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

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ARTICLES

MATING DISRUPTION OF PEACH TWIG BORER, *ANARSIA LINEA TELL4* ZELLER: PROGRESS AND PROBLEMS

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Abstract

Field trials for efficacy of mating disruption of the peach twig borer (PTB), *Anarsia lineatella,* have been conducted in the San Joaquin Valley of California since 1989. Trials have been variously placed in orchards of 0.5 to 2.0 ha in nectarines, peaches, apricots, prunes, and almonds. Pheromone dispensers were manufactured by AgriSense, Inc., Fresno, CA, BASF, Ludwigshafen, Germany; and Consep Membranes, Bend OR. Dispenser design and load rates have varied with each manufacturer, but pheromones in all disruption dispensers have been a two-isomer blend of E5-10:Ac and E5-10:OH. Reexamination of pheromone components produced by virgin female PTB (Dr. Jocelyn Millar, UC Riverside) has shown that the original identifications by Roelofs in 1975 are essentially correct; the minor additional components identified by Millar add no significant improvement to pheromone trap catches. Field longevity of the various pheromone dispensers under central California weather conditions ranged from approximately 50 days to 75 days regardless of load rate. Control of PT`B in the

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various host crops through mating disruption has generally been good, with early season cultivars showing the least damage compared to untreated checks, while mid- and late-season maturing cultivars experience increasingly heavy damage, some unacceptably high. Long-term control of M by mating disruption will probably require at least two applications of pheromone per season.

Introduction

The peach twig borer, *Anarsia lineatella* Zeller (PTB), is a pest of stone fruits and almonds in many parts of the world. Although it occurs throughout the deciduous fruit growing areas of North America, it is a major pest in commercial orchards only in California. It occasionally reaches pest status in southern Washington peach orchards near Yakima. The standard control program for peach twig borer in the western United States has been annual dormant applications of organophosphate insecticides and oil, which also controls San Jose scale, *Parthenolecanium* spp., and mite and aphid eggs.

A preliminary trial using pheromones for mating disruption of PT`B was carried out near Parlier, CA in 1986 to evaluate alternative controls for PTB in lieu of in-season pesticide sprays. The pheromone dispensers used in this trial were Shin-Etsu ropes containing mixed peach twig borer pheromone and oriental fruit moth pheromone in their normal isomeric ratios. The results of this initial field test were very encouraging, with the pheromone treated block sustaining 1.5% PTB damage while the nearby untreated check had 31.7% twig borer infested fruit. In spite of this initial success, it was determined that the standard control program using organophosphate insecticides and oil in the winter was still more economical than pheromones for PTB control, and at that time the potential market for M mating disruption was still considered too small for development. Consequently, no further trials for mating disruption of peach twig borer were conducted until 1989. By that time dormant sprays had come under increasing scrutiny and criticism due to drift of spray in winter fog onto non-target crops (primarily winter vegetables), and possible toxic effects on raptors and other types of birds, thus leading to a renewed interest in the efficacy and potential use of pheromones for control of PTB.

Pheromone Dispensers

The pheromone dispensers used for FITB mating disruption efficacy trials in 1989 were manufactured by AgriSense Co., Fresno, CA. These dispensers contained a nominal load of 250 mg ai of the standard, two-component PTB pheromone blend [(E)-5-decenol and (E)-5-decenyl acetate (15:85)] in a polymer get substrate. The AgriSense dispensers were projected for a three-month field life, and were applied at 500 dispensers per ha. Release rate studies in the field soon showed that these dispensers did not uniformly release pheromone over a three-month period, but were expended in 50-70 days due to cracking and disintegration of the gel substrate, thus exposing a greater surface area for release of the pheromone along with some loss of gel particles from the dispenser. Laboratory work on pheromone release rates from these dispensers had also shown that a maximum of 86% of the initial pheromone load would be released; field-exposed dispensers lost ca. 60 percent of the pheromone after 35 days of field exposure and 80 percent after 63 days.

The results of the trials for PTB mating disruption in 1989 (Table 1) were erratic, probably due to the relatively short and non-uniform release rate of the pheromone from the AgriSense dispensers. Fresh dispensers were not available for the planned second field application in mid-June. However, the results were encouraging enough to warrant continued work on PTB mating disruption in the following years. Because of the problems with the AgriSense dispensers and the obvious need to reformulate this particular pheromone release system, the manufacturer declined to continue working with PTB mating disruption in 1990.

In 1990 and 1991, mating disruption of PT`B was continued using a standard BASF double-ampule dispenser (RAK® 5-6) containing both peach twig borer and oriental fruit moth pheromones. This dispenser (already registered in Europe) was applied in both years at 500 dispensers per ha.. As in 1989, the BASF dispensers were applied only once each year at the beginning of the first PTB flight in April. The results of M mating disruption using the BASF dispensers also showed good control of PTB in most field trials (Table 1). However, it became obvious that single applications of any pheromone dispenser in the hot Central Valley of California could not sustain pheromone releases through the entire growing season as shown in the data for Fairtime peach (Table 1). None of the dispensers have been capable of releasing sufficient pheromone with single applications over the required five-month period (three PTB generations) to provide adequate disruption into the late maturing cultivars. The results of the trials for disruption of FM in 1990 and 1991 were also encouraging, particularly in view of the ambiguous results observed with the AgriSense dispensers in 1989.

Due to persistent problems in obtaining the BASF RAK® 5-6 OFM/PTB pheromone dispensers in North America, it was decided to continue the PTB mating disruption program in 1992 using pheromone dispensers manufactured by Consep Membranes Inc., Bend, Oregon, U.S.A. These dispensers were loaded with 100 mg of PTB pheromone and applied at 500 dispensers per ha. Field release rate studies with these dispensers in 1991 had shown that they were essentially depleted of pheromone after 60 days. Consequently, two applications of these dispensers were made in the field efficacy trials in 1992.

As in previous years, the first fruit harvested in May had relatively low levels of infestation in both the pheromone treated blocks and in the untreated checks (Table 2). As the harvests progressed into June, infested fruit in the checks generally increased, while the pheromone treatments held infestations to acceptable levels. One significant failure in PTB control occurred in the 1.6 ha apricot orchard harvested July 1, 1992. This organically-managed orchard (without fungicides) sustained severe crop losses to brown rot fungus *(Monilinia* spp.) in the three weeks prior to harvest, which greatly increased the PTB pressure on the remaining fruit and probably contributed to an increase in PTB infested fruit.

Differences in PTB infestations between pheromone treated blocks and untreated checks tended to lessen as the season progressed into late July, but orchards that had been under PTB mating disruption for several successive years generally maintained good control.

Reevaluation of Peach Twig Borer Pheromone Isomers

Comparisons of PTB pheromone trapping data from several researchers at the Kearney Agricultural Center in the spring of 1990 showed considerable variation and discrepancies in trap numbers that could not be explained through weather or known population densities. As a result of these comparisons, a research project was established with Dr. Jocelyn Millar at the UC Riverside to reevaluate and examine the components of natural peach twig borer pheromone produced by virgin female moths and also to identify the reasons for the extreme variations in PTB trap counts observed in 1989 and 1990. Dr. Millar has identified several minor constituents in extracts of female PTB pheromone glands as decyl acetate, (E)- and (Z)-4-decenyl acetate and (E,E)- and (Z,E)-decadienyl acetate. Decyl acetate and (E)-4-decenyl acetate were also identified in effluvia from live female moths. None of these identified compounds enhanced the attractiveness of the standard blend of (E)-5-decenol and (E)-5-decenyl acetate (20:80) in field tests (Table 3). However, the analogous compounds (E)-6-decenyl acetate and (Z)-6-decenyl acetate were identified as behavioral antagonists and suppressed trap captures (Table 4). The contents of a variety of commercial pheromone lures and mating disruption devices were analyzed and one batch of lures which had performed very poorly in field tests was found to contain the inhibitory compound (E)-6-decenyl acetate.

Summary

The results of field trials for mating disruption of *Anarsia lineatella* using several types of pheromone dispensers containing the standard two-component blend of PTB pheromone have shown promise as an acceptable commercial control for PTB in California. The problems with use of dormant spray programs for control of PTB continue and are increasing, leading to greater interest on the part of growers and pest managers for this technology. Inherent problems, particularly in logistics and application, associated with use of point source or hand-applied pheromone dispensers include the cost of the pheromone for two applications per season, with a minimum of 120 grams ai per ha per season, which may be prohibitive in the short term. Also, hand application of pheromone dispensers in the upper one-third of stone fruit tree canopies 5-6 m high exacerbate difficulty of application, while hand application of dispensers to almond trees 7-9 m high becomes almost a physical impossibility. In spite of these difficulties, however, growers and pest control advisors continue to support the concept of mating disruption for peach twig borer in a variety of California crops and it is anticipated that a registered commercial product will be available for application in California by 1994.

Table 1. Efficacy of peach twig borer mating distribution pheromone treatments applied to various cultivars, Parlier, CA, 1989-91.

Cultivar		PTB % infested 1989	1990	1991
Red Diamond (n)	Phero[1]	0.6	0.1	0.0
	Check	0.4	0.2	0.0
Elegant Lady I (p)	Phero	3.1	1.0	2.4
	Check	3.2	2.5	3.4
Elegant Lady H (p)	Phero	-	-	10.5
	Check	-	-	51.3
Fantasia (n)	Phero	1.2	0.2	0.7
	Check	6.9	6.4	29.6
Fay Elberta (p)	Phero	8.0	-	5.6
	Check	26.3	-	47.3
Fairtime (p)	Phero	2.0	5.0	6.6
	Check	3.3	11.0	8.8

[1]AgriSense PTB dispensers used in 1989; BASF RAK® 5-6 OFM/PTB dispensers in 1990 and 1991. (n)=nectarine;
(p)=peach

Table 2. Field trials for mating disruption of peach twig borer, *Anarsia lineatella*, in central California stone fruits; 1992.

Cultivar		Harvest Date	Plot Size (ha)	Years-MD	% infested
May Glo (n)	Phero	5/19	0.8	1	0.2
	Check				0.4
Sparkling May (n)	Phero	6/2	0.8	1	0.2
	Check				5.2
Blenheim (a)	Phero	6/10	0.8	4	0.2
	Check				8.4
Red Diamond (n)	Phero,	6/22	0.8	4	0.8
	Check				11.6
Babcock (p)	Phero	6/29	1.6	3	0.3
	Check				0.4
Blenheim (a)	Phero	7/1	1.6	1	21.5
	Check				12.6
Elegant Lady (p)	Phero I	7/6	0.8	4	1.3
	Phero II		1.0	1	5.3
	Check				23.2
Fay Elberta (p)	Phero	7/22	0.5	4	3.7
	Check				39.2
O'Henry (p)	Phero	7/25	0.8	3	0.8
	Check				1.6
French (prune)	Phero	7/27	1.2	1	1.3
	Check				5.5
Dr. Davis (p)	Phero	7/30	2.0	1	2.6
	B.t. Ck.				3.3
Nonpareil (al)	Phero	7/29	2.0	1	13.4
	Check				19.4
Starn (p)	Phero	8/10	2.0	2	0.4
	B.t. Ck.				1.2
Fairtime (p)	Phero	8/18	0.8	4	9.2
	Check				29.2

1 1st applications Feb. 24-27; 2nd applications May 18-26. Consep pheromone dispensers applied @ 500/ha in all tests except BASF in French prunes and almonds. (n) = nectarine; (a) = apricot; (p) = peach; (al) = almond.

Table 3. Comparison of PTB catches in traps baited with the PTB pheromones standard blend vs. the standard blend + minor components.

Host Crop	Lure[1]	Trap Catches (males) Mean'
3		
Almond	Standard Blend	729 a
	Std Blend + Minor Comp.[2]	723 a
Plum	Standard Blend	340 a
	Std Blend + Minor Comp.	
Peach	Standard Blend	96.2 a
	Std Blend + Minor Coml2.	72.5 a

[1,3] Standard blend, E5-10:Ac (400 µg) + E5-10:OH (100 µg).
Six replicates per treatment, traps counted 3 times.
[2] Minor components, E4-10:Ac (5 pg), Z4-10:Ac (5 µg), 10:Ac (20 µg). Z3,E5-10:Ac (5 µg), E3,E5-10:Ac (10 µg).

Table 4. Field bioassay in almonds of standard peach twig borer pheromone blend and potential inhibitors. Caruthers, CA, 1990.

	Attractant	Total No. PTB Collected'
1	Standard PT13 pheromone	7235 a 2
2	Standard + 20 pg E-6 Ac.	1207 c
3	Standard + 100 pg E-6 Ac.	496d
4	Standard + 20 pg Z-6 Ac.	6702 a b
5	Standard + 100 tLg Z-6 Ac.	6095 b
6	Blank septa	97 e

[1] 4 traps (reps) per treatment; 8 counts from Oct. 3-22, 1990.

[2] Data transformed to $\sqrt{x} + .5$. Numbers followed by different letters are different at 0.05 according Duncan's Multiple Range Test.

COVER CROPS AND NEMATODE SPECIES

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The ground cover growing between rows of tree and vine crops is referred to as a cover crop or occasionally as a companion crop. At maturity the cover crop may be mowed and left as stubble or incorporated into the soil as a green manure. In this study we focused on the host status of the cover crop to nematodes, in order to avoid those cover crops which build nematode populations in preference to those providing relief from nematodes. The final process of handling the cover crop and its impact on nematodes and grapevines will be discussed elsewhere.

Each cover crop is going to have its own pest and disease problems. Because of this, our philosophy has been that after two or three years of a single cover crop one should be considering an alternative ground cover. For these reasons, we have been looking for a series of cover crops or perhaps cover crop mixes which were poor hosts of nematodes that might be present in orchards and vineyards of the San Joaquin Valley.

Nineteen cover crops were evaluated for their influence on growth of one-year-old grapevines in the presence or absence of a diversity of nematode species. In the absence of nematodes, some cover crops were poor companions and significantly reduced grapevine growth. In the presence of various nematode species, some good companion crops become poor companion crops. In situations of relatively poor soil tilth, cover crops tended to be a good companions to grapevines. The reproductive success of nematodes on grapevines was frequently reduced if a mediocre or poor nematode host was utilized as a cover crop. In some situations this occurred even in the presence of an excellent host as a cover crop. Cover crops evaluated included summer, winter, and permanent grown selections. Three winter cover crops which were good companions to young grapevines, and non-threatening relative to nematode build-up, included Cahaba White Vetch, Barley, and Blando bromegrass. Cover crops that were antagonistic to the growth of young grapevines included Marigold, Nimblewill, and volunteer weeds. Allelochemicals are suggested as the source of antagonistic effects. Sudan Grass should receive field evaluation as an antagonistic rotation crop for populations of *Criconemella xenoplax* and *Pratylenchus vulnus.* Barley should receive field evaluation as a potential cover crop to reduce populations of *P. vulnus.* Blando bromegrass should receive field evaluation as a potential cover crop to reduce populations of *Tylenchulus semipenetrans. Meloidogyne incognita* Race 3 was hosted by all 19 of the cover crops evaluated. Characteristics of the 19 cover crops are cataloged below.

<u>Cahaba White Vetch</u>, *Vicia sativa* x *Vicia cordata,* proved to be a good companion crop among young grapevines regardless of the nematode species present. It is an excellent host for *Meloidogyne hapla*. *Paratylenchus hamatus,* which is normally an ectoparasite, was found within vetch roots at high population levels. *P. vulnus* was present within its roots but no eggs were ever found within and *P. vulnus* population increases did not occur in its presence. Because *M. hapla* and *P. hamatus* are not damaging to central California vines or trees, unless they reach exceptionally high population levels, we consider this vetch to be our preferred legume as a cover crop. A single concern about this cover is it use in orchard sites where *C. xenoplax* can reach high population levels.

In our root observations on Cahaba White Vetch we detected galls only on the periphery of the root system when grown in the presence of *Meloidogyne javanica.* This led us to believe that the vetch had potential to be a good trap crop for *M. javanica.*

Under California conditions the vetch should be planted to irrigated soil by October 1 and will reach a few to 15 cm height by December. Eighty percent of its biomass is produced in the months of April and May. It flowers in May and is lying prostrate by June. It provides a good habitat for mites, *Tetranychus spp.,* and can supply the nitrogen requirements for a vineyard. This vetch is susceptible to *Sclerotinia trifoliorum* when planted in the same site year after year. This vetch can be mowed low to the ground during March to early April as a method of spring frost protection in vineyards.

<u>Columbia Barley</u>, *Hordeum vulgare,* is a good companion to young grapevines regardless of nematode species present. It is a good host of *M. javanica* and *P. hamatus.* We are generally unconcerned about *P. hamatus* and *Meloidogyne* spp. would not build-up as long as the barley is planted and tilled under at times when soil temperatures are below 20'C (mid-October to mid-April in Fresno, CA). Barley grows relatively well during winter months and can be tilled under by March to avoid frost damage in vineyard settings. Barley is perhaps the least expensive cover crop selection and will grow well in combinations with less upright covers such as vetches. Of particular interest has been the ability of barley to markedly reduce populations of *P. vulnus* in these microplot tests. Field evaluations are underway in walnut *(Juglans sp.)* orchards where *P. vulnus* is a serious pest.

<u>Blando Bromegrass</u>, *Bromus mollis*, is a low growing grass which we find to be a good companion among grape roots. It also is a non-host or poor host for any nematodes which occur in our orchards and vineyards. It appears to be antagonistic to the development of citrus nematode populations, however, field testing is needed. This grass planted in the fall months can be kept green into June and is manageable with mowing. The grass refuse is readily decomposed and has not posed a problem for the harvesting operations of almonds or raisins.

<u>Hubam Sweet White Clover</u>, *Melilotus alba,* is an upright-growing, winter cover that can grow more than 1 m in height by mid-May and is high yielding in nitrogen. It is an excellent host for M. *hapla* and can host *Meloidogyne incognita* which may penetrate as soil temperatures climb above 20^{o}C. This cover is a good companion in vineyards without root knot nematodes or in orchards on 'nemaguard' rootstock. This legume is also highly susceptible to Sclerotinia rot under moist conditions.

Salina Strawberry Clover, *Trifolium fragiferum,* did not host *Meloidogyne* spp. we tested it against except *M. hapla,* where it was a poorer host than most legumes. This clover is not the best companion crop next to young grapevines, but it could be a useful legume during occasional years where *M hapla* populations may be building too high.

Oats, *Avena fatua,* as a cover crop hosted three of the four *Meloidogyne* spp. we screened. It provides a relatively large biomass of organic matter, but is ranked as an antagonistic companion.

Volunteer Winter Weeds are probably the most common winter cover for orchards and vineyards. The weeds included *Lactuca serriola, Calandrinia ciliata, Sonchus oleraceus, Heterotheca grandifiora, Poa annua,* and *Stellaria media.* This combination of weeds provided a good to excellent host for such species of *Meloidogyne* tested. Vine growth was reduced in the presence of winter weeds whether or not nematodes were present. Vines growing in the presence of *M hapla* and weeds grew significantly better than those in the presence of *M incognita* and weeds. Vine damage occurred while reproduction of *M hapla* was 10-fold greater than that of *M. incognita* on the weeds. Broadleaf plants are among the best hosts for *Meloidogyne* spp. They should be turned under or controlled before soil temperatures reach 20°C. We rank weeds as antagonistic companions adjacent to young February-planted grapevines. In these tests, the weeds were removed by early April with hand hoeing.

Volunteer Summer and Winter Weeds tended to result in a grassier cover than did winter weeds only. This cover was also antagonistic to the development of young grapevines although weeds were not permitted to shade young vines.

Chewings Red Fescue and Elka Perennial Rye, *Festuca rubra* and *Lolium perenna,* a combination mix, forms a permanent sod but after 2 or 3 years in a field setting this low growing sod can become heavily weeded. We found this sod without weeds to be a reasonably good companion but there were a few examples where it became antagonistic. It is a poor host to most nematode species that occur in a vineyard except that it appears to host *Xiphinema index..* Longer-term studies will be needed for confirmation but we cannot recommend such a cover where the Grape Fan Leaf Virus or *X. index* are known to occur.

Sudan Grass, *Sorghum halepense,* is a cover grown during spring, summer, and fall which produces high biomass, requires repetitive mowing, depletes nitrogen from soil, and generally reduces vigor of accompanying grapevines. It is used for the purpose of pulling down nitrogen levels in vineyards where the nutrient is in excess. It appears to be a good host for *M. incognita, M. javanica,* and *M. arenaria.*

Magnolia Cowpea, *Vigna sinensis,* was evaluated as a summer cover because of its reported resistance to *M. incognita* and *M. javanica.* It appeared to be an excellent host for an *M. javanica* population common to central California vineyards. It also hosted *P. vulnus.* Cowpea was only a good companion to the grapevine in the absence of *M. javanica* or *P. vulnus.* The Cowpea aphid, *Aphis craccivora* Koch, was prevalent on this cover in the early summer. It should not be used as a cover crop for trees and vines of central California.

California Poppy, *Escholzia papaver,* is a native low growing, re-seeding plant which, in a solid planting, is antagonistic to weed growth. In a laboratory screening we had found extracts of it to possess nematicidal properties. These data show poppy to be a host for all *Meloidogyne* spp. and in their presence it is an antagonistic companion. Its extracts were phytotoxic to treated perennials (unpublished results, McKenry).

Buckwheat, *Eriegonium fasiculatum,* hosted all eight of the nematode species we tested on it. In our trials it was damaged by the aphid *Aphis craccipora* Koch and the associated ant *Tetramorium caespitum* L. The ants girdled the Buckwheat plants, making re-seeding necessary. The plant may be somewhat antagonistic but should not be considered as a cover crop for central California, unless it is to be turned under within 70 days.

Esperance Subclover, *Trifolium subterraneum,* is attractive as a potential cover crop because it is a low-growing legume for the summer period. In every case, this cover was a good companion to the adjacent grapevine but it hosted seven of the eight nematode species we tested. As the nematodes multiplied on the cover they also tended to increase on the adjacent grapevine.

Berber Orchardgrass, *Dactylis glomerata,* has been recommended as a tool to slow soil erosion in sloping vineyards and orchards. We found it to be antagonistic to grapevines without nematodes and also in the presence of *M. javanica.* Although it was a poor host for *M. hapla* it was a good host for the other vine-damaging *Meloidogyne* spp. Root galling consisted of root swelling which was not readily visible.

Black Eyed Susans, *Rudbeckia hirta,* have been reported to possess thiarubrina (a nematicidal agent previously shown to be effective against *M. incognita).* In the absence of nematode feeding, the plant was not antagonistic to the grapevine. In the presence of nematode feeding it became antagonistic. This plant is one of the few summer covers to be a poor host to *Meloidogyne* spp. which occur in vineyards and orchards. It is worthy of further testing in the row centers as a suitable host plant for rearing insect predators.

'Nematode' Marigold, *Tagetes patula,* has been reported to be a nematode trap crop as well as a source of terthienyl compounds which are suppressive to nematode populations. We find marigold to be a very antagonistic companion crop. It is a host for mites, *Tetranychus urticae* Koch, and white fly, *Trialeurodes* sp., and it can build populations of *M. hapla* and *M. incognita.* The refuse of Nemagold when placed around established trees for several years can reduce yields of the trees. Marigold culture in an established vineyard or orchard is difficult to maintain because of competition from volunteer grassy weeds. Marigold appeared to be a trap crop for *M. javanica* in that short-lived galls were formed on marigold roots in the presence of *M javanica.* Marigold growth was significantly reduced in the presence of *M. javanica.*

Nimblewill, *Muhlenbergia schrebari*, in appearance is very much like a rhizomeless Bermuda Grass, *Cynodon dactylon* (L) Pers. It was tested because it has been recommended as suppressive to *P. vulnus* and perhaps *C. xenoplax* populations in southeastern U.S. orchards. The grass is an antagonistic companion in the absence of nematodes and a good host for *M. javanica.*

Sesbani, *Sesbania exaltata*, was not a very antagonistic companion except that it grew 3 meters tall and attracted Grape Leaf Skeletonizer, *Harrisina americana* Guerin. It also hosted all species of *Meloidogyne.* It has been recommended for control of Pecan Aphid, *Monelliopsis pecanis* Bissell, in Pecan orchards. Pecans are not highly affected by nematodes. Mowing of this sparse, stemmy plant would be a necessity.

Conclusions

1. Nematode species which are hosted by one plant species can build-up and attack roots of other plant species in the proximity.

2. Adjacent plants can impart significant negative and positive effects upon each other, and these effects can be exacerbated by nematode feeding.

3. Due to a myriad of plant and plant-pest interactions, any cover cropping adjacent to perennial crop schemes should involve a rotation of cover crops.

4. Selection of cover crops should take into account the neighborliness of the cover in the presence or absence of nematodes. Nematode reproduction will be a poor predictor for selection of the best companions, but is an important factor in the final selection process.

5. Soils in good tilth may not show the benefits of a cover crop as much as those of poor structure and tilth. However, to develop or maintain a soil in good tilth appears to require organic input.

6. Nematode populations associated with roots of a perennial crop may be less successful in maintaining their populations in the presence of a cover crop.

7. Cover crops for tree and vine crops are basically grown in the areas where the water and equipment are utilized and not where the roots of the perennial crop are most abundant. Therefore, any antagonistic or beneficial effects relative to nematode populations or vine growth may take several years to become noticeable, unless in some way delivered to the site where vine roots are most prevalent. We refer to this mechanical process as handling of a cover crop, a separate issue from this discussion of selection of a cover crop.

8. We have identified 3 winter cover crops which, when used in a reasonable rotation, will not result in nematode increases except for those sites involving ring nematode. These include: Columbia barley, Blando bromegrass and Cahaba white vetch.

9. Several cover crops have been identified as being poor choices, including Marigold, Nimblewill, and volunteer weeds.

10. Several plants have been identified as having potential antagonistic effects on nematodes including:

Sudan Grass against *C. xenoplax* and *A vulnus*, preferably as a rotation crop with no perennials in place; *Rudbeckia* as a potential rotation crop against a wide selection of *Meloidogyne* spp.; barley as a cover crop potentially antagonistic to *P. vulnus* in established orchards and vineyards; and Blando bromegrass cover crop as a potential antagonist of T *semipenetrans* in established orchards and vineyards.

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COMBINING LEAF REMOVAL AND FUNGICIDES TO MANAGE GRAPE POWDERY MILDEW IN THE SAN JOAQUIN VALLEY

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Introduction

Powdery mildew, caused by the fungus *Uncinula necator* [Buff (Schw.)], is probably the most damaging disease of wine grapes in California. It occurs in every climatic growing region in the State, and most producers regularly apply fungicides including dust, lime, and wettable sulfur formulations; and/or ergosterol biosynthesis inhibitors (EBI's) to prevent its occurrence (2).

In recent years, canopy management by leaf removal has been shown to provide economic management of bunch rots and some insect pests (3-5,6). Chellemi and Marois (1) indicated that the practice of leaf removal significantly reduced the incidence and severity of powdery mildew in the coastal Napa Valley. This study was designed to determine if leaf removal could provide control of powdery mildew in the San Joaquin Valley. The question as to whether leaf removal might reduce the quantity of fungicide needed to prevent the disease was also addressed.

Materials and Methods

Five field experiments were done in commercial winegrape vineyards in the San Joaquin Valley during 1989-1991. Three were located near Madera, in the central part of the Valley, and the other two were near Lodi, in the northern Valley:

<u>Powdery mildew control and harvestable yield.</u>

Madera - 1989. A 2 x 2 factorial experiment to evaluate the effects of leaf removal and a conventional spray program for management of powdery mildew in the San Joaquin Valley was done in Madera. The 'Carignane' vineyard was bilateral cordon-trained, spur pruned. Rows were oriented in a north-south direction. Treatments included leaf removal (both sides of the vines), the grower's spray program, leaf removal plus the spray program, and a nontreated control. Eight replications of 12 vines were used.

Lodi - 1989. The experimental site was a head-trained, spur-pruned 'Carignane' vineyard with a history of powdery mildew. A 2 x 2 factorial experiment was designed, with leaf removal as the mainplot, and a wettable sulfur application at budbreak the subplot. Eight replications of 6 vines were used for each of the 12 treatments.

Madera - 1990. The experimental procedure of 1989 was repeated in another 'Carignane' vineyard with a history of severe powdery mildew problems. Cultural conditions were identical to those in 1989, except rows were oriented in an east-west direction.

Lodi - 1990. A similar factorial experiment was done in a 'Chardonnay' vineyard with rows oriented north-south. Leaves were removed only from the east side of vines.

Madera - 1991. The experiment was done as in 1989 except that three levels of fungicide dose was used 100, 50, and 0% of the normal grower practice. Leaves were removed only from the southeast side of vines to allow for protection from sunburn.

Powdery mildew disease data were expressed as percent incidence and severity at all locations. Data were arcsin-transformed prior to statistical analysis by factorial analysis of variance.

Results

<u>Powdery mildew control and harvestable yield.</u>

Madera - 1989. Leaf removal and the grower's fungicide program each were highly significant in reducing incidence and severity of powdery mildew in the 'Carignane' vineyard at both rating times (Table 1). Leaf removal alone reduced incidence and severity over the nontreated control treatment by 75% and 65%, respectively; while the fungicide program reduced the same disease parameters by 94% and 68%. Total grape yield was significantly reduced 6-7% by leaf removal.

Lodi - 1989. Leaf removal on the head-trained 'Carignane' vines did not result in significantly reduced powdery mildew. However, the grower's fungicide program was successful in reducing incidence and severity of powdery mildew by 89% and 85%, respectively. No significant effect of either treatment on yield was found.

Madera - 1990. Leaf removal in a 'Carignane' vineyard with a history of more severe mildew than the one used in 1989 did not have a significant effect on the two disease parameters. The grower's fungicide program, with or without leaf removal, was highly significant in reducing incidence and severity of powdery mildew.

Lodi - 1990. Leaf removal did not significantly affect incidence or severity of powdery mildew in a 'Chardonnay' vineyard with a history of moderate disease pressure. The fungicide program was highly significant in reducing both disease parameters and increasing usable yield.

Madera - 1991. A significant treatment effect was found with powdery mildew severity, but not incidence, after leaf removal in the 'Carignane' vineyard used in 1989. Fungicide treatments were highly significant in reducing both parameters.

Discussion

Leaf removal has been successfully employed to reduce the impact of Botrytis bunch rot (3,5,6) and the summer bunch rot complex (4,5), and of insects including leafhoppers and omnivorous leafroller (4,6) in California. A recent report indicated that leaf removal could reduce powdery mildew incidence and severity in the coastal Napa Valley (1). Similarly, results of the present study showed that leaf removal could sometimes reduce incidence and severity in the warmer, drier San Joaquin Valley. However, both studies concluded that leaf removal alone should not be relied upon for commercial management of powdery mildew.

Literature Cited

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Table 1. Influence of leaf removal and fungicide sprays on incidence and severity of powdery mildew (*Uncinula necator*) and yield of 'Carignane' wine grapes in the San Joaquin Valley.

Year, location, Treatment	**Incidence (%)**	**Severity (%)**	**Yield (kg/vine)**
1989, Madera			
Leaf Removal (LR)	17.7	11.0	21.5
Grower Practice (GP)	4.2	9.8	24.6
LR + GP	2.1	20.0	21.7
Control	70.8	31.0	23.3
Factorial ANOVA			
ILR	0.001	0.05	0.05
GP	0.001	0.001	0.01
LR*GP	0.001	0.05	0.05
1989, Lodi			
LR	57.3	30.1	29.1
GP	7.3	5.3	30.1
LR + GP	4.2	1.9	35.2
Control	66.7	34.5	33.7
Factorial ANOVA			
IR	NS	NS	NS
GP	0.001	0.001	NS
LR*GP	NS	NS	0.01
1991, Madera			
LR + Full fungicides	33.1	10.4	24.2
LR + Half fungicides	42.5	5.4	25.9
LR + No fungicides	87.5	42.6	21.5
No IR + Full fungicides	50.6	20.0	27.1
No LR + Half fungicides	56.9	22.3	28.2
No LR + No fungicides	79.4	59.8	28.6
Factorial ANOVA			
LR	NS	0.01	0.005
Fungicides	0.0001	0.0001	NS
LR*Fungicides	NS	NS	NS

SWEET POTATO WHITEFLY *(BEMISIA TABACI)* IN THE SAN JOAQUIN VALLEY

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The recent confirmation of the presence of sweet potato whitefly strain B in the San Joaquin Valley is not good news to producers. This pest, dubbed 'superbug' by the media, has wreaked havoc in the Imperial Valley, parts of Arizona, Lower Rio Grande Valley in Texas, and vegetable producing areas of Florida. Losses in the Imperial Valley in 1991 exceeded 122 million dollars.

This pest has been present in the SJV for a number of years; however, the shift from Strain A (Sweet Potato Whitefly) to Strain B (Poinsettia Whitefly) provides reasons for concern. The host range of Strain B is wider encompassing most agronomically important crops and common weeds. A partial list of over 300 hosts includes:

CROP		**WEED**
alfalfa	okra	buffalo gourd
bean	peanut	cheeseweed
broccoli	pepper	ground cherry
cauliflower	pumpkin	
cotton	squash	**LANDSCAPE**
cucumber	sugar beets	
grape	tomato	chrysanthemum
lima bean	watermelon	honeysuckle
maize		Lantana
mulberry		periwinkle
muskmelon		rose

The pest causes its damage by sucking the sap from the plant and producing a sticky extract called honeydew.The reproductive capability is immense and has resulted this insect swarming over fields. The A Strain will vector plant virus, but the B Strain has not been associated with virus diseases in California, although symptoms such as silver leaf in squash, irregular ripening in tomato, white stalk in broccoli and cauliflower, white root in carrot and white petiole in sugar beets have been noted.

In the Imperial Valley, this pest overwinters on vegetables such as broccoli and cauliflower, as well as weeds such as prickly lettuce, bindweed, malva, and sowthistle. Nondormant alfalfa can also provide overwinter refuge. The insects migrate into melon and tomato fields in May, June, and July where they multiply. Adults go into cotton during the same period and increase dramatically. Melons planted in July and August are killed by the pest. Alfalfa can be affected from June until October. Broccoli and cauliflower planted in late August through early September can be severely stunted by feeding. Carrots, lettuce, and sugar beets can be damaged.

In the San Joaquin Valley, it is unknown just how this pest will affect these same crops. This semitropical pest cannot survive severe winters, but will find ample refuge in the urban areas. Our summer temperatures are less extreme and therefore the number of generations may well be fewer. While its direct impact cannot be accurately predicted, it can be safely stated that this is a pest to be concerned about. Within the San Joaquin Valley, many IPM programs are in place. This pest could disrupt or destroy such programs.

Currently, there is little threat to San Joaquin Valley agriculture. The pest's appearance so late will not cause major problems this year. Honey dew in cotton has been found near Bakersfield. Cantaloupe fields in the same area are heavily infested. In the case of cotton, the earliest defoliation possible will reduce the reproduction. Heavily infested melon fields should be disked to eliminate the pest.

Chemical management options are limited, due to rapidly-developing resistance, the high populations, and the difficulty in getting the chemicals to the target. Long-term regional crop management and introduction of natural enemies will probably be the key. Local San Joaquin Valley UC Extension and Experiment Station scientists are currently developing the required teams. Local leadership is being developed to facilitate and coordinate activities. Close communication with local producers and key industry personnel is essential for a well-coordinated research, education, and management program.

Sources:

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BIOGRAPHICAL SKETCH OF DR. KRISHNA V. SUBBARAO

Dr. Krishna Subbarao has accepted the position of Assistant Cooperative Extension Specialist/Plant Pathologist with the Department of Plant Pathology, University of California, Davis. He will be based at the USDA Research Station in Salinas. Dr. Subbarao will be responsible for both research and extension; this is the first such split-appointment in the department.

Dr. Subbarao is a native of India and obtained his Bachelor's degree in Chemistry, Botany, and Zoology, and Master's degree in Botany (Plant Pathology) from the University of Mysore, Mysore, India. He then worked at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. Dr. Subbarao obtained his Ph.D. in Plant Health from Louisiana State University (LSU) in 1989. As a graduate student at LSU, he received the C.W. Edgerton Honor Award for overall excellence and outstanding scholarship. He then continued as a postdoctoral researcher at LSU for 18 months before arriving at the Kearney Agricultural Center in January 1991 to work as a postdoctoral scientist with Dr. Themis Michailides.

Since arriving at the Kearney Agricultural Center, Dr. Subbarao has been working closely with the fig industry researching various aspects of fig endosepsis (caused by *Fusarium moniliforme)* and fig "smut" (caused by *Aspergillus niger).* Evaluation of physiological variability among the *F. moniliforme* isolates showed that the isolates from the wild caprifigs (inedible male figs) were significantly more virulent than those from the cultivated caprifigs. This finding has a direct bearing on long-term disease dynamics, because the caprifig growers collect wild caprifigs to augment shortages in cultivated caprifigs in some years, thereby infusing some of the most virulent isolates of the fungus into the agroecosystem. In collaboration with Dr. Michailides, Dr. Subbarao has confirmed the previous findings that sanitation practices such as carefully choosing disease-free male figs to pollinate female figs reduces endosepsis as much as or better than fungicide treatments. This practice also significantly improved the vigor of the insect pollinator. Another promising discovery has been the use of *Paecilomyces lilacinus,* a natural inhabitant of fig cavity, as a biocontrol agent of endosepsis. Sanitation in combination with a *P. lilacinus* spore suspension spray on the male fig trees provided endosepsis control as high as 60%.

Dr. Subbarao is excited about his new job because it is located in the most intensive vegetable growing area, and provides an opportunity to be closer to the problems. He is looking forward to working closely with everyone concerned in solving the disease-related problems of vegetables in the Salinas valley.