ENVIRONMENTALLY SOUND PRUNE SYSTEMS (E.S.P.S.)

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ABSTRACT

Due to the impending loss of many pesticides, stricter regulations on their use and concerns over contaminating natural resources this project was begun to develop, research and implement alternative practices in order to reduce pesticide use and conserve natural resources.

The core of the project revolves around monitoring and developing treatment thresholds for pest, plant nutrition and irrigation needs. Pest being studied include: European and web-spinning mites, San Jose Scale, prune aphids, peach twig borer, leaf-rollers, prune rust, and fruit brown rot.

Results from this year's pest monitoring and applying pesticide treatments only when the pest reaches the treatment threshold indicated that, by using the monitoring/treatment threshold data being developed in this project, nearly three million dollars in pesticides and their application could have been saved in 1999. Most of the savings would have been with the controversial dormant pesticide application and prune rust treatments.

Tree water status monitoring indicated that many of the growers in the program are applying more water than needed for best production. Additional savings appear to be available where tree water needs are monitored and irrigation's applied only as needed.

Some cooperators have well water with nitrate nitrogen in them, which could be utilized by the tree. This available nitrogen source could reduce the cost of applied nitrogen. Over fertilization or poor fertilization timing may be responsible for this well water contamination.

Over ten educational meetings, which discussed progress and implementation of the data being developed, were held in 1999 for an audience of 830 individuals interested in prune production. Many newsletters and a popular article was also published and widely distributed about the progress of the project. Electronic media is being used in at least three counties to advise prune growers of pest status and "reduced risk" treatment options.

PROBLEM AND ITS SIGNIFICANCE

Economics and regulations are creating change in the way prunes are farmed. Cost of farming is going up, the industry is expanding creating concerns of over production and the industry will no longer pay for small poor quality fruit. Federal acts, and California ballot initiatives such as the Federal Clean Air Act, Federal Food Quality Protection Act and California's Proposition 65 and 204 dealing with water quality establish expiration dates and/or threaten the continued use of many

pesticides. Some pesticide expiration dates are scheduled for the year 2000. Regulations established by California Department of Pesticide Regulations (DPR) have created new requirements and certification for the application of pesticides. Misuse of natural resources is becoming a common environmental concern.

Alternative practices, to the conventional way prunes have been farmed, need to be researched, demonstrated and implemented to keep pace with current economics and approaching and/or existing regulations. Economic thresholds and monitoring techniques need to be discovered so that pesticide use can be safely reduced or at least used in a timely fashion when needed. Water conservation that does not interfere with prune production needs to be researched and demonstrated.

OBJECTIVES

Environmentally Sound Prune Systems (ESPS) is a research/demonstration project that 8 University of California (U.C.) Prune Farm Advisors, 2 U.C. IPM Advisors, 3 U.C. Faculty Members and 3 U.C. Specialists are participants in to advance economically and environmentally sound approaches to prune production. The project objectives involve the reduced use of biocides, more effective use of fertilizers and natural resources and encourage known useful cultural operations into a more sustainable farming system.

The overall project was begun in 1998 with support from the California Prune Board. The project is being conducted on individual prune farms ranging from Tulare to Tehama County, twenty-two sites total.

The objective is to compare cultural practices dealing with pest management, fertilization and irrigation between the conventional and more sustainable or "reduced-risk" approach to growing prunes. Reduced-risk means a reduced risk to the environment without additional risk to the grower. After a few years of establishing these comparisons, an economic comparison will also take place.

"Satellite projects" to evaluate single aspects of ESPS may be established in one or more areas. These satellite projects are "stand alone" projects. Their objectives are designed to address single researchable questions. For example, evaluating aphid control with soft chemicals. ESPS satellite projects will be reported separately by those involved.

PROCEDURE

Research/Demonstration:

In Tulare (1 site), Madera (1 site), Merced (2 sites), Fresno (1 site), Yolo (1 site), Sutter (5 sites), Yuba (2 sites), Butte (3 sites), Glenn (2 sites) and Tehama (4 sites) Counties establish trials which compare two prune farming systems to an untreated check: 1) conventional system and 2) a "reduced-risk" system. Each system will consist of at least 5 acres. The conventional system will consist of the grower's normal practices but must include an Asana and oil dormant spray. Pest control for the reduced-risk system is based on monitoring protocols that are being developed for this project (see protocol 3 at end of report for example). A small-untreated "check" area is also present at each site to help validate the two prune farming systems. The organisms being monitored

for include: San Jose Scale, European Red Mite eggs, prune aphids, peach twig borer and the leaf roller complex, beneficial insects, prune rust, fruit brown rot, and spider mites. In addition, the nutrient status and tree water status is being monitored. Tree water status is being used for irrigation scheduling purposes. Field Assistants (Scouts) are doing the monitoring in each site. There are currently nine scouts hired to do the monitoring. From using these monitoring tools recommendations are made to the grower-cooperators about pest control, fertilization and irrigation scheduling. The cooperator has agreed to apply these recommendations to the reduced-risk segment of the orchard. In some cases separate irrigation schedules can not be applied to the conventional and reduced-risk plots. In these cases our irrigation recommendations are applied in the entire block. As new monitoring techniques and recommendations become available they will be incorporated into the project. These techniques and recommendations will, most likely, come from the satellite projects described earlier and reported on below.

Evaluation of these two farming systems is being carried out using data collected throughout the season and using final plot evaluations that are conducted just prior to harvest. Additionally, these systems will be evaluated based on grade sheets, yield, and dry-away information provided by the grower cooperator.

Education/Outreach:

Each farm advisor is required to have at least one educational meeting each year focusing on the ESPS project. Farm Advisors are also encouraged to write newsletters and other popular articles about the ESPS project. Insect day-degree accumulation equipment was purchased for use in this project. E-mail and web site communication between advisors and clientele, regarding pest monitoring, day-degree accumulation and field observations is also encouraged.

Securing Additional Grant Support:

It is recognized that the California Prune Board can not support this project to the extent needed to attract rapid, wide adoption of reduced risk practices by clientele. To this end, an attempt at securing additional grant support from other agencies is being conducted to expand the project beyond the capabilities of the California Prune Board. However, securing other grant funding is contingent upon prune industry support provided by the California Prune Board.

Satellite Projects:

Projects need to be researched before being demonstrated or adopted on a wide scale. In previous years, under the ESPS project, research was conducted on: 1) Alternate year dormant spray program, 2) A predictive model for forecasting scab off-grade at harvest, 3) Aphid control using soft chemicals, and 4) Mow and throw technique of mowing cover crop, using the residue as a mulch for weed control and the use of rice straw (ag-waste) as mulch for weed control.

This year, under the ESPS project, material efficacy trials were conducted for control of prune aphids using soft materials including a number of novel products not yet registered. These satellite projects will be reported on by those involved.

RESULTS

Research/Demonstration:

Results from this year's project are first discussed by the individual monitoring protocols and final plot evaluations and then by field evaluation of fruit at harvest. Ultimately, site grade sheets will be used to further evaluate the success of the project. This report precedes the receipt of all grade sheets.

Fall Presence-Absence Monitoring for Prediction of Springtime Aphid Populations and a Dormant Spray Recommendation Guide.

Through dormant spur monitoring we can now assess the population of European Red Mite eggs and San Jose Scale (Protocol 1). The need for a dormant treatment for these two pests can be predicted and an oil application can control these two pests. The pests that are giving us the most problem when we do not put on a dormant insecticide and oil spray, are prune aphids. Both mealy plum aphid and leaf curl plum aphid can be a problem.

To help with the aphid problem the ESPS Project has developed a fall monitoring technique to predict if aphids will be present next spring. By sampling 100 leaves per tree on 20 trees in the fall of 1998 and recording the presence or absence of aphids on a tree in the spring of 1999, we were 70% accurate in predicting the presence of mealy plum aphid populations. (Graph 1). Our accuracy for Leaf Curl Plum Aphid has not been as good. Sampling is done when 75% of the leaves have fallen off (late October- early November). To improve accuracy, we have increased the number of trees monitored for the 1999-2000 season.

If less than 5% of the sampled trees have aphids in the fall we would predict very few aphids next spring and a treatment should not be needed. If 7.5-15% of the trees sampled have aphids in the fall, the model predicts some aphid problem that may justify a treatment. If more than 15% of the trees sampled in the fall have aphids the model predicts a wide spread aphid problem next spring that would definitely require treatment (Table 1).

Using this technique we have found that 64% of the orchards did not have an aphid problem and did not need a dormant insecticide and oil treatment. For the orchards that were predicted to have an aphid problem we are recommending: 1) oil spray during or near bloom or 2) be prepared to control aphids during the growing season with standard insecticides or suppressing aphids with oil.

Coupling this monitoring technique with the dormant spur sampling technique for European Red Mite and San Jose Scale (protocol 1) we have been able to develop the following "Dormant Treatment Recommendation Guide" (Table 2).

Graph 1.

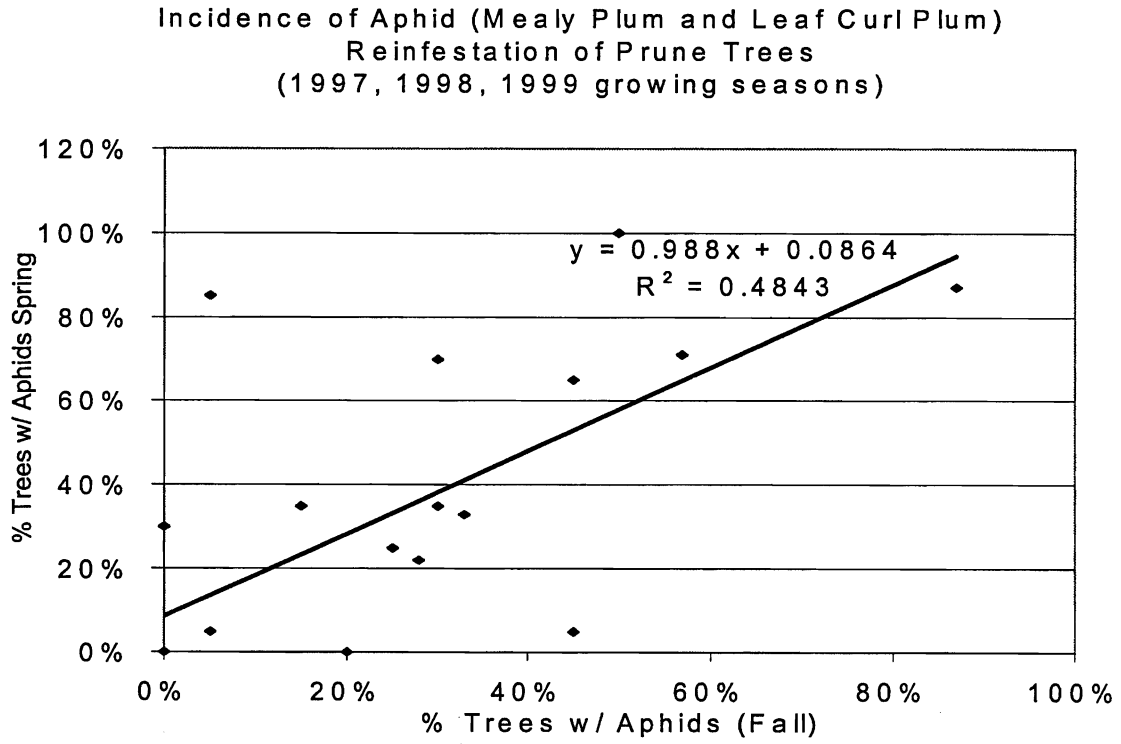


Table 1. Spring aphid prediction model.

Level of Aphid Infestation	# of Trees w/ Aphids Out of 40	% Trees Infested	Expected Spring Aphids
Level 1	0 - 2	0 - 5 %	Very Few
Level 2	3 - 6	7.5 - 15 %	Some
Level 3	7 or more	Over 15%	Wide Spread

Table 2. Dormant Treatment Recommendation Guide

Aphids at Level:			Mites and/or Scale Above Threshold?	Treatment Recommendation
Level 1	Level 2	Level 3		
X			No	Nothing
X			Yes	Dormant oil
	X		No	Oil at bloom
	X		Yes	Delayed dormant oil or oil at bloom
		X	No	Oil at bloom* + in-season
		X	Yes	Delayed dormant oil or oil at bloom* + in-season

* Be concerned with oil applications near Captan or Bravo.

Dormant Spur Sampling for Red Mite Eggs (ERM) and San Jose Scale (SJS) – Protocol # 1:

This monitoring protocol involved the evaluation of prune spurs once during the dormant period. If more than 10 percent of the spurs have ERM eggs or SJS crawlers, a delayed-dormant oil spray is recommended. If less than 10 percent of the spurs have mite eggs or live SJS present, no treatment is recommended. Three sites out of 22 (Madera, Fresno and Tulare) exceeded the threshold for ERM eggs. Only 27 % of the orchards (6 of 22) exceeded the treatment threshold for over wintering San Jose Scale (Butte, Sutter (2 sites), Yuba (2 sites), and Tulare (Table 3). These sites received a dormant or delayed-dormant oil spray for one or both of these pests. None of the reduced-risk sites had an ERM or scale problem during the growing season.

Table 3. % Sites Requiring Dormant Spray for ERM or SJS (22 sites total):

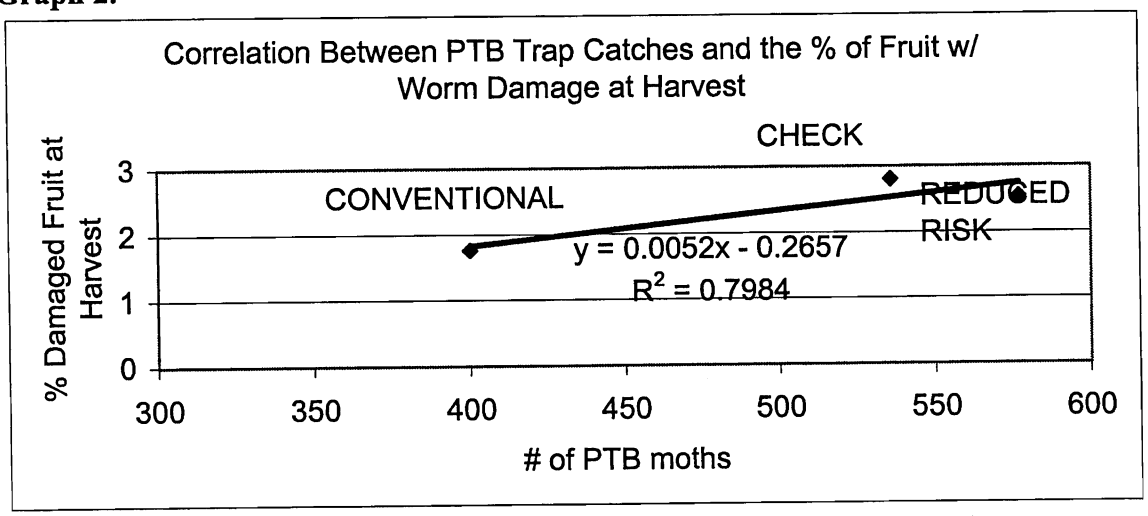
ERM eggs	SJS	Total
14%	27%	36%

Monitoring of Pheromone Traps for PTB, SJS, and Parasitoids of SJS - Protocol # 2

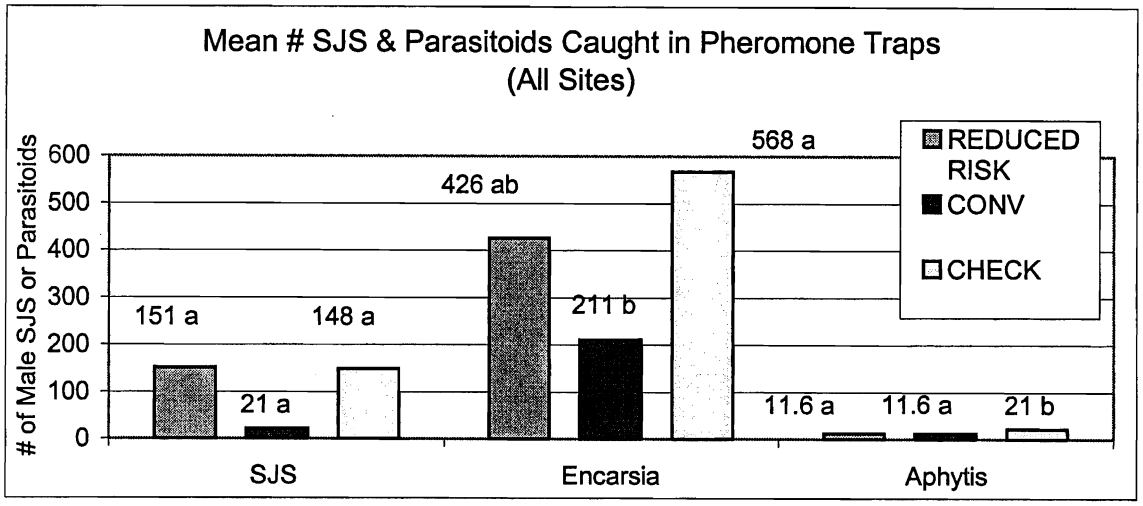
Peach twig borer pheromone trap catches in the reduced risk, conventional, and check plots were not significantly different. Peach twig borer trap catches are correlated (R=.89) to the percentage of fruit with worm damage at harvest (Graph 2).

San Jose Scale pheromone traps were used to monitor SJS and two parasitoids that attack SJS. No significant differences in pheromone trap catches were found for male SJS between the conventional, reduced-risk, and check plots. Significant differences in parasitoid populations between the test plots did occur. *Encarsia* (*Prospatella*) wasps were caught in significantly larger numbers in the check plots that the conventional. *Encarsia* trap catches in the reduced-risk plots were intermediate, but not significantly different from the check or conventional. Trap catches of *Aphytis melinus* in the check plots were significantly higher than the conventional and reduced risk plots (Graph 3).

Graph 2.



Graph 3.



Treatment means that are not followed by a common letter are significantly different from each other at the 5% level according to Duncan's Multiple Range Test for Mean Separation.

Evaluation of Green Fruit for SJS and Parasitized SJS – Final Evaluation

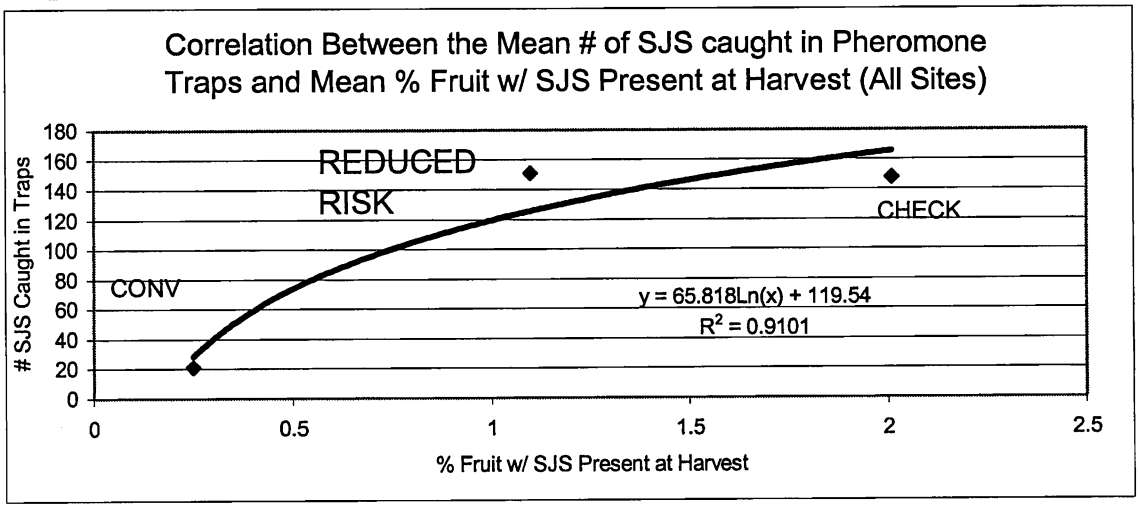
For each of the 22 sites, five hundred fruit per treatment were examined for the presence of SJS or parasitized SJS during the final evaluation. The untreated check plots had significantly more fruit with SJS present compared to the conventional plots. The reduced risk plots were intermediate and not significantly different from the check or the conventional. No significant differences occurred in terms of parasitized SJS (Table 4). There was a strong correlation (R=.95) between the number of male SJS caught in pheromone traps and the percentage of fruit with SJS present at harvest (Graph 4).

Table 4. Mean % Fruit w/ SJS or Parasitized SJS Present at Harvest (All Sites)

TREATMENT	% Fruit w/ SJS	% Fruit w/ Parasitized Scale
REDUCED RISK	1.1 ab	.01 a
CONVENTIONAL	.25 b	0 a
CHECK	2.01 a	0 a

Treatment means not followed by a common letter are significantly different from each other at the 5% level according to Duncan's Multiple Range Test for Mean Separation.

Graph 4.



Blossom/Shoot Tip Sampling for PTB, Leaf Roller Complex, and Other Larvae (Protocol # 3)

Sampling of blossoms and shoot tips is used to determine the need for "bloom time" or "in-season" applications of *Bacillus thuringiensis* (*Bt*) to control lepidopterous larvae. Two techniques were evaluated this season. One technique (old protocol) involved random sampling of 20 blossoms and 20 shoot tips on 20 trees for the presence of damage or larvae. The mean percentage of blossoms/shoot tips with larvae or larval damage present was not significantly different for the three systems (Table 5).

The other method (new protocol) involved visual inspection of entire trees (80 per plot) to determine the presence or absence of larvae or larval damage. The conventional plots had significantly fewer trees with larvae or larval damage present compared to the reduced risk and check plots (Table 6).

For each of the 22 sites, five hundred fruit per treatment were examined for the presence of larvae or damage during the final evaluation. There were no significant differences between the three treatments (Table 7).

Table 5. Old Protocol. Mean % of Blossoms/Shoots w/ Larvae or Damage Present

TREATMENT	% Blossoms/Shoots w/ Worms or Damage
REDUCED RISK	0.56 a
CONVENTIONAL	0.39 a
CHECK	0.41 a

Treatment means not followed by a common letter are significantly different at the 5 % level according to Duncan's Multiple Range Test for Mean Separation.

Table 6. New Protocol. Mean % of Trees with Larvae or Damage Present

TREATMENT	% Trees w/ Worm Damage
REDUCED RISK	8.6 a
CONVENTIONAL	6.0 b
CHECK	9.7 a

Treatment means not followed by a common letter are significantly different at the 5 % level according to Duncan's Multiple Range Test for Mean Separation.

Table 7. Mean % Fruit w/ Larvae or Damage Present (Final Evaluation)

TREATMENT	% Worm Damage
REDUCED RISK	2.54 a
CONVENTIONAL	1.76 a
CHECK	2.80 a

Treatment means not followed by a common letter are significantly different at the 5 % level according to Duncan's Multiple Range Test for Mean Separation.

Spring Prune Aphid Monitoring – Protocol # 4:

Beginning in April, a random sample of 75-80 trees per plot is examined for the presence of leaf curl plum aphids (LCPA) and mealy plum aphids (MPA). If more than 10 % of the trees examined are infested with aphids, then a treatment is justified. The conventional plots had significantly fewer trees infested by mealy plum aphid and leaf curl plum aphid compared to the reduced risk plots and the check plots, which were statistically similar to each other (Table 8). Thirty-two percent of the reduced risk plots (7 of 22) exceeded the treatment threshold for leaf curl plum aphid. These orchards were located in Sutter (2 sites), Tehama (2 sites), Glenn (1 site), Yolo (1 site) and Butte (1 site) Counties. Twenty seven percent of the reduced risk plots (7 of 22) exceeded the treatment threshold for mealy plum aphid. These orchards were located in Sutter (2 sites), Glenn (2 sites), Merced (1 site), Madera (1 site) and Butte (1 site) Counties.

Table 8. Mean % of Trees w/ Prune Aphids Present – All Sites

TREATMENT	% Trees w/ LCPA	% Trees w/ MPA
REDUCED RISK	12.78 a	14.6 a
CONVENTIONAL	2.05 b	2.0 b
CHECK	12.99 a	20.8 a

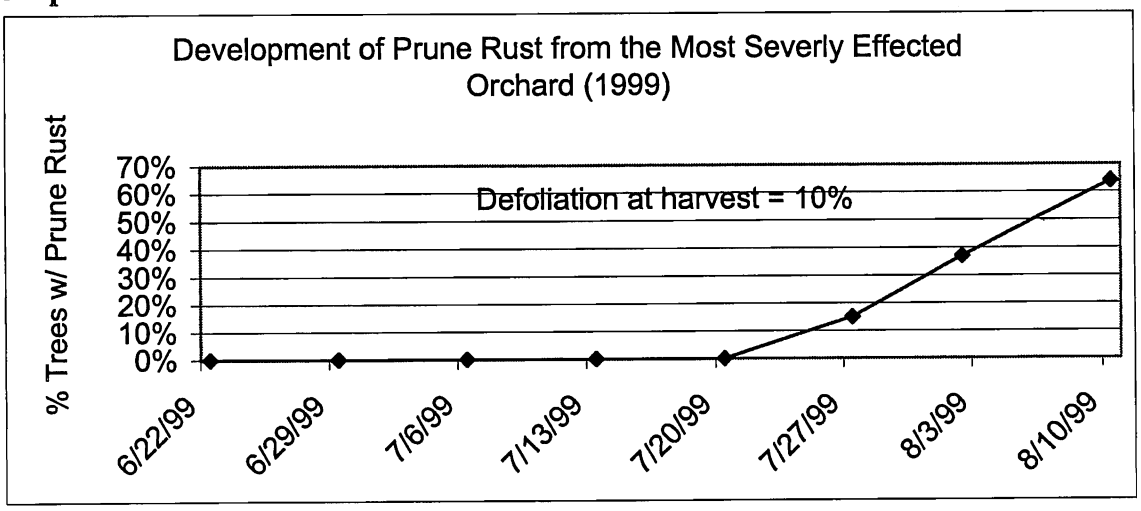
Treatment means not followed by a common letter are significantly different at the 5 % level according to Duncan's Multiple Range Test for Mean Separation.

Prune Rust Monitoring and Treatment Timing Recommendations:

Previous research has shown that rust treatments applied close to the onset of rust infection are most beneficial. This monitoring technique involves watching trees for the first signs of rust. Once rust is first detected, a treatment is recommended. After a rust treatment is applied, and continued monitoring indicates an increase in rust, additional treatments are recommended. Only three of the sites (14%) had rust, all in the Sacramento Valley. However, the rust did not show up till August and consequently no rust treatments were needed. Only one of the three orchards had any defoliation

prior to harvest. The percent of trees with some defoliation in this orchard was 10 percent (Graph 5). Most defoliation was on young replants. The time to monitor a plot for rust took 30 minutes for one person. Monitoring took place over an 8-week period.

Graph 5.



Presence–Absence Sequential Sampling for Webspinning Mites:

Only four of the twenty-two sites were over the treatment threshold (over 53 percent of the leaves having webspinning mites with predacious mites present). Only one site was treated. This site had some defoliation, which was stopped once a treatment was applied. There was no statistical difference between webspinning mite populations or mite predator populations in the ESPS, conventional, and check plots for the 22 sites (data not shown). Monitoring for mites took 1.5 hours per week per person. Monitoring took place over a 10-week period.

Fertilization:

Plant tissue and water samples for each site were collected in July. The tissue and water nutrient data are shown in Tables 9 and 10. Highlighted tissue analysis sites indicate a deficiency in one or more nutrients. Highlighted water analysis sites indicate either high N or high salt. Five sites were considered to have low leaf nitrogen levels. Four of them were new sites to the program. Two sites were considered to have low zinc levels in the tissue samples. No sites were considered deficient in potassium or boron. In the water samples, nine sites had high nitrate nitrogen levels, and one site had high Ec levels.

Table 9. 1999 Tissue Analysis for Various Nutrients

County & ID	Treatment	N-Total (%)	K-Total (%)	B (ppm)	Zn (ppm)
Butte-BJ	Conv.	2.268	2.27	44	178
Butte-BJ	ESPS	**2.153**	2.22	44	160
Butte-CSUC	Overall	2.632	3.15	66	27
Butte-OO	Overall	**2.029**	3.64	60	22
Glenn-B	Overall	2.546	3.44	71	165
Glenn-WG	Conv.	2.614	3.55	58	93
Glenn-WG	ESPS	2.306	2.73	54	36
Merced-GL	Conv.	2.923	2.18	66	21
Merced-GL	ESPS	2.467	3.23	80	17
Merced-TB	Conv.	2.367	2.74	47	17
Merced-TB	ESPS	2.67	2.07	55	182
Sutter-DC	Overall	2.284	2.25	48	18
Sutter-GC	Overall	**2.213**	2.48	52	19
Sutter-JH	Overall	2.389	2.25	45	**16**
Sutter-MJ	Overall	**2.202**	3.93	61	**14**
Sutter-TR	Overall	2.407	2.14	58	88
Tehama-F	Overall	2.245	4.05	46	20
Tehama-M	Conv.	2.38	2.89	73	263
Tehama-M	ESPS	2.59	2.49	73	26
Tehama-RB	Conv.	2.518	3.29	102	194
Tehama-RB	ESPS	2.684	3.42	106	231
Tehama-SV	Overall	2.746	3.73	71	231
Tulare-A	Conv.	2.579	3.23	59	70
Tulare-A	ESPS	2.54	2.33	51	33
Tulare-A	Check	2.482	195	57	30
Yolo-T	Conv.	3.353	1.82	46	51
Yolo-T	ESPS	2.467	2.2	51	50
Yolo-T	Check	2.464	2.08	52	47
Yuba- KJ	Overall	2.333	2.92	57	36
Yuba-M	Overall	**2.199**	3.39	47	18

Table 10. 1999 Water Analysis

County & ID	pH	EC	Ca	Mg	Na	SAR	Cl	B	NO3-N	Lbs.N/
		mmhos/ cm	meq/L	meq/ L	meq/ L		meq/ L	ppm	ppm	Acre Ft
Butte-BJ	7.2	0.67	2.5	4.5	0.9	<1	0.2	<0.1	**10.5**	**28.6**
Butte-CSU	7.4	0.34	1.6	1.7	0.4	<1	<0.1	0.1	**5.71**	**15.5**
Butte-OO	7.6	0.08	0.4	0.2	0.1	<1	<0.1	<0.1	<0.05	0.0
Glenn-B	7.7	0.63	3.1	2.5	1.3	1	1	0.3	**5.18**	**14.1**
Merced-TB	NA	0.04	0.2	0.1	0.1	<1	<0.1	<0.05	<0.05	0.0
Sutter-DC	7.2	0.24	0.8	1.4	0.5	<1	0.1	<0.1	1.3	3.5
Sutter-GC	7.4	0.08	0.4	0.2	0.1	<1	0.1	<0.1	<.05	0.0
Sutter-JH	7.2	0.34	1.1	1.5	0.8	1	0.3	0.1	**5.9**	**16.0**
Sutter-MJ	7	0.73	2.7	4.8	1	1	0.7	<0.1	**8.17**	**22.2**
Sutter-TR	7.6	0.65	2.4	3.9	1.1	1	0.3	0.1	**11.1**	**30.2**
Tehama-F	6.9	0.28	0.9	1.2	0.7	1	0.1	<0.1	**6.05**	**16.5**
Tehama-M	7	0.15	0.5	0.5	0.5	1	0.1	0.1	0.09	0.2
Tehama-RB	6.8	0.6	1.1	1.5	3.2	3	2.5	1.4	2.11	5.7
Tulare-A-1	7.8	0.26	1.2	0.1	1.4	2	0.2	0.1	2.36	6.4
Tulare-A-2	7.2	0.62	4	1	1.8	1	0.4	0.1	**10.1**	**27.5**
Yolo-T	7.3	**0.88**	2.9	5.7	2.1	1	1.6	0.43	**6.28**	**17.1**
Yuba- KJ	7	0.66	2.7	3.9	1.3	1	0.5	0.1	1.71	4.7
Yuba-M	7.1	0.55	<0.1	<0.1	1	<1	0.3	<0.1	1.76	4.8

Irrigation Management (Objective, procedure, results):

The reduced-risk recommended management of irrigation is based on research findings in prune, that: 1) stress can be accurately and reliably measured using the midday bagged leaf method (midday stem water potential), and 2) prune tree economic production appears to benefit from mild to moderate water stress later in the season, when dry yield is not affected but fruit hydration ratio is improved. Additional beneficial effects may also occur in prune (reduction in excess vegetative growth, increased return bloom), but these have been more difficult to clearly identify. Reduced water input is also one of the goals of ESPS, and so the objective of our irrigation management strategy are to minimize the applied water without causing detrimental effects on economic yield.

Midday stem water potential is measured by selecting an interior canopy leaf, attached near the trunk or main scaffold, and enclosing this leaf in a foil-covered black polyethylene envelope to stop leaf transpiration. After about 2 hours, at midday, the water potential of this non-transpiring leaf is measured with a pressure chamber. The relationship of this measurement to the midday conditions of temperature and humidity have been determined for fully irrigated prune trees (Table 7), and this

value is used as a reference value for any particular date and site.

Table 11. Values of midday stem water potential (in Bars) to expect for fully irrigated prune and almond trees, under different conditions of air temperature and relative humidity.

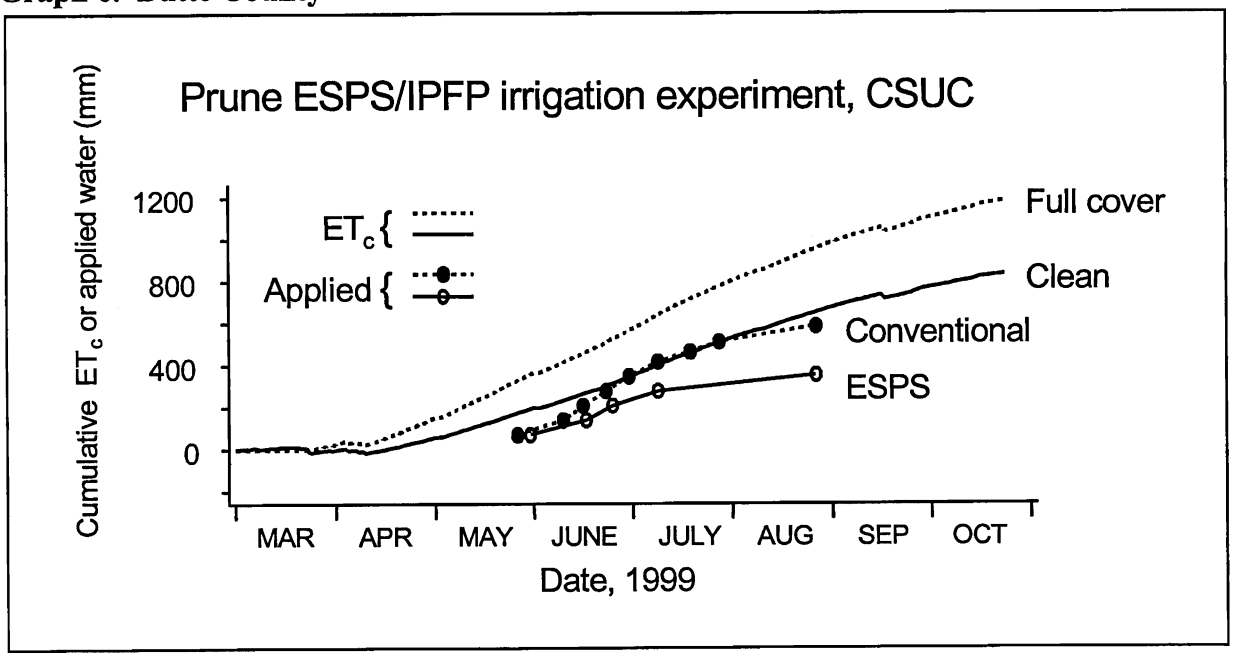
Temperature (°F)	Air Relative Humidity (RH, %)						
	10	20	30	40	50	60	70
70	**-6.8**	**-6.5**	**-6.2**	**-5.9**	**-5.6**	**-5.3**	**-5.0**
75	**-7.3**	**-7.0**	**-6.6**	**-6.2**	**-5.9**	**-5.5**	**-5.2**
80	**-7.9**	**-7.5**	**-7.0**	**-6.6**	**-6.2**	**-5.8**	**-5.4**
85	**-8.5**	**-8.1**	**-7.6**	**-7.1**	**-6.6**	**-6.1**	**-5.6**
90	**-9.3**	**-8.7**	**-8.2**	**-7.6**	**-7.0**	**-6.4**	**-5.8**
95	**-10.2**	**-9.5**	**-8.8**	**-8.2**	**-7.5**	**-6.8**	**-6.1**
100	**-11.2**	**-10.4**	**-9.6**	**-8.8**	**-8.0**	**-7.2**	**-6.5**
105	**-12.3**	**-11.4**	**-10.5**	**-9.6**	**-8.7**	**-7.8**	**-6.8**
110	**-13.6**	**-12.6**	**-11.5**	**-10.4**	**-9.4**	**-8.3**	**-7.3**
115	**-15.1**	**-13.9**	**-12.6**	**-11.4**	**-10.2**	**-9.0**	**-7.8**

Based on: McCutchan and Shackel, 1992. Stem-water potential as a sensitive indicator of water stress in prune trees (*Prunus domestica* L. cv. French). Journal of the American Society for Horticultural Science 117(4):607-611 and Shackel et al. 1997. Plant water status as an index of irrigation need in deciduous fruit trees. HortTechnology 7(1):23-29.

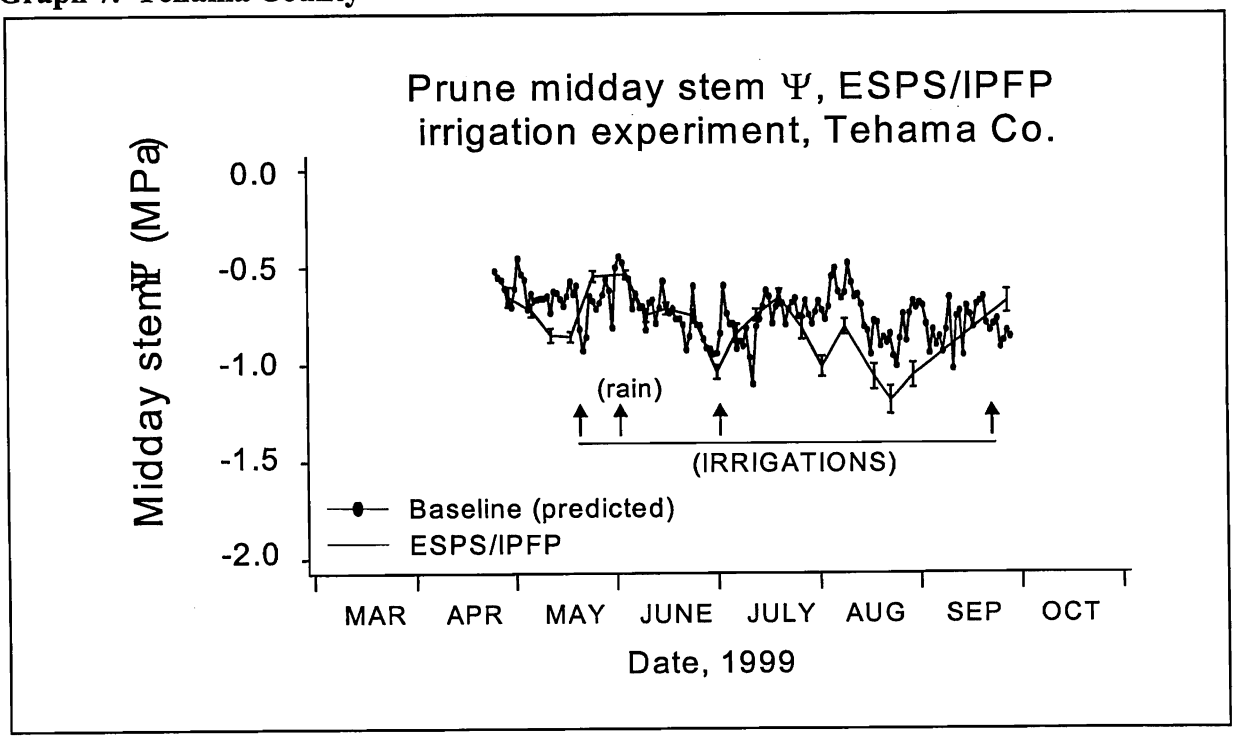
Mature prune trees can be allowed to progressively decline through the growing season towards mild levels of stress (-15 bars on average) by harvest, with no effect on yield, and some improvement in fruit quality (lower fresh fruit moisture content). Rapid recovery from a stress of -15 bars or more should be avoided during the crack sensitive period (late June/early July), and substantial recoveries should probably also be avoided near harvest, since we have associated this with increased pre-harvest fruit drop.

Each of the 22 sites were monitored using a gas or pump up pressure chamber. All sites showed the expected increases in stem water potential following irrigation and declines as soil water was depleted (Graph 6, Butte Co. and Graph 7, Tehama Co). The Butte site compared the grower's conventional practice against irrigation recommendations based on monitoring. At this location, the number of micro sprinkler irrigation's totaled nine for the conventional and five for the reduced risk plot. At the Tehama site, the entire orchard was irrigated based on pressure chamber monitoring. At this site, one timely rain and three flood irrigations were applied. The number of irrigations applied in 1999 was far less than the grower's previous practice.

Graph 6. Butte County



Graph 7. Tehama County



ONFIT Procedure – Fruit Brown Rot Predictive Model:

A predictive model for estimating fruit brown rot infection has been developed by Themis Michailides, plant pathologist at the Kearney Agricultural Center. The "Overnight Freezing Technique" (ONFIT) involves freezing green fruit to reveal latent infections by *Monilinia fruticola* or *Monilinia laxa*. Levels of latent infection revealed using the ONFIT model are correlated to levels of fruit brown rot infection that will become visible in the field later in the season as well as post harvest infection. This information is used to determine the need to protect fruit from brown rot infection with a fungicide application. Results of the ONFIT procedure predicted that 8 of the 22 sites had low levels of latent brown rot present. No fungicide treatments for fruit brown rot were recommended for any of the 22 sites based on the ONFIT fruit brown rot predictive model. At harvest, 2000 fruit per plot were examined for the presence of brown rot infection. Results of the final field evaluations at harvest indicted that fruit brown rot was present at 4 of the 22 sites. Brown rot levels at harvest did not exceed 1% infected fruit at any of the 22 sites (Table 12).

Table 12.

	% Infected Fruit or Clusters of Fruit			
County and Site	ONFIT Prediction	Brown Rot Present at Harvest		
	ESPS	ESPS	CONV	CHECK
Butte - CS	0%	0.2	0	0
Yuba - KJ	0%	0	0	0
Yuba - MP	1%	0	0	0
Butte - BJ	1%	0	0	0
Sutter - MJ	0%	0	0	0
Sutter - DC	0%	0	0	0
Sutter - GC	1%	0	0	0
Sutter - JH	0%	0	0	0
Tehama - VM	0%	0	0	0
Tehama - RB	0%	0	0	0
Glenn - WG	0%	0.1	0	0
Yolo - JT	0%	0	0	0
Merced - GL	0%	0	0	0
Merced - TB	0%	0	0	0
Fresno - CB	0%	0	0	0
Tulare - DA	0%	0.45	0	0
Madera - ST	0%	0	0	0
Glenn - B	1%	0	0	0
Butte - OO	4%	0	0	0
Tehama - FM	2%	0	0	0
Tehama - SV	5%	0	0	0
Sutter - TR	6%	0.05	0.35	0.85

Yield and Quality Evaluation from P-1 Gradesheets:

Yield and quality grade sheets ("P-1") were not received in time to be included in this report.

Education/Outreach:

Each participant advisor held one or more educational meeting which discussed the ESPS project. Over 830 people received information on the ESPS project at meetings. Following is a list of meetings held, dates, and subjects covered:

County	Date(s)	Subjects Covered
Butte/ Sutter	1/20, 3/4, 10/8, 10/10/99	Sprayer calibration, ESPS case history, ESPS overview, Aphid monitoring
Glenn	5/5/, 11/17/99	Vegetation to reduce dormant spray runoff, ESPS overview
Merced	Twice monthly during Spring and summer	Pest updates
Tehama	5/6/, 10/6/99	Cover crop planting, ESPS overview
Tulare	2/26/99	ESPS overview
Yolo	5/13/99	ESPS overview, prune aphids

In addition, Tehama, Glenn, and Butte County advisors provided insect day degree accumulation to clientele via e-mail or web site on a regular basis. Advisors wrote several newsletters and one popular article was published.

Securing Additional Grant Support:

Additional grant support was solicited and secured from several sources. Listed below are the sources of each additional grant that is being used to support this project:

DPR-Pest Management Alliance
BIFS/SAREP
USDA/CSREES
USDA/NRCS

CONCLUSIONS

Research/Demonstration:

Fall Presence-Absence Monitoring for Prediction of Springtime Aphid Populations and a Dormant Spray Recommendation Guide.

The fall aphid sampling was only 70 percent accurate in predicting mealy plum and leaf curl plum aphid populations in the spring. The technique was more accurate in predicting mealy plum aphid than in predicting leaf curl plum aphid. This monitoring protocol has been modified to improve the ability to predict aphid populations and will be tested in the fall of 1999 and spring of 2000.

The "Dormant Spray Recommendation Guide" was very useful. This guide accurately predicted a

dormant insecticide and oil treatment would be useful in controlling aphids and/or SJS and /or ERM in 64 percent of the orchards and that 36 percent of the orchards would not benefit from a dormant treatment. Not treating 36 percent of California's bearing prune orchards with a dormant insecticide and oil spray would save the industry approximately $1,102,000 and go a long way in demonstrating a reduction in pesticide use and a conscious effort to reduce pollution of our natural resources.

Dormant Spur Sampling for European Red Mite (ERM) Eggs and San Jose Scale (SJS) Crawlers:

This sampling technique has the potential of helping to decide if a dormant insecticide spray is justified. Only 8 of the 22 orchards needed a dormant treatment for SJS or ERM. Since grade sheets report several defect categories together, we have found it necessary to use harvest time fruit evaluations in the field to accurately validate our thresholds for SJS on the dormant spur samples.

Pheromone Trap Monitoring for PTB, SJS, and for Parasitoids of SJS – Protocol # 2:

Peach twig borer pheromone trap catches in the reduced risk, conventional, and check plots were not significantly different. Peach twig borer trap catches are correlated (R=.89) to the percentage of fruit with worm damage at harvest.

No significant differences in pheromone trap catches were found for male SJS between the conventional, reduced-risk, and check plots. Significant differences in parasitoid populations between the test plots did occur. *Encarsia* (*Prospatella*) wasps were caught in significantly larger numbers in the check plots that the conventional. *Encarsia* trap catches in the reduced-risk plots were intermediate, but not significantly different from the check or conventional. Trap catches of *Aphytis melinus* in the check plots were significantly higher than the conventional and reduced risk plots.

Based on fruit evaluations at harvest, the untreated check plots had significantly more fruit with SJS present compared to the conventional plots. The reduced risk plots were intermediate and were not significantly different from the check or the conventional. No significant differences occurred in terms of parasitized SJS. There was a strong correlation (R=.95) between the number of male SJS caught in pheromone traps and the percentage of fruit with SJS present at harvest suggesting high trap catches would indicate a significant number of SJS on fruit.

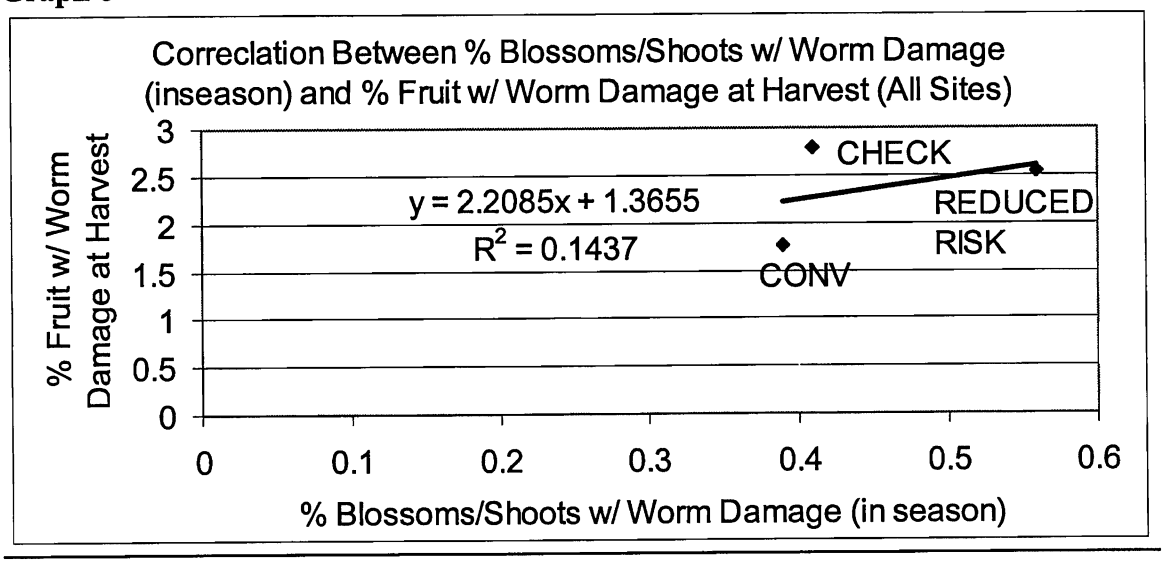
We are finding that both the dormant spur sampling and use of pheromone trapping provide the grower with useful information.

Shoot Tip and Blossom Sampling for Evaluating the Presence of Peach Twig Borer and the Leafroller Complex:

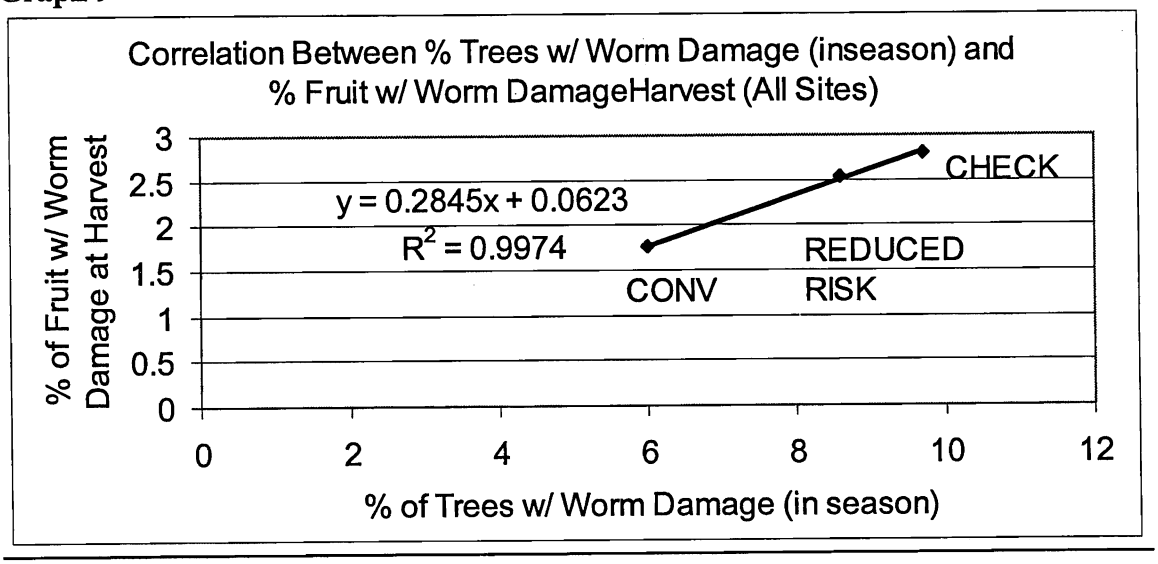
The new protocol, which involves evaluating entire trees for the presence of absence of larvae or damage and looking at more trees, has greatly improved the accuracy of this monitoring technique. Using the old protocol, there was not a strong correlation (R=.37) between the percentage of blossoms/shoot tips damaged and the % of fruit with worm damage at harvest (Graph 8). Using the new protocol, there is a strong correlation (R=.99) between the percentage of trees with larvae/damage present and the percentage of damaged fruit at harvest (Graph 9). Shoot and blossom

monitoring for PTB and leafrollers can help determine the need for a *B.t.* spray as well as the optimum treatment timing.

Graph 8



Graph 9



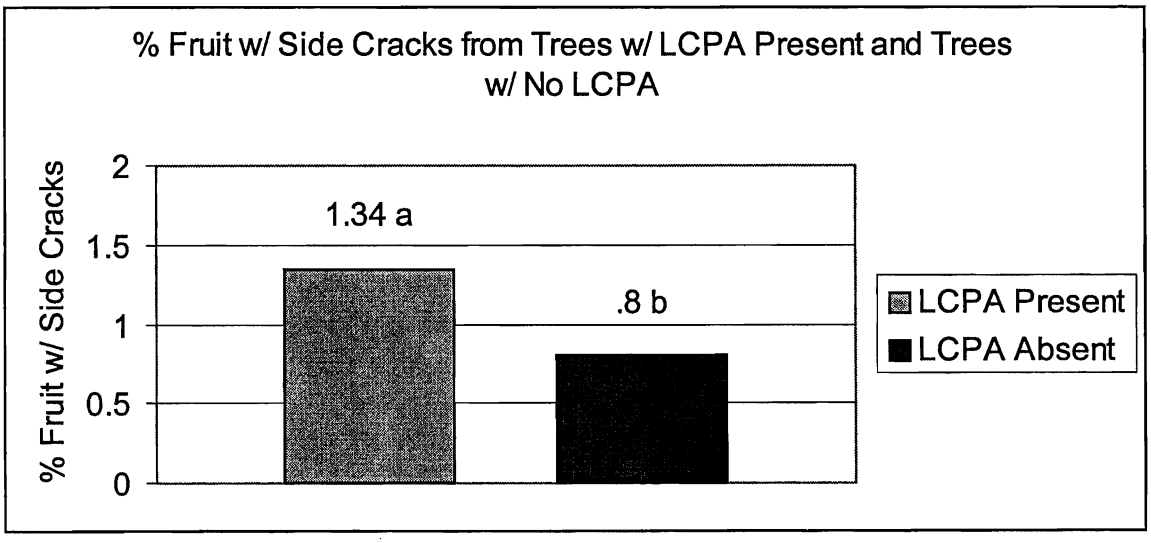
Spring Aphid and Monitoring:

The new monitoring technique, which involved looking at more trees and noting the presence or absence of aphids, was more reliable than the previous protocol. The 10 percent treatment threshold appears to be fairly accurate.

During the final evaluations, 1000 fruit were examined from trees which had been infested by prune aphids and 1000 fruit were examined from trees which had no prune aphid infestation (100 fruit from 10 different trees were examined for cracked fruit.) Trees with leaf curl plum aphids present had

significantly higher levels of side cracks present on fruit than trees without leaf curl plum aphids present (Graph 10). There was no significant difference in fruit cracking between trees with or without mealy plum aphids.

Graph 10.



Prune Rust Monitoring and Treatment Timing Recommendations:

Previous research (Teviotdale and Sibbett) has shown that post harvest defoliation from rust has no influence on fruit quality or productivity. In 1997 Olson, Krueger, and Teviotdale reported the appearance of rust infection on leaves has no influence on fruit soluble solids, dry away, size, etc. Pre-harvest defoliation from rust has been reported to result in reduced fruit dry away and other fruit damage. The rust monitoring protocol appears to be a very good tool in timing and predicting needed treatments. None of the orchards monitored needed to be treated for rust and only one had any defoliation prior to harvest. In the Sacramento Valley, where rust is more prevalent, monitoring should be done weekly.

This monitoring technique is easy, accurate and takes little time. It accurately predicted that rust sprays were not needed this year. Many growers were aware of this through our e-mail and web site "Pest Updates". Had all Sacramento Valley prune orchards (where most of the prune rust is found) followed this predictive model, it would have saved the industry $1,920,000 in 1999 in unneeded preventative prune rust applications.

Presence-Absence Sequential Sampling for Webspinning Mites:

The presence- absence mite monitoring technique takes too long. To shorten the time required, monitoring will only take place every other week until mites are near the threshold and monitoring only 6 trees instead of 20 trees per site will be required. Only one of the four orchards that exceeded the threshold had any defoliation. This suggests that the treatment threshold may be adequate for prunes. Further evaluation of the treatment threshold will take place as more orchards with mites have defoliation.

Fertilization:

Based on critical mid summer leaf tissue levels a few sites had nitrogen and zinc levels below U.C. recommendations. The advisors involved at these sites will be working with their cooperators with fertilizer recommendations. Water samples did indicate several wells with significant levels of nitrate nitrogen in the water. This will be considered when making fertilizer recommendations. Some of these high nitrate- N levels may be the result of contamination due to fertigation. Advisors will be investigating if fertigation is involved and the extent that this practice could account for the nitrate nitrogen in the water.

Irrigation Scheduling:

Many grower cooperators were quite impressed with the irrigation-scheduling component of this project. Several growers found that they could apply fewer irrigation's than they had been used to applying. This will be reflected in lower electric bills and labor cost. One drawback to the monitoring technique is that it takes "decoding" and interpretation of the field data before an irrigation recommendation can be made. Next season we will attempt to use the following table which lists the suggested irrigation threshold values for midday stem water potential (bars) during the growing season for prunes. These values should be considered preliminary, but are based on research showing that levels of –15 bars by harvest will improve fruit drying ratio with no detrimental effects on yield or quality.

Suggested Threshold Values for Midday Stem Water Potential (bars) During the Growing Season for Prunes.

	Month						
Period	March	April	May	June	July	August	Sept.
Early-	-6	-8	-9	-10	-12	-13	-14
Mid-	-7	-8	-9	-11	-12	-13	-15
Late-	-7	-9	-10	-11	-12	-14	-15

ONFIT Procedure – Fruit Brown Rot Predictive Model:

The ONFIT procedure is a valuable tool to help determine the levels of fruit brown rot infection. Accurate prediction of brown rot levels at harvest can help determine the likelihood of economic loss and the necessity of preventative treatments.

Some latent infection levels indicated there would be higher fruit brown rot levels at the end of the season than was actually experienced. The discrepancy is probably due to difficulty in identifying brown rot in the laboratory. Training on identifying laboratory colonies will be important to correctly predict populations of brown rot on fruit at harvest.

Yield and Quality Evaluation:

The removal of the dormant insecticide and oil treatment, treatments for mites, rust, and aphids based on monitoring and treatment thresholds and irrigation scheduling based on leaf stem water

potential had no visible adverse effects on productivity or fruit quality. Final grade sheets will be used to verify these observations. Adjustments to the monitoring techniques and treatment thresholds are ongoing. Long term production and fruit quality impacts that occur as a result of these reduced-risk techniques will be measured over the next few seasons.

Education/Outreach:

Meetings to share information were numerous and well attended. In total over 830 people attended meetings that discussed the ESPS project in 1999. A wide spread popular article on the ESPS project was also published. The word is starting to get out about this project. Educational meetings are a vital part of this project and will continue. In 2000, all advisors are encouraged to use the insect day-degree equipment and report findings to interested clientele by electronic communication.

Securing Additional Grant Support:

The new grants secured will allow this project to expand to new sites and utilize new tools. We tentatively plan on reducing the number of comparison sites but increasing the number of demonstration sites. In total there will be more sites involved in the project in 2000. With the support of the California Prune Board and other sources of grant support, this work can continue to produce "reduced risk" pesticide and cultural options for prune producers.

New Directions in the ESPS Project:

- For next year the ESPS project will become more self reliant on advising growers on irrigation scheduling by using the irrigation scheduling table found in the conclusions.
- There will be fewer sites, which have a conventional. "reduced risk", and a check plot. But more sites demonstrating the "reduced risk" techniques researched.
- Pest Control Advisors (PCA's) will become more involved in the project by using the monitoring techniques in some demonstration plots.
- Some of the monitoring techniques will be modified to be more "PCA friendly."
- Possible inundative releases of *Harmonia axyridis* (multicolored Asiatic lady for aphid control.
- Begin trapping for leaf rollers to help improve monitoring protocol.

ESPS Protocol No. 3

Monitoring for P.T.B., Leafroller Complex, and Other Larvae using Blossom and Shoot Tip Sampling

(Under Evaluation)
Revised 7/28/99

Bill Olson, Carolyn Pickel, and Nadeem Shawareb

Purpose: Determine the need for "bloom time" and "in-season" applications of *Bacillus thuringiensis* (Bt) to control over wintering Peach Twig Borer Larvae and Leafroller Larvae. Several species of leaf roller are difficult to identify in the field such as fruit tree leafroller and oblique-banded leafroller. Other larvae that should be counted in this category are canker worm, green fruit worm, and rarely omnivorous leafroller.

Monitoring Timing: Bloom Time- Monitoring for blossom feeding should start when flowers are nearly at "popcorn stage" and continued weekly until the end of April.

In-season- Start monitoring for leaf rollers in mid June. Monitor each orchard weekly until August.

Method: Bloom time- Randomly sample 50 trees minimum for each plot (Conventional, ESPS, and Check plot). DO NOT sample the same trees each week. Inspect 10 shoots per tree by reaching up from ground. Shoots and blossoms do not need to be picked from the tree. If you suspect there is larvae or damage present then pick the blossom/shoot tip for a closer examination. Sample around the tree. Record the number of damage sites from larval feeding or, if present, larvae for each tree.

In-season- Visually inspect 80 trees per plot by walking around trees and looking for larvae or larval damage. (These can be the same trees as used in the aphid protocol). Be sure to look in areas where fruit are touching and where fruit are touching leaves. Record the number of larvae found or larval damage sites for each tree. Also record the type of damage: (rolled leaves and webbing; hole in shoot; scar on fruit or hole in fruit).

Treatment Threshold: Bloom time-If a total of more than 25 shoots (5%) have larvae present or are damaged and have some larvae (PTB or leafroller) present, a treatment is recommended. For fresh prunes, 1 % is the treatment threshold.

In-season- If more than 4 trees of the 80 (5%) have evidence of larvae or larval damage and have some larvae present a treatment is recommended. For fresh prunes, 1 % is the treatment threshold.

Orchard History: If last years crop had significant P.T.B. or leafroller damage, bloom time *B.t.* treatments are recommended regardless of monitoring levels. However, monitoring is still encouraged to further refine technique and treatment thresholds.

Treatment Timing and Rates: If populations exceed the treatment threshold, treatment should be made during bloom with *B.t.* and as soon as possible in-season. See Pest Management Guidelines for recommendations.

Note: Record the amount of time it took to sample for cost analysis.