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EARLY LEAF LOSS, LEAF REMOVAL IMPACTS ON UPLAND COTTON GROWTH AND YIELD

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Abstract

Field studies were initiated in cotton in the San Joaquin Valley of California to evaluate the impact of different amounts of leaf loss on growth and yield when the losses were concentrated in the first seven leaves of developing cotton plants. Evaluations were made over multiple growing seasons in field trials based on two approaches to looking at responses to leaf loss: (1) physical removal of specific main stem leaves at certain growth stages using a razor blade; and (2) measured leaf area loss produced using different rates and timing of insecticide applications to provide partial or more complete control of the thrips. Worm damage in any of the plants during the season was very light, particularly during early season growth, and the presence of thrips was confirmed visually and by field sampling. Other insect pests were controlled during the course of the growing season in all plots according to University of CA sampling guidelines, and kept below threshold levels in plots. Leaf removal treatments were 0, 29, 43, 57, 71 and 86 percent removal of the first seven main stem leaves on developing plants (with specific patterns and timing of leaf removal). Leaf area loss treatments produced using variable insecticide timing and rates produced leaf area losses ranging from 0 to 84 percent leaf area reduction as measured when the 7th leaf reached 25 mm diameter in the 0 percent leaf loss control treatment. Early season leaf loss up to about 60 percent had no significant impact on lint yields. Leaf loss in the 77 and 86 percent treatments resulted in 6 to 16 percent reductions in final plant leaf area (measured in August), moderate delays (3 to 7 days) in reaching boll maturity (defined as 60% open bolls) and 9 to 16 percent reductions in yield.

Introduction

Early season leaf damage or leaf loss in cotton can occur as a result of damage from a range of causes, including injury from insect and mite feeding, weather-related damage coming with hail or cold-weather injury, or with physical or mechanical injury associated with cultivation or phytotoxic responses to early chemical sprays. Regardless of the cause of the injury, leaf loss has potential to impact growth rates and growth patterns if damage is substantial.

Observations in California's San Joaquin Valley have been made that early season leaf damage can be a relatively common occurrence in CA cotton when thrips populations rise to high levels very early in the season, particularly when plant growth rates are relatively slow due to cool or cloudy weather. The injury from thrips usually results in a wavy, irregular pattern of leaf development and significant reductions in leaf size. Depending upon the vigor of growth and duration of pest pressure, the damage can impact several or many leaves in early development, and in the worst cases can produce damage to the primary meristem, resulting in initiation of numerous secondary, vegetative branches. The primary reasons for hesitation in making pesticide applications to control thrips has been due to consistent past experience with negative impacts of early season insecticide applications on beneficial insect populations, including impacts on thrips which can help limit early season spider mite problems. This study was initiated to evaluate the degree of leaf loss within the first seven main stem leaves that can be tolerated and potential impacts on leaf area, delays in boll set and maturity, and lint yield.

Materials and Methods

Cotton was planted in multiple years (1996, 1999, 2001) at two field sites in a clay loam soil. Three field replications of four row plots, 30 feet in length were planted with the Acala variety "Maxxa" and Pima variety "S-7". Leaf removal treatments were imposed to create what amounted to 0, 29, 43, 57, 71 or 86 percent removal of the first seven leaves on each plant by removal of specific leaves as shown in the Table 1. Leaves were physically removed from the plants at the time they reached a minimum of 0.4 inch length or greater, and leaf removal was only done on Tuesdays or Fridays of each week, and only as leaves reached the minimum size of 0.4 inch for removal. Leaf removal was done near the point of leaf blade connection to the developing petiole using a razor blade. Care must be exercised in describing the results of the leaf removal studies. The percent leaf number reduction classifications shown in Table 1 are reductions in number of leaves expressed as a percentage of the total seven leaves, not a leaf area reduction. Typically, average leaf size increases with later-developing main stem leaves, so the percent leaf number reductions would not be equivalent to leaf area reductions. Measured average leaf area by leaf position on control plants from these fields will be applied to this data set as it is prepared for later publication in order to better estimate treatment averages for leaf area reduction.

For comparison with physical leaf removal treatments, variable rates and timing of a foliar applied insecticide were made on a weekly basis to provide different levels of control of developing populations of thrips. Relative impacts of pesticide treatments on leaf area reduction were assessed by comparing leaf area of a ten plant sample collected at the seven-leaf stage in each treatment to the leaf area of a treatment receiving the highest rate and amounts of pesticides, which were verified as maintaining the lowest average thrip populations across treatments. Note that in these pesticide treatment evaluations, relative leaf damage is measured as leaf area changes, not leaf number as in the leaf removal studies.

The presence of thrips was assessed visually in plots on a weekly basis, and a relative index of thrips populations was made in each by placing a piece of paper under a section of plant row, and tapping plants to knock off thrips and get a relative index "count" of thrip populations. This was done in 5 different areas of representative plots. Leaf area index was measured mid-season on a 5-plant harvest, and in mid-August using an area-harvest of a three foot row length in two adjacent rows. Yields were measured on seventeen-foot lengths of row in all field replicates for each treatment.

Results and Discussion

Removal of three leaves (43% removal treatment) or more resulted in a significant reduction in total plant leaf area measured in mid-June (Figure 1). When the leaf removal was spread over a range of times in the 43% treatment (removal of leaves 1, 3, 5), a more rapid rate of leaf growth in the following months resulted in no net reduction in leaf area when compared to lower leaf area reduction treatments (Fig. 1). By comparison, when all early leaves were removed (43%-early treatment which removed leaves 1, 2, 3), leaf areas measured in later months (July, August) were significantly reduced. All leaf removal treatments with 57 percent leaf removal or greater resulted in significant reductions in measured leaf area. This data and similar data for other years (data not shown) generally indicated that leaf number reductions greater than about 50 to 60 percent resulted in reduced total leaf area when compared to all treatments with lower amounts of leaf removal. Similar responses were measured for Pima cotton (data not shown). Lower leaf areas does not necessarily imply a limitation to cotton lint yields, so measurement of lint yields was also an important component of the study.

Lint yields were significantly reduced in data from 2001 (Figure 2) and 1999 (Figure 3) in leaf removal studies in the 43%-early treatment, and in all other treatments with 57 percent or more of the first seven leaves removed. Similar responses were seen in another year with Acala "Maxxa" and in two years with Pima "S-7", although the magnitude of the yield responses varied with year and type of cotton (data not shown). In general, leaf area losses, if combined with a shorter growing season with cool fall, had greater impact on Pima yields, presumably because Pima requires a longer growing season to mature out late bolls. When early season weather conditions were less favorable for rapid seedling growth (1999 data, Figure 3), impacts of leaf loss on lint yields were lower in pounds of lint yields lost than in a better early season weather year (2001, Figure 2), but yield losses expressed as a percent of yields in the control treatment were similar.

Leaf damage treatments produced with variable insecticide rates and timings produced basically similar results as seen in leaf removal treatments just described, with significant yield losses occurring mostly when leaf area was reduced by 60 percent or more (Figure 4, 1999; data not shown other years). One additional finding with the leaf damage naturally produced by thrips as compared with artificial leaf removal, was the more severe yield reductions that occurred in plots in which the terminal meristem was also severely injured. Damage to the terminal meristem reduced yields (see 59%-term and 84%-term treatments in Figure 4), reduced leaf area significantly (data not shown) and delayed maturity (data not shown).

Results from this study help form a basis for consideration of just how much early season leaf loss should be tolerated under San Joaquin Valley conditions. Based on the results of these evaluations, mild to moderate leaf loss associated with thrips injury or perhaps other problems would not likely result in significant yield losses or delays in crop production. Results suggest that leaf damage that is becoming severe enough to reduce leaf area more than about 60 percent of what is considered "normal" development, or evidence of significant damage to the terminal meristems should prompt additional field assessments and consideration of treatments to limit additional leaf area loss.

Table 1. Leaf removal treatments in field studies with Acala and Pima cotton. First leaf above cotyledons was identified as leaf #1, the second leaf above cotyledons as leaf #2, and so on through leaf # 7. An "X" in the row indicates that leaf was removed for the treatment shown.

Leaf # removed	Leaf removal treatment (percent of leaves removed out of first 7 main stem leaves)							
	0	29	43	57	71	86	43-early	43-late
1		X	X	X	X	X	X	
2					X	X	X	
3			X	X		X	X	
4					X			
5		X	X	X	X	X		X
6						X		X
7				X	X	X		X

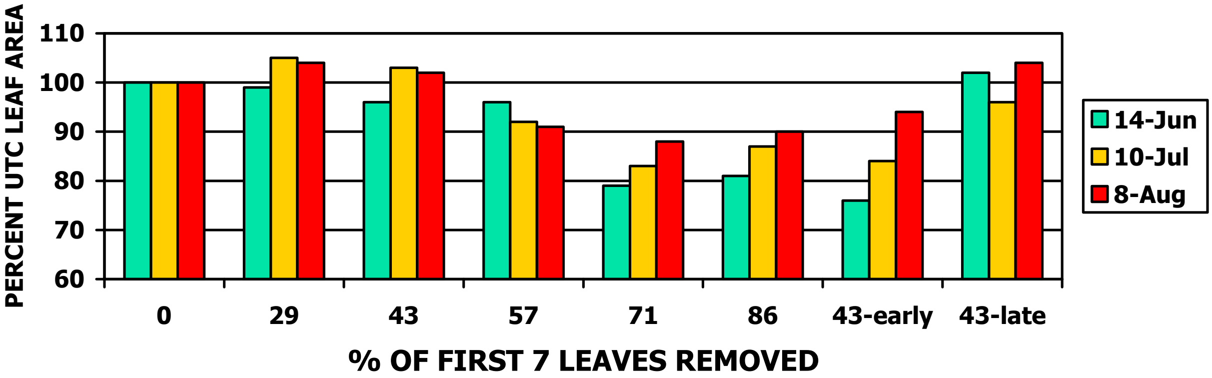

Figure 1. Leaf area of Acala "Maxxa" cotton in 1999 study as a function of leaf removal treatment measured three times during growing season expressed as a percent of the treatment with no leaf removal (0%)

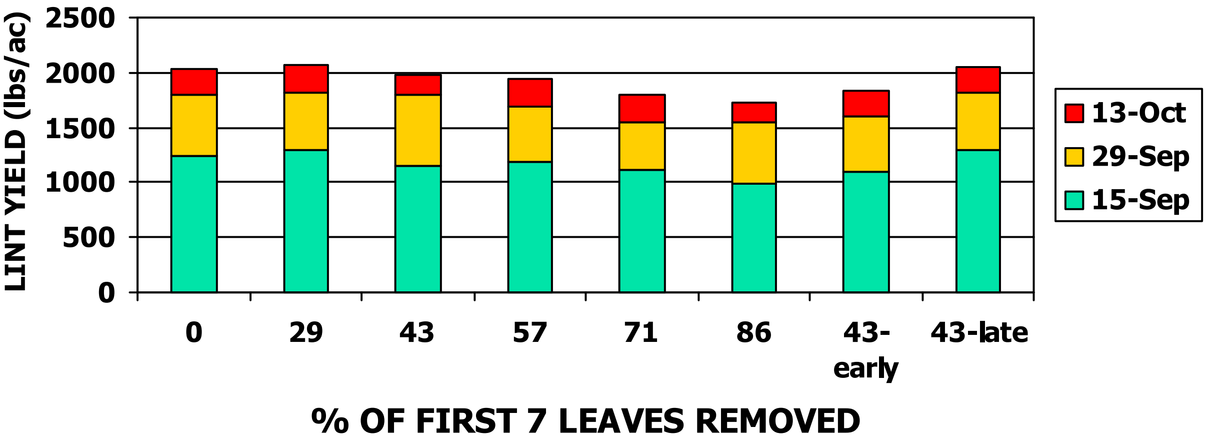

Figure 2. Lint yield of Acala "Maxxa" cotton in 2001 study as a function of leaf removal treatment. Dates shown and different parts of each bar graph represent the portion of total lint yield present in bolls open on that specific date. The early 2001 growing season was characterized by relatively warm, good early seedling growth conditions.

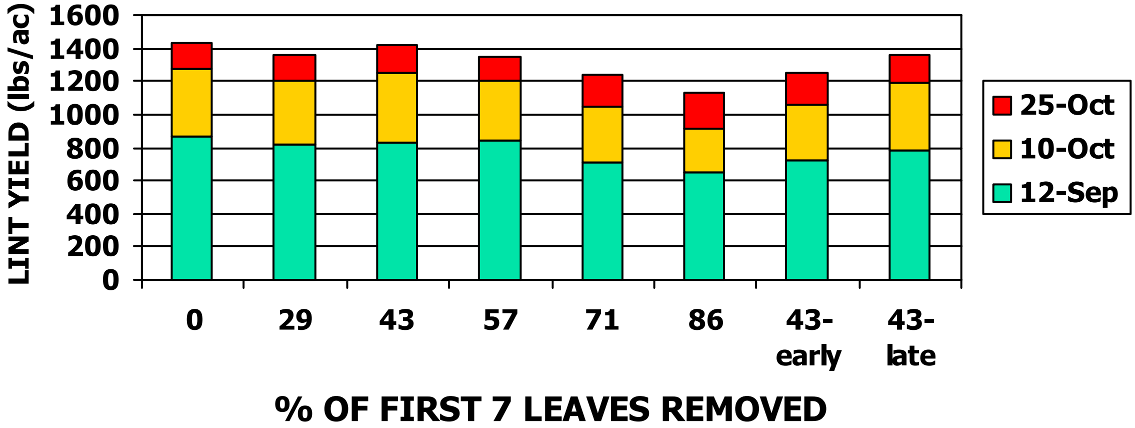

Figure 3. Lint yield of Acala "Maxxa" cotton in 1999 study as a function of leaf removal treatment. Dates shown and different parts of each bar graph represent the portion of total lint yield present in bolls open on the date shown. The early 1999 growing season was characterized by fairly cool, wet conditions that were relatively poor for early seedling growth.

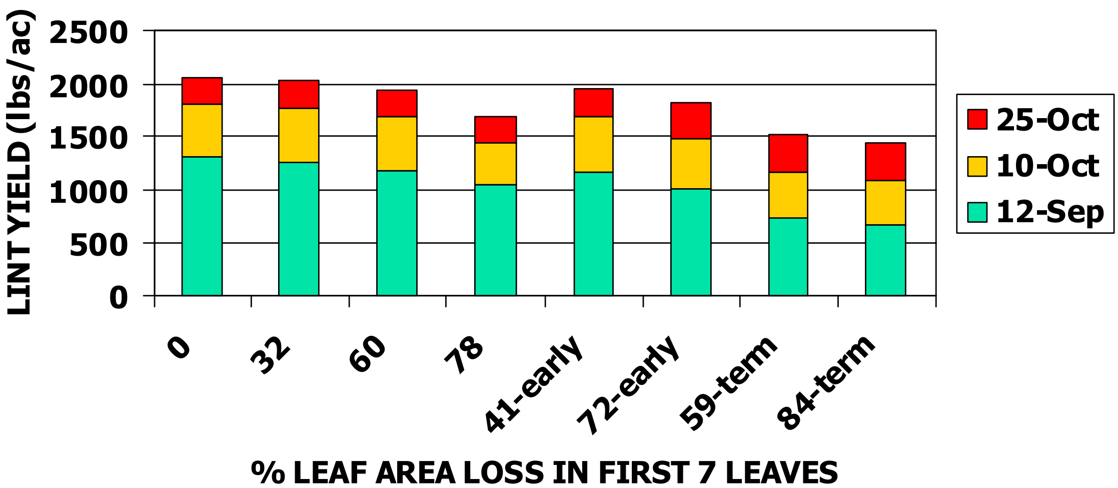

Figure 4. Lint yield of Acala "Maxxa" cotton in 1999 as a function of leaf damage and leaf area loss produced by thrip damage. Differential treatments were produced using different insecticide application rates and timing.