Efficacy of Cyclaniliprole for Western Cherry Fruit Fly (*Rhagoletis indifferens*) Control in Tart Cherry in Northern Utah
2015

Diane Alston, Entomologist, and Thor Lindstrom, Research Associate
Utah State University

Objective:
To evaluate the efficacy of a new insecticide in IRAC Class 28, IKI-3106 (cyclaniliprole) from ISK Bioscience Corporation, for control of western cherry fruit fly (*Rhagoletis indifferens*) in tart cherry in northern Utah. The performance of cyclaniliprole was compared to an untreated control and a registered insecticide in the same class, chlorantraniliprole (Altacor).

Class 28 insecticides are ryanodine receptor modulators. Previously discovered insecticides in this class are in the diamide subgroup and are known to impair nerve and muscle function which leads to rapid feeding cessation, regurgitation, lethargy, and contractile paralysis. Translaminar and limited systemic activity have been demonstrated for insecticides in this class, as well as excellent safety to mammalian, avian, and aquatic organisms.

Methods:
Experimental Design
The study was conducted in a 2.6-acre 'Montmorency' tart cherry orchard planted in 2003 at the Utah State University (USU) Horticulture Research Farm in Kaysville, UT. Tree and row spacing was 11 and 20 ft, respectively. Trees were approx. 15-20 ft tall and the canopy had filled its space within the row. Plot size was 18 trees (three rows by six trees within a row) surrounded by one row of untreated buffer trees, and replicated four times in a randomized complete block design (see plot map). All insecticide treatments were applied three times at a 7- or 9-day interval on June 3, 12, and 19. Insecticides were applied with a multi-tank orchard airblast sprayer pulled behind a tractor. Spray volume was 100 gal per acre and sprayer pressure was 100 psi. All spray solutions were buffered to pH 7. Other pesticides applied to the plots included fungicides for powdery mildew control, but no insecticides other than those included in the study treatments were applied.

Treatments:
1. Untreated control
2. Altacor WG 3.0 oz per acre (label rate is 3.0 to 4.5 oz per acre)
3. Cyclaniliprole 16.4 oz/acre
4. Cyclaniliprole 22 oz/acre

Insect Monitoring
One Pherocon AM yellow sticky trap with additional ammonium carbonate (AC) bait was placed on the southwest side of one center tree in each plot on May 12. Traps were checked every 2-3 days; the first capture of western cherry fruit fly (WCFF) was on May 20. Traps were serviced approximately weekly through June 30 when the trial was concluded. On each weekly sample date, WCFF were collected, AC bait boxes refilled, and all traps replaced on June 9. Adult WCFF were placed into labeled vials with

histoclear to dissolve the adhesive. After several weeks in histoclear, flies were transferred to 70% ethyl alcohol for storage. Flies were examined under a dissecting microscope (10-30 × magnification) to determine their sex, and female abdomens were dissected to determine reproductive maturity (fully developed eggs present, or not). Numbers of captured adults across sampling dates, and cumulative numbers of adults captured during the study period, were compared among treatments with analysis of variance (SAS Institute Ver. 9.3; Proc Mixed). The frequency of capture of male vs female adults, and immature vs mature females, was compared among treatments with a chi-square test (SAS; Proc Freq).

Fruit Injury Sampling

One hundred of the ripest cherry fruits were collected from the center four trees of each plot on June 2, 9, 15, 23, and 30 (for a total of 2,000 fruit per treatment). Fruits were transported in labeled press-seal plastic bags on blue ice to the lab. Any WCFF larvae that had exited the fruit within the bag were counted. Fruit were placed on wire mesh trays over plastic bins (18 cm wide × 30 cm long ×12 cm deep) to collect third-instar larvae as they emerged from fruits. A strip of Vaseline was smeared around the inside rim of each plastic bin to prevent escape of larvae. The emergence bins were placed in a cool, dry storage room for four weeks, and the number of WCFF pupae in the bottom of each bin was counted. The number of WCFF that emerged from fruit (larvae and pupae) was compared among treatments and sample dates with analysis of variance (SAS; Proc Mixed).

Leaf Arthropod Density Sampling

To assess if the insecticide treatments influenced densities of mites and insects on leaves, twenty leaves were collected from the center four trees in each plot on June 18 and 30. Leaves were selected from the inner and outer canopy, and high and low in the trees. Leaves were processed with a mite brushing machine (Bioquip Products, Rancho Dominguez, CA), and arthropods counted under a dissecting microscope at 10-30× magnification.

Phytotoxicity Assessment

On June 30, the leaves and fruits of treated trees were observed for symptoms of phytotoxicity, including discolored spots, shriveling, puckering, or bronzing.

Results:

WCFF Adult Densities

The first emergence of WCFF adults was detected on May 20 at 1,074 degree-days base 41°F (DD_{41}). The phenology model developed by AliNiazee and Stark (AliNiazee 1979, Stark and AliNiazee 1982) predicted first emergence at 950 DD_{41}, which occurred on May 12, eight days earlier than observed. Although the study orchard has a history of high WCFF densities which can contribute to early first emergence (Alston and Murray 2010), unusually warm temperatures during January and February caused large DD_{41} accumulations relative to tree phenology and historical calendar dates of first WCFF emergence. First emergence of WCFF was the earliest date on record for the USU research farm.

Beginning in late May, trap capture gradually increased and peaked in mid-June (Fig. 1). There were significant differences in adult capture among sample dates ($p < 0.0001$) with highest counts on June 9, 15, and 23. Insecticide treatments significantly influenced cumulative trap capture of adults ($p = 0.04$)

with highest densities in the untreated, lowest densities in the high rate of Cyclaniliprole (22 oz), and intermediate densities in Altacor and Cyclaniliprole 16.4 oz (Fig. 2).
Comparison of frequency of male vs female adults did not vary among insecticide treatments ($p = 0.84$); for all treatments, more males than females were caught on traps (Fig. 3). In contrast, the frequency of female adults with immature vs mature ovaries did vary among insecticide treatments ($p = 0.05$); substantially more immature than mature females were captured in untreated plots, while the ratio was similar or slightly opposite in all insecticide-treated plots (Fig. 4).

Fruit Injury
Fruit infestation differed among treatments, but not among sample dates (Figs. 5 and 6). Infestation was greatest in the untreated control, Altacor had intermediate infestation levels, and both Cyclaniliprole treatments had the fewest WCFF ($p < 0.0001$) (Fig. 5). Both of the Cyclaniliprole rates had a very low number of fruit infested on the first sample date, June 2, but no further infestation was detected on later dates. Altacor had low numbers of WCFF infesting fruit on all sample dates. In the untreated control, fruit infestation levels increased with later sampling dates (Fig. 6).

Leaf Arthropod Densities
Densities of arthropods on cherry tree leaves during mid- and late June were low, less than five per 20 leaves. There were no differences in arthropod densities among treatments ($p > 0.05$); however, there were differences among the two sample dates: there were more twospotted spider mites and white apple leafhoppers on June 30 than on June 18 ($p = 0.01$ and 0.002., respectively) (Figs. 7 and 8).

Phytotoxicity
No symptoms of phytotoxicity were observed on leaves or fruit for any of the insecticide treatments.

Conclusions:
Population pressure of western cherry fruit fly in this study was high. The larger plot size used in 2015 (18 trees) vs 2014 (6 trees) increased the WCFF population due to a higher proportion of unsprayed trees, and allowed for greater differentiation in adult densities and fruit infestation among treatments.

The high rate of Cyclaniliprole significantly reduced the number of adults captured on traps as compared to the untreated control. Altacor and the low rate of Cyclaniliprole had intermediate densities of adults. Similar ratios of male to female adults were captured in all treatments. In contrast, the ratio of mature to immature females (ovaries of mature females contain fully developed eggs) was closer to 50:50 for all insecticide treatments, but was skewed toward more immature females in the untreated control. The greater proportion of immature females in the untreated control could be caused by higher overall adult populations in these plots, but the reason for this difference is unknown.

In contrast to the 2014 trial, Cyclaniliprole at the high rate exhibited adulticide activity. Additionally, the low rate of Cyclaniliprole and Altacor showed modest reductions in adult populations, but not significantly less than the untreated. A likely explanation for observation of adulticide effects in 2015 is the larger plot size. WCFF populations were able to build up to high levels in the untreated plots, resulting in greater differentiation with insecticide-treated plots. In addition, the lowest label rate of

Altacor was used in the 2015 study (3 oz per acre), whereas the highest label rate was used in 2014 (4.5 oz per acre). Use of the lower rate may have reduced the efficacy of Altacor against WCFF as compared to the 2014 study. The reason the lower rate of Altacor was used is the maximum allowable label amount is 9 oz per acre per year (3 applications × 3 oz per application = 9 oz).

There was differentiation in fruit infestation among the treatments. Untreated control plots had significantly more WCFF emerge from fruits than all of the insecticide treatments. Altacor did not perform as well as Cyclaniliprole in protecting fruit. Low numbers of WCFF larvae emerged from fruits treated with Altacor on all five sample dates; however, both Cyclaniliprole rates had a very low infestation on the first sampling date, but not on any other date. Fruits may have become infested before the first insecticide treatments were applied on June 3. The first adults were caught on traps on May 20, 14 days before the first applications were made. WCFF females require about one week after emergence to fully mature their ovaries (Alston and Murray 2010); therefore, fruit infestation on the first sample date was likely caused by eggs that were laid before insecticides were applied.

Neither Altacor nor Cyclaniliprole stimulated pest mite or insect densities on leaves. Leaf arthropod densities were low, and there were no differences among treatments; however, white apple leafhopper densities were higher, but not significantly, in both Cyclaniliprole treatments. The reason for the slight increase in leafhoppers in Cyclaniliprole plots isn't certain, but the insecticide may have reduced a parasitoid or predator that wasn't measured in the leaf samples.

Three applications of Chloraniliprole (7-9 day intervals) at 16.4 and 20 oz per acre were effective in protecting tart cherry fruits from infestation by western cherry fruit fly. The very low fruit infestation on the first fruit sample date, June 2, was likely caused by a late start in insecticide applications. Both rates of Cyclaniliprole protected cherry fruits from WCFF throughout the fruit maturation period.

References:

AliNiazee, M. T. 1979. A computerized phenology model for predicting biological events of Rhagoletis indifferens (Diptera: Tephritidae). The Canadian Entomologist 111: 1101-1109.

Alston, D. and M. Murray. 2010. Western cherry fruit fly (Rhagoletis indifferens). Utah Pests Fact Sheet ENT-102-06. Utah State University Extension, Logan, UT. http://extension.usu.edu/files/publications/factsheet/western-cherry-fruit-flies06.pdf

Stark, S. B. and M. T. AliNIazee. 1982. Model of postdiapause development in the western cherry fruit fly. Environmental Entomology 11: 471-474.

Fig. 1. Effect of insecticide treatments on adult WCFF trap capture from May 20 to June 30, 2015, Kaysville, UT. Arrows indicate treatment spray timings.

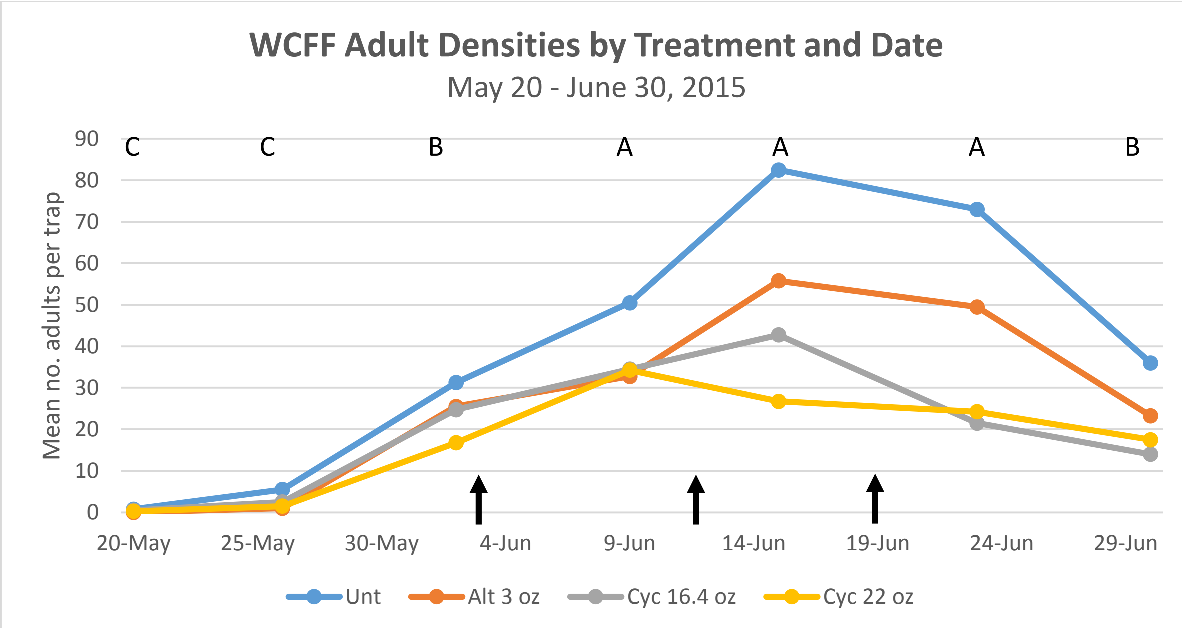


Fig. 2. Cumulative capture of WCFF adults during the study period: May 20 to June 30, 2015, Kaysville, UT.

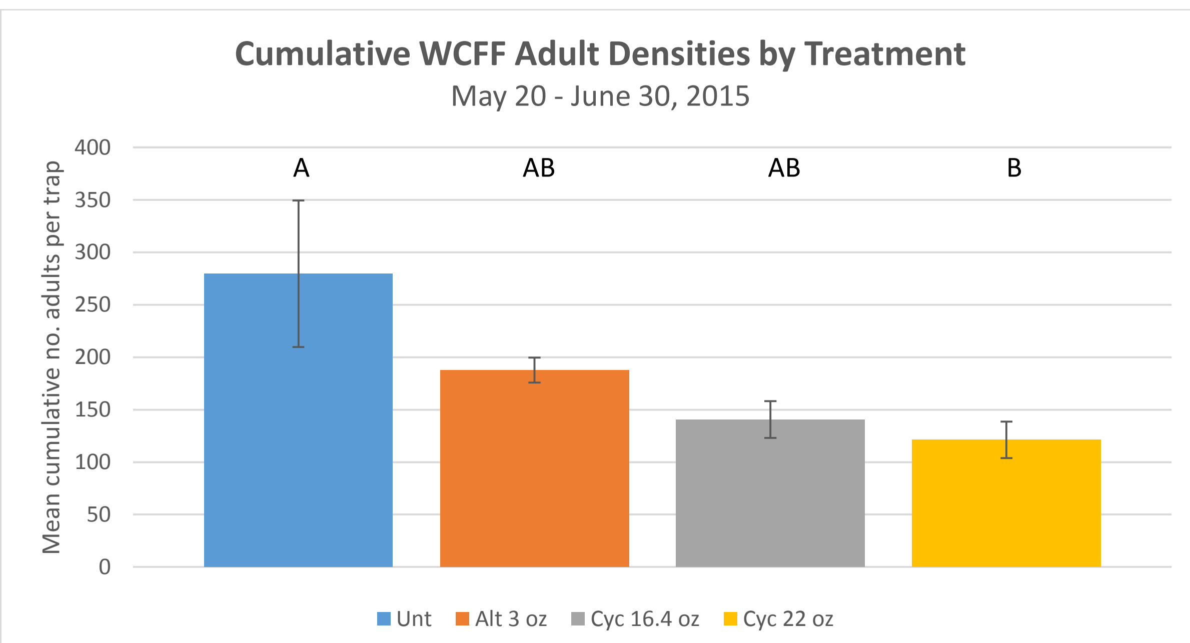


Fig. 3. Comparison in cumulative capture of male and female WCFF among insecticide treatments.

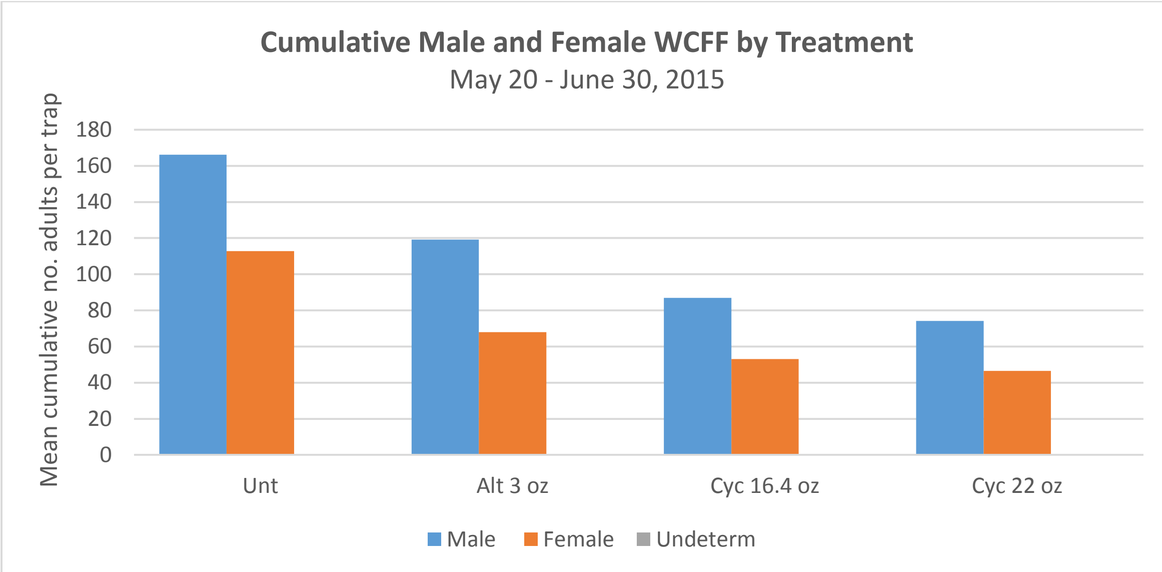


Fig. 4. Comparison in cumulative capture of immature and mature female WCFF based on ovary status among insecticide treatments.

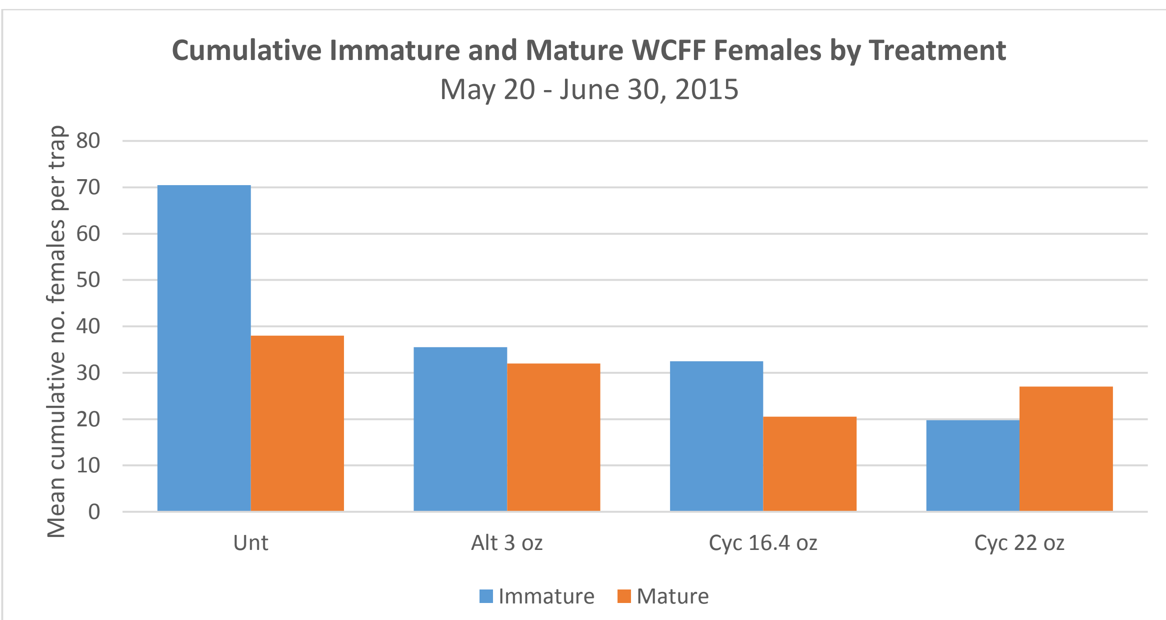


Fig. 5. Influence of insecticide treatments on fruit infestation by western cherry fruit fly (WCFF), Kaysville, UT, 2015. Stacked bars show mean number of emerged larvae per 100 fruit per sample date.

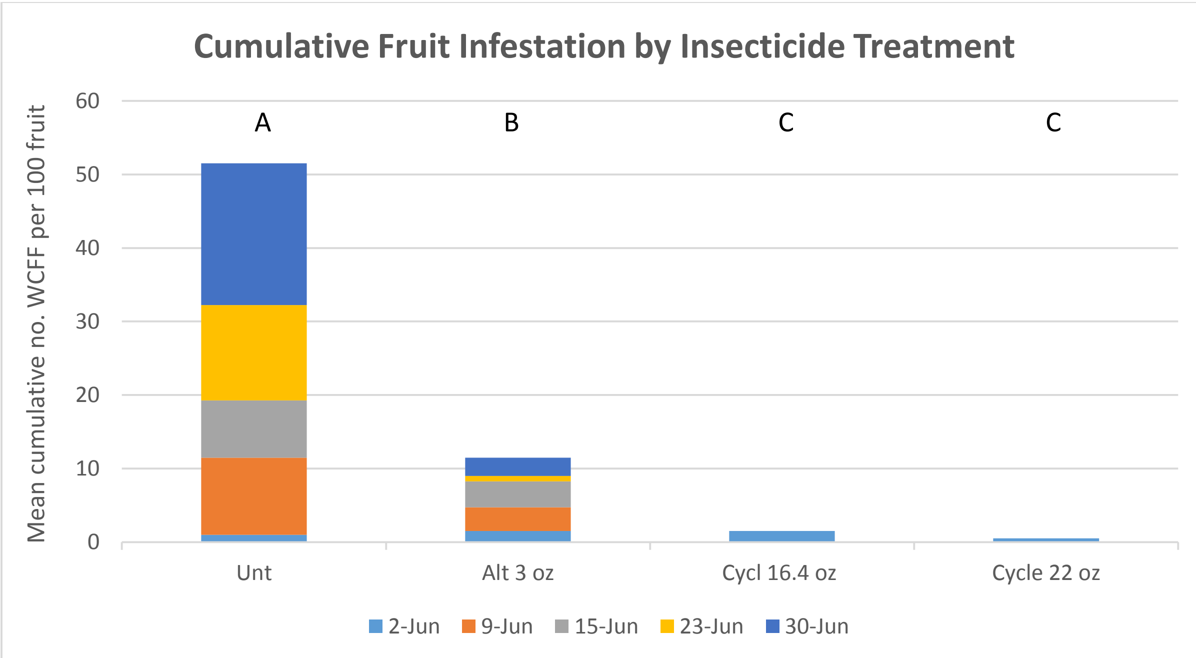


Fig. 6. Fruit infestations as influenced by insecticide treatments plotted across sample dates, Kaysville, UT, 2015.

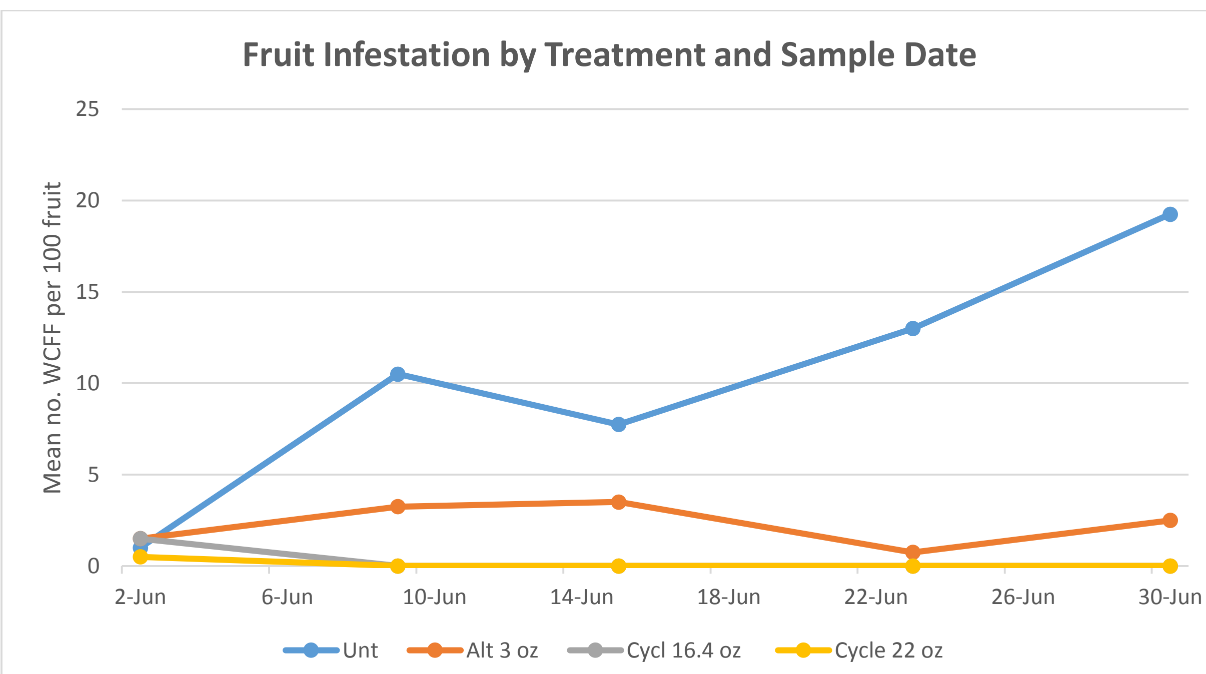


Fig. 7. Influence of insecticide treatments on densities of arthropods (spider mites, rust mites, leafhoppers, thrips, and predatory mites) per 20 tart cherry leaves on June 18, 2015, Kaysville, UT.

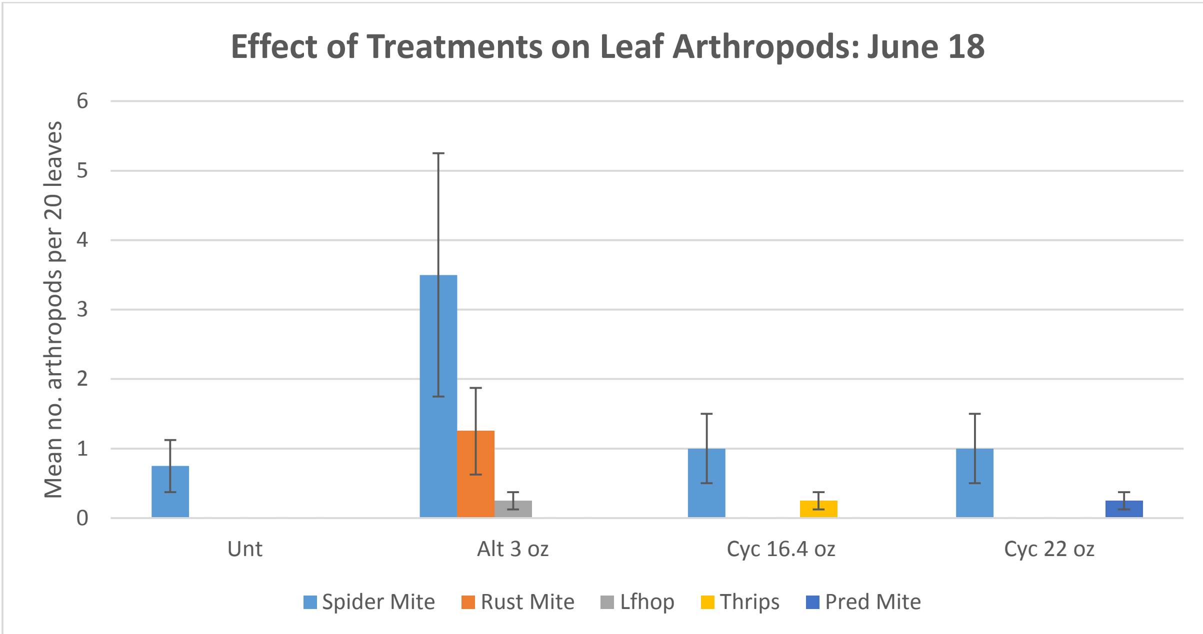
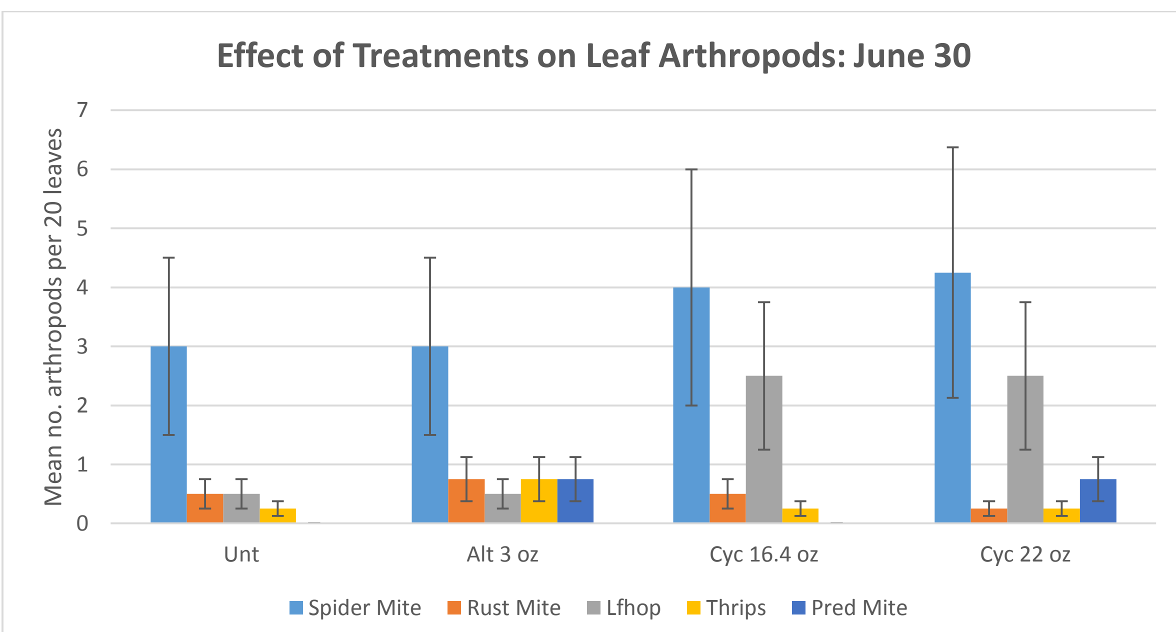


Fig. 8. Influence of insecticide treatments on densities of arthropods (spider mites, rust mites, leafhoppers, thrips, and predatory mites) per 20 tart cherry leaves on June 30, 2015, Kaysville, UT.



Plot map. In this map, treatment 1 = untreated control, 2 = Altacor, 3 = low rate Cyclaniliprole, and 4 = high rate Cyclaniliprole.

2015 Western Cherry Fruit Fly Control Trial

IPM Tart Cherry Orchard (planted in 2003), USU Kaysville Research Farm, UT

4 treatments X 4 replicates = 16 plots

Orchard size: 16 rows (20 ft) X 32 trees (12 ft)

Plot size = 3 rows X 6 trees = 4,320 ft^2 = 0.099 acre

North

Farm road