UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

UC PLANT PROTECTION QUARTERLY

October 2000 Volume 10 Number 4

Available online: www.uckac.edu/ppq

This newsletter is published by the University of California Kearney Plant Protection Group and the Statewide IPM Project. It is intended to provide timely information on pest management research and educational activities by UC DANR personnel. 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.

Editors
James J. Stapleton
Charles G. Summers
Beth L. Teviotdale
Peter B. Goodell

Cooperative Extension
Agricultural Experiment Station
Statewide IPM Project

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

IN THIS ISSUE

INSECTICIDE RESISTANCE TRENDS IN LYGUS BUGS AND COTTON APHIDS

Beth Grafton-Cardwell, Julie Christiansen, Becky Striggow, Greg Montez, and Pete Goodell, UC Kearney Agricultural Center

Lygus bugs (*Lygus* spp.) and cotton aphid (*Aphis gossypii*) are two of the most important pests of San Joaquin Valley cotton. Because control tactics for one species influence population densities of the other species, and because they are treated with the same insecticide chemistries, discussions of pesticide resistance management must include both pests. For more than 30 years, aphids and lygus bugs have been treated with organochlorine, organophosphate, and carbamate insecticides. In the early 1990s, the pyrethroid Capture® (bifenthrin) was introduced for control of these pests. Between 1985 and 1995, pesticide use in San Joaquin Valley cotton increased from 1.5 applications to 6 applications per season for all cotton pests. Yields were very low in 1995 and insecticide resistance was blamed for the loss of insect control.

However, insecticide resistance wasn't the only reason that cotton aphids became a problem. In the early 1990s, San Joaquin Valley growers began to plant higher yielding varieties of cotton that responded favorably to higher rates of nitrogen and irrigation. Growers used plant growth regulators, rather than water stress, to control plant development. Increasing amounts of nitrogen and irrigation helped create an environment that allowed aphids to grow and reproduce faster. Cotton aphid, which had previously been an early season or late season pest problem became a serious mid-season pest, thus increasing pesticide use.

Another reason for escalating pesticide use was the introduction in the early 1990s of early season applications of Capture® for lygus bug control. When pyrethroids are used early in the season, subsequent insecticide use for secondary pests such as cotton aphids, spider mites, and various Lepidoptera tends to rise. This is because pyrethroids are toxic to the natural enemies that control these pests and because they cause Capture®-resistant aphids to reproduce faster. Cotton aphid developed resistance to Capture® rapidly, and by 1993, it was no longer effective for controlling aphids. Resistance to Capture® in lygus was also detected by 1996, however, resistance in lygus was not as severe or as stable as resistance in cotton aphids. Because the pyrethroids gave longer residual control than other insecticides, growers continued to use pyrethroids for lygus control in spite of resistance.

In response to the extremely heavy broad-spectrum pesticide use and low yields experienced in 1995, University of California Extension personnel held a cotton industry workshop to review the pest situation. One outcome of this review was a series of insecticide resistance management guidelines that emphasized the preservation of natural enemies by avoiding early season broad-spectrum insecticides and the careful rotation of insecticide chemistries.

In this article, we report on the pesticide use patterns, and pesticide resistance of lygus bugs and cotton aphids during 1993-2000, the period just prior to and following implementation of the resistance management guidelines.

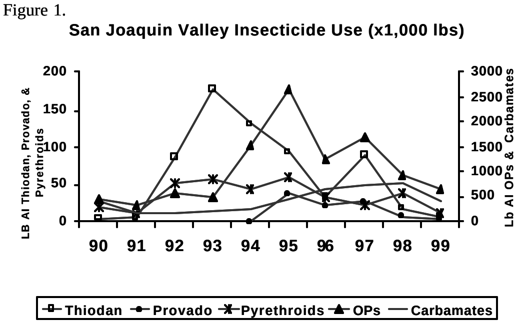
Procedures

Insecticide resistance bioassays for aphids were prepared by treating plastic petri dishes with discriminating concentrations of formulated pesticides mixed in ethanol. We expected to observe greater than 80% mean mortality of individuals placed in these dishes if the population was susceptible to the pesticide. We could not test all insecticides registered, and so we chose insecticides from major chemical classes. For aphids, the insecticides included the organophosphate Lorsban® (chlorpyrifos), the organochlorine Thiodan® = Phaser® (endosulfan), the pyrethroid Capture®, and the chloronicotinyl Provado® with mortality assessed after 3 hours of exposure. For Lygus, plastic ziploc bags were treated with 5 µl technical grade insecticide in acetone and mixed with the pyrethroid Capture®, the organophosphate Metasystox-R® (MSR) (oxydematon-methyl), the carbamate Lannate® (methomyl), or the chloronicotinyl Provado®. The bags were prepared by Dr. Bill Brindley (Utah State University) and kept frozen until used. Lygus mortality was assessed after 8 hours. Lygus bugs were collected from both cotton and neighboring alfalfa in order to obtain enough individuals for bioassays. Pesticide use data was obtained from the California Department of Pesticide Regulation for 1990-1999 and summarized for Merced, Madera, Fresno, Kings, Tulare and Kern counties. Estimates of pest densities were obtained from the Cotton Insect Losses summary for the National Cotton Council.

Results

Pesticide use for lygus and aphid control between 1990-1999 in the San Joaquin Valley is illustrated in Figure 1. Thiodan®/Phaser® use reached a peak in 1993, organophosphate and pyrethroid use peaked in 1995, carbamate use peaked in 1998 (primarily Temik®), and Provado® use was initiated in 1995. In 1995, when organophosphate and pyrethroid use was at it's highest, pesticides were not very effective in controlling cotton aphid or spider mites. The resistance monitoring program was initiated the following year (1996) in response to concerns that resistance was the cause of the aphid and spider mite problems.

Figure 1.



Cotton aphid numbers were high during 1994-97. The percentage of cotton aphid populations with resistance to Capture® was high in 1996 (85% of populations tested) when resistance monitoring was initiated (Fig. 2). Capture® resistance declined slightly in subsequent years as pyrethroid use in cotton declined, however, reduction in pyrethroid use did not bring the San Joaquin Valley cotton aphid population back to a pyrethroid-susceptible state and in 2000 resistance to pyrethroids increased. Growers no longer use Capture® for cotton aphid control.

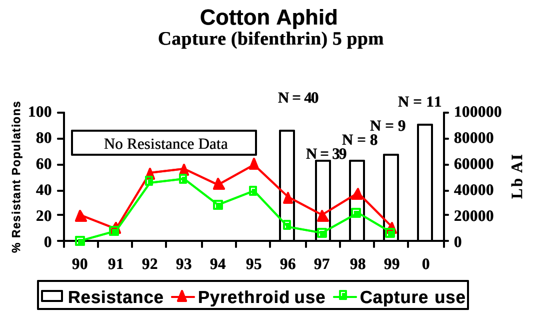


Figure 2. Capture and pyrethroid use (lb AI) during 1993-99 and the percentage of Capture-resistant cotton aphid populations of total (N) tested during 1996-2000.

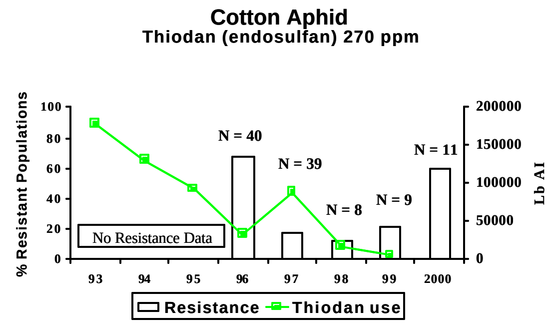


Figure 4. Thiodan (and Phaser) use (lb AI) during 1993-99 and the percentage of Thiodan-resistant cotton aphid populations of total (N) tested during 1996-2000.

In contrast, resistance to Lorsban was fairly high in 1996 (40% of populations tested), but as use declined after 1995, so did the percentage of resistant populations (Fig. 3). This suggests that organophosphate resistance in cotton aphids is unstable and manageable through minimizing organophosphate applications and careful rotation of insecticide classes.

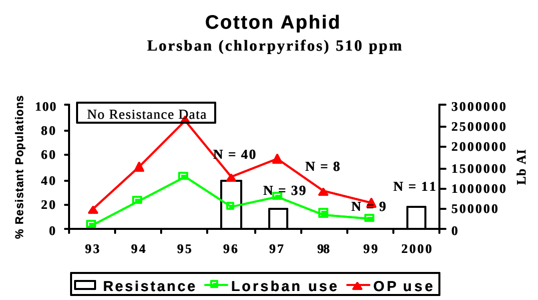


Figure 3. Organophosphate and Lorsban use (lb AI) during 1993-99 and the percentage of Lorsban-resistant cotton aphid populations of total (N) tested during 1996-2000.

A similar pattern is seen for Thiodan (Fig. 4) with 67% resistant populations in 1996 dropping to as few as 12% of populations in 1998 and increasing again in 2000. Imidacloprid was registered for use in 1995, and to date, no resistance to this insecticide has been detected in cotton aphids. Part of the reduction in organophosphate and pyrethroid use in the late 1990s was due to the introduction of this new insecticide class (chloronicotinyl). Continued rotation of these different insecticide classes with any insecticides that become registered in the future is recommended.

Lygus bugs become a key pest in cotton fields as foothill vegetation dries and as neighboring alfalfa fields are harvested. In 1996 and 1997, lygus bugs were found to be fairly susceptible to Capture® at the beginning of each season before insecticides were applied. Resistance was observed to increase after Capture® was applied to seed alfalfa and cotton in June-July. These data suggested that resistance could be managed by limiting Capture® to a single application per year. However in the 1998-2000 resistance surveys, resistance to Capture® in lygus bugs, averaged over the entire season, increased to $\geq$80% of populations tested (Fig. 5).

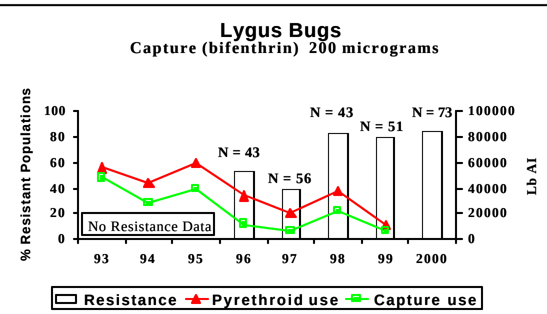
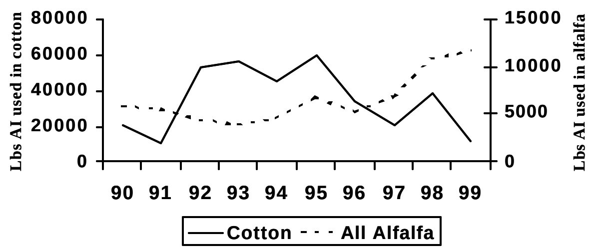


Figure 5. Capture and pyrethroid use (lb AI) during 1995-99 and the percentage of Capture-resistant Lygus populations of total (N) tested during 1996-2000.

Although pyrethroid use generally declined in cotton after 1995, use in alfalfa has dramatically increased (Fig. 6). Recent registration of pyrethroids for alfalfa weevil control and other pests of alfalfa hay greatly escalated pyrethroid use in this crop. If the heavy pyrethroid use in alfalfa continues, we are likely to see Capture® resistance in lygus continue to intensify.

Figure 6. San Joaquin Valley Pyrethroid Use



Resistance to the organophosphate Metasystox-R® subsided to a fairly low level in 1997. Resistance to MSR during 1998-2000 is on the increase in spite of lower overall organophosphate use (Fig. 7). Resistance to the carbamate Lannate® fluctuated, as did use of this insecticide (Fig. 8).

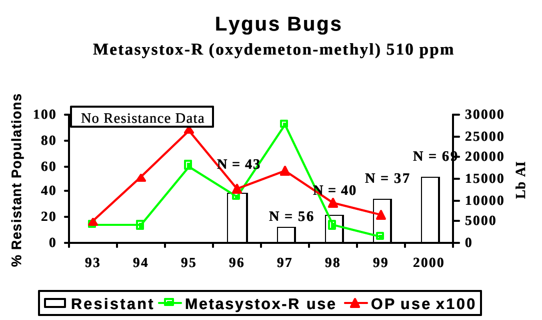


Figure 7. Metasystox-R and organophosphate use (lb AI) during 1995-99 and the percentage of oxydemeton-methyl-resistant Lygus populations of total (N) tested during 1996-2000.

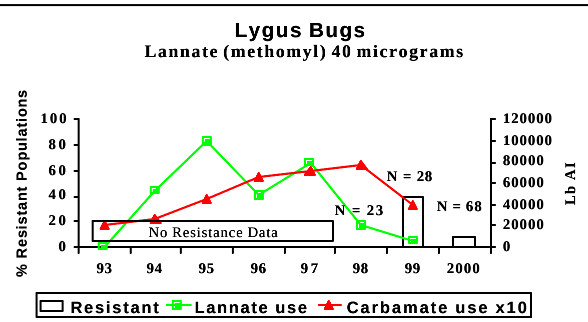


Figure 8. Lannate and carbamate use (lb AI) during 1995-99 and the percentage of Lannate-resistant Lygus populations of total (N) tested during 1998-2000.

A low percentage of populations with resistance to Provado® (16%) was first detected in 2000. There is a great need for development of selective insecticides for lygus control that would allow natural enemies of the other pests to survive.

Summary

Pesticide bioassays were useful for detecting trends in resistance to major groups of insecticides. The data indicate that pyrethroid resistance in lygus and cotton aphids is quite high, and very stable in spite of a reduction of the use of pyrethroids in cotton. These data suggest that pyrethroid usefulness on these cotton pests may be approaching an end. In contrast, resistances to organophosphates, carbamates, and organochlorines occur, yet the level or frequency of resistance fluctuates in response to pesticide use. There is greater potential for maintaining susceptibility to these pesticides if their use is limited.

We have learned several things from examining these data and reflecting on recent pest problems. Use of insecticides for either lygus or cotton aphids selects for resistance in both insects. Heavy use of early season broad-spectrum pesticides for lygus disrupts biological control resulting in increased use of acaricides for spider mites and insecticides for aphids. Finally, cotton pests are influenced by insecticide use in neighboring crops. Escalating pyrethroid use in alfalfa is a likely cause of increased resistance in lygus infesting cotton. The best resistance management program is one that reduces all pesticide use and the University of California Resistance Management Guidelines help growers follow that strategy.

Acknowledgments

The Cotton Incorporated Core Program and California State Support Committee supported this research.

BAND CANKER

Beth Teviotdale, UC Kearney Agricultural Center

Band canker is a generally uncommon disease of almond trees caused by *Botryosphaeria dothidea*. Because it causes amber-colored gum balls to form on the trunk and scaffolds it is sometimes misdiagnosed as a *Phytophthora* or *Ceratocystis* infection. Band canker gumming occurs in horizontal bands around the trunk and primary scaffolds whereas Phytophthora or Ceratocystis cankers expand more rapidly up and down the tree, forming longer-than-wide roughly elliptical cankers. *B. dothidea* grows more rapidly around the tree creating wider than long cankers Often the infections are relatively shallow and do not penetrate to the cambium or conducting tissues. Such shallow cankers cause no apparent damage and heal in time. Deeper infections kill the inner bark and wood. Because the cankers go around the trunk or scaffold, deep cankers can easily girdle limbs or trees. Many band cankers are annual and do not reactivate the following year. Those that do resume growth stand a good chance of causing damage.

The disease has not been extensively studied; consequently, our information is limited. Natural *B. dothidea* infections at pruning wounds or other bark injuries have not been reported on almond trees. However, in artificial inoculations, pruning wounds or wounds that exposed the cambium were very susceptible. Artificial band canker infections initiated at these sites formed long cankers instead of the bands found in natural infections. In nature, the band canker fungus appears to invade almond trees through growth cracks, which occur in narrow bands around the tree. The cortical tissue near growth cracks differs from regular bark. For some reason, the fungus is best suited to the tissue in the area of growth cracks and grows best there.

Inoculations made in spring, summer, and fall produced cankers, but winter inoculations were unsuccessful. Most natural infections probably occur in spring. The fungus produces spores that require water for dissemination, and spring rains probably carry spores to trees. Young, vigorous trees have more growth cracks, and growth cracks would be most likely during rapid development in spring and summer.

The pathogen, *B. dothidea*, causes diseases of many woody plants, including a serious disease of pistachio. Although the disease on pistachio is very different from that on almond, almond isolates can infect pistachio and vice versa.

Band canker occurs sporadically in orchards in the Sacramento and northern San Joaquin Valleys. Several cultivars are susceptible, but usually vigorous Nonpareil and Carmel trees, 4-6 years old, are most susceptible. Often only a few trees are infected but in some orchards tree loss has been substantial, exceeding 10%. Topical applications and surgery have not resulted in reduced disease or protection. Thus, no control is recommended.

FURTHER INVESTIGATIONS IN THE MANAGEMENT OF SAN JOSE SCALE WITH NARROW RANGE HORTICULTURAL OIL

Walt Bentley, Lee Martin, Dick Rice, Brian Ribiero, and Kevin Day, UC Kearney Agricultural Center and UCCE Tulare County

This study was initiated in 1999 to evaluate the efficacy of narrow range horticultural oils applied during the delayed dormant period to plums for control of San Jose scale (SJS) (*Quadraspidiotus perniciosus*). In 1999, either Volck Supreme or Orchex 692 oil applied at the green tip stage of growth (8 gallons of oil in 400 gallons of water per acre) gave significantly better ($P<0.05$, Fisher's Protected LSD) control of SJS than no treatment (Bentley et al, 1999). Infestation of Black Amber cultivar did not exceed 1.50% with either oil (untreated check 10.75%). Infestation of the Queen Rosa cultivar was less than 5% (untreated check 14%). Additionally, in August harvested Royal Diamond and Rosemary cultivars, there was a significant ($P<0.05$, Fisher's Protected LSD) interaction between the efficacy of oil spray, as measured by harvest infestation, and the abundance of SJS measured by the previous years infestation.

In 2000 we further studied the efficacy of a delayed dormant oil application (8 gallons of Exxon 100 Dormant Spray Oil) on SJS fruit infestation of these same cultivars, as influenced by the volume of water/oil mixture applied.

Methods and Materials

The 2000 study was done in a 3.5-acre block of mid-June-harvested plums (Black Amber and Queen Rosa cultivars) and late-July harvested plums (Royal Diamond and Rosemary cultivars). On February 11, individual plots of trees were sprayed with 8 gallons of Exxon 100 Dormant Spray Oil in either 100 gallons or 400 gallons of spray mixture or left untreated. Treatments were made with an FMC air carrier sprayer driven at 2 mph. The desired volume per acre was achieved by changing nozzle size. The individual plots of the mixed Black Amber and Queen Rosa plums consisted of 64 trees and treatments were replicated four times in a randomized complete block design. Harvest (200 fruit from central trees from each plot) occurred on 6/16/2000 (Black Amber) and 6/21/2000 (Queen Rosa). An analysis of variance was performed on the number of SJS infested fruit.

Two experiments were performed in the late July harvested plums. Individual plots were smaller than that used in the earlier harvested fruit and consisted of 30 trees. Using four replicates, one trial was designed to compare the 100-gallon per acre rate, the 400-gallon per acre rate, and an untreated check. A randomized complete block design was used. A paired experimental design was also evaluated where 10 replicated treatments were used to compare the efficacy of 100 and 400 GPA in reducing SJS infestation. The additional replicates allowed for a more powerful test of the efficacy of the two treatments. The late harvested plums were Royal Diamond (harvested 7/26) and Rosemary (harvested 7/28) cultivars. The determination of infestation for each variety was made by sampling 200 fruit from the central two rows of trees in each plot. An analysis of variance measuring the number of scale infested fruit was performed in both experiments. In all evaluations a single scale on a fruit would classify it as being infested.

Results

Both the 100 GPA and 400 GPA treatments gave significantly ($P<0.05$, Fisher's Protected LSD) better control SJS than the untreated check. There was no difference between the 100 and 400 GPA treatments. Infestation in the Black Amber cultivar was 0.88, 1.38, and 14.38% for the 400 GPA treatment, the 100 GPA treatment and the untreated check respectively. Infestation in the Queen Rosa cultivar was 1.50, 2.50, and 15.13% for the 400 GPA, 100 GPA, and untreated check respectively. The Royal Diamond harvest infestation was 5.5, 13.63, and 19.88% for the 400 GPA, 100 GPA, and the untreated check respectively. The 400 GPA treatment resulted in significantly ($P<0.05$) fewer scale infested fruit than the untreated check. The 100 GPA treatment was not significantly different ($P<0.05$) from the 400 GPA treatment or the untreated check. Infestation on Rosemary at harvest was 5.00, 7.75, and 18.75% for the 400 GPA, 100 GPA, and untreated check treatments respectively. Both the 400 GPA and 100 GPA treatments resulted in significantly ($P<0.05$) fewer infested fruit than the untreated check. There was no difference between 400 GPA and 100 GPA treatments.

The 10 replicate paired comparison between the 400 GPA and 100 GPA treatments resulted in a highly significant ($P<0.01$) difference in scale infested fruit for both the Royal Diamond and Rosemary cultivars. For Rosemary plums, the 400 GPA treatment resulted in 4.55% infested fruit and the 100 GPA treatment resulted 11.2% infested fruit. The Royal Diamond plums had 8.85 and 13.4% infested fruit in the 400 and 100 GPA treatments respectively.

Discussion

The 2000 study established the benefits of a narrow range superior horticultural mineral oil (Exxon 100 Horticultural Spray Oil) in reducing San Jose scale infestation in four cultivars of plum. This confirmed work done in 1999 showing similar efficacy. There was no clear difference in infestation based on the volume of spray mixture applied to plums when four replicates were used to evaluate treatment effects.

Where additional replicates were evaluated, in a paired comparison, in each of two late July harvested cultivars, clear differences were seen between 100 and 400 GPA in reducing SJS infestation. Ten replications result in a more sensitive statistical test. Because of non-uniform infestation by SJS throughout the test orchard, additional replications are needed to establish significant differences.

Horticultural mineral oils can be used to manage SJS in plums with acceptable efficacy against SJS. There are a number of benefits to using such a program. First, the use of oil alone reduces the cost of the pesticide to the grower. Unless SJS populations are extreme, an 8-gallon rate of oil can be applied with minimal infestation at harvest, eliminating the need for an organophosphate or insect growth regulator. Secondly, horticultural mineral oils can be used to combat insecticide resistance. Oils physically smother the insect; efficacy is not dependent upon the detoxification ability of the target pest. Thirdly, oils can be used safely with minimal hazard to those applying the spray. Also, horticultural mineral oils are allowable for organic farmers. Based on the results obtained with paired comparison of 100 & 400 GPA, using 10 replications, fruit harvested after the end of June should be sprayed with the higher volume of spray mixture. This may not be needed for fruit harvested in June. Later harvested fruit is exposed to at least one and possibly two additional generations of SJS. The greater volume of spray mixture appears to give better coverage of wintering scale, in the parameters of this study. The greater time needed to apply a 400 GPA mixture is a disadvantage. If a farmer contracts with a private applicator the additional application time will cost more.

ABSTRACTS

97th International Conference of the American Society for Horticultural Science, Orlando, FL, June 23-26, 2000.

Evaluation of Reflective and Cover Crop Mulches in Fresh Market Tomato Production System

Jeff Mitchell, Charlie Summers, and Jim Stapleton, UC Kearney Agricultural Center

Three systems for fresh-market tomato production (transplanting into reflective mulch, transplanting into a cover crop that had been chopped and killed, and standard transplanting into fallow beds) were evaluated in two field experiments in California's San Joaquin Valley in 1999. The first study was a spring tomato planting (April) and summer (July) harvest in which a mixture of rye, triticale, and vetch was used as the cover crop mulch. The second trial consisted of a summer tomato planting (July) and fall (September) harvest in which a sorghum/sudan hybrid was used as a mulch. In both experiments, tomato plants growing over the reflective mulches accumulated significantly more biomass than did plants growing in the other production systems. These larger, more-robust plants growing over reflective mulch also produced significantly higher yield. In the summer planting, there was almost no tomato biomass accumulation in the cover crop plots due to the fact that the sorghum-sudan hybrid we chose as the cover crop turned out to be allelopathic to tomatoes when shredded and used as a mulch.

Potential Allelopathy of Sorghum-Sudan Mulch

J. P. Mitchell, C. Summers, T. S. Prather, J. Stapleton, and L. M. Roche, UC Kearney Agricultural Center and UC Davis

Observations that tomato transplants died or were severely stunted when set into unincorporated sorghum-sudan hybrid surface mulch led us to further investigate the potential allelopathic impacts of this warm-season cover crop in a series of field experiments. Survival and dry weights of tomato, lettuce, and broccoli transplants were determined in fallow, incorporated sorghum-sudan, and unincorporated sorghum-sudan mulched soils. All three species transplanted into plots in which the sorghum-sudan had been cut and left on the soil surface had a significantly lower dry weight than plants transplanted into fallow soil or into soil where the sorghum-sudan had been incorporated. Additionally, fewer transplants survived in the mulch treatment. The surface mulch plots also significantly reduced weed biomass nearly 10-fold. We believe that a water-soluble compound that is leached out of the sorghum-sudan hybrid is toxic to all three of the plants tested. Further laboratory and greenhouse tests are underway to determine the exact nature of the toxic substance.