COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

Kearney Plant Protection Group

PLANT PROTECTION QUARTERLY

January 1992 **Volume 2, Number 1**

This newsletter is published by the University of California Kearney Plant Protection Group and the Statewide IPM Project. It is intended to provide UC DANR personnel with timely information on pest management research and educational activities in the South Central Region. DANR personnel desiring to be added to or deleted from the mailing list may contact the editors at Kearney Agricultural Center, 9240 S. Riverbend Ave., Parlier, CA 93648. In order to best serve you, comments and suggestions for improvement of this newsletter are invited. Farm Advisors and Specialists may reproduce any portion of this publication for their newsletters, giving proper credit to individual authors.

James J. Stapleton, Charles G. Summers, Beth L. Teviotdale
Editors

IN THIS ISSUE

ARTICLES

ECONOMIC THRESHOLDS REVISITED: CONSIDERATIONS FOR PRACTICAL APPLICATIONS

P.B. Goodell U. C. Kearney Agricultural Center

Introduction and Background

One of the basic tenets of modern pest management is understanding the crop as an agroecosystem and that a complex of organisms will be present in it. The key is to maintain a balance by living with pest populations which are below economically damaging levels. This is accomplished by using evaluation techniques which incorporate biology (sampling), ecology (interactions between pests and antagonists), and economics (loss balanced with cost of protection). Successful pest management depends on the intimate linkage of these components.

The economic threshold concept and its application have received excellent reviews (Stern, 1973; Pedigo *et al*, 1986), especially in the application of economic theory (Headley, 1972; Mumford and Norton, 1984). The objectives of this article are to briefly review the concept and examine current issues surrounding the practical application of economic thresholds to the field.

This material is based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project section 3(d), Integrated Pest Management

Basic Concepts and Definitions

Stem *et al* (1959) established the formal definitions of economic threshold to include:
Economic threshold: Pest density at which control measures should be determined to prevent an increasing population from reaching the economic injury level;

Economic injujy level: Lowest population which will cause economic damage;

Economic damage: amount of injury which justifies the cost of pest control measures.

Mumford and Norton (1984) review the different ways from which economists and entomologists have approached economic thresholds. Headley (1972) approached economic thresholds from a economic theory of marginality. That is, given a pest population, what level of control is most profitable for that particular pest density. In contrast, entomologists have been asking at what pest population should a particular control action be taken.

Much confusion has arisen during the decades since Stem suggested his definitions, especially between the economic injury level and economic threshold. Pedigo *et al* (1986) suggested expressing economic injury level in standard units of injury and distinguishing between injury and damage. They state "injury would be the effect of the pest (insect) on host physiology that is usually deleterious and damage as the measurable loss .... of yield quantity or quality or esthetics. Thus a certain level of injury may produce damage or yield loss".

This concept is incorporated into the development of a lygus evaluation technique in cotton which uses the probability of floral bud retention and the rate of insect feeding to determine if intervention should occur. Ferris suggested a similar approach in proposing nematode economic threshold equivalents, that is, the severity of damage a plant parasitic nematode could do relative to that of *Meloidogyne* spp. His dynamic model included geographic location, soil type, pest species and their densities, crop response, crop value, and control costs.

The economic threshold concept has had application in all pest disciplines. In weed science it is reviewed by Cousens (1987). In plant pathology, its application has been more common to soil borne diseases and is generally reviewed by Zadoks (1986). Within nematology, theoretical considerations (Ferris, 1985) and practical applications (Ferris *et al*, 1986) have been explored.

The degree to which an economic threshold is implemented depends on a number of factors including the ability to measure the pest population, the ability to develop relationships between pest densities and damage, and the ability to predict efficacy of control. These factors are the central issues which will be addressed in the remainder of this paper.

Estimating Populations

Depending on the pest organism, estimating its population can be direct (insects) or indirect (nematodes). With nematodes, it is important to know the extraction efficiency of the lab in order to interpret the numbers for damage estimates.

Plant pathogens in particular are difficult to estimate and often it is the disease which is monitored. Depending on the need, disease phenology, environmental parameters, or inoculurn level have been measured. Environmental parameters have been useful in the development of fungicide scheduling programs (Eversmeyer and Kramer, 1987) including late blight in potatoes, scab in apples, wheat leaf and stem rust in wheat. In the Netherlands, EPIPRE is a centralized decision-support program which utilizes disease incidence as part of its evaluation (Zadoks, 1985). However in general, the application of economic thresholds to plant diseases has been limited by the difficulty of monitoring and the ability of the pathogens to increase rapidly.

Limitations exist even when pest populations can be estimated. Ferris points out the importance of considering sample and experimental errors when developing economic thresholds. It is essential, when researchers determine economic thresholds, that the sample method used to estimate the population of pests under study can be related and calibrated to sampling tools used by field practitioners.

One aspect often overlooked in developing thresholds and evaluating pest populations is the ability of that population to inflict damage. Certainly the requirement for species identification plays a major role in distinguishing among similar species in a genera, such as root-knot nematode. However, in some cases, pests from different sources may have dramatically different feeding rates. If economic thresholds developed from specific populations (well fed or starved), the resulting damage relationship may apply to those specific conditions. This has been empirically observed in cotton with lygus bugs migrating from alfalfa and those migrating from drying/dying hosts. The latter were causing considerably more damage than those from alfalfa.

Estimating Damage

The heart of economic thresholds is the ability to relate damage per unit of pest. One approach to such relationships involves developing damage functions in which yield or commodity value is related to increasing pest density. In many situations it is desirable to describe the yield response in a normalized manner on a 0 to 1 scale. This removes the issue of productivity potential of an individual field and allows the damage function to be applied to any field.

Specific crop and pest situations lend themselves to this relationship more easily than others. Plant pathogens, when occurring in conditions conducive for epidemic outbreaks, can increase too rapidly for conventional economic threshold theory. Weeds provide another challenge to the application of economic thresholds. In-season loss estimates can be determined using competition studies. However, such studies do not take into account the multiyear impact of seed production, especially on subsequent crops. Weed scientists are examining thresholds which optimize the control costs and predict yield losses over several years (Auld *et al*, 1987). Ferris (1985) has examined tactics which optimize for multiyear management for root-knot nematode in annual and perennial crop systems.

One of the most perplexing problems in the application of economic thresholds is the problem of quality vs quantity losses. The discussion thus far has been about the latter, but many production systems are based on the former, including ornamentals and fresh and processing fruits and vegetables. In many cases, the pest density which can result in rejection of product or produce is nearly non-detectable, giving essentially a nonthreshold (Pedigo *et al,* 1986). In addition, determination of quality is subjective and, in some cases, governed by external market forces thus making such thresholds erratic (Zadoks, 1985).

Estimating Control Costs

One aspect of economic thresholds often overlooked by researchers is the component of control. The economists have considered control costs to be of great importance (Headley, 1972). Of particular interest is the optimum level of control to maximize return. Timing is another issue which should be addressed in economic thresholds. For example, the current level of 50% defoliation by leaf-feeding worms in cotton is the level beyond which production is impacted. However, this level of damage occurs after the worm population has reach a size which is much less susceptible to control by existing insecticides. Other control issues include degree of residual, specificity of controls, optimal level of control relative to preservation of beneficial organisms, and impact of pesticide on the plant itself.

Estimating External Costs

External costs of pest control actions are very difficult to estimate and usually are not considered in economic threshold development. Side effects of pesticide use are an example and include off-site pesticide drift, cost of environmental cleanup, and ground water contamination. The rate of pesticide resistance is an external cost which could have major implications for some pests. Economic thresholds which promote judicious use of pesticides can extend the useful life of products. The same argument could be made for host plant resistance as well. Another external consideration is human health and safety. While often considered outside the realm of pest control decision making, this issue is moving to the forefront.

Finally, the value to the producer of pest control insurance has not been adequately addressed (Antle, 1988). Risk aversion is a very personal issue and the degree to which one is willing to accept risk varies greatly among individuals.

Summary

Economic thresholds are the cornerstone of pest management. They provide a rational approach to pest control decisions. Their application and usefulness vary and is dependent on the commodity, the pest, and the status of the individual pest science. Economic thresholds are very practical tools and require a team approach in their development and application. From research to extension implementation to application by field practitioners, communication is essential for their successful development and acceptance.

References

1. Antle, J.M. 1988. Integrated Pest Management: it needs to recognize risks, too. Choices (3rd Quarter):811.

2. Auld, B.A., K.M. Menz, and C.A. Tisdell. 1987. Weed Control Economics. Academic Press, London. 177 pp.

3. Cousens, R. 1987. Theory and reality of weed control thresholds. Plant Protection Quarterly 2(l): 13-20.

4. Eversmeyer, M.G. and C.L. Kramer. 1987. Components and techniques of integrated pest management threshold determinations for aerial pathogens. Plant Disease 71:456-459.

5. Ferris, H. 1985. Population assessment and management strategies for plant-parasitic nematodes. Agric., Ecosystems, and Environ. 12:285-299.

6. Ferris, H., D.A. Ball, L.W. Beem, L.A. Gudmundson. 1986. Using nematode count data in crop management decisions. Calif. Agric. 40 (1&2):12-14.

7. Headley, J.C. 1972. Economics of agricultural pest control. Ann. Rev. Entomol. 17:273-286.

8. Mumford, J.D. and G.A. Norton. 1984. Economics and decision making in pest management. Ann. Rev. Entomol. 29:157-174.

9. Pedigo, L.P., S.H. Hutchins, and L.G. Higley. 1986. Economic injury levels in theory and practice. Ann. Rev. Entomol. 31:341-368.

10. Stem, V.M. 1973. Economic thresholds. Ann. Rev. Entomol. 18:259-280.

11. Stem, V.M., R.F. Smith, R. van den Bosch, and K.S. Hagen. 1959. The integration of chemical and biological control of the spotted alfalfa aphid. 'Me integrated control approach. Hilgardia, 29:81-101.

12. Zadoks, J.C. 1985. On the conceptual basis of crop loss assessment: The threshold theory. Ann. Rev. Phytopath. 24:455-473.

PREDICTION OF WIND SCAB IN PRUNE ORCHARDS AND PREDISPOSITION OF FRENCH PRUNE FRUITS TO POSTHARVEST FUNGAL DECAY BY RUSSET SCAB AND WIND SCAB

Themis J Michailides and David A Morgan, Dept. of Plant Pathology, U C. Berkeley/Kearney Agricultural Center

Introduction

In two commercial French prune orchards severe incidence of russet scab (RS), [which is an environmentally induced fruit disorder caused by high rainfall during bloom of prune trees (3)] and windscab (WS) (4) was associated with outbreaks of postharvest brown rot decay caused primarily by *Monilinia fructicola.* In addition, in two experimental prune orchards in Davis, California, wind-scabbed fruit showed high levels of decay caused by Phomopsis *cinerascens* and/or *Aspergillus melleus* and A. *ochraceous. To* determine whether RS or WS predispose French prune to postharvest decay and to understand the predisposition, we initiated a study in two experimental and one commercial prune orchard in northern California. Our objectives were:

1) Determine relationships of wind and wind scab incidence.

2) Determine relationships of wind scab before and after dehydration of fruits.

3) Determine if and why russet scab and wind scab predispose French prune to postharvest brown rot and Phomopsis decay.

Procedures

Effect of wind on l2rune fruits. To assess damage by WS, we collected six samples of 100 ripe prunes each on 6-20 September from the north or south side of three to six replicate trees in two rows in three orchards (1, 2, and 3) and evaluated them for incidence and severity of WS before and after dehydration. The percentage of fruit with decay initiated from wind bruises was recorded in samples collected from orchards 1 and 3. Wind parameters were retrieved (CIMIS Weather Service) for 1982 through 1991 from the weather station (Davis.A) which is adjacent to the experimental plots.

Relationship of WS before and after dehydration of fruits. To determine the relationship between symptoms of WS developed on mature fruit with symptoms after dehydration, samples of 50 prune fruits each were harvested from 24 trees not sprayed with chemicals or water and separated according to the size of wind abrasion into five severity categories, using a scale of 0 to 4: 0=healthy (no abrasions); 1=2-4 mm abrasions; 2=5-8 mm; 3=9-12 mm; and 4≥15 mm abrasions. After evaluation, samples were placed in plastic net bags, marked accordingly, and dried in a commercial dehydrator at 80 C for 18 hours. Using the same severity scale, the fruits were again evaluated for WS (incidence and severity) after dehydration. The experiment was repeated in a second prune orchard with samples of 100 mature prunes harvested from 41 trees selected at random.

Effects of RS and WS on postharvest brown rot decay. Prunes showing severe RS were harvested from an orchard next to the Sacramento River in Tehama County in 1991. Prunes having wind-scab lesions were collected from two orchards in Yolo County. After removing the stems, fruits were surface sterilized, allowed to dry on a laboratory bench, and stem ends were either left unsealed or sealed with melted paraffin. The prunes were then placed in plastic containers so that the wind-scabbed or russet-scabbed surface faced up. Fruits without WS or RS served as controls in these experiments. All fruits were inoculated by spraying them to run off with a suspension of about 50,000 spores/ml prepared from a culture of *M. fructicola* isolated from prunes. Four replicated plastic containers with 24 inoculated fruits each were covered with a plastic bag and incubated on a laboratory bench at 23 ± 2 C for 4 days when percentage of infected fruit was recorded.

Relationship of WS to *Phomopsis* decay. *Phomopsis cinerascens* was the fungus most commonly isolated from prunes decaying in the field. To determine whether WS predisposes fruit to infection by *P. cinerascenes,* healthy ripe and overripe fruits were collected as well as fruits with WS symptoms (severity 3 and 4) but without obvious decay. All fruits were surface sterilized, allowed to dry, placed over waxed wire screens in plastic containers (24 fruits per container), and inoculated by placing on the margins of wind-scabbed areas 40 µl of a 10^5 spores/ml suspension of *P. cinerascens.* Uninoculated fruit with WS and healthy unwounded, inoculated fruit served as controls. Three days after inoculation with *P. cinerascens*, fruit was used for scanning electron microscopy to determine the way spores of Phomopsis infect prune fruits. There were four replications for each experiment, which was repeated twice.

Effects of epicuticular wax and cuticle on infection of 12rune fruit *by Monilinia fructicola*. Healthy fruits were collected from the orchard in Tehama County on 26 June (immature fruit) and before harvest on 28 August 1990 (mature fruit), surface sterilized, and allowed to dry. Half of the fruit was dipped in chloroform for 10 sec to remove epicuticular wax and probably alter thickness of the fruit cuticle. Healthy fruit not dipped in chloroform served as controls. Fruits were placed in plastic containers and inoculated with 40 µl per fruit of a suspension of 20,000 spores/ml in 0.3% water-agar, so that inoculum drops did not roll off.

The importance of the cuticle in resistance to infection by *M. fructicola* also was tested with ripe 'Casselman' plums. Plums were harvested from an experimental orchard at the Kearney Agricultural Center and were prepared and inoculated similarly to the prunes. Infected fruits and diameter of lesions were recorded 3 and 5 days after inoculation.

Results and Discussion

Effects of winds on WS. There were 12, 10, and 12 north or northwest winds within 3 weeks after full bloom in 1984, 1988, and 1991, respectively. Speeds of the three strongest winds within 3 weeks after full bloom ranged from 20.9-27.4 km/hr for 1984, 24.1-30.6 km/hr for 1988, and 23.7-27.8 km/hr for 1991, with average wind speeds within these periods of 14.5, 15.3, and 16.6 km/hr, respectively.

Interestingly, only in 1984, 1988, and 1991 were the levels of WS high enough to attract our attention for measurements. The average incidence of WS was 14, 31-35, and 12% in 1984, 1988, and 1991, respectively. In 1982 and 1983, 1985-1987, and 1989 and 1990, WS was very sporadic (1-3%) and replicated counts were not made. In addition, the overall average levels of off-graded prunes (evaluated by commercial inspectors) were higher for 1984, 1988, and 1991 and WS was reported and included in these off-graded fruit. These results suggest that winds of >21 km/hr occurring within a 3-week period after full bloom can result in significant levels of WS of French prune.

That wind was the cause of WS in 1984, 1988, and 1991 is indicated by the results presented in Table 1. Both incidence and severity of WS were significantly higher on fruit samples collected from the north rather than the south side of the trees in all three orchards (Table 1). In addition, fruit harvested from the north side of trees showed significantly higher incidence of decay initiated from WS areas than fruit harvested from the south side in 1938 and 1991 (Table 1). Since strong winds prevailed in Davis, CA,, in the spring, fruit on the north side of trees were subjected to th(; force of prevailing north winds while fruit on the south side, protected by the canopy of the tree, received less force and developed less WS (Table 1). Young fruit are easily damaged, especially during the first 3 weeks after full bloom. More WS developed in years with 10-12 north or northwest winds, at least three of which reached speeds of >21 Km/hr.

Table 1. Incidence and severity of wind scab on French prune and percentage decay initiated from wind scab in three experimental orchards

			Wind scab (%)		Wind scab index[w]		
			Before	After	Before	After	Decayed
		Side of	dehy-	dehy-	dehy-	dehy-	fruit
Year	**Orchard**	**tree**	**dration**	**dration**	**dration**	**dration**	**(%)[x]**
1984	1	North	21.0 ay	21.3 a	0.36 a	0.41 a	ND[z]
		South	7.7 b	7.3 b	0.14 b	0.09 b	ND
1988	1	North	63.8 a	50.1 a	1.87 a	1.42 a	17.5 a
		South	19.2 b	12.3 b	0.35 b	0.27 b	4.3 b
1988	2	North	66.8 a	56.2 a	1.44 a	1.55 a	ND
		South	26.0 b	14.7 b	0.36 b	0.30 b	ND
1991	3	North	30.7 a	22.3 a	0.59 a	0.42 a	6.1 a
		South	5.7 b	1.7 b	0.09 b	0.02 b	1.1 b

[v] One hundred prunes each were collected from the north and south sides of three to six replicate trees in two rows on 6-20 September.

[w] Five (0, 1, 2, 3, and 4) wind scab severity categories were used, where 0 = fruit without wind scab and 4 = the most severe wind scab, based on area size (see text and Fig. 1).

[x] Only decay initiated from wind scab was recorded; (84-96% was caused by *Phomopsis cinerascens).*

[y] Numbers in each column followed by a different letter are significantly different according to a t-pairwise test (P = 0.05).

[z] ND = Not determined.

<u>Relationship of WS before and after dehydration.</u> In both experiments in 1988 the incidence and severity of WS of mature fruit correlated positively with the incidence and severity of WS after dehydration (Figs. 1 and 2).

<u>Predisposition of RS to postharvest decay.</u> A significantly (E<0.01) higher percentage (58.5%) of unwounded russet-scabbed fruit were infected after inoculation with M. fructicola than healthy fruit with sealed stems (30.3%) or healthy fruit with unsealed stems (33%). The higher levels of infection of russet-scabbed fruit can be explained by the lack of or the thinner cuticle of these fruits (Fig. 3A) in comparison with the thicker cuticle of healthy fruits (Fig. 3C).

(Figure is unavailable)

Figure 1. Relationship of incidence of wind scab of mature French prunes before dehydration with incidence of scab on prunes after dehydration *(r* significant at P < 0.001). (A) Orchard 1 and (B) Orchard 2.

(Figure is unavailable)

Figure I Relationship of wind scab severity on mature French prunes before dehydration with severity of scab of prunes after dehydration *(r* significant at P < 0.001).

<u>Relationship of WS to fungal deg&.</u> Ninety-eight to 100% of ripe and overripe healthy fruit wounded and inoculated with *Phomopsis cinerascens* decayed and 42-69% of unwounded healthy fruit were infected (Table 2). Significantly more overripe than ripe unwounded, inoculated fruits decayed from *Phomopsis* and significantly more inoculated fruits with WS

(81%) were infected than ripe or overripe, healthy, unwounded and inoculated fruit. About 41% of the uninoculated fruit with WS showed decay by *P. cinerascens* (Table 2). Scanning electron and thin section microscopy indicated that, although fruit cell layers of the affected areas were cutinized extensively (Fig. 3B), there were fractures in some areas which could facilitate fungal invasion. *P. cinerascens* can actively invade prune fruits, especially ripe or overripe fruits but not mature fruits.

Table 2. Infection of healthy ripe and overripe prunes and prunes with wind scab (WS) by a *Phomopsis cinerascens* (gray strain isolated from decaying prunes)

Condition of fruits[w]	**Treatment'**	**Fruit Infected (%)**[y]
Ripe	Fruit with WS/inoculated	81 a[z]
	Fruit with WS/uninoculated	41 b
Ripe	Healthy/wounded/inoculated	100 a
	Healthy/unwounded/inoculated	42 b
Overripe	Healthy/wounded/inoculated	98 a
	Healthy/unwounded/inoculated	69 b

[w] Ripe prune fruits were harvested on 16 September and overripe on 29 September.

[x] Four replications of 16 fruit each; the experiment was repeated twice. Uninoculated controls for ripe and overripe fruit (without WS) had 0% infection by P. *cinerascens sp.* and were not included in the ANOVA.

[y] Decay was obvious from the growth of the distinctly white mycelium of Phomopsis on the surface of the fruit.

[z] ANOVA indicated that overripe unwounded fruit was more susceptible to the fungus (F = 8.44; 1 df; P < 0.01).

When wind-scabbed fruit were inoculated with *M. fructicola*, 89% of them were infected and about 87% of the inoculated healthy prunes were infected, indicating that WS will favor pathogens that require wounds for infection but not so much infection by *M. fructicola*, which can infect unwounded, mature prunes. However, alterations of cuticle and epicuticular wax can affect the process of infection. Biggs and Northover (2) showed that sweet cherry cultivars with thicker outer epidermal cell wall required more time to become infected by *M. fructicola* than cultivars with thin outer epidermal cell walls. Similarly, *M. fructicola* infected more fruit with russet scab, probably because these fruits were lacking epicuticular wax and had thinner cuticle (3). Adaskaveg *et al*. (1) showed that genotypes of peach susceptible to brown rot have a thinner cuticle than resistant genotypes.

(Figure not available)

Figure 3. Cross sections of French prunes. A, With russet scab: epidermal cells lack cuticle or have a very thin cuticle. B, With wind scab: layers of periderm cells on the outer surface of fruit stained black with sudan IV show fractures of cutinized cells layers (arrow). C, Healthy tissues with well developed, thick cuticle stained with Sudan IV. (Bar = 50μm).

<u>Effects of removal of epicuticular wax and alteration of cuticle on infection of prune and plum by *M.* fructicola.</u> Incidence of infection of prunes by *M. fructicola* was not affected by the chloroform treatment; however, the diameter of developed lesions was significantly larger, indicating that infection of chloroform-treated prunes occurred faster than that of control fruits (Table 3). Chloroform affected plum infection by *M.* fiucticola, increasing both the incidence and the severity of infections of treated plums (Table 3). Although the differences decreased rapidly, they remained significant after five days incubation (Table 3).

Table 3. Effects of removal of epicuticular wax and cuticle on infection of prune and plum by *Monilinia fructicola* after three days at 23 ± 1 C

Fruit[a]	**Treatment**	**Incidence of infection (%)**	**Diameter of lesion (mm)**
Prune	Control	100	17.7
	Chloroform	100	26.7*[b]
Plum	Control	4.2 (7.5) [c]	5.0 (27.2)
	Chloroform	85.3* (100)*	14.7* (39.0)*

[a] Each experiment included 48 prunes and was repeated once.

[b] * indicates significant different from the control [*t* - pairwise test (P < 0.05)].

[c] After 5 days incubation.

Conclusions

The results of this study indicate that WS can create significant losses in some years, namely in those when wind speeds exceed 21 km/hr during the 3-week period after full bloom. Prune fruit may also suffer loss through the predisposition of wind-scabbed or russet-scabbed fruit to postharvest fungal decay caused by fungi such as *P. cinerascens* or *M. fructicola*. Penetration of fungi through the wind-scabbed areas is facilitated by the cracking of the epidermal, cutinized cell layers (Fig. 3B). More frequent infection of russet-scabbed prunes may be due to the absence of cuticle or the presence of a very thin cuticle on these fruits.

References

1. Adaskaveg, J. E. *et al.* 1991. Evaluation of the cuticle as a barrier to penetration by *Monilinia fructicola* in peach fruit. (Abstr.). Phytopathology 81:1150.

2. Biggs, A. R., and Northover, J. 1989. Association of sweet cherry epidermal characters with resistance to *Monilinia fructicola*. HortScience 24:126-127.

3. Michailides, T.J. 1991. Russeting and russet scab of prunes, an environmentally induced fruit disorder: Symptomatology, induction, and control. Plant Dis. 75:1114-1123.

4. Michailides, T.J. 1988. Control and induction of russet scab and wind bruise damage ("wind scab") of French prunes. Pages 94-104 in: Annu. Prune Res. Reports. California Prune Board, San Francisco.

ABSTRACTS

FIRST HAWAIIAN ENTOMOLOGICAL SOCIETY CONFERENCE, Honolulu, HI, October, 1991

<u>Manipulating populations of the predatory mite, *Euseius tularensis*, for improved control of citrus thrips, *Scirtothrips citri*</u>

E. E. Grafton-Cardwell, Y. Ouyang, S. Vehrs, U. C. Kearney Agricultural Center

The predatory mite, *Euseius tularensis*, is an important predator of citrus thrips in San Joaquin Valley, California citrus. However, its numbers are reduced by many broad spectrum organophosphorus and carbamate insecticides. The overall goal of our research program is to discover ways to manipulate natural populations of this abundant predator and so improve the level of control of citrus thrips it provides. Screening *E. tularensis* for their response to pesticides demonstrated that some populations of this species have developed moderate levels of resistance to the carbamates and organophosphates used for armored scale control (chlorpyrifos and carbaryl) and low levels of resistance to pesticides used for citrus thrips control (formetanate and dimethoate). The levels of resistance to the thripsicides are not high enough to prevent severe suppression of the predatory mites during thrips season. Thus, the resistant strain is still not compatible with a control program that depends on carbamates and organophosphates. However, the resistant strain may be useful for orchards that are moving from a broad spectrum pesticide program to a softer control program that depends on selective insecticides such as the botanicals sabadilla and ryania. A resistant strain of *E. tularensis* would easily survive the residues present from broad spectrum treatments applied the year before. Growers prefer to use broad spectrum pesticides for citrus thrips control because the level of control is more predictable and the residual effect greater.

Since this predatory mite feeds on pollen as well as citrus thrips, we are also experimenting with different levels of spring releases of pollen and predatory mites per tree to improve the overall density of predatory mites in citrus. Bioassays of commercial tree pollens indicate that *E. tularensis* reproduces well on apple pollen. We have also found various annual and perennial grasses that are good food sources for *E. tularensis* and could be grown as cover crops in or near citrus.

<u>Biology of *Chrysoperla comanche* (Banks): A Potential Biocontrol Agent</u>

Yuwei Zheng, Kent Daane, Kenneth Hagen, U. C. Keamey Agricultural Center

The developmental rates of egg, larva and pupa of *Chrysoperla comanche* (Banks) were determined at 15.6, 21.1, 26.7 and 32.3 OC. The relationship between temperature and the developmental rate is described with a sigmoid curve for each instar. The threshold temperatures of egg, first, second, and third instars, and pupal stages were 10.6, 12.9, 11.5, 10.3 and 11 *C, respectively, and their corresponding accumulated degree days were 73.5, 38.5, 37.4, 44.3 and 140.4. The weight of 3-day old cocoons was nonlinearly related to temperature, and the relationship described with the product of the average daily weight gained and the longevity of larvae (feeding stage) showed a domeshaped curve.

Larvae consumed an average of 302 fourth and fifth instar nymphs of the variegated grape leafhopper in 8.3 days of development. Adults produced an average of 1,108 eggs over their entire lives of 53.6 days, with 77.3% (857 eggs) of eggs produced in the first 30 days of reproductions.

<u>Augmentative Release of *Metaphycus helvolus* for Black Scale Control in Olive Orchards</u>

Kent Daane and Marco Barzman, U C Keamey Agricultural Center

Black scale, *Saissetia oleae*, is a sporadic yet damaging pest of olives. There is a large complex of natural enemies which attack the scale in California; however, due to the scale development pattern these parasites do not build up to numbers large enough to provide control. Augmentative release of *Metaphycus helvolus* was investigated as a control practice.

Release rates comparable to pesticide application costs were used in five central valley orchards in 1989 and 1990. Multiple and single releases were compared.

In three of the five orchards there was a significant reduction in black scale numbers in release plots. The greatest amount of parasitism occurred in the spring following fall releases. There was no difference between multiple and single releases, however, scale development patterns in 1989 may have favored single or late season releases. Results indicate that inoculative rather than inundative releases may be more efficient.

Augmentative Release of *Chrysoperla carnea* for Leafhoppgr Control in Grape Vineyards
Kent Daane and Yuwei Zheng, U. C Keamey Agricultural Center

The variegated leafhopper, *Erythroneura variabilis*, has become the dominant insect in California's central valley vineyards. To improve natural control, experiments were conducted to determine the potential of augmentative release programs with *Chrysoperla comanche* and *Chrysoperla carnea*. Feeding studies were done to determine prey consumption and develop release rates. Adult fecundity was determined to investigate nutritive quality of leathopper diet. Closed caged release studies and the monitoring of vineyards with and without commercial release of lacewings were conducted to determine field potential of augmentative releases.

C. comanche was found to be a voracious predator consuming over 250 forth and fifth instar variegated leafhopper nymphs over an average nine day development period. Adults produced over 1,000 eggs during their lifespan.

Closed caged studies found that C. *carnea* release rates, equivalent to commercial rates, significantly reduced variegated leafhopper populations. Seven vineyards, with 10,000 to 20,000 *C. carnea* released per acre, had significantly lower leafhopper populations than control vineyards.

A preliminary survey found five *Chrysoperla* species: *C. comanche, C. carnea, C. coloradensis, C. oculata*, and *C. nigricornis.* In release and non-release fields, *C. comanche* rather than C. *carnea* was the most common lacewing species. This implies a greater naturally occurring than augmented lacewing population and the great potential for *C. comanche* as the release species.

BELTWIDE COTTON PRODUCTION RESEARCH CONFERENCES, Nashville, TN, January, 1992

Plant Based Measurements for Lygus Bug Management Decisions in Cotton
P. B. Goodell, T A. Kerby, J. A. Young, and R E. Plant, U. C Kearney Agricultural Center

The current interest in plant mapping for agronomic decisions has led to the application of such data to lygus bug control. The method extends the current missing square technique for lygus control decisions from the early period of the fruit set into the entire fruiting period. By evaluating the number of missing squares and the current boll load, the impact of lygus feeding can be directly measured. Validation of the method has occurred over two years in a limited number of field situations and has proven to be as accurate as current evaluation methods but less laborious. Additionally, the cost of data collection can be amortized over several other production decisions.

Preliminary Results of a Two-Year Survey of Cotton Root-Knot Nematode in the San Joaquin Valley
P. B. Goodell. K E. Estil, and M Assemi, U. C Kearny Agricultural Center

Cotton fields in the San Joaquin Valley of California were sampled for *Meloidogyne incognita* using a proportional random sample based on the presence of a pink bollworm trap. The soil samples were bioassayed for the presence of root-knot nematode using a susceptible tomato cultivar. In 1990, 362 soil samples were taken from Kern, Kings, and Tulare Counties with 23.4% being infested with root-knot nematode. In 1991, 389 samples were taken from Fresno, Madera, and Merced Counties with 17.7% being infested. The overall average of 20.5% of soil samples with root-knot nematode supports distribution estimates for inferring crop loss.

ABSTRACT FROM 1991 CTFA PROGRESS REPORT

San Jose Scale Control and Its Effect on Peach Twig Borer and Mite Suppression

J. Dibble, S. Haire and S. Johnson, U C. Kearney Agricultural Center

San Jose Scale (SJS) is commonly treated in the dormant time of the year (December to February) but can also be controlled through spring and possibly summer sprays. Since control has been good to excellent when practiced during the dormant period, growers tend to prefer this application time. The farming pace is not only slower at this time of year but more importantly Peach twig borer and overwintering European red mite eggs can also be reduced by these winter sprays. Reports of poor control due to either chemical resistance, rate amounts or improper application do at times question the effectiveness of this application for a number of reasons.

Peach and plum orchard sites were obtained on the basis of an active SJS population. SJS is commonly found on all stone fruit trees and if neglected can cause branch and limb death. The orchards selected had a high population and a poor control record. Sprays starting in the dormant period (the ideal control time) were made to evaluate materials, spray gallonages and speed of sprayer travel as well as time of application.

One test evaluated the commonly used materials applied in dormant spray and combined with oil. Orchex 796, a narrow range base stock oil was used as the standard with most of the materials. Most of the combinations were applied both as high and low volume sprays (400 vs 40 gpa) as well as on trees having a heavy vs. a medium SJS population. In addition, a dormant only treatment was compared to a dormant plus a spring treatment. The materials used were diazinon 2 lbs., Lorsban 2 lbs., Imidan 2 lbs., Dibrom 3 lbs., and Supracide 1 & 2 lbs., each with two different rates of oil except Supracide. There was no significant difference between the materials as applied, high volume (dilute) vs. low volume (concentrate). There was, however, some real difference as to the degree of control between the heavy and medium infested orchards. Generally, the double treatment gave only a slightly better control than the dormant only spray.

Timing of SJS control treatments seems to continually be of interest. Results are usually not too dramatic as long as good application practices are observed - a proper chemical and rate is used along with correct timing. As the season progresses timing becomes more difficult regardless of whether determination is made by properly observed crawlers on sticky tape or degree days and male scale activity. It is difficult to improve on the time and target opportunity of the dormant period. This test was to show relative scale control as obtained from a dormant, dormant plus spring, spring, and spring plus summer sprays. This trial was also run on both peaches and plums and the percent control relates to that population found in the untreated check. The two early sprays showed a significant effect on Peach twig borer and little to very little on the Pacific (summer) mite. Although SJS can be knocked down with spring and summer applications, these timings are not as effective as the dormant and dormant plus spring. The same is true of PTB. Pacific mite is more susceptible to the latter oil sprays simply because they are active and exposed at that time.

Another dormant trial was set up to show SJS control on both peaches and plums as a result of speed and nozzling. When 2.5 mph in dilute and 2 mph in concentrate is exceeded control goes down. Improper nozzling can also have an effect on control. Where 2/3 of the spray comes out of the nozzles on the top half of the spray manifold and 1/3 out of the nozzles on the bottom, better control is obtained than having all the same size nozzles from the top of the manifold to the bottom that discharge the same amount of spray from each nozzle. An arrangement such as the latter does not take into account the configuration or density of the tree or the different distances of travel required by a certain percentage of the spray droplets. The 2/3-1/3 pattern allows for better coverage and consequently control.

Editors wish to thank JoAnn Coviello for newsletter preparation.