Physiological Response of Cotton to Terminal Damage

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Abstract

The terminal of a cotton (Gossypium spp.) plant controls the growth of lower vegetative branches through the production of hormones. If the terminal is damaged then the lower vegetative branches will begin to grow and produce new mainstems. The objective of this study was to determine what delays, if any, are caused by damage to the terminal meristem. Three identical experiments (differing only by their planting date) were conducted in the greenhouse in which Upland (G. hirsutum L., var. DPL 5415) cotton was planted in 24 pots and allowed to grow until the majority of the plants reached the four true-leaf stage. At that point half of the plants had their terminals removed. Twice weekly series of plant measurements were recorded for each plant in the study. Measurements taken included the number of mainstem nodes, plant height, node of the first fruiting branch (FFB), days after terminal removal (DATR) until the appearance of the FFB, node of the first bloom, and DATR until the appearance of the first bloom were recorded. Removal of the terminal significantly increased the node of the FFB, the node of the first bloom, and the occurrence of each of these by 7 to 8 days. Regression analysis was used to model plant height and the accumulation of mainstem nodes as a function of DATR. Results showed that plants with terminals removed did reach the same height as the control group. However, the plants with their terminals removed never accumulated as many mainstem nodes as their counterparts in the control group.

Introduction

Growth of the cotton shoot generally proceeds in a predictable manner through the production of mainstem nodes and the elongation of the internodes. The lower 4 to 6 nodes of a cotton plant generally produce vegetative branches, while subsequent nodes generally form fruiting branches. All growth, whether as vegetative or fruiting branches, proceeds laterally from the meristems. Under most situations the apical meristem at the top of the plant (terminal) controls the growth of vegetative branches at lower nodes through the production of hormones as a means of internal regulation of the overall growth and development of the plant. If however, the terminal is damaged in some way (i.e., hail, wind, insects, etc.) then the lower vegetative branches will begin to grow and produce new mainstems. It is through this type of self regulation that cotton can recover from damage in the apical meristem so that new nodes and fruiting branches can be produced. This ability to recover does, however, result in some increased period of time to produce new mainstems. Late season insect pressure (sweet-potato whitefly, lygus, etc.) and increasing production costs have given rise to an emphasis on "earliness". Any delays in maturity can be costly, if not fatal to resultant yield. For these reasons we conducted the following study to determine what delays in plant growth and development, if any, are caused by damage to the terminal meristem.

Materials and Methods

Three identical greenhouse studies were conducted at the University of Arizona Campus Agriculture Center (CAC) in Tucson, AZ. Each study consisted of 24 pots with two treatments arranged in a completely randomized design with twelve replications. Upland (var. DPL 5415) cotton was planted in each pot and thinned to a single plant after emergence. When the fourth true leaf stage was reached by the majority of the plants, the two treatments were imposed which included plants with the terminal left intact (control group, or check) and plants that the terminal removed. All of the three experiments had the same treatments imposed and differed only by their planting date. The planting dates were 6 January, 2 February, and 25 February 1993 with treatments imposed (terminal removed, TR, from the treated plants) on 7 February, 6 March, and 27 March 1993, respectively. After the treatments were imposed, basic plant measurements were made twice weekly which included the number of mainstem nodes, plant height, the node of the first fruiting branch (FFB), the number of days after terminal removal (DATR) until the FFB appeared, the node of the first bloom, and the DATR until the first bloom appeared for each plant. This was continued until nodes above white bloom (NAWB) was zero, indicating complete cut-out, for the majority of the plants within each planting date.

Results and Discussion

Analysis of variance indicated that there were significant differences due to the treatments on all of the measured variables except NAWB. Analyses among the three planting dates for FFB, DATR until the FFB appeared, the node of the first bloom, and the DATR until the first bloom appeared, showed that treatment affects were significant for all planting dates, and that there was no difference between the first and second planting dates. Therefore, Table 1 contains the mean values for these measured parameters averaged over the first two plant dates and the mean values from the third planting date separately. The growth and development of the cotton in the last planting date was more rapid due to warmer conditions in the greenhouse at this date. Removing the terminal delayed the appearance of the FFB and first bloom by 7 and 8 days, respectively for the first two planting dates, and 7 and 4 days, respectively for the last planting date (Table 1).

Due to the similar nature of the first two planting dates, regression analysis was conducted only on the data from these planting dates. Regression analysis was used to model the treatment affects upon plant height and the accumulation of mainstem nodes as a function of DATR. The resultant regression equations, and levels of significance for the estimated parameters for the entire model are given in Table 2. All of the equations are quadratic (concave down), indicating, as would be expected, a diminishing growth rate as the plant reaches maturity. To get a better idea of what these equations represent, the regression equations for plant height and the accumulation of mainstem nodes are displayed graphically in Fig. 1 and Fig. 2, respectively. It is interesting to note that plants which had their terminals removed did reach the same height as the control plants by maturity (Fig. 1). However, the plants with terminals removed never did obtain the same number of mainstem nodes as the control group (Fig. 2).

Summary

Damage to the terminal meristem of cotton had a significant impact upon subsequent development of fruiting branches and fruiting forms. Removal of the terminal at the four true leaf stage delayed appearance of the FFB and first bloom by 7 to 8 days. It should also be pointed out that the results from greenhouse work are much more controlled with regard to environmental factors than results which could be obtained from a field situation. As such, these results would tend to indicate a best-case situation when compared to what might actually occur in the field. Therefore, delays in appearance of FFB and first blooms may be even longer than what is indicated here. Notwithstanding, this experiment clearly indicates that the growth and development of a plants fruiting structure, with a damaged terminal is significant, and even though cotton is an extremely resilient crop, it cannot completely compensate for terminal loss.

Table 1. Average of the first fruiting branch node (FFB), days after terminal removal (DATR) until the FFB appeared, node of the first (1st) bloom, and DATR to 1st bloom for each planting date and treatment.

Treatment†	Node of FFB	DATR to FFB	Node of 1st Bloom	DATR to 1st Bloom
		Planting Dates 6 January and 2 February, 1993‡		
check	6.0	17	6	41
TR	6.5	24	7	50
OSL§	0.025	0.0003	0.010	0.0001
$LSD_{0.05}$¶	0.34	3.2	0.58	2.0
		Planting Date 25 February, 1993#		
check	5.4	14	5.5	34
TR	5.6	21	5.5	38
OSL	0.4	0.002	1.0	0.0001
$LSD_{0.05}$	0.44	4.2	0.68	1.7

† Treatments were terminals left intact (check) and terminals removed (TR) at the fourth true leaf stage.
‡ Values have a sample size (n) of 24 observations in each mean.
§ Observed significance level for the treatment differences, or the probability that there are no differences among the treatments.
¶ Least significant difference ($\alpha = 0.05$) between means to declare them significantly different.
# Values have a sample size (n)of 12 observations in each mean.

Table 2. Regression models to predict plant height and the accumulation of mainstem nodes for each treatment.

Treatment†	Intercept	Independent Variable Coefficient Estimate		Model R^{-2}
		DATR	$DATR^2$	
		Plant Height		
check	5.0279***	1.0884***	-0.008827***	0.93***
TR	3.6248***	0.9461***	-0.005422***	0.89***
		Nodes		
check	3.8118***	0.2866***	-0.001960***	0.90***
TR	2.3646***	0.2721***	-0.001500***	0.91***

*** Significant at the 0.0001 probability level.
† Treatments were terminals left intact (check) and terminals removed (TR) at the fourth true leaf stage.

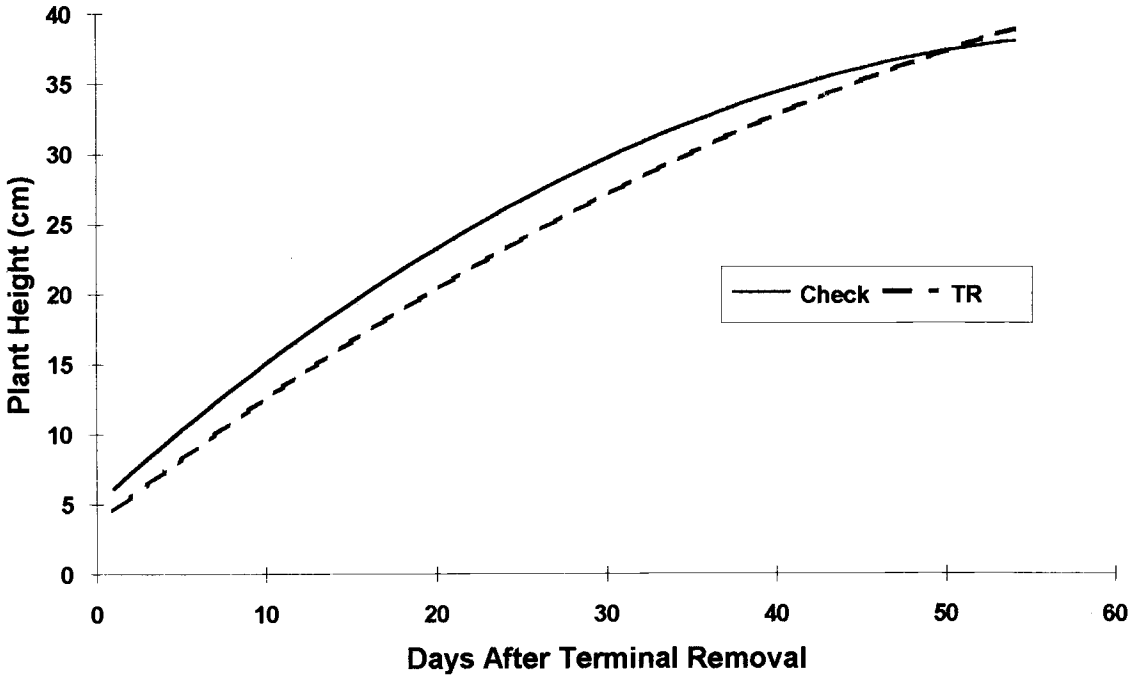

Fig. 1. Predicted cotton plant height as affected by terminal removal (TR) at the fourth true leaf stage and no terminal removal (check).

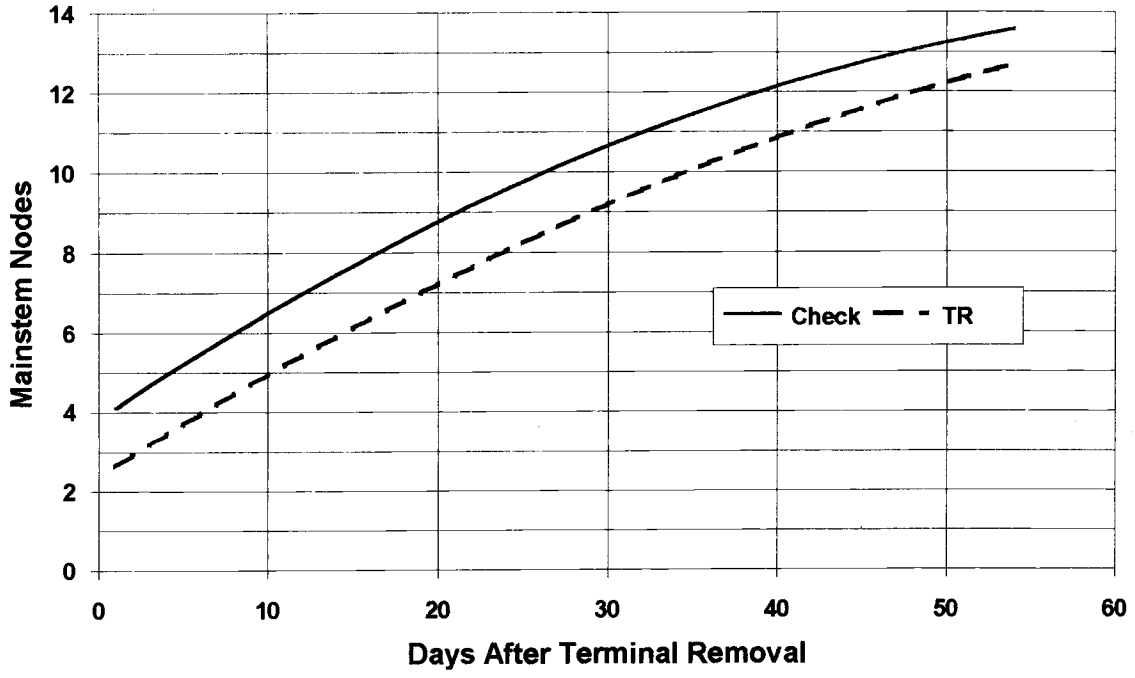

Fig. 1. Predicted accumulation of mainstem nodes in cotton as affected by terminal removal (TR) at the fourth true leaf stage and no terminal removal (check).