FIELD EVALUATION OF PLANT GROWTH REGULATORS FOR EFFECT ON THE GROWTH AND YIELD OF COTTON SUMMARY OF 1995 RESULTS

D. M. Oosterhuis and J. N. Egilla
Department of Agronomy, University of Arkansas, Fayetteville, AR

Abstract

Plant growth regulators (PGR's) have been used to control growth and enhance yield in commercial cotton production. A field study was conducted to evaluate eight commercially available PGR's for their effect on cotton growth and development. Lint yield averaged over the four-year period from 1992 to 1995 was increased numerically over the untreated control by all the PGR's tested. In 1995, there were no statistically significant differences (P=0.05) in lint yield although PGR-IV and PHCA caused a numerical increase in lint yield. Both Pix and Cytokin reduced plant height and height:node ratio significantly compared to all the other PGR's tested in 1995. Crop+2 had significantly higher boll number:node ratio (BNR) compared to the control and MAXON treatments, while average boll weight was significantly higher for Atonik compared to Crop+2 and Pix. Crop+2 which had the highest BNR also had significantly higher number of first position bolls compared to the control and Pix treatments. The PGR's tested had variable effects on leaf photosynthesis, and additional research is required to determine their influence on the CO_2 assimilation and gas exchange of cotton. This report supplies additional evidence to previous years data that supports the use of PGR's in cotton as a useful production practice for controlling plant growth and enhancing yield.

Introduction

Cotton (*Gossypium hirsutum* L.) is perennial with an indeterminate growth habit. The desire to control plant growth while at the same time increasing yield, has led to interest in plant growth regulators (PGR's). In the past two decades many new PGR compounds have been developed and tested on cotton. Variable and sometimes disappointing results have been obtained due to the extremely varied environments and crop conditions under which the PGR's are used. Field evaluation of available PGR's has been routinely conducted at the University of Arkansas for the past ten years (Urwiler et al., 1989; Oosterhuis and Janes, 1994). Recent research has focused on the physiological effects and underlying mechanisms of PGR's (Guo et al., 1994) in order to be able to adapt their use to the growth requirements of specific crops.

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The following provides a summary of research in progress at the University of Arkansas aimed at comparing available PGR's for their effects on the growth and yield of field-grown cotton. Other research not reported here is aimed at improving our understanding of the mechanisms of these PGR's in order to adapt the technology to best fit into current cotton production systems.

Materials and Methods

Field Comparison of Available PGR's

A field experiment was planted at the Cotton Branch Station, Marianna, Arkansas on 17 May 1995 using the cotton cultivar DPL 51. Treatments consisted of an untreated control and eight PGR's applied at the manufacturer's recommended rate and timing (Table 1). All treatments were applied with a CO_2 backpack sprayer at 93.5 liters/ha (10 gallons/acre) of solution. The experiment was laid out in a randomized block design with six replications, and plots were split for Pix application. Seed was machine planted 10 cm apart (3 plants per foot) with 0.97 cm (38 in) row spacing. Plot size was 8 rows by 15.2 m (50 ft.).

Preplant fertilizer consisted of N:P:K applied at 0-52-67 kg/ha (0-46-60 lb/acre) preplant, plus 90 kg/ha (80 lb N/acre) side-dressed at mid-squaring and 45 kg N/ha (40 lb/acre) at first flower. Furrow irrigation was applied as needed throughout the growing season. Weed and insect control measures were according to Extension Service recommendations.

Measurements

Pre-season soil analysis was conducted to establish residual N, P, and K levels for fertility management (data not shown). Leaf photosynthetic rate and stomatal conductance of the fourth uppermost leaf on the main stem was determined on 1 August 1995 with a LICOR 6200 photosynthesis system (LICOR Inc., Lincoln, NE). Crop maturity was determined for each treatment as the number of days to NAWF = 5 (nodes above the uppermost white flower) (Bourland et al., 1991).

The final plant height, number of main-stem nodes, and number of first and second position bolls, were measured after defoliation from six plants on three replications. Lint yield was determined by mechanically harvesting the two center rows from each split plot, and components of yield were obtained from cotton hand-picked from 2-m row lengths.

Results and Discussion

Effect of PGR's on Yield

Lint yield averaged over the four year period from 1992 to 1995 for all the PGR's increased numerically over the untreated control (Table 2). In 1995 the application of PGR-IV and PHCA caused numerically higher lint yield per hectare although there were no significant differences

(P=0.05) among the treatments (Fig. 1, Table 2). The response of yield to Pix, when applied in combination with other PGR's was variable (Fig. 1). The Pix, PGR-IV plus Pix, Cytokin plus Pix and Crop+2 plus Pix treatments caused a numeric increase in lint yield.

Crop maturity as measured by the number of days to NAWF=5 (Fig. 2) was attained by day 84 after planting for Atonik, Bio-21, Crop+2, MAXON and PHCA. However, by day 84 PGR-IV and Cytokin had NAWF = 3 and 4, respectively. For those treatments NAWF=5 was attained 80 days after planting.

The application schedule for Atonik, Bio-21, MAXON, PGR-IV and PHCA included in-furrow placement at planting. Oosterhuis and Zhao (1994) have shown that in-furrow application of PGR-IV positively influenced seedling growth and root development. However, the benefits of this treatment may depend on the early season conditions, and may well serve as an insurance against poor early-season growing conditions as are often experienced in the Mississippi River delta. Concurrent on-going growth room studies (Oosterhuis and Egilla unpublished) have shown that a number of other PGR compounds applied in-furrow or as seed treatment have the potential to positively influence seedling growth.

Effect of PGR's on Plant Growth and Development

Plant Height and Number of Main-stem Nodes: With the exception of Cytokin, plant height was significantly reduced by Pix (P=0.05) compared to all other PGR's (Fig. 3). Similarly, Pix had a significantly lower number of main-stem nodes compared to the control and the other PGR's except Atonik and Cytokin (Table 3). Crop+2 had the highest node number numerically, but its node number and plant height were numerically similar to those of the control, Bio-21 and MAXON. PGR-IV and PHCA had similar main-stem node numbers.

Plant height:node ratio (HNR) was significantly higher (P=0.05) for PGR-IV and PHCA compared to all the other PGR's except the control, Bio-21 and MAXON (Table 3). Pix and Cytokin had the smallest HNR. Plants with lower HNR are desirable since boll and node number are positively correlated, and excessive height is undesirable.

Components of Yield: Crop+2 had higher boll number:node ratio (BNR) compared to the control and MAXON treatments; all other PGR's were similar. A higher BNR could indicate a greater yield potential. Despite a low number of main-stem nodes for the Pix treatment, the BNR was similar to all the PGR's in this experiment (Table 3). Boll weight was significantly higher for Atonik compared to Crop+2 and Pix, but not the other PGR's and the control treatment. Boll weight may be an index of seed number and size per boll.

The number of first position bolls (FPB), which accounted for 70% of the total boll number per plant was significantly higher for Crop+2 and PHCA compared to the control and Pix treatments. However, the number of second position bolls (SPB) was similar for Bio-21, Crop+2 and PGR-IV, which had significantly higher values compared to Atonik, MAXON and Pix. Cytokin and PHCA were intermediate and similar to the control. The SPB was approximately 50% of the FPB for all the PGR's, but did not differ significantly (P=0.05) compared to the control treatment.

CO_2 Assimilation and Gas exchange

Carbon assimilation varied among the PGR treated cotton. Pix treated plants showed a significantly higher (P=0.05) photosynthetic rate compared to the control and MAXON treatments, but similar to PGR-IV and PHCA. Increased leaf photosynthesis in Pix treated cotton has been reported previously (Oosterhuis et al., 1991). Stomatal conductance was significantly higher (P=0.05) for PGR-IV compared to the control, but similar to MAXON, PHCA and Pix. This data indicates a correlation between CO_2 assimilation and lint yield, since PGR-IV and PHCA had numerically higher lint yields compared to the control and the other PGR treatments. Additional research is needed to determine the effects of the PGR's studied on the CO_2 assimilation and gas exchange of cotton.

Conclusions

This study have shown that the use of PGRs in cotton is a useful production practice for controlling plant growth, and enhancing yield. There are a number of promising PGR's available, but additional information is required on their mode of action in order to best adapt their use to current cotton production systems. These studies will be continued with additional physiological and biochemical measurements to elucidate the specific effects of the PGR's on growth and yield.

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Table 1. Plant growth regulators, time of application and rate used.

Treatment[1]	Timing	Rate
Control	no added PGRs	---
Atonik	IF, PHS,	200 ml/A, 200 ml/A
	FF, 3 wks after FF	500 ml/A, 500 ml/A
Bio-21	IF, PHS, FF	1 oz*/A, 2 oz/A, 4 oz/A
Crop+2	4 leaf stage, PHS, FF	16 oz/A, 16 oz/A, 16 oz/A
Cytokin	PHS, FF, 3 wks after FF	4 oz/A, 8 oz/A, 8 oz/A
PGR-lV	IF, PHS, FF	1 oz/A, 4 oz/A, 4 oz/A
PHCA	IF, 2 and 4 wks after FF	8 oz/A, 8 oz/A, 16 oz/A
Pix	PHS, FF	8 oz/A, 8 oz/A

[1]All the treatments were split for Pix one week after PHS and FF @ 8 fl. oz/acre
[2]IF = in-furrow, PHS = pinhead square, FF = first flower.
*oz for liquids imply fl. oz.

Table 2. Effect of plant growth regulators on lint yield of cotton, 1992-1995 at Marianna, Arkansas.

PGR	1992	1993	1994	1995	Mean
			(%)		
Control	936	888	1229	1236	1072
Atonik	990	955	1296	1202	1111
Crop+	969	1057	1263	1195*	1122
Cytokin	977	988	1304	1155	1140
PGR-IV	1103	1018	1313	1260	1174
PHCA	968	1095	1302	1293	1165
Pix	948	1079	1268	1154	1112
LSD (0.05)	60	82	61	160	---

*Crop+2 was used in 1995.

Table 3. Effect of PGR application on the growth and yield of cotton cv. DPL 20 (Cotton Research Station, Marianna, Arkansas 1995).

PGR	Main stem node #	Height/ node ratio	Boll/ node ratio	Boll weight (g)	Boll number 1st position	Boll number 2nd position
Control	22.1 ab*	5.14 abc	0.46 b	4.13 ab	7.11 c	3.06 ab
Atonik	21.3 bc	5.05 bc	0.48 ab	4.97 a	8.06 abc	2.06 b
Bio-21	22.0 ab	5.24 abc	0.53 ab	4.29 ab	7.89 abc	3.83 a
Crop+2	22.6 a	5.04 c	0.55 a	3.86 b	8.72 a	3.67 a
Cytokin	21.5 bc	4.17 d	0.48 ab	4.32 ab	7.22 bc	3.17 ab
MAXON	21.9 ab	5.16 abc	0.46 b	4.79 ab	7.44 abc	2.50 b
PGR-IV	21.8 b	5.27 ab	0.52 ab	4.16 ab	7.67 abc	3.67 a
PHCA	21.8 b	5.27 ab	0.52 ab	4.19 ab	8.56 ab	2.78 ab
Pix	19.7 c	4.16 d	0.48 ab	3.75 b	6.94 c	2.50 b

*Mean separation within columns by LSD. Means with the same letters are not significantly different (P = 0.05).

Table 4. Effect of plant growth regulators on leaf photosynthesis and tomatal conductance of cotton at Marianna, Arkansas 1995.

PGR	Photosynthesis (mmol m^{-2} s^{-1})	Stomatal conductance (mol m^{-2} s^{-1})
Control	29.77 bc*	1.21 b
MAXON	28.40 c	1.37 ab
PGR-IV	30.69 ab	1.41 a
PHCA	30.58 ab	1.32 ab
Pix	30.83 a	1.38 ab

*Mean separation within columns by LSD. Means with the same letters are not significantly different (P = 0.05).

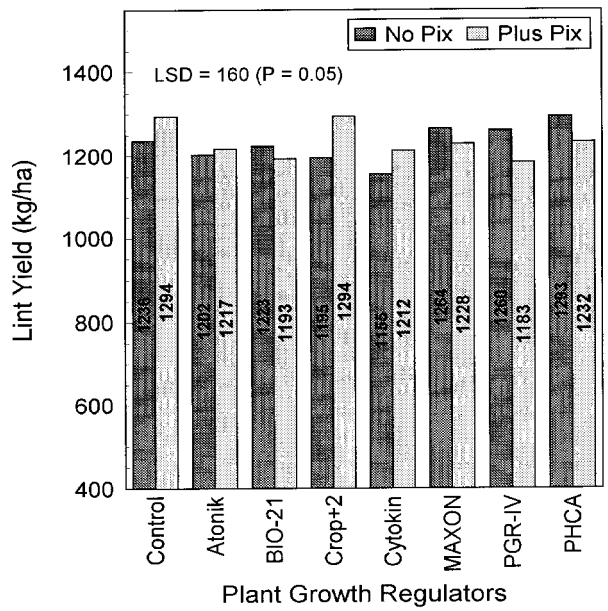

Figure 1. Effect of PGRs on lint yield, Field Evaluation of PGRs in Arkansas Marianna, AR 1995. All PGR treatments were split for Pix applications.

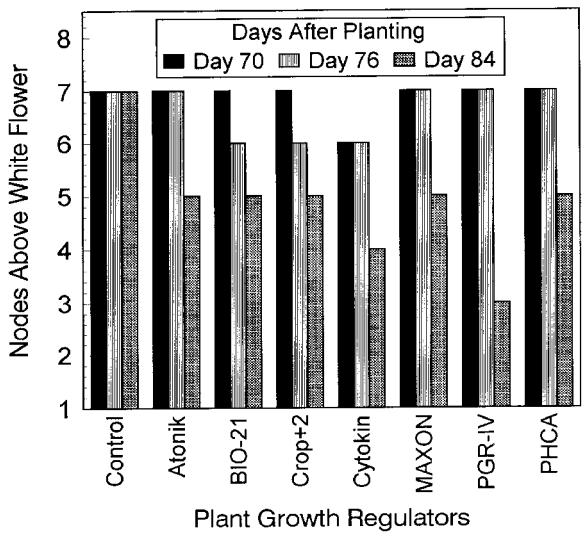

Figure 2. Effect of PGRs on NAWF, Field Evaluation of PGRs in Arkansas Marianna, AR 1995.

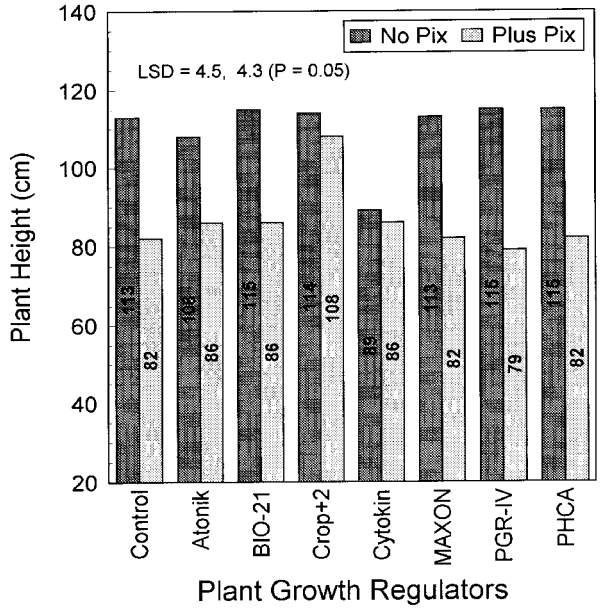

Figure 3. Effect of PGRs on plant height, Field Evaluation of PGRs in Arkansas Marianna , AR 1995.