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IN THIS ISSUE

Marigolds....................

Further Tests on Effectiveness of Disinfectants for Preventing Transmission of Fireblight ....

Augmentative Release of *Metaphycus helvolus* for control of Black Scale *Saissetia Olea,* in Olives....................

Abstracts ....

News Items....................

ARTICLES

MARIGOLDS AND NEMATODE MANAGEMENT

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Introduction

Marigolds, *Tagetes* spp., have been reported by numerous researchers to provide a method for protecting crop plants from damage caused by various nematode and insect pests. Gardeners will occasionally plant marigolds adjacent to their garden plants for insect protection or will turn under marigolds as a rotation crop in order to reduce nematode populations. Agronomists with commercial farming operations have occasionally commented that crops such as carrots, following a planting of marigolds, seem to exhibit less nematode damage. Since marigolds can also be an economic crop when grown for seed or flower petals, there is adequate reason to quantify the nematode management value of marigolds.

During the last five years we have carried out a number of laboratory and field experiments to evaluate the nematode management potential of several marigold

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species as a rotation crop, cover crop, soil amendment, and as a home-grown source of nematicides.

Marigolds as a Rotation Crop

Annual Crops. Marigolds have been reported to be a useful rotation crop where nematodes pose a problem (1,2). Scientists disagree about which Tagetes sp. provide the best nematode control, but there are few negative reports on the performance of marigolds as a tool for nematode management. Some researchers have referred to marigolds as a nematode trap crop (1,3,4) and others have referred to them as a source of thiophene compounds which are nematicidal (5). The most active thiophene compound, ∝terthienyl, was rejected as a nematicide since the compound was only effective when nematodes were also exposed to UV light (6).

As a rotation crop there are at least two important factors to consider. First, all of the Tagetes cultivars that we worked with were allelopathic. In other words, they contained general biocides that affect nematodes and adjacent or subsequent plants. In 1980, entomologists suggested that French marigolds reduced populations of *Helicoverpa zea* but promoted an allelopathic response in adjacent bean plants (7). In 1990, reports from Long Island, NY indicated that marigolds planted for 60 days in spring, turned under, damaged subsequently planted cabbage (8). Interestingly, it was further reported from Long Island, that a year's growth of marigolds, allowed to freeze down in winter and then turned under the following spring, provided useful nematode protection for a subsequent potato crop with no evidence of allelopathy. However, since the average winter rainfall on the sandy soils of Long Island is 100 cm, the rainfall may have pushed the highly soluble allelochemicals below the root zone.

The second consideration is that marigolds host several nematode species which commonly occur in California. There have been reports of Tagetes sp. being a host for ring nematode, Criconema mutabile (9) and certain root knot nematode *(Meloidogyne hapla*), populations (10). In our own host range studies we found the following nematode-host responses by root knot nematodes in the presence of *T. patula* cv. Nemagold: 1) *M. incognita* Race 3 from cotton was hosted at 4.6 nematodes/gr of root; 2) *M. hapla* from Visalia alfalfa was hosted at 6.7 nematodes/gr root; 3) *M. javanica* from Thompson Seedless grape formed root galls but was unable to reproduce (trap crop) leaving only 0.05 nematodes per gram of root; and, 4) *M. arenaria* from Cibola alfalfa near Blythe, CA was not hosted by Nemagold.

Perennial Crops. Solving the general replant problem between plantings of permanent crops requires treatments that kill old roots, modify the soil profile, and greatly reduce soil populations of nematodes and other pests. In 1988, a report from New York indicated that *T. patula* cv. Sparky gave 98% control of apple replant disease and suppression of root lesion nematode (11). Hearing the positive results, Farm Advisor Rachel Elkins and I established a plot to evaluate a marigold extract in comparison to methyl bromide as a pre-plant control for the general replant problem of pears. The extract of *T. erecta* cv. Cracker Jack was sprayed onto the field surface in November prior to a rainy period. One year later, the benefits achieved from methyl bromide were visually evident, however there were no benefits derived from the marigold extracts in this non-nematode site. In other words, the marigold extract did not solve the general replant problem in pears.

In 1989-90, we evaluated *T. tenuifolia* cv. Nemakill as an incorporated summer crop in two five-acre parcels, one being out of plums 1 year and the other being out for 2 years. Treatments included: 1) marigold tops and roots incorporated; 2) marigold tops incorporated; 3) marigold roots incorporated; 4) soil fumigation; and, 5) non-treated fallow check. Forty cherry trees on Mazzard rootstock and 25 Cabernet Sauvignon grapevines were planted to each of four replicates in each of 2 field sites. Nematodes were not a problem in either site and the soil was ripped to 60 cm depth before planting of perennials. Vines in the fallowed check area grew as well as in any treated area. Cherry trees grew significantly better in the fallowed check than where marigold tops were incorporated. Soil fumigation gave significantly better growth than the fallowed check in the cherry trees. The results of this experiment indicate that marigold tops carry some allelopathic effect, but not enough to damage the old plum roots and associated rhizosphere organisms and therefore did not solve the general replant problem.

Marigolds as a Cover Crop for Orchards/Vineyards

A cover crop planted in the "drive row" between rows of trees or vines can provide a source of nematode build-up or decline in that area. For this reason we have been searching for cover crops which are non-hosts for the nematodes of tree and vine crops. Although a single year or two of marigolds is not a bad choice from a nematode host standpoint, we cannot recommend marigolds as a cover crop. Our most serious problem with the use of marigolds as a cover crop has been their inability to compete with grassy weeds present on the orchard floor. These weeds have resulted in a need for greater herbicide use and use of taller statured marigolds such as *T. erecta* cv. Cracker Jack. A two year study with Cracker Jack and Janie Flame cultivars planted in spring gave slight, but non-significant, reductions in populations of root lesion nematode, *Pratylenchus vulnus* in a plum orchard. Additionally, marigolds are a host of mites and white flies which are potential pests in orchards and vineyards.

We have observed that marigolds are especially allelopathic to young grapevines. Nemagold cultivar of *T. patula* was responsible for a 75% reduction in growth of young grapevines when grown as a 1 year companion crop to French Colombard. This effect was not expected and was non-significant only because the trial was not designed to test for allelopathic effects.

Marigold Refuse as a Soil Amendment

Marigolds can be easily grown off the site and the refuse applied to nematode infested soils to lower their populations, but the yield of subsequent or adjacent plantings may not improve. In our studies in California there were no yield improvements. We have reported elsewhere that 15,680 kg/ha (7 tons/acre) of refuse from *T. patula* cv. Janie Flame incorporated and irrigated into a plum orchard produced very good reductions of *P. vulnus* for 180 days after treatment (12). However, the plum trees did not show improved yield as a result of treatment.

Nemagold, Cracker Jack, and Nemakill may be grown in open land with relative ease. Sprinklers should be used where mites are a potential problem. The refuse can be hauled to irrigated tree and vine crops for incorporation and irrigation. Nemakill is a wild cultivar from Guatemala growing 3 m in height. All its flowers and seed production come in late October and November. This marigold can even be grown in old orchard sites without the use of any pesticides, except perhaps for a wicking treatment with glyphosate, if weeds develop before it reaches 1 m height. Nemakill is most easily planted in April, and mowed in late July and again in late October. It produces 22,400 kg/ha (10 tons/acre) fresh refuse. 1 acre (0.4 ha) can be aromatic for a distance of 400 m downwind. All three marigolds listed above are easily harvested with a flail mower.

On-Farm Water Extracts of Marigold

Processing and Delivery. In central California, marigold tops can be harvested from July through November. A flail mower is used to chop and deliver the refuse into a bin. The refuse in several bins is placed into a large tank. Sufficient water is added to the tank to submerge the chopped refuse. Our usual extract contains about 565 g fresh biomass per 1 liter of water. After two days of soaking, an outlet at the bottom of the tank is opened and the extract is passed through a 74 micron sieve (200 mesh) and into a storage tank. There is almost no fermentation of marigold extract. It may be stored one week in ambient summertime conditions. At 3° to 4°C the extract may be stored for 150 days with less than 15% loss in biological activity. Frozen extracts do not lose biological activity after 150 days of storage.

The extract is delivered to affected root systems by mixing it into irrigation water. Our usual procedure has been to calculate the volume of water needed to wet soil down to the 90 cm depth. We then mix the extract into the irrigation water with the goal of achieving a treatment rate of 18 g fresh refuse for every liter of irrigation water applied. Using low volume irrigation systems such as drippers in vineyards, one hectare of marigold provides enough extract to treat 30 to 90 ha of vineyard land, depending on the number of marigold treatments made per annum.

Laboratory Data. Table I depicts the biological activity of various marigold extracts against *Meloidogyne* spp. The lethal dosage effects are determined from sealed exposure vials from which the nematodes are removed at various times, rinsed in tap water, allowed to sit for 24 hours and then assayed for motility. Nematodes undergo a paralysis when exposed to marigold extracts. The observed paralysis is accompanied by a reduction in the dissolved oxygen levels within exposure vials containing the extracts. Extracts of *T. tenuifolia* cv. Nemakill reduced dissolved oxygen levels from 11.8 ppm in tap water to 4.3 ppm and 2.6 ppm at concentrations of 3 g/l and 18 g/l, respectively.

The addition of sugar was prompted by our observation of nematode paralysis when they were exposed to marigold extract. We speculated that if nematodes were paralyzed they may also be unable to osmoregulate if fertilizer salts or common table sugar was also placed into their environment. The data in Table 1 indicate that sugar added to the marigold extract increased its nematicidal value.

Table 1. Lethal dosage values for selected marigold extracts against *Meloidogyne* spp.

Marigold Cultivars	**LD_{50}**	**LD_{95}**
T. tenuifolia cv. Nemakill	7g/l/72 hr	18g/l/72 hr
T. sp cv. Kenya #1	9g/l/24 hr	20g/l/72 hr
T. erecta cv. Cracker Jack	18g/l/72 hr	-
T. erecta cv. Xanthophyll	>18g/l/96 hr	-
T. patula cv. Nemagold	18g/l/72 hr	-
T. Patula cv. Janie Flame	>18g/l/96 hr	-
C & H brand sugar	>10g/l	-
T. Patula cv. Janie Flame + sugar for 72 hr	3g/l + 1g/l	9g/l + 1g/l

Bioassays conducted in sealed vials, rinsed for 24 hr and then assayed for motility. LD_{50}. is a measure of the lethal dosage (concentration x time) to kill 50% of the nematode population.

Field Data. From 1986 through 1989 we treated 15 field sites with marigold extracts with and without sugar and other fertilizer salts. Across all our field tests we never experienced a single numerical yield improvement in the marigold treated versus non-treated. In four of 15 trials, Nemacur® provided a significant yield increase. We never measured a significant ($\underline{P}$ = 0.05) yield decline due to the use of marigolds, but yields usually averaged none to 10% less than the non-treated check. The addition of 145 kg/ha of sugar at the time of delivery of marigold extract improved nematode control slightly but that amount of sugar by itself, applied twice yearly for 2 years, was responsible for 10% yield reduction in a vineyard. The sites included plantings of kiwifruit, plums, grapes, nectarines, prune, and peaches. Nematode populations were monitored for 2 years and plant yields monitored for 2 or 3 years. We generally made one treatment in spring and another in the fall. Nemacur® treatment and a non-treated check provided standards for comparison. All treatments were made with extracts applied at 18 g fresh plant material per liter of irrigation water.

The marigold extracts provided a 50% or better reduction in nematode populations for a period of 6 months. The conventional treatments with Nemacur, using 2 lb ai/acre, usually provided a 75% reduction of endoparasitic nematodes for 6 to 8 months and a 50% reduction of ectoparasites for 6 months.

Conclusions

Marigolds may be of some nematicidal value as a rotation crop between plantings of annuals if the marigolds have cash value, but the biocidal effects will have to be neutralized or diluted before the planting of the next annual crop. It's important to recognize that marigolds may host nematodes that are pathogenic to the subsequent crop.

We can visualize no procedure by which marigolds are a useful tool for nematode management in perennial crops. Marigolds contain an abundance of water soluble compounds other than thiophene compounds which are biocidal and nematicidal. These biocides are not active enough to correct the general replant problem of perennial crops but can result in a subtle phytotoxicity to established permanent crops if applied at nematicidal rates.

As a cover crop for orchards or vineyards, marigolds cannot be recommended because they cannot compete against grassy weeds.

Marigolds can be grown off site and transported to infested fields to reduce nematode populations; however, we have not seen improvements in plant growth or yield. The performance of marigold extracts has been similar to that of the plant refuse.

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FURTHER TESTS ON EFFECTIVENESS OF DISINFECTANTS FOR PREVENTING TRANSMISSION OF FIREBLGHT

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Fireblight attacks many pomaceous fruit trees including apple, pear, and quince. European and Asian pears are especially susceptible and may be devastated by the disease. Apple cultivars vary greatly in their response to fireblight. For instance, large limbs or entire trees of cv Fuji may be killed whereas infections of cv Granny Smith apple trees usually are restricted to fruit spurs or small shoots. Death of major branches is standard in more susceptible plants.

The disease is difficult to manage when weather is advantageous for the pathogen. Control is based upon frequent applications of antibiotic sprays during bloom followed by consistent removal of infected branches as they appear during summer and fall. Branches killed by fireblight are easily identified but the extent of the invasion of internal tissues cannot be ascertained. The bacteria, *Erwinia amylovora*, which causes fireblight, may inhabit seemingly healthy tissue well in advance of the visible necrotic margin of the canker. Thus, even though infected limbs are cut well below discernible cankers, there is a risk of contaminating the tools then transmitting the pathogen with the next cut. To avoid this, pruning shears should be disinfected between cuts. Household bleach is an excellent disinfectant and has been used successfully for this purpose by growers for many years. However, it also is corrosive to metal and blemishes clothing.

In 1990, we tested several disinfectants for effectiveness in preventing transmission of fireblight. The results of that work appear in the July/August 1991 issue of California Agriculture. One reviewer of that paper suggested that a quaternary ammonium compound should have been included in the tests. There are many such materials from which to choose, but one, Greenshield, has an agricultural label and thus is registered for use on crop plants. In 1991, we tested the efficacy of two quaternary ammonium products, Greenshield and Physan, and Clorox and Lysol concentrated disinfectant for preventing transmission of *E. amylovora*, and here report the results.

Materials and Methods

The disinfectants (active ingredients in parentheses) were: Clorox (sodium hypochlorite 5.25%), Lysol concentrated disinfectant, NOT Lysol cleanser, (soap 16.5%, o-phenylphenol 2.8%, o-benzyl-p-chlorophenol 2.7%, ethyl alcohol 1.8%, xylenols 1.5%, isopropyl alcohol 0.9%, tetrasodium ethylenediamine tetraacetate 0.7%), Greenshield (n-alkyl dimethyl benzyl ammonium chloride 10%, n-alkyl dimethyl ethylbenzyl ammonium chloride 10%), and- Physan (n-alkyl dimethyl benzyl ammonium chloride 10%, n-alkyl dimethyl ethylbenzyl ammonium chloride 10%).

The bactericidal qualities of the disinfectants were tested in this manner. A water suspension of *E.* amylovora, 10^6 colony-forming units per ml, was prepared and 1 ml added to 9 ml each of sterile deionized water and undiluted, 1:5, 1:10, and 1:20 dilutions of each disinfectant. The inoculated solutions were shaken briefly then 0.1 ml aliquots spread over the surface of culture plates containing Miller Schroth sorbitol medium. The seeded plates were incubated at room temperature for five days then colonies present counted.

A bioassay was used to evaluate the disinfectants for ability to prevent transmission of *E. amylovora*.

Shinseikii Asian pear fruit, 1 to 2 cm in diameter, were collected from an orchard in Tulare County. The fruit were surface sterilized in 1:10 clorox for 5 minutes (to eliminate any *E. amylovora* that may have been on the fruit surface), rinsed with tap water and allowed to air dry. Twenty fruit were inoculated with an isolate of *E. amylovora* and incubated at room temperature for 5 days by which time they were overtaken by fireblight and were black and oozing. These fruit were used as sources of inoculum for the transmission experiment as follows. A scalpel blade was infested with *E. amylovora* by drawing it through a diseased pear fruit. Immediately afterwards, the scalpel blade was disinfested by a dip, spray, and/or 1 minute-soak in each dilution of each disinfectant. Two cuts, 1-2 mm deep, then were made in a healthy fruit with the treated blade and there were six fruits per treatment. The scalpel blade was sterilized by alcohol dip and flaming between fruits. Controls included cuts made with an infested, nontreated blade, infested blade dipped in water, and infested blade surface sterilized by alcohol flame and dip. The fruit were incubated in moist chambers at room temperature for five days then observed for symptoms of fireblight.

The corrosiveness of the disinfectants were tested by immersing surgical carbon steel razor blades into water and each dilution of each disinfectant for 4, 8, and 24 hours.

Results and Discussion

Bacteria did not grow on culture plates after exposure to any dilution of any disinfectant tested, but grew abundantly on the water suspension control plates. Thus all four materials displayed excellent bactericidal properties under these conditions. However, *E. amylovora* was transmitted in some treatments of each disinfectant when the materials were used to cleanse the contaminated scalpel blade (Table 1). Of the cleansing methods tested, the dip was the least and the 1 minute soak the most effective. Transmission was prevented most often by Clorox, less by Lysol, and least by Greenshield and Physan. Razor blades soaked in Clorox were covered with a grainy rusty substance and the amount of damage increased with longer soak times. Greenshield and Physan caused a darkening of the blade but otherwise did not appear to harm the metal. Lysol and water did not affect the razor blades except for slight rusting after 24 hr in water.

Table 1. Effectiveness of disinfectants in preventing transmission of *Erwinia amylovora* to immature Shinseikii Asian pear fruit. 1991.

		Number Infected Fruit [a]		
		Dip	**Spray**	**1 min soak**
Clorox	Undil	0	0	0
	1:5	0	1	1
	1:10	0	1	0
	1:20	1	0	0
Lysol	Undil	2	2	0
	1:5	2	0	0
	1:10	6	3	0
	1:20	6	4	2
Greenshield	Undil	2	1	0
	1:5	5	3	1
	1:10	6	4	1
	1:20	4	0	4
Physan	Undil	3	3	0
	1:5	4	0	0
	1:10	4	0	2
	1:20	4	2	1
Water		6	6	6

[a]Six fruit per treatment, incubated 5 days after inoculation.

Testing disinfectants for activity against bacterial pathogens by exposing bacterial suspensions to solutions of disinfectants then observing growth on culture plates can be misleading. Products that completely exterminated bacteria in such tests did not also protect against transmission to young pear fruit. On the other hand, our bioassay method was extremely demanding in that we used very susceptible tissue, the young pear fruit, and probably very high numbers of bacteria on the infested blade. This may have been a far more stringent circumstance than pruning infected trees. However, we do not know the relative susceptibility of pruning wounds and wounds on young pear fruit.

Clorox was the most effective material tested and also the least expensive. The cost per gallon of the products were: Clorox $1.55, Lysol $37.33, Greenshield $38.16, and Physan $29.43. Greenshield and Physan are chemically identical and both were inadequate except when undiluted. Household bleach is perhaps the best choice unless damage to tools is a serious consideration. If so, then Lysol concentrated disinfectant (NOT Lysol cleanser) appears to be an acceptable alternative.

AUGMENTATIVE RELEASE OF *METAPHYCUS HELVOLUS* FOR CONTROL OF BLACK SCALE, *SAISSETIA OLEAE*, IN OLIVES

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Olives are one of the world's most important crops, planted on five continents and in over 25 countries. Black scale, Saissetia oleae, is the major insect pest of olives in California's Central Valley. "low-input" pest management hinges on black scale control as insecticide sprays may disrupt the excellent biological control of olive scale, *Parlatoria oleae*, and good biological control of oleander scale, *Aspidiotus nerii*. Black scale causes damage directly to the tree through feeding, and indirectly by producing honeydew upon which sooty mold grows, decreasing the photosynthetic capacity of the plant. Because of its high reproductive capabilities, black scale can increase to economically damaging levels in a single generation, which prompts many growers to annually use organophosphates as a prophylactic control.

To improve natural controls, black scale parasitoid importation to California began in the 1890's and continues today (Bartlett 1978, Kennett 1986, Daane & Caltagirone 1989, Daane et al. 1991). As a result of these efforts a number of parasitic and predaceous insects have become established, however, their success in controlling populations in the Central Valley is impeded by the scale's development pattern. Establishment of black scale parasitoids is best understood in light of the population dynamics of their host. From egg to adult, seven black scale stages can be differentiated (Argyriou 1963). Harsh climate and olive management practices produce black scale populations that are strongly univoltine and synchronous in the Central Valley (Figure 1). This results in long periods where two or more of the seven developmental stages are not found. Most black scale parasitoids are specific to only two or three consecutive host stages (Smith & Compere 1928, Compere 1940), making it difficult for them to establish where scale development is univoltine and synchronous.

University of California researchers are investigating a number of methods to increase natural control of black scale. Use of alternative host plants in olive orchards may provide scale populations that develop asynchronous with the olive tree population, thereby supplying host material for parasitoids and preserving resident natural enemies in the orchard. For example, the scale's developmental rate is faster on oleander, *Nerium oleander*, than it is on coyote brush *Baccharis pilularis consanguinea* (Bromberger et al. 1990). This habitat management technique is akin to the use of cover crops.

Another method to increase natural enemy populations, which has gained considerable attention in recent years, is through the mass release of parasitoids, predators, or pathogens. For black scale control on citrus, the Fillmore Insectary has been providing *Metaphycus helvolus*, an encyrtid parasitoid, to its members as an inoculative/ augmentative control practice. They report continued success. *M. helvolus* has a number of attributes that make it a good candidate for an augmentative release program in the Central Valley. These include the black scale host stages it attacks, its host feeding behavior which can account for greater scale mortality than direct parasitization, and its commercial availability.

To test the potential of *M. helvolus*, experimental blocks were established in Madera (1989 & 1990) and Tulare counties (1990). In 1989, each block consisted of three plots of 25 trees (5x5), separated by approximately 100-120 meters. The plots were assigned either no release, single release, or multiple release treatments. Single release treatments consisted of one release of 1,500 *M.* helvolus females. Multiple releases consisted of five releases of 300 *M. helvolus* females, every two weeks, beginning in late July (total 1,500). In 1990, each block consisted of paired control and treatment plots, separated by 300-500 meters. Treatment plots received one or two releases of 500 *M.* helvolus females, with the number and timing dependent on black scale population dynamics.

Plots were sampled every two weeks during the release period (June to September) and once or twice monthly thereafter. At each collection, five trees were randomly chosen in each plot and eight sample branches (20-30 cm) were taken from low inner and outer canopy sections, making 40 samples/plot/collection. Tree, number of leaves and olives, percent honeydew and sooty mold coverage, and black scale numbers, development stage, and condition (alive or parasitized) were recorded for each sample. Counts were transformed to the number of black scale per 100 leaves.

In 1989, scale densities were initially higher in treatment than control plots. In each block, percent black scale mortality, percent parasitism, and number of parasites were significantly higher in treatment plots, on most collection dates, after *M. helvolus* release (Figures 2-4). However, there was little difference in black scale numbers between treatment and control plots after parasite release.

Surprisingly, there was little difference between multiple and single release treatments. Parasite release began on a calendar schedule, designed from previous years' average scale developmental rate. Scale development was unusually slow in 1989 and initial *M. helvolus* release dates corresponded to field scale populations predominantly in the first instar stage which were unavailable for *M. helvolus* oviposition. The slow start of parasitism underlies the importance of release timing and implies that a single, well-timed release may be as effective as the more costly multiple release.

In 1990, two of the paired plots had low scale populations (<50 crawlers/100 leaves) and three had moderate to heavy scale populations (>100 crawlers/1 00 leaves). In plots with low scale density, black scale numbers decreased throughout the summer and there was no consistent difference in percent scale mortality between release and control plots. While there were significantly greater numbers of parasites in treatment plots after parasitoid release (t = 1.335; df = 1; P = 0.015), scale density or sample size may have been too low in these orchards to show the effect of augmentation on black scale numbers. In two plots with moderate scale densities, there was a significantly greater mortality of first (t = 4.108; df = 1; P 0.001), second (t = 2.904; df = 1; P = 0.004), and third (t = 2.481; df = 1; P = 0.015) instar scale (the stages which *M. helvolus* attacks), significantly greater parasite numbers (t = 5.419; df = 1; P <0.001), and significantly higher percent parasitism (t = 8.112; df = 1; P <0.001), in treatment plots than controls after *M. helvolus* release.

It was also observed that after the 1989 release, there was significantly higher parasite numbers in spring 1990, before the 1990 fall release, in treatment than control plots. It is suspected that there was substantial overwintering of the progeny of released *M. helvolus* that helped reduce scale numbers. The parasite numbers were subsequently reduced during the summer, when the proper host stages are not present. The winter 1990-91 freeze dramatically reduced scale populations in the study blocks and disrupted further investigation of the overwintering potential of released *M. helvolus* progeny.

In conclusion, augmentative release programs with *M. helvolus* for black scale control can be an important component of environmentally acceptable crop protection practices. Work is still needed to determine optimal release rates and methods. An important component of this program's success is the reliable supply of *M. helvolus*, usually produced by specialized, commercial insectaries, and their proper use by growers and pest control advisors. Through the combined efforts of growers, pest control advisors, insectary managers, and researchers we will see the continued development and use of successful augmentation programs for a number of crops.

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(figure unavailable)

Figure 1. Black scale development in Central Valley olive orchards is typically univoltine and synchronous, which hampers parasite establishment (from Daane 1989).

(figure unavailable)

Figure 2. The top graph shows greater percent black scale mortality in *M. helvolus* release plots than in control plots. The bottom graph shows consistently higher parasitism in the release plots. Arrows indicate the release dates.

(figure unavailable)

Figure 3. Parasites were released into to plot with the greater number of black scale, on a single data, indicated by the arrow. The bottom graph shows a dramatic increase in the number of parasites in the treatment plot

(figure unavailable)

Figure 4. Data in the top graph show that black scale density in the release plots remained higher than in the control plot. This may be due to differential pruning in the control plot and indicates the importance of open canopies for scale mortality, even with the addition of natural enemies. The bottom graph shows significantly higher parasite numbers in release plots than in the control plots, there is no difference between single and multiple release. Arrows indicate release dates.

ABSTRACTS

43rd ANNUAL CALIFORNIA WEED CONFERENCE, Santa Barbara, January, 1991

Can 2,4-DB Amine Replace 2,4-DB Ester for Weed Control in Alfalfa?

Bill B. Fischer and Kurt J. Hembree, UCCE Fresno County

During the past quarter century, 2,4-DB ester has been effectively used for the control of seedling broadleaved weeds in newly planted alfalfa. The superiority of 2,4-DB ester over 2,4-DB amine was first demonstrated in a trial conducted during the winter of 1960 in an alfalfa seed field near Coalinga, CA.

The use of 2,4-DB ester was continued until the spring of 1990 when Rhone-Poulenc Chemical Company decided to discontinue marketing Butoxone Ester®, the only formulation of 2,4-DB ester sold in California.

Re-Evaluation of 2+DB amine

Several trials were conducted during 1990-91 in Fresno County in newly planted alfalfa, grown for seed and hay, to evaluate the effectiveness of 2,4-DB amine applied in combination with adjuvants. In fields where the trials were conducted, the weeds and the alfalfa were in different stages of growth.

The results and observations can be summarized as follows:

- 2,4-DB amine (Butyrac 2000®) with a surfactant provided as effective control of broadleaved weeds as was obtained with 2,4-DB ester (Butyrac Ester).

- Both 2,4-DB amine and 2,4-DB ester caused temporary retardation in the growth (vigor) of the young alfalfa.

- Both formulations of 2,4-DB provided the most effective control of weeds in the seedling stage of growth.

- Alfalfa exhibited greater tolerance to both formulations of 2+DB when treated in the unifoliate to first trifoliate leaf stage of growth.

- The symptoms observed on the alfalfa in the 2,4-DB amine treated areas differed from the symptoms caused by 2,4-DB ester. Constricted veins and strapped leaves are often observed on alfalfa treated with 2,4-DB ester. The symptoms caused by 2,4-DB amino plus a surfactant were necrotic spots on the leaves, or entire leaflets became chlorotic and necrotic.

- The surfactant X-77 at 1/2% of the spray volume, and Surfel, a paraffin-based adjuvant, at 1.0 qt/a, in combination with 2,4-DB amine, provided equally effective control of susceptible weeds.

The amine formulation of 2,4-DB (Butyrac 200) with an adjuvant can be substituted for the ester formulation of 2,4-DB (Butyrac Ester) for the control of certain broadleaved weeds in alfalfa. Timing the application relative to the growth of the weeds is critical. The most effective control can be obtained when the herbicide is applied on weeds having 2 to 4 true leaves. Several weed species, especially shepherd's purse (*Capsella bursa pastoris),* fiddleneck *(Amsinckia* spp.*),* common groundsel *(Senecio vulgaris),* and common knotweed *(Polygonum aviculare)* become tolerant in their rosette stage or when their stems start elongating. Chickweed *(Stellaria media),* cudweed *(Gnaphalium* spp.), cheeseweed *(Malva* spp.), and some other broadleaved weeds and grasses are not controlled by 2,4-DB ester or 2,4-DB amine.

75TH ANNUAL PACIFIC BRANCH, ENTOMOLOGICAL SOCIETY OF AMERICA, Sacramento, Ca, June, 1991

<u>Translating Spray Application Coverage from Visual to Video/Computer Object Counts</u>
J. E. Dibble and S. Haire, U. C. Kearney Agricultural *Center*

Spray coverage tests in 50 foot tall walnuts were evaluated using water soluble food color dyes. Readings were made using a binocular microscope. Thus, a percentage figure value for coverage could be given to each spray card. The evaluations for 1990 needed to be upgraded yet not suffer for accuracy. A monochrome AgVision system was obtained to speed up the study. By coupling an IBM-AT compatible computer having microfloppy and hard disc drives, a math coprocessory high-resolution monochrome monitor and logitech bus mouse with a video camera, monitor and digitizer board, an object count of spray droplets could be obtained from the target cards via the AgImage Plus software and various translations. This digital image analysis system as used presently requires five video readings from each target card. By relating the object count to that percent coverage as obtained by the old visual-binocular microscope technique, the parameters of this relationship were determined.

<u>Cover Crops as an Element in the Development of a Pest Management Program for Grapes</u>
Harry H. Shorey, U. C. Kearney Agricultural Center

A movement has been seen during recent years toward the increased use of cover crops in the management of many vineyards. Cover crops are intended by growers not only to provide agronomic functions of improvement of soil fertility and tilth, but also to provide a pest management function of reducing pest densities in the vines, presumably through the attraction of harboring on beneficial predator and parasitic arthropods.

During the period from March through October, 1990, we surveyed plant-feeding and beneficial arthropods in 40 blocks of grapes in 14 vineyards in the Coachella and San Joaquin Valleys, California. Approximately half of the blocks had cover crops on the vineyard floor, and the other half were kept clean by cultivation. Each field was visited at 2- to 4-week intervals, and arthropods in both cover crops and vines were sampled by D-Vac suction sampling machine, followed by Berlese funnel separation of arthropods from plant debris. Also, counts of pest and beneficial arthropods were made on 30 grape leaves per block.

On the average, vineyards having cover crops developed about half as high a leafhopper population as did vineyards without cover crops. Certain predatory insects and spiders also were found in higher numbers in blocks of vines associated with cover crops.

We observed a diversity of management techniques for cover crops, including: (a) the use of many different individual or blended plant species or resident grasses and "weeds" as cover crops, (b) different irrigation approaches, with cover crops being maintained in some cases in a lush state and in others in a state of moisture stress during much of the time, (c) different proportions of the vineyard surface devoted to cover crops, and (d) different periods when cover crops were very low or absent, as caused by mowing and tilling operations.

More research is needed to assess the impact of these and other variables on the number and diversity of beneficial arthropods that build up in the cover crops and the degree of pest management success in the associated vines.

Distribution and Flight Phenology of the Russian Wheat Aphids, *Diuraphis noxia*, in California

C. G. Summers and A. S. Newton, U. C. Kearney Agricultural Center

The Russian wheat aphid, *Diuraphis n*oxia, was first recorded in California from Imperial County in March, 1988. It has spread throughout the cereal-growing regions of California and is presently in 34 counties from Imperial in the south to Modoc and Siskiyou in the north.

In 1989, 11 suction traps were established throughout California to monitor aphid flight activity. In 1989, limited flight activity occurred from September through November. In 1990 no fall flights were observed. The majority of flight activity occurred from mid-winter through late spring. Peak migration is in mid to late May. This coincides with grain maturity in the Central Valley and represents movement from ripening cereals to summer hosts.

Based on trap data, the high desert area, Antelope Valley in Los Angeles County, and the West Side of Fresno County, have the highest aphid populations.

PACIFIC BRANCH, AMERICAN PHYTO-PATHOLOGICAL SOCIETY, Bozeman, MT, June, 1991

Induction of Russet Scab with Cupric Hydroxide (Kocide 101) and Misting During Full-Bloom/Petal-Fall Stages of French Prune

Themis Michailides and David Morgan U. C. Kearney Agricultural Center

At full bloom of prunes application of IAA-producing strains (R299 and T565) of fluorescent *Pseudomonas* spp. did not affect the incidence nor the severity of russet scab (RS) on green, mature, or dehydrated prune fruit. However, fixed copper (Kocide 101) sprayed at full bloom one or three days after the application of R299 bacteria on misted trees significantly increased both the incidence and the severity of RS on green, mature, and dehydrated fruit. In addition, Kocide 101 applied on unmisted trees during full bloom significantly ($P < 0.05$) increased the incidence and the severity of RS on green and dehydrated fruit. Misting trees at petal-fall stage caused significantly greater incidence and severity of RS than misting during full bloom. RS of fruit developed on trees misted at full-bloom stage did not differ from that on fruit from nonmisted trees. In all cases, fruit collected near the misters developed significantly ($P< 0.05$) greater RS than those collected far from the misters. These results suggest that RS is triggered by the presence of free water on the young developing prune ovary, especially during the petal-fall stage.

Management of Omnivorous Leafroller, Summer Bunch Rot, and Leafhoppers in Wine Grapes by Leaf Removal and Use of *Bacillus thuringiensis*

J. J. Stapleton and W. W. Barnett U. C. Kearney Agricultural Center

A field experiment near Livingston, CA was done in 1990 to evaluate contributions of leaf removal and the biological insecticide *Bacillus thuringiensis* (BT) in managing omnivorous leafroller (*Platynota stultana* - OLR) in a 'Chenin blanc' vineyard. Incidence of sour rot and Botrytis bunch rot (summer rot complex), and seasonal dynamics of grape *(Erythroneura elegantula*) and variegated (*E. variabilis*) leafhopper also were determined. Leaf removal reduced incidence of sour rot and Botrytis bunch rot (P=0.05). Both leaf removal and BT reduced incidence of OLR (P=0.01). A consistent trend toward reduced numbers of leafhopper nymphs during the growing season was found following leaf removal.

Effect of Infection of Almond Fruit by *Wilsonomyces carpophilus*

B. L. Teviotdale and D. H. Harper, U. C. Kearney Agricultural Center

Almond fruit, infected by *Wilsonomyces carpophilus,* may bear many shot hole lesions on the hull without sustaining any apparent damage. Almond flowers (at full bloom) then fruit were inoculated at weekly intervals for 9 wk with 10^3,10^4, and 10^5 conidia/ml suspensions of the pathogen. Inoculation was followed by a 48-hr misting period. Significantly larger percentages of fruit were dropped from trees in treatments inoculated with 10^5 conidia/ml at shuck split and shuck fall stages of fruit development than with other concentrations or the noninoculated control. There were no significant differences in percent fruit dropped among treatments at other inoculation dates. Most dropped fruit bore a large, slightly sunken brown lesion and *W. carpophilus* was recovered from 80% of these lesions. Percent infected fruit and number lesions per fruit increased significantly with increasing levels of inoculum.

NEWS ITEMS

UCIPM Notes
Peter B. Goodell, U.C. Kearney Agricultural Center

The UCIPM Education and Publication unit provided this update of the following titles:

IPM for Citrus has been recently revised by Steve Dreistadt and is available from ANR Publications in Oakland or through local CE offices.

IPM for Apples and Pears is finished and on its way to the printers. This will be available probably in July. Barbara Ohlendorf is the writer who put this one together.

I PM for Strawberries, being compiled by Larry Strand, will be out probably by mid-year, 1992.

IPM for Landscape Ornamentals, being compiled by Steve Dreistadt, is well underway.

Larry Strand has begun making minor changes to IPM for Potatoes which will go into its 2nd printing and be available by the end of this year.

Barbara Ohlendorf has started revisions of IPM for Rice which is currently out of print.

Mary Louise Flint is senior author with Sheila Daar and Richard Molinar on UCIPM Publication Number 12 - Establishing Integrated Pest Management Policies and Programs: A Guide for Public Agencies. This 9 page booklet is available from the IPM Education and Publications Office.

Not an IPM manual, but the second volume of the Pesticide application Compendium -- Residential, Industrial, and Institutional Pest Control -- by Pat Marer is finished and on its way to the printers. It will be available by the end of June.

and don't forget. . .

Pests of the Garden and Small Farm by Mary Louise Flint is an outstanding compilation of pest management information and pest photos geared toward the homeowner or small-scale grower. This book is much more comprehensive than anything else on the market. It is available from ANR Publications or local CE offices.