***Enhancement of Attraction of Western Cherry Fruit Fly (Rhagoletis indifferens) to Yellow Sticky Traps* - 2007**

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Justification and Objectives:

The current trap design used to monitor western cherry fruit is only moderately attractive to adult flies. It primarily utilizes visual attraction, yellow color. The objective was to evaluate compounds that have been demonstrated as attractive to cherry fruit fly in laboratory and field experiments: ammonia, cherry fruit juice, yeast, and sugar. Several types of each attractant source will be evaluated in combination with the standard yellow sticky trap used for monitoring cherry fruit fly, the Pherocon AM® trap. Enhancement of the attractiveness of the yellow sticky trap will likely improve fruit fly detection in cherry orchards. In addition, effective attractants could be evaluated for addition to insecticide-bait products, such as GF-120®. Insecticide-baits are an alternative to more highly toxic, broad-spectrum insecticide cover sprays for fruit fly control.

Methods:

Experimental Design

To compare the attraction of thirteen compounds to western cherry fruit fly adults when added to yellow sticky traps, experiments were conducted in five 'Montmorency' tart cherry orchards from first adult activity (mid May) through post-harvest (mid August). The first experimental site was a 4-year-old, 3.1 acre research orchard at the Utah Agricultural Experiment Station in Kaysville. The other four sites were in commercial orchards in Utah County. Commercial orchards ranged in size from approximately 10-20 acres. Four Pherocon AM® traps with ammonium carbonate bait were placed in each study orchard before first adults were expected to emerge based on a degree-day phenology model. Adults were first caught in some sites on May 13 (biofix). On May 16 in the Kaysville site and on May 17 in the commercial orchard sites, Pherocon AM® traps with the 13 adult attractant treatments were placed in each orchard. Each treatment was replicated four (commercial orchards) or five (research orchard) times. To avoid effects of trap position on fly capture, trap position was rotated weekly to the next position from south to north (e.g., trap for Treatment 1 was rotated to position of Treatment 2, etc.) (see plot maps).

Treatments

The treatments were: 1) ammonium acetate (AA), 2) ammonium carbonate (AC), 3) ammonium hydroxide (AH), 4) urea (U), 5) sweet cherry essence (SWCE), 6) sour cherry essence (SOCE), 7) single strength cherry juice (20-25 brix) (SSCJ), 8) concentrate cherry juice (65 brix) (CCJ), 9) torula yeast (TY), 10) brewer's yeast (BY), 11) molasses (M), 12) sucrose (S), and 13) no bait (NB).

Liquid attractants were contained in 20 ml plastic vials and attached to a lower corner of the trap. Vials contained a cotton wick and were closed with a plastic lid with a 3 mm diam opening. The yeasts were diluted (1 g yeast in 20 ml distilled water) and placed in plastic vials as for liquid materials, but without a wick. Table sugar was made into syrup (30 ml sugar in 5 ml distilled water) for the sucrose (S) bait. Solid attractants

(M and S) were applied as 15-20 droplets directly onto the surface of traps. Attractants were refreshed or replaced weekly.

Adult Fly Data and Analysis

Adult counts were collected weekly and debris and non-fruit fly insects removed. Traps were replaced every three or four weeks or when adhesive became diminished. Flies were collected into vials with Histoclear® to dissolve the adhesive and their sex determined in the laboratory. Female flies were dissected to determine if ovaries contained mature eggs. Fly counts have been completed, but fly sexing and dissections remain to be completed.

Fly densities caught on traps were compared among attractant treatments within each date and across dates with repeated measures analysis (Proc GLM, SAS Institute). Pair-wise mean comparisons among treatments were controlled for experiment-wise Type I error and means separated, when significantly different, using the Tukey-Kramer method. Density data were square root transformed before analysis to meet normality assumptions. Cumulative adult capture was compared among attractants for specific fruit maturity periods (when majority of fruits were green, yellow and rose, red, and post-harvest). These comparisons allowed assessment of attractants when cherry fruits were immature and later in the season when riper fruits may compete or interfere with the attractants. Data of sex ratio and female ovary maturity will be analyzed at a later time when data processing is completed.

Results:

Across all orchards, adult capture on traps was highest in June to early July (Fig. 1). Differences among attractants occurred in late May to mid June. On May 31 and June 8, more adults were caught on traps baited with ammonium carbonate (AC) and ammonium hydroxide (AH) than on non-baited (NB) traps and on traps baited with most of the other attractants. On June 20, significantly more flies were caught in the AH treatment than in most others (Fig. 1).

Substantially more adults were caught at the Kaysville research site than in any of the commercial orchards. Looking at adult captures in the research orchard alone showed similar trends to a combination of all the orchards (Fig. 2). Again, the highest adult captures occurred in June to early July and significantly more flies were caught on traps baited with AH and AC (on two dates) than in some of the other treatments. Traps baited with brewer's yeast (BY) also caught higher numbers of flies on dates near harvest when fruits were mostly rose to red in color (Fig. 2).

Evaluating fly captures in the four commercial orchards only showed that highest numbers of adults were caught in early to mid June (Fig. 3), but densities were ten times lower than in the research orchard. Again, AH and AC were the most attractive treatments. Molasses (M) increased catch on two dates over the non-baited and some of the other treatments (Fig. 3).

Total cumulative adult capture on traps showed similar results to fly captures over time (Fig. 4). More adults were caught on traps baited with AH than in all other treatments except AC. More flies were caught in the AC treatment than all others except AH and BY. Only AH and AC caught significantly more flies than the non-baited (NB)

traps. Traps baited with single strength cherry juice (SSCJ) caught the least flies, significantly fewer than even the non-baited traps. Separating cumulative adult captures by fruit maturity periods, the most flies were caught from late June to early July when the majority of cherries on the trees were rose to red in color (Fig. 4). The second most active time for fly capture was during mid to late June when most fruits were yellow and rose in color.

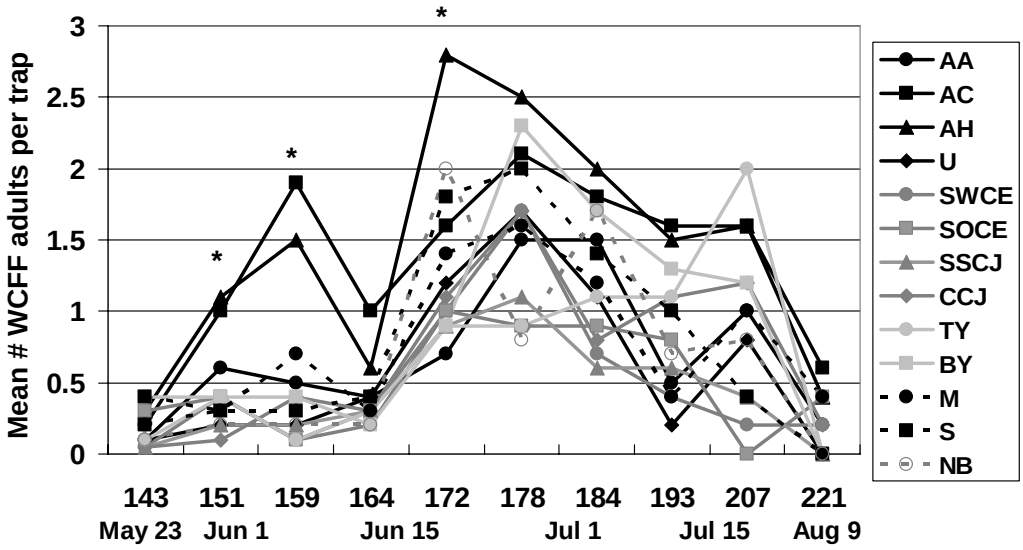
Discussion and Conclusions:

Two of the ammonia containing compounds were the most attractive to western cherry fruit fly adults: ammonium hydroxide (AH) and ammonium carbonate (AC). On most dates, AH and AC increased adult capture by about ten times over non-baited traps. Brewer's yeast (BY) also enhanced attraction over non-baited traps and some of the other treatments on some dates, especially when fruit were mature or nearly mature in late June to early July, but BY did not significantly enhance total cumulative fly capture over non-baited traps. The highest densities of adults were caught on traps in June and early July when cherry fruits were predominantly yellow, rose, or red in color. More adults were caught during this period than earlier in the season when most fruits were still green or post-harvest after most fruits were removed or dropped from the trees.

Although AH and AC showed promise for enhancing trap capture across the season, and BY showed some increase when fruits were near maturity, increases in trap capture were not as dramatic as hoped for, especially in the research orchard. Also, none of the other potential attractants tested showed strong promise for enhancing trap attractiveness. AC is already available commercially as an additional bait to enhance cherry fruit fly trap capture. AH performed slightly better than AC, but because of its liquid form and high volatility it is a more difficult compound to use in the field. Development of an AH bait formulation conducive to orchard use bears merit. BY and molasses (M) did show some promise, but were inconsistent in their attraction, and should be evaluated further. In this study, the yeast materials were mixed with water, but the water evaporated over time. The traps were serviced weekly and although the yeast mixtures were still moist one week later they may have lost volatility as they dehydrated. Evaluation of other options to package and release yeast odors on the trap may enhance the attractiveness of BY or other yeasts to cherry fruit flies.

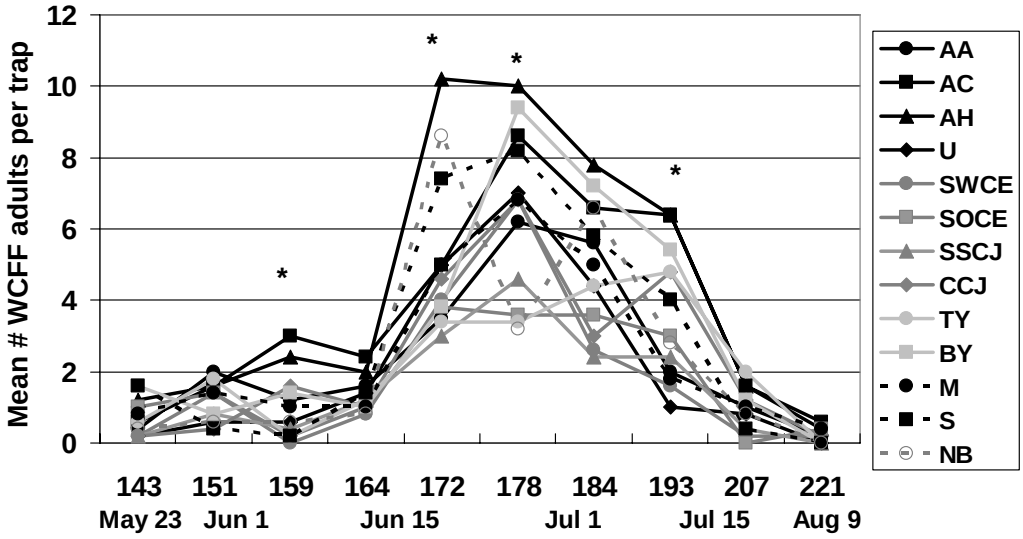
In conclusion, use of commercial AC bait boxes is strongly recommended over not using any additional baits on the Pherocon AM® yellow sticky traps to monitor cherry fruit flies. Regardless of the additional bait, the yellow sticky traps do not have a large sphere of influence in attracting adult flies. Using the current trap design, greater accuracy of fruit fly detection will depend on the use of higher trap densities than commercial growers currently use in Utah.

Figure 1. Mean adult trap catch for five orchards over time as influenced by potential adult attractants. AA=ammonium acetate, AC=ammonium carbonate, AH=ammonium hydroxide, U=urea, SWCE=sweet cherry essence, SOCE=sour cherry essence, SSCJ=single strength cherry juice, CCJ=concentrate cherry juice, TY=torula yeast, BY=brewer's yeast, M=molasses, S=sucrose, and NB=no bait.



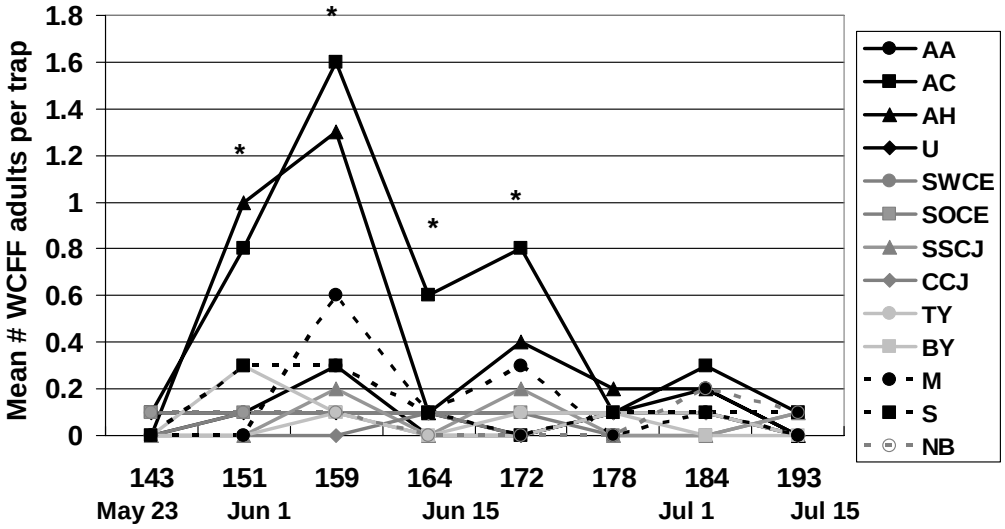
* indicates treatment means were significantly different (Tukey-Kramer test; $p \geq 0.05$) on indicated dates.

Figure 2. Mean adult trap catch for the Kaysville research orchard over time as influenced by potential adult attractants. AA=ammonium acetate, AC=ammonium carbonate, AH=ammonium hydroxide, U=urea, SWCE=sweet cherry essence, SOCE=sour cherry essence, SSCJ=single strength cherry juice, CCJ=concentrate cherry juice, TY=torula yeast, BY=brewer's yeast, M=molasses, S=sucrose, and NB=no bait.



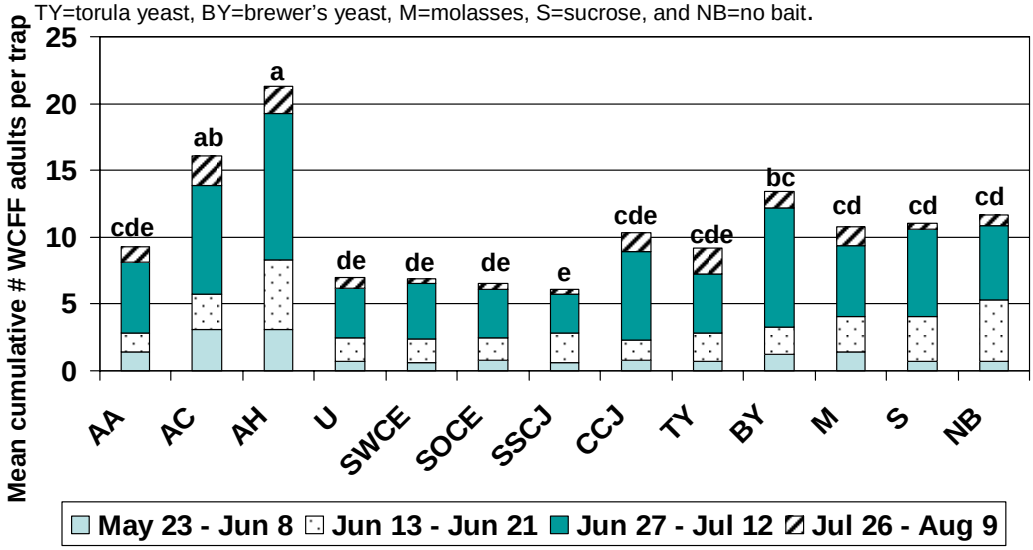
* indicates treatment means were significantly different (Tukey-Kramer test; $p \geq 0.05$) on indicated dates.

Figure 3. Mean adult trap catch in four Utah County commercial orchards over time as influenced by potential adult attractants. AA=ammonium acetate, AC=ammonium carbonate, AH=ammonium hydroxide, U=urea, SWCE=sweet cherry essence, SOCE=sour cherry essence, SSCJ=single strength cherry juice, CCJ=concentrate cherry juice, TY=torula yeast, BY=brewer's yeast, M=molasses, S=sucrose, and NB=no bait.



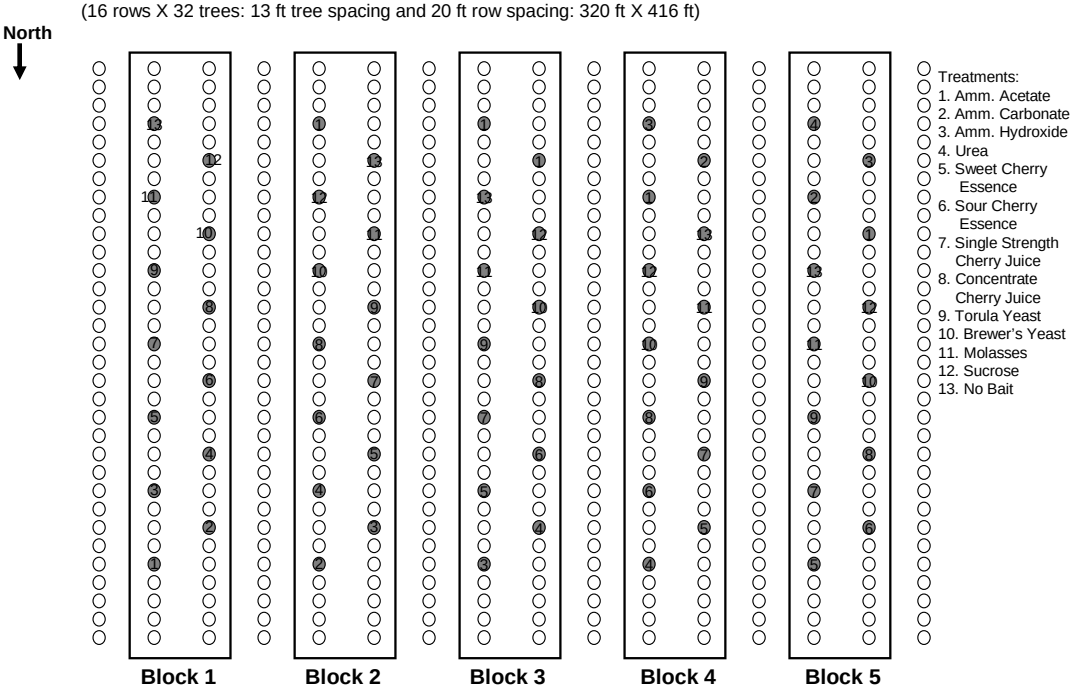
* indicates treatment means were significantly different (Tukey-Kramer test; $p \geq 0.05$) on indicated dates.

Figure 4. Mean cumulative number of adults per trap for five orchards as influenced by insecticide treatments during four fruit maturity periods: May 23-Jun 8 (fruits mostly green), Jun 13-21 (fruits mostly yellow and rose), Jun 28-Jul 12 (fruits mostly red), and Jul 26-Aug 9 (post-harvest). AA=ammonium acetate, AC=ammonium carbonate, AH=ammonium hydroxide, U=urea, SWCE=sweet cherry essence, SOCE=sour cherry essence, SSCJ=single strength cherry juice, CCJ=concentrate cherry juice, TY=torula yeast, BY=brewer's yeast, M=molasses, S=sucrose, and NB=no bait.



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

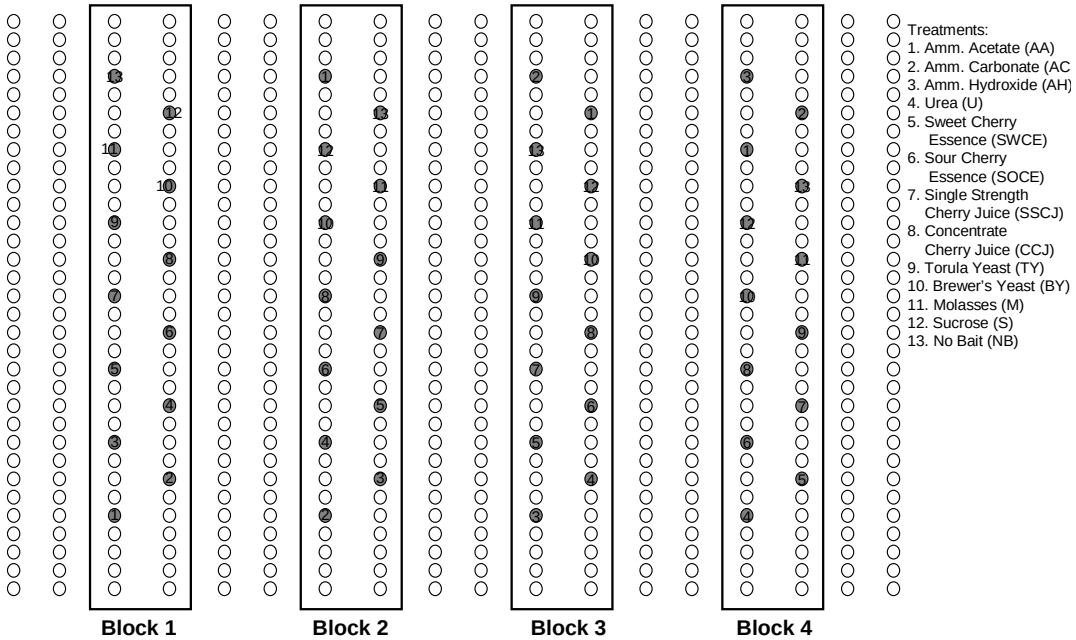
Map of Kaysville 2003 IPM Tart Cherry Orchard
2007 Western Cherry Fruit Fly Attraction to Traps
(16 rows X 32 trees: 13 ft tree spacing and 20 ft row spacing: 320 ft X 416 ft)



● = tree with trap

Position of treatments upon initial placement of traps indicated by numbers. Traps will be rotated weekly to the next position form south to north.

Map of Utah County Tart Cherry Orchards
2007 Western Cherry Fruit Fly Attraction to Traps
(Need at least 16-18 rows X ca. 30 trees; skip 1-2 edge rows and 2-4 end trees per row)



● = tree with trap

Position of treatments upon initial placement of traps indicated by numbers. Traps will be rotated weekly to the next position from front to back.