EVALUATION OF PLANT GROWTH REGULATORSFOR EFFECT ON THE GROWTH AND YIELD OF COTTON

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Abstract

Studies were conducted in field 1993-1997 to evaluate the effect of new and existing plant growth regulators (PGRs) on growth, yield and physiology of field-grown cotton (*Gossypium hirsutum* L.). Treatments consisted of an untreated control and the following PGRs: Atonik, Crop^{+2}, CCC, Cytokin, Early Harvest (EH), Maxon, MepPlus, Mepiquant Chloride (MC), PGR-IV, and PHCA. Most PGRs tested could influence plant growth and numerically increase lint yield. However, results have varied with season. Studies have also been conducted on the physiological effect of PGRs on cotton growth and yield, and are discussed in this paper. These results provide a data base for producers to use in the selection of PGR use in cotton management.

Introduction

Since cotton is a perennial with an indeterminate growth habit and is very response to management and changes in the environments. Plant growth regulators and other cultural practices provide a means to manage the balance between vegetative and reproductive growth for efficient cotton production. Chemical plant growth regulators have been widely used in cotton production to adjust plant growth, and to improve lint yield and fiber quality. In the past two decades, many new PGR compounds have been developed and tested on cotton with variable and sometimes with disappointing results due to varied environments and production practices. Field evaluation of available PGRs has been routinely conducted at the University of Arkansas for the past fourteen years (Urwiler et al., 1989; Oosterhuis and Janes, 1994; Oosterhuis and Egilla, 1996). The information from these studies can provide useful information for farmers to select and use PGRs. Recent research has focused on the physiological effects and underlying mechanisms of PGRs (Guo et al., 1994; Oosterhuis, 1996; Zhao and Oosterhuis, 1997) in an effort to adapt their use to the growth requirement of specific crops and environments.

The following provides a summary of field research in progress at the University of Arkansas aimed at comparing available PGRs for their effect on yield of field-grown cotton. Additionally, the physiological responses of cotton plants to select PGRs have also been studied.

Materials and Methods

Plant Culture

Experiments were conducted at the Cotton Branch Station at Marianna, the Delta Branch Experimental Station at Clarkedale, or the Southeast Branch Experiment Station at Rohwer, Arkansas during 1993-1996.

In 1997, cotton cultivar Deltapine 20 was seeded 19 May 1997 at Arkansas Agricultural Research and Extension Center, University of Arkansas, Fayetteville, AR. Each plot consisted of 4 row, 16.4 feet in length, spaced 39 inches apart with 3 plants per foot row. The seven treatments consisted of (1) untreated control, (2) Early Harvest (EH), (3) PGR-IV, (4) Cytokin, (5) MepPlus, (6) Mepiquat Chloride (MC), and (7) CCC . Details about timing and rates of applying PGRs are given in Table 1.

Measurements

In the 1993-1996 studies, petiole nutrient concentrations were determined at different growth stages. Nodes above white flower (NAWF), plant height and maturity were observed (data not shown). Lint yield was determined by mechanically harvesting the center two rows of each plot.

During the 1997 experiment, petiole NO_3-N, P, K and S concentrations of the uppermost fully-expanded main-stem leaves were determined at different growth stages. Net photosynthetic rates, stomatal conductance, intercellular CO_2 concentration, and transpiration rates of five leaves from the same position of each plot were measured using a potable photosynthesis system (LI-6200, LI-COR, Lincoln, NE) on 5 days after spraying the PGRs at the first flower (FF) stage. At 7 days after treatment at FF, thirty 7-mm diameter leaf discs for each treatment were collected from 30 uppermost fully-expanded main-stem leaves (5 leaves per plot), and cell membrane leakage of the leaf discs was determined with an ASA 610 automatic seed analyzer (Agro Science, Inc. MI) at 24 h and 48 h after sample collection. Nodes above white flower (NAWF) were counted each week after flowering until plant physiological cutout (NAWF=5). Plant mapping was done on 10 plants from each plot before harvesting to determine boll distribution in plant canopy. Finally, seedcotton from two 1-m middle rows was picked by hand, and the number of harvestable bolls recorded. Boll weight, lint percentage, lint yield, and fiber quality (HIV) determined.

The control of weeds and insects, fertilizer management and furrow irrigation were given as needed according to Arkansas cotton production recommendations. Experimental design was a randomized complete block with six replicates. A calibrated CO_2-pressurized backpack sprayer was used to foliarly apply PGRs at 10gal/acre of solution.

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Results and Discussion

I. Growth Evaluation

Plant Height, Main-stem Nodes, and the Number of Fruiting Branches

Compared with control plants, applying PGR-IV at pinhead square (PHS) and first flower (FF) growth stages significantly increased main-stem nodes and number of fruiting branches (Table 2). EH, Cytokin and MepPlus did not affect the numbers of main-stem nodes and fruiting branches, although EH caused taller plants and MepPlus shorter plants than the control. MC and CCC significantly reduced plant height and the number of fruiting branches.

Maturity

NAWF measurements indicated that the treatments of CCC, MepPlus and MC had significantly lower NAWF than all other treatments. These three treatments reached physiological cutout (NAWF=5) about 8 days earlier than untreated control plants. No significant differences were observed between other PGR treatments and the control in NAWF (data not shown). There were no significant differences among treatments in maturity which was expressed by the percentage of open bolls compared to total boll numbers (data not shown).

II. Yield Evaluation

Lint Yield

The mean lint yield averaged over a four-year period (1992-1995) for all PGRs increase over the untreated control (Oosterhuis, 1996). Results of lint yields from individual years are presented in Table 3. Overall, application of most PGRs numerically increased cotton yield. Substantial variability in yields between treatments and years.

In the 1997 study, lint yield did not statistically differ among treatments ($P>0.05$), although treatments of PGR-IV, EH, MepPlus and Cytokin showed numerically higher yields, and CCC and MC treatments showed lower yields than the untreated control.

Yield Components

Among the 1997 treatments, PGR-IV and Cytokin treatments showed the highest number of bolls; Early Harvest and MepPlus treatments had the greatest average boll weight; MC and CCC treatments exhibited the lowest lint percentage (Table 4). Boll distribution within the plant canopy was also investigated using a plant mapping computer program. Fiber quality (HVI) was determined for the 1997 study (data not shown).

III. Physiological Evaluation

Leaf Net Photosynthetic and Transpiration Rates

Plants treated with MepPlus and MC showed the highest, and EH treated plants the lowest leaf net photosynthetic rate (Table 5). Application of all PGRs increased leaf stomatal conductance, except for EH, compared to the control plants. Plants treated with PGRs also had higher transpiration rates than control plants. Higher transpiration rate was associated with increased stomatal conductance.

Leaf Cell Membrane Leakage

Cell membrane leakage is an important indicator of membrane integrity. Leaf discs were collected from 10 uppermost fully-expanded main-stem leaves of each plot 9 days after applying PGRs at the FF stage to measure membrane leakage. EH and PGR-IV treatments showed the lowest membrane leakage among the six treatments 24 hr after sampling (Fig. 1), although all PGR treatments did not differ from the control plants in membrane leakage. However, 48 hr after sampling the untreated control and Cytokin-treated plants showed significantly higher membrane leakage compared other treatments, and MepPlus treated plants exhibited the lowest membrane leakage among treatments. Therefore, foliar application of EH, PGR-IV, MepPlus and MC appeared to increase membrane stability and to improve leaf tolerance to environments, because a higher membrane leakage indicates greater membrane damage.

Petiole Nutrients

All PGR-treated plants exhibited significantly higher concentrations of petiole NO3-N and K 9 days (July 16) after applying PGRs at the PHS stage, except for Cytokin treatment, but lower S concentration compared to control plants (Fig. 2). MepPlus treatment showed the highest petiole K concentration among all treatments. At 9 days (Aug. 5) after applying PGRs at the FF stage, MC treatment showed the highest NO_3-N, and PGR-IV treated plants had the highest S concentrations ($P<0.05$) among treatments. During boll development (Aug. 14), PGR-IV treated plants had numerical higher petiole P, K and S concentrations, and MepPlus treated plants had higher N concentration than other treatments, although the differences were not significant.

Summary

Application of PGRs can effectively control cotton plant growth, and improve lint yield. Increased yield from some PGRs was probably associated with the increase in leaf photosynthetic capacity, improvement of plant nutrient status and other physiological phenomena. Additional research is needed to explain the effect of PGRs on cotton growth and yield.

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Table 1. Details of timing and rates of applying PGRs for 7 treatments in 1997 at Fayetteville, Arkansas.

Treatment	In-furrow	PHS[†]	FF	FF+3 weeks
Control	---[‡]	---	---	---
EH	1 oz/A	4 ozs/A	4 ozs/A	---
PGR-IV	1 oz/A	4 ozs/A	4 ozs/A	---
Cytokin	---	4 ozs/A	8 ozs/A	8 ozs/A
MepPlus	---	8 ozs/A	8 ozs/A	---
MC	---	8 ozs/A	8 ozs/A	---
CCC	---	1 oz/A	1 oz/A	---

[†] PHS and FF showed pinhead square and first flower stages, respectively.
[‡] No PGR application.

Table 2. Effects of applying PGRs on cotton plant growth in 1997. Measured 10 days after PGRs application after the FF stage.

Treatment	Plant height	Main-stem nodes	Fruit branch number
	cm plant^{-1}	no. plant^{-1}	no. plant^{-1}
Control	84.5	15.6	11.3
EH	90.7	16.0	11.4
PGR-IV	90.1	16.6	12.2
Cytokin	81.9	15.6	10.9
MepPlus	64.9	15.5	10.6
MC	61.8	14.9	10.1
LSD(0.05)	5.7	0.7	0.8

Table 3. Effect of PGRs on lint yield in Arkansas 1993 - 1997.

PGR	1993	1994	1995	1996	1997
	---------- kg ha^{-1} ----------				
Control	790	1094	1100	1297	1245
Atonik	850	1153	1070	1245	----
CCC	----[†]	----	----	----	1179
Crop+	941	1124	1064[‡]	1339[‡]	----
Cytokin	879	1161	1028	1266	1263
EH	----	----	----	1308	1290
Maxon	----	----	----	1328	----
MepPlus	----	----	----	----	1270
PGR-IV	906	1169	1121	1374	1299
PHCA	975	1159	1151	1308	----
MC	960	1129	1027	1389	1209
LSD(0.05)	73	54	42	69	NS

[†] Not evaluated in that year.
[‡] Crop^{+2} used in 1995 and 1996.

Table 4. Effects of PGRs on yield components of cotton in 1997 at Fayetteville, Arkansas.

Treatment	Seedcotton weight	Boll number	Boll weight	Lint fraction
	g m^{-2}	no. m^{-2}	g boll^{-1}	%
Control	324	77.5	4.18	39.0
EH	335	76.7	4.38	38.5
PGR-IV	338	82.7	4.10	38.5
Cytokin	325	80.0	4.07	38.8
MepPlus	335	76.7	4.36	38.0
MC	324	79.2	4.07	37.3
CCC	312	78.2	4.00	37.7
LSD(0.05)	NS	4.3	0.19	1.3

Table 5. Effects of PGRs on leaf net photosynthetic rate (Pn), stomatal conductance (Cs), and transpiration rate (E) in 1997. Measurement were taken 5 days after applying PGRs at the FF stage.

Treatment	Pn	Cs	E
	μmol CO_2 m^{-2} s^{-1}	cm s^{-1}	mmol m^{-2} s^{-1}
Control	21.3	2.83	16.3
EH	18.9	2.88	16.5
PGR-IV	26.4	4.54	17.8
Cytokin	22.7	4.67	18.0
MepPlus	29.0	5.20	20.1
MC	30.0	4.59	19.1
LSD(0.05)	4.3	1.53	4.1

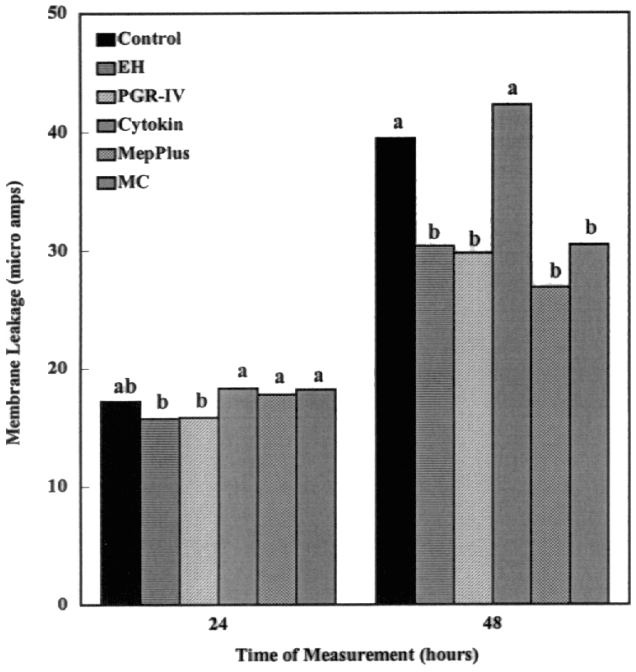

Figure 1. Effect of PGRs on leaf cell membrane leakage in 1997. Measurements were taken 8 days after applying PGRs at the FF stage. Means with same letter within a group are not significant (P>0.05).

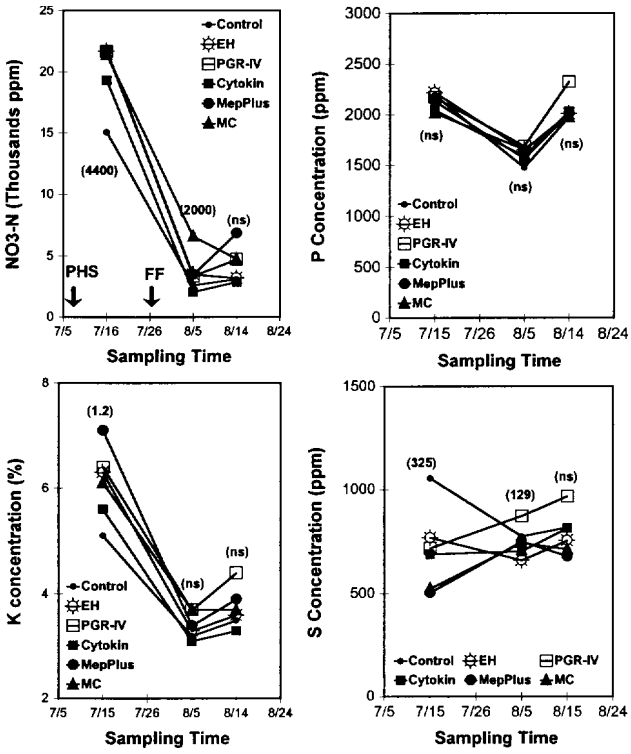

Figure 2. Changes in petiole nutrient concentration for different PGR-treated plants during grown in 1997, Fayetteville, Arkansas. Values in parentheses are LDS0.05 values. Arrows show times of applying PGRs.