Project Title*: Implementation of cherry fruit fly killing stations to reduce the use of hazardous insecticides in commercial and home orchards*

Funded by the Utah Specialty Crop Block Grant Program (USDA NIFA)

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Project Summary: For over 50 years, Utah cherry growers have relied primarily on insecticides in the organophosphate class to effectively manage western cherry fruit fly [*Rhagoletis indifferens* Curran (Diptera: Tephritidae)]. Registration of Guthion, the most-used organophosphate insecticide, ended in 2012. Recent insecticide registrations have emphasized those with a reduced risk for impacts on human health and the environment, but these products typically last only 5-7 days as compared to 14-21 days for organophosphates. Home orchardists have few insecticide options, and home cherry trees are often left unsprayed. This creates havoc for commercial producers because fruit flies move into nearby commercial orchards, threatening the zero-tolerance policy on infested fruit.

In a previous specialty crop block grant project, we demonstrated both good efficacy of spinosad, a low-toxicity bacterial insecticide for cherry fruit fly control, and the enhanced attraction and protection of a spinosad bait insecticide, GF-120 Naturalyte (Dow AgroSciences, Indianapolis, IN), by spraying GF-120 onto yellow "killing stations" (an inverted saucer hung in cherry trees). Cherry fruit fly is strongly attracted to the yellow color, and the killing station protects GF-120 from degradation by rain and UV light to extend its longevity. Cherry growers have adopted GF-120 sprays, especially near harvest because of its 0-day pre-harvest interval.

Based on our research findings on enhanced efficacy of GF-120 when applied to killing stations, growers asked for assistance in implementing killing stations in commercial orchards. We were also interested in trying killing stations in home cherry trees as a means to enhance cherry fruit fly control with a low toxicity method and reduce external sources of fruit flies in commercial production districts. We collaborated with commercial cherry producers and home orchardists in three fruit-production counties of northern Utah to evaluate the efficacy of killing stations treated with GF-120 for protection of fruit from cherry fruit fly. The findings are pertinent to both home and commercial cherry production in the state and western U.S., and will help promote production of organic cherries because GF-120 is a certified organic product.

Project Approach:

Objective 1: Management of western cherry fruit fly in home cherry trees

We evaluated the efficacy of killing stations treated with GF-120 in home yard cherry trees in 2013 (6 sites) and 2014 (4 sites). Three treatments, insecticide (IN), killing station (KS), and untreated (UN) were applied to individual sweet and tart cherry trees in homeowner sites in four counties of northern Utah: Davis, Salt Lake, Utah, and Weber. Two (2013) or four (2014) killing stations (14 inch diameter yellow saucers) were placed in each KS tree in early June and treated weekly with 20% GF-120 through late June or early July. Ortho acetamiprid insecticide was applied every 10 days to IN trees for the same time period. The UN trees were not treated. One Pherocon AM yellow sticky trap with external ammonium carbonate bait was placed in each tree during June, and western cherry fruit fly adults counted and

collected weekly. Female flies were dissected to determine if mature eggs were present in the ovaries, indicating that they were capable of laying eggs in fruit. The effect of the three treatments on cumulative trap capture and fruit infestation was determined with one-way analysis of variance (SAS 9.3, Proc Mixed). Data were square-root transformed before analysis to meet normality assumptions of the statistical model. The relationship between cumulative trap capture and fruit infestation was described with a linear regression (SAS 9.3, Proc Reg).

In 2013, some of the backyard sites had extremely high pressure from cherry fruit fly, and we found that two killing stations per tree treated weekly with GF-120 were inadequate to lower fruit fly populations and protect fruit as well as insecticide-treated trees. Use of killing stations reduced, but not significantly, fruit infestation as compared to untreated trees. Fruit infestation in the IN trees still averaged 0.73 larva per fruit. These results demonstrate the challenge, even for insecticides, in managing cherry fruit fly in highly infested home yard trees.

In 2014, we selected sites with more modest cherry fruit fly populations. Treatment and sample week significantly influenced mean weekly trap capture of adult western cherry fruit fly ($p = 0.003$ for treatment, $p = 0.02$ for sample week). More adults were caught on traps in untreated trees than on those treated with insecticides, and captures in trees with killing stations was intermediate (Fig. 1). For females with mature eggs, there was no difference among treatments or sample week ($p > 0.05$); however, there was a trend for fewer mature females caught on traps in trees with killing stations (Fig. 1).

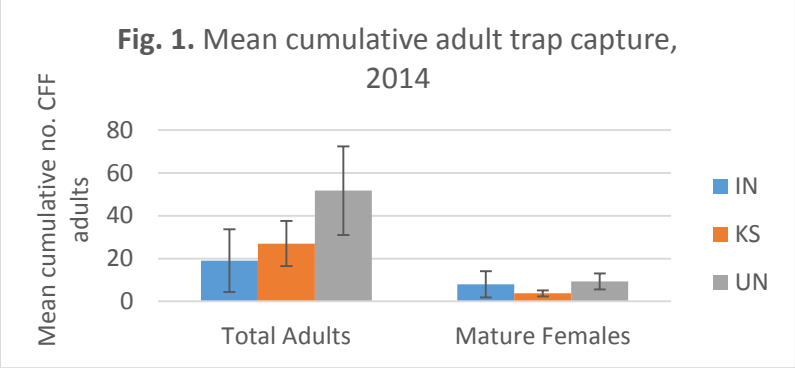
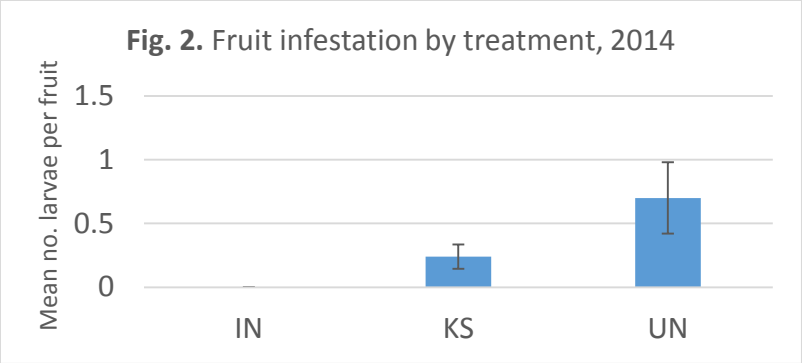


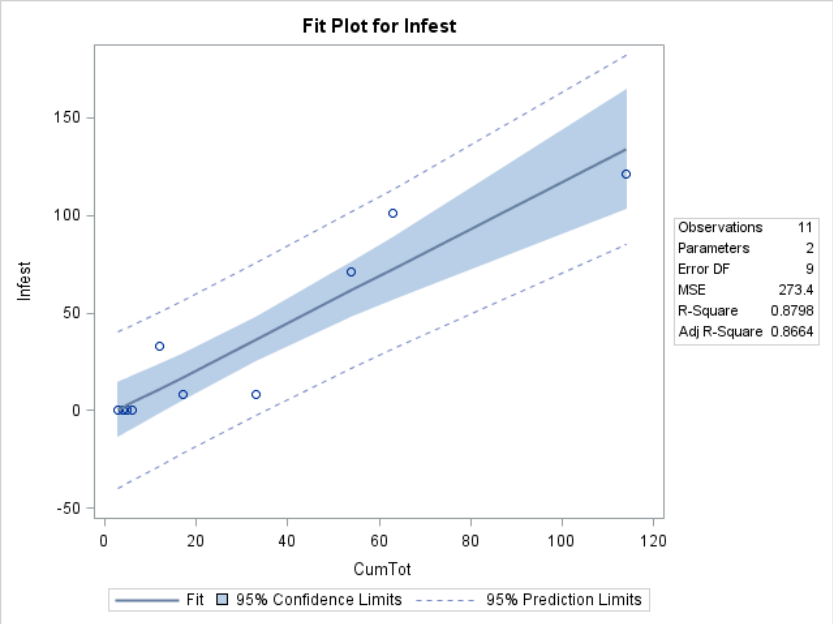
Fig. 1. Mean cumulative adult trap capture, 2014

Treatments significantly influenced fruit infestation ($p = 0.002$): the most larvae were found in fruits from untreated trees (mean = 0.70 larva per fruit), an intermediate number were in KS fruit (mean = 0.24 larva per fruit), and the least were in IN fruit (mean = 0 larva per fruit) (Fig. 2).



Cumulative trap capture of adults was a good predictor of fruit infestation (R^2 = 0.87) (Fig. 3).

Fig. 3. Regression of fruit infestation (%) on cumulative total adult trap capture, 2014.



Objective 2: Commercial cherry orchards

Studies were conducted in four tart cherry orchards on two commercial farms and in one orchard at a USU research farm during 2013. In the commercial orchards, killing stations and monitoring traps were deployed on May 9 and 16 in trees along the borders of the orchards. Plot size ranged from 12 to 24 contiguous border trees. In each orchard there were two plots with killing stations and two plots without for a total of eight plots each with and without stations across the four orchards. One killing station was placed in each tree within a "killing station plot". Commercial grower cooperators applied insecticide treatments as per their standard program, so even plots with killing stations were treated. Because the primary source of cherry fruit fly infestation in commercial orchards is flies immigrating from external sources, our goal was to determine if killing stations placed along orchard borders could

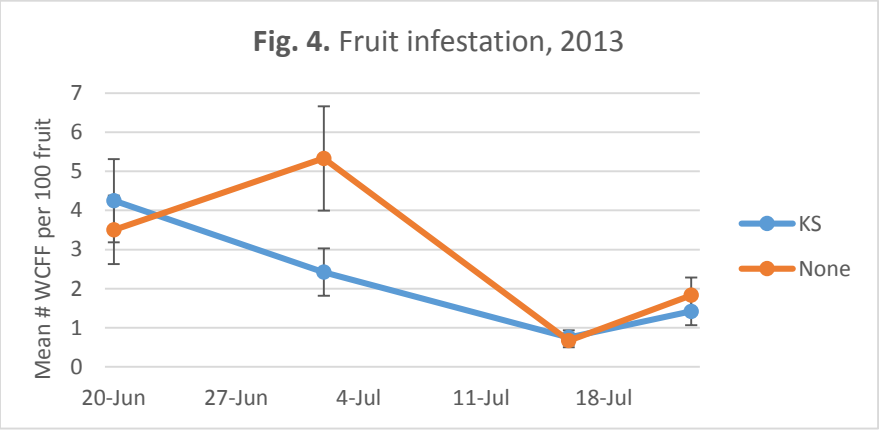
reduce fruit infestation as compared to trees without stations. GF-120 was applied weekly, and traps were checked weekly and flies collected. Fruit samples (400 per plot) were collected on June 26 and July 10.

In the research orchard, killing stations and monitoring traps were deployed on May 21 in six replicates of four border trees alternated with replicate plots of trees without stations. No insecticides were applied to the plots in the research orchard. Gf-120 was reapplied to traps and flies collected from traps weekly. Fruit samples (200 per plot) were collected on June 20, and July 2, 16, and 23. Fly and fruit samples were processed as described for home yard trees.

In the commercial and research orchard studies, there was no difference in cumulative trap catch among treatments for total adults, females, and reproductively mature females (data not shown).

Very few fruit fly larvae were found infesting fruit in the commercial orchards: three larvae in one untreated plot in one orchard on July 10, and one larva in a killing station plot in a different orchard, also on July 10. Sample size was 400 fruit per plot per sample date. No statistical analyses were conducted due to too few positive data.

In the research orchard, there was a significant interaction between sample date and treatment for fruit infestation (p=0.03) (Fig. 4). Infestation was significantly lower in plots with killing stations on July 2, but this trend did not hold up across the other sample dates.



Conclusions and Implications

High population pressure of western cherry fruit fly in home cherry trees in 2013 (weekly average of 20-50 adults per trap) resulted in poor performance of all treatments. Even the insecticide treatment was inadequate to reasonably lower fruit injury which averaged 73 larvae per 100 fruit. In comparison, population pressure was more modest in 2014 (mean weekly trap capture of $\leq$ 25 adults per trap), and allowed for greater differentiation among cherry fruit fly control treatments.

In home cherry trees, applications of the insecticide acetamiprid significantly lowered the number of fruit fly adults caught on traps and prevented larval infestation of fruit better than the killing stations;

however, the killing stations did reduce fruit injury as compared to the untreated trees. The killing stations were not as effective as the insecticide in lowering adult populations, but trees with killing stations had the fewest female flies with mature eggs caught on traps, although not significantly lower. In 2014, acetamiprid applications completely prevented larval infestation of fruit. Cumulative trap capture provided a good prediction of fruit injury. Cumulative trap capture below 20 adult flies resulted in less than 20% fruit injury in home cherry trees.

These results suggest that killing stations can be effectively used in home cherry trees to protect fruit from infestation by western cherry fruit fly when trap capture is $\leq$ 25 adults per trap per week. Killing stations reduced fruit infestation to an average of 24 as compared to 70 larvae per 100 fruit in untreated trees. Deployment of killing stations and weekly application of 20% GF-120 to the lower surface is easy and convenient. GF-120 is a reduced-risk bacterial insecticide bait; safe for applicators and consumers. The killing station protects GF-120 from washing off in rain and breaking down in sunlight. The yellow color of the killing station attracts cherry fruit flies to land on the surface and ingest the insecticide-bait. Good coverage of large cherry trees with homeowner-type sprayers can be difficult. Acetamiprid is a neonicotinoid insecticide with low mammalian toxicity, but there may be side-effects of it use on non-target insects, including pollinators. Acetamiprid was the most effective treatment, and completely prevented fruit infestation when fruit populations were modest. Killing stations treated with GF-120 provide a reduced-risk alternative to cover-spray insecticides for management of western cherry fruit fly in home cherry trees, and is an organically certified option.

In commercial cherry orchards, external sources of cherry fruit fly are the primary source of fruit injury. We hypothesized that there would be very low fruit infestation due to an effective insecticide program, but that we might observe a reduction in trap capture of cherry fruit fly adults in border trees with killing stations. Our results do not support this hypothesis. There was no effect of killing stations on trap capture or in protecting fruit when infestation levels were very low.

In the research orchard site, insecticides were not applied and cherry fruit fly pressure was moderate, in between that of the home trees and commercial orchards. Killing stations placed in trees along orchard borders did reduce fruit injury on the peak infestation date in early July. Killing stations did not significantly suppress fruit fly populations attracted to yellow sticky traps.

Contributions of Project Partners

Diane Alston and Marion Murray were the project co-investigators who oversaw and organized all aspects of the research and outreach dissemination. Four Utah county extension agents collaborated on the study: James Barnhill, Weber Co.; Katie Wagner, Salt Lake Co.; Britney Hunter, Davis Co.; and Taun Beddes, Utah Co. The agents identified homeowners with cherry trees who were willing, after training from project investigators, to apply the treatments and collect fly and fruit samples. Seven homeowners and two commercial cherry producers served as cooperators by volunteering their trees/orchards and implementing treatments as requested. Four undergraduate students over the two years were employed on the project to assist with plot set-up and fly and fruit sample processing.

Goals and Outcomes Achieved:

We proposed to determine if a reduction in cherry fruit fly occurred following deployment of killing stations treated with GF-120 in commercial and home cherry trees. This goal was measured by comparing the percentage of fruit infested and fruit fly counts on monitoring traps in trees with killing stations, trees treated with a broad-spectrum insecticide, and untreated trees (home trees only). We hypothesized that cherry fruit fly control will be similar among trees protected with GF-120 killing stations and those that are sprayed with a broad-spectrum insecticide based on results from previous studies.

We found that although killing stations did not consistently lower cherry fruit fly populations in trees, they did lower fruit infestation when populations were low to moderate ($\leq$ 25 flies per trap per week). When cherry fruit fly densities were high (> 25 flies per trap per week), even insecticide applications were inadequate to protect fruit from infestation. In commercial cherry orchards where fruit is protected by frequent insecticide applications, the addition of killing stations along orchard borders did not reduce trap capture of adult flies that migrated into the orchard from outside sources. However, in home cherry trees, which can be a source of fruit flies for nearby orchards, killing stations lowered numbers of flies and fruit injury as compared to untreated trees.

The use of bait stations for insect management is easy, safe, and inexpensive. Killing stations are a good fit for homeowners seeking organic cherry fruit fly control options, and the use of stations will reduce pest pressure for nearby orchards.

Dissemination of Results

Project results were disseminated to a total of 365 face-to-face contacts and 5,400 subscribers via the USU Tree Fruit IPM Advisory newsletter (http://utahpests.usu.edu/IPM/htm/advisories/treefruit/).

Alston, D. G. Western cherry fruit fly research update. Utah State Horticultural Association Annual Convention, January 22-23, 2014; Spanish Fork, UT. (90 attendees)

Alston, D. G. Tree fruit insect management update. Northern Utah Fruit Growers' Meeting, February 5, 2014; Brigham City, UT. (45 attendees)

Alston, D. G. Fruit fly update. Utah State University Extension Annual Conference In-Service Workshop, March 4, 2014; Logan, UT. (30 attendees)

Alston, D. G. Integrated pest management for fruits and vegetables: insect and mite pests. Utah State University Extension Master Gardener Course, March 18-20, 2014; Kaysville, Ogden, Salt Lake City, and West Jordan, UT. (115 attendees)

Alston, D. G. Integrated pest management for organic growing. Utah State University Organic Growing Workshop, March, 29, 2014; Salt Lake City, UT. (60 attendees)

Alston, D. G. General principles of organic arthropod management. Utah State University Small Farms Organic Workshop, April 16, 2014; Hurricane, UT. (25 attendees)

Beneficiaries:

The target audiences for this project included commercial cherry producers, tree fruit industry support professionals such as agricultural product suppliers and packing plant managers, professional orchard consultants, extension educators, relevant federal and state agency professionals such as the Utah Department of Agricultural and Food regulatory specialists and Natural Resources Conservation Service agricultural service providers, and home gardeners including Master Gardener volunteers. The Utah State Horticultural Association (USHA) which is the tree fruit grower organization in Utah was a primary beneficiary. USHA provided stakeholder support for the proposal and they have received direct reports of the project results at multiple meetings and workshops. There were a total of 365 face-to-face contacts and 5,400 contacts via newsletter articles (see Dissemination of results above).

Utah has 3,300 acres of tart and 500 acres of sweet cherries for a total value of utilized production of $22.3 million (Utah Agricultural Statistics 2013). Tart cherry was the highest value tree fruit crop in Utah in 2012, more than three times higher than peach and five times higher than apple. These figures do not include the value of home cherry trees. All cherry acreage in Utah was impacted by this project because cherry fruit fly is the key pest that must be managed in all cherry orchards in order for the state's cherries to be viable, successfully marketed, and enjoyed for their high quality flavor without the presence of insect larvae.

Lessons Learned:

Use of bright yellow disks treated weekly with an organic insecticide bait, GF-120, during cherry maturity (June and early July) lowered western cherry fruit fly populations and fruit infestation in home yard trees. A major concern for commercial cherry producers is migration of cherry fruit fly into orchards from external sources. Killing stations provide home cherry growers with a viable, convenient, and organic option to significantly lower fruit fly infestation. However, our studies did not show that killing stations would lower cherry fruit fly densities in the borders of commercial orchards. Commercial orchards are managed with frequent insecticide applications, thus causing fruit fly densities to be very low. When fruit fly populations were low to moderate ($\leq$ 25 adults per trap per week), such as in the untreated research orchard and home yard cherry trees, killing stations reduced fruit fly infestation.

Project results have and will continue to be disseminated to the public to provide a viable organic option for home gardeners and small-scale orchardists to manage western cherry fly in Utah.

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