FINAL REPORT

Project title: *Lygus* Bug and Thrips Ecology in Washington State Stonefruit Orchards
Final Report 2001-2003

PI: D.B.Walsh, Agrichem./Environ. Educ. Spec., WSU- Prosser
Organization: WSU, Dept. of Entomology, IAREC, Prosser
Co-PI(s): M. Bush, Coop. Ext. Agent, Yakima, County
R. Wight, Field Research Dir., IR4 Project, WSU-Prosser

Objectives: *Lygus*

1. Compare Lygus sampling techniques for *Lygus* on the orchard floor.
2. Establish damage thresholds for *Lygus* on stone fruits in the Yakima Valley and Columbia Basin.
3. Attempt to fine tune the UC Lygus phenology model to fit eastern Washington Lygus populations.
4. Develop riparian habitats that will not serve as a point source for *Lygus* infestations.
5. (New for 2003) Evaluate the role of cover crop and orchard floor management on pest and beneficial abundance.

Objectives: Thrips

1. Screen candidate compounds for their ability to suppress thrips populations that are infesting stone fruit orchards. Candidate compounds include spinosyns, insect growth regulators, synthetic pyrethroids, and neonicotinyls.
2. Evaluate several sampling techniques to determine thrips abundance.
3. Develop a relationship between thrips feeding and fruit injury.
4. (New for 2003) Evaluate orchard floor insecticide/ herbicide treatments on thrips abundance

SIGNIFICANT FINDINGS- *LYGUS*

Orchard Sampling. In 2001, 2002 and 2003 several *Lygus* abundance sampling techniques were investigated. Techniques tested included sweep net samples of the orchard floor, beat sampling of trees, and colored sticky cards. Sweep net sampling of the orchard floor was the only technique tested that caught substantial numbers of *Lygus*. The use of colored sticky cards in measuring abundance of *Lygus* was not efficient at capturing Lygus.

Phenology Model. A phenology model currently used in California proved effective at predicting the first generation hatch of *Lygus* in late-May in Eastern Washington and the subsequent peak hatch event in mid-July. However, the model lost predictive accuracy as the season progressed and would provide little predictive value for when adult migration into orchards might occur in April or May.

Biological Control. A parasite *Peristenus* spp. attacks the nymph stages of Lygus and keeps individuals from reaching sexual maturity by emerging in the late instar nymph or early adult stage. Extensive surveys conducted by Walsh in 2002 and 2003 determined the presence of Lygus parasitism by *Persitenus* spp. in several important fruit production regions in Washington State. However, the results of the survey were disappointing in that levels of parasitism were low or not detected in several important stone fruit growing areas

SIGNIFICANT FINDINGS-THRIPS

Flight monitoring. Thrips flight activities were monitored in stonefruit orchards with yellow and blue sticky card traps in 2001 and 2002. Blue cards are proving to be significantly (P<0.01) more effective then yellow cards at catching western flower in stone fruit orchards. We have observed a definite orchard edge effect with the orchard floors bordering riparian buffers having significantly (p<0.01) greater populations of thrips then the orchard floor 92 meters inside the orchard. There were also significant (P<0.05) differences in abundance of thrips as measured by blue sticky card with the orchard floor having a greater abundance of thrips then cards placed in the canopy on both the orchard edge and 92 meters in.

Cover Crops. Replicated plots of 14 cover crop blends were established on the Roza unit at WSU IAREC in May 2003. We have documented significant differences among cover crop blends in their potential to build populations of western flower thrips.
Orchard floor treatments. Post-harvest orchard floor insecticide and herbicide treatments were inconclusive in their effect on the distribution of thrips population within the tree canopy.

SIGNIFICANT FINDINGS-RIPARIAN BUFFERS. We have developed considerable evidence that riparian areas are confirmed sources of hemipteran and thrips pests. These include both stinkbugs, (Jay Brunner, personal com), *Lygus* bugs and flower thrips (Walsh unpl. data). We have also documented an increase in the populations of several beneficial arthropods in riparian buffers. We have also identified host plant on which Lygus can complete development and feral plants around which the abundance of flower thrips are greater then plants that appear to be non-hosts for flower thrips

Methods: *- Lygus*

1. Lygus sampling. We compared several sampling techniques to assess Lygus populations in the riparian sites and nearby orchard floors in early spring to assess when adults became active and to determine when the first generation egg hatch takes place. Sampling techniques tested included sweepnet, colored sticky cards, whole plant quadrants, and insect vacuums.
2. Lygus damage thresholds. Sleeve cages were sewn in 2001 that covered 1 meter lengths of tree branch. Fruit was thinned so that constant ratios of *Lygus* to fruit can be maintained. Adult *Lygus* were introduced into the sleeve cages on apricot trees on May 21 at ratios of 0.8, 0.4, 0.2, 0.1, 0.067, 0.05 and 0 *Lygus* per fruit. Each cage treatment was replicated 4 times on apricot trees on May 21, 2001 and April 30, June 25, 2002. Cages were left on the trees for 2 weeks and when they were removed the branches
were treated with acephate. A damage assessment was taken just prior to commercial harvest.

Phenology Model. A phenology model currently used in California proved effective at predicting the first generation and subsequent hatch of *Lygus* in late-May in Eastern Washington and the subsequent peak hatch event in mid-July. This model has little predictive value for when adult migration into orchards might occur
in April or May.
Biological Control. A parasite *Peristenus* spp. attacks the nymph stages of Lygus and keeps individuals from reaching sexual maturity by emerging in the late instar nymph or early adult stage. Extensive surveys conducted by Walsh in 2002 and 2003 determined the presence of Lygus parasitism by *Persitenus* spp. in several important fruit production regions in Washington State. However, the results of the survey were disappointing in that levels of parasitism were low or not detected in several important stone fruit growing areas.
Orchard floor cover crops. Replicated plots of 14 cover crop blends were established on the Roza unit at WSU IAREC in May 2003. Irrigation was applied by handline sprinklers and irrigation was applied to mimic recommended orchard management practices. Sweep net surveys were conducted every 2 weeks and the number of Lygus, thrips and spiders captured was quantified and calculated.

Methods- Thrips

1. Insecticide efficacy. An insecticide efficacy trial was established in a nectarine orchard in the lower Yakima Valley to test the post fruit set efficacy of registered and candidate compounds on flower thrips. Registered compounds that will be screened include endosulfan, carzol, and spinosad. Candidate compounds tested include lamda-cyhalothrin, pyriproxifen, thiamethoxam, and novoluron. Insecticides were applied by hand wand at 100 gallons per acre to 6 one tree replicates. Shake samples were taken taken prior to and at timed intervals following insecticide application.

Orchard floor insecticides and herbicides were applied post harvest to determine their effect on the distribution of thrips in the tree canopy.

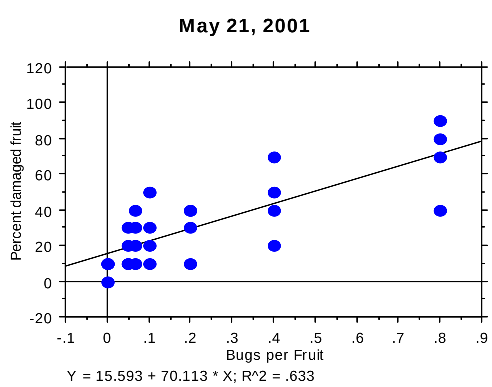
2 Insecticide residual. A primary constraint for efficacy studies on thrips on tree fruits is inconsistency in pest distribution. Following insecticide application we caged 4 individual fruit per tree/replicate in the orchard. Into these cages we placed approximately 10 immature thrips. These individual treated fruit were collected several days prior to commercial harvest. The fruit was evaluated and graded for thrips damage.

3. We have tested several techniques for evaluating thrips population abundance in stone fruits and other crops. Techniques tested have included several colors of sticky card traps, a beating sample, a water shake sample, and an alcohol shake sample. We will adapt these techniques to provide recommendations for sampling thrips abundance in stonefruit orchards.

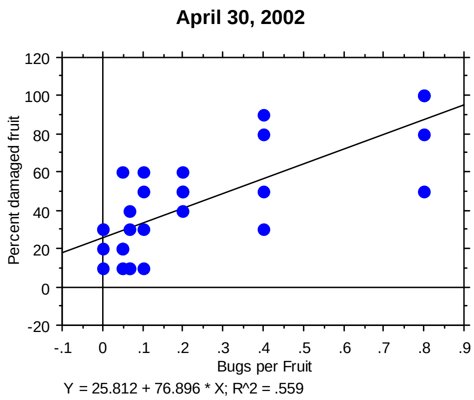
RESULTS/ DISCUSSION LYGUS-2001-2003

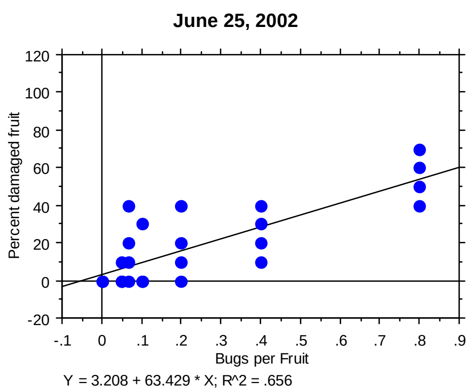
Lygus have an extensive host range of both native and exotic plants. In extensive field surveys conducted during summer of 2001, 2002, and 2003 we have observed a greater abundance of *Lygus* in riparian field sites directly adjacent to orchards with established stands of exotic flowering weedy plants then in sites comprised mainly of bunch grasses or native shrubbery. This research has enabled us to develop a list identifying which introduced and native plants are serving as alternate hosts for *Lygus*.

Lygus feeding has been likened to chemical injury. *Lygus* feeding damage in stonefruit orchards is a significant concern after fruit set Branch cage studies in 2001 and 2002 have helped quantify proportional *Lygus* abundance to fruit damage. Sleeve cages were sewn in 2001 that covered 1 meter lengths of tree branch. Fruit was thinned so that constant ratios of *Lygus* to fruit can be maintained. Adult *Lygus* were introduced into the sleeve cages on apricot trees on May 21 and April 30, June 25, 2002 at ratios of 0.8, 0.4, 0.2, 0.1, 0.067, 0.05 and 0 *Lygus* per fruit. Each cage treatment was replicated 4 times on apricot trees on each date. Cages were left on the trees for 2 weeks and when they were removed the branches were treated with acephate. A damage assessment was taken just prior to commercial harvest. Lygus damage was noted if necrotic feeding spots were present below the fruit surface.



Lygus feeding injury results of regression analysis between the ratio of adult Lygus bugs per fruit to the percent of fruit observed to





Biolgical control. A parasite attacking Lygus spp. was discovered in 1995 in Washington State and subsequent collections in Parma, Idaho in 1996 and 1997 showed that the parasite was present (Mayer unpublished data). The parasite has been described as *Peristenus howardi* Shaw (Hymenoptera: Braconidae), a new species . Previously, *Peristenus pallipes* Curtis was reported from Idaho. However, recent taxonomic work on the genus indicates that these may have been misidentified. *Peristenus* spp. attacks the nymph stages of Lygus and keeps individuals from reaching sexual maturity by emerging in the late instar nymph or early adult stage.

Collections made in 2000 (Mayer, unpublished data) did not document the parasite's presence beyond the Touchet, Washington and Parma, ID regions. Extensive surveys conducted by Walsh (AE News 2003) in 2002 and 2003 determined the presence of Lygus parasitism by Persitenus spp. in several important fruit production regions in Washington State. However, the results of the survey were disappointing in that levels of parasitism were low or not detected in several important fruit growing areas Extensive surveys in 2002 and 2003 determined the presence of Lygus parasitism by *Persitenus* spp. In total over 75 sites were surveyed and over 8,000 Lygus were dissected to determine if *Peristenus* spp were present. Parasitism by of Lygus by *Peristenus* was greatest in areas that were less disturbed by human activity.

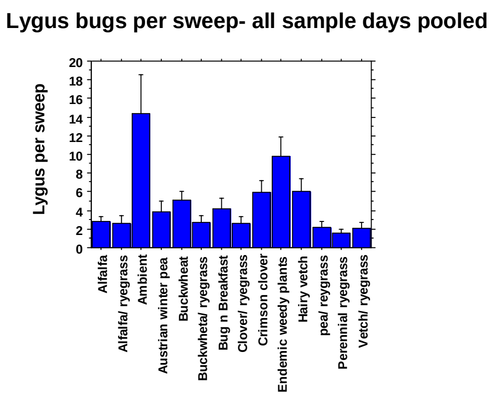
Phenology Model. A phenology model Walsh helped develop in 1990 (www.ipm.ucdavis.edu) proved effective at predicting the first generation hatch of *Lygus* in spring in Eastern Washington (Table 1) and the subsequent peak hatch periods for the 2nd and 3rd generations of Lygus in 2001, 2002, and 2003. In running this model degree days are accumulated starting on March 1 with 54° Fahrenheit serving as a horizontal lower-cutoff for development. Eggs laid by adult Lygus in late-winter will require approximately 252 degree days in order to hatch. This corresponded well with when we observed our 1st generation of nymphs in both orchards and in our riparian survey sites

(Table 1) in mid to late May. Although this model proved fairly effective at predicting hatch periods for Lygus during the summer months it has been our observation that the majority of feeding injury on tree fruits is caused by adult Lygus and that this model does little towards predecting when adult Lygus will migrate into tree fruit orchards. Rather rainfall patterns and the subsequent dry-down of the over-wintering hosts of Lygus is a prime cause of spring movement of adult Lygus. During the summer months harvest of field and forage crops (primarily alfalfa) also contributes to movement of adult Lygus.

Table 1. Cumulative degree day accumulations 54°, predicted dates of peak hatch for the 1st, 2nd, and 3rd generations of Lygus and the actual average number of Lygus caught per sweep among all of the samples taken bi-weekly at our riparian survey sites (n=72) for 2001 and 2002.

	2001			**2002**		
Date	Cumulative DD	Model Prediction	Nymphs /sweep	Cumulative DD	Model Prediction	Nymphs / sweep
March 1	0		n/a	9		n/a
April 1	35	(1st adult 4/2)	n/a	27	(1st adult 4/9)	n/a
April 15	39		n/a	69		n/a
May 1	109	1st hatch	0	119	1st hatch	0
May 15	198	(May 23)	0	166	(May 27)	0
June 1	384		**1.6**	307		**0.6**
June 15	484		1.2	473		1.3
July 1	675		0.8	713		1.5
July 15	961	2nd hatch	1.3	991	2nd hatch	**3.2**
August 1	1196	(July 23)	**3.0**	1351	(July 17)	0.3
August 15	1513		1.6	1573		1.2
September 1	1784	3rd hatch	0.7	1870	3rd hatch	**3.4**
September 15	1984	(Sept. 8)	**2.4**	2052	(Sept. 8)	1.3
October 1	2153		1.2	2173		1.3
October 15	2215		0	2235		0
November 1	2237		0	2272		0
	2003					
March 1	0		n/a			
April 1	50	(1st adult 4/2)	n/a			
April 15	84		n/a			
May 1	131	1st hatch	0			
May 15	194	(May 25)	0			
June 1	360		**1.3**			
June 15	555		1.5			
July 1	758		0.6			
July 15	987	2nd hatch	0.9			
August 1	1370	(July 22)	0.8			
August 15	1619	3rd hatch	2.1			
September 1	1900	(Aug 22)	3.2			
September 15	2074		**6.1**			.

Orchard floor cover crops. Replicated plots of 14 cover crop blends were established on the Roza unit at WSU IAREC in May 2003. Cover crop blends included perennial rygrass, buckwheat, buckwheat/ryegrass, alfalfa, crimson clover, hairy vetch, alfalfa/ryegrass, clover/ryegrass, vetch/ryegrass, Austrian winter pea, pea/ryegrass, Bug n Breakfast, and naturalized and endemic weeds. Irrigation was applied by handline sprinklers and irrigation was applied to mimic recommended orchard management practices. Sweep net surveys were conducted every 2 weeks and the number of Lygus, thrips and spiders captured was quantified and calculated. In total the cover crop plots were sampled 6 times on 30 June, 14 July, 29 July, 12 August, 9, September and 22 September respectively. Analysis of variance demonstrated that there were no significant differences in Lygus populations among the sample dates so all the dates were pooled.



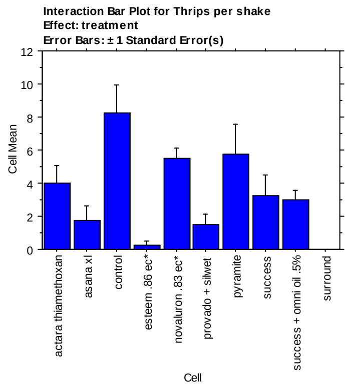
In 2003, the “Ambient” and “Endemic weedy plants consisted primarily of pigweeds and barnyard grass. These plots are essentially the same but have extra plots will prove helpful in the future as we expand these studies. We can conclude that all of the cover crops were superior to no weed control in reducing populations of Lygus bugs as estimated by sweep net samples.

RESULTS/ DISCUSSION- Thrips 2001, 2002, and 2003

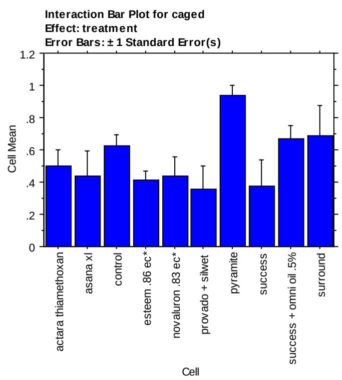
2001. An efficacy trial was established in a nectarine orchard in the Columbia Basin at which 9 insecticides were evaluated for their ability to suppress thrips on nectarines. Insecticides were applied on July 27, 2001 with a handgun sprayer to runoff.

Insecticide efficacy was measured in 3 ways. (1) shake samples of branches were taken 3 days after insecticide application. (2) To measure insecticide residual sleeve cages made of floating row crop cover were placed over 4 individual fruit per replicate tree 3 days following insecticide application. Approximately 10 western flower thrips were then placed into each individual cage. The cages were then left on for 1 week. After which the individual fruit were picked, transported to IAREC and evaluated for thrips feeding damage. (3) An equivalent number of representative non-caged fruit were harvested at the same and transported to IAREC and evaluated for the presence of thrips feeding injury.

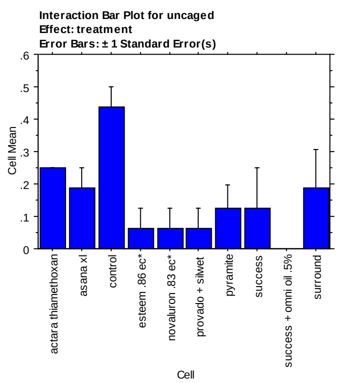
Formulated product	Active ingredient	lb ai/Acre
Novaluron 0.83 EC	novaluron	0.039
Esteem 0.86 EC	pyriproxyfen	0.11
Success	spinosad	0.156
Success + Omni oil 0.5%	spinosad	0.156
Asana L	esfenvalerate	0.075
Provado + Silwet	imidacloprid	0.10
Surround	kaolin	50 (product)
Actara	thiamethoxam	5.5 oz (product)
Pyrimite	pyribaden	0.3
Untreated control		



Results for thrips shake samples 3 days after insecticide application on July 30, 2001. Actara, Asana, Esteem, Provado, both Success treatments and Surround provided significant control (p<0.01) of thrips compared the untreated control in pairwise *t*-tests.



Results of damage assessment of caged fruit. Approximately 10 thrips were placed w/i individidual fruit cages for 1 week. No insecticide treatment provided effective residual and prevented thrips feeding injury compared to the no treated control in this study



Results of damage assessment of non-caged fruit..All of the insecticides provided significant (p<0.01) control of thrips and prevented thrips feeding injury compared to the non treated control in pairwise *t*-tests in this study.

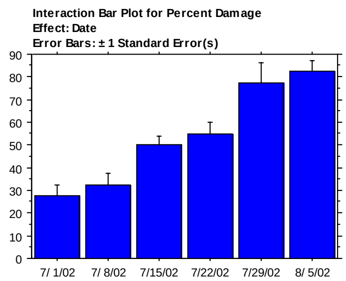
Insecticide Efficacy 2002

Two insecticide trials were established in 2002. The first was established in early April in the Mesa, WA area. A late frost devastated the orchard about 3 days after we made the applications. A second trial was established in Sunnyside, WA on 4/26/02 and the following insecticides were applied

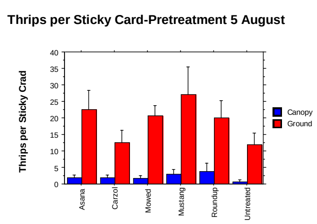
Formulated product	Active ingredient	lb ai/Acre
Success + Omni oil 0.5%	spinosad	0.156
Carzol	Formetanate-hydrochloride	2 # product
Actara	thiamethoxam	5.5 oz (product)
Fujimite	fenpyroximate	0.15
Asana L	esfenvalerate	0.075
Untreated control		

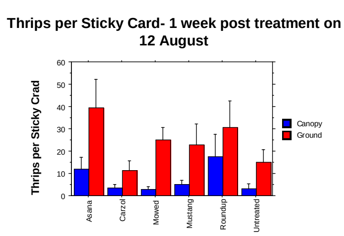
Shake samples of branches were taken 3 days after insecticide application and sticky cards were placed in the tree canopy. No differences in thrips populations were observed within this trial

Temporal Thrips feeding injury. In 2002 we designed a sequential sample experiment in which we established cages weekly from July 1, 2002 through August 5, 2002. Cages were placed over individual fruit on control trees. Fifteen to 20 thrips were placed into 10 per tree to total 40 cages each week. On August 8, 2002 the fruit were removed from each cage site and rated for thrips feeding injury. Damage from thrips feeding in these no choice tests increased with fruit maturity though the month of July and demonstrates that late-season suppression of thrips is important at high population densities.



Orchard floor treatments. The orchard floor of a late bearing cherry orchard was treated post harvest with some candidate compounds, roundup and mowing to determine if these treatments changed the distribution of thrips within the canopy. The treatments included Carzol, Asana, Mustang-Max, Roundup, and mowing. Pretreatment samples determined that populations were fairly low as measured with yellow sicky cards place at 5 inches above the soil surface and 5 feet in the canopy. Cards were placed out on 2 August, 2003 and were removed on 5 August. Subsequently all of the treatments and mowing were applied on 5 August 2003. A post-treatment 3 day sticky card samples were taken on 12 August.





These treatments were inconclusive and will require repeating.

Thrips Sampling. Thrips flight activities were monitored in a peach orchard in the Yakima Valley near Wapato and at a peach and a nectarine orchards near Mesa. This study was run in conjunction with other projects that we had ongoing on thrips management on several other crops comparing blue or yellow sticky cards as a monitoring tool. At present thrips abundance has been counted on 320 blue cards and 320 yellow cards in or near stonefruit orchards. Blue cards are proving to be significantly (P<0.01) more effective then yellow cards at catching western flower thrips in or near stonefruit orchards.

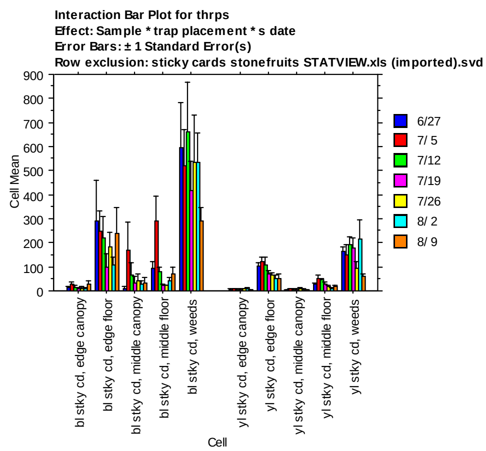
ANOVA Table for thrps

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Sample	1	918090.000	918090.000	44.715	<.0001	44.715	1.000
Residual	638	13099350.000	20531.897				

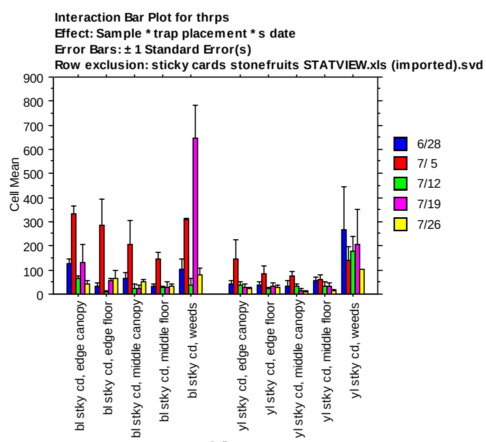
Means Table for thrps
Effect: Sample

	Count	Mean	Std. Dev.	Std. Err.
bl stky cd	320	128.375	189.163	10.575
yl stky cd	320	52.625	72.671	4.062

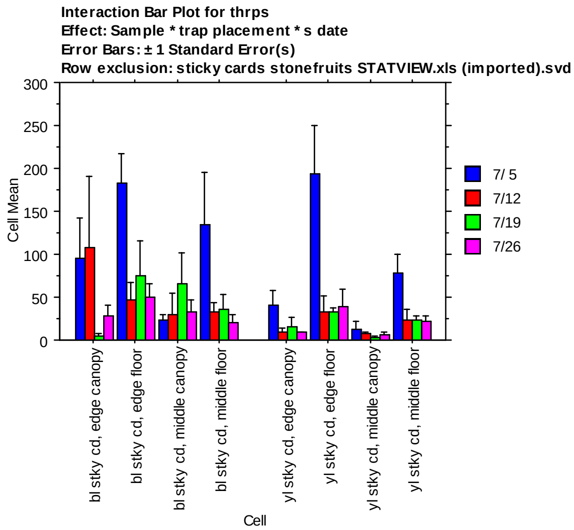
At each orchard site blue and yellow sticky cards were placed weekly in weeds near the orchards edge, on the orchard floor and canopy on edge of the orchard and on the floor and canopy of trees 160 feet in the orchard. At each site the blue cards consistently caught more thrips then the yellow cards and the greatest abundance of thrips was observed in nearby “weeds” followed by cards placed on the edge of the orchard floor.



Results from sticky card traps collected weekly from a peach orchard near Wapato, WA. The counts are the number of thrips captured per 5” by 3” sticky card in the 72 hours prior to the day listed. There is a definite edge effect with utilizing sticky cards to estimate thrips populations in this orchard



Results from sticky card traps collected weekly from a peach orchard near Mesa, WA. The counts are the number of thrips captured per 5” by 3” sticky card in



Results from sticky card traps collected weekly from a nectarine orchard near Mesa, WA. The counts are the number of thrips captured per 5” by 3” sticky card in the 72 hours prior to the day listed.

Orchard floor cover crops. Replicated plots of 14 cover crop blends were established on the Roza unit at WSU IAREC in May 2003. Cover crop blends included perennial rygrass, buckwheat, buckwheat/ryegrass, alfalfa, crimson clover, hairy vetch, alfalfa/ryegrass, clover/ryegrass, vetch/ryegrass, Austrian winter pea, pea/ryegrass, Bug n Breakfast, and naturalized and endemic weeds. Irrigation was applied by handline sprinklers and irrigation was applied to mimic recommended orchard management practices. Sweep net and yellow sticky card surveys were conducted every 2 weeks and the number of thrips and captured was quantified and calculated. In total the cover crop plots were sampled 5 times on 30 June, 14 July, 29 July, 12 August, and 9, September respectively. Population estimates on sticky cards varied across dates and within plots. However, thrips populations tended to be reduced in buckwheat/ buckwheat combination plot. Since this was the establishment year for these plots we will have to see how things change as the cover crops mature over the next several years.