PEST AND BENEFICIAL ARTHROPOD ABUNDANCE IN CALIFORNIA ORGANIC AND BIOINTENSIVE COTTON FIELDS: THE "BASIC" EXPERIENCE

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Abstract

Beginning in 1996, the California BASIC Management Team has been testing and disseminating innovative ideas in cotton pesticide use reduction and organic production of cotton in the northern San Joaquin Valley of California. The team does this through an organized outreach program to enrolled growers. The team is made up of cotton farmers, pest control advisors, agronomists, and researchers interested in novel production approaches. Team researchers document field-level efficacy and suitability of alternative insect management options in the cotton production system by monitoring field management techniques that significantly reduce or eliminate agrochemical use. We summarize here three years of yield and arthropod abundance data relevant to the performance of BASIC-enrolled fields.

During the past three years, we have monitored multiple fields in the BASIC program. BASIC growers use various pesticide use-reduction techniques including: natural enemy introduction and conservation for biologically based management of arthropod pests; flame and mechanical weeding as a non chemical weed control method; and use of organic acids as alternatives to conventional defoliants. Each year we have also analyzed production parameters including: yield, fiber quality, pesticide use, economics, and energy use, comparing these with those of conventional cotton production. A subset of enrolled BASIC fields are managed using organic techniques, and separate analyses of these fields has been done. In 1996, yields in BASIC fields were significantly lower than in conventionally-managed fields, but organic yields did not differ from conventional yields. In 1997 yields in organic BASIC were lower than conventional yields, but yields from non-organic BASIC fields were the same as conventional yields. In 1998 (a low-yield year due to cool weather during stand establishment and early plant development), yields in both organic and non-organic BASIC fields were significantly lower than those in conventionally-managed fields. Key pest outbreaks in BASIC and organic fields have not been a production problem in any of the three years. Although BASIC fields periodically show higher abundance of mites and lygus bugs, retention data has indicated no increased shedding of squares or bolls. Plant density differences, late planting dates (in 1996 and 1998), and an unusually early cutout (in 1997) may have contributed to observed yield differences. In an evaluation of a subsample of non-organic BASIC fields adjacent to alfalfa fields and conventional control fields with no adjacent alfalfa, we could not detect significant differences in abundance of lygus bugs or predacious natural enemies.

Introduction

Pesticide use reports indicate that California cotton is highly dependent on synthetic pesticides, In 1991, over 14 million pounds of pesticides were used, and cotton led all state crops in the total amount of insecticides, desiccants, and defoliants used (CDPR, 1992). Rising costs of inputs and impacts of environmental regulations, including pesticide regulatory pressures, have stimulated interest in cotton production systems which limit or do not require synthetic pesticides as inputs.

The BASIC Management Team was formed in 1995 as an extension of our research on organic cotton production (Swezey and Goldman, 1996). While several non-chemical methods used in organic cotton production appear to be agronomically and economically viable alternatives to the chemical inputs of conventional cotton, many growers are not interested in converting to organic production. However, growers expressed interest in the application of selected non-chemical production methods to simultaneously reduce costs and pesticide use. Techniques include biologically-based management of arthropod pests and use of non chemical weed control methods.

Over a three-year period, the BASIC Management Team assessed the agronomic and economic potential for biologically-based pest management in cotton in the northern San Joaquin Valley. This knowledge is crucial for reducing agrochemical use and environmental impacts in one of California's most pesticide-dependent crops. The project has completed three production seasons, in which we recruited growers; selected and enrolled individual BASIC fields; established and executed the BASIC monitoring protocol (plant mapping, monitoring key arthropod populations, initiating calculations of on-farm water use, input energy equivalents, yields, and quality); evaluated and discussed these data with BASIC growers through periodic mailed updates of research results; and conducted public outreach through a series of breakfast meetings and on-farm field days.

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Methods

Grower Involvement and Outreach

We recruited 10 growers in 1996, 13 (4 new, 9 retained) in 1997, and 12 growers in 1998 to participate in the program, enrolling from one to four fields each. Each BASIC field was matched with a nearby (but not adjacent) conventional control field in which growers used their preferred management practices. Growers were selected based on having both good production practices and a willingness to share information on those practices with researchers. Components of the BASIC program were selected based on grower interest. In 1997 and 1998, the arthropod management program included: (1) reduction or elimination of early-season insecticide and acaricide spraying; (2) extensive monitoring and updates on production fields; (3) releases of green lacewings (*Chrysoperla carnea*) for pest control; and (4) location adjacent to at least one alfalfa field. A fifth component of early (April) planting date could not be consistently implemented in 1998 due to early cold and moist weather during optimum planting intervals.

We kept growers and other interested parties informed of our research findings through monthly breakfasts, field days, and newsletters. In 1998, we continued these activities and sent two field updates to growers during the season, and an end-of-season update in January 1999. In these updates we provided a summary of plant and arthropod population parameters in the BASIC group as a whole; showed graphs comparing these values in BASIC and conventional fields; and provided charts detailing the performance of each individual field. Interest in research and outreach activities has in general been excellent, with good grower feedback about the field days and updates.

Plant Development and Yields

We monitored plant development in all years from early in the season (April in 1996, June in 1997, and July in 1998) until defoliation (October in 1996; September in 1997; November in 1998). Using the average of five plants from each of four field quadrants per treatment replicate, we measured plant height, number of nodes, number of fruiting branches, first position retention on the bottom five and top five fruiting branches, and nodes above white flower (an indicator of the amount of time to cutout). Immediately prior to harvest we took one final plant sample, for which we constructed complete maps of fully developed plants, measuring all the in-season development parameters as well as total numbers of open bolls and green bolls at each position (first, second, and third+).

At the time of the final plant sample, we also estimated per-acre cotton yields for each field by hand-harvesting four one-thousandth-acre pick plots per treatment replicate (chosen randomly within each replicate quadrant), and using appropriate conversion factors to determine equivalent machine-harvested and then ginned cotton yields (machine harvest = hand harvest * 0.9; ginned cotton weight = seed cotton wt. * turnout; turnout assumed to be 32.5% for organic BASIC fields and 35% for non-organic BASIC and conventional fields). This method was used because of the inconsistent availability of gin records separated by field. We have used pick plot estimates with increasing accuracy over the past several years, adjusting estimates by the most recent turnout values for each grower. We verify these estimates with individual field gin records as they become available.

Arthropods

Arthropods were monitored throughout the three production seasons, both with leaf samples (for thrips, spider mites, and aphids, as well as eggs and immature stages of common natural enemies) and weekly with sweep samples (for lygus bugs and generalist natural enemies). Leaf samples were taken by randomly selecting 5 plants within each of the 4 quadrants of each treatment replicate, and counting all the arthropods present on the leaf at the 8th node from the top of the plant. Spider mite and aphid numbers were recorded as a rank (none present = rank of 1; 1 to 10 present = rank of 2; 11 to 100 present = rank of 3; over 100 present = rank of 4). In 1998, we converted these data to percent leaf infestation. Sweep samples were conducted weekly by taking one 50-sweep sample in each of the four quadrants of each treatment replicate and then averaging the four values to obtain an overall value for the treatment replicate.

Results and Discussion

Plant Development and Yields

Cotton lint yields were significantly greater in the conventional than in the BASIC treatment in 1996 (2.20 bales/acre vs. 1.79 bales/acre), a difference which was not present when the organic BASIC fields (2.19 bales/acre) were compared to conventional ones (Figure 1). This result may be related to plant densities: a comparison of yields and plant density showed a negative correlation between the two, when analyzed by treatment (BASIC: r = 0.520; conventional: r = 0.223). Plants in the organic BASIC treatment had more outer position bolls, a parameter strongly influenced by plant density. In the 1996 production season, results were potentially confounded by density differences among the treatments. Specifically, end-of-season plant density in organic BASIC fields was on average 25,000 plants per acre (ppa), while conventional check fields and non-organic BASIC fields were on average about 50,000 ppa. Density differences did not result from plant losses in the organic fields, but were planned to enhance outer boll formation. With these differences in mind, there were no other notable treatment differences in any of the per-plant parameters measured through the season (height, number of nodes, number of vegetative nodes, number of fruiting branches, time to cutout [measured as nodes above white flower], and retention of the top five and bottom five positions (Swezey and Goldman, 1998).

In 1997, the BASIC treatment produced yields significantly lower than those of the conventional treatment (BASIC = 2.00 bales/acre, conventional = 2.69 bales per acre, p = 0.001, Figure 2). Within the BASIC treatment, the non-organic field yields (2.36 bales/acre) were not significantly different from conventional yields (p = 0.389), while the organic field yields (1.7 bales/acre) were lower than conventional yields (p = 0.001). When end-of-season plant density was included as a covariate, the overall BASIC treatment yield did not differ from the average conventional yield, but the organic yield remained significantly lower than conventional yield (p = 0.025). Plant density differences were not as great in 1997; Swezey and Goldman (1998) discuss the possible effect of early cutout date on boll positions and yield in 1997.

Estimated yields in 1998 (Figure 3) were the lowest for each treatment over the three-year period (non-organic BASIC=1.3 bales/acre, conventional=1.9 bales/acre, organic= 1.1 bales/acre). Significant yield differences existed between all treatments. However, final retention rates at the lowest positions were uniformly low (40%) and not significantly different between treatments (data not shown). Late planting date and prolonged cool weather prevented normal early plant development and accumulation of sufficient heat units for full crop formation by normal harvest dates.

Arthropods

Early season *Lygus* populations during all years were low in both BASIC and conventional fields (Figure 4), and were similar between the two throughout the production seasons except for one sampling date each year in late July or August, when BASIC fields had more *Lygus* than did conventional fields. However, at that point in August in 1996 and 1997, plants were beyond the peak squaring period which is the critical period of *Lygus* damage. *Lygus* nymph populations were similar in both BASIC and conventional fields. We have not detected a significant difference in square retention (upper five positions) on any date during critical squaring for any treatment (data not shown). A possible explanation for this result may be found in the abundant planting of alfalfa hay crops in adjacent fields. As a preferred host, alfalfa retains more lygus bugs than adjacent cotton (Godfrey and Leigh, 1994).

In all years, total natural enemy (predator) numbers were consistently higher in BASIC fields than conventional fields on several dates (Figure 5). This difference in all years was mainly due to *Geocoris* spp. abundances.

Leaf samples from all years showed larger early season spider mite populations in BASIC treatment fields than in conventional fields (Figures 7). When converted to percent leaves infested in 1998, mite populations were slightly higher than a common treatment threshold (50%) early in the season, but declined after mid-July. Populations of western flower thrips, a mite predator which can also cause plant damage, were also low throughout the season, and were slightly higher in the BASIC than in the conventional fields. Aphid populations, remained low in all years and did not differ between treatments (data not shown).

In order to evaluate the effect of adjacent alfalfa plantings on arthropod abundance in BASIC fields, we segregated a sample of non-organic BASIC and conventional fields (n=4) which differed only in that the BASIC fields had an alfalfa hay field immediately bordering on one side in 1998, while the conventional control fields did not have an adjacent alfalfa planting. Control fields appeared to have higher total lygus at mid-season (Figure 8) and earlier peaks of lygus nymphs (Figure 9) but we could not detect significance of differences on any on any date. No differences could be detected in the pattern of natural enemy abundance (Figures 10 and 11). We are continuing our analysis of these data.

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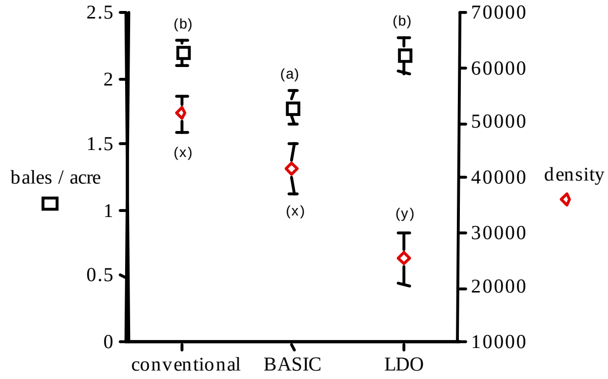
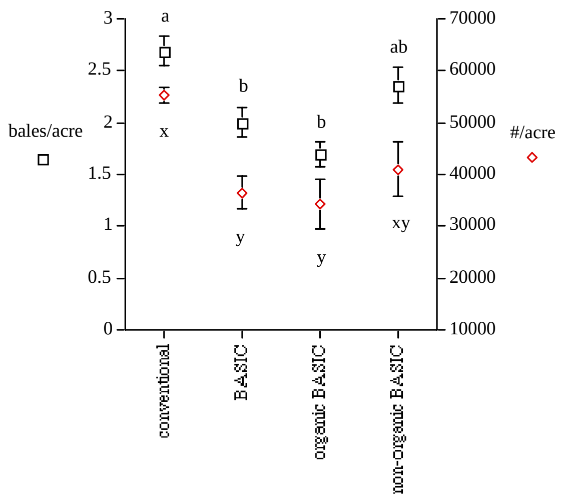


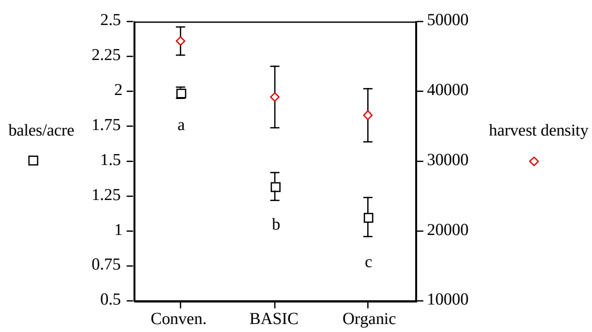
Values labelled with different letters are significantly different (ANOVA, p<0.05; Tukey HSD for post-hoc analysis). LDO = low-density organic component of BASIC.

Figure 1. 1996 BASIC. Yields and plant density



Values labelled with different letters are significantly different (ANOVA, p<0.05).

Figure 2. 1997 BASIC. Yields and plant density.



Values labelled with different letters are significantly different (p<0.05, Kriskal-Wallis).

Figure 3. 1998 BASIC. Yields and plant density

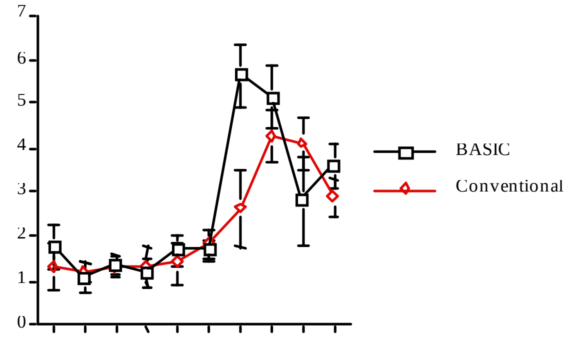


Figure 4a. 1996 BASIC. Total lygus.

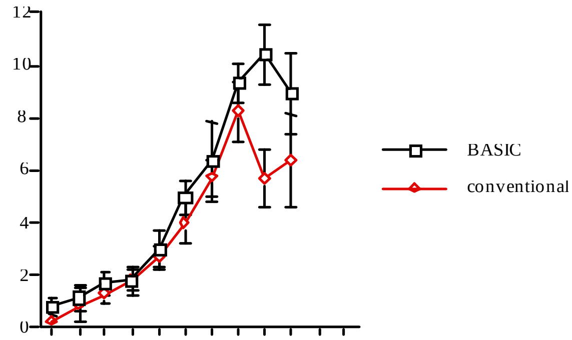


Figure 4b. 1997 BASIC. Total lygus.

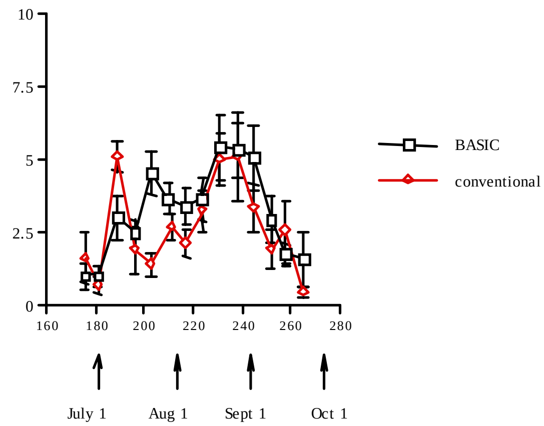


Figure 4c. 1998 BASIC. Total lygus.

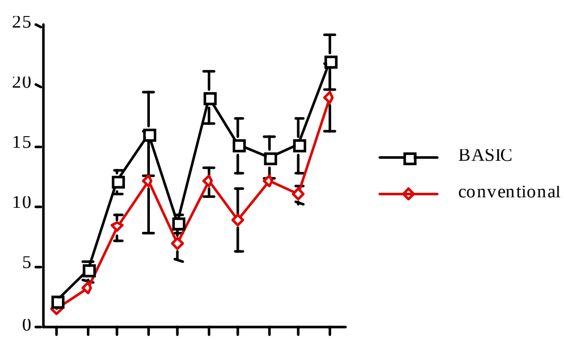


Figure 5a. 1996 BASIC. Total natural enemies.

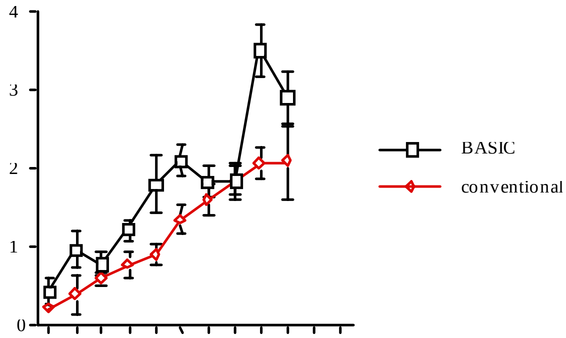


Figure 5b. 1997 BASIC. Total natural enemies.

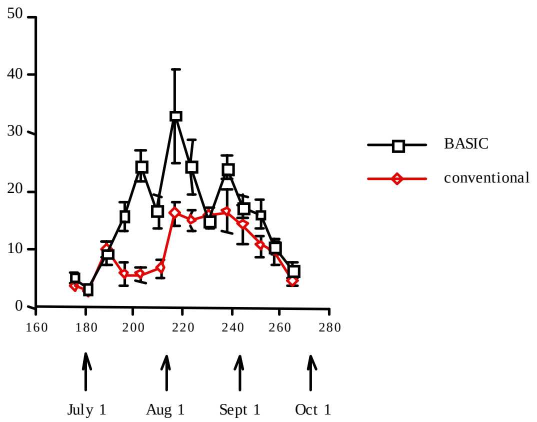
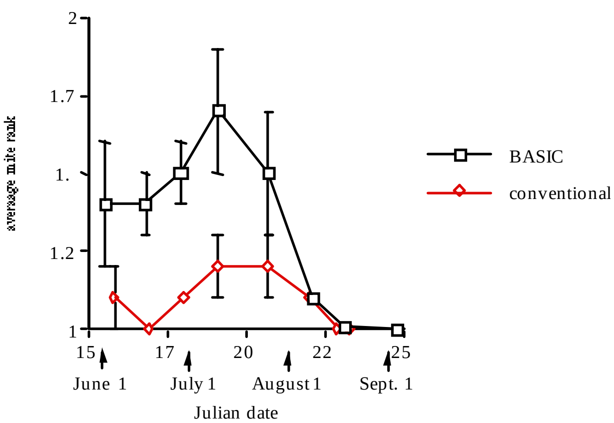


Figure 5c. 1998 BASIC. Total natural enemies.



A rank of 1 = no mites; 2 = 1 to 10 mites; 3 = 11 to 100 mites; 4 = over 100 mites

Figure 7a. 1996 BASIC. Spider mites.

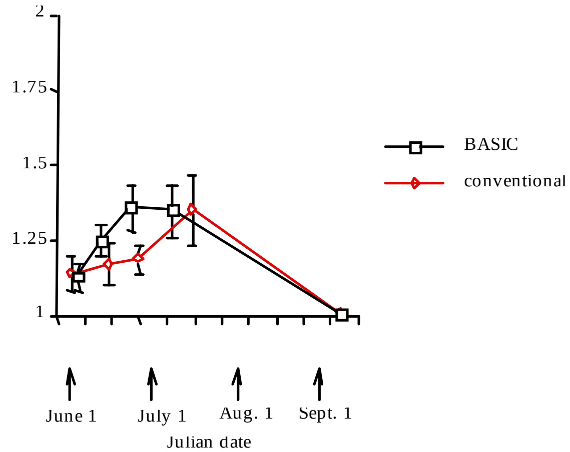


Figure 7b. 1997 BASIC. Spider mites.

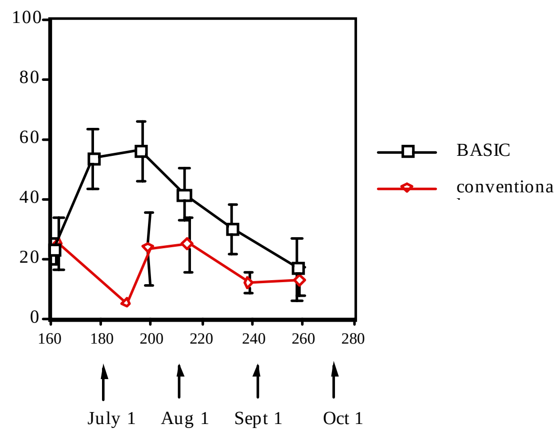


Figure 7c. 1998 BASIC. Percent Mite Infestation.

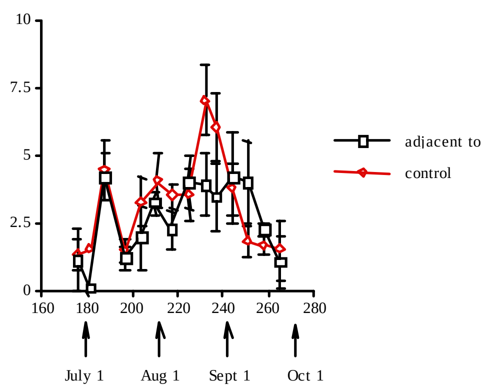


Figure 8. 1998 BASIC. Total lygus in fields adjacent to alfalfa.

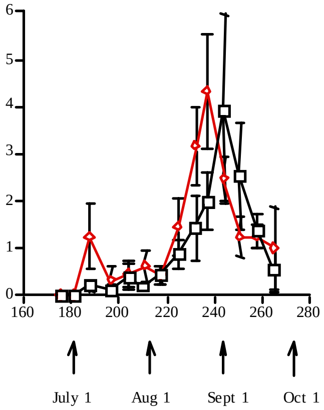


Figure 9. 1998 BASIC. Lygus nymphs in fields adjacent to alfalfa.

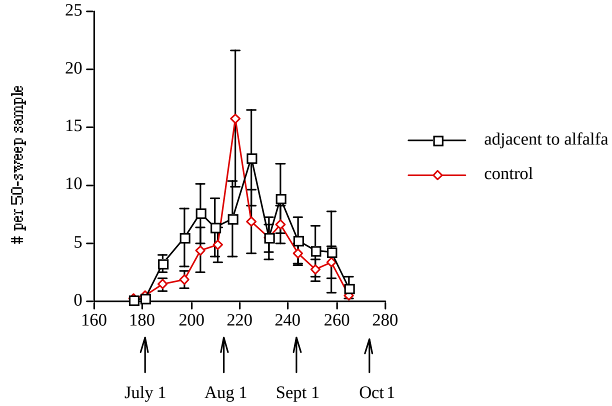


Figure 11. 1998 BASIC. Total *Geocoris* spp. In cotton fields adjacent to alfalfa.

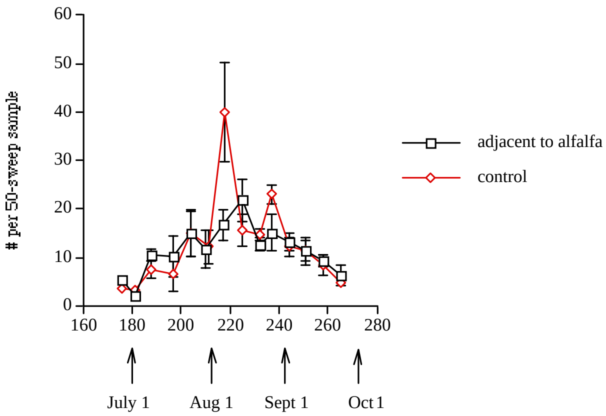


Figure 10. 1998 BASIC. Total natural enemies in cotton fields adjacent to alfalfa.