Codling Moth Adult Monitoring in Mating Disrupted Apple Orchards
USHA Research Project, 2006

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Objectives:

To compare the effectiveness of three codling moth adult trap lures (attractants) in apple orchards treated with pheromone mating disruption. To determine if codling moth trap catch is a good predictor of fruit injury in mating disrupted orchards.

Methods:

Trapping studies were conducted in nine commercial apple orchards in Payson, Santaquin, and Genola in southern Utah County. Biofix (first catch) of codling moth occurred from May 2-6 in this area. Mating disruption (MD) pheromone dispensers were applied to trees in orchards in mid to late May. Three codling moth lures were compared: 1) 1X codlemone (standard codling moth pheromone lure), 2) 10X codlemone (10 times the concentration of pheromone in the standard lure), and 3) CM-DA Combo (Pherocon®; combination of codlemone and a pear ester that attracts males and females to traps). Two replicate sets of lures were placed in large plastic Delta traps in each of the nine apple orchards (3 lures × 2 replicates × 9 orchards = 54 total traps). Traps within a replicate (row) were rotated each time they were checked to remove effects of trap location on numbers of moths caught. Traps were placed in orchards on May 15 (1X and 10X traps in 6 orchards), May 26 (DA-Combo traps in same 6 orchards), or May 31 (all trap types in remaining 3 orchards).

The number of moths caught in each trap was counted twice per week from late May to mid July and approximately weekly through early September. Lures were replaced every 30 days (10X lures) or 60 days (1X and DA-Combo were long-life (LL) lures). The sticky trap liners were replaced as needed after they became filled with moths and/or debris. Moths in the DA-Combo traps were sorted into male or female based on the structure of the tip of their abdomen (the tip of a female's abdomen bears a heart-shaped oviposition pad while male abdominal tips are blunter), except when catch per trap exceeded approximately 40 moths so that sorting by gender was too time consuming.

Fruit injury caused by codling moth larvae was assessed following completion of the first generation on Jul 5 and again following the second generation on Aug 23. On each sample date, four replicates of 100 fruit each were visually inspected for surface stings and larval entries in each of the 9 study orchards. Fruit were cut open as needed to verify entries. Fruit injury data are presented as the percentage of fruit with stings and entries.

Comparisons among lures are presented as the number of moths caught per night for the different trap types across orchard sites, as cumulative numbers of moths for each codling moth generation and for the season, and by regressing fruit injury for each orchard on trap catch for each lure type.

Results:

After MD dispensers were applied, adult catch was highest in traps baited with DA-Combo lures during most weeks in all orchards (Fig 1.). Moth numbers were low in 1X and 10X traps during most weeks in most orchards. Based on a degree-day model for codling moth development, the first generation of codling moth ended on approximately Jul 4, the second generation ended on Aug 17, and the third generation ended on Sep 15. Moth flight patterns as monitored with DA-Combo baited traps generally tracked codling moth generation times and expected flight peaks (Fig. 1). Moth numbers in 1X and 10X trap catch generally did not track the three generations with the exception of small peaks during the second generation in two grower sites (Growers B and C) (Fig. 1).

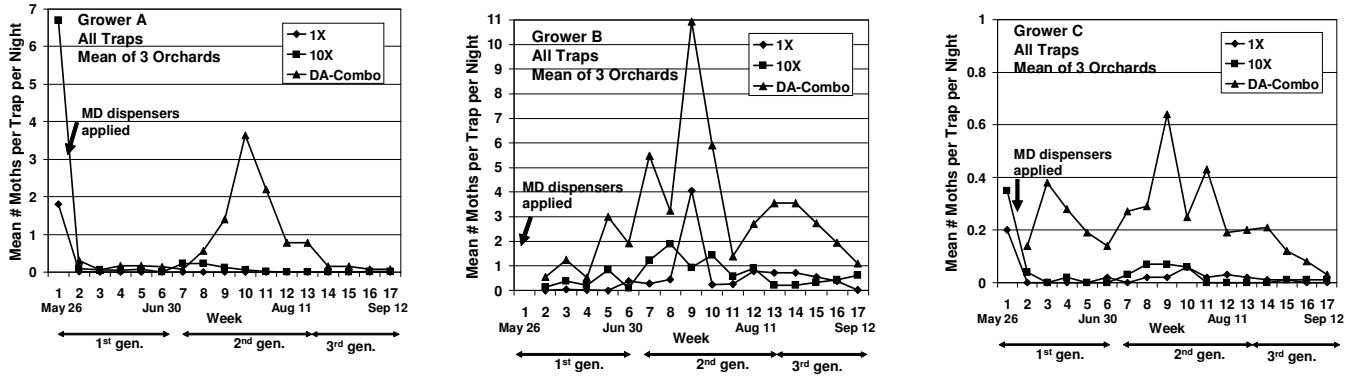

Figure 1. Number of codling moths attracted to traps with three types of lures (1X, 10X, and DA-Combo) in 9 apple orchards from three grower sites (means of 3 orchards per grower site are presented) from May 26 to Sep 12, 2006.

Development of trap catch thresholds for trap catch to indicate when supplemental insecticide sprays are needed have been evaluated in Washington state. Guidelines recommended for a high-load trap (10X lure) at a density of one trap per 2.5 acres is a cumulative catch of 4-10 moths (Brunner and Gut, www.tfrec.wsu.edu/IPMnews/IPM501.html#Trap). General guidelines for the CM-DA Combo lure provided by Trece Corporation, a distributor of the lures, is 5-10 moths per trap per week. Using the most conservative threshold for 10X traps of 4 cumulative moths (= 0.57 cumulative moths per night), Grower A orchards reached this threshold only during Week 8 (Jul 15), Grower B orchards first reached this threshold during Week 4 (Jun 23) and on many of the following weeks, and Grower C orchards did not reach this threshold (Fig. 1). Comparing the most conservative DA-Combo lure threshold of 5 moths per trap per week (= 0.71 moths per night), thresholds were reached on Weeks 9-13 (Jul 21-Aug 18) in Grower A orchards, on all weeks except 2 and 4 in Grower B orchards, and the threshold wasn't reached during any week in Grower C orchards (Fig. 1).

More male than female moths were caught in the DA-Combo baited traps throughout the flight season in most orchards (Fig. 2). Moths were not separated into gender for several weeks during peak flight of the second and third generations in two of the grower sites (Growers A and B) when moth counts exceeded approximately 40 per trap. The DA-Combo lure is a blend of the codling moth sex pheromone, codlemone, which attracts exclusively male moths and a pear fruit volatile that is attractive to both sexes. There is added value in obtaining female moth counts in traps as these provide a more direct measure of potential break-down in disruption of mating behavior due to MD dispensers in orchards. We did collect female moths to attempt to determine if they had mated before being caught in traps, but these data have not yet been completed.

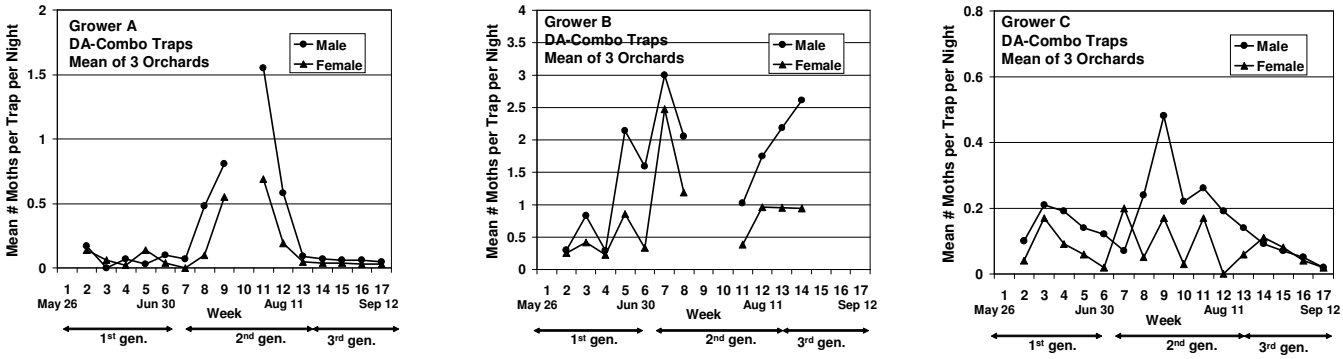

Figure 2. Capture of male and female codling moths in traps baited with DA-Combo lures in 9 apple orchards in southern Utah County during 2006. Missing data reflect weeks when moth counts exceeded approximately 40 per trap and so were not separated by gender.

The cumulative number of moths caught in traps baited with the three lure types were calculated for each of the three codling moth generations, totaled for the season, and compared to the percentage of apple fruits that were injured by codling moth larvae (stings, larval entries, and total injury) (Table 1). Results are provided for each orchard and the

cultivar of apple is indicated. As indicated above, many more moths were caught in DA-Combo traps than in the others and moth counts were highest during the second generation. Total fruit injury was greater in the second than first generation, but the percentage of fruit with stings declined while the percentage of fruit with larval entries increased by the second generation (Table 1). Results of regression analyses (looking for a linear relationship) found that only trap catch in DA-combo traps was a reasonable predictor of fruit injury. Cumulative moth counts in 1X and 10X traps were not related to observed fruit injury. Relationships were significant for regression of second generation and season total fruit injury on trap catch in DA-Combo traps ($p = 0.0007$, $r^2 = 0.53$; $p = 0.001$, $r^2 = 0.48$, respectively) (Fig. 3; only the graph for the second generation regression is shown). Based on slopes of the regression lines for both second generation and season total data, approximately 0.1% of fruit injury occurred for every moth per night caught in a DA-Combo trap (Fig. 3).

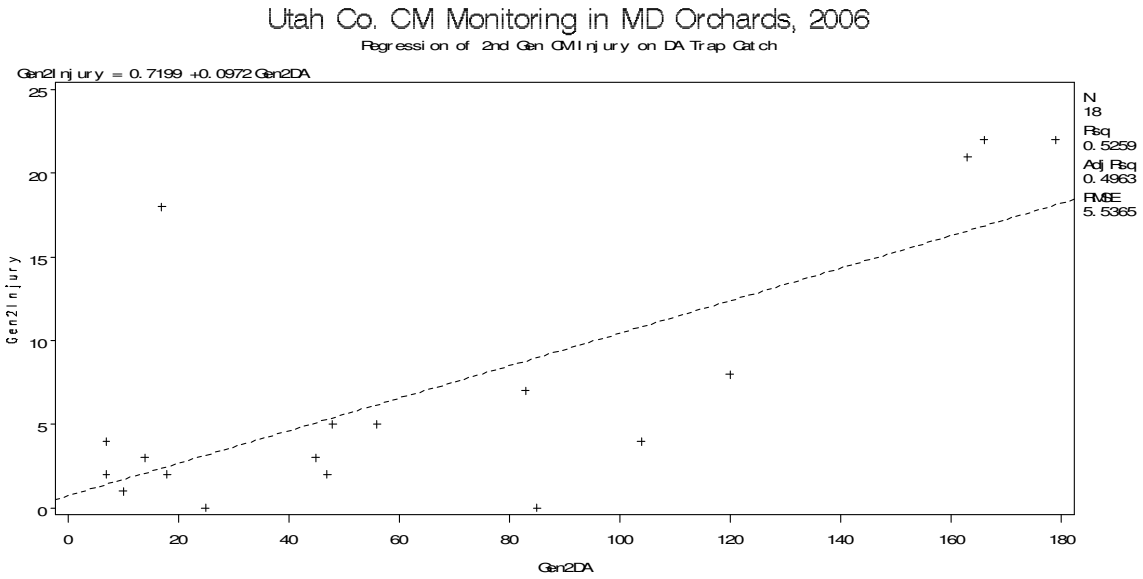

Figure 3. Regression of percentage fruit injury on cumulative moth catch in DA-Combo traps for the second codling moth generation across 9 apple orchards (two replicates per orchard = 18 data points) in southern Utah County, 2006.

Conclusions:

CM-DA Combo lures (Pherocon®) caught the most moths in all three codling moth generations across the nine apple orchards and provided the best prediction of fruit injury following the second generation and for season totals. Comparing moth catches for use in trap thresholds, the conservative DA-Combo threshold of 5 moths per week recommended supplemental insecticide sprays more frequently than did the conservative 10X trap threshold of 4 cumulative moths. Considering only larval entries, season total fruit injury ranged from 1.3-32.3% across the nine orchards. Because supplemental insecticide sprays were applied to most orchards, it is difficult to determine if implementation of these trap thresholds may have improved fruit protection, but it seems very likely that their use would have reduced fruit injury in orchards with the highest injury levels (Red Delicious, Jonathan, and Jonathan2 orchards in Table 1). Trap catch information from the DA-Combo lure provided more accurate codling moth population information than the standard lure used in MD orchards, the 10X lure. Comparing costs for the different lures, DA-Combo lures are 2-2.5X more expensive than 10X lures.

Based on this small sample size of nine apple orchards, there was a significant relationship between fruit injury and weekly trap catch in the DA-Combo traps. During the second codling moth generation, approximately 0.1% fruit injury occurred for every moth caught per night in DA-Combo traps. This relationship held, but was weaker for season total data. Because moth numbers are greatest in the second generation, this generation has the most influence on season totals. By collecting data from more orchards and years, a more refined predictive model between trap catch and fruit injury could be developed.

Table 1. Effect of codling moth trap lures on mean catch of adult moths for three generations and means for fruit injury by generation and season.

Orchard	Cumulative # moths per trap												% fruit with codling moth injury						
	1st generation*			2nd generation*			3rd generation*			Season total*			1st generation^		2nd generation^		Season total^		
	1X	10X	DA-Combo	1X	10X	DA-Combo	1X	10X	DA-Combo	1X	10X	DA-Combo	Stings	Entries	Stings	Entries	Stings	Entries	Total
Braeburn	0.0	3.0	3.5	0.0	5.5	47.5	0.0	0.5	1.0	0.0	9.0	52.0	7.0	1.0	1.5	2.8	8.5	3.8	12.3
Fuji	0.0	1.0	5.0	0.0	2.0	84.0	0.0	0.0	5.5	0.0	3.0	94.5	7.3	1.5	2.0	1.0	9.3	2.5	11.8
Fuji2	0.0	1.0	16.0	2.5	1.5	19.5	0.0	0.0	8.5	2.5	2.5	44.0	1.8	0.5	0.5	1.0	2.3	1.5	3.8
Gala	0.5	0.5	5.5	0.5	3.0	12.5	0.0	0.0	0.0	1.0	3.5	18.0	0.0	0.0	0.8	1.3	0.8	1.3	2.0
Gala2	0.0	3.5	12.5	8.5	29.0	74.5	1.0	10.5	32.5	9.5	43.0	119.5	2.3	2.5	1.3	4.3	3.5	6.8	10.3
Golden Del.	0.0	0.0	0.0	0.0	0.0	8.5	0.5	0.5	3.5	0.5	0.5	12.0	1.5	1.5	0.3	3.0	1.8	4.5	6.3
Jonathan	0.5	1.5	10.0	0.0	5.0	36.5	0.0	0.5	5.0	0.5	7.0	51.5	7.5	8.5	0.3	12.5	7.8	21.0	28.8
Jonathan2	1.5	15.5	27.0	37.0	67.5	143.0	26.5	31.0	106.5	65.0	114.0	276.5	2.5	5.8	3.0	21.5	5.5	27.3	32.8
Red Del.	8.5	7.5	87.5	16.5	17.5	171.0	8.0	6.5	98.0	33.0	31.5	356.5	3.0	12.0	1.5	20.3	4.5	32.3	36.8

*First trap catch (biofix) occurred in orchards on May 2-6. Traps with test lures were placed in orchards from May 15 to Jun 5, 2006. First generation ended approx. Jul 4, 2nd generation ended approx. Aug 17, and 3rd generation ended Sep 15.

^1st generation fruit injury was sampled on Jul 5 and 2nd generation injury was sampled on Aug 23, 2006.