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

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ABSTRACT

The Walnut Pest Management Alliance (PMA) continued work to reduce pesticide inputs in California walnuts with a ninth year to demonstrate implementation of pest management strategies based on pheromone mating disruption (PMD). Efforts to improve efficacy, reduce cost, and demonstrate reliability are still necessary so that walnut growers have confidence in pheromone-based pest management programs. In 2007, two long-term, area-wide projects continued for a third year using aerosol pheromone puffers for codling moth (CM) control and an additional site was created. Puffers were deployed at an economical rate of one unit per two acres with the updated model Suterra puffer cabinet which is easier for growers to use and more reliable. The benefits of using PMD over a large area for several years are reduced crop damage, and reduced CM populations which can be managed using fewer insecticide sprays. 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.

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 and Glenn Counties and add new site in Butte County. Monitor codling moth populations 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 or eliminated.
2. Field test new pheromone application technologies that have a high potential for use in walnuts.
3. Assist with and demonstrate the use of monitoring for CM damage for growers who are interested in implementation of pheromone mating disruption.

PROCEDURES

Locations chosen to demonstrate Suterra's 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. The Glenn County site is 185 acres of walnuts and consists of three blocks, each a different variety and age (Figure 1) the Butte site, created in 2007, is two blocks totaling 205 acres (Figure 2), and the San Joaquin County site is 564 acres comprised of 22 blocks of various tree size, age, and variety (Figure 3).

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 would be eliminated or switched to less effective but more selective insecticides that are more environmentally responsible. Although the benefits of pheromone puffers extend equally over the whole treated area, each block is managed separately. In 2005, all 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 2007, 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 were assembled and deployed at or before the start of codling moth flight when possible. The units are hung with rope in the upper ¼ of the tree canopy and programmed to emit a 40 mg. "puff" of pheromone at 15-minute intervals for a period of 12 hours each night, beginning at 5 PM. Although they are designed to last 200 days, the trial protocols called for servicing of the units at least once during the growing season to ensure operational integrity. The aerosol cans were weighed at servicing, and again at the end of the season when they were removed from the field.

The trial blocks were monitored with Delta traps used in sets of two. Each pair included one trap baited with the newer "DA/CM combo" lure and hung high in the tree canopy and one with the traditional 1X pheromone lure 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. The Glenn County trial had 8 pairs of traps, one pair per every 25 acres and the Butte site was monitored with six pairs. The San Joaquin trial used traps at a higher density, with a total of 39 pairs of traps. All traps were checked weekly and the lures changed as recommended by the manufacturer.

In-season "canopy counts" of CM-damaged nuts were performed twice, at the end of each flight. At the Glenn and Butte sites, 1000 nuts throughout the tree canopies were examined for CM damage in each block, and at the SJ site, 625 nuts were examined in each block. 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. Tables 1, 2 and 3 list all applications to the Glenn, Butte and San Joaquin, sites respectively, and include all those which could affect codling moth, though some sprays target other insect pests such as walnut husk fly or navel orangeworm. The Butte site received no supplemental insecticides in 2007, a decision based on very low trap counts all season. 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.

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 site, twenty 25-nut samples were collected after shaking in each test block. At the northern Sacramento Valley sites (Glenn

and Butte), samples were collected at two different harvest timings in order to represent the whole crop. During the first shake, ten 50-nut samples were collected in each of the monitoring blocks/areas (eight sampling locations at Glenn and six at Butte). Samples were collected again during a second shake which occurred 2-3 weeks later, except the sampling areas did not correspond exactly to the earlier sampling date. 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. A large portion of the assembly and installation was done by each grower's field staff after receiving training from either UC or Suterra personnel. Once the puffers were functioning, traps baited with the 1X lure caught no moths in treated areas, as expected. 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 during one season. Graphs of 2007 Combo trap catches at the Glenn site are shown in Figure 4, and the Butte site, Figure 5, and cumulative totals from the traps at the SJ site in Figure 6.

The puffer units performed well all season with very few malfunctions. Installed at 2 per acre, the three project sites described here are using a total of 466 puffer units, some of which have been in the field for several years. The current design is very reliable, with field records showing only one problematic unit each out of the 81 puffers at Glenn and the 105 puffers at Butte. 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.

Canopy counts were performed twice during the season, late July and in late August at the two N. Sacramento Valley sites and late June and early August at the SJ site. Very little evidence of damage from CM was found during these surveys, with all treated blocks at all sites showing less than 1% damage with only a couple of minor exceptions. At the Glenn site, (Table 4), after inspecting thousands of in-canopy nuts, only two were found with any evidence of CM damage. A 40 acre block at the Butte site (Table 5) showed an average of 1.4% CM damage in the first canopy count and all other areas had less than 1% damage. The SJ site continued to have very little in-season damage, a couple of blocks with 1.1% damage and all others significantly below 1% (Table 6).

Harvest samples reported here include only damage found in "sound" nuts (with intact kernels) and not "unsound" nuts (with shriveled kernels) that would probably be removed and discarded during normal pickup and processing operations. Thus sample damage levels are comparable to growers' harvest grade results. The SJ site (Table 6, right side of table) had almost zero damage from either CM or NOW, of the approximately 10,000 nuts examined, less than 10 nuts had any type of damage and the majority of the treated area showed zero damage. Harvest damage at the two N. Sacramento Valley trial locations is harder to interpret. The first shake produced mostly nuts with husks still attached, and left many nuts still in the tree. Approximately 21 days later, a second harvest produced nuts without any green husks. Sampling areas were slightly different

and fewer areas were sampled, making a direct comparison between the two harvest timings inaccurate. To gain a more meaningful damage assessment of the entire crop, a weighted average was calculated using grower-provided yield data. Tables 7 (Glenn) and 8 (Butte) show results from samples collected from both harvest timings, and also the weighted averages of the whole block where appropriate. There was no significant NOW damage at any of the trial sites.

Codling moth population reduction can be shown by comparing the total moth capture in combo traps for each year. At the Glenn site (Figure 7), although seasonal trap captures mainly declined from 2005 to 2006, numbers increased in 2007 at ¾ of the trapping locations, possibly due to earlier warm weather and CM flight. The trap catches from the northeast Vinas increased for a second year, indicating an area with high CM pressure that may need extra monitoring. Total seasonal trap catches at the SJ site (Figure 8) over three years show a considerable population reduction in 2007 for a huge majority of the acreage. Comparing crop damage from the same blocks over time is also useful for tracking progress and identifying field areas that may need more attention. Percent CM damage over three years is shown in Figure 9 for the Glenn site and in Figure 10 for the San Joaquin site. All treated blocks at the SJ site continued to show a decline in crop damage for the third year.

DISCUSSION

The grower/cooperators at the puffer trial sites are enthusiastic about integrating aerosol puffers into their pest management program. The PMA plans to continue the aerosol puffer trials for up to three more years to demonstrate the long term population reduction and reduced use of pesticides that have been seen in other crops such as pears. In the next couple of years these trials will rely less on pesticide inputs, with 2005 acting as a baseline for the comparisons of damage and documentation of pesticide use reduction in each block.

An ongoing challenge is the monitoring of CM flights in and close to pheromone-disrupted orchards. 2007 was the fourth year of using combo lures to overcome this difficulty. In some cases, lures were provided to neighboring growers in case the pheromone treatments (especially the puffers) shut down their conventional pheromone-baited traps. In fact, communication with neighboring growers is becoming more important as pheromones are being more widely used for pest management.

Goals for 2008 include expansion of the puffer treated areas 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. Applications to Glenn Puffer Trial in 2007

Field	Date	Treatment	Target Pest
Vinas	Mar 29	CM puffers deployed	CM
	June 12	NOW puffers deployed, 2/ac	NOW
	July 2	Lorsban 4E, ½ gal/ac	CM
	Aug 21	Ethrel + Perm-Up, 16 oz/ac	NOW
Tehamas	Mar 29	CM puffers deployed	CM
	July 2	Lorsban 4E, ½ gal/ac	CM
	Aug 21	Ethrel + Perm-Up, 16 oz/ac	NOW
Chandlers	Mar 29	CM puffers deployed	CM
	July 2	Lorsban 4E, ½ gal/ac	CM
	Aug 21	Ethrel + Perm-Up, 16 oz/ac	NOW

Table 2. Applications to Butte Puffer Trial in 2007

Field	Date	Treatment	Target Pest
24	Mar 22	CM puffers deployed	CM
	May 25	NOW puffers deployed, 2/ac	NOW
25	Mar 22	CM puffers deployed	CM
No insecticide sprays in 2007			

Table 3. Applications to San Joaquin Puffer Trial in 2007
CM Puffers Deployed April 4-6, 2007

Field	Date	Treatment	Target Pest
1	2-Aug	Success 3.2oz/A, Nulure 3pts/A, Provado 1.6F 4oz/A, 50gal/A	WHF
	15-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	5-Sep	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
2	17-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	4-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	22-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	28-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
3 & 20	26-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	10-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	27-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
4	19-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	8-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	29-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	10-Sep	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
5	17-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	4-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF

	22-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	28-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	
	10-Sep	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
6	2-Aug	Success 3.2oz/A, Nulure 3pts/A, Provado 1.6F 4oz/A, 50gal/A	WHF
	15-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	5-Sep	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
7	17-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	3-Aug	Success 3.2oz/A, Nulure 3pts/A, Provado 1.6F 4oz/A, 50gal/A	WHF
	30-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
8	28-May	NOW puffers deployed, 2/ac	NOW
	19-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	6-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	23-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	27-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
9	28-May	NOW puffers deployed, 2/ac	NOW
	18-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	8-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
10	28-May	NOW puffers deployed, 2/ac	NOW
12	19-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	6-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	23-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	27-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
13 & 22	25-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	13-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	28-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
14& 15	24-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	9-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
18		No Sprays	
19		No Sprays	
23	3-Aug	Success 3.2oz/A, Nulure 3pts/A, Provado 1.6F 4oz/A, 50gal/A	WHF
	16-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	30-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
24	20-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	6-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	14-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
25	17-Jul	Brigade 1.5lb/A	Aphid, WHF, CM, Mites
	4-Aug	Success 3.2oz/A, Nulure 3pts/A, Provado 1.6F 4oz/A, 50gal/A	WHF
	14-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	29-Aug	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF
	7-Sep	Success 3.2oz/A, Nulure 3pts/A, 50gal/A	WHF

Table 4. Glenn Puffer Trial 2007 Canopy Counts

	Canopy Counts July 26	**% CM** Aug 28
Vinas NE	0.0	0.0
Vinas NW	0.0	0.0
Vinas SE	0.2	0.0
Vinas SW	0.0	0.0
Tehamas W	0.0	0.0
Tehamas E	0.0	0.0
Chandlers W	0.0	0.0
Chandlers E	0.0	0.0
	1,000-nut sample each	

Table 5. Butte Puffer Trial 2007 Canopy Counts

	Canopy Counts July 25	**% CM** Aug 24
Field 25 SE	0.6	0.2
Field 25 W	0.5	0.3
Field 25 NW	0.6*	0.7
Field 25 NE	ND	0.4
Field 24 SE	1.6*	0.4
Field 24 N	1.2*	0.9
	1,000-nut sample each *500-nut sample	

Table 6. San Joaquin Puffer Trial 2007 Canopy Counts and Damage at Harvest

Block	Variety	**Canopy Counts, % CM** June 27	Aug 9	**Damage at Harvest** % CM	% NOW
1	Tulare	ND	ND	0.0	0.2
2	Serr	0.8	1.1	0.0	0.2
3 & 20	Chandler	ND	ND	0.0	0.0
4	Chandler Serr	0.3	0.0	0.0	0.0
5	Serr Chandler	1.1 0.5	0.5 0.3	0.0	0.0
6	Tulare	0.2	0.3	0.2	0.2
7	Howard	0.0	0.0	0.0	0.0
8	Serr Chandler	0.5	0.5	ND 0.0	ND 0.0
9	Serr Chandler	0.3	0.8	0.0 0.0	0.0 0.0

10	Vina, Serr	0.2	0.2	0.0	0.0
12	Serr/Chandler	0.8	0.6	0.0	0.0
13	Chandler	ND	ND		ND
14 15	Serr Serr	0.3	0.8	0.2 0.6	0.0 0.0
18	Serr	0.0	0.0	0.6	0.2
19	Hartley	0.0	0.0	0.0	0.0
22	Chandler	ND	ND	ND	ND
23	Howard	ND	ND	0.0	0.0
24	Vina	0.2	0.2	0.0	0.0
25	Serr Chandler	0.2	1.1	0.2 0.0	0.0 0.0
		625-nut sample each		500-nut sample each	

Table 7. Glenn Puffer Trial Damage at Harvest 2007

Harvest Date	Field & Location	% CM	% NOW	Field average % CM	% of Total Yield by wt.*	Weighted average, whole field % CM
Sep 8	Vinas NW	1.8	0.6	2.3	75%	2.1
Sep 7	Vinas SW	1.6	0.4			
Sep 7	Vinas SE	1.0	0.0			
Sep 8	Vinas NE	4.8	0.6			
Oct 1	Vinas NW	0.0	0.0	1.4	25%	
Oct 1	Vinas NE	2.8	0.2			
Sep 12	Tehamas E	2.6	0.2	1.6	75%	1.7
Sep 12	Tehamas W	0.6	0.0			
Oct 4	Tehamas	1.8	0.2	1.8	25%	
Oct 1	Chandlers E	0.6	0.2	0.3		
Oct 1	Chandlers W	0.0	0.0			
500-nut sample each						

* Based on harvest weight at each date.

Table 8. Butte Puffer Trial Damage at Harvest 2007

Harvest Date	Field & Location	% CM	% NOW	Field average % CM	% of Total Yield by wt.*	Weighted average, whole field % CM
Sep 13	24 N	7.6	0.0	5.9	23%	4.29
Sep 13	24 SE	4.2	0.0			
Oct 2	24	3.8	0.2	3.8	77%	
Sep 14	25 NE	2.2	0.0	2.8	30%	1.88
Sep 14	25 NW	3.8	0.0			
Sep 14	25 SE	4.8	0.0			
Sep 14	25 W	0.2	0.2			
Oct 3	25 S	1.6	0.0	1.5	70%	
Oct 3	25 N	1.4	0.0			
500-nut sample each						

*Based on harvest weight at each date.

Figure 1
Glenn puffers 2007

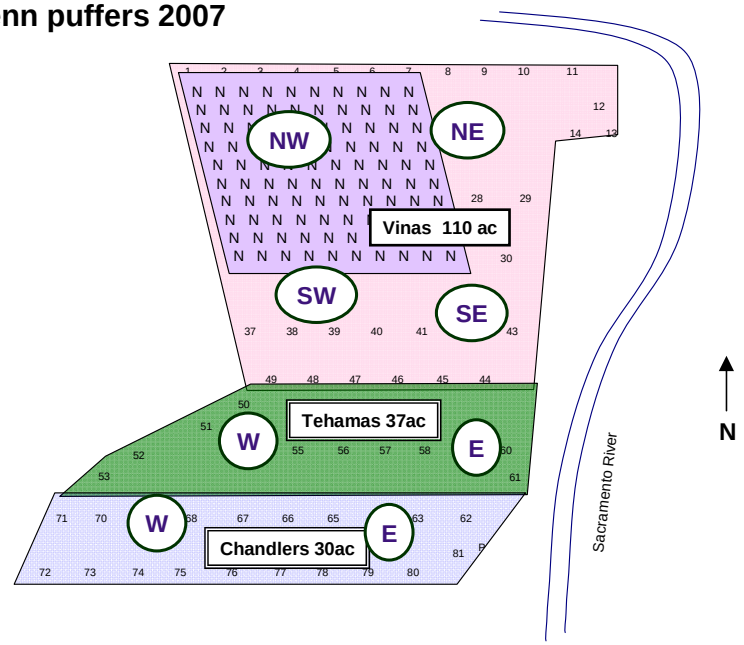


Figure 2
Butte puffers 2007
Field 24
25 CM puffers,&
88 NOW puffers

Field 25
80 CM puffers

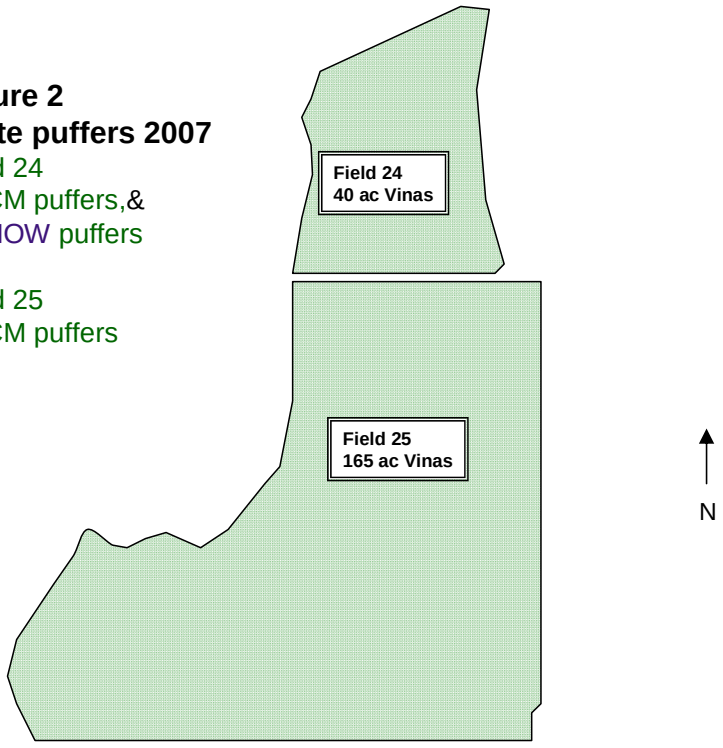
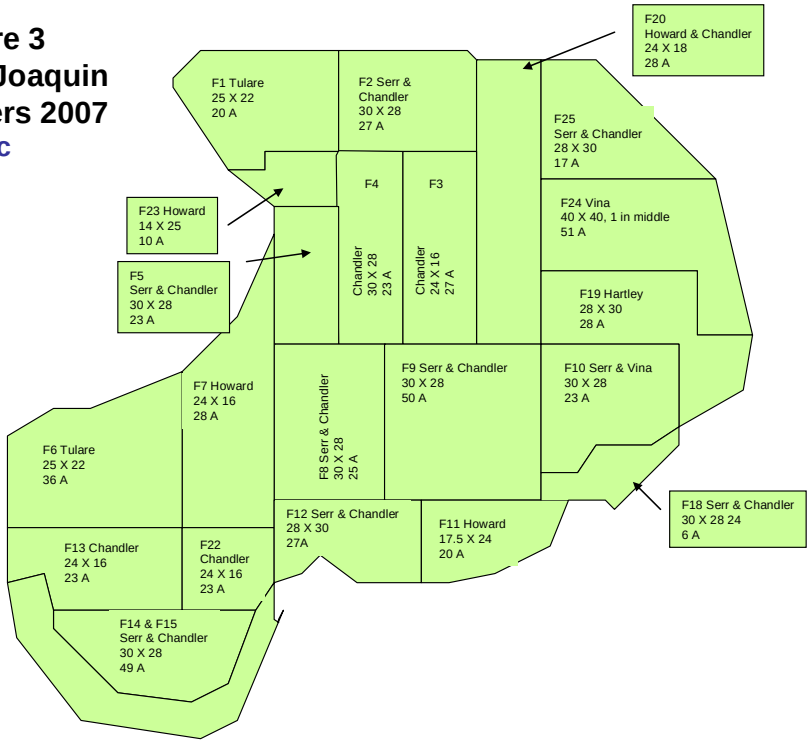


Figure 3
San Joaquin Puffers 2007
560 ac



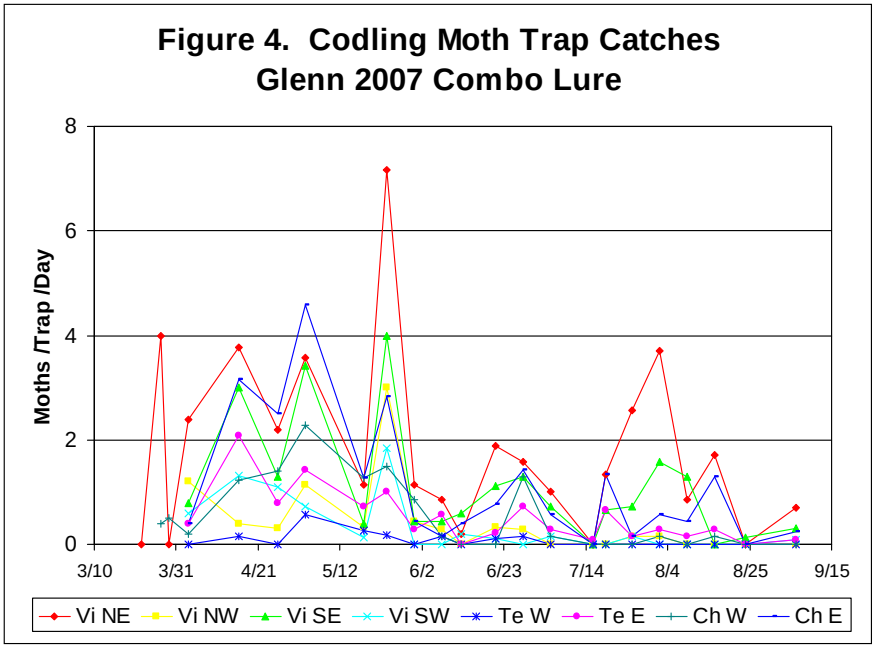


Figure 4. Codling Moth Trap Catches
Glenn 2007 Combo Lure
Moths /Trap /Day
8
6
4
2
0
3/10
3/31
4/21
5/12
6/2
6/23
7/14
8/4
8/25
9/15
Vi NE
Vi NW
Vi SE
Vi SW
Te W
Te E
Ch W
Ch E

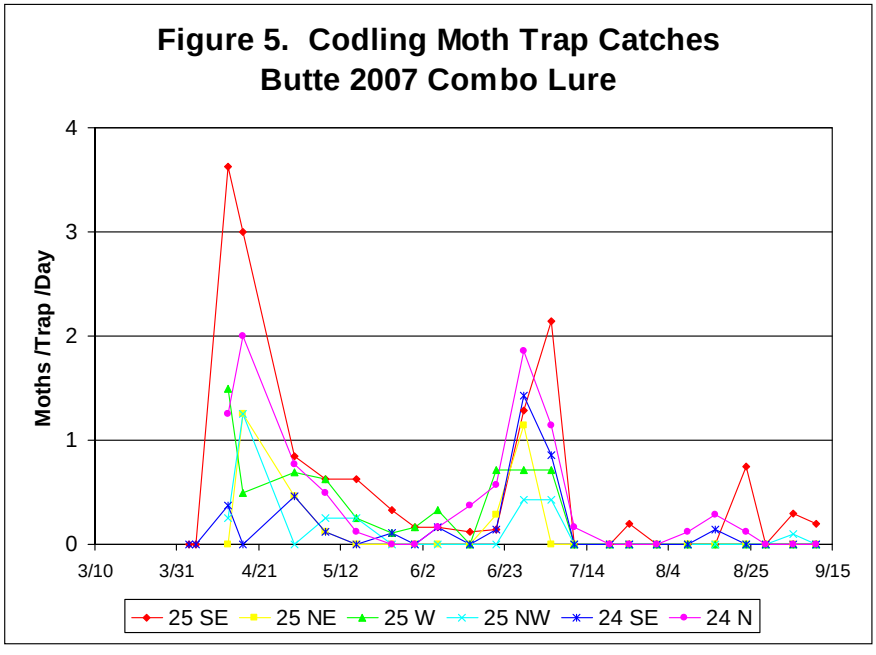


Figure 5. Codling Moth Trap Catches
Butte 2007 Combo Lure
Moths /Trap /Day
4
3
2
1
0
3/10
3/31
4/21
5/12
6/2
6/23
7/14
8/4
8/25
9/15
25 SE
25 NE
25 W
25 NW
24 SE
24 N

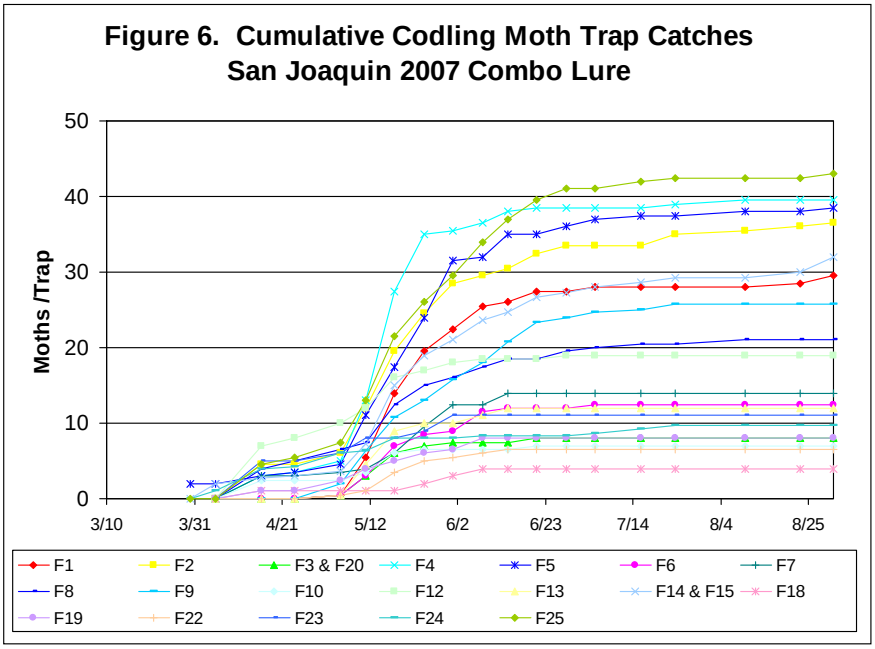


Figure 6. Cumulative Codling Moth Trap Catches
San Joaquin 2007 Combo Lure
Moths /Trap
50
40
30
20
10
0
3/10
3/31
4/21
5/12
6/2
6/23
7/14
8/4
8/25
F1
F2
F3 & F20
F4
F5
F6
F7
F8
F9
F10
F12
F13
F14 & F15
F18
F19
F22
F23
F24
F25

Figure 7. Glenn 2005-2007
Total CM Trap Catches, Combo lure

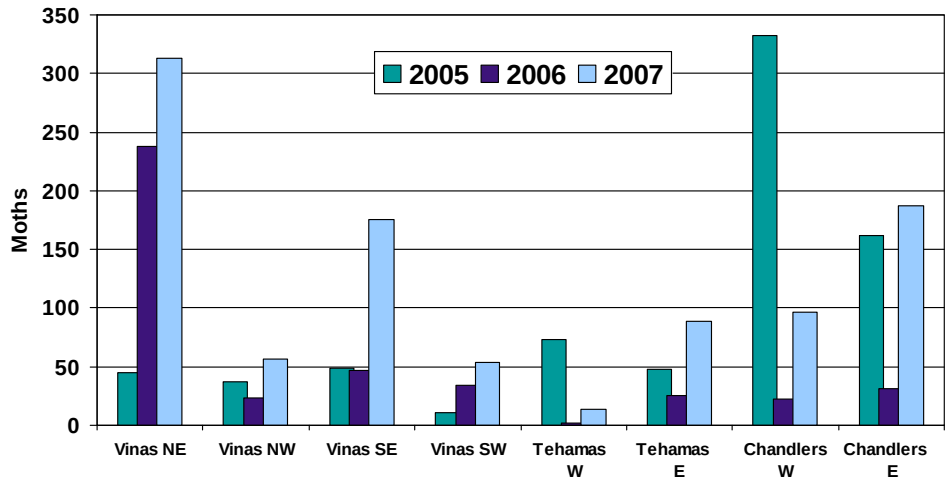
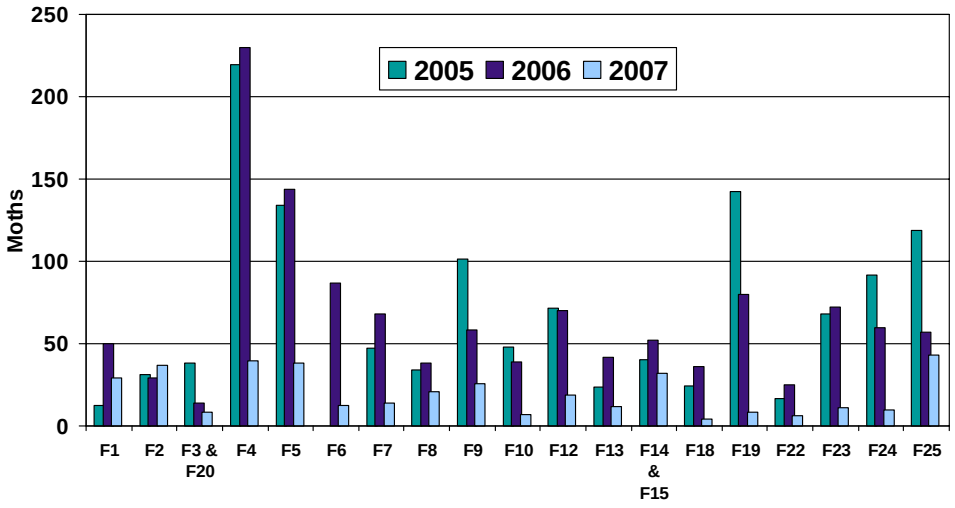


Figure 8. San Joaquin 2005-2007
Total CM Trap Catches, Combo lure



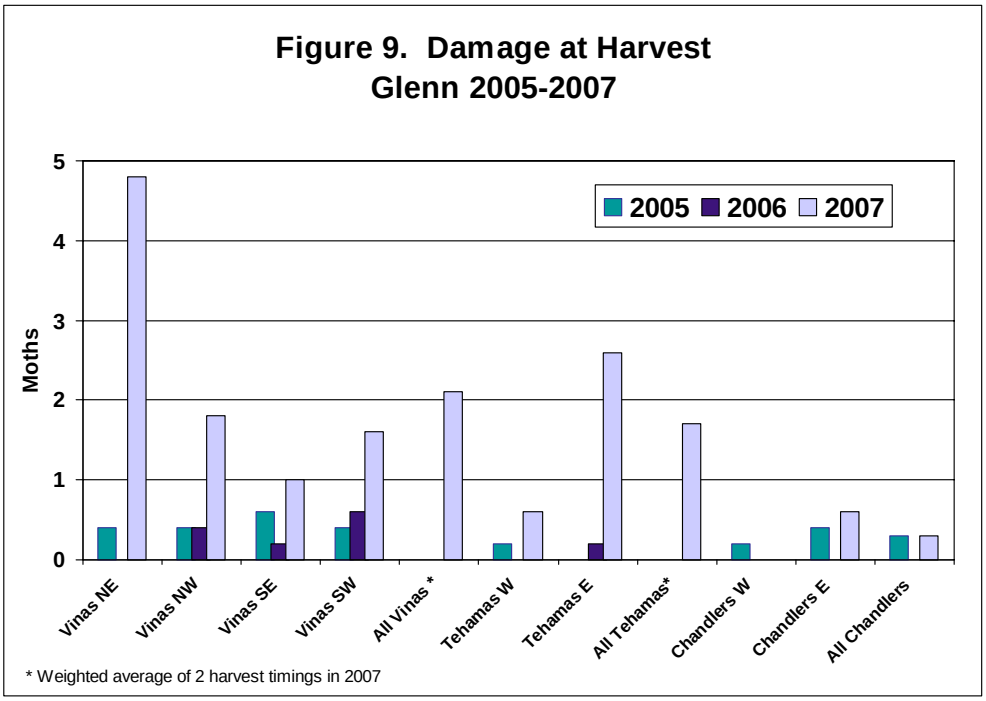


Figure 9. Damage at Harvest
Glenn 2005-2007
Moths
0
1
2
3
4
5
2005 2006 2007
Vinas NE
Vinas NW
Vinas SE
Vinas SW
All Vinas *
Tehamas W
Tehamas E
All Tehamas*
Chandlers W
Chandlers E
All Chandlers
* Weighted average of 2 harvest timings in 2007

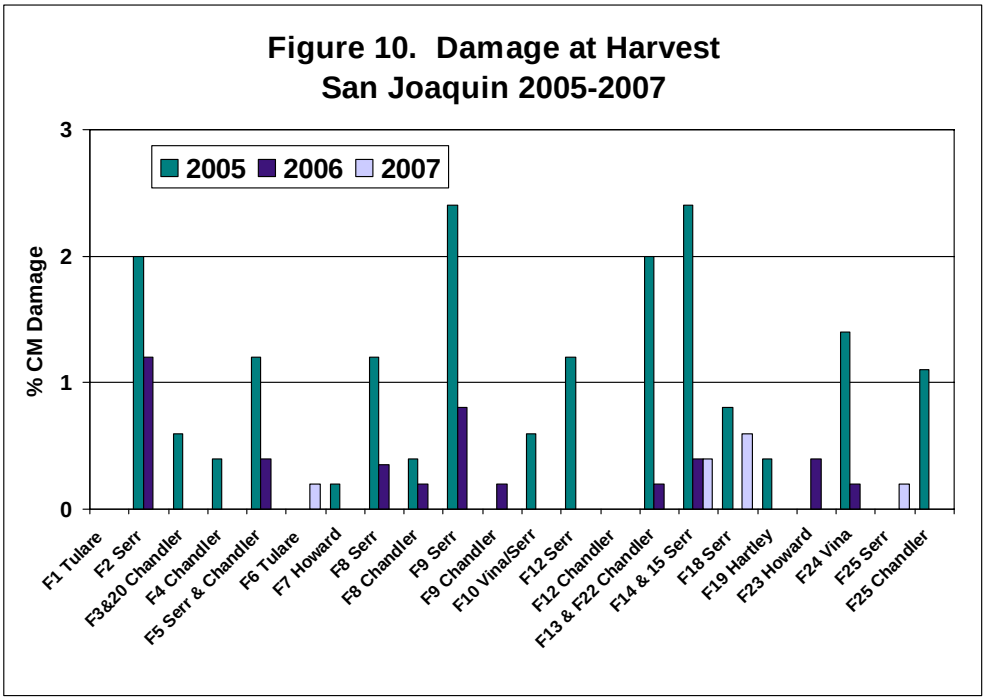


Figure 10. Damage at Harvest
San Joaquin 2005-2007
% CM Damage
0
1
2
3
2005 2006 2007
F1 Tulare
F2 Serr
F3&20 Chandler
F4 Chandler
F5 Serr & Chandler
F6 Tulare
F7 Howard
F8 Serr
F8 Chandler
F9 Serr
F9 Chandler
F10 Vina/Serr
F12 Serr
F12 Chandler
F13 & F22 Chandler
F14 & 15 Serr
F18 Serr
F19 Hartley
F23 Howard
F24 Vina
F25 Serr
F25 Chandler