Almond Culture and Orchard Management

Project No.: **15-HORT3-Buchner/Symmes**

Project Leader: Rick Buchner
2015 Almond Workgroup Chair
1754 Walnut Street, Red Bluff, CA 96080
530.527.3101
rpbuchner@ucanr.edu

Report prepared by: Emily J. Symmes
2016 Almond Workgroup Chair
2279-B Del Oro Avenue
Oroville, CA 95965
530.538.7201
ejsymmes@ucanr.edu

Project Cooperators and Personnel:
Rick Buchner, UCCE Tehama County
Roger Duncan, UCCE Stanislaus County
Brent Holtz, UCCE San Joaquin County
Franz Niederholzer, UCCE Colusa County
Katherine Pope, UCCE Yolo County
Dani Lightle, UCCE Glenn County
Blake Sanden, UCCE Kern County
Emily Symmes, UCCE Butte County

The Almond Culture and Orchard Management report summarizes a series of projects conducted by University of California Cooperative Extension (UCCE) Farm Advisors to address local, regional, and/or statewide issues facing almond production throughout California.

Project Title: **Monitoring and Reporting of Almond Insect Pest Dynamics in Tehama County**

Project Leader: Rick Buchner
UCCE - Tehama/Shasta Counties
1754 Walnut Street
Red Bluff, CA 96080
530.527.3101
rpbuchner@ucdavis.edu

Interpretive Summary:

Four insect trap location replications in Tehama County almonds were used to monitor Oriental Fruit Moth (OFM), Peach Twig Borer (PTB) and male, female and egg laying for Navel Orangeworm (NOW). Traps and Degree Days were monitored twice weekly and insect activity

reports went to the email grower list once per week on Monday. The weekly pest update includes dates of sustained insect activity or biofix, insect activity reported as moths/day, average day degrees per day for each insect and total day degrees from biofix by insect. For PTB we set the first biofix on 3/16/15 the second on 5/26/15 at 1009 Degree Days (DD) and a third biofix on 7/2/15 at 997 DD. OFM first biofix occurred 2/16/15,the second on 5/4/15 at 1201 DD, the third on 6/11/15 at 959 DD and a fourth on 7/20/15 at 1332 DD. NOW egg traps indicated first eggs on 4/6/15,second egg laying on 6/11/15 at 896 DD, third egg laying on 7/6/15 at 708 DD with a fourth egg laying on 7/30/15 at 730 DD. Female traps did not appear to catch many females showing relatively low activity throughout the season. Male NOW emerged ahead of the females and their flight activity was more steady and not clearly mirroring female flights or egg laying. Insect updates are available online at cetehama.ucanr.edu.

Project Title: **Mechanical Topping of Nonbearing Almond Trees**

Project Leader: Roger Duncan
UCCE - Stanislaus County
3800 Cornucopia Way, Suite A
Modesto, CA 95358-9492
209.525.6800
raduncan@ucdavis.edu

Objectives:

- Compare mechanical topping of first-leaf almond trees to various hand pruning strategies of tree training.
- Evaluate effects on tree size, anchorage and early yield.
- Compare costs & net income associated with each method of training.

Interpretive Summary:

More growers are mechanically topping their non-bearing almond trees in an attempt to produce a shorter, more compact tree while reducing labor costs. Growers in windy areas especially desire a shorter tree architecture to reduce tree leaning or blowover. Typically, mechanically headed trees are “flat topped” at a height of five to six feet, depending on tree vigor. While mechanical topping may inexpensively reduce tree height, the short and long term effects of this practice need to be evaluated. Questions to be answered include: what are the labor / cost savings? Does mechanical topping create a bushier, more fruitful tree, leading to larger, earlier production? Does making indiscriminant heading cuts stimulate excessive bud break, resulting in premature shading in the lower tree canopy? Does this reduce long-term yield?

In this trial, mechanical topping reduced training costs by $23 per acre compared to a more conventional, long pruned training system. However, when topped trees also were subjected to scaffold selection, costs were about $12 per acre higher than conventionally trained trees. Mechanically topped trees grew vigorously the year following topping and were just as tall as

unpruned trees by the end of the second season. Mechanically topped trees tended to have smaller trunk calipers than unpruned trees but not short-pruned trees. Topping and other methods of tree training did not affect tree anchorage, as measured by a protractor to document tree leaning.

Materials and Methods:

The replicated field trial was established in November, 2014 in a first-leaf Nonpareil and Monterey orchard on Titan peach x almond rootstock near Westley, on the Westside of Stanislaus County. This area is notoriously windy and growers often short prune their trees to reduce tree leaning and blowovers. In this trial, trees were either mechanically topped by a custom operator or left untopped. Some topped trees were trained to 4-5 scaffolds while others had no scaffold selection. In addition, untopped trees were either short-pruned by hand to 4-5 scaffolds, long-pruned to 4-5 scaffolds or left untrained without scaffold selection.

Prior to training, the first-leaf Nonpareil trees were 9.0 – 9.5 feet tall while the Monterey trees were 8.0 – 8.5 feet tall. On November 6, 2014, first-leaf trees were mechanically topped with a mechanical topper (Baker Topping, Visalia, CA) to a height of approximately six feet. In December, a hand crew trained some of the topped trees to four or five scaffolds as described above while others had no scaffold selection. The professional pruning crew was timed to determine the cost of each pruning treatment, not including stacking and disposing of brush.

At the end of the second leaf, tree height and trunk circumference was documented for each treatment. During the third season, the degree of tree leaning was determined by using a large protractor to measure trunk angels relative to the orchard floor. Yield will be determined at the end of the third and fourth growing season.

Results and Discussion:

Mechanical topping did not save a substantial amount of money compared to hand training (**Table 1**). The most expensive tree training method was mechanical topping followed by hand selection of 4-5 scaffolds ($82.80 / acre). Topping decreased the time for hand training but still cost more than hand training alone. Topping without selecting scaffolds but removing limbs too low on the trunk cost about $48 per acre compared to short pruning by hand ($66/acre) or long pruning ($70.77), a savings of $18-$23 per acre. The least expensive treatment was no scaffold selection or heading, removing only low, problematic limbs off the trunk by hand ($18.00 / acre).

Table 1. Number of person-hours and approximate cost for various training methods		
	Person-hours / acre	Cost / acre[1,2]
Mechanical topping; no scaffold selection	1.5 hours	$30 + $18.00 = $48.00
Mechanical topping with scaffold selection	Topping + 4.4 hours	$30 + $52.80 = $82.80
No topping, short pruned	5.5 hours	$66.00
No topping, long pruned	5.9 hours	$70.77
No topping, no scaffold selection	1.5 hours	$18.00

[1] Cost of labor calculated at $12.00 per hour. Does not include cost of stacking and shredding brush.
[2] Cost of mechanical topping was $30 / acre, performed by professional contractor.

Although mechanical topping initially reduced tree height by 2.5 – 3 feet, topped trees were the same height as untopped trees by the end of the second growing season due to vigorous shoot growth stimulated by indiscriminant heading cuts (**Table 2**). These heading cuts also resulted in a mass of shoots originating in the same plane which may substantially reduce sunlight penetration into the lower canopy in future years. Mechanically topped Monterey trees had statistically smaller trunk circumference compared to untrained trees ($P< 0.05$). Nonpareil and Monterey trees that were short pruned by hand had the smallest trunk circumference.

Table 2. Effect of Training System on Tree Size (End of 2nd Leaf)				
	Tree Height (ft)*		Trunk Circumference (cm)*	
	Nonpareil	Monterey	Nonpareil	Monterey
Untrained	12.9 a	13.9 a	36.5 a	32.8 a
Topped with No Scaffold Selection	12.7 a	13.5 ab	34.6 b	31.3 bc
Topped with Scaffold Selection	12.5 a	13.6 ab	35.2 ab	31.5 b
Hand Trained (“long pruned”)	12.5 ab	13.5 ab	35.6 ab	30.3 cd
Hand Trained (“short pruned”)	11.9 b	13.1 b	33.2 c	30.1 d

* Data followed by the same letter are statistically similar ($P \leq 0.05$).

Tree anchorage (leaning) was not affected by training method (**Table 3**). All trees, whether topped, short pruned, long pruned or unpruned had undesirable numbers of leaning trees (angles more acute than about 80 degrees). It was noted that by the end of the first leaf (prior to topping / training), many trees in the orchard were already beginning to lean.

Table 3. Effect of Topping and / or Hand Training on Tree Anchorage. July, 2016, Third Leaf		
	Trunk Angle (degrees)*	
	Nonpareil	Monterey
Untrained	74.6 a	75.1 a
Topped with No Scaffold Selection	74.8 a	75.1 a
Topped with Scaffold Selection	76.2 a	76.9 a
Hand Trained (“long pruned”)	76.7 a	76.6 a
Hand Trained (“short pruned”)	76.2 a	76.7 a

* Trunk angles were statistically similar for all training treatments ($P< 0.05$).

In summary, mechanically topped trees plus scaffold selection by hand were the most expensive trees to train. In addition, topped trees were the same height as untrained trees by the end of the second growing season and did not have better anchorage than unpruned or handpruned trees. Yield will be determined at the end of the third and fourth season to determine effects on production.

Project Title: **Almond Bloom Disease Control Trials**

Project Leader: Brent A. Holtz, PhD
County Director and Farm Advisor
UCCE - San Joaquin County
2101 East Earhart Avenue, Suite 200
Stockton, CA 95206-3924
209.953.6124
baholtz@ucdavis.edu

Problem and its Significance: Brown Rot, Shot Hole, Scab

There are several fungal diseases that can infect almond trees during bloom, infecting and killing blossoms and ultimately reducing yield. Fungicides are commonly sprayed on almond trees, and other stone fruits, during bloom to prevent disease. In some instances, fungicide resistance has developed in pathogen populations. Resistance to single site-specific fungicides (Strobilurins) have been reported. These new fungicides have low residual activity and are environmentally safe, but since they are single-site specific, resistance can also develop to them. Thus, it is important that growers practice a fungicide rotation program where different classes of fungicides are used so that pathogen resistance will not build up in response to the over use of any one fungicide or class of fungicides. It is also important that these new and previously registered fungicides are evaluated for disease efficacy by unbiased personnel that can extend such information to growers and PCAs.

Summary:

Sequential treatments of Fontelis (penthiopyrad), Bumper (propiconazole), tebuconazole, Abound (azoxystrobin), Gem (trifloxystrobin), an experimental fungicide, Merivon (fluxapyroxad + pyraclostrobin), Bravo Weather Stick (chlorothalonil), Quadris Top (difenoconazole + azoxystrobin), Inspire EC (difenoconazole), Quash (metaconazole), Rovral (iprodione) + oil, Luna Sensation (fluropyram + trifloxystrobin), Luna Experience (fluropyram + tebuconazole), Pristine (pyraclostrobin + boscalid), Indar (fenbuconazole), Serenade Optimum (Bacillus subtilis), Microthiol Disperse (micronized wettable sulfur), and Regalia (extract of *Reynoutria sachalinensis*) in tank-mixtures and in various combinations and timings for the control of common almond bloom diseases: brown rot, shot-hole, scab, and rust. All treatments, except the experimental fungicide, significantly reduced the incidence of almond scab when compared to our two untreated controls. Because of the lack of precipitation at bloom we did not have enough brown rot or shot-hole to rate.

Scab Incidence - Carmel Variety

Treatment	Rates per acre	Incidence[a]	
1	Fontelis 1.67 SC[1,2,3], 20 fl oz	2.75	a
10	Quadris Top[1] 14 fl oz + DA, Bravo[2] 4 pt, Inspire EC[3] 7 fl oz + DA	2.75	a
11	Fontelis 1.67 SC[1] 16 fl oz, Inspire EC[2,3] 7 fl oz + DA	3.50	a
14	Indar 6 fl oz + DA 0.25%[1], Indar 6 fl oz + Abound 15 fl oz+ DA 0.25%[2,3]	4.00	a
17	Pristine[1], 14.5 oz + DA, Luna Experience[2,3], 8 fl oz + DA	4.25	a
9	Merivon SC[1,2,3] 5.5 fl oz + DA 0.25%	4.50	a
3	Fontelis + Tebucon 45DF[1,2,3], 20 fl oz + 8 oz	4.75	a
18	Microthiol Disperse[1,2,3] 20 lbs	5.75	a
15	Luna Sensation SC[1,2,3], 5 fl oz+ DA 0.25%	6.00	a
2	Fontelis + Bumper 3.6EC[1,2,3], 20 fl oz + 8 fl oz	7.25	a
13	Rovral + oil[1], 16 fl oz+1%v/v, Luna Sensation SC+ DA[2,3], 7 fl oz + 0.25%	10.25	a
5	Fontelis + Gem 4.05SC[1,2,3], 20 fl oz + 2.9 fl oz	11.00	a
12	Quash 3.5 oz + Dyne-Amic 0.25%[1,2,3]	12.00	a
4	Fontelis + Abound 2.0 8F[1,2,3], 20 fl oz + 12 fl oz	12.00	a
8	Experimental + DA[1,2,3], 57.8 fl oz + 0.25%	13.00	a
16	Serenade Optimum 16.0 oz + DA 0.25%[1], Luna Experience[2,3] 6 fl oz + DA	14.25	a
7	Experimental + DA[1,2,3], 43.4 fl oz + 0.25%	16.50	a
6	Experimental + DA[1,2,3], 28.9 fl oz + 0.25%	36.25	b
19	Regalia[1,2,3] 1.0% v/v dilution	37.75	b
20	Untreated Control	51.00	b
21	Untreated Control	80.25	c

[a] Incidence = number of nuts that have scab lesions on 100 nuts randomly sampled per tree. 100 nuts per Carmel tree/replication were randomly sampled on July 15th and taken back to the laboratory to determine incidence and severity. Data was analyzed by ANOVA with means separated by Fisher's Protected LSD ($\alpha = 0.05$) test. Means followed by the same letter are not significantly different. Most treatments significantly reduced the incidence of almond scab when compared to our two untreated controls.

The following trial applications are outlined above:
[1] First trial application was performed at 100% full bloom (100 % FB) on February 18th.
[2] Second trial application was performed 1 week after petal fall (1WPF) on March 5th.
[3] Third trial application was performed was 5 weeks after petal fall (5WPF) on April 2nd.

Project Title: **Does Fall Nitrogen Application Improve Almond Yield?**

Project Leader: Franz Niederholzer
UCCE Colusa/Sutter/Yuba Counties
142-A Garden Highway
Yuba City, CA 95991
530.822.7515
fjniederholzer@ucdavis.edu

Cooperating Personnel: Bruce Lampinen, Plant Sciences Department, UC Davis
Stan Cutter, Nickels Soil Lab

Problem and its significance:

The current N management program developed by University of California researchers recommends 20% of the annual N budget be applied between hull-split and leaf drop. This program was developed in the southern San Joaquin Valley where low rainfall results in limited, if any, winter N leaching. Post-hull split fertilizer N may remain in the root zone until the following spring and be available for orchard use at that time. However, winter rainfall in the Sacramento Valley regularly exceed the root zone soil water holding capacity, producing conditions where excess soil nitrate can be leached towards groundwater and eliminate any soil nitrate carry over from one season to the next.

How important is a post-hull split nitrogen application for successful almond production? We are unaware of any research results directly supporting a yield benefit from post-hull split N applications in almond. [Fall N application did not improve peach yield the following year in UC research conducted by Drs. DeJong and Weinbaum in the 1990's.] Since excess soil N-NO_3^- is vulnerable to leaching and leaching risk is highest during the late fall/winter in almond orchards in the Sacramento Valley, post-hull split N application in almond may be more environmentally risky than spring applications. If post-hull split N application has no yield benefit the following spring, this practice may need to be reconsidered. If it has significant benefit, this needs to be documented in light of the leaching risk and steps taken to minimize potential leaching loss. Such steps might include adjustment of timing, rate, and application practices.

Plans:

This is the second year of this project. In 2016, the trial will shift to four rows (44 trees long) of mature Nonpareil almonds on 'Lovell' rootstock planted in 1997 (124 trees/acre). The treatment units will be row sections of 11 trees (0.09 acres), each. Each treatment will be replicated five times. There will be three treatments – 0, 30, or 60 lbs N/acre applied as UN32 in late October, 2015. This amount is equal to 12% or 24% of the annual N budget for this orchard (Average yield = 2500 kernel lbs/acre = 243 lbs N/acre assuming 70% nitrogen efficiency). Experimental units will be blocked based on yield potential (% light interception) the previous year. All trees will be fertilized following the current UC recommendations in the spring (Mar—early June) with all treatments receiving the same amount of N in 2016 to see if fall N applied makes a difference in yield. Yield for each row length will be measured and compared at harvest to assess the benefit of fall N application.

Project Title: **Young Orchard Educational Material**

Project Leader: Katherine Pope, Orchard Systems Advisor
UCCE - Sacramento, Solano and Yolo Counties.
70 Cottonwood St, Woodland, CA
530.377.9528
kspope@ucanr.edu

Project Cooperators and Personnel:

David Doll, UCCE Merced
Allan Fulton, UCCE Tehama
Brad Hanson, UCCE Weed Specialist
Bruce Lampinen, UCCE Almond Specialist
Roger Baldwin, UCCE Vertebrate Pest Specialist
Joe Grant, UCCE San Joaquin
Blake Sanden, UCCE Kern
Joe Connell, UCCE Butte (Emeritus)
Dani Lightle, UCCE Glenn

Objectives:

Create educational material specific to early orchard management.

Interpretive Summary:

The Young Orchard Handbook was created based on the 2015 Young Orchard Workshop, posted online and presented at the Almond Conference. A second Young Orchard Workshop was held in 2016. Presentations from 2016 were recorded and posted online. The information from the 2016 workshop is currently being integrated into an updated version of the Young Orchard Handbook. Since the Young Orchard Handbook was presented at the Almond Conference in December 2015, the homepage featuring links to the Young Orchard Handbook and video recordings ((http://ceyolo.ucanr.edu/Fruit_and_Nuts/) has received almond 1,000 unique visitors.

Materials and Methods:

Presentations were given by the above-listed cooperators in January of 2015 and 2016 at the Woodland Community Center in Woodland, CA, recorded and integrated (or are in the process of being integrated) into the written Handbook. Recordings were made of the 2016 presentations and posted, along with the pdf of the Handbook, on the UC Cooperative Extension Yolo County website, on the Fruit and Nuts section homepage (http://ceyolo.ucanr.edu/Fruit_and_Nuts/).

Results and Discussion:

Reception of the Handbook and recorded videos have been positive. A press release by the Almond Board led to articles in Western Farm Press and Ag Alert. Since the Young Orchard Handbook was presented at the Almond Conference in December 2015, the homepage featuring links to the Young Orchard Handbook has received 837 unique California visitors (plus 136 unique non-California visitors). Not all videos are formatted to track views, but the one which is, Brad Hanson's talk on weed management in young orchards, has been viewed 90 times.

Project Title: **Assessing Feeding Potential of Brown Marmorated Stink Bug**

Project Leader: Dani Lightle
UCCE - Glenn County
P.O. Box 697
Orland, CA 95963
530.865.1107
dmlightle@ucanr.edu

Objectives:

I. Estimate the potential depths to which brown marmorated stink bug (BMSB) can feed (penetration potential).
II. Compare stink bug penetration potential to almond development sizes.

Interpretive Summary:

Brown marmorated stink bug (BMSB) is an invasive, cosmopolitan insect pest with over 300 known host species. BMSB has been shown to feed on almonds under laboratory conditions. This study was done to assess the possible feed damage potential that BMSB may have to almonds in the field. Using stylet measurements of adult BMSB, females were shown to have a potential feeding depth (penetration potential) of 2.66 ± 0.016mm and males had a potential of 2.39 ± 0.019mm. If adult BMSB was feeding at its full potential early in the growing season (up to 20-30 days after full bloom), it could reach the kernel and contribute to kernel abortion or nut drop. During mid-season, BMSB would be unlikely able to reach the kernel and damage may instead result in gumming. The penetration potential of BMSB is no greater than another pest known to feed on almonds, the green stink bug (*Acrosternum hilare*). Therefore, the risk that BMSB poses to almonds is likely caused by potentially high population numbers and difficulty to control with insecticides than to any feeding advantage over other hemipteran pests already known to almonds.

Materials and Methods:

Estimating the penetration potential of BMSB. 30 adult BMSB insects were obtained from a laboratory colony maintained by Charlie Pickett (CDFA) in Sacramento. The ventral side of each insect was photographed using a USB microscope camera (Dino-Lite Digital Microscopes, Taiwan) at a magnification of 30 power. The length of the first and second rostrum (mouthpart) segments were measured digitally using the program DinoCapture 2.0 (V1.5.15). There were 13 females and 17 males measured for this study.

The penetration potential (potential feeding depth) was estimated using the methods of Esquival (2011). Briefly, the depth that a piercing/sucking insect can feed is a function of the length of the first and second rostrum segments and the position at which the insect is feeding relative to the food substrate. Using the model developed by Esquival (2011), the penetration potential can be calculated through the following equations:

$$d = (a^2 + b^2 - 2ab\cos\theta)^{1/2}, \quad (1)$$

where a = length of rostrum segment 1, b = length of rostrum segment 2, θ = the anterior angle formed by the distal end of segment 1 and the proximal end of segment 2, and d = unknown distance between front of the head and the distal end of segment 2; and

$$P = (a+b) - d, \quad (2)$$

where a = length of rostrum segment 1, b = length of rostrum segment 2, d = unknown distance (calculated from equation 1), and P = penetration potential of the insect.

The penetration potential (P) was calculated separately for adult female and male BMSB using theoretical feeding positions that gave a θ of 50º, 60º, 70º, 80º, and 90º.

Comparison of BMSB penetration potential to almond development. Hull width was of interest because feeding bugs exceeding that width would reach the almond kernel. Measurements of almond hull width (here defined as epicarp + mesocarp + endocarp) were obtained from the published literature.

Results and Discussion:

The potential penetration depth into a substrate by adult BMSB is shown in **Table 1**. Females have a greater potential to reach the kernel than males; female stink bugs are typically larger than males and that holds true for BMSB. Using the theoretical models, a female BMSB has the potential to feed to a depth of approximately 2.66mm.

Table 1. Potential feeding depth (mm ± SE) of adult male and female BMSB at a given feeding position, θ (see equation 1 for more details).

Feeding position (θ)	Potential Penetration Depth (mm ± SE)	
	Adult Female	Adult Male
90º	1.35 ± 0.007	1.21 ± 0.010
80º	1.65 ± 0.009	1.48 ± 0.012
70º	1.97 ± 0.011	1.77 ± 0.014
60º	2.31 ± 0.013	2.07 ± 0.017
50º	2.66 ± 0.016	2.39 ±0.019

The penetration potential model has been calculated for another stink bug known to attack almonds, the green stink bug, *Acrosternum hilare* (Esquivel, 2015), with a resulting penetration potential depth of 2.548 ± 0.048mm at the deepest position (θ = 50º) which is not significantly different than the calculated values for BMSB reported here.

Unsurprisingly, there was a range in hull width values among cultivars reported in the literature. When focusing on Nonpareil, shortly after full bloom (up to 20 days after full bloom), the fruits are small, with a hull width in the range of 2mm or less (Brooks, 1939). Feeding in the kernel at this stage is likely to cause the nuts to abort or drop, as seen with other piercing/sucking insect pests in almonds. The hull width exceeded the penetration potential of adult females after around 30 days after full bloom (Brooks, 1939), suggesting that gumming symptoms but not direct kernel damage may be expected in response to BMSB feeding. As the hull begins to dry out, the potential for BMSB to feed directly on the kernel increases; this bug has shown in other crops such as hazelnut that it is able to penetrate directly through a shell to feed on the kernel (Hedstrom et al., 2014).

Though BMSB carries an infamous reputation as a destroyer of many crops, its potential for damaging almonds likely lies in its overall numbers and difficulty to control with insecticides than for any inherent feeding advantages over other Hemipteran pests already known to almonds such as green stink bug or leaffooted bug. Until BMSB moves into agricultural areas out of the urban areas it currently inhabits in California, it will be difficult to fully assess the risks it poses to the industry.

Research Effort Recent Publications:

none.

References Cited:

Brooks, R.M. (1939). A growth study of the almond fruit. Proceedings of the American Society for Horticultural Science 37: 193-197.

Esquivel, J.F. (2011). Estimating potential stylet penetration of southern green stink bug – a mathematical modeling approach. Entomologia Experimentalis et Applicata 140:163-170.

Esquivel, J.F. (2015). Stylet penetration estimates for a suite of phytophagous Hemipteran pests of row crops. Environmental Entomology 44: 619-626.

Hedstrom, C.S., P.W. Shearer, J.C. Miller, and V.M. Walton (2014). The effects of kernel feeding by Halyomorpha halys (Hemiptera: Pentatomidae) on commercial hazelnuts. Journal of Economic Entomology 107: 1858-1865.

Project Title: Sodium, Chloride and Boron Accumulation in Almonds – Westside Survey

Project Leader: Blake Sanden
Irrigation & Agronomy Advisor Kern County
1031 S. Mt. Vernon Ave
Bakersfield CA 93307
661.868.6218
blsanden@ucdavis.edu

Project Cooperators and Personnel:
Patrick Brown, UC Davis Pomology
Wegis & Young Farms, Kern

Objectives:

1. Using a 3rd leaf planting (Hansen rootstock, Nonpareil and Monterey scions) select 4 areas that range from 0.5 to 5 dS/m EC and ppm soluble boron.

2. Document differences in tree stature corresponding to these areas.
3. Correlate soil salinity and specific ion concentration with rootstock, scion and traditional leaf tissue samples to see if wood sampling provides an early indication of pending toxicity problems.

Interpretive Summary:

Problem and its Significance: Almond growers have been pushing the limits on almond salt tolerance for the last 10 years as land price and availability have skyrocketed while available surface water supplies have decreased and groundwater salinity is increasing. Many of these plantings look good for several years and then hit the wall as one or more specific toxic ions (especially boron) finally reaches the critical level in the tree that can limit water/nutrient uptake, cause severe gumming, leaf burn, reduced growth and eventually death. There is no data documenting woody tissue deposition / concentration of these ions as a function of soil salinity to determine if sampling of the woody xylem tissue would give a grower an early warning sign of significant upcoming toxicity problems not yet showing in leaf tissues.

Kern survey/results: The selected Kern quarter section almond planting 5 miles NW of Lost Hills provides the perfect location to test this idea. Salinity in this block varies from an EC of 1.8 to 6.1 dS/m from the east to west side. Soluble boron in the same manner increases from 0.3 ppm in the east to 1.0 in the west. Despite these significant native soil salt differences across the field the salt tolerant Hansen rootstock has not really shown differential xylem wood or leaf tissue nutrient/salt concentrations for any of the areas – even though some trees in western Area 4 show visible gummosis on the scion. Actually, the final 11/18/2015 tissue sampling showed about 60% more boron and potassium in the xylem wood of the scion for the low salt area (Area 1) compared to the other higher salinity areas to the west. There was no difference in the rootstock wood. We suspect contamination.

Tree trunk circumference, height and canopy volume and the 2015 3rd leaf yield consistently decreased with increasing salinity. There is no replication for this survey and therefore no statistical analysis. Three popular different surfactant/plant digest materials were applied in replicated plots on the westside to evaluate their benefit to the trees in the higher salinity area. None of the above growth indicators were improved by the use of these materials.

Materials and Methods:

A 3rd leaf quarter section almond block in NW Kern County – 50/50 Nonpareil and Monterey was planted on Hanson rootstock in 2013. A significant gradient in increasing native salt load in this soil is obvious as you move from East to West despite having leached this ground with two feet of water using sprinklers prior to planting. The total soil salt load (EC), sodium (Na), chloride (Cl) and boron (B) increases 2 to 3-fold from Area 1 to 4 (**Figure 3**). Tissue and soil samples are collected from the same 2 discreet trees for each area at the end of the season. Nonpareil kernel yield is also taken. **Figure 1** illustrates the AREA layout along with CERES aerial imagery indicating increasing water stress from east to west.

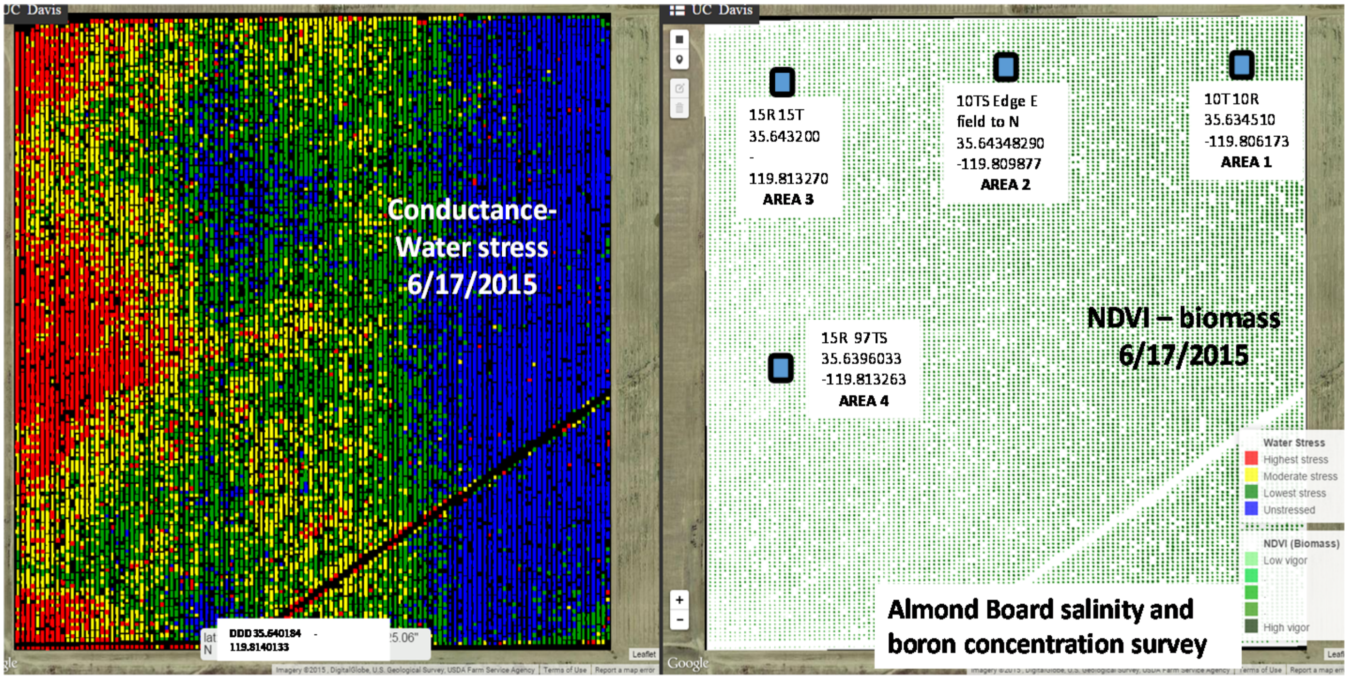

Figure 1. CERES aerial remotely sensed CONDUCTANCE (6/17/2015) and geographic locations of AREAS 1 to 4.

Excess sodium and the extremely fine particle size of many of these soils results in poor aggregation, soil structure and, therefore, water movement. Efficient water penetration and leaching is critical to enable profitable production in these orchards. A second, replicated AMENDMENT TRIAL (**Figure 2**) was nested in the western AREA 4 zone to evaluate 3 liquid amendments currently used by growers:

<u>Treatments (applied in replicated blocks by hand in addition to grower use of gypsum and acid):</u>

1. Control – no additional surfactant
2. Aquatrols Water Max (non-ionic surfactant + long-chain alkyl/polyol aggregation aid): 1st application 5/21 @ 1 g/ac, 2nd @ 0.5 g/ac, 3rd @ 0.5 g/ac, 4th @ 0.5 g/ac
3. H-2-H Soluble Organics (digested food waste yielding complex amino acids, micronutrients, etc.): 1st application 5/27 @ 20 g/ac, 2nd @ 10 g/ac, 3rd @ 10 g/ac, 4th @ 10 g/ac
4. WetSol (non-ionic surfactant): 1st application 5/21 @ 1 g/ac, 2nd @ 0.5 g/ac, 3rd @ 0.5 g/ac, 4th @ 0.5 g/ac

Subsequent application windows depending on irrigation schedule: 2nd 6/8-12, 3rd 6/22-26, and 4th 7/6-10

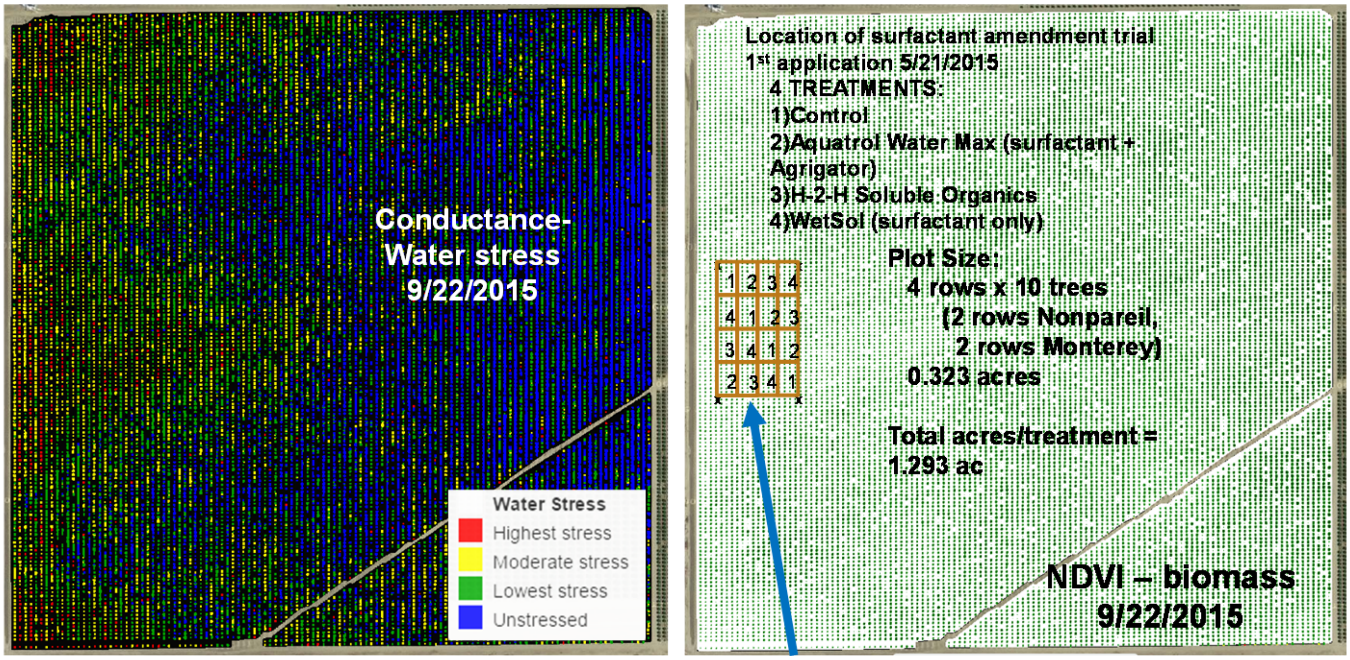

Figure 2. CERES CONDUCTANCE (9/22/2015) and location/design of amendment test plot.

Results and Discussion:

The interesting result so far is that all tissue samples for leaves, trunk corings and hull boron content at harvest show no real difference with respect to Na, Cl and B. The trunk circumference of Area 4 is 19% less than Area 1, as would be expected with the higher salinity stress. The 3rd leaf yield was very disappointing for this block – being 312 lb/ac at best for Area 1 and 137 lb/ac for Area 4, a 56% decrease (**Figure 7**).

At this time there is no measurable increase in rootstock or scion wood tissue Na, Cl or B correlated with higher soil concentrations from Areas 1 to 4 (**Figures 5 and 6**). There does appear to be a higher amount of gummosis on the occasional tree in Areas 3 and 4 compared to Area1. The elevated salt load and associated osmotic resistance to water uptake has definitely decreased tree size as salinity increases (**Figure 7**) but the usual marginal salt burn associated with this is basically absent. Indeed, leaf tissue concentrations of the normal specific toxic ions Na, Cl and B were at reasonable levels for all areas at the end of the season (**Figure 4**).

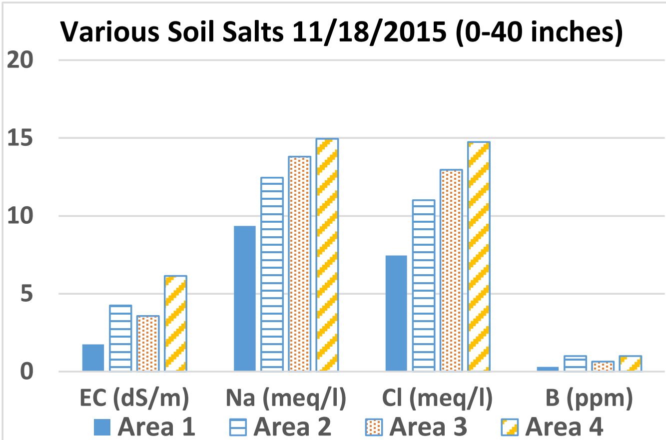

Figure 3. Selected soil salt concentrations to 40".

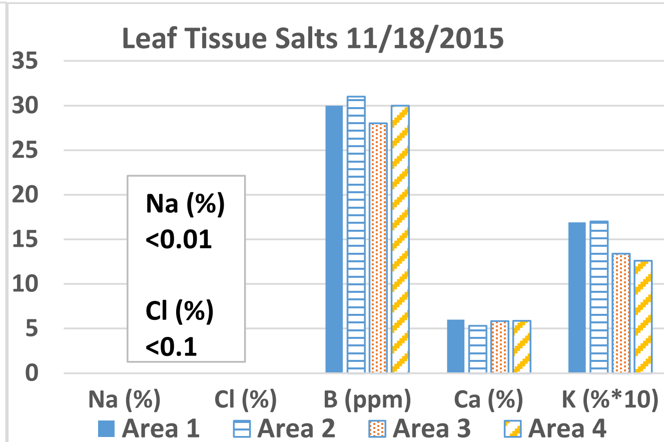

Figure 4. End of season leaf tissue Na, Cl, B, Ca, K.

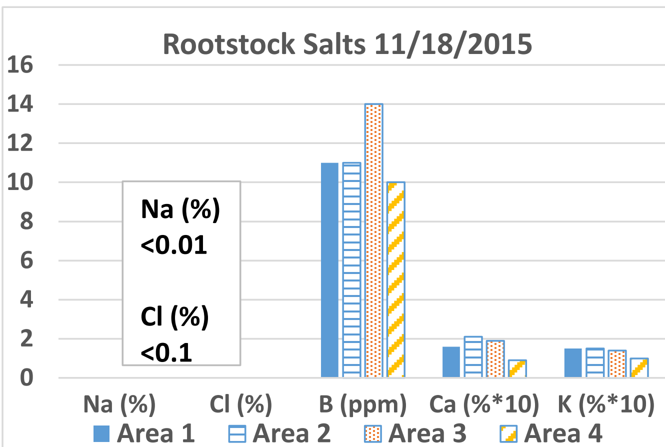

Figure 5. End of season rootstock Na, Cl, B, Ca, K.

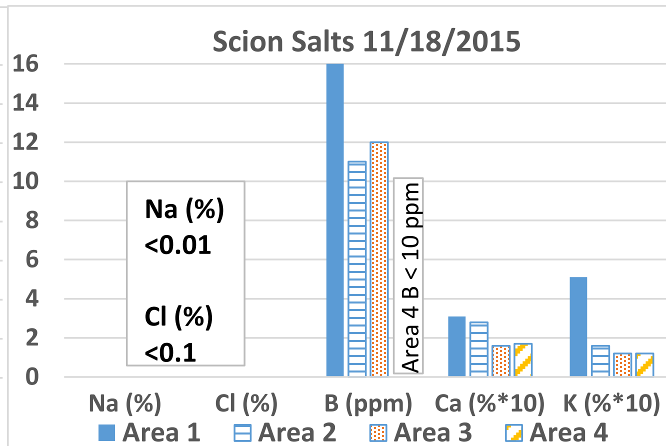

Figure 6 End of season scion Na, Cl, B, Ca, K.

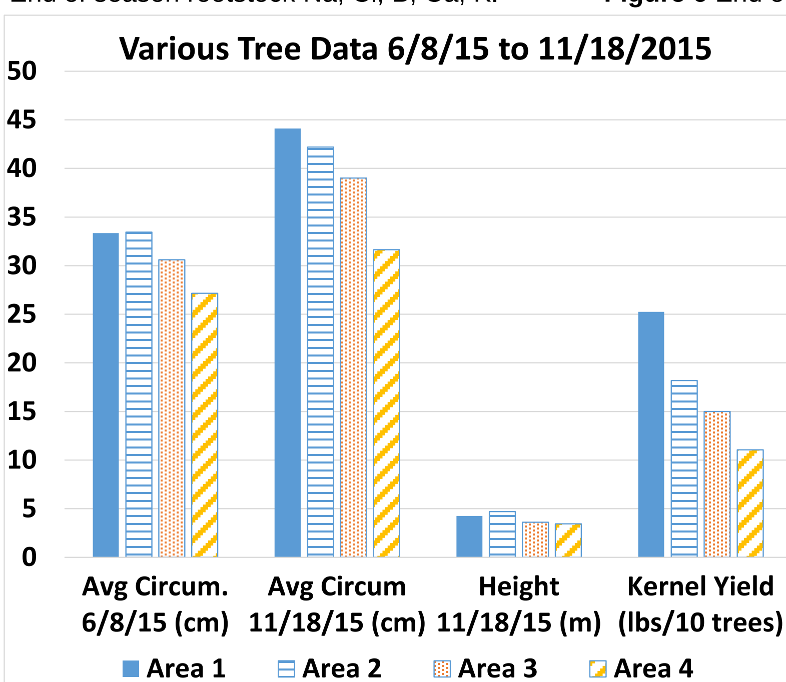

Figure 7. Scion circumference, tree height and kernel yield for all areas.

Surfactant amendments made no difference in tree water stress (COND) or growth/vigor (NDVI).

Table 1. CERES aerial measurements of CONDUCTANCE and NDVI for all amendment treatments.

	6/17/2015		7/8/2015		7/29/2015	8/27/2015		9/22/2015	
	COND[1]	NDVI[2]	COND[1]	NDVI[2]	NDVI[2]	COND[1]	NDVI[2]	COND[1]	NDVI[2]
Aquatrol	78.82 a	0.65	64.74 ab	0.62	0.58	245.48 a	0.51	96.42	0.60
Control	89.15 b	0.65	74.71 b	0.62	0.59	259.17 b	0.52	105.00	0.61
H2H	74.46 a	0.65	58.29 a	0.62	0.58	244.32 a	0.51	99.70	0.60
WetSol	79.34 a	0.64	59.59 a	0.61	0.58	248.91 a	0.51	102.56	0.60

[1]COND: abbreviation for CONDUCTANCE -- a proprietary calcultion using canopy and ambient air temperature differential and vapor pressure deficit to provide an estimated stomatal conductance in mmol H2O/m^2/sec.

[2]NDVI: in it's simplest form a unitless ratio using the near infrared spectrum canopy reflectance and the wider total infrared canopy reflectance, NDVI = (NIR-IR)/(NIR+IR). Considered an index of plant vigor based on chlorophyll concentration.

Project Title: Navel Orangeworm Monitoring in the Sacramento Valley

Project Leader: Emily J. Symmes, Area IPM Advisor
UCCE Butte, Colusa, Glenn, Sutter-Yuba, and Tehama Counties and UC Statewide IPM Program
UCCE - Butte County
2279 Del Oro Avenue, Suite B
Oroville, CA 95965
530.538.7201
ejsymmes@ucanr.edu

Objectives:

Navel orangeworm (NOW) is a key pest in almond production throughout the state. There are currently three commercially available trap types for monitoring NOW populations to aid in treatment timing: egg traps, pheromone traps, and kairomone traps. Egg traps have long been the industry standard monitoring tool for NOW, and existing models for optimal treatment timing using egg trap data combined with degree-days are well-supported. However, the reliability of egg traps to accurately detect spring biofix in lower pressure orchards (often typical of the Sacramento Valley relative to more southern regions of the Central Valley), combined with the ease of use of adult traps, make these alternative technologies attractive to pest control advisers and growers.

Ongoing studies by fellow University of California researchers are focused on elucidating relationships between egg and pheromone traps. However, little is known about the utility of the kairomone-based traps for monitoring adult females. In addition, research-based economic thresholds based on trap catches (for any trap type) have yet to be established. The objective of this study was to investigate relationships among the three trap types in the Sacramento Valley almond production region.

Interpretive Summary:

Navel orangeworm (NOW) was monitored in three orchards in the Sacramento Valley growing region in 2015 using three different trap-lure combinations: egg traps, pheromone-baited adult male traps, and kairomone-baited adult female traps. The relationships among the three trap types to detect seasonal moth activity were evaluated. In two of the three orchards, egg and kairomone-baited female trap catches exhibited an apparent level of synchrony throughout the growing season. At all three sites, peak second flight activity was distinct for egg and female traps. Pheromone-baited male traps were not as sensitive during the second flight period at two of the three sites. Additional years of data are needed to confirm the utility of female and male traps for timing NOW treatments and establishing treatment thresholds.

Materials and Methods:

Beginning in March 2015, traps were deployed to monitor NOW populations throughout the growing season in three commercial almond orchards in the Sacramento Valley (one each in Butte, east Glenn, and west Glenn counties). Three replicated trap sets were placed within each orchard and monitored weekly. Each trap set consisted of 4 egg traps (baited with Trécé Pherocon® IV almond meal), 1 wing trap to monitor adult males (baited with Suterra® NOW Biolure ®), and 3 wing traps to monitor adult females (baited with ground almond-pistachio kairomone lures, Peterson Trap Company, LLC). Thus, a total of 12 egg traps, 3 pheromone traps, and 9 kairomone traps were monitored in each orchard. Trap data were collected through September to mid-October depending on location. All blocks were treated for NOW at hullsplit. Harvest samples (min. 1000 nuts per site collected on the day of harvest) were obtained and NOW damage quantified.

Results and Discussion:

Figures 1-3 show the seasonal NOW trap catches at each monitoring site (eggs and males plotted on the primary axis; females plotted on the secondary axis). Overall, fewer total females were trapped in kairomone-baited traps than eggs on egg traps or males in pheromone traps.

2015 marked the first year of data collection evaluating kairomone-based traps in concert with egg and pheromone traps for comparison. While there appears to be some level of synchrony in egg trap and kairomone-baited female trap numbers throughout the season in Butte and west Glenn Counties (where overall NOW pressure was higher), the trend was less apparent at the lower-pressure east Glenn county location. At all three locations, both egg and female traps showed marked increases during the second flight (June-July), while pheromone-baited male traps did not follow the same pattern in all locations.

Extremely low NOW damage occurred at all three sites (< 0.2%), therefore no statistical significance was detected when comparing ultimate harvest damage with various trapping parameters (peak catches, flight timings, total moths trapped) for any trap type.

Additional years of data from the various trap types should be collected. Efforts should continue to investigate the relationships among trapping data and evaluate their individual and combined utility as monitoring tools for treatment timing(s) and thresholds.

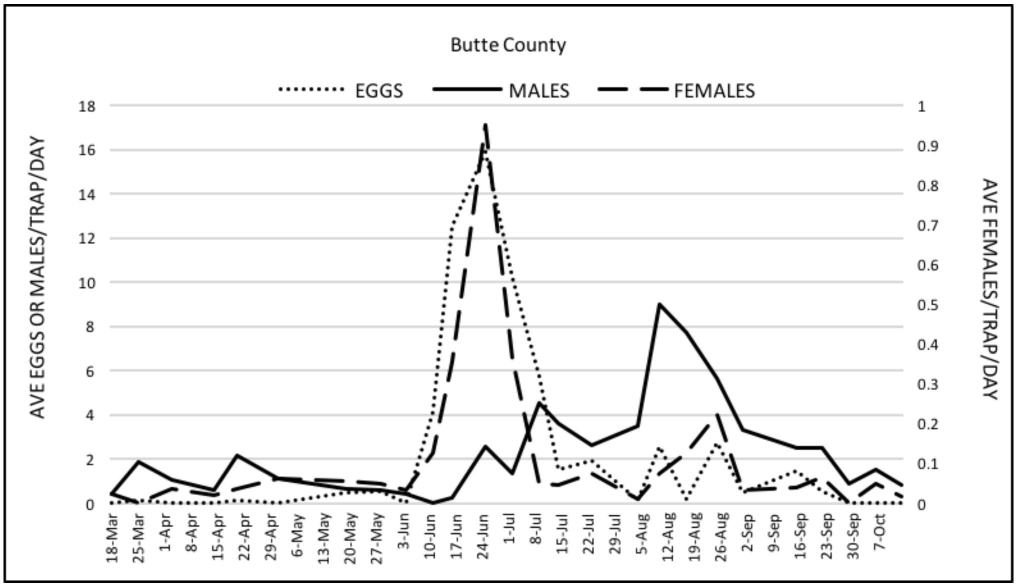

Figure 1. Seasonal navel orangeworm trap catches in Butte County in 2015.

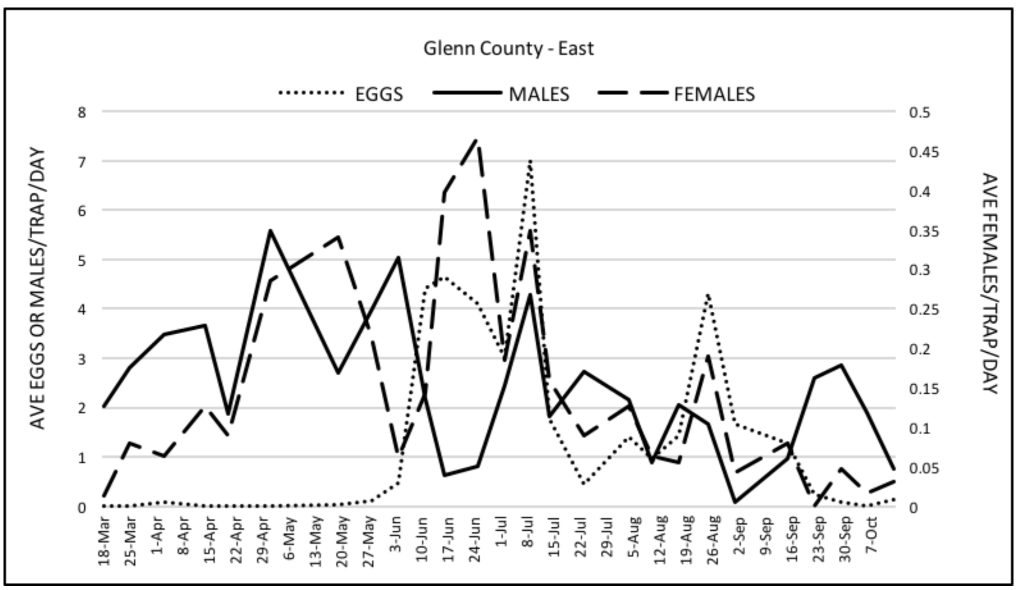

Figure 2. Seasonal navel orangeworm trap catches in east Glenn County in 2015**.**

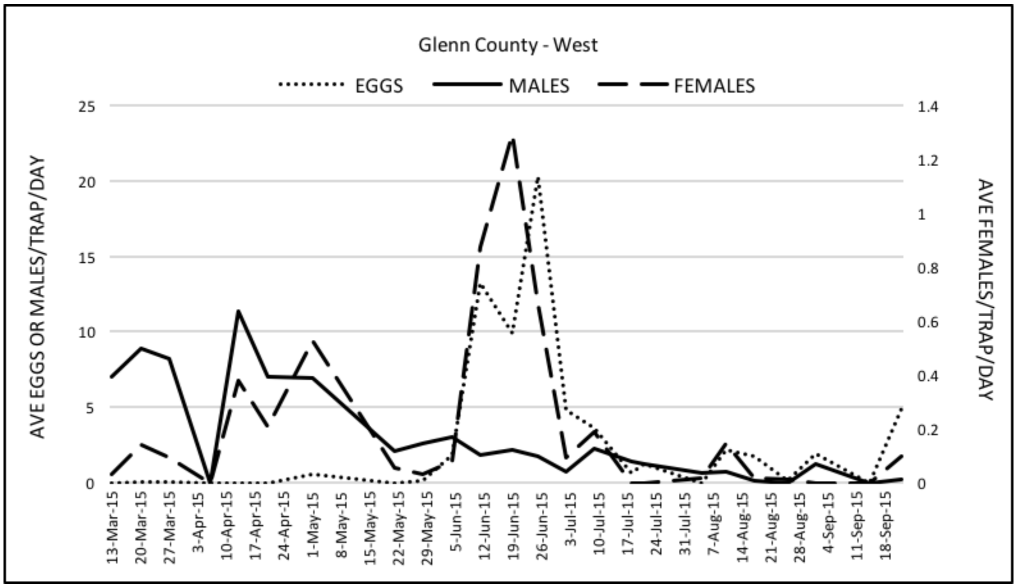

Figure 3. Seasonal navel orangeworm trap catches in west Glenn County in 2015.