This newsletter is published by the University of California Kearney Plant Protection Group and the Statewide IPM Project. It is intended to provide UC DANR personnel with timely information on pest management research and educational activities. Further information on material presented herein can be obtained by contacting the individual author(s). Farm Advisors and Specialists may reproduce any portion of this publication for their newsletters, giving proper credit to individual authors.

James J. Stapleton, Charles G. Summers, Beth L. Teviotdale, Peter B. Goodell, Timothy S. Prather, Editors

IN THIS ISSUE

ANNOUNCEMENT

NOTE ON CITING THIS PUBLICATION: If you cite articles from UCPPQ in any outlet, including peer reviewed manuscripts, please include the "UC" in the name i. e. *UC Plant Protection Quarterly*. This differentiates us from a similar publication from Australia called Plant Protection Quarterly.

This issue of UC Plant Protection Quarterly introduces two new features. First is "**New California Pests**" Here we will report on newly discovered or introduced pests, including organisms that appear to have become adapted to new hosts or have built up to numbers capable of causing damage and crop loss on hosts not previously affected. We will include a brief description of the pest, its damage, and its known distribution. Second is a reference list of "**Recent Publications**" with a brief description of the contents, that might be of interest or use to the readership of UCPPQ. You are invited to submit material for either of these new sections to: Dr. James J. Stapleton, Kearney Agricultural Center, 9240 S. Riverbend Ave., Parlier, CA 93648. Please follow the format presented in this issue. Decisions on publication will be made by the editors.

NEW CALIFORNIA PESTS

Cowpea Aphid, *Aphis craccivora,* **in alfalfa** -- This aphid was reported in mid-February causing serious damage to alfalfa in the Barstow area. While known from alfalfa, cowpea aphid has traditionally not been considered an alfalfa pest and is generally found only in small numbers. Current populations in some fields in the Barstow area exceed 75 to 100 per stem. Cowpea aphid is a small aphid, shiny black in the adult and dull slate grayish in the nymph. Plants in infested fields are stunted and covered with honeydew. Cowpea aphid is currently found infesting alfalfa in San Bernardino, Riverside, and Imperial counties. The sample received from the Barstow area was heavily parasitized, but many fields are still requiring insecticide treatment. Please report any infestations to Charlie Summers at chasum@uckac.edu —*Charles G. Summers*.

Lettuce Aphid, *Nasonovia ribis-nigri***, and Foxglove aphid,** *Aulacorthum solani* -- These aphids were first reported in the Salinas Valley in 1998. Both species appear similar and both infest the inner portion of lettuce. The lettuce aphid appears to be the more important of the two. It is considered one of the most important lettuce pests in Europe, Canada, and South America. However, foxglove aphid can vector lettuce mosaic virus (LMV) while transmission of LMV by the lettuce aphid has not been documented. *A. solani* was reported from the Salinas Valley several years ago, but current discovery may represent a new biotype. While both infest lettuce, only *A. solani* infests celery. Both aphids have short life cycles and populations can build rapidly. Lettuce aphid has several color forms, ranging from green to orange to deep pink. Both prefer the youngest tissues near the center of the plant. —*Bill Chaney*.

Vine mealybug, *Planococcus ficus* **(Signoret) in grapes** -- Vine mealybug was first found in California in June 1994 in the Coachella Valley. In June 1998 it was found in the San Joaquin Valley south of Arvin. Subsequently, two additional finds have been made in Fresno County.   All SJV infestations have some association with Coachella Valley vineyards where the pest is well established. Vine mealybug can be found on all parts of the vine including the roots while grape mealybug is found only above ground. Vine mealybug is slightly smaller than grape mealybug and the wax filaments protruding from the body are much shorter. Vine mealybug is very similar in appearance to citrus mealybug which can be viewed in the Citrus Pest Management Manual available at the local Cooperative Extension offices. If suspected finds are made, contact your local Farm Advisor and Ag Commissioner. —*Walt Bentley.*

Aspergillus Vine Canker -- Aspergillus vine canker, caused by *Aspergillus niger*, was first noted in the San Joaquin Valley in the fall of 1989. It is currently found in Tulare, Kern, and Fresno counties on Red Globe, Crimson Seedless, Chardonnay, and Grenache. Parasitic activity on shoots is unusual for this fungus. Symptoms include sap exuded from the infection site and cutting into the shoot reveals discolored tissue.   In October/November, the canopy of girdled vines prematurely display fall colors. The trunk is slightly larger where the canker occurs.   Black spores are abundant within the canker and are sometimes visible on the surface. Cutting back in the fall assures that all the cankers have been removed. In April the growers should revisit the vines and evaluate shoot growth. Vines with normal growth can be left alone and those with weak shoot growth should be cut back below the canker and the vine retrained. —*Bill Peacock, Themis Michailides, & Pete Christensen.*

Olive fruit fly, *Bactrocera (Dacus) oleae* -- Olive fruit fly was first found in California in West Los Angeles in October, 1998. It is presently found in West Los Angeles, Santa Monica, Cheviot Hills, and Beverly Hills. Flies have also been found in Garden Grove, Rossmor, and outlying areas of Los Angeles County. Both adults and larvae have been found. Olive is the only known host. Olive fly is a typical trypetid fruit fly, and has characteristic "pictured" wings.   Trapping continued throughout the winter using food bait and yellow sticky traps baited with ammonium bicarbonate. When it is available, sticky traps will also be baited with the olive fly pheromone. Eradication of olive fruit fly is expected to require at least two years, and longer if flies are found during the summer of 1999 in other areas of the state. Failure to eradicate olive fruit fly could mean the end of commercial olive growing in California.—*Richard E. Rice*

RECENT PUBLICATIONS

Please contact the individual authors if you would like a reprint of any of the publications listed here.

Holtz, B. A., T. J. Michailides, and C. X. Hong. 1998. Development of apothecia from stone fruit infected and stromatized by *Monilinia fructicola* in California. Plant Disease 82:1375-1380.

This paper describes experiments in which apothecia of *Monilinia fructicola* were produced in February and

March from fully stromatized "mummies" that were placed in the orchard (on the soil surface or buried to a depth of 2 to 3 cm) in October, November, or December. Mummies placed in the field in August, September, January, and February did not produce apothecia. Leaving mummies on the soil surface versus burying them 2 to 3 cm below did not affect the development of apothecia. Apothecia were never produced from non-stromatized or recently-infected (fleshy) fruit. In orchard experiments, apothecia were only observed in plots with non-disturbed orchard floor vegetation whereas no apothecia were found in either herbicide-treated or rototilled plots. The results of this study suggest that stone fruit growers should remove fruit infected by *M. fructicola* soon after harvest instead of knocking mummies from the trees during December and January.

Hong, C. X., Michailides, T. J., and Holtz, B. A. 1998. Effects of wounding, inoculum density, and biological control agents on postharvest brown rot of stone fruits. Plant Disease 82:1210-1216.

The effects of wounding, inoculum density, and biological agents (*Trichoderma* and *Rhodotorula* spp.) on postharvest brown rot of stone fruits were determined. Brown rot caused by *Monilinia fructicola* was observed frequently on wounded nectarine, peach, and plum fruit inoculated with two spores of *M. fructicola* per wound, and occasionally on unwounded nectarine and peach fruit inoculated with the same spore load. Lesion diameter of brown rot increased when wounded nectarines and peaches were inoculated with 20 or 200 spores per wound. All *Trichoderma* isolates substantially reduced brown rot on peaches by 63 to 98% and on plums by 67 to 100% when fruit were inoculated with *M. fructicola* following the application of a biological control agent. This study identified two isolates of *Trichoderma atroviride*, one isolate of *Trichoderma viride*, and one of *Rhodotorula* yeast which show potential for further development as biocontrol agents of postharvest brown rot control of stone fruits.

Summers, C. G. 1998. Integrated pest management in forage alfalfa. Integrated Pest Management Reviews 3:127-154.

This review paper summarizes the current status of pest management in forage alfalfa. Included are the roles of host plant resistance, biological, chemical, cultural and mechanical control, as they relate to pest management of insects, diseases, nematodes, weeds, and vertebrates. Multiple pest interactions are evaluated and strategies for the management of multiple pests occurring

simultaneously are discussed. There is a section on modeling, including economic models, of the alfalfa ecosystem and the role of the World Wide Web in alfalfa pest management. The paper describes alfalfa's role in the agricultural landscape including its use as a rotational crop and its status as a field insectary in the production of natural enemies. The paper contains 291 literature citations.

Stapleton, J. J., and R. A. Duncan. **1998**. Soil disinfestation with cruciferous amendments and sublethal heating: effects on *Meloidogyne incognita, Sclerotium rolfsii* and *Pythium ultimum*. Plant Pathology 47:737-742.

Controlled environment experiments were carried out to test the effects of amending soil with fresh and dried residues of certain cultivated and noncultivated cruciferous plants, including *Brassica nigra, B. oleracea* var. *chinensis, B. oleracea* var. *italiensis, B. oleracea* var. *capitata, B. oleracea* var. *compacta* and *Raphanus sativus*; and of a sublethal soil heating regime (38° C day/27° C night) on survival and activity of nematode and fungal plant pathogens including *Meloidogyne incognita, Sclerotium rolfsii* and *Pythium ultimum*. Addition of the various cruciferous amendments to soil without heating resulted in significantly reduced tomato root galling (38-100%) by *M. incognita* or reduced recovery of active fungal pathogens (0-100%) after 7 days incubation. When cruciferous soil amendments were combined with the sublethal heating regime, nematode galling was reduced by 95-100%, and recovery of active fungi was reduced by 85-100%. No differences were found between fresh or dried cruciferous residues.

Guo, L. Y., T. J. Michailides, and D. P. Morgan. 1999. Survival of *Mucor piriformis* in soil of apple orchards in California. Plant Disease 83:189-193.

Apple orchards were sampled in 1995 and 1996 to determine the population levels of *Mucor piriformis*. The highest population of 119 propagules of *M. piriformis*/g of dry soil occurred during winter. Populations declined during summer and fall and increased again in winter and early spring of the following year. The time of increase in *M. piriformis* populations corresponded with postharvest drop and decay of apples. Experiments compared changes of *M. piriformis* populations in soil with intact fruit left on the orchard floor, sliced fruit, or after removal of fruit from the orchard. The greatest numbers of *M. piriformis* propagules occurred in soil with apple pieces, followed by soil with intact apples and finally the lowest numbers

were in soil without apples. Results suggest the best time to sample soils for the occurrence of *M. piriformis* is from January to March. Flail-mowing the orchard floor after harvest may increase population levels of *M. piriformis* propagules in soil.

Doster, M. A., and T. J. Michailides. 1999. Relationship between shell discoloration of pistachio nuts and incidence of fungal decay and insect infestation. Plant Disease 83:259-264.

Shell discoloration of pistachio nuts taken from orchards and processing plants was related to kernel fungal decay and insect infestation. Nuts with ruptured hulls varied in the amount of shell discoloration, ranging from none to extensive. As shell discoloration increased, kernel decay increased. Nuts with no discoloration had little or no fungal decay or navel orangeworm (*Amyelois transitella*) infestation. Processed nuts with an oily-shell appearance had the highest incidences of kernel fungal decay and navel orangeworm infestation. Nuts with a crinkled shell, extensive dark brown discoloration, or moderate dark brown discoloration along the suture had relatively high levels of decayed and infested kernels. Nuts with yellow discoloration, moderate dark brown discoloration not along the suture, or no discoloration had little or no decay and infestation. Shell characteristics may be used to identify poor quality nuts and thus improve the quality of nuts packaged for market.

ARTICLES

STUDIES ON SOURCES OF INOCULUM OF ALTERNARIA LATE BLIGHT OF PISTACHIO
N. Evans, T. J. Michailides, D. Morgan and D. Felts. UC Kearney Agricultural Center

Introduction

Alternaria late blight caused by *Alternaria alternata* (Fr.) Keissler is a destructive disease of California pistachios and continues to be an annual problem. Although typical symptoms of Alternaria late blight appear later in the season, the disease is thought to develop from latent infections which occur on leaves and developing fruit early in the season. In August and September, typical late season symptoms characterized by angular or circular, dark brown to black, necrotic lesions are observed on leaves of both male and female trees. Later in the season, black sporulation can usually be observed at the center of the lesions. Multiple infections on leaf blades cause leaf blight and defoliation. On mature fruit, infected areas are black irregular lesions along the site of cracked hulls and

severe infections on the fruit can cause hull necrosis and lead to shell staining. Alternaria also invades the kernel where it causes rot and the development of off flavors that reduce fruit quality. Control of Alternaria blight is problematic and continuing research is being carried out to optimize fungicidal and cultural control methods. The goal of this project was to investigate the sources of primary inoculum which infect the crop early in the season and produce the latent infections on leaves and developing fruit.

Materials and Methods

Orchard survey

More than 100 buds were randomly collected from each of 26 orchards throughout California. Buds were processed using two methods. In order to assess the percentage of infected buds, 60 buds were surface sterilized, split and plated on acidified potato dextrose agar (APDA). In order to assess the number of infective propagules within the bud scales, three replicate sets of 15 buds were crushed in a mortar with 20 ml sterile distilled water (SDW), shaken in sterile plastic bottles on a shaker for two hours and aliquots (100µl) were plated on APDA. Colonies of *A. alternata* were counted following incubation at 25°C for 6 days.

Study of bud infection and other sources of inoculum at two orchards

Bud, leaf and fruit trash, male and female flowers and leaf and fruit material were collected from two orchards in Kings County, California throughout the 1998 growing season (Kettleman Pistachio Growers [KPG] and Nichols Farms). Buds scales were individually dissected with a sterile scalpel and shaken with 50 ml SDW for 2 hours. Leaf trash (25 g = ~ 50 leaves) was shaken in 500 ml SDW for 2 hours. Leaflets (3 samples x 20 leaflets), developing fruit (3 samples x 10 fruit) and male and female flowers (3 samples x 5 flowers) were shaken in 500 ml, 100 ml and 50 ml SDW, respectively, for 2 hours. Aliquots (100 µl) of shaken solutions from all tissues were plated onto APDA and the number of *A. alternata* colonies was counted following incubation at 25°C for 6 days. Male and female flowers (surface sterilized) and pollen were also plated onto APDA and assessed for *A. alternata* colonies following 6 days incubation at 25°C. An Anderson spore trap was used at both sites (4 samples x 0.5 hour samples). Spore trap Petri dishes containing APDA were transported back to the laboratory, incubated at 25°C and the number of *A. alternata* colonies was assessed after 6 days.

Results and Conclusions

Table 1 shows there was a high levels of *A. alternata* infection on buds and a high number of propagules per bud throughout the whole of the California pistachio growing area. The percentage of buds infected and the mean number of propagules per bud in northern counties (Butte and Glenn) reflects the dominance of *Botryosphaeria dothidea* which is the major pathogen in this area. *In vitro* competition experiments have shown that *B. dothidea* is able to outcompete *A. alternata* with respect to mycelial growth. In the main pistachio growing area of California (Kings, Tulare and Kern counties) percentage infection was very high (98.2 -100 %) but the number of propagules per bud was observed to decrease from samples for the southern boundaries of the growing area (Kern county).

Data from the two orchards in Kings County indicated that bud scales from Nichols Farm orchard carried significantly more *A. alternata* infection propagules than those from the KPG orchard (Table 2). Levels of *A. alternata* propagules in the leaf trash were also higher at this site in comparison to levels observed at the KPG orchard. These two results are interesting as they reflect general levels of disease observed later in the season at harvest when Alternaria late blight is a serious annual problem at Nichols Farms. This orchard is flood irrigated and consequently relative humidity levels are much higher (Evans et al., 1998).

Infection of flowering structures data (Table 3) indicate that *A. alternata* levels were generally lower on surface sterilized male than female flowers. This is surprising as the leaves of male "Peters" pistachio trees are far more susceptible to Alternaria late blight and the data from washed flowers is in agreement with this observation. Once again, the pattern of higher levels of inoculum at Nichols Farm is reflected in the data for infected pollen.

The level of *A. alternata* propagules washed from both leaflets (Table 4) and fruit (Table 5) sampled at the KPG orchard remained fairly low and constant throughout the season, however a significant increase was observed immediately prior to harvest. In contrast, changes in the amount of propagules washed from both leaflets and fruit sampled from the flood irrigated site (Nichols Farms) were much more dynamic. In general, levels were significantly higher for some sample dates than others, when the number of propagules decreased dramatically. Close analysis of the weather data for this site indicated that the sharp decreases recorded were associated with heavy El Niño rains which had occurred during the days immediately preceding the sample being taken, presumably conidia were washed from the leaves. The exception to this was the sharp decrease in propagules on leaflets sampled from the Nichols Fams orchard during the last three sampling dates. This decrease was due to a dramatic increase in *Penicillium* and *Aspergillus* spp. (predominantly *A. niger*) which outgrew all other fungi on Petri dishes.

The levels of aerial *A. alternata* conidia present at the Nichols Farms orchard during the 1998 season was significantly higher than was observed at KPG (means; 21.85 and 6.53, respectively. $P < 0.001$, Figure 1). Whether this is associated with any one of the particular inoculum sources investigated is not known at this time and further studies will be conducted during the coming season. As *A. alternata* is fairly ubiquitous throughout the environment (Rotem, 1994), it would seem plausible that inoculum for the onset of this disease is derived from a multitude of sources. It is interesting that buds appear to be so heavily infested in California pistachios and, as the pathogen was observed to be actively growing and sporulating on bud scales early in the season, it may be possible that leaf and flower material (and subsequently fruit) are infected as they emerge from the breaking bud. However, as bud scales are generally regarded to be dead tissue, whether the observed growth forms a saprophytic phase in the life cycle of this pathogen or whether there is a closer association between pathogen and host is not known at this time.

References

1. Evans, N., T. J. Michailides and D. P. Morgan. 1998. Environmental and cultural parameters affecting the progress of Alternaria late blight development. Calif. Pistachio Industry Annu. Rep. Crop Year 1997-98. pp. 99-103.

2. Rotem, J. 1994. The Genus *Alternaria*; Biology, Epidemiology and Pathogenicity. APS Press, St Paul. pp. 326.

Table 1. Mean percentage of pistachio buds infected with *Alternaria alternata* and mean number of *A. alternata* propagules per bud by county.

County	Number of orchards sampled	Percentage of buds infected	Mean number of propagules per bud
Butte (north CA)	2	69.0	70.2
Glenn	4	94.5	183.1
Merced	3	78.9	211.95
Madera	4	96.0	293.52
Kings	6	99.2	225.2
Tulare	2	100.0	137.8
Kern (south CA)	5	98.2	95.6

Table 2. Mean number of *Alternaria alternata* propagules per bud scale and in leaf and fruit trash material at two pistachio orchards in Kings County, California.

	Propagules per bud scale (3/25/98)	Aa propagules per gm leaf trash (4/8/98)
Kerman Pistachio Growers Kings Co.	22.17 a	500 a
Nichols Ranch, Kings Co.	42.78 b	700 a

Table 3 Infection of pistachio flower material by Alternaria alternata at two orchards in Kings County, California.

	Colonies per directly plated surface-sterilized flower		Flower washings (propagules per flower)		Pollen, Colonies per plate
	Male	Female	Male	Female	
Kerman Pistachio Growers Kings Co.	0.82 a[1] (a)	1.63 b (a)	443.3 a (a)	136.7 b (a)	0.33 (a)
Nichols Ranch, Kings Co.	1.35 a (b)	2.10 b (a)	686.7 a (a)	326.7 b (b)	2.8 (b)

1 Means followed by a different letter are significantly different according to LSD test at *P*=0.05. Letters in parenthesis indicate differences in site-site data.

Table 4. Mean number of propagules of *Alternaria alternata* washed from leaflets of pistachio sampled from two orchards in Kings County, California during the 1998 season.

Date	Kettleman Pistachio Growers	Nichol Farms
6-May	317 C	975 bc
13-May	842 Bc	800 bcd
20-May	633 C	642 bcde
27-May	825 Bc	1733 a
2-Jun	350 C	1000 bc
10-Jun	483 C	933 bcd
17-Jun	450 C	1117 b
24-Jun	350 C	1950 a
1-Jul	333 C	942 bcd
8-Jul	358 C	417 cde
15-Jul	175 C	317 de
22-Jul	250 C	308 de
5-Aug	250 c	308 de
26-Aug	2725 a	625 bcde
2-Sep	675 c	8 e
7-Sep	1458 b	25 e
16-Sep	1500 b	33 e

1 Means followed by a different letter are significantly different according to LSD test at *P* = 0.05.

Table 5. Mean number of propagules of *Alternaria alternata* washed from fruit of pistachio sampled from two orchards in Kings County, California during the 1998 season.

Date	Kettleman Pistachio Growers	Nichols Farms
6-May	16.67 b[1]	70 cd
13-May	23.33 b	63.33 cd
20-May	116.67 b	56.67 cd
27-May	66.67 b	90 cd
2-Jun	10 b	76.67 cd
10-Jun	76.67 b	233.33 ab
17-Jun	46.67 b	120 bcd
24-Jun	23.33 b	66.67 cd
1-Jul	66.67 b	116.67 bcd
8-Jul	60 b	123.33 bcd
15-Jul	70 b	310 a
22-Jul	26.67 b	110 bcd
5-Aug	50 b	136.67 bcd
26-Aug	240 a	163.33 bc
2-Sep	43.33 b	6.67 d
7-Sep	83.33 b	3.33 d
16-Sep	43.33 b	10 d

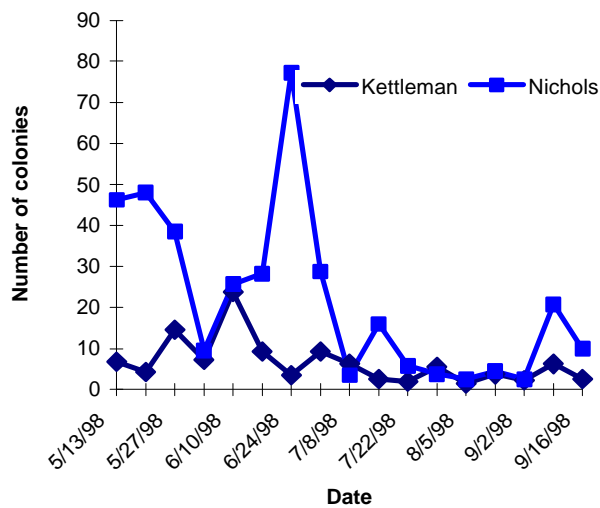1 Means followed by a different letter are significantly different according to LSD test at *P* = 0.05.

Figure 1 Mean number of *Alternaria alternata* colonies produced per Petri dish placed in an Anderson spore sampler

MONITORING DISEASE MODEL MICRO-CLIMATES: A PERSPECTIVE ON LEAF WETNESS INSTRUMENTATION PITFALLS

Phil A. Phillips, UCCE, Ventura County

The Sensor Placement Issue

Because of the importance of meteorological conditions on plant disease development (Jones, 1986), research over the last decade has focused more on understanding disease epidemiology and the development of disease forecasting or risk models that quantify the influence of environmental and biological factors on disease. Over the last several years, interest in utilizing disease models to more effectively time fungicide applications has increased (Pest Cast Survey, 1996). By 1997, several weather networks, both public and private, had been established throughout California (Broome et al., 1998). Despite the proliferation of weather stations, there remain some critical instrumentation issues to resolve before many of the models can be fully implemented in the field. One such issue is the industry-wide standardization of instrumentation so that each disease model operates similarly with different hardware. Another issue, to be addressed in the following discussion, is that of instrument placement. More specifically, the placement of leaf wetness sensors (or data loggers containing leaf wetness sensors), which are used to drive many of the models, can have significant effects on disease model outputs. Both sensor proximity to the crop and placement within the crop being

monitored can be critical. Meteorological factors can vary greatly in amplitude once the crop canopy is encountered (Fig. 1). Sensor placement outside of or at the periphery of the crop to be monitored can produce very erroneous model inputs because the sensor is not measuring the microclimatic effects of irrigation or dew point condensation that the disease causing organism is experiencing within the managed crop area. Similarly, sensor placement within the crop may be critical. Depending upon elevation and orientation within the canopy, sensor readings can be as much as four or more times greater at one location versus another. General observations indicate that leaf wetness sensor placement is most critical in row crops, where crop canopies are in close proximity to irrigated soil. For tree and vine crops, canopies are further removed from the irrigated orchard or vineyard floor and the canopies are more exposed to aeration and uniformity of drying. In these situations, leaf wetness sensor placement within the canopy is generally less critical and thus plays a less subjective role in disease model outputs.

Practical application of a disease model: the celery late blight model

The disease model currently being validated in California for Septoria leaf spot or late blight of celery, (caused by *Septoria apiicola*) (Phillips, 1997), is a good example of the dramatic effects the subjective placement of leaf wetness sensors can have on model outputs. This model is patterned after the "TomCast" model for Alternaria blight of tomato and was first validated in Canadian studies on celery. The model is actually quite simplistic, operating solely on daily inputs of average temperature during periods of leaf wetness and the duration in hours of those leaf wetness events (Madden and Ellis, 1988; Sheridan, 1968). The model measures critical periods of disease development (Mathieu and Kushalappa, 1991). There is a lower thermal threshold of 13 degrees C (70 degrees F), below which disease development is so minimal as to be inconsequential. Once temperatures rise above the lower threshold, subsequent periods of measured leaf wetness will drive the model, accumulating what are commonly known as DSV or "disease severity values" (the disease "index" in other models). This is similar to degree-day accumulations used for determining arthropod development over time. For Septoria late blight of celery, a threshold of between 20-30 accumulated DSV after the celery is transplanted is generally used to determine the initial and each subsequent fungicide application. The DSV "clock" is reset to zero and accumulations resume immediately after each fungicide application. Depending upon field history relative to

fungal pressure in previous crops and on the stage of celery crop growth, the threshold used may be either stringent or more relaxed. For example, in a field with a history of significant previous Septoria pressure, the grower may elect to use the more conservative threshold of 20 DSV before the initial fungicide is applied or between subsequent fungicide applications. Conversely, in new ground or in a field with minimal previous Septoria history, the grower may elect to use a DSV threshold of 30 DSV early in the crop while the canopy is open, well aerated, and easily covered by a fungicide application. He may then decide to gradually shift to more conservative thresholds for subsequent fungicide applications as the canopy closes and fungicide coverage is more difficult.

Sensor placement: elevation effects

A problem with the elevation of leaf wetness sensor placement in celery emerges when the plant canopy approaches a height of 15-18" above the bed surface. At this point and thereafter, canopy closure produces a strong vertical gradient in leaf wetness readings, especially after an irrigation. Celery plants can remain wet nearly all day in the lower ½ of the canopy while the upper and more exposed portions experience a daily cycle of condensation and wetting overnight and then drying during the day. Comparative temperature and leaf wetness data for two leaf wetness sensor elevations within the celery canopy during December 1997, are shown in Figure 2 using two Spectrum Technologies, Inc. leaf wetness/temp. loggers (model #3610T). One set of data is from a logger placed 2" above the bed top while the other set is from a logger placed at 15" above the bed even with the heart tissue of the maturing celery crop (the top of the celery canopy was 6" above this logger). In this example, there are clearly strong differences in both the daily maximum temperature and the daily average hours of leaf wetness recorded between the lower canopy and the upper middle celery canopy.

Sensor placement: orientation effects

A corollary issue is the orientation of the sensor at any given elevation within the crop canopy. Placement of the leaf wetness sensor with its moisture sensitive surface oriented straight down verses straight up and either parallel to the soil surface or at a 45 degree angle to the soil surface can give drastically different readings. Comparative data for these leaf wetness sensor orientations are shown in Figures 3 and 4. Again, Spectrum Technologies loggers were used during December 1997 (Fig. 3) and January 1998 (Fig. 4). Where these loggers were located at 15" above the bed

in the upper middle canopy, the logger oriented face up produced an average daily high temperature nearly 4 degrees higher than the logger oriented face down. Furthermore, the average daily hours of leaf wetness recorded were nearly four times as great with the logger oriented face down than with the logger oriented face up. For this study and the previous studies conducted during December 1997, the temperatures recorded during the periods of leaf wetness were too low to generate DSVs for the celery late blight model. However, for the 45 degree angle orientation study conducted in January 1998, temperatures during periods of leaf wetness were high enough to generate DSV (Fig. 4). As in the previous study, the average daily high temperature was about 4 degrees higher with the sensor oriented up versus the sensor oriented down. The difference in recorded average daily hours of leaf wetness was not as great as in the parallel orientation study. However, leaf wetness was 50% greater with the sensor oriented down at a 45 degree angle verses in the up position. More importantly, the downward oriented sensor accumulated 5 times as many DSV as the sensor in the upward orientation at the same elevation within the plant canopy. Extrapolated to the entire season this could mean five times as many fungicide applications would be recommended with the downward oriented leaf wetness logger than one in an upward facing position.

More studies needed

Sensor orientation studies need to be conducted with a number of different commercially available leaf wetness sensors. For leaf wetness sensors, it may be the bulk mass of the sensor itself that plays a role in the readings it generates. Those with the greatest mass may tend to take longer to heat up after a cool, moist night, causing a delay in water evaporation off the sensor. For now, the bottom line is how conservative the end user wants to be with the model outputs. For the celery example, the closer the sensor placement is to irrigated soil, the more frequently the model will indicate the need for fungicide applications. For the celery late blight model, a realistic compromise for leaf wetness sensor placement is mid-canopy, just above the crown tissue and at an upward facing orientation of 45° to prevent moisture puddling on the sensor surface. Using this protocol, this model has been successfully validated in Ventura and Santa Barbara Counties. An average savings of one fungicide application per crop resulted with no loss in crop quality or yield due to Septoria late blight (Reitz et al., 1999).

Leaf wetness sensor placement should always be within the field being monitored. Placement outside the field, even if only a few feet away, can give erroneous

readings, generally underestimating periods of leaf wetness the crop foliage is actually experiencing. Differences in dew point and RH within the crop versus just outside the crop can produce significant differences in measured duration of leaf wetness. Additionally, temperatures experienced by a sensor outside a field can be considerably different due to increased radiant energy from the soil and lack of evaporative cooling from the plant. A general rule of sensor placement is to place the sensor in the optimum environment for development of the plant disease being monitored.

In commercial agriculture, the application of disease models that rely on inputs from leaf wetness sensors or loggers comes with several caveats. Growers and PCAs need to understand that placement of this instrumentation within production fields, orchards, and vineyards requires careful thought and field to field consistency if the full benefit of the model being used is to be realized.

References

1. Broome, J. C., W. D. Gubler, A. C. Bordas and J. F. Strand. 1998. Use of weather data and disease risk assessment in California - *Botrytis cinerea* on grapes and strawberries. Sustainable Agriculture Newsletter 10(3):7.

2. Broome, J. C., J. T. English, J. J. Marois, B. A. Latorre, and J. C. Aviles. 1995. Development of an infection model for Botrytis bunch rot of grapes based on wetness duration and temperature. Phytopathology 85:97-102.

3. Jones, A. L. 1986. Role of wet periods in predicting foliar disease. Pages 87-100 in: Plant Disease Epidemiology, Population Dynamics and Management. K.J. Leonard and W.E. Fry, eds. MacMillan Publishing Co., New York.

4. Madden, L.V. and M.A. Ellis. 1988. How to develop plant disease forecasters. Pages 191-207 in: Experimental Techniques in Plant Disease Epidemiology. J. Kranz and J. Rotem, eds. Springer-Verlag, New York.

5. Mathieu, D. and A.C. Kushalappa. 1991. Effects of temperatures and leaf wetness duration on the infection of celery by *Septoria apiicola*. Phytopathology 83:1036-1040.

6. Pest Cast Project at http://www.ipm.ucdavis.edu/ DISEASE/california_pestcast.html

7. Phillips, P. A. 1997. Late blight of celery (*Septoria apiicola*): timing fungicide applications based on its biology as predicted by in-field weather stations. Lompoc Row Crop Pest Management Project "IPM Information Series #6", 4 pp.

8. Reitz, S. R., G. S. Kund, W. G. Carson. P. A. Phillips, and J. T. Trumble. 1999. Economics of reducing insecticide use on celery through low-input pest management strategies. Agriculture, Ecosystems and Environment: in press (accepted for publication 2/5/99).

9. Sheridan, J. E. 1968. Conditions for germination of pycnidiospores of *Septoria apiicola*. New Zealand Journal of Botany 6:315-322.
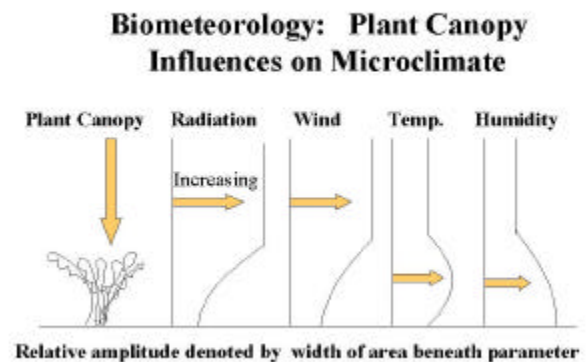
Figure 1. Solar radiation and wind speed decrease within the crop canopy while temperature and humidity increase.
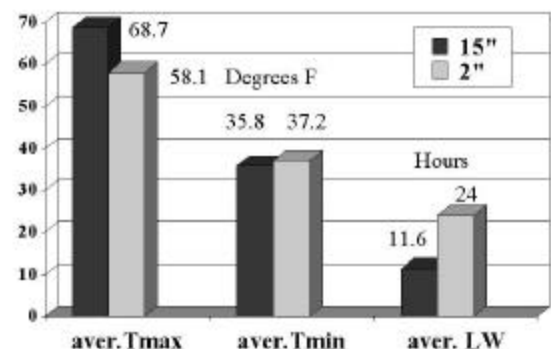

Figure 2. Average daily maximum and minimum temperatures are more moderated and daily hours of leaf wetness are much greater with sensors located at bed level than at 15" above the bed in the heart of the celery canopy. LW = leaf wetness; Tmax = no maximum temperature; Tmin = minimum temperature; DSV = disease severity values.

Leaf Wetness and Temperature Sensor Placement: Orientation 45deg. Face Up vs Face Down
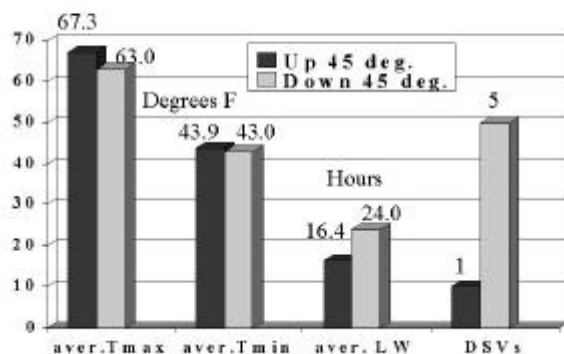

Figure 3. Average daily maximum and minimum temperatures are slightly lower while daily hours of leaf wetness are nearly four times greater when the sensors are oriented face down rather than face up at the same elevation within the celery canopy. LW = leaf wetness; Tmax = no maximum temperature; Tmin = minimum temperature; DSV = disease severity values.

Leaf Wetness and Temperature Sensor Placement: Orientation Face Up vs Face Down at 15"
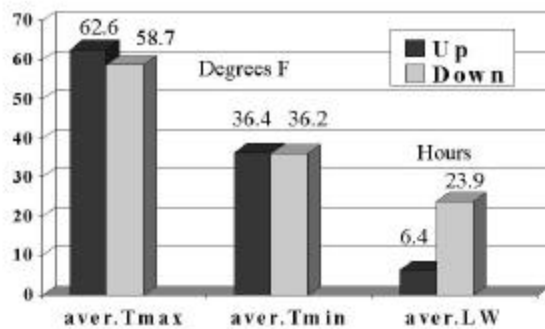

Figure 4. Average daily maximum and minimum temperatures are slightly lower while daily hours of leaf wetness are 50% greater resulting in 5 times the accumulated DSV's when the sensors are oriented at a 45° angle face down rather than face up. LW = leaf wetness; Tmax = no maximum temperature; Tmin = minimum temperature; DSV = disease severity values.

COTTON IPM IN CALIFORNIA: WHAT DOES IT MEAN TO USE IPM? *Peter B. Goodell, UC Kearney Agricultural Center*

Presentation to the Field to Fashion Cotton Conference February 25-26, 1999, San Francisco, California.

The annual damage caused by cotton insect pests in the San Joaquin Valley (SJV) of California is estimated at $47,013,275 (Williams 1994-98). Lygus bugs, spider mites, and aphids cause the bulk of the damage. Control costs have risen at an average rate of $15/ac/year while yield has been reduced due to weather and insect pressure.

IPM seeks a balance between the prevention of yield loss and excessive insecticide spraying. IPM can be described as a continuum of practices stretching from complete reliance on insecticide controls to a high reliance on biological control. Practices associated with highly integrated, bio-intensive IPM include:
- Increased reliance on indigenous natural enemies
- Availability of reduced risk, narrow-spectrum insecticides
- Availability of biological control agents for management of key pests
- Proactive prevention strategies to avoid or dilute the pest problem

This presentation seeks to answer the questions: what constitutes a reasonable suite of IPM practices and where on the continuum does cotton IPM lie? The discussion will be developed around the production system of the West Side SJV that was part of a three year study supported by UC-SAREP's Biologically Integrated Farming System program (BIFS).

The West Side stretches from Merced County in the north through Fresno, Kings, and Kern Counties, roughly along the Interstate 5 corridor. This area is extremely productive and characterized by intensive production schedules with production units usually 160-acre in size. It has a diverse cropping pattern including cotton, melons, seed alfalfa, alfalfa hay, onions, garlic, safflower, grain, almonds, pistachios, and vines.

The IPM Continuum

The concept of the IPM continuum as presented by Benbrook (1996) suggests increased complexity as an IPM program moves from being chemically based to biologically based. The complexity also can be described in terms of the scope of management:
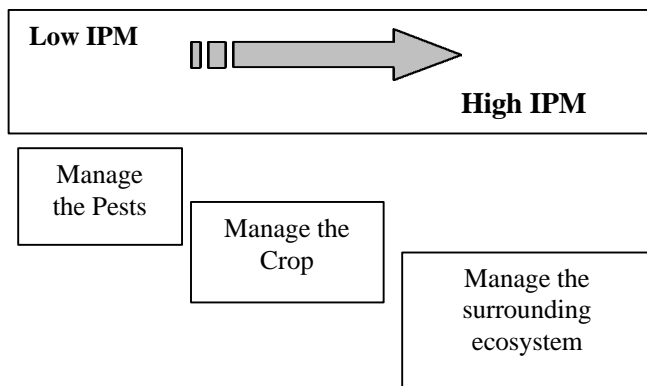
Managing the **pest** is the most basic function of IPM. It requires knowledge of the pest, its population density, and its potential impact on yield. As experience and knowledge increase, interactions among multiple pests are considered simultaneously. Examples of practices include:
- Frequent inspections of the field for insects and natural enemies
- Treating only when pest population threatens yields
- Preserving natural enemies; avoiding broad-spectrum insecticides
- Managing the pest population to maintain insecticide susceptibility

IPM recognizes that **crop management** is the basis for pest management. The objective is to favor the plant and provide it the advantage of strong growth and development. General approaches include:
- Choose the plant variety best suited for the conditions
- Utilize host plant resistance to nematodes and vascular diseases
- Plant early into conditions conducive for rapid plant emergence
- Manage the crop for the minimum season
- Terminate the crop as soon as possible

Managing the **surrounding ecosystem** is the most complex and long-term aspect of cotton IPM. It requires the development of a community that recognizes the need for cooperative management within a region. Key to the success is knowledge about ecological relationships of pests, natural enemies, and their habitats within the community and across time. For example, any success in Lygus management must manage the sources where this pest develops and sinks to which it migrates (Stern et al., 1967). Several key practices might include:
- Coordinated management efforts such as removal of hosts (e.g volunteer plants supporting whiteflies)
- Controlling pests on the borders of problem areas, including regional mating disruption strategies

- Developing regional management strategies to mitigate pest migrations such as providing alternative, preferred habitats
- Developing biological control programs aimed at off-site sources where pests develop prior to migration to cotton.

Are West Side Farmers using IPM?

In 1996, the Federal government committed 75% of the nation's agricultural acres to be using IPM by the year 2000. This goal will be evaluated using a generic list of practices referred to as PAMS (Prevention, Avoidance, Monitoring and Suppression) (USDA Special Circular, 1998). By definition, if practices from three of the four groups are utilized, then the farm is considered an IPM farm. This base standard of IPM practices can serve as the definition for Low IPM. The following list provides generic practices with the specific activities practiced by West Side cotton farmers and PCAs.

Prevention
1. Plow down to manage pests (pink bollworm plow down)
2. Use irrigation scheduling (schedule last cotton irrigation to minimize excessive late season growth)

Avoidance:
3. Adjust planting dates to manage pests (5-day planting forecast; 90 day host free period for pink bollworm)

Monitoring:
4. Scout for pests (twice weekly by PCA)
5. Keep written records (formal written weekly report)
6. Pheromones for insect monitoring (pink bollworm trapping program)

Suppression:
7. Seed treatments (seedling disease protection)
8. Use action thresholds for control decisions (UC IPM Guidelines for Lygus, aphids, mites)
9. Use ground cover or physical barrier (bean strips to catch Lygus)
10. Adjust plant density to control pests (limit density to less than 55,000 plants/ac)
11. Alternate pesticides to prevent resistance from building up (1998 Resistance Management Guidelines)

These eleven practices were integrated into the West Side cotton farming practices in 1998 and most had been in use for many years (Mitchell and Goodell, 1998) (Table 1). National Agricultural Statistics Service lists

20 tactics under the 4 PAMS heading. When an area has utilized any of the practices from three out of four categories, it is considered to have an IPM base. West Side farmers used 11 practices from all four categories in 1998 and therefore are practicing IPM at a higher than base level.

This practice list (Table 1) can be placed into complexity categories as described previously. The practices consist of five pest practices, four crop practices, and four ecosystem practices. If the position on an IPM continuum is judged by the number of practices being used from the all levels of complexity, current IPM practices in West Side cotton production should place it in at least the mid-range on a continuum.

Is IPM resulting in less pesticide use?

One measure of pest management impacts is to examine pesticide use patterns. California has a 100% reporting system with data readily available, though not very timely. The most recent "official" data set is 1995. Using 1995 data from the Department of Pesticide Regulation as a baseline of comparison, 1997 and 1998 use from the West Side BIFS Demonstration farms are contrasted (Figure 1).

These figures are based only on insecticide (and miticide) use, not total pesticide. These do not include adjuvants such as stickers or spreaders that may have been used during the treatment. These data show a 17% decrease in insecticide use in 1998 compared to 1995 and follow the insecticide use patterns for CA (Figure 2).

Insecticide use as an indicator of the progress in IPM programs should be considered with caution. As an indicator it is open to interpretation by numerous factors including:
➢ The type of insecticide including selectivity and risk factors to the environment and human health
➢ The size (amount) of the dose per acre used
➢ What types of pesticides are included in the comparison
➢ The average use in the state which indicates the overall pest pressure for that year
➢ Specific environmental and ecological conditions of the area being reviewed and compared to averages and/or other years and locations.

Conclusions

Integration of IPM practices should result in a reduction of insecticides. This is especially true in systems in which little or no information has been collected on the population density of pests, natural enemies, and crop development. In mature IPM systems such as those found in California cotton, increasing complexity is required to push the IPM practices toward more biological integration. However, agricultural ecosystems are dynamic and under constant pressure to change. Conditions that cause an insect to become a pest (Clark, 1979) include the introduction of new pests (silverleaf whitefly), changes in cultural practices (i.e. shifts in chemical usage; shifts in cropping patterns) or changes in the insect (reduced susceptibility to insecticides; changes in feeding patterns). Such changes can result in pest outbreaks and resulting insecticide increases.

The keys to IPM are knowing if treatment is needed, when to apply, what the side-effects of the control measure might be, selecting the least disruptive materials, and holding off treatments to allow natural enemies or cultural control measures to do their work. The general approaches are then modified to fit the site-specific requirements of the cotton production system being managed.

References

1. Benbrook, C. 1996. Pest Management at the Crossroads. Consumers Union. 272 pages.

2. Clark, L. R. 1979. Analysis of pest situations through life systems approach. In: Concepts of Pest Management. North Carolina State University.

3. Mitchell, J. R., and P. B. Goodell. 1998. Annual Report of West Side BIFS Demonstration.

4. Stern, V. M., R. van den Bosch, T. F. Leigh, O. D. McCutcheon, W. R. Sallee, C. E. Houston, M. J. Garber. 1967. *Lygus* Control by Strip Cutting Alfalfa. UC Agricultural Extension Service, Bulletin AXT-241. 13 pp.

5. USDA Pest Management Practice. 1997 Summary. August 1998. Special Circular 1 (98).

6. Williams, M. 1994-98. Cotton insect losses. Insect Research and Control Conferences. 1994 through 1998 Proceedings of the Beltwide Cotton Conferences.

Table 1. List of practices developed by West Side BIFS participants that increase biological integration in cotton IPM and the number of side-by-side sites that incorporated the practice, (n=10).

Suggested Practice	Now Using	No. Years in Use	Complexity Category
Plant cotton according to soil temperature and five-day forecast	10	9.3	Crop
Planting at densities no more than 45,000 – 55,000 plants/ac[1]			Crop
Use of resistant varieties where appropriate and available[1]			Crop
Twice weekly inspections for insects and mites	10	6.4	Pest
Pest density to reach action thresholds before pest control	9	9.7	Pest
Follow 1998 Insecticide Resistance Management Guidelines	9	6.1	Pest
Monitor insecticide resistance with bioassays	7	11.6	Pest
Use of cowpea buffer strip on upwind edge of field	5	1.8	Ecosystem
Release of natural enemies	3	1.7	Ecosystem
Conservation of natural enemies	10	11.3	Pest
Consider the condition of neighboring crops for managing pests	9	9.5	Ecosystem
Crop termination as early as dictated by plant monitoring indices	9	8	Crop
Attend UCCE summer production meetings and BIFS field days	10	8.2	----
Provide alternative habitat for natural enemies	2	8	Ecosystem

[1] Farmers not specifically asked this question. Data collected from farm profile reports.
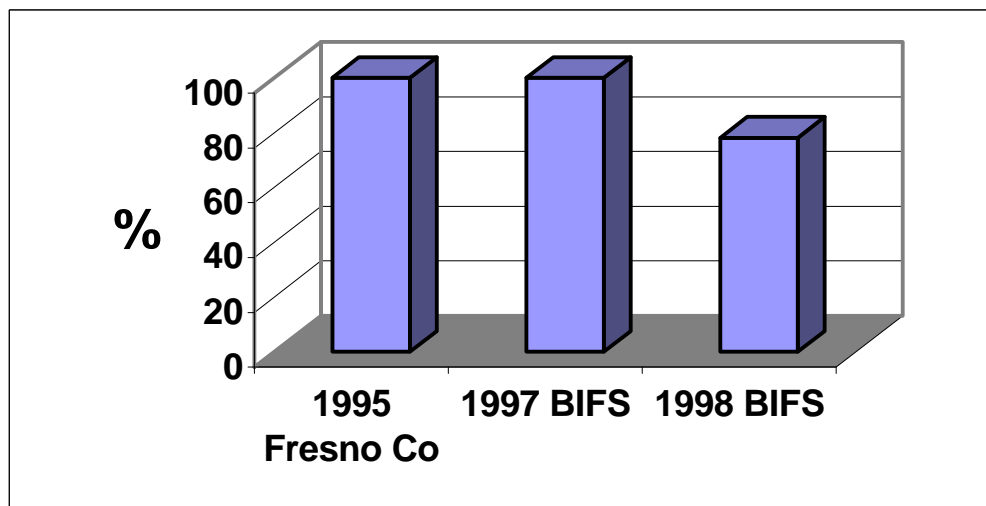

Figure 1. Insecticide use by Fresno Co. West Side cotton farmers. Percent ai/ac compared to 1995 Fresno Co. average.
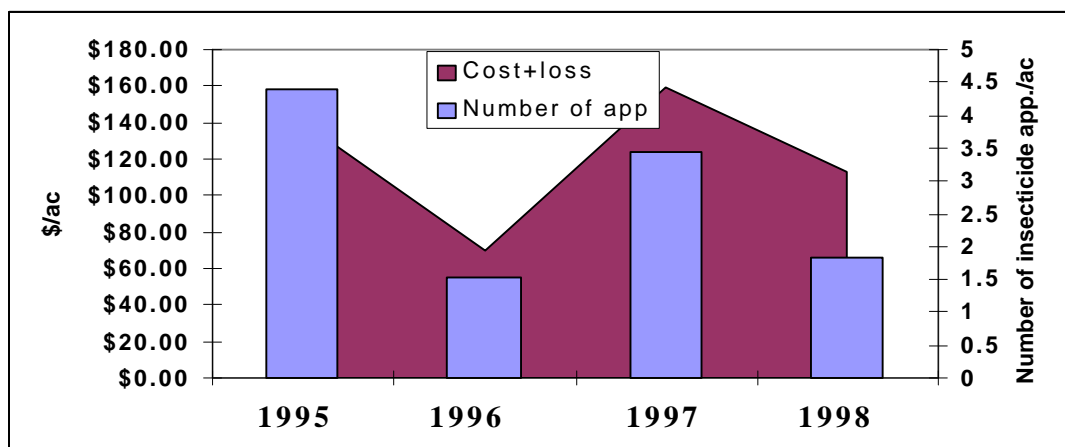

Figure 2. Estimated loss and number of insecticide applications to CA cotton.

METHYL BROMIDE ALTERNATIVES: CDFA APPROVES A SOLARIZATION TECHNIQUE TO ENSURE AGAINST NEMATODE PEST INFESTATION OF CONTAINERIZED NURSERY STOCK

J. J. Stapleton, M. V. McKenry, and L. Ferguson, UC Kearney Agricultural Center

According to regulations of the Nursery Stock Nematode Control Program, CCR Sections 3055-3055.6 and Section 3640, the California Department of Food and Agriculture (CDFA) specifies treatment and handling procedures to ensure against nematode pest infestation of media (soil, etc.) used for nursery stock for farm planting. Because of the impending international regulatory phaseout of methyl bromide scheduled for 2005, there is an urgent need to provide California growers with usable alternatives. Various solarization techniques were tested during summer 1995-1998 for potential to disinfest soils for containerized nursery stock of certain nematode and fungal pathogens which attack a variety of high-value horticultural crops in California's inland valleys. Moistened field soils, free of roots and organic debris larger than 12mm x 12mm and naturally infested with nematode pathogens including citrus (*Tylenchulus semipenetrans*), root lesion (*Pratylenchus vulnus*), root knot (*Meloidogyne incognita*), ring (*Criconemella xenoplax*), and others; and with the fungal pathogen *Pythium ultimum*, were placed in black polyethylene (poly) planting sleeves (20 x 20 or 20 x 45 cm) or left in 23 or 30 cm high piles and subjected to one of four treatments for a period of one to four weeks: (1) placed on a sheet of poly in the field and exposed daily to open sun; (2) as #1, but also covered with a single layer of transparent poly film; (3) as #1, but also covered with two layers of transparent poly separated by wire hoops; or (4) not heated. Soil temperatures reached as high as 74 C in treatment 3. Among the various solarization techniques, treatment #3 was the most effective in reducing nematodes to undetectable levels as determined by soil extractions and root bioassays in susceptible test plants. Results of the experiments indicated that solarization may be used commercially in nursery operations in the SJV and other desert areas in California, and data were provided to the Nematode Study Committee of the CDFA for review. A protocol for Treatment #3 (above) was recently approved for certified production of container, flat and frame grown nursery stock as follows. We are continuing to work on these techniques to increase efficiency for end users, and perhaps, to include other treatment options.

Approved Solarization Treatment (excerpted from CDFA NIPM Item #12).

"Solarization of soil until the temperature of all the soil reaches a minimum of 158° F (70° C) that is maintained for at least 30 contiguous minutes. Soil must be either in polyethylene planting bags or in piles not more than 12 inches high. Soil in piles must be placed on a layer of polyethylene film, disinfested concrete pad, or other materials which will not allow reinfestation of soil, and covered by a sheet of clear polyethylene film. An additional layer of clear polyethylene film must be suspended over the first layer to create a still air chamber over the soil to be treated. Soil moisture content must be near field capacity. Soil temperature at the bottom center of the pile or bag must be monitored and recorded to ensure that the minimum temperature of 158°F (70°C) for 30 minutes is achieved.

Following treatment, the soil and containers shall be protected from reinfestation by nematodes."