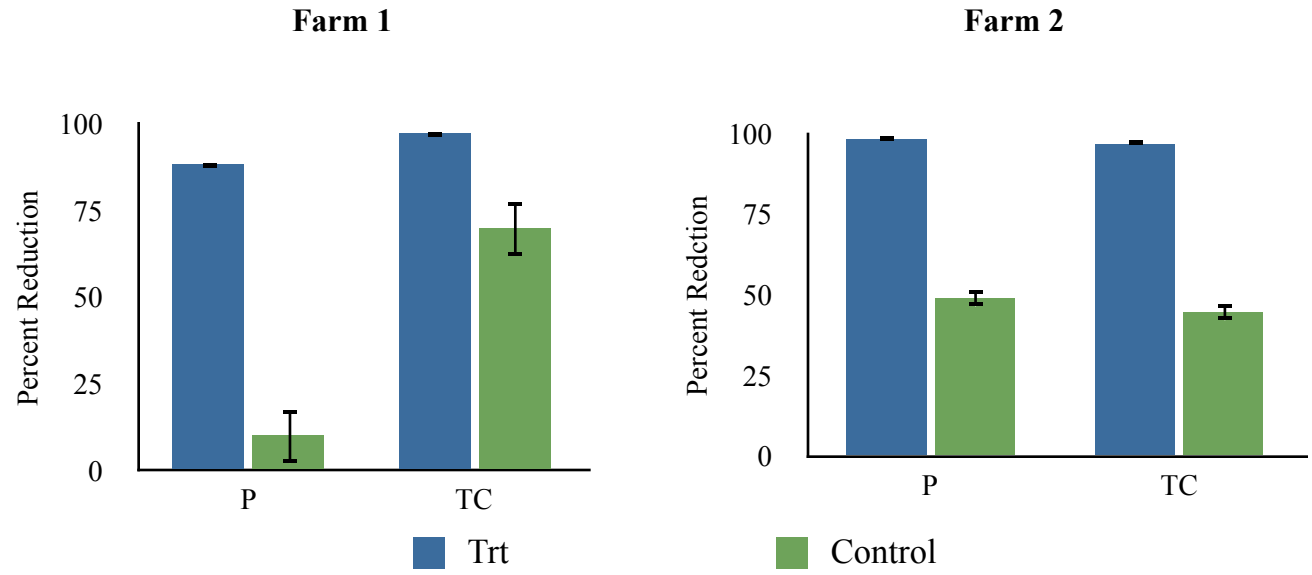
Percent Reduction in Beat Sampling Collections, Entrust Timing Study
Farm 1
Farm 2
Percent Reduction
Percent Redction
100
75
50
25
0
P
TC
Trt
Control

Fig. 5

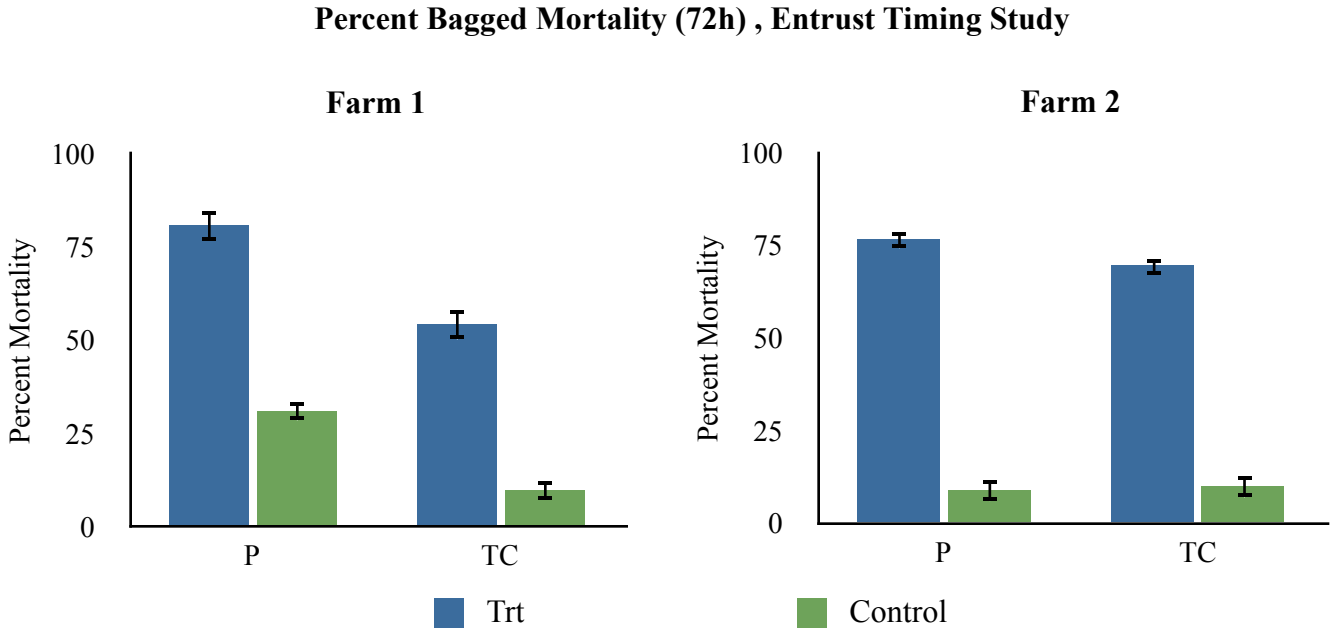
Percent Bagged Mortality (72h) , Entrust Timing Study
Farm 1
Farm 2
Percent Mortality
100
75
50
25
0
P
TC
Trt
Control

Fig. 6

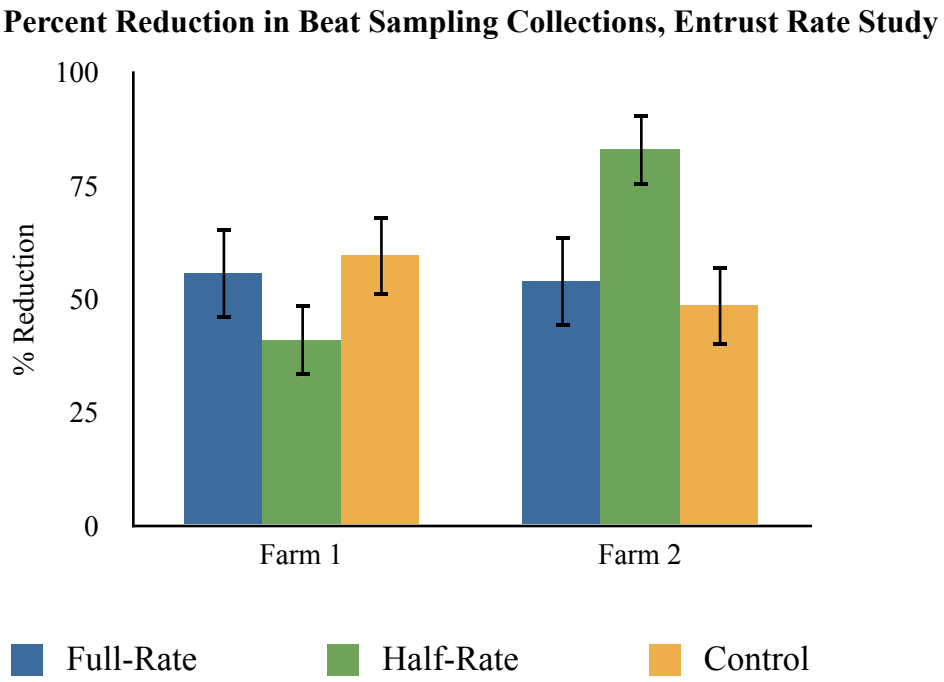
Percent Reduction in Beat Sampling Collections, Entrust Rate Study
100
75
50
25
0
% Reduction
Farm 1
Farm 2
Full-Rate
Half-Rate
Control

Fig. 7

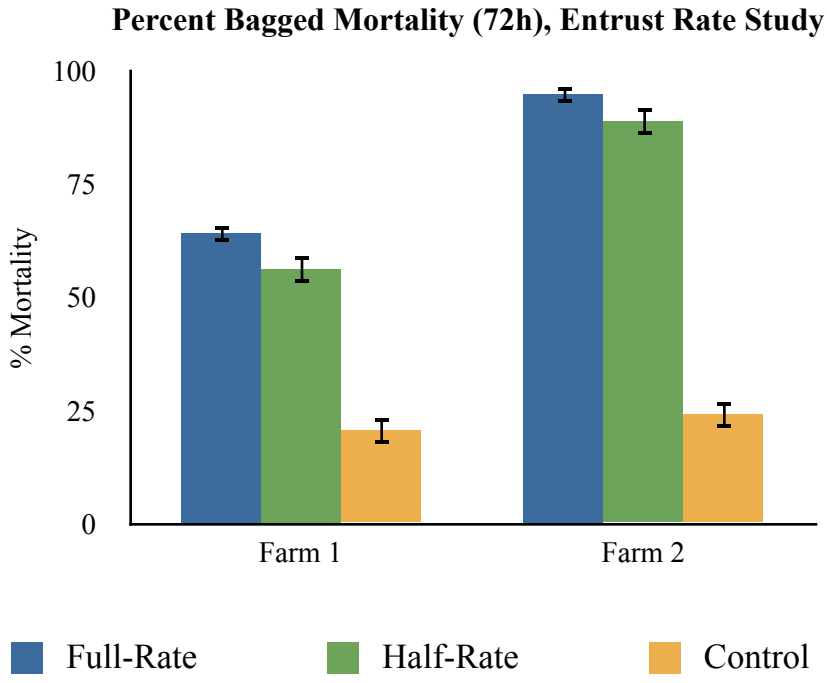
Percent Bagged Mortality (72h), Entrust Rate Study
100
75
50
25
0
% Mortality
Farm 1
Farm 2
Full-Rate
Half-Rate
Control

Fig. 8

Fig. 9 Apple Flea Weevil Adult

Fig. 10 Apple Flea Weevil Leaf Damage