

Effect of Paclobutrazol on Fiber Quality of Cotton (*Gossypium hirsutum* L.)

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An important objective for using plant growth regulators in cotton is to balance vegetative and reproductive growth as well as to improve lint yield and fiber quality. Field study was conducted in a randomized complete block design with 4 replications under irrigated conditions in the Southeastern Anatolia Region of Turkey to determine fiber technological properties of cotton to soil applications of 0.05 and 0.1 g/m² doses of the paclobutrazol, gibberellin biosynthesis inhibitors, were applied once after the first and second irrigation for the growing season. Compared with the untreated control, application of paclobutrazol significantly affected fiber micronaire, uniformity and short fiber content parameters, whereas there were no significant differences in fiber strength and length parameters.

Key Words: Cotton, Fiber crops, Fiber quality, Paclobutrazol, Plant growth retardant.

INTRODUCTION

Improvements in textile processing, particularly advances in spinning technology, have led to increased emphasis on breeding cotton for both improved yield and improved fiber properties¹⁻³. Most of the cotton production researches carried out by physiologists and agronomists have been directed toward improving yields, so the few cultural-input strategies suggested for improving fiber quality during the production season are of limited validity. Thus, the producers have limited alternatives in production practices that might result in fibers of acceptable quality and yield without increased production costs. Fiber quality traits are influenced by numerous factors, including the genetic potential, environment in which the genetics is expressed and cotton physiology. Cotton fiber properties provide a useful system to investigate the effects of plant hormones or other chemicals on fiber development. Many synthetic compounds that are foreign to a living system aggressively interfere with metabolism and disrupt its normal functioning. They themselves also undergo various chemical transformations. Retardants, growth regulators, occupy a special place among compounds that actively affect vegetative processes in plants. Retardants cause growth

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to cease and nutritive substances to accumulate in fruiting bodies by exerting an inhibitory effect on gibberellins⁴. Studies of the effect of retardants on cotton concern mainly the study of their influence on the growth of plants, the chlorophyll content in leaves, the preservation of fruiting bodies, increased productivity⁵.

An important objective for using plant growth regulators in cotton (*Gossypium hirsutum* L.) is to balance vegetative and reproductive growth as well as to improve lint yield and fiber quality⁶. One of the used plant growth regulators is paclobutrazol which affects plant growth in 2 major ways: (1) it reduces cell elongation by reducing the production of gibberellic acid and (2) it helps conserve water and slows growth by reducing destruction of abscisic acid. Simply stated, paclobutrazol reduced cambial growth and induced smaller and darker green leaves as well as smaller stomatal pores, thicker leaves and increased tolerance to environmental stress. On this subject, Wang and Yi⁷ reported that paclobutrazol decreased plant height and increased yield, leaf chlorophyll content by 11.8 % and photosynthetic efficiency by 20 % of soybean. Cimen *et al.*⁸ found that paclobutrazol application decreased first nod number of fruiting branch, number of vegetative branch, the first flowering date and the first opening date of bolls, mentioned all data showed earliness criterion of cotton. El-Dayem *et al.*⁹ reported that fiber properties were insignificantly affected by the paclobutrazol, endogenous gibberellin and auxin concentrations were decreased due to the application of paclobutrazol, while the abscisic acid concentration increased. Paclobutrazol treated plants have dark green foliage. This has been associated with increased chlorophyll content of the leaf tissue¹⁰⁻¹² and more densely packed chloroplasts per unit leaf area due to reduced leaf expansion¹³. The increase in chlorophyll content may be ascribed to higher cytokinin content that is known to stimulate chlorophyll biosynthesis and/or reduced chlorophyll catabolism¹¹. It has been proposed that paclobutrazol stimulates cytokinin synthesis that enhances chloroplast differentiation and chlorophyll biosynthesis and prevents chlorophyll degradation¹⁴. The observed higher epicuticular wax deposition on treated leaves may be related to the increase in endogenous abscisic acid levels in response to paclobutrazol treatment¹⁵. An increase in abscisic acid stimulates the synthesis of lipid transfer proteins in barley that play an important role in the formation of epicuticular waxes, a process that affects the water relation of the leaves¹⁶.

The objective of this study was to shed a light upon the effect of soil application of the paclobutrazol on improving fiber quality of field-grown cotton, because the number of studies on the influence of paclobutrazol on fiber quality is limited.

EXPERIMENTAL

This study was carried out in Diyarbakir (lat 37° 54' N, long 40° 14' E and altitude of about 660 m). The soils of the experimental area were thinly structured alluvial material or limestone. The soil is low in organic material and phosphorus and has adequate calcium and high clay content (49-67 %) in the 0-150 cm profile. Water permeability of the soil is good and salt levels are suitable for cotton production¹⁷.

Chemical material used in this study was paclobutrazol (PBZ) (PP-333, Cultar; 25 % a.i) (2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1*H*-1,2,4-triazol-1-yl)-pentan-3-ol), which is effectively transported systematically *via* both xylem and phloem and retarded plant growth by inhibition of the plant hormone gibberellin, which controls cell elongation. The experiment was carried out with Sure-Grow SG 501 cotton variety sown (3 May 1999) in the field according to randomized complete block design with 4 replications, treatments consisted of an untreated control and paclobutrazol at two rates 0.05 and 0.1 g/m², applied once after the first (29 June 1999, 5 days prior anthesis) and second (15 July 1999, 10 days post anthesis) irrigation for the growing season. Fiber quality was determined from the hand-picked seed cotton samples by High Volume Instrument, after the crop was harvested and ginned by a mini laboratory roller gin.

Data obtained from the various analyses and measurements were subjected to analysis of variance in MSTAT-C¹⁸ statistical program and the least significant difference (p: 0.05) was used to verify the significance of differences among treatment means to determine the effects of paclobutrazol.

RESULTS AND DISCUSSION

There were significant differences (p: 0.05) between treatments for short fiber content, micronaire and fiber uniformity traits except for fiber strength and fiber length traits (Table-1). Both rates and application timing of paclobutrazol decreased short fiber content and increased micronaire (except for 0.05 g/m², after the first irrigation), fiber strength, fiber length, fiber uniformity compared with the untreated control. Especially, in both rates of paclobutrazol applied after second irrigation (except for fiber strength and fiber length, both 0.05 and 0.1 g/m², and 0.1 g/m², respectively) tended to more effective than first one.

TABLE-1
EFFECT OF DIFFERENT DOSES OF PACLOBUTRAZOL ON THE FIBRE QUALITY PROPERTIES AT VARIOUS TIMES IN SURE GROW ST 501 COTTON VARIETY

Paclobutrazol ^a treatments (g/m ²)	Short fiber content (sfc)	Micronaire (mic.)	Fiber strength (g/tex)	Fiber length (mm)	Fiber uniformity (%)
Control	8.235a*	3.35c*	33.70	27.79	82.18b*
0.05	1st ^b	7.515ab	3.25c	34.90	82.65ab
	2nd	6.845b	3.70a	34.50	83.10a
0.10	1st	7.110b	3.38bc	35.35	83.00a
	2nd	6.740b	3.58ab	34.53	83.38a
Average	7.289	3.47	34.60	28.10	82.86
LSD (%)	0.9231	0.2233	n.s.	n.s.	0.7516
CV (%)	8.23	4.14	3.99	1.90	0.59

* **Significant at the 0.05 and 0.01 levels of probability, respectively.

^aThe doses of paclobutrazol (control, 0.05 and 0.1 g/m²)

^bThe timing of paclobutrazol treatment (after the first and second irrigation).

n.s. = non-significant.

These results indicated that paclobutrazol application affected the fiber development stages. Two most important stages of development are fiber elongation and secondary wall synthesis. Fiber elongation is the stage during which the fiber is lengthening and occurs as a thin cell wall of carbohydrate polymers is deposited allowing the fiber to elongate. Elongation of the primary cell wall begins around anthesis, with maximum length occurring at *ca.* 20 to 25 d post anthesis and directly corresponds to the fiber length. During secondary wall synthesis or thickening, cellulose is deposited inside the elongated fiber. This synthesis starts at about 15 to 22 d post anthesis and continues until *ca.* 50 d post anthesis and directly corresponds to the fiber strength and micronaire¹⁹. Cellulose is derived from photosynthetic rate. Thus, any factor that influences photosynthetic efficiency ultimately influences the fiber properties. Increased chlorophyll content in response to paclobutrazol treatment may substantially contribute for enhanced photosynthetic efficiency because higher chlorophyll content is one of the main factors stimulating the rate of photosynthesis and biological productivity^{11,20}. Sankhla *et al.*²¹ reported that paclobutrazol treatment increased productivity by enhancing photosynthesis efficiency in soybean, rapeseed²² and tomato¹¹.

Thus, it can be concluded that photosynthesis and correspondingly the formation of carbohydrates such as glucose, saccharose, *etc.* increased due to chlorophyll content in response to paclobutrazol treatments compared with the untreated control. Especially the paclobutrazol treatments at 10 d post anthesis influenced sharply short fiber content, micronaire and fiber uniformity associated with the increased assimilate supply to the developing boll during the period when the secondary cell wall was being deposited, because of positive correlations between photosynthesis and fiber quality. On the other hand, both rates and application timing of paclobutrazol increased slightly fiber strength compared with the untreated control. Especially, in both rates of paclobutrazol applied 5 d prior anthesis tended to more increase the fiber strength than 10 d post anthesis. The reduction in fiber strength in both rates of paclobutrazol applied 10 d post anthesis may have associated with near the end of the fiber development period when strength is thought to develop, but is in the early stages of secondary cell wall deposition, one of the components determining micronaire.

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