# CONVERSION OF COTTON PRODUCTION TO CERTIFIED ORGANIC MANAGEMENT IN THE NORTHERN SAN JOAQUIN VALLEY: PLANT DEVELOPMENT, YIELD, QUALITY, AND PRODUCTION COSTS

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## Abstract

Replicated mapping and harvest of sample plants in organic and conventional production systems in 1995 showed that yields did not significantly differ in the two systems, although yields were low in both production systems due to delayed planting under wet spring conditions. Boll retention was numerically higher in the organic production system; however this difference was only statistically significant at harvest at the lowest five positions. Boll retention at the first position was negatively correlated with increased plant density in both production systems. Average internode length and weekly height-to-node ratios, both indices of plant vigor, did not differ significantly between production systems. 1993 and 1994 quality factor measurements indicate that length, strength, micronaire, and leaf grade did not significantly differ between production systems. However, 36% of organic bales were classified as light spotted color grades in 1994, while conventional bales had few spotted grades. A preliminary comparison of 1994 operational costs of production showed that organic cotton had higher per acre production costs ($646/acre) than conventional cotton ($582/acre), including higher labor costs due to increased hand weeding requirements. Positive returns above operational costs for organic cotton could be projected for an average 1.6 bales/acre at a reported average price of $1.21/lb compared with positive returns above operational costs projected for conventional yields of 1.8 bales per acre at $0.80/lb in 1994. An average 44% premium was obtained for certified organic cotton.

## Introduction

In 1992, over 12.1 million lbs. of pesticides were used in California cotton (CDPR, 1992). Cotton is the fifth largest contributor to total farm income in the state, and has a gross value of nearly $1 billion in lint and seed (CDFA, 1994). However, rising costs of inputs and environmental regula tions (including pesticide regulatory pressures) and potential for technical and marketing innovation, have stimulated interest in California cotton production systems which do not require conventional synthetic pesticides and fertilizers as inputs (CIRS, 1993). Transitional or certified organic cotton acreage in California was estimated to be approximately 8,000 acres in 1994 (CCOF, 1994; Allen, personal communication).

The period of transition to certified organic production, defined as three years under new federal statute, is not well-documented for California cotton. Several important farm-level issues confront organic cotton production in California, perhaps the most important of which are soil fertility, pest and weed control, and crop preparation for harvest.

Certified organic cotton production requires planning of a 3-5 year rotational sequence to ensure adequate soil and plant nutrition during the period of transition and beyond. California organic cotton growers have used alfalfa, tomatoes, oats, wheat, and fallow, as well as leguminous cover crops and specialty crops (vegetables, garlic) in rotation with organic cotton. A well-planned rotational program is essential for the avoidance of soil disease, weed, nematode, and soil nutrient problems. Rotations to non-host crops or fallow have successfully reduced or eliminated the use of nematicides and fumigants for nematode and disease control in California cotton (Johnson and Goodell, 1988; DANR, 1984).

Barley, wheat, garbanzo bean, pea, and vetch green manures have been successfully managed between cotton crops on a small scale by California organic cotton growers. Timing of green manure and cotton plantings must remain somewhat flexible in response to weather in any given year. However, compost applications integrated with green manures have been substituted for synthetic fertilizer use, while inoculating the soil with beneficial organisms, building organic matter, and reducing or suppressing certain soil pests and diseases.

The principle arthropod pest of cotton in the San Joaquin Valley is the lygus bug (Lygus hesperus); mites, aphids, and caterpillars cause occasional damage. In an organic production system, the lygus bug can be controlled by strip-cropping the preferred host, alfalfa, as a "trap" crop (Stern, 1969; Sevacharian and Stern, 1974) introduction or conservation of natural enemies, possibly in strip-cut alfalfa and/or non-crop vegetation (Rakikas and Watson, 1974; Leigh and Gonzalez, 1976; Fleischer and Gaylor, 1987), and alternate-row conservation watering practices. California organic cotton growers often maintain field strips of native or planted vegetation as beneficial insect habitats in which native predators are conserved and/or mass-reared predators (lacewings, predacious mites) are released in the early spring. These predators colonize

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early cotton and are generally observed in increased numbers in cotton not treated with insecticides. Habitat strips have been established without sacrificing production acreage by planting or maintaining the strips in alleys, ditch and reservoir bank areas, and road and stream margins. Pests can be also be managed by release of beneficial arthropods or application of sulfur or natural disease agents.

In-season monitoring of plant development and damage to cotton squares is highly developed in California. Most organic cotton growers make use of plant mapping software (DANR, 1991) and calculations during the critical period of bud formation and boll maturation (Kerby and Goodell, 1990). Based on these measurements, organic cotton growers refrain from early treatments for thrips, mites, and aphids. Aphids are rarely an economic pest to early cotton (Rosenheim, 1995) and early pesticide applications to cotton fields are considered counter-productive for the survival of natural enemies.

In most years, organic cotton bed preparation, varietal selection, and row spacings do not vary from current conventional practice (Kerby, 1988). However, in a wet spring, substitution of herbicide use for cotton weed control is costly in the early stages of cotton growth. Organic cotton growers generally make increased use of hand-weeding and hooded cultivators, allowing close work to small plants without damaging them or covering them with soil. Soil capping, flaming, mowing, wire and string weeding, deep plowing, and alternate row irrigation have also been used for weed control.

One of the greatest production barriers for California organic cotton growers is organic substitution for convnetional crop preparation materials for growth regulation and defoliation. Growers have substituted mechanical topping of cotton plants for chemical growth regulation, and regulation of late season irrigation water and nutrients have been used to encourage dry down. Foliar nutrient sprays, including mild organic acids, humates, salts, sodium nitrate, and zinc and magnesium sulfate, are used on organic cotton in late season. The effects of the use of these materials on natural defoliation have been irregular, and the effective use of these materials is not well-understood in terms of timing, mode of action, or effective field application rates.

Over the past several years, California organic cotton growers have sought and applied a wide combination of biological, cultural, nutritional, and mechanical means to confront production problems (CIRS, 1992). However, little research-based information is presently available to growers about the relative agronomic performance of certified organic cotton production systems in California. In 1992, we began a multi-year study of plant growth, nutrition, and yields; soil characteristics, pest and beneficial arthropod abundance, pest damage, and economic and energetic performance of organic cotton production systems in the northern San Joaquin Valley. Reported here are in-season plant growth and retention for critical positions, as well as year-end plant mapping and yield information for replicated organic and conventional cotton production plots in 1995. We also report comparative fiber grades and classifications in 1994, and a preliminary operational costs of production study for the 1994 season.

## Materials and Methods

In April 1995, four certified organic cotton fields were selected in an area bounded by Highway 152 and Avenue 25 (south-north) and Roads 5 and 7 (west-east), 10 miles west of Chowchilla, California. These fields were among those managed by Sheppard Farms Inc. (Claude and Linda Sheppard, owner-operators). These certified organic cotton fields were matched with the closest conventional fields planted to the same variety (San Joaquin Acala-Maxxa). Conventional field replicates were managed by growers Sean Moss, Craig Farmer, and Kelby Hooper. Replicate fields ranged in size from 20-70 acres. Organic fields were fertilized with a late-winter application of composted chicken manure, in contrast to at-planting application of a synthetic nitrogen fertilizer in the conventional production system. Two applications of foliar nutrients and year-end zinc sulfate were also made to the organic fields. The conventional production system received preemergent herbicide at planting, and several in-season insecticide sprays for mite, lygus bug, and aphid control. The conventional system also received one growth regulator application, and an application of dessicant and/or defoliant at the end of the growing season. Both systems used hand hoeing and cultivations with tillage implements for in-season weed control, and furrow irrigation schedules were similar, although alternate-row watering was employed in some irrigations of the organic production fields. The organic production system used periodic spring releases of immature green lacewings (10-15,000/acre) into field margins for management of key pests (lygus bug, mites, aphids). The organic production replicates were picked largely green, although foliar nutrients, humates, and zinc sulfate applications were made as a nutritional supplement prior to harvest.

At weekly intervals during the growing season, and in one final sample immediately before harvest, 20 randomly selected cotton plants were removed from each of the eight replicate fields. The architecture of these plants was mapped based on the University of California CALEX/Cotton manual and plant mapping software (DANR, 1991). Plant height, internode length, number of nodes, number and position of vegetative and fruiting branches, and position and percent retention of fruiting parts were measured. Plant density and yield were calculated in each replicate immediately prior to machine harvest with four, 1/1000 acre linear row samples, in which plants were counted and hand-harvested. Hand-harvested samples were weighed and yield was calculated based on the average of the four 1/1000th acre samples from each replicate field. 34% and 38% estimated turnout was used to make a final yield calculation for organic and conventional cotton, respectively.

1994 fiber quality grades and measurements were averaged for all bales based on gin records from each replicate field. 1994 operational costs of production were established based on post-harvest grower interviews, management records, and baseline operational budget calculations for organic and conventional cotton (Klonsky et al, 1995a and b) in California. Budget Planner software (Klonsky, 1990) was used for final per acre operational cost calculations. Grower interviews established an estimate of average price obtained for both organic and conventional cotton crops in 1994.

Significance of differences between production systems treatments was determined with an analysis of variance (F ratio) test, using non paramentric tests (Kruskal-Wallis) in cases of non-normality or unequal variances. The level of significance was set at $p< 0.05$.

## Results and Discussion

Table 1 shows the tabulated results of the 1995 year-end plant mapping and yield calculations. These results indicate that although yield, height, nodes, and fruiting branch production did not differ between production systems, boll retention at all positions was numerically greater in the organic production system. No in-season statistical difference could be determined for growth rate in terms of height-to-node ratio (Figure 1) or fruit retention at the top (Figure 2) or bottom (Figure 3) five positions. 1995 was the first year of observation in which repli cate organic and conventional planting densities overlapped, due to variable seeding rates and stand establishment under wet planting conditions. No statistical significance for differences between average plant densities could be established due to this variability. However, retention at harvest of the bottom five first positions was significantly higher in the organic production system, possibly indicating some density-related effect. Organic plants did not appear to suffer any deficiencies that would lead to growth stress in terms of internode length/HNR or height when compared to conventional plants. Yields were low and not significantly different in 1995 due to wet planting conditions and late replant start. Some replicate fields were replanted several times and establishment and growth was generally limited until early June.

Early boll retention, an index of critical boll development in early season, was greater for the organic production system. Across treatment replicates, planting density was negatively correlated with boll retention at every position, ie. the lower the plant density, the higher the boll retention rate (data not shown). Since no significant difference in yield was detected between production systems, this result may indicate the continuing influence of a lowered density-higher retention rate strategy for the organic production system.

Statistically indistinguishable growth parameters between conventional and organic cotton production systems in 1995 (the fourth conversion year) indicate that organic production conditions are not stressful for cotton plants, given the otherwise late start of the 1995 season. Possible stress effects due to lack of water and nutrients (often coincident with extreme temperatures) would be expressed in reduction of height or nodes, abnormal shedding, or early plant cut out. These effects were not observed in terms of the variables compared.

First position bolls accounted for a lower percentage of total open bolls at harvest in the organic production system in 1995 and previous years of observation (Swezey, 1995). Since first position bolls are expected to produce higher quality fiber, quality parameters of the bales from the replicated fields for both treatments, (based on 1993 and 1994 gin records) were evaluated. The only significant differences appeared in fiber grades (Figure 4); an average of 36% of organic bales were classified as light spotted (color grades 22,32,42,and 52) and 6% as spotted (color grades 33 and 43) in 1994. There were no significant differences between the two production systems in leaf rating (Figure 5), length (Figure 6), strength (Figure 7) and micronaire (Figure 8). While organic cotton leaf content is manageable by modifying harvest practices, light spotting of fiber is a clear difference in grades due to less effective defoliation conditions. While this spotting did not present an overall grading problem (due to good leaf, length, strength, and micronaire classifications), demonstration of acceptable certified organic defoliation practices and materials for California organic cotton is a high research/extension priority for organic cotton growers.

A preliminary operational costs of production comparison for organic and conventional cotton in the 1994 conversion study year is shown in Table 2. Organic production was 11% higher in per acre operational costs, and 25% higher in per bale operational costs. Differences in labor (increased hand weeding) and custom cultivation (increased mechanical tillage) and harvest were the largest cost increases observed. However, the cost of synthetic fertilizer and chemical pesticides within the materials budget were greatly reduced in the organic production system. At harvest, the organic production system required more labor and field power, due to second picking in most fields. Material costs of harvest aids (defoliants, dessicants) were also low in the organic production system. At an average price of $1.21/lb for the organic cotton and $0.80/lb for the conventional cotton, positive returns above operational costs could be projected for both production systems of $313 and $138 respectively, per acre. A price premium of 51% for organic cotton was necessary for this difference under the conditions observed in 1994.

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**Table 1.**
**1995 CASFS Cotton Conversion Study**
**End-of-Year Summary Statistics**
*denotes significant difference, $p < 0.05$ (one-way ANOVA)

| measurement | organic | conventional |
|---|---|---|
| plant height | 33.3 | 32.0 |
| # nodes | 18.6 | 17.5 |
| internode length | 1.8 | 1.8 |
| veg nodes | 5.0* | 5.8 |
| # FB | 13.7 | 11.7 |
| # 1st pos. OB | 5.5 | 4.3 |
| # 2nd pos. OB | 2.5 | 1.7 |
| # 3rd+ OB | 1.7 | 0.5 |
| B-5 retention | 3.3* | 2.7 |
| plant density | 29750.0 | 38875.0 |
| yield (model) | 1.1 | 1.3 |

**Table 2.**
**1994 CASFS Cotton Conversion Study**
**Per Acre Cost and Yield Comparisons**

| | | Organic | Conventional |
|---|---|---|---|
| **Cultural** | Labor | 120.33 | 44.10 |
| | Field power | 53.70 | 39.73 |
| | Materials | 108.34 | 228.48 |
| | Custom/Rentals | 162.00 | 75.00 |
| | **Total Cultural** | **444.37** | **387.31** |
| **Harvest** | Labor | 13.80 | 9.51 |
| | Field Power | 46.29 | 25.11 |
| | Materials | 5.81 | 24.86 |
| | Custom/Rentals | 89.60 | 100.80 |
| | **Total Harvest** | **155.50** | **160.28** |
| **Interest** | | 30.11 | 25.15 |
| **Assessments** | | 8.20 | 9.24 |
| **Certification fees** | | 8.29 | 0.00 |
| **TOTAL COSTS/ACRE** | | **646.47** | **581.98** |
| **YIELD (bales/acre)** | | 1.60 | 1.80 |
| **TOTAL COSTS/BALE** | | **404.04** | **323.32** |

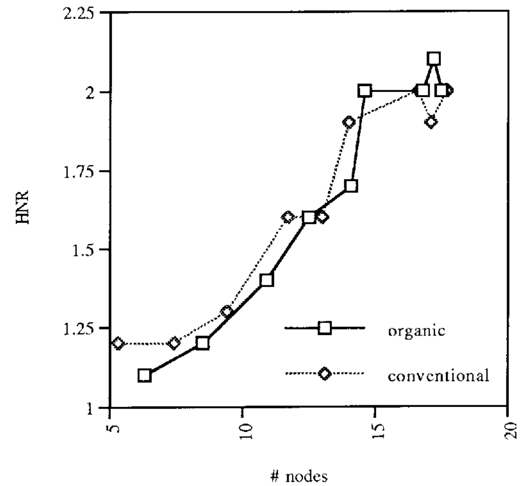


**Figure 1.**
**1995 CASFS cotton conversion study.**
**# Nodes vs. Height to Node Ratio (HNR)**

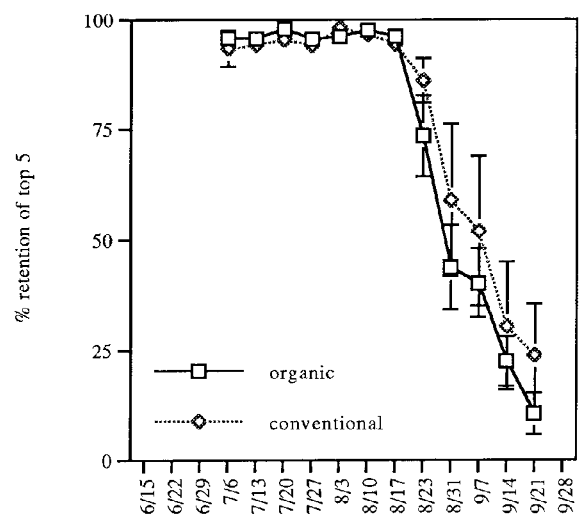


**Figure 2.**
**1995 CASFS cotton conversion study.**
**Retention of top 5 position bolls.**

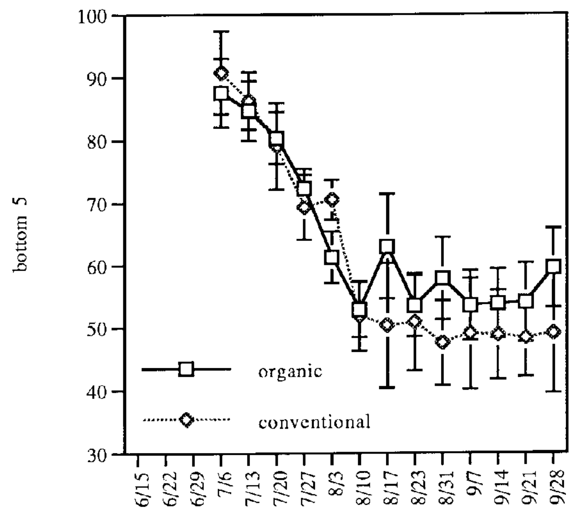


**Figure 3.**
**1995 CASFS cotton conversion study.**
**Retention of bottom 5 position bolls.**

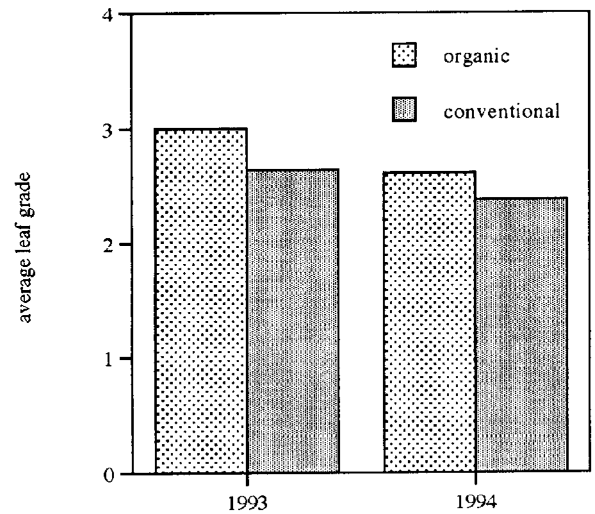


**Figure 5.**
**CASFS Cotton Conversion Study.**
**1993/94 Average Leaf Rating.**

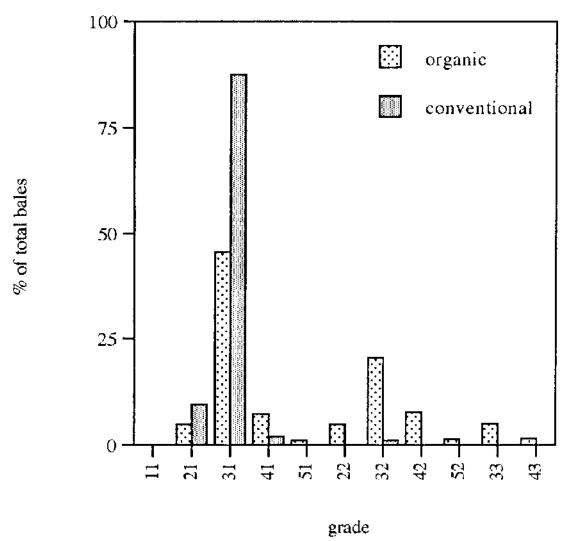


**Figure 4.**
**1994 CASFS Cotton Conversion Study.**
**Average Color Grades.**

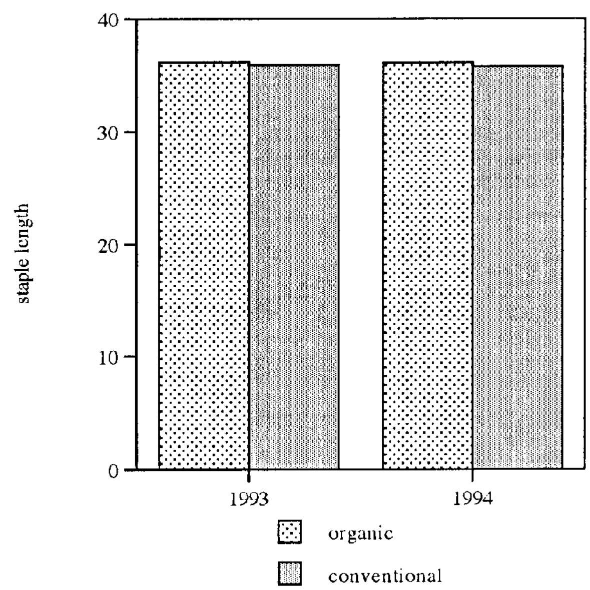


**Figure 6.**
**CASFS Cotton Conversion Study.**
**1994 Staple Length.**

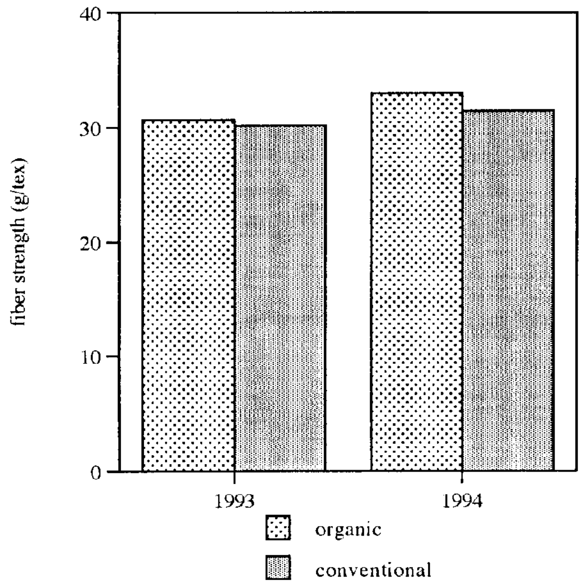


**Figure 7.**
**CASFS Cotton Conversion Study.**
**1994 Fiber Strength.**

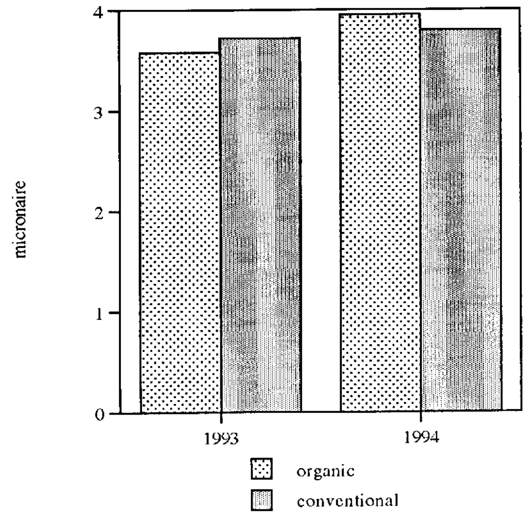


**Figure 8.**
**CASFS Cotton Conversion Study.**
**1993/94 Micronaire.**