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MAINTAINING AN IPM PROGRAM IN A SHIFTING PEST ENVIRONMENT: THE NEED FOR CONSENSUS IN SOLVING PROBLEMS

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Background

The IPM program in cotton in the San Joaquin Valley (SJV) of California has developed over the past 60 years. The foundation of the insect management program through the years has been 1) reliance on indigenous natural enemies, 2) close monitoring of insect populations, 3) rational and justified use of broad spectrum chemicals.

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A unique feature of the insect pest complex in the SJV is the absence of a single dominant pest, such a cotton bollworm, budworm, boll weevil, or whitefly. The SJV has key pests which must be managed but whose annual severity depends on environmental factors. The arthropod pest complex requires management, but over-correction through the frequent use of insecticides, creates disruptions and secondary pest outbreaks.

Such a situation can be characterized by the experience of SJV growers during the 1960's when they faced the disastrous results of over managing Lygus *(Lygus hesperus*) with organochlorine and organophosphate insecticides. Secondary outbreaks of spider mites (*Tetranychus* spp.*)*, cotton bollworm (*Helicoverpa zea*) and foliar worms (*Spodoptera exigua* and *Trichoplusia ni*) were common with the result being 8-10 applications of broad spectrum insecticides (Falcon et al. 1968).

Relief came as research improved Lygus management decisions by relating bug numbers to fruiting stage of the plant. As a result, insecticide applications for Lygus were reduced in their frequency and general yield increases were achieved through the 1970's (Bassett and Kerby 1996). Natural enemy populations increased and secondary problems diminished, including bollworm. At about the same time, area-wide compulsory crop destruction and stubble burial were implemented to prevent the establishment of pink bollworm. This area-wide program may have played an important role in reducing overwinter survivorship of bollworm (Roach 1981). During the 1970's and 1980's yields increased (Bassett and Kerby 1996) and insecticide/acaracide use was at an all time low (Phillips et al. 1986). Widespread cotton bollworm problems have not been experienced since the late 1960's.

<u>Crisis Develops in the 1990's</u> During 1990's insect management has become much more problematic. In particular, Lygus became more difficult to manage with organophosphates resulting in multiple applications and a shift to pyrethroid insecticides (Fig. 1). Bifenthrin, in particular, became a popular means of providing general protection to early fruit development because of its residual protection and activity against spider mite, nymphs, and adults. At about the same time, cotton aphids became a mid-season pest and competed directly with the bolls for plant assimilates. Bifenthrin was very effective against cotton aphid and provided acceptable residual control. However, within 2 seasons, its effectiveness had diminished and high levels of resistance in aphids could be found throughout the SJV (Grafton-Cardwell and Goodell 1996). Evidence is emerging which links pyrethroid use with aphid outbreaks (Kidd et al. 1996), suggesting these insecticides should be used with great caution.
Between 1985 and 1995, insecticide/miticide use increased from one and a half applications to 6 applications in some cases. The average season cost of applications rose from about $16.00/acre to $75.00/acre (Phillips et al. 1986; Hardee and Herzog 1996) and yields decreased in 1995. Even though weather conditions could account for much of the yield depression, increasing use of insecticides and associated side effects sent a wake-up call through the industry.

Not since the last insect crisis of the 1960's had there been as much concern about insect pest management and profitability. Faced with diminishing profit caused by increased arthropod control costs and the grim prospect of stepping onto an insecticide treadmill, the industry requested a review of the situation.

<u>Developing an Industry Consensus to Managing Arthropods</u> In November 1995, a meeting was organized jointly by Cooperative Extension and the California Cotton Growers Association. The invitation list was limited to 60 participants composed equally of growers and pest control advisors (PCAs). Those invited were charged with acting as multipliers of the information to the larger industry. The meeting was developed around the format of a facilitated workshop with the specific goals being 1) what has changed in the cotton ecosystem to cause the increased arthropod pest problems; 2) how do we prepare for the following year?

The workshop was divided into 2 main sessions. The 1st session broke out by region to identify local issues and highlight problems with emphasis placed on participation by individuals. The whole group was reformed and common elements of the various regions were identified. The 2nd session broke out by growers and PCAs whose primary task was to identify solutions to the earlier identified issues. The separate groups were asked to vote on the top 5 approaches for improving pest management. The 2 groups were reconvened and the priority lists presented to the whole and combined (Table 1). Both long and short term approaches emerged from the discussions including improve host plant resistance, a need to reexamine early Lygus management, and caution when "unholstering" broad spectrum insecticides, especially pyrethroids. A final list of guidelines was developed to specifically address problems faced in 1995 (Table 2).

In November 1996, a similar review was held with the goal of reviewing the 1995 guidelines and developing management plans for Lygus, silverleaf whitefly, aphid, and spider mites. Additional participants included agrichemical manufacturers, county agricultural commissioners, and representatives from California Department of Pesticide Regulation. In general, the guidelines suggested for 1996 worked well during 1996 but the rapid expansion of silverleaf whitefly in the SJV and early season spider mite outbreaks require new chemistries to manage resistance and limit early applications of broad spectrum insecticides. To approach CDPR and USEPA for emergency exemptions, well laid out management plans are required, similar to those developed by Arizona's Whitefly Management Program (Ellsworth et. al., 1996). A subcommittee met the day before and developed draft plans for Lygus, silverleaf whitefly, aphid, and spider mites as well as overarching guidelines. These were drawn from UC DANR guidelines and experience of the group. The draft was presented to the whole group, discussed in detail, and accepted. Draft copies will be developed and circulated for comment. Final copies will be available by April 1997.

Summary

In managing an ecosystem such as cotton and its associated arthropods, knowledge of the system will never be complete. It is unclear what has caused the shift in insect pests but a change of insecticide classes is certainly one of the contributing factors. Other factors could include variety shifts, changes in surrounding cropping patterns, changes in water and nutrition management, unique weather events, or changes in pest behavior and susceptibility to control measures. However, very few of these factors can be managed as directly as the choice of insecticides used in the field.

In 1996, pest management tactics were reconsidered in areas which had severe mite and aphid populations. Of key importance was understanding that pests cannot be managed individually, but actions toward 1 pest must be considered in the larger multiple pest complex. PCAs and growers reported changing attitudes about early Lygus management and holding off treatments until populations justified applications, based on established square retention thresholds. New approaches to managing Lygus, mites, aphids, and whiteflies are being investigated including evaluation of action thresholds, insecticide/miticide resistance monitoring, and development of alternative management approaches.
The development of industry consensus for managing pests is essential for implementing and maintaining IPM programs. The process of issues identification and resolution develops commitment to the outcomes. A community is brought together to share the common elements of the crisis thus building stronger ties within it. Communication is improved between the various segments of the industry and results in stronger relationships. Questions are raised which provide direction for research and support for that research is garnered. Needs are identified for education and extension which can be addressed immediately.

The specific outcomes of the annual arthropod reviews establish valuable milestones against which the industry can measure progress. However, as important is the process itself which allows larger issues to be revealed, suggests actions to correct the situation, and develops a sense that the larger community is involved to finding solutions.

References

1. Bassett, D.M. and T.A. Kerby. 1996. A history of California cotton. In: Cotton Production Manual. S. J. Hake, T.A. Kerby, and K.D. Hake (eds.). Publ. 3352, UC DANR.
2. Ellsworth, P.C., T.J. Dennehy, and R.L. Nichols. 1996. Whitefly management in Arizona cotton. Univ. Arizona, College of Agriculture, IPM Series, No. 3.
3. Falcon, L.A., R. van den Bosch, C.A. Ferris, L.K. Stromberg, L.K. Etzel, R.E. Stinner, and T.F. Leigh. 1968. A comparison of season long cotton pest control programs in California during 1996. J. Econ. Entomol. 61:633-642.
4. Grafton-Cardwell, E.E. and P.B. Goodell. 1996. Cotton aphid response to pesticides in the San Joaquin Valley. Proc. of the 1996 Beltwide Cotton Production Conf., Vol. 2: 849-850.
5. Hardee, D.D. and G.A. Herzog. 1996. 49th annual conference report on insect research and control. 1996 Proc. of the Beltwide Cotton Conf.: p. 642-669.

6. Kidd, P.W., R.R. Rummel, and H.G. Thorvilson. 1996. Effect of cyhalothrin on field populations of the cotton aphid in the Texas High Plains. SW Entomol. 21:293-301.
7. Phillips, J.R., E.G. King, and R.B. Head. 1985. 1986. 39th annual conference report on insect research and control.. 1986 Proc. of the Beltwide Cotton Conf., p. 126-135.
8. Roach, S.H. 1981. Emergence of overwintered *Heliothis* spp. moths from three different tillage systems. Environ. Entomol. 10:817-818.

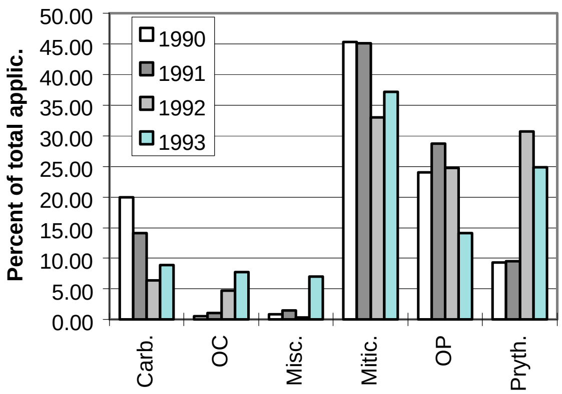

Figure 1. Proportional use of insecticides and miticides in the SJV by chemical "class". Axis titles: Carb. (carbamates), OC (organochlorines), Misc. (miscellaneous products, e.g. Bt, pyrethrins), Mitic. (miticides, dicofol, propargite, and avermectin), OP (organophosphates), Pyrth. (pyrethoids). Sulfur dust is not included. Data from CA Dept. of Pesticide Regulation

Table 1. Top issues identified by SJV cotton growers, and Pest Control Advisors, 1995 Insect Review Meeting.

	Producers' List
1.	Plant breeding to increase resistance or tolerance to arthropods
2.	Improve understanding of why plants shed squares
3.	Improve aphid action thresholds
4.	Improve mite resistance management
5.	Improve understanding of early Lygus thresholds and influence on early damage to yield
	Pest Control Advisors' List
1.	Avoid early applications of broad spectrum insecticides
2.	Lygus thresholds need to be re-evaluated, especially early season
3.	Use of broad spectrum insecticides will lead to mite outbreaks
4.	Temik™ applied side dressed is less disruptive than other insecticides for Lygus
5.	Breed host plant resistance for aphids

Table 2. General guidelines for arthropod management developed through a consensus of cotton producers and pest control advisors, 1995.

1. Anticipate aphid as number one pest
2. Early Lygus treatments lead to spider mites
   - Avoid using pyrethoids early in the fruiting period
   - Tolerate lower square retention, especially during a cool spring
   - Consider Temik™ as a side dress during high Lygus years or in areas prone to Lygus problems
3. Cool weather causes shed , increases thrips problems
4. Preventative mite control, especially if Lygus predicted to be a problem
5. Maximum profit rather than maximum production
6. Use selective insecticides/miticides - But where are they?

EVALUATION OF SPINOSAD FOR CONTROLLING CODLING MOTH IN A CONVENTIONALLY SPRAYED AND MATING DISRUPTION APPLE ORCHARD

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Introduction

Codling moth [Cydia (Laspeyresia) pomonella] (CM) is the most important insect pest of apples in California. In the San Joaquin Valley, there are between three and four generations per year which can cause extensive damage if uncontrolled. Traditional control programs include three to four organophosphate or carbamate insecticide sprays per year.

In an effort to reduce environmental impact and preserve beneficial arthropods, many growers have been incorporating *Bacillus thuringiensis* (Bt), a biological control agent, as an alternate material for insect control. As use of Bt has become common place in many tree crops, there has been some concern over the development of resistance, though only one such case has been reported so far. The primary weakness of Bt is its short residual.

There is also considerable interest in using mating disruption (MD) to control CM, and to supplement this technology with Bt which would be applied two or more times to control other lepidopteran pests such as leafrollers and fruitworms. It is presumed that some secondary CM control results from the Bt.

In these two trials, I tested the efficacy of Spinosad, the common name for a product derived from *Saccharopolyspora spinosa*. Spinosad has similar beneficial attributes to Bt. It is active against a wide variety of insect pests and is considered to have low toxicity to beneficial organisms.

Materials and Methods

In the first trial we used a mature Granny Smith apple orchard that had a conventional insecticide program for several years. The trees were irrigated with overhead sprinklers. Weeds were controlled with herbicides in the tree row and were mowed in the middles. Diseases were controlled with a conventional fungicide program.

There were three treatments: (1) 1.5 LB Lorsban 50W per acre, (2) 0.9 oz Spinosad per acre and (3) untreated check. Treatment dates are as follows: (1) 19 April - emergence of first brood (2) 6 May - 3 weeks later as a bracket spray (3) 13 June - emergence of second brood

The plot consisted of six, single-tree replications in a randomized complete block design. Each tree and half of each adjacent tree was sprayed with a hand-gun sprayer to the point of run-off in such a manner that all foliage and fruit was thoroughly wetted. The surrounding trees were treated with 1.5 LB Lorsban/acre.

On 29 June, 100 fruit were picked from the center tree of each replication and examined for insect damage of any type. The leaves were randomly sampled and examined for leafminer damage. The number of fruit with CM strikes were recorded. On 14 August 200 fruit were sampled in the same way.

In the second trial, I used a similar block of Granny Smith the utilized MD as the primary control for CM during the last two seasons. There were three treatments: (1) 1 LB formulated/acre of Dipel 2X, (2) 2.88 oz formulated per acre of Spinosad, and (3) untreated check. Both materials were applied on 4 April and 12 April 1996 for the control of miscellaneous lepidopteran pests other than CM. CM control was to be achieved with Consep mating disruption dispensers which were applied 18 March, 16 May and 18 July.

We used a randomized complete block design with four replications that were five rows wide and 20 trees long. The treatments were applied at 100 gallons per acre with a commercial air blast sprayer.

On 29 June, 200 fruit were picked from the center row of each replication and examined for insect damage of any type. The leaves were randomly sampled and examined for leafminer damage. The number of fruit with CM strikes were recorded. On 14 August the block was re-sampled in the same way except that the fourth replication was not sampled.

Results and Discussion

In the conventional orchard there was significant damage from CM. The average number of fruit with CM strikes is presented below. There was no appreciable damage from leafminer or lepidopteran pests other than CM. There was a small amount of mite damage.

	Mean No. CM Strikes on	
Treatment	June 20	August 21
Check	2.3	32.7 a
Lorsban	1.0	18.3 b
Spinosad	1.0	13.1 b
	n.s.	LSD 11.81
	Significant at the 1% level	

The data shows that Lorsban and Spinosad significantly reduced CM damage below that of the check. Spinosad clearly shows promise as a control agent for CM in apples and warrants further testing under commercial conditions.

In the disruption orchard there was no appreciable damage from leafminer nor lepidopteran pests other than CM. There was significant damage from CM. The average number of fruit with CM strikes is presented below.

	Mean No. CM Strikes on	
Treatment	June	August
Check	27.8 a	118.3
Dipel	17.3 b	104.7
Spinosad	12.8 b	97.7
LSD =	9.73	n.s.
	Significant at the 5% level	

In the June sampling, both the Dipel and the Spinosad treatments had damage levels significantly lower than the Check. In the August sampling, there was no significant differences among the treatments.

While our original intent was to evaluate control of pests other than CM we observed a difference in CM control among the treatments. In this trial, under these conditions, the Spinosad and Dipel provided control of CM that was significantly better than the check.

FACING PESTICIDE RESISTANT ARMORED SCALE IN CITRUS: WHAT ARE OUR OPTIONS? *Elizabeth E. Grafton-Cardwell, UC Kearney Agricultural Center*

California red scale, *Aonidiella aurantii*, and yellow scale, *A. citrina,* are important economic pests in California citrus. These armored scale cause not only cosmetic damage to the fruit, resulting in downgrading or rejection at the packing house, but also cause yellowing of leaves, defoliation, branch dieback, and possible tree death when pest densities are high. Fruit that is sent to the juice market does not bring in sufficient returns to pay for cultural and pest control practices that occurred earlier in the season. Thus, growers experience great losses when the fruit is juiced or culled. To prevent losses due to scale infestations, San Joaquin Valley California citrus growers have depended primarily on broad spectrum insecticides.

Recently, populations of California red scale and yellow scale in various areas of the San Joaquin Valley have been found to have resistance to all of the currently registered broad spectrum insecticides including the organophosphates chlorpyrifos (Lorsban) and methidathion (Supracide) and the carbamate carbaryl (Sevin). Whereas a single application of an organophosphate or carbamate was effective in reducing scale populations for 1-2 years when these pesticides were first introduced, now, some citrus growers in the San Joaquin Valley are applying 3-4 applications of these insecticides per year and still not achieving control because of resistance.

Over 200 laboratory bioassays were conducted to detect organophosphate- and carbamate-resistant armored scale in the San Joaquin Valley during 1990-96. The majority of these orchards were located in Tulare and Kern Counties. Of the Tulare and Kern County orchards, 77 and 72%, respectively, had at least low levels of resistance in the scale to 1 or more of the broad spectrum pesticides and 46 and 50% had very high levels of resistance requiring multiple applications of pesticides. Our sample was biased towards locations with resistant scale, because we required heavily infested green citrus fruit to test for resistance. It is difficult to estimate the exact percentage of acreage in the San Joaquin Valley with a pesticide resistance problem. However, given the data, I estimate that 25-30% of the 110,000 fruit-bearing acres of citrus grown in the San Joaquin Valley of California are affected by pesticide resistance problems. Field trials have demonstrated that high scale resistance detected in laboratory bioassays corresponds with only 1 generation of scale control or complete lack of control in the field. Scale have 4 generations per year and so resistance problems result in multiple applications of broad spectrum insecticides in an attempt to reduce each generation. Even with multiple insecticide applications, fruit frequently become encrusted with scale and end the season with a significant percentage (up to 48%) of fruit that is downgraded in the packinghouse if the grower does not have a high pressure washer available to remove the scale.

When resistance monitoring was first initiated in 1990, resistance appeared to be patchy. During the ensuing 6 years, resistance has increased and now localized hot spots are developing. These hotspots consist of 50-150 contiguous orchards in which scale have developed moderate to high levels of resistance to organophosphate and carbamate insecticides. Localized hotspots have been found in Tulare County (Orosi, Lindcove, Lindsay, Strathmore, and Terra Bella) and Kern County (Richgrove and Edison). Other hotspots may exist, but have not yet been sampled. Not surprisingly, the areas of greatest resistance are where the scale have infested trees for a long period of time and where the pest management strategy has depended upon these insecticides. Growers have depended upon organophosphate and carbamate insecticides since the late 1950s, and so it is not surprising that the scale have developed resistance to these insecticides.

Armored scale insecticide applications in citrus are extremely expensive compared with other pests. This is because once the 1st instars settle, the scale do not move and so insecticides must be applied in high gallonages of water (750 to 2000 gallons/acre) to penetrate the foliage and move the insecticide to the insect pest. In addition, spray rig speed must be kept to 1.5 miles/hour to keep the leaves of the citrus tree from forming a sheet and a barrier to spray penetration. The application cost averages $90/acre for a 1500 gal/acre ($0.60/gal of water), 1.5 mph spray application. The cost of the pesticide is $65-75/acre. Thus, the full cost of an armored scale spray averages $160/acre. In situations where resistance is a serious problem, growers are applying insecticides 3 times per season.

Thus, scale control alone is costing $480/acre and this is making growing citrus in some orchards unprofitable.

The current alternative to broad spectrum pesticides, is biological control in combination with oil sprays. In southern California, where winters are mild, a group of natural enemies including the parasitoids *Aphytis melinus* and *Comperiella bifasciata*, as well as predatory beetles work together in conjunction with occasional oil sprays to provide effective control of armored scale. The parasitoids prefer to oviposit in 2nd- and 3rd-instar scale. Because of the extensive overlap of generations of scale in southern California, there are scale of the appropriate age-class available for parasitism year round. In contrast, in the San Joaquin Valley winter temperatures are more extreme and this causes the first 1 or 2 generations of scale to develop synchronously in the spring. This synchrony minimizes overlap of scale age classes, and consequently, there are periods during the early season when 2nd- and 3rd-instar scale are not available. This causes a delay in the build up of parasitoid populations until the 3rd generation of scale, which is often too late for preventing scale infestation of citrus fruit. Thus, biological control alone is sometimes not sufficient to control armored scale in the San Joaquin Valley. Citrus growers often use Narrow Range 415 and 440 oil sprays to help the natural enemies reduce the scale population. However, oil sprays can be phytotoxic to citrus resulting in lowered yield and possible tree death and therefore must be used infrequently and carefully. Oils can only be used during July through September in carefully irrigated orchards when temperatures are below 90^{o} F. NR 415 oil sprays are generally not as effective in controlling armored scale compared with organophosphate and carbamate insecticides. Successful biological control also requires a large commitment on the part of the grower to eliminate broad spectrum pesticides for other pests of citrus such as citrus thrips. The alternative selective insecticides are not always as effective in controlling pests compared to the broad spectrum insecticides. Thus, growers risk increased fruit damage when they use a selective pesticide program in combination with natural enemies.

The response of citrus growers to pesticide resistance in scale has been to a) increase rates and numbers of broad spectrum insecticide applications or b) to use oils and *Aphytis* wasp releases. The first option is no longer cost effective, eliminates natural enemies, reduces worker safety, and increases environmental hazards. The second option, release of natural enemies in combination with selective pesticides, can be effective in some situations, however, there is increased risk that there will be fruit damage due to scale or other citrus pests. A third option that may be available soon is the use of several new, currently unregistered, insecticides that have demonstrated efficacy in controlling armored scale populations. The new insecticides include several insect growth regulators (pyriproxifen, diofenolan, and buprofezin) and a novel systemic insecticide (imidacloprid). These new insecticides have low mammalian toxicity which greatly increases worker safety. One problem with the new insecticides is that they have been found to be toxic to Coccinellid beetles needed for control of pests such as cottony cushion scale. Therefore, when they become registered we will need to use them carefully. However, in situations where scale resistance is high and biological control is not effective enough, these insecticides are likely to become important tools for managing armored scale in citrus.

The citrus industry is currently developing a Section 18 registration request for imidacloprid (Provado) and buprofezin (Applaud) for use in the pesticide-resistant scale locations. We are requesting a registration of two products so that we can avoid depending on one pesticide and delay the development of resistance to either one. Use of Provado and Applaud would be restricted to 1 application each during a season. Orchards with resistant scale tend to have high densities of scale and so both Provado and Applaud are likely to be needed to control scale in the 1st season. After the 1st season, when scale densities are lower, the grower may be able to control the scale with only 1 insecticide application. We would continue to encourage the growers to rotate between different insecticides each year to reduce and delay resistance. Pesticide resistance in insect and mite pests of crops is a worldwide problem and each new pesticide that is registered must be carefully managed to prolong it's useful life.

THINNED FRUIT: SIGNIFICANT SUBSTRATE OF SECONDARY SPORE INOCULUM FOR BROWN ROT IN CALIFORNIA NECTARINE ORCHARDS

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Summary

The significance of thinned fruit serving as a substrate for production of secondary spore inoculum was investigated in 5 commercial nectarine orchards in 1995 and 1996. The incidence of pre-harvest fruit brown rot increased as the density of thinned fruit on the orchard floor increased. The incidence of pre- and post-harvest brown rot was significantly greater on fruit from plots where thinned fruit were not removed than where thinned fruit were completely removed. These results suggest that control of fruit brown rot can be achieved by removing thinned fruit immediately after thinning or preventing thinned fruit from infection by, and sporulation of *Monilinia fructicola*.

Introduction

Brown rot, caused by *Monilinia fructicola* (Wint.) Honey, is one of the most destructive diseases of stone fruits in California (7) and elsewhere in the world (2). Current approaches for brown rot control emphasize chemical protection of the blossoms in spring followed by two to three cover sprays and 1 to 2 pre-harvest sprays and a postharvest treatment (7). Repeated application of fungicides has induced the resistance of *M. fructicola* to bezimidazole (benomyl) (6,7) and dicarboximide (iprodione) (4) fungicides and reduced the sensitivity to demethylation inhibitor (DMI) fungicides (triforine) (3). Also choices of fungicides for brown rot control are very limited because of increasing public concern about pesticide residues on fruit and environmental pollution. So there is an urgent need to investigate alternatives to chemical control of this disease. Since there are no obvious significant differences in susceptibility among the various cultivars of stone fruits to infection by *M. fructicola*, one of the best strategies would be to reduce the inoculum potential in order to reduce the severity of brown rot epidemics.

Objectives

1. To determine the significance of thinned fruit as a substrate for production of secondary spore inoculum of *M. fructicola* in nectarine orchards.
2. To investigate the relationship between density of thinned fruit and pre-harvest fruit brown rot.

Procedures

The effect of completely removing thinned fruit from the orchard floor on pre- and post-harvest fruit brown rot was investigated in 3 commercial nectarine orchards (#951, 952, & 953) in 1995 and 2 orchards (#961 & 962) in 1996, respectively. The control treatment consisted of leaving the thinned fruit on the orchard floor after they were thinned. There were 2 treatments, 3 to 4 replicated plots per treatment, and 8×8 trees per replicated plot in each orchard. Nectarine varieties of these orchards were 'Fantasia,' 'Summer Grand,' and 'August Red.' Tree ages ranged from 9 to 22 years. Density of thinned fruit ranged from 162 to 2114 fruit per tree. Thinned fruit left on the ground were periodically examined for sporulation of *M. fructicola*. Pre-harvest brown rot was assessed by observing 200 fruit per tree in 4 center trees in each plot once to twice before the first harvest. Mature fruit were harvested from the same 4 center trees of each plot, then stored at 4^{o}C for 7 days, and then incubated at 20^{o}C for 3 days. Post-harvest fruit brown rot was then assessed. Relationship between density of thinned fruit and pre-harvest fruit brown rot was investigated using REG procedure of SAS.

Results

Thinned fruit exhibited increased levels of sporulation of *M. fructicola* for the first 4 weeks after fruit thinning and declined afterwards. The incidence of thinned fruit showing sporulation ranged from 13 to 60%. The incidence of pre-harvest brown rot was significantly greater on fruit in plots where thinned fruit was left on the orchard floor in 3 orchards (#951, 952 & 953) in 1995 and 2 orchards (#961 & 962) in 1996 (Fig. 1). Also, the incidence of post-harvest brown rot was significantly greater on fruit from plots where thinned fruit were not removed than where thinned fruit was removed in 1 orchard (#962) in 1996 (Fig. 1). A similar trend of post-harvest fruit brown rot was observed on the fruit from the 2 treatment plots in the other 4 orchards, although the differences were not significant (Fig. 1). Further analyses demonstrated that pre-harvest fruit brown rot increased as the density of thinned fruit left on the orchard floor increased (Fig. 2).

Conclusions and Discussion

1. Thinned fruit can serve as a significant substrate for development of secondary spore inoculum for fruit brown rot. Control of pre- and post-harvest

fruit brown rot can be achieved by completely removing thinned fruit from orchards.

2. Incidence of pre-harvest fruit brown rot increased as the density of thinned fruit left on the orchard floor increased.

This is the first report of thinned fruit as an important source of secondary spore inoculum of *M. fructicola* in California stone fruit orchards. Thinned fruit was also reported as a source of secondary inoculum of *M. fructicola* in South Carolina (5) and Canada (1). But the present study further provides quantitative evidence demonstrating that these fruit are significant substrate for production of secondary inoculum. This information can help to estimate the relative importance of primary and secondary inoculum for stone fruit brown rot in California orchards.

More importantly, the results of this study lead to development of new strategies for management of nectarine brown rot, i.e. by controlling the size of secondary spore inoculum produced on thinned fruit. Removing thinned fruit from treatment plots was a time-consuming procedure, taking about 100 to 160 h of man labor per hectare, depending largely on the density of thinned fruit on and surface morphology of the orchard floor. Apparently, it would take additional labor and cost to remove the thinned fruit out of orchards of similar size and varieties. An alternative to this procedure could be spraying chemicals or biological agents to suppress sporulation of *M. fructicola* or to expedite the decomposition of thinned fruit through cultural practices, such as disking or rototilling. Obviously, the more growers in an area follow such practices the more likely will be the chances of reducing brown rot. The applicability of our results to orchards of other stone fruit species and possible ways of destroying thinned fruit in orchards are under further investigation.

Literature cited

1. Biggs, A.R. and Northover, J. 1985. Inoculum sources for *Monilinia fructicola* in Ontario peach orchards. Can. J. Plant Path. 7:302-307.
2. Byrde, R.J.W. and Willets, H.J. 1977. The brown rot fungi of fruits: their biology and control. Pergamon Press, Oxford. 171 pp.
3. Elmer, P.A.G., Braithwaite, M., and Saville, D.J. 1992. Changes in triforine sensitivity in populations of *Monilinia fructicola* from Hawkes Bay orchards. Proc. of the 45th N.Z. Plant Protection Conf. 1992. p.138-140.
4. Elmer, P.A.G. and Gaunt, R.E. 1993. Effect of frequency of dicarboximide applications on resistant populations of *Monilinia fructicola* and brown rot in New Zealand orchards. Crop Prot. 12:83-88.
5. Landgraf, F.A. and Zehr, E.I. 1982. Inoculum sources for *Monilinia fructicola* in South Carolina peach orchards. Phytopathology 72:185-190.
6. Michailides, T.J., Ogawa, J.M., and Opgenorth, D.C. 1987. Shift of *Monilinia* spp. and distribution of isolates sensitive and resistant to Benomyl in California prune and apricot orchards. Plant Dis. 71:893-896.
7. Ogawa, J. M. and English, H. 1991. Diseases of Temperate Zone Tree Fruit and Nut Crops. University of California, DANR Publ. 3345.

(Figure not available)

Figure 1. Pre- and postharvest brown rot on fruit from plots where thinned fruit were completely removed (A1) and not removed (A2) in five commercial nectarine orchards in 1995 (#951, 952, & 953) and 1996 (#961 and 962).

(Figure not available)

Figure 2. Relationship between preharvest fruit brown rot and the density of thinned fruit in four nectarine orchards of similar maturity varieties, in 1995.

CONTROL AND MANAGEMENT OF SAN JOSE SCALE

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Introduction

Control of San Jose scale on stone fruit hosts has become more difficult over the past few years with some growers experiencing significant economic losses from this pest. Recent research has indicated that selected field populations of San Jose scale may have developed a high level of tolerance or resistance to dormant-spray organophosphate insecticides. This would contribute to control failures along with other factors such as improper application techniques and/or coverage.

The objectives of the 1996 project funded by the California Tree Fruit Agreement were to: 1) continue and finalize laboratory research on resistance of selected laboratory and field populations of San Jose scale to chlorpyrifos, a common organophosphate insecticide; 2) compare and evaluate standard dormant treatments for San Jose scale control using conventional dilute and concentrate sprays applied to stone fruits; and 3) evaluate efficacy of new insect growth regulators for control of San Jose scale as possible alternatives to organophosphate insecticides.

<u>San Jose Scale Resistance to Organophosphate Insecticides</u> The laboratory trials initiated at the Kearney Agricultural Center in 1994 to evaluate resistance of San Jose scale to chlorpyrifos (Lorsban) were continued in the fall of 1995 and spring of 1996. Procedures included collection of scale crawlers from grower and untreated orchards, establishment of scale colonies on banana squash, and treatment of small gourds infested with first instar scale using various rates of chlorpyrifos. Four colonies of San Jose scale were established in the laboratory at the Kearney Agricultural Center. One of these colonies has been in culture and not sprayed with any insecticides for approximately 20 years (±200 generations). This colony is considered to be the most susceptible of any San Jose scale colony available for research in California. Three other scale colonies were established using field-collected crawlers from infested trees. The 1st of these new colonies was collected in field 32 at Kearney, which is an unsprayed orchard. Two other colonies, both from commercial orchards in the Reedley-Parlier area, were established in the laboratory in the same manner as the field 32 orchard.

Once these colonies reached sufficient population levels, small field-collected wild gourds (*Cucurbita foetidissima*) similar to those used in previous research trials with scale were infested with crawlers from the 4 respective laboratory colonies. All of the gourds used in the laboratory treatments were infested from 31 January to 2 February 1994. After crawlers had settled and developed to the whitecap stage, all gourds were dipped on February 4 into a water check solution or solutions of Lorsban (chlorpyrifos) to determine mortality within the 4 respective colonies. After the gourds were dipped in the respective treatments, they were set aside for continued development in laboratory temperature cabinets maintained at 75 ±2°F and 60 to 80% relative humidity and a 16L:8D light regime.

Continued replication of chlorpyrifos dosage rates in 1995-96 confirmed earlier data that the populations of San Jose scale from 2 mature commercial nectarine orchards in the Reedley-Parlier area had developed a strong tolerance or resistance to the insecticide chlorpyrifos. Fig. 1 shows that San Jose scale in the 2 commercial orchards are 40-100 times more tolerant of chlorpyrifos at the 90% mortality level than the laboratory colony, and there are some scale in the KAC Field 32 population that are equally resistant. The untreated research orchard population of scale from Kearney (Field 32, nectarines) is intermediate in its susceptibility to chlorpyrifos compared to an untreated or unselected laboratory colony from Kearney. These data conclusively show what had been suspected, that San Jose scale field populations do in fact have resistance to organophosphate insecticides, which has contributed to control failures in several tree fruit commodities over the past several years. As a result of these findings, it is apparent that growers, pest control advisors, and applicators must now pay much greater attention to the details of proper spray application and coverage in order to achieve economic control of San Jose scale when using organophosphate insecticides, either in dormant or post-bloom sprays.

Dilute Versus Concentrate Spray Applications for Control of San Jose Scale A mature orchard of 'Fantasia' nectarines at the Kearney Agricultural Center was used for a dilute dormant spray at 400 gal/acre compared to a concentrate dormant spray application at 100 gal/acre for control of San Jose scale. This orchard (approximately 20 years old) had been under a standard dormant spray program using diazinon and oil at 100 gal/acre for at least the previous 5 years. During this time, increasing levels of San Jose scale had been observed on harvested fruit. Consequently, the orchard had a relatively high resident population of scale throughout the orchard. In both the dilute and concentrate spray treatments, diazinon 50 WP at 2 lb. a.i./acre was applied in combination with Volck Supreme oil at 6 gal/acre and Kocide at 2.5 lb/acre using an Air-O-Fan GB-35 sprayer. Both spray treatments were applied on 29 January 1996 in a randomized complete block design of 5 replications per treatment, nine trees (3 x 3) per replicate. The 2 spray treatments were compared to an untreated check in the same orchard. Fruit was harvested on 10 July 1996 by randomly selecting 200 fruit from the center tree in each replication (1,000 fruit per treatment) for direct examination of scale infestation. In these treatments, the presence of a single scale on a fruit resulted in that fruit being scored as infested. No attempt was made to count the total number of scales present on each piece of fruit.

The fruit infested by scale at harvest are shown in Table 1, and indicate that there were no statistically significant differences between the untreated check and the two treatments with diazinon and oil applied on 29 January. It was surprising in fact to see that both of the insecticide treatments were actually slightly higher in scale infestation levels than the untreated check. The results of this field trial confirm the conclusions reached with the laboratory studies on San Jose scale resistance: field populations of scale that have been treated annually with at least 1 organophosphate insecticide spray have developed high levels of resistance to these insecticides.

Along with the infested fruit data from this trial, crawler populations of scale were monitored in each treatment by placing two sticky-tape crawler traps on the upper scaffold limbs in the center tree of each replicate. Two counts of the tapes at weekly intervals were made at the peak of the first, and again at the second, generation of scale crawlers in May and July. The crawler populations observed in the 3 treatments using sticky tapes are shown in Table 1 and indicate that there were no significant differences in crawler populations between the untreated check and the dilute diazinon treatment while the concentrate diazinon treatment had a much higher population of crawlers in both generations. Although the amount of infested fruit at harvest in the concentrate treatment was only slightly higher than the dilute application and check, the data from the tapes in the concentrate treatment tend to support the hypothesis that concentrate spray applications in large mature trees often may not produce the level of scale population reduction observed with dilute applications of the same insecticide.

Table 1. Efficacy of dormant dilute and concentrate sprays of diazinon and oil for control of San Jose scale on Fantasia nectarines. January 29, 1996; Kearney Agricultural Center, Parlier

		Average Number Crawlers/Tape	
Treatment	% Infested Fruit[2]	1st Generation	2nd Generation
Check	32.3 a	24.4 a	40.6 a
Diazinon[1] 400 gpa	37.0 a	32.6 a	42.2 a
Diazinon[1] 100 gpa	37.3 a	144.4 b	149.2 b

[1] 2.0 lb. a.i. diazinon and 6.0 gal Volck oil per acre.
[2] July 10, 1996; 1,000 fruit per treatment. Values in columns followed by the same letter are not significantly different at *P* = 0.05, Fishers Protected LSD.

Efficacy of Unregistered IGR Insecticides for Control of San Jose Scale In addition to the evaluations of dilute and concentrate dormant spray applications for scale control, 2 new unregistered insect growth regulators (IGR) were evaluated for efficacy on San Jose scale in nectarines and plums (peach growers may question the use of plums or nectarines in evaluating scale infestations, but it is recognized that scale treatments are much easier to evaluate on smooth-skinned fruit than on fuzzy fruit).

The IGR insecticide Applaud (buprofezin; AgrEvo USA) was evaluated in a trial similar to the preceding organophosphate insecticide spray trial. Buprofezin was applied to 'Fantasia' nectarines at 1.0 lb and 1.5 lb a.i./acre in 400 gallons of spray using an Air-O-Fan GB-34, 500 gallon sprayer. Both buprofezin treatments were compared to an untreated check in a 5 replication randomized complete block design; they were applied on 22 April 1996 at the beginning of emergence of the first crawler generation. Evaluation of infested fruit at harvest (10 July 1996) showed infested fruit levels in both buprofezin treatments to be significantly better than the untreated check (Table 2).

Table 2. Efficacy of buprofezin (Applaud) for control of San Jose scale on Fantasia nectarines. Kearney Agricultural Center, Parlier, CA

Treatment	% Infested Fruit[2]	Average Number Crawlers/Tape 1st Generation	2nd Generation
Check	32.3 a	24.4 a	40.6 a
Applaud 1.0 lb. a.i. [1]	16.4 b	80.0 a	5.0 b
Applaud 1.5 a.i.	12.1 b	64.4 a	9.4 b

[1]Applied April 22, 1996 at 400 gpa.
[2]1,000 fruit per treatment, harvested July 10, 1996. Values in columns followed by the same letter are not significantly different at *P* = 0.05, Fishers Protected LSD.

In addition to the infested fruit data, crawler populations in the buprofezin and untreated check treatments were evaluated using the sticky tape traps as described for the dormant diazinon treatments. Counts of San Jose scale crawlers on sticky tapes in both buprofezin treatments were higher than the check in the 1st (treated) generation, but were significantly reduced compared to the untreated check in the 2nd SJS generation (first generation post treatment). This illustrates the delayed effect of IGRs compared to conventional insecticides that have been used in the past. In this trial, the treated crawler population (1st generation) continued to emerge and was trapped on tapes or settled on fruit in May. As a result of the treatment, however, a high proportion of the first generation failed to develop and mature to adults, resulting in a greatly reduced 2nd generation.

The results of both the fruit infestation data and sticky tape crawler counts showed that buprofezin provided good control of San Jose scale in the generation following treatment, and indicate that the IGR insecticides may be strong candidates for replacement of organophosphate insecticides in scale control programs.

A 2nd field trial with another new IGR, "Arbor" (CGA 59205; Ciba-Geigy Corporation) was applied by hand gun in a randomized complete block trial to Friar plums on 1 February 1996 as a dormant spray with oil and on 22 April 1996 to the 1st generation of scale crawlers. A standard treatment of diazinon 50 W at 2 lb. a.i. and 6 gallons of Volck oil per acre was included in this trial for comparison to the Arbor treatments and an untreated check. On 23 July harvest samples comprised of 100 fruit per replication (700 fruit per treatment) were examined for presence of San Jose scale. The results of the fruit evaluation (Table 3) showed that both treatments with Arbor and the diazinon and oil treatment had significantly lowered the population of San Jose scale compared to the untreated check.

Collections of scale crawlers on sticky tapes in this trial also showed significant reductions of scale crawlers in each of the first two generations of the Arbor + oil and diazinon + oil (both dormant treatments) compared to the untreated check (Table 3). The post-bloom Arbor treatment without oil had high numbers of first-generation crawlers and was not significantly different from the untreated check. In the second generation, however, crawler populations in this treatment were significantly lower than the check, similar to the effect observed in the other IGR (Applaud) trial.

Table 3. Efficacy of CGA 59205 (Arbor) for control of San Jose scale in Friar plums. Kearney Agricultural Center, Parlier, CA

Treatment	% Infested Fruit[2]	Average Number Crawlers/Tape 1st Generation	2nd Generation
Check	39.0 a	450.3 a	327.4 a
Diazinon[1]	10.1 b	8.0 b	24.1 b
Arbor, dormant	9.7 b	4.0 b	10.0 b
Arbor, April	18.0 b	431.3 a	114.7 b

[1]Hand gun sprays at 400 gpa.
[2]700 fruit per treatment, harvested July 23, 1996. Values in columns followed by the same letter are not significantly different at *P* = 0.05, Fishers Protected LSD.

As with the buprofezin trial, the efficacy of Arbor for control of San Jose scale shows good potential for this IGR as a replacement for the currently used organophosphate insecticides in stone fruit IPM programs.

(Figure not available)

Figure 1. Comparison of an organophosphate-susceptible laboratory population of San Jose scale to scale collected from three nectarine orchards. KAC Field 32 unsprayed; Grower 1 and 2 orchards treated annually with dormant organophosphate and oil sprays.

REFLECTIVE MULCH FOR MANAGING APHIDS, APHID-BORNE VIRUSES, AND SILVERLEAF WHITEFLY: 1996 SEASON REVIEW

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The complex of aphid-vectored virus diseases has been causing increasingly heavy losses in many vegetable crops grown in the inland valleys of California. Several field experiments were conducted on-farm or at KAC in 1996 in cantaloupe melon, cucumber, pumpkin, fresh market tomato, and zucchini squash to test the effectiveness of reflectorized, spray, and polyethylene soil mulches for management of aphids and aphid-borne virus diseases in San Joaquin Valley vegetable crops. Because we had observed benefits of the mulches in repelling silverleaf whitefly in 1995, effects of treatments on seasonal dynamics and damage caused by this insect also were determined.

Cantaloupe. Three different reflectorized mulches (AEP, Specialty Ag net, and Specialty Ag solid) applied either to contiguous rows or to alternate rows. The latter treatments were included to determine if alternate row mulching (application cost half of contiguous row mulching) would provide an economic benefit to users. All mulches applied to contiguous rows significantly delayed or reduced the incidence of virus diseases. As in previous experiments, contiguous row mulching with the three mulch products were equally effective in repelling aphids and reducing virus disease incidence. Mulching alternate rows was less effective in reducing virus incidence (Fig. 1).

All three mulch products (AEP, Specialty Ag net, Specialty Ag solid) performed equally well in increasing total marketable cantaloupe yield 2.0-2.2 fold over the nonmulched control treatment. The alternate row mulch treatments were less effective, increasing yield by only 14-31% over the nonmulched controls (Table 1). This relatively low level of increased yield associated with alternate row mulching would probably not be acceptable to growers given the cost of using the mulch.

Cucumber. Three treatments were evaluated in this commercial, on-farm experiment; nonmulched, every row mulched, and alternate rows mulched. A total of 5 acres was included in the plot. The silver reflectorized mulch provided excellent results under commercial conditions. At the end of the growing season, ca. 60%

of unmulched cucumber plants showed virus symptoms, as compared to 0% in the every row mulched, and a mean of 1% in the alternate row mulch treatment (Fig. 2).

The reflectorized mulch treatments had a marked effect on yield. With respect to number of fruit, the continuous mulch and alternate row mulch produced 5.2- and 2.5-fold more than nonmulched rows. Similarly, the continuous mulch and alternate row mulch produced 3.8- and 2.2-fold more fresh weight than nonmulched rows (Table 2). In addition, the grower stated that the shape and quality of the fruit produced over the reflectorized mulch was visually superior to fruit from nonmulched beds.

Pumpkin. In this on-farm experiment, Specialty Ag net mulch was applied to approximately one acre of a 20 acre pumpkin planting. Four mulched or unmulched areas, each 25 feet long, were randomly marked off for data collection. Assay of symptomatic foliage showed that ZYMV and WMV, and to a lesser extent, CMV and AMV was present in the field. By midseason, 100% of plants in the nonmulched area of the field were virus-infected, while only 19% of plants in the mulched area showed foliar symptoms.

At harvest, the mulched plots produced a mean fresh yield of 136 lb. per 25 row feet, while the nonmulched control treatment yielded 43 lb. mean fresh yield. This represented a 3.2-fold yield increase in conjunction with reflectorized mulch usage. The mean fresh weight per pumpkin was 12.4 lb. on mulch, and 2.8 lb. on nonmulched control soil (4.4-fold increase).

Tomato. This experiment was conducted at KAC to compare effects of AEP, Specialty Ag, and silver spray mulches as compared to a nonmulched control treatment for management of aphids, whitefly, and virus diseases. The reflectorized mulch treatments all were effective in repelling aphids and silverleaf whitefly, and in reducing incidence of foliar virus symptoms of CMV and PVY. Although serodiagnosis was not performed, presumptive foliar symptoms of the thrips-transmitted tobacco streak virus (TSV) also were observed in this experiment. Numbers of silverleaf whitefly were reduced by silver spray and plastic mulches by 40-100% over the season.

Fresh yields were somewhat anomalous in this experiment. Three of the four mulch treatments (Specialty Ag net and solid film; silver spray mulch) gave larger yields than the nonmulched control treatment, ranging from 0.43 to 3.3-fold increases. However, the AEP silver plastic mulch gave a very small yield - only 30% of the nonmulched control treatment. Further studies will be done to evaluate this phenomenon.

Zucchini Squash. Results from the on-farm zucchini squash plot were similar to those obtained from experiments conducted at KAC in 1994 and 1995. Silver polyethylene mulch did an excellent job of repelling aphids [virtually all cotton-melon aphid (*Aphis gossypii*)] throughout the season. Unlike the previous three years, late season virus pressure was only moderately high, with WMV, ZYMV, and CMV present in the field. The mulch treatment delayed the onset of virus symptoms by ca. 3 weeks. Virus disease incidence in the nonmulched portion of the field reached 100% on 10 October, while only 20% of plants in the mulched section showed foliar symptoms (Fig. 3). Similarly, the reflective mulch was effective in repelling silverleaf whitefly and reducing silverleaf symptoms by ca. 70% at the end of the season (Fig. 4).

Each treatment area was picked by the grower's workers and was weighed by our crew. After 9 harvests, total fresh weight from the mulched area was 311 lb., as opposed to a fresh weight yield of 216 lb. (44% increase). In addition, harvest in the mulched area began 5 days earlier than in the control area. The results from this commercial location agreed well with those from our previous small plot experiments at KAC in 1994 and 1995.

In the 1996 experiments, yield and plant health differences attributable to reflective mulch treatments were easily apparent throughout the season in each of the cucurbitaceous crops. All reflective mulch products tested were very effective in contiguous row application for repelling aphids and silverleaf whitefly, and delaying the effects of virus diseases in all experimental crops. Use of alternate row mulching was less effective and not recommended. The list of vegetable crops shown to benefit from reflective mulches was expanded to include cucumber and pumpkin. The results of this research project have been incorporated into the updated UCIPM Pest Management Guidelines for Cucurbits.

Table 1. Summary of total cantaloupe melon yields from mulched, nonmulched, and alternately mulched rows (KAC, 1996)

Treatment	Carton acre per	
Specialty Ag solid film	699.9	c
Specialty Ag net film	666.7	c
AEP solid film	625.6	c
Specialty Ag net (alternate)	416.4	b
AEP solid (alternate)	363.4	ab
Nonmulched Control	317.5	a

Table 2. Summary of total cucumber yield (9 harvests) from mulched, nonmulched, and alternately mulched rows (Kubo, Parlier, 1996)

Treatment	No. of Fruit	Yield in lbs.	Weight/ Fruit
Mulched Rows	609	441	0.73
Unmulched Rows	117	117	1.00
Altlernate Rows Mulched[a]	435	361	0.83
Alternate Rows Unmulched[b]	143	143	1.00

[a]Every other row mulched.
[b]Every other row unmulched.

(Figure not available)

Figure 1. Percentage of virus infected cantaloupe plants grown over reflective mulches applied either to contiguous rows or alternate rows.

(Figure not available)

Figure 2. Percentage of virus infected cucumber plants grown over reflective mulches (all rows mulched) or bare soil (all rows unmulched [top]. Percentage of infected cucumber plants grown over alternately mulched and unmulched rows [bottom].

(Figure not available)

Figure 3. Percentage of virus infected zucchini squash plants grown over reflective mulch or bare soil.

(Figure not available)

Figure 4. Percentage of zucchini squash plants grown over reflective mulch or bare soil showing symptoms of whitefly induced squash silverleaf.