Effect of Plant Water Status on Defoliation and Yield of Pima Cotton

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Abstract

A field study was conducted at the Maricopa Agricultural Center to determine the influence of plant water status at the time of defoliation on the effectiveness of defoliants and the yield of Pima cotton. Irrigation termination dates of 3 and 20 September and 8 October were used to achieve different levels of plant water stress at the time defoliants were applied (26 October). A single application of defoliants was not adequate to defoliate the cotton under the conditions of this test. The 3 September irrigation termination date resulted in the highest percentage of defoliation (63%). CWSI and plant water content (RWC) measurements indicated that the irrigation termination treatments resulted in large differences in plant water stress at defoliation time. There was a significant increase in the percent defoliation as the CWSI values increased from 0.54 to 0.99.

Introduction

Pima cotton has generally been more difficult to defoliate than upland cotton, requiring multiple applications of defoliants to properly prepare the crop for harvest. Research is currently being conducted to develop defoliation treatments that are effective in a single application (Nelson and Hart, 1992; Silvertooth et al, 1992; Silvertooth et al, 1993).

Although the use of chemicals to promote defoliation has been studied, little research has been done on the management of water to condition the Pima cotton plant for defoliation. In general, excessive water during the season and prior to defoliation can result in vegetative plants with dense canopies and favor regrowth after defoliation. An inadequate supply of water during the season may result in changes in the cotton leaf cuticle and a decrease in the efficiency of defoliation (Oosterhuis et al, 1991).

If the plants are very dry at the time defoliants are applied, there may not be sufficient physiological activity in the leaves to carryout the effects of the defoliants. In addition, if leaves are dried past a certain point, leaf weights may not be great enough to allow the leaf to break free of the plant at the abscission layer.

However, late season stress can increase defoliation because stressed plants produce fewer new leaves and existing leaves age faster. A general recommendation has been to allow one month between the final irrigation and the application of defoliants (Silvertooth et al, 1992). Work was initiated in 1992 to study the use of CWSI (Crop Water Stress Index) and other plant water status measurements as guides to when defoliants will be most effective (Nelson and Hart, 1993). The objective of this study was to determine the effect of plant water status at the time of defoliation on the effectiveness of defoliants and yield of Pima cotton.

Materials and Methods

Seed of Pima S-7 cotton was planted at the Maricopa Agricultural Center in moist soil on 12 April 1993. During the season and prior to September the planting received irrigations on 26 April, 27 May, 11 June, 8 July, 22 July, 4 August, and 16 August. Three irrigation treatments to provide different levels of plant water stress were established using different irrigation termination dates. The irrigation treatments were as follows:

Treatment	Date of termination irrigation	Days from termination irrigation to defoliation	% Depletion of of available water
I_1	3 September	53	88
I_1	20 September	36	68
I_3	8 October	18	49

Treatments I_1, I_2, and I_3 all received irrigations on 3 September. On 20 September the I_2 and I_3 treatments were irrigated and on 8 October only the I_3 treatment was irrigated.

Soil water content in each irrigation treatment was measured weekly with a neutron moisture probe to a depth of 6 feet after the termination irrigation and on the date of defoliation. Just prior to defoliation, canopy temperatures were measured with a hand held infrared thermometer and vapor pressure deficits were determined using an aspirated psychrometer. This information was used on determine the CWSI for cotton in each irrigation treatment at the time defoliants were applied. Tissue water content as expressed by the relative water content (RWC) of fully mature leaves , was determined just prior to defoliation. Leaf discs were collected from plants in each treatment in the field and placed immediately in sealed tared containers in a cooler. After the fresh weights of the leaf discs were obtained they were rehydrated by placing them in water overnight. They were then weighed and ovendried for 24 hrs. and then weighed again to obtain their dry weights. Values of RWC were then calculated as follows:

$$RWC = \frac{\text{fresh weight - dry weight}}{\text{saturated weight - dry weight}}$$

The cotton was defoliated on 26 October using a tank mix of Dropp at 0.15 lb.a.i./acre + DEF at 0.75 lb.a.i./acre + 1 pt/acre crop oil. These defoliants were applied using a HiBoy sprayer with a 7 nozzle/row boom and spray volume of 20 GPA. Petiole NO_3-N content of plants in all irrigation treatments averaged 2200 ppm on 15 September. During the 14 day period after defoliants were applied only 149 HU were accumulated. Average maximum and minimum temperatures for the same period were 81 and 44°F, respectively. Plots were rated visually for defoliation 7 and 15 days after defoliants were applied.

Each irrigation treatment plot was divided into six, 38 ft. long subplots for CWSI measurements, RWC measurements and defoliation estimates. Experimental design was a randomized complete block with four replications. The cotton from the center 2 rows/plot was machine harvested on 16 November.

Results and Discussion

In this test, none of the irrigation treatments resulted in acceptable defoliation from a single application of defoliants (Table 1). The highest defoliation obtained 15 days after application of defoliants was 63% in the I_1 treatment. Temperatures were very cool during the 14 day period after defoliation and only 149 HU were accumulated during that time. Defoliation has generally been found to be more successful when >200 HU are accumulated within 14 days after application of defoliants (Silvertooth et al, 1993). Irrigation treatments had a significant effect on the effectiveness of defoliants with the earliest irrigation termination date giving the highest defoliation percentage (Table 1). Treatments did not have a statistically significant effect on lint yield, but there was a trend toward lower yields as the interval between the termination

irrigation and defoliation date increased.

Plant water stress measurements indicated that irrigation treatments resulted in large differences in plant water stress at the time of defoliation. In this test, average CWSI values ranged from 0.60 in the I_3 treatment to 0.98 in the I_1 treatment (Table 2). There was a highly significant relationship between CWSI and defoliation percentage 15 days after application of defoliants ($r^2=0.81^{**}$) As the CWSI values increased from 0.54 to 0.99 there was a significant increase in the effectiveness of defoliation. In 1992, in a similar test, CWSI values were not related to percent defoliation, probably because defoliation percentages were very high in all treatments (Nelson and Hart, 1993).

Relative water content (RWC), a measurement of the plant leaf water status, was also influenced by irrigation treatments (Table 2). There was a significant relationship between RWC and percent defoliation ($r^2=0.44^{*}$); however, this relationship was not as close as the relationship between CWSI and defoliation. Since RWC is a more difficult and time consuming measurement to obtain, it would appear that CWSI has the most potential as a method for determining when a cotton crop has achieved the optimum water status for defoliation.

References

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Table 1. Effect of irrigation treatments on defoliation and lint yield of Pima S-7 cotton.

Treatment	Days from final irrigation to defoliation	% Defoliation 0 days	7 days	15 days	Lint yield (lbs./acre)
I_1	53	31a*	43a	63a	1290a
I_2	36	27b	39b	54b	1320a
I_3	18	25b	36c	52b	1340a

* Means in columns followed by the same letter are not significantly different at the 0.05 probability level.

Table 2. Effect of irrigation treatments on defoliation, CWSI and RWC of Pima S-7 cotton.

Treatment	Days from final irrigation to defoliation	Defoliation % 15 days	CWSI*	RWC*
I_1	53	63a**	0.98a	0.668b
I_2	36	54b	0.76b	0.717ab
I_3	18	52b	0.60c	0.776a

* Measurements taken just prior to application of defoliants.
** Means in columns followed by the same letter are not significantly different at the 0.05 probability level.