USING AEROSOL PHEROMONE "PUFFERS" FOR AREA-WIDE SUPPRESSION OF CODLING MOTH IN WALNUTS: YEAR FOUR

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ABSTRACT

The Walnut Pest Management Alliance (PMA) for a tenth year continued work to reduce pesticide inputs in California walnuts and demonstrate and increase implementation of pest management strategies based on various formulations of pheromone mating disruption (PMD). Three long-term, area-wide projects continued in 2008 with aerosol pheromone puffers for codling moth (CM) control and three additional sites and an expansion area were created. The majority of the PMD acreage in this project in 2008 did not need supplemental insecticides to control CM, but some blocks did need treatments to control walnut husk fly and navel orangeworm which are not affected by the pheromone program. Several years of using PMD over a large area demonstrate the benefits of this system which include reduced crop damage, reduced CM populations which can be managed using fewer insecticide sprays, reduction of broad spectrum insecticides and a move to softer insecticides to supplement PMD. Data collected from the same locations over several years allows measurement of these reductions. The trial locations are independent and the results are not meant to be compared to each other. Monitoring data from several of the puffer sites was compared to a non-pheromone treated orchard and the resulting graph (Figure 1) was shared regionally. The success of this program depends on the inputs from many collaborators including pest control advisors (PCAs), UCCE Farm Advisors, Suterra LLC, Trece Inc, USDA-ARS, Ca. Dept. of Pesticide Regulation, UC IPM, Walnut Marketing Board, Walnut Entomology Workgroup, growers, and several field assistants. The project is supported by grants from:

- Walnut Marketing Board, $23,000
- Western IPM, $55,000
- USDA areawide project, $49,000
- UC IPM Demonstrations, $10,000

OBJECTIVES

1. Validate pheromone application technology required for control of codling moth with an emphasis on "area-wide" control over multiple years. Continue using aerosol puffers at sites in San Joaquin, Glenn, and Butte Counties and expand acreage of SJ site to take advantage of area-wide CM suppression.
2. Create new sites where growers have shown interest in Yolo, and Tehama Counties to increase local visibility and experience with the pheromone puffers.
3. Demonstrate the use of monitoring CM to watch for population increases and to determine spray timings. Monitor damage to the crop with in-season surveys of nuts in the canopy. Over time, the need for supplemental sprays should be decreased and eliminated with CM population reductions.

PROCEDURES

Locations chosen to demonstrate aerosol pheromone puffers for CM management are large areas of contiguous walnut orchards of several different varieties. Sites include blocks with historically high CM pressure as well as portions planted with varieties that are more resistant to CM damage. Varieties include Ashley, Chandler, Hartley, Howard, Serr, Tehama, Tulare, and Vina. Table 1 shows acreage, number of blocks, and varieties included for each site as well as the number of years each location has used the puffers.

This project was designed to manage codling moth with pheromones by lowering populations aggressively in the early years with insecticides. After this, the supplemental treatments are eliminated or switched to selective insecticides that are more environmentally friendly. Although the benefits of pheromone puffers extend equally over the whole treated area, the blocks are usually managed separately. In 2005, all first-year pheromone treated blocks at Glenn and San Joaquin (SJ) were supplemented with at least one insecticide treatment to ensure high quality nuts at harvest and reduce population levels at the start of the 2006 season. In 2006 and beyond, an emphasis was placed on managing codling moth population based on combo lure trap catches and not based on potential damage to the nuts.

Suterra CM puffers were arranged in a grid, at a rate of one puffer per two acres with a slightly higher concentration along the outside edges. The units are deployed at or before the start of codling moth flight and are automatically programmed to emit a “puff” of pheromone at 15 minute intervals for a period of 12 hours each night. The puffers are assembled in the field and hung with rope in the upper ¼ of the tree canopy. The trial protocols originally called for servicing of the units at least once during the growing season to ensure operational integrity, even though they are designed to last 200 days without any maintenance. The puffers very rarely malfunction and servicing has been reduced to spot checks.

The trial blocks were monitored with Pherocon VI Delta traps (Trece, Inc.) baited with the newer DA-CM “Combo” lure and hung high in the tree canopy. For assurance that mating is being disrupted, additional traps with “1X” lures (Trece Standard Lure) were hung low in the canopy. The 1X traps act as an “early warning system”: they should not catch any moths in a pheromone-treated orchard. Trap density varied according to CM pressure and the needs of the grower. Very large orchards were divided into smaller blocks for monitoring purposes. Monitoring blocks ranged in size from 10 to 25 acres, each with at least one Combo lure trap high in the canopy. Traps were checked weekly and the lures changed as recommended by the manufacturer. Data from Combo lure traps provide a picture of CM generations and peaks in flight, useful for timing of sprays. Seasonal total catches from these traps represent annual CM population size, and the same data, when viewed as cumulative totals show population suppression over time.

When possible, dropped nuts were examined for CM damage at the end of the first flight. Nut damage from the subsequent generations was monitored with “canopy counts” performed mostly from ground level and occasionally with a pruning tower. In each block, 500 to 1,000 nuts at random locations in the canopy were examined and percent CM damage was recorded. In-season damage surveys followed protocols available at http://www.ipm.ucdavis.edu/index.html.

Data collected from all monitoring activities was shared with the grower/cooperator and the independent consulting firms providing Pest Control Advisor service to the grower.

Supplemental insecticides were applied as needed using the growers' choice of materials, based on field monitoring and damage in individual blocks. Supplemental insecticides for CM control were unnecessary at many of the project locations, although sprays to control walnut husk fly (WHF) and navel orangeworm (NOW) were applied at some sites. Table 2 shows applications to the Sacramento Valley sites in 2008 and includes sprays which were aimed at other insect pests but could affect codling moth. A minority of the project acreage received supplemental CM control with insecticides in 2008, usually applied in response to rapidly increasing trap catches. At the Glenn site, pesticide inputs were reduced in 2006 and 2007, but the 2008 season began with high trap catches and Lorsban was applied in early May. After about 3 weeks of control, trap numbers increased rapidly and the entire site was treated with Penncap-M at the suggestion of project leaders, and average CM damage was 0.1%. At the Yolo site, Warrior was applied in May to only the Vinas, about ¼ of the site acreage. In the SJ expansion area's first year, about 1/6 of the acreage received supplemental insecticides for CM; the balance received no CM treatments. No CM sprays were needed at the 600 acre SJ site, although some blocks were treated for WHF.

Harvest samples were collected during commercial harvesting operations. Protocols for the collection of harvest samples varied slightly between sites due to differences in plot layout and to additional shaking and harvesting activities. At the San Joaquin sites, twenty 25-nut samples were collected after shaking in each test block. At the Yolo, Glenn and Butte sites, ten 50-nut samples were collected in each of the monitoring blocks/areas. At the Butte site, samples were collected again during a second shake which occurred 2-3 weeks later, because the majority of the crop remained on the trees after the first harvest. All nuts were cracked and examined to assess damage from codling moth and navel orangeworm.

RESULTS

This year, puffers were deployed in a timely manner, before any significant CM activity. As this technology is at the implementation stage, most of the assembly and installation was done by each grower's field staff after receiving training from UC and Suterra personnel. The puffer units performed well all season with very few malfunctions. Installed at an overall density of one puffer per 2 acres, the project sites described here use a total of 993 puffer units, many of which have been in the field for several years. The current design, in use since 2007, is very reliable, with field records showing more than 99% of the units working all season without problems. In previous years, calculations based on the weight loss of the aerosol cans showed them to be emitting pheromone within the daily expected range; the average weight loss was 2.2 grams per day. Details of the puffer units' servicing records are not presented here.

Once the puffers were functioning, traps baited with the 1X lure caught no moths in treated areas, as expected. Traps placed high in the canopy and baited with Combo lures usually catch enough moths to determine when flights begin and end, but sometimes in late summer they don't catch anything for weeks at a time. Due to these concerns, average trap catches from each of the Sacramento Valley sites were plotted on a graph and compared to trap data from a similar field not treated with pheromone. This graph, (Figure 1) illustrates the higher trap catches seen without pheromone and also shows that Combo lures do attract moths all season long. Other studies have confirmed that low late-season CM-DA trap catches reflect a low CM population and are not due to lure performance failures. The graph was sent monthly, via e-mail, to all participating growers, Farm Advisors and Pest Control Advisors (PCA's).

Canopy counts were performed twice during the season whenever possible. In 2008, some blocks were surveyed with the use of a pruning tower due to concerns that ground-based searches may underestimate CM damage. Very little CM damage from was found during either type of these surveys, less than 1% damage in all pheromone treated blocks at all sites with only a couple of minor exceptions. Variations in sampling procedures prevented statistical analysis comparing the two methods and protocols for determining in-season damage levels continue to be refined.

Harvest samples reported here include total damage found in "sound" nuts (with intact kernels) and "unsound" nuts (with shriveled kernels) that would probably be removed and discarded during normal pickup and processing operations. Thus sample damage levels are sometimes higher than growers' harvest grade results. The majority of the acreage received less than 1% CM damage including both first-year sites and those that have used puffers for several years. The 600 acre SJ site showed 0% damage except for samples collected near the edges of some blocks around the periphery of the site, Figure 2. The Yolo and Glenn sites both averaged 0.1% CM damage, Figure 3 and 4, and the Tehama-S site had 0% CM also. Using the Butte site grower's records of truckload weights, it was determined that approximately 30% of the crop was collected during the early harvest and the other 70% harvested 3 weeks later. This information was used to calculate a weighted average that would represent total crop damage which ranged from 0.1% to 0.7% and averaged 0.4% across the whole site. Harvest samples were not collected from the Tehama-N site because the crop was damaged by frost on April 20th and 21st.

Codling moth population reduction can be shown by comparing the total moth capture in combo traps for each year. The SJ site, after 4 years use of puffers use, , is the best example of this reduction, shown in Figure 5. During the first two years, total trap catches in most blocks were between 50 and 150 moths; in 2008, total trap catches were 15 or less in all but 2 small blocks. At the Glenn site, also with 4 years of puffers, seasonal trap captures mainly declined from 2005 to 2006, but numbers increased in 2007 and 2008 in the Vina and Tehama blocks. The Chandler block does show population decrease over time. This data is valuable because it shows high population areas in the field that may continue to require extra attention or spot treatment. A reduction in total trap catches is evident after two years using puffers at the Butte site.

Total trap catches are not always a reliable indicator of damage at harvest. Comparing crop damage from the same blocks over time is more useful for tracking progress and identifying field areas that may need more attention. Figures 6 and 7 show damage at harvest over four years at the San Joaquin and Glenn locations. The San Joaquin data shows a large decrease in CM crop damage from 2005 when some blocks had more than 2% to 2008 when damage was 0% or 0.2% in all blocks but one. At Glenn, most blocks had zero damage in 2008 even though many blocks had high total trap catches. After two years, the Butte site also showed a large decrease in damage across all blocks.

Related monitoring projects addressed the movement of aerosol pheromone from the puffer areas into neighboring orchards and whether Combo traps provide accurate data when hung low in the canopy. Most of this work was performed by Carolyn DeBuse in fields surrounding the Yolo puffers site. One hundred and fifty acres of Chandlers to the south of the Yolo puffers was monitored with 1X traps placed at increasing distances from the pheromone. The traps nearest to the puffers were about 135 feet and the furthest were about 2,075 feet away. Figure 8 shows increasing trap catches at increasing distances as the influence of the aerosol pheromone moving from the north decreases. None of the 1X traps was completely shut down. The same field was monitored with Combo traps hung both high and low in the canopy to address efficacy of the low traps. Hanging and checking traps high in the canopy is more time consuming but is necessary for accurate flight data as shown in Figure 9.

DISCUSSION

Codling moth damage, total trap catches, and the number of sprays can be compared to previous years to demonstrate reduction of broad spectrum insecticides and a move to softer insecticides to supplement PMD.

The grower/cooperators at the trial sites are enthusiastic about integrating aerosol puffers into their pest management program. Most of the sites began with grower-initiated implementation and all the growers now purchase their own puffer units and aerosol cans without monetary support from this project. The PMA plans to continue aerosol puffer implementation assistance for a fifth and final year at the San Joaquin and Glenn, sites and, if funding allows, several more years at the more recently created sites to demonstrate the long term successes that have been seen in other crops such as pears. Several of the cooperating growers have expressed a desire to eliminate supplemental insecticides for CM and rely solely on the puffers for control from the first year on. This strategy was successful in 2008, with very little CM damage found in any of the blocks. Monitoring insect populations and in-season damage in pheromone-treated blocks will always be necessary and is especially important as insecticides are reduced or eliminated. Efforts to develop treatment thresholds if/when supplemental sprays are needed are ongoing so walnut growers have confidence in pheromone-based pest management programs. The puffer units have been very reliable as well as cost effective at approximately $70.00 per acre, a cost which is competitive with conventional insecticide programs used by many growers.

Communication with neighboring growers is becoming more important as pheromones are being more widely used for CM management. The project's "Good Neighbor Program" provides education and assistance with the purchase and use of combo lures in case the aerosol pheromone treatments shut down their conventional pheromone-baited traps.

The expansion area in San Joaquin County was developed by encouraging the neighboring walnut growers to participate, taking advantage of the benefits of a larger area utilizing PMD to control CM. These successful demonstrations are creating more interest and confidence in integrating pheromone mating disruption into walnut pest management programs.

TABLES AND FIGURES

Table 1. 2008 CM Puffer Project Sites.

LOCATION	# YEARS	ACRES	# BLOCKS	VARIETIES
San Joaquin	4	600	22	Chandler, Hartley, Howard, Serr, Tulare, Vina
SJ expansion	1	540	10	Chandler, Hartley, Serr, Vina
Glenn	4	180	3	Chandler, Tehama, Vina
Butte	2	205	2	Vina
Yolo	1	180	4	Chandler, Hartley, Tehama, Vina
Tehama-S	1	120	2	Ashley, Tehama
Tehama-N	1	160	2	Vina

Table 2. 2008 Supplemental Insecticide Applications

LOCATION	BLOCK	DATE	MATERIAL	TARGET
Glenn	All	May 5	Lorsban	CM
	All	July 21	Penncap-M	CM
	All	Sept. 1	Warrior (generic)	NOW
Butte	North block	Aug. 1	GF-120	WHF
	South block	July 26	Lorsban + bait	WHF
	South block	Sept. 1	Perm-up	NOW
Yolo	Vina only	May 23	Warrior	CM
Tehama-S	Ashley	Aug. 1 & 8	Brigade + bait	WHF
		Aug. 24	Perm-up	NOW
	Tehama	Aug. 1 & 8	Brigade + bait	WHF
		Sept. 4	Perm-up	NOW

Figure 1. 2008 Trap Catches with Combo Lure At 5 Puffer Sites and One Untreated

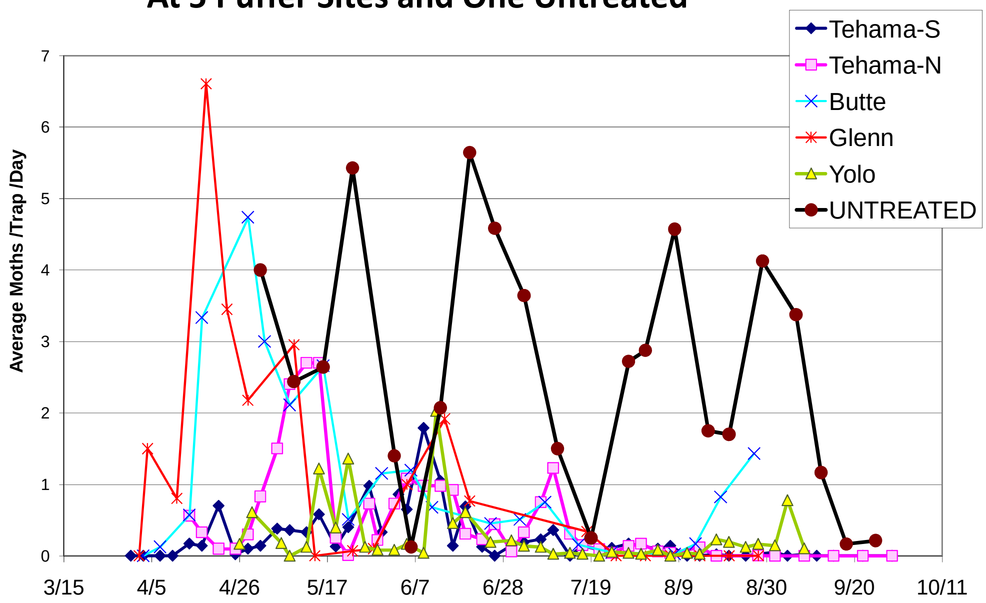


Figure 2. San Joaquin: 0% CM except at edges of some blocks.

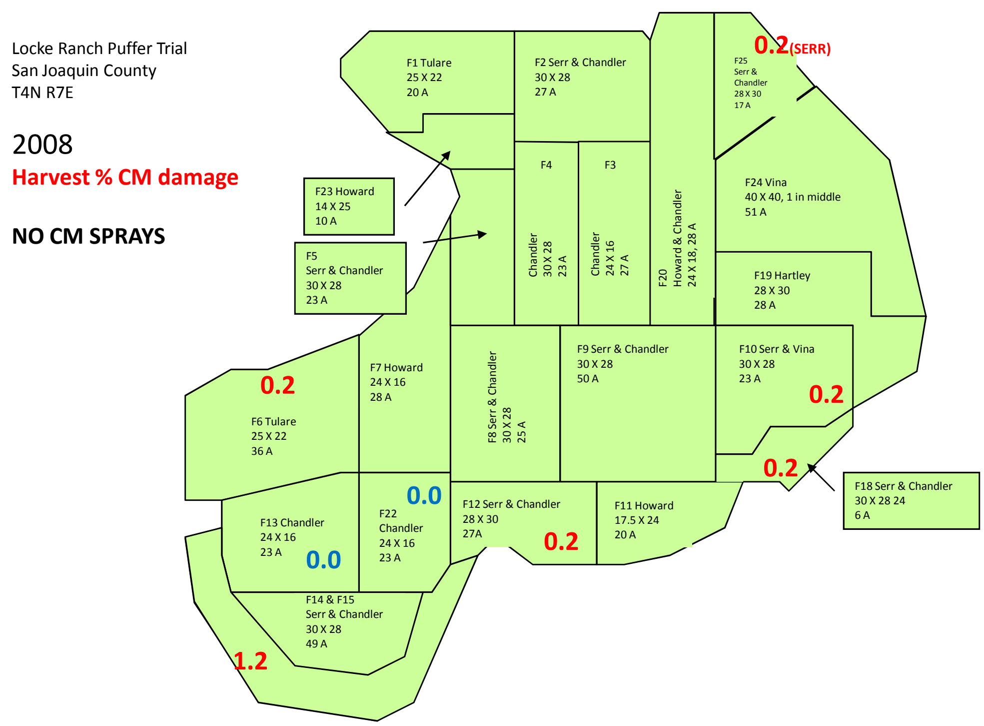


Figure 3. Yolo Puffers & Neighbors
Damage at Harvest 2008

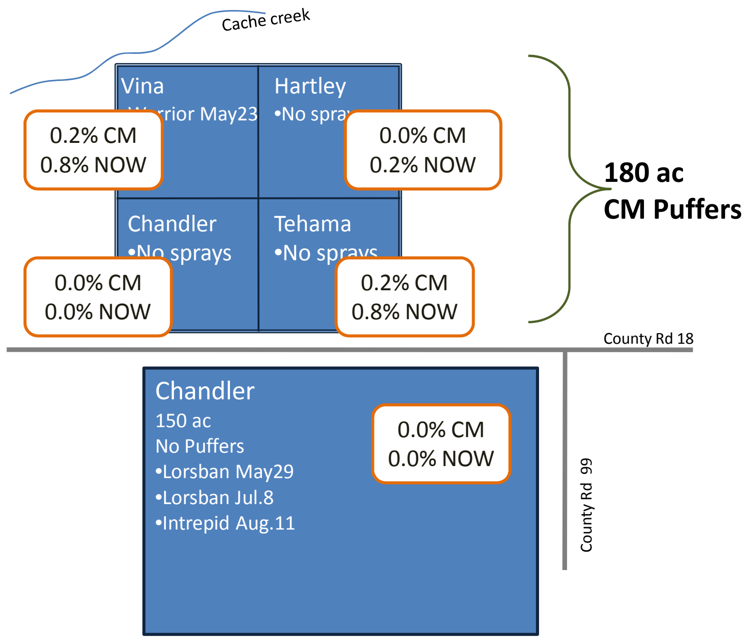


Figure 4. **Glenn Puffers**
Damage at Harvest 2008

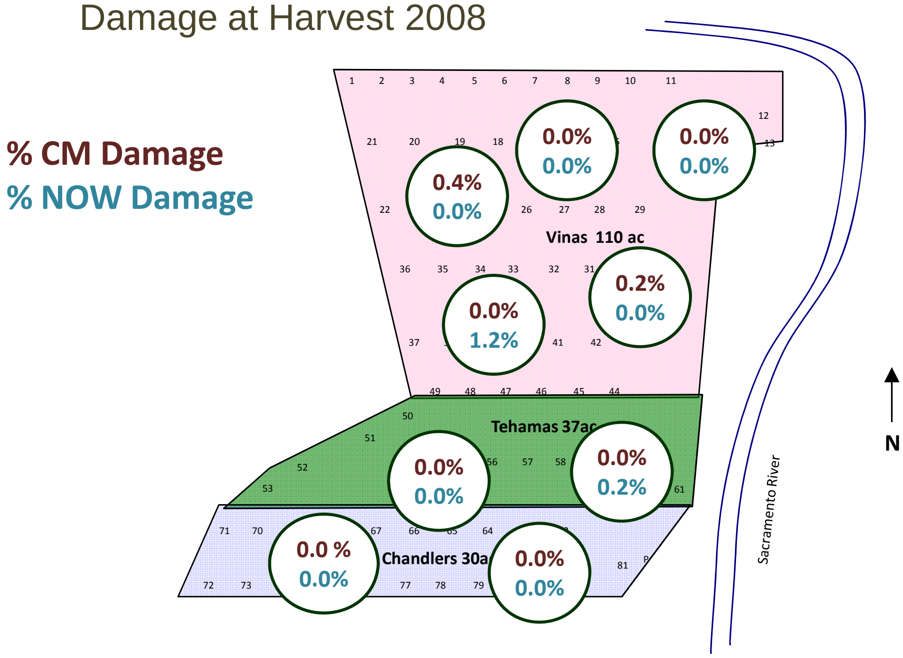


Figure 5. Population decline over time
San Joaquin Puffers 2005-2008

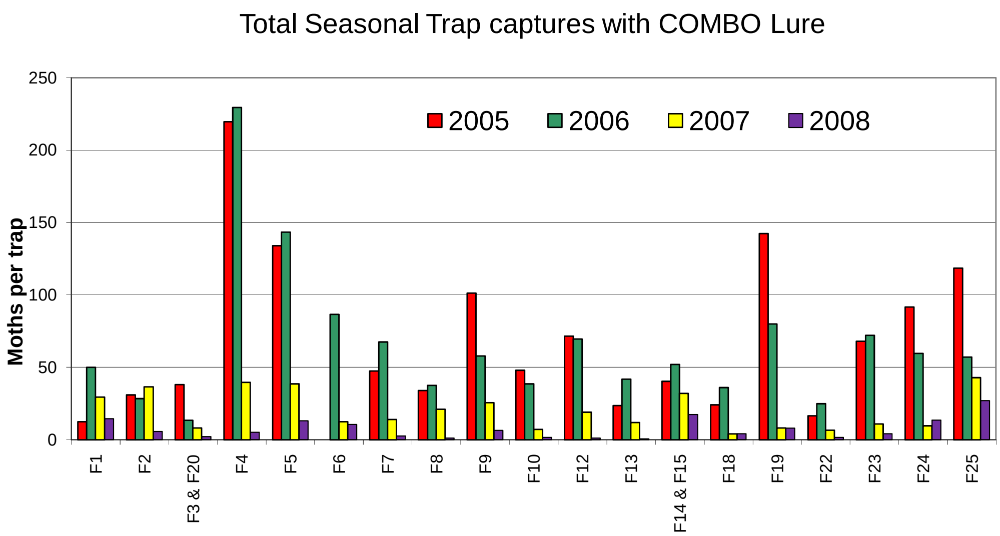
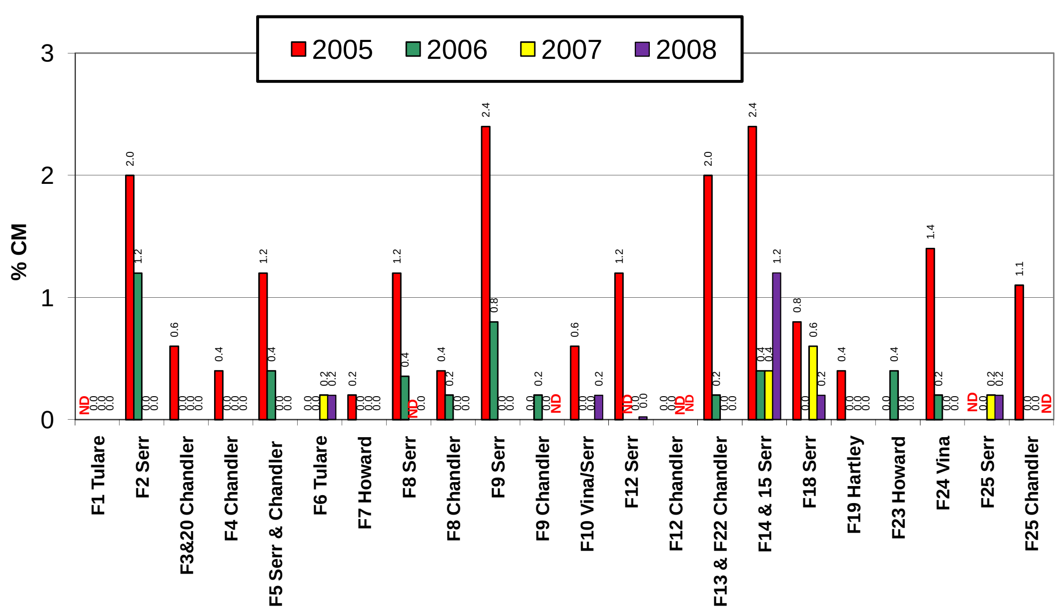


Figure 6. Damage at Harvest Decrease over 4 Years
San Joaquin Puffers 2005-2008



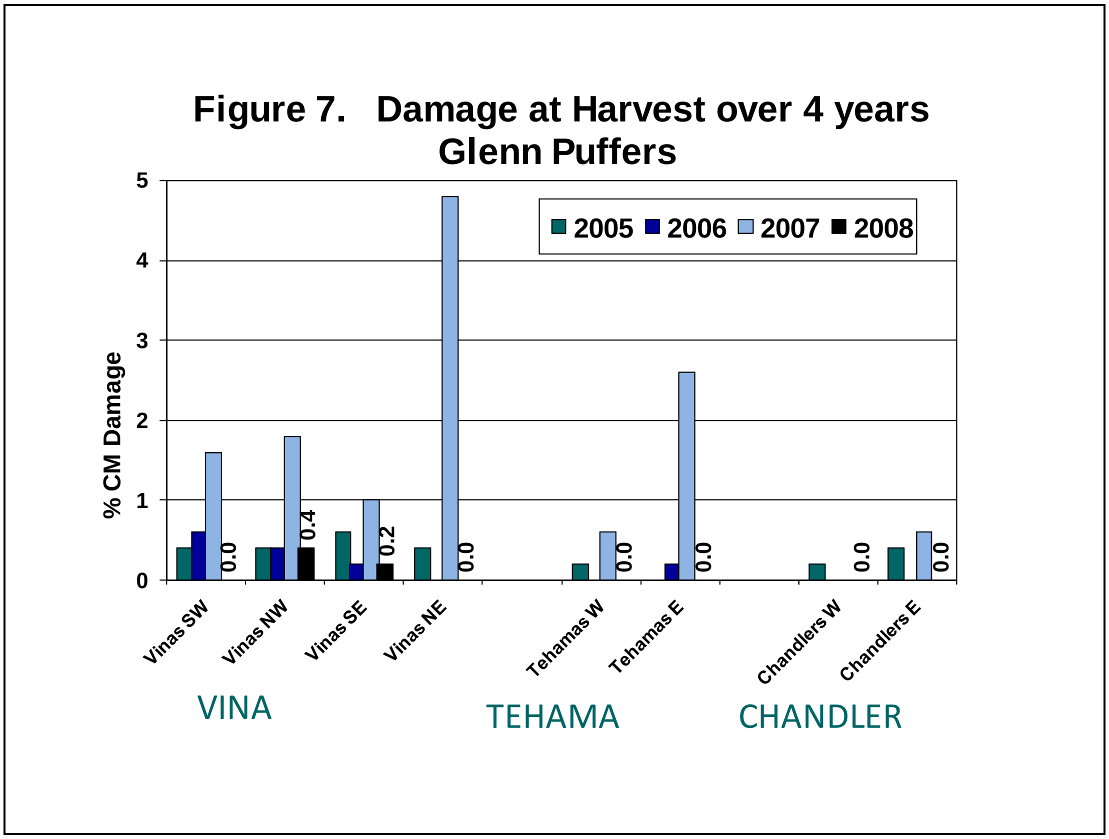


Figure 7. Damage at Harvest over 4 years
Glenn Puffers
% CM Damage
5
4
3
2
1
0
2005
2006
2007
2008
0.0
0.4
0.2
0.0
0.0
0.0
0.0
0.0
Vinas SW
Vinas NW
Vinas SE
Vinas NE
Tehamas W
Tehamas E
Chandlers W
Chandlers E
VINA
TEHAMA
CHANDLER

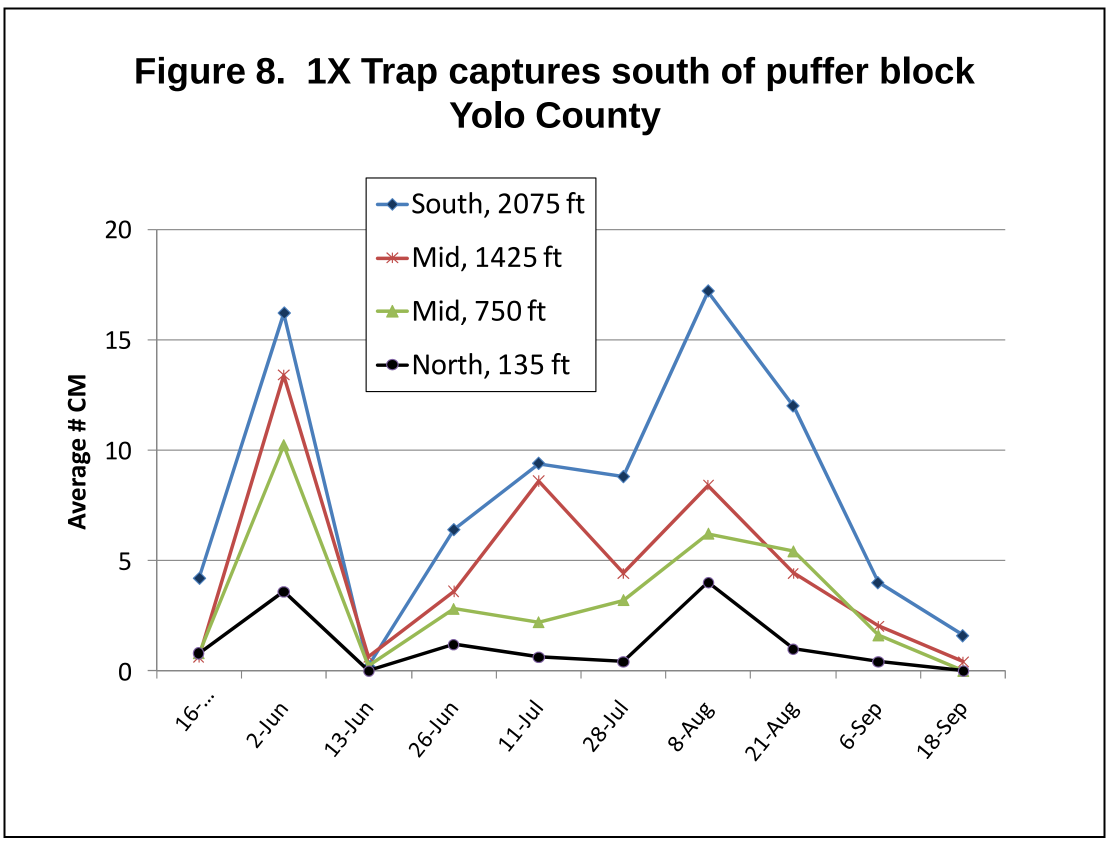


Figure 8. 1X Trap captures south of puffer block
Yolo County
South, 2075 ft
Mid, 1425 ft
Mid, 750 ft
North, 135 ft
Average # CM
20
15
10
5
0
16-...
2-Jun
13-Jun
26-Jun
11-Jul
28-Jul
8-Aug
21-Aug
6-Sep
18-Sep

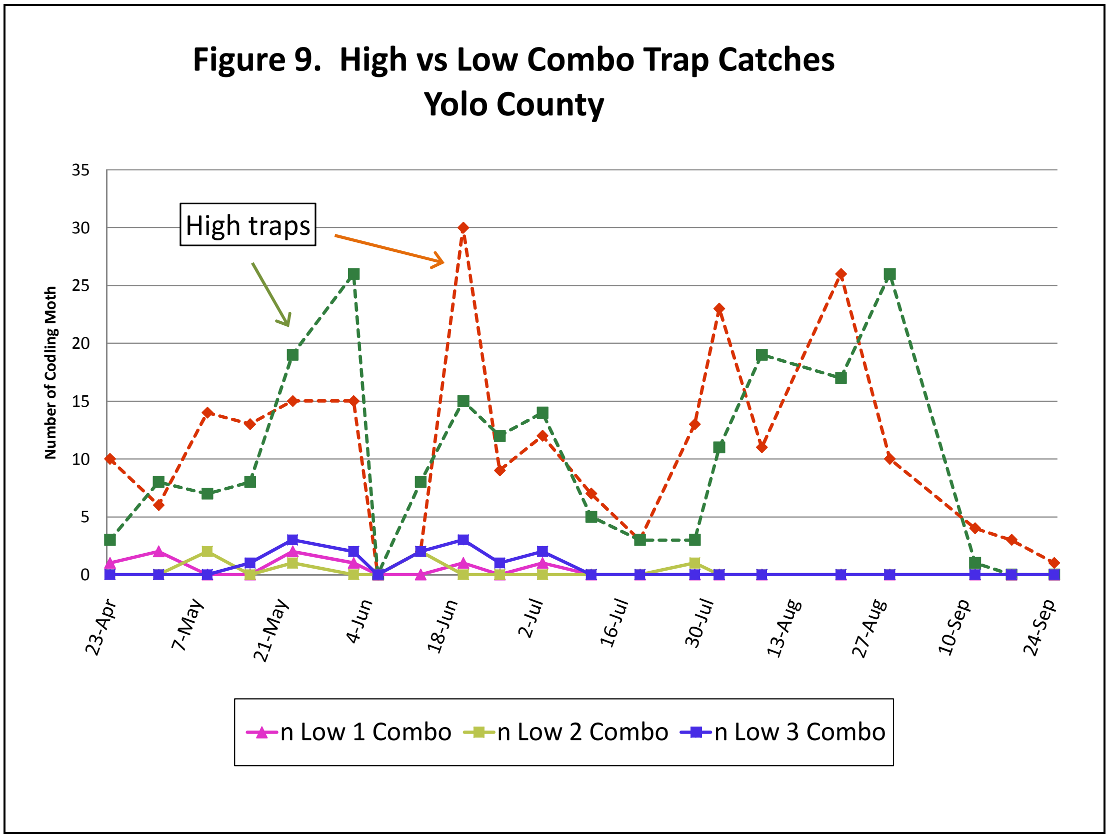


Figure 9. High vs Low Combo Trap Catches
Yolo County
High traps
Number of Codling Moth
35
30
25
20
15
10
5
0
23-Apr
7-May
21-May
4-Jun
18-Jun
2-Jul
16-Jul
30-Jul
13-Aug
27-Aug
10-Sep
24-Sep
n Low 1 Combo
n Low 2 Combo
n Low 3 Combo