2007 Western Cherry Fruit Fly Control Trial:
Attraction of Adults to GF-120 Insecticide-Bait Droplets by Addition of Potential Attractants
Utah Agricultural Experiment Station, Kaysville, UT

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Justification:

Insecticide-baits such as GF-120® are an alternative to more highly toxic, broad-spectrum insecticide cover sprays for fruit fly control. The current bait in the commercially available GF-120® product has been shown to not be very attractive to eastern and western cherry fruit fly adults (*Rhagoletis cingulata* and *R. indifferens*, respectively). GF-120® and other fruit fly attract-and-kill products would be a more effective control technology if the droplets were more attractive to cherry fruit fly adults rather than relying on chance encounters during foraging bouts in the tree canopies. Materials that are thought to be attractive to western cherry fruit fly adults will be evaluated for addition to insecticide-bait products.

Objective: To evaluate the influence of four potential western cherry fruit fly adult attractants (ammonium acetate, urea, torula yeast, and concentrate cherry juice) in combination with GF-120® sprays on fruit injury and adult trap catch.

Methods:

Experimental Design

The experiment was conducted in a 17-year-old 2.1 acre 'Montmorency' tart cherry orchard at the Utah Agricultural Experiment Station in Kaysville, UT. Plots were 0.31 acres in size, four rows wide by 14 trees in length (12 ft tree spacing x 20 ft row spacing). Each plot was divided into four subplots for sampling (see plot map). The first catch of adults on yellow sticky traps (biofix) was on May 13. Cherry fruits were primarily still green at this time. Fruits began to turn yellow and a low percentage had a salmon to rosy colored blush by May 31. The first application of treatments occurred on May 29. All insecticide treatments were applied with a 4-wheeler-mounted electric-pump sprayer (D3 nozzle and 45 psi), and reapplied every seven days or the next day following a rain event. The pattern of spray coverage was a 4 to 5 ft wide swath down the tree canopy of every other row. A total of seven treatment sprays were applied: May 29, June 5, 8, 15, 22, and 29, and July 6. The only other pesticide applied to the orchard during the trial was the fungicide, Elite, on May 14 for powdery mildew suppression.

Treatments

1) GF-120 alone @ 20 fl oz per acre (diluted 1:4 in water; 100 fl oz dilute spray per acre)

2) GF-120 @ 20 fl oz per acre (diluted 1:4 in water; 100 fl oz dilute spray per acre) + 10% w/v Ammonium Acetate (AA)
3) GF-120 @ 20 fl oz per acre (diluted 1:4 in water; 100 fl oz dilute spray per acre) + 10% w/v Urea (U)
4) GF-120 @ 20 fl oz per acre (diluted 1:4 in water; 100 fl oz dilute spray per acre) + 10% w/v Torula yeast (TY)
5) GF-120 @ 20 fl oz per acre (diluted 1:4 in water; 100 fl oz dilute spray per acre) + 10% v/v Concentrate Cherry Juice (CCJ)
6) Untreated Control

WCFF Adult Trapping

Three Pherocon® AM yellow sticky traps with additional ammonium carbonate (AC) bait were placed in the study orchard before first adults were expected to emerge based on a degree-day phenology model. After first adult catch occurred on May 13 (biofix), two traps with AC bait were placed in each subplot (N = 8 traps per treatment and 48 traps total) on May 16. Traps were serviced weekly to collect fruit fly adults, fill AC bait boxes, and remove other insects and debris. Traps were replaced when adhesive coverage diminished (at least monthly).

Adults collected from traps were counted and placed in Histoclear® to dissolve the sticky adhesive adhering to the flies. After the adhesive dissolved, flies were transferred to 70% ethanol. Adult samples still remain to be processed. Flies will be sexed and the females dissected to determine ovary maturity status (immature or mature with fully developed eggs). The densities of adults per trap were compared among treatments on each sample date and over time with repeated measures analysis (Proc Mixed, SAS). Cumulative numbers of adults were compared among treatments for designated time periods (post-treatment through peak fruit injury and post-harvest) (Proc Mixed, SAS). Summaries of sex ratio and female ovary maturity will be analyzed at a later time when data processing is completed.

Fruit Injury Sampling

Fruit infestation was assessed approximately weekly for five weeks beginning on June 13 when about one-third of the fruits had a rosy blush. On June 13, 21, and 28, and July 5 and 12, 100 fruit were collected from each of two center trees of each subplot (N = 8 fruit samples per treatment and 48 total). Fruits were placed on wire mesh trays above plastic bins (12 in long × 6.5 in wide × 4.5 in deep) to collect third-instar larvae. Fruit bins were kept in a ventilated indoor room for 4-5 weeks to ensure that all larvae had emerged. When fruit were mature on July 12, an additional type of fruit injury sample was collected: two samples of 100 fruit per subplot were picked and dissected to determine the number of 1st, 2nd, and 3rd instar larvae and exit holes. The number of larvae per 100 fruit was compared among treatments within a sampling date and over time with repeated measures analysis (Proc Mixed, SAS).

Results:

Adult Densities

Trap catch peaked before treatments were applied in late May and then again in late June, declined during July, and then increased slightly in August before trapping was discontinued (Fig. 1). Weekly trap catch numbers followed the same trend among treatments, but were significantly different on all dates except August 9. Trap catch on post-treatment dates (Jun 8 and after) was higher in the untreated control than in most other treatments. There were few differences among the GF-120 treatments. On June 8 only, adult densities were higher in the torula yeast than ammonium acetate additive treatment (Fig. 1). Repeated measures analysis showed similar results to within date comparisons. Date and treatment effects were significant ($p<0.001$ for each), but there wasn't an interaction ($p>0.05$) confirming that the treatments behaved similarly over time.

Cumulative catch from the first post-treatment date (June 8) to when peak fruit injury occurred on June 28 was greater than cumulative catch later in the season (July 3-August 9) (Fig. 2). Total cumulative catch for the trial period was significantly greater in untreated control plots than in all insecticide-treated plots. There was no difference in cumulative adult trap catch among GF-120 treatments (Fig. 2).

Fruit Injury

None of the GF-120 treatments completely prevented fruit infestation either before fruits were fully mature (June 13 to July 5 sampling dates) or when they were mature (on July 12).

Cherry fruit fly larvae emerged from the first fruit samples collected on June 13. On this date, about one-third of the fruits were green, one-third were yellow, one-third were rosy, and a very few were red in color. Across all fruit sample dates, third instar larvae emerged from cherry fruits immediately after collection of fruits from the orchard up to three weeks later. Fruit were held for four to five weeks, but no larvae emerged more than three weeks after collection.

Larvae emerged from all treatments on all dates, except from the GF-120 + urea treatment on June 13 (Table 1). Larval emergence was $\leq$ 2.5 larvae per 100 fruit in all GF-120 treatments. Fruit infestation was significantly greater in the untreated control than in GF-120 treatments on all sample dates. There were no differences among GF-120 treatments (Table 1). Just as for within date comparisons, repeated measures analysis found that across all dates the untreated control differed from all of the GF-120 treatments ($p<0.001$). Fruit infestation also differed among some dates ($p<0.001$), but there was not an interaction between treatment and date ($p>0.05$) confirming that treatment trends were the same over time.

For mature fruits collected on July 12 and dissected to determine numbers of larvae and exit holes, significantly fewer infested fruit were found in all GF-120 treatments than in the untreated control (Fig. 3). Most of the injury was due to exit holes and third instar larvae. First instar larvae were found only in untreated fruits.

Discussion and Conclusions:

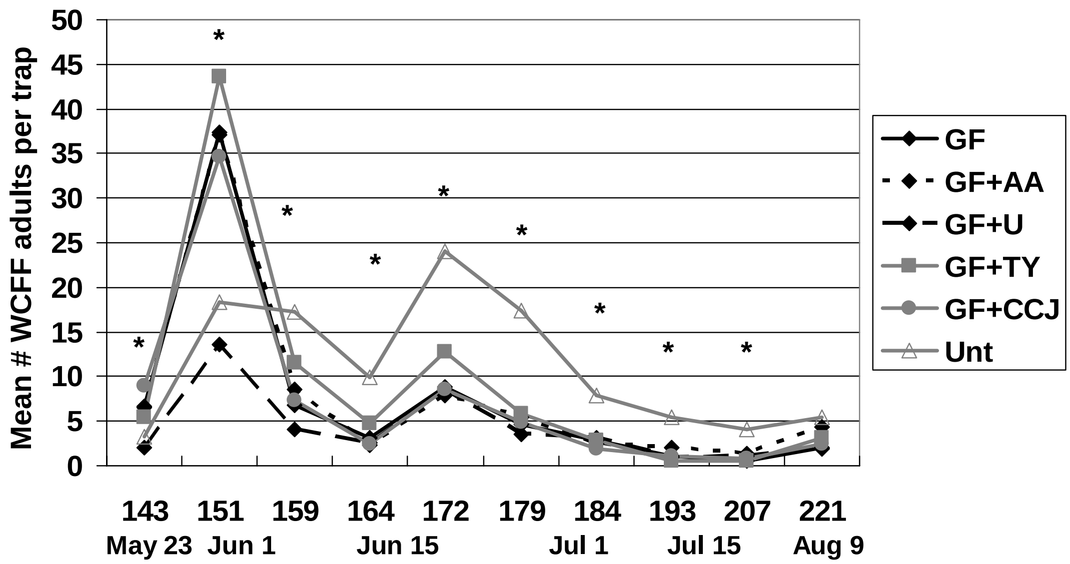
None of the GF-120 treatments, either alone or combined with an additional potential adult attractant, completely prevented fruit infestation by western cherry fruit fly in this study. All of the GF-120 treatments performed similarly, resulting in 0-2.5 larvae per 100 fruit on weekly sampling dates before harvest and 0.5-1.9 larvae per 100 fruit when fruits were mature on July 12. For comparison, fruit injury in the untreated control plots was about 7-19 larvae per 100 fruit before harvest and 9 larvae per 100 fruit on the harvest date of July 12.

Fruit were infested on the first sample date of June 13 when about one-third of the fruits had a rosy blush on a dark yellow background. Fruits may have been infested before June 13. We initiated fruit sampling based on past years' experience on first infestation dates where first infestation did not occur before June 15. By July 12 when most fruit were mature, the majority of injury was due to exit holes where larvae had already completed development and emerged. Therefore, peak fruit infestation occurred in late June to early July just after peak adult catch on traps in late June.

Adult trap catch was generally related to the performance of treatments. Higher numbers of adults were caught in untreated control traps on most weekly sample dates and cumulative numbers of adults were greater pre- and post-harvest in untreated plots as compared to all of the GF-120 treated plots. Again, there was no separation in suppression of trap catch among the GF-120 treatments. GF-120's mode of action is adult mortality upon ingestion of spinosad-laced droplets. The cherry fruit fly population in this study orchard was large compared to typical commercial orchards. Total cumulative adult trap catch in the untreated plots was 90 flies per trap. It was about two-thirds less in the GF-120 treated plots. So although GF-120 alone and in combination with the potential attractants tested did lower adult populations by about two-thirds, it wasn't enough to prevent fruit infestation. In a typical commercial orchard, fly capture rates are often less than 20 flies per trap for a full season. If GF-120 reduced fly densities in a similar fashion, cumulative capture levels would be <7 flies for the season. It is likely that GF-120 would prevent detectable injury in most commercial orchards. But it is important to be aware that GF-120 may not prevent fruit injury when fruit fly populations are high such as in this study.

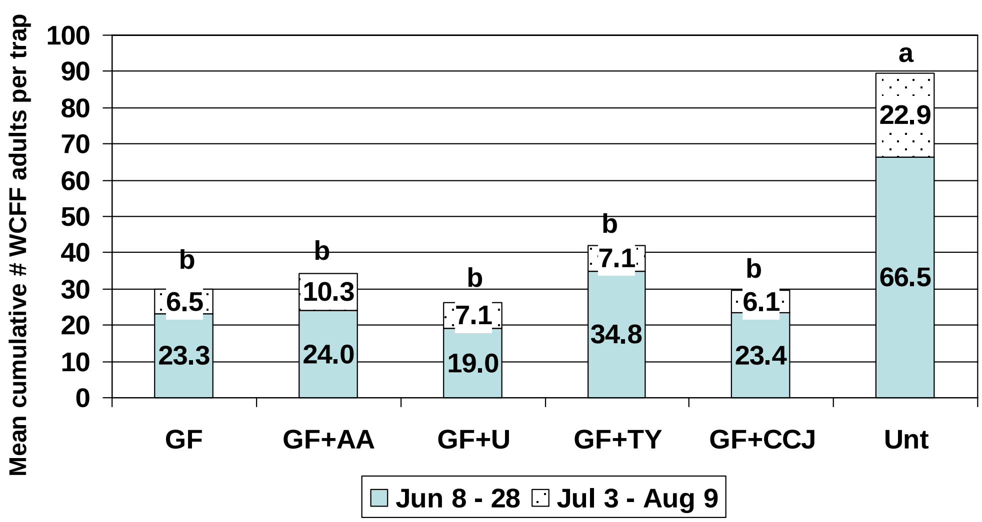
None of the potential adult attractants tested in this study enhanced the performance of GF-120 over use of the bait-insecticide product alone. As discussed, the high fruit fly population in this study site may preclude the ability of any bait product to prevent fruit injury. The ten times reduction in fruit injury from untreated to GF-120 treated plots observed in this trial may translate to prevention of detectable injury in typical commercial cherry orchards.

Figure 1. Influence of insecticide treatments on adult trap catch during the season. GF=GF-120 alone, GF+AA=GF-120+10% ammonium acetate, GF+U=GF-120+10% urea, GF+TY=GF-120+10% torula yeast, GF+CCJ=GF-120+concentrate cherry juice, and Unt=untreated control.



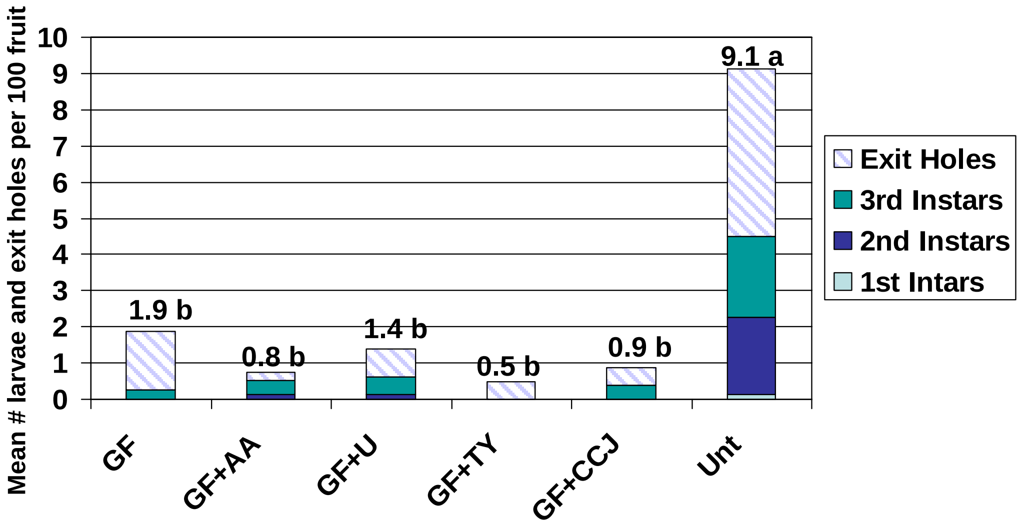
* indicates treatment means were significantly different (Tukey-Kramer test; $p \geq 0.05$) on indicated dates.

Figure 2. Mean cumulative number of adults per trap for post-treatment through peak fruit injury (Jun 8 – 28) and through post-harvest (Jul 3 – Aug 9) as influenced by insecticide treatments. GF=GF-120, GF+AA=GF-120+10% ammonium acetate, GF+U=GF-120+10% urea, GF+TY=GF-120+10% torula yeast, GF+CCJ=GF-120+concentrate cherry juice, and Unt=untreated control.



Means followed by the same letter are not significantly different (Tukey-Kramer test, $p \geq 0.05$)

Figure 3. Fruit infestation at harvest (Jul 12) presented by age of larvae and exit holes per 100 fruit. GF=GF-120, GF+AA=GF-120+10% ammonium acetate, GF+U=GF-120+10% urea, GF+TY=GF-120+10% torula yeast, GF+CCJ=GF-120+10% concentrate cherry juice, and Unt=untreated control.



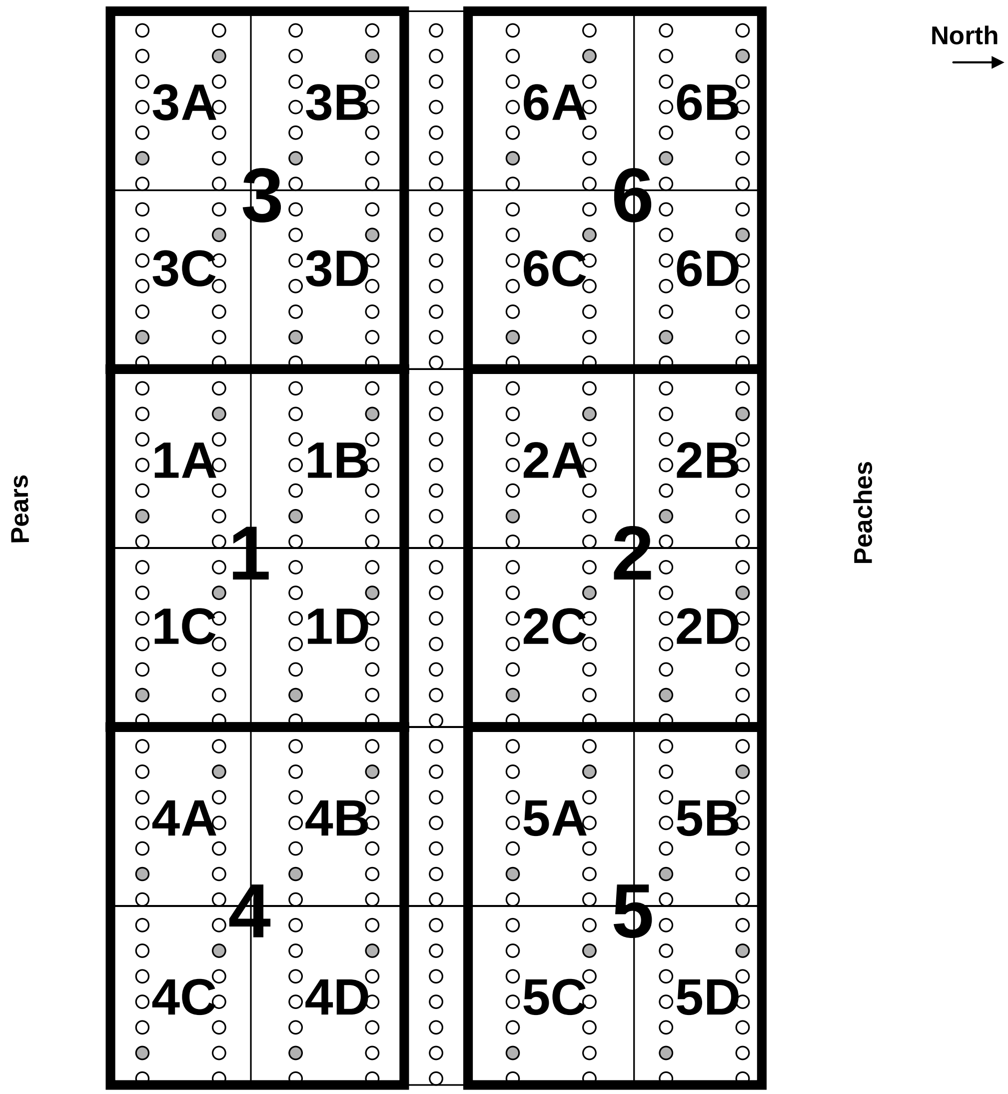
Values above bars are total numbers of larvae and exit holes.
Means followed by different letters are significantly different (Tukey-Kramer test; $p \geq 0.05$).

Table 1. Influence of potential attractants added to GF-120® sprays on fruit infestation by western cherry fruit fly from mid June to mid July. Fruit were placed on larval emergence traps for 4 to 5 weeks and data are presented by date of fruit collection from the orchard.

Treatment	Mean number of fruit fly larvae emerged per 100 fruit				
	13-Jun	21-Jun	28-Jun	5-Jul	12-Jul
GF-120	0.13 b	1.13 b	2.13 b	0.75 b	0.63 b
GF-120 + AA	1.25 b	1.88 b	2.38 b	1.13 b	0.88 b
GF-120 + Urea	0 b	1.75 b	2.25 b	2.50 b	0.38 b
GF-120 + Torula Yeast	0.13 b	0.50 b	1.88 b	1.50 b	1.00 b
GF-120 + Con. Cherry Juice	0.50 b	0.88 b	0.75 b	1.38 b	0.63 b
Untreated Control	6.63 a	11.75 a	18.75 a	12.63 a	9.00 a
P>F	*< 0.001*	*< 0.001*	*< 0.001*	*0.003*	*< 0.001*

N=48 observations per date.
Data were square-root transformed (x+0.1) before analysis to meet normality assumptions.
Treatment means were separated with Tukey-Kramer pair-wise comparisons when significantly different in analysis of variance (Proc Mixed; $p \leq 0.05$).

IPM Tart Cherry Orchard, Kaysville, UT
2007 Western Cherry Fruit Fly Control Trial
Evaluation of Adult Feeding Attractants with GF-120
(9 rows X 42 trees: 12' X 20' spacing)



○ = Trap tree, Trap 1 is in the south row and Trap 2 is in the north row

Insecticide Treatments:

1. GF-120 alone (Pink)
2. GF-120 + AA (Blue/White Stripe)
3. GF-120 + Urea (Yellow/Black Stripe)
4. GF-120 + Torula Yeast (Orange)
5. GF-120 + Concentrate Cherry Juice (Blue)
6. Untreated Control (White)