PHYSIOLOGICAL AND YIELD RESPONSES OF COTTON TO MEPPLUS AND MEPIQUAT CHLORIDE

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Introduction

Cotton (*Gossypium hirsutum* L.) is a perennial crop with an indeterminate growth habit, and is very responsive to environmental changes and management. Consequently, producers and researchers have long been interested in the use of plant growth regulators (PGRs) for controlling plant growth and improving cotton yield (Oosterhuis and Egilla, 1996). Various PGRs have been used for controlling plant growth. Mepiquat chloride has been the most successful and widely used in cotton production. Application of PGRs to improve cotton growth and yield has been a widely accepted practice in cotton production.

The plant growth regulator MepPlus is a new PGR from Micro Flo Company (Lakeland, FL), first tested in 1994 and registered in 1997. It consists of Mepiquat Chloride (MC) and the bacteria *Bacillus cereus*. Recent studies have indicated that applying MepPlus had a similar effect on plant height control as applying MC. MepPlus has been reported to improve leaf photosynthesis, dry matter partitioning (Wells, 1997) and lint yield (Parvin and Atkins, 1997; Wells, 1997) of field-grown cotton compared with both untreated control and MC-treated plants. Objectives of our field and greenhouse studies in 1997 were: (1) to compare MepPlus with MC for effect on growth and yield of field-grown cotton, and (2) to investigate the physiological effects of MepPlus compared to MC on plant growth.

Materials and Methods

Field Studies

Field trials were conducted at two locations in Clarkedale and Fayetteville, Arkansas in 1997. At Clarkedale, the cultivar Suregrow 125 was seeded on 7 May 1997 at the Delta Branch Experimental Station. Rows were spaced 38 inches apart and oriented in a north-south direction. Each plot consisted of 4 rows, 50 feet in length. At Fayetteville, cotton cultivar DPL 20 was planted 20 May 1997 at Arkansas Agricultural Research and Extension Center, University of Arkansas in Fayetteville. Plots consisted of four rows, 16.5 feet in length, spaced 39 inches apart, and hand thinned to 3 plant foot^{-1} when seedlings had 3 true leaves. Weeds and insect control, fertilizer management and furrow irrigation were given as needed according to Arkansas cotton production recommendations. At both locations three treatments were used consisting of (1) an untreated control, (2) MepPlus, and (3) MC. Experiments were arranged in a randomized complete block design with six replicates.

At Clarkedale, four foliar applications of MepPlus and MC were applied, each at 4 oz. acre^{-1} in 10 gallons water using a CO_2-pressurized backpack sprayer. The first application was given on July 1 when plants had 10 main-stem nodes. The second, third, and fourth applications were at 9, 18 and 27 days after the first application. At Fayetteville, two foliar applications of MepPlus and MC were made at 8 oz. acre^{-1} in 10 gallons water at the pinhead square (PHS, July 6) and first flower (FF, July 27) growth stages using a CO_2-pressurized backpack sprayer.

Plant height and the number of main-stem nodes were recorded twice during the season. Plants in 1-m lengths of the middle row of each plot of three replications were harvested 100 days after planting (DAP), and leaf area, specific leaf weight, and dry matter of plant components were measured.

Net photosynthetic rates, stomatal conductance, intercellular CO_2 concentration, and transpiration rates of five uppermost fully-expanded main-stem leaves of each plot was measured using a portable photosynthesis system (LI-6200, LI-COR, Lincoln, NE) at noon, 5 days after spraying the PGRs at the FF stage. Nine days after FF, thirty 7-mm diameter leaf discs were collected from each treatment from 30 uppermost fully-expanded main-stem leaves (5 leaves per plot) for membrane leakage determination with an ASA 610 automatic seed analyzer (Agro Science, Inc. MI) at 24 h and 48 h after sample collection.

Before final harvesting, distributions of bolls in the plant canopy was recorded and analyzed using a plant mapping computer program. Boll number, average boll weight and lint percentage were recorded. Finally, either mechanical picking (Clarkedale) or hand-picking (Fayetteville) was used to harvest the middle two rows of each plot for total seedcotton weight. Lint yield was calculated according to seedcotton weight and lint percentage. Fiber quality (HVI) was also determined.

Greenhouse Study

Cotton (cv. DPL 20) seeds were planted in 2-L pots with a medium of top soil and sand (7:3). Water and nutrients were supplied daily as needed. Greenhouse day/night temperatures were 30/25 °C and the photoperiod was 12 h. MepPlus and MC treatments were applied at 4 oz. acre^{-1} in 5 gallons of water at the pinhead square stage. At 8 days after MepPlus and MC application, the petiole sap from uppermost fully expanded main-stem leaves was collected at 1200 h using a pressure chamber. Glucose, fructose, sucrose and myo-inositol concentrations of petiole fluids were determined using HPLC. Furthermore, net photosynthetic rates and stomatal conductance of leaves at

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the same positions on the main stem were recorded at midday, 7 days after spraying PGRs using a LI-COR-6200 portable photosynthesis system.

Results and Discussion

Plant Growth

Plants receiving MepPlus and MC were significantly shorter than untreated control plants three weeks after the PGRs were applied (Table 1). There were no differences in the number of main-stem nodes among treatments. Therefore, the height/node ratios were similar for both PGR treated plants and much smaller than the control. This indicated that decreased plant height was mainly due to the shorter internode length rather than the decreased number of main-stem nodes. No significant differences were observed in both plant height and main-stem nodes between MepPlus and MC.

Accumulation and Partitioning of Dry Matter

Plant growth analysis at 100 DAP indicated that there were no significant differences in the number of bolls and leaf area index among treatments. However, MepPlus and MC treated-plants exhibited significantly higher specific leaf weight (11-25%) than untreated control plants (data not shown).

Among the three treatments, no significant differences were observed in total dry weight and fruit dry weight although the dry weights of stems and leaves for both PGR- treated plants were lower than the control (data not shown). The fraction of fruit dry weight in total dry matter of MepPlus treatment (41%) was significantly higher than that of both the control (33%) and the MC treatment (34%) (Fig. 1). This indicated that applying MepPlus improved partitioning of dry matter in plants compared to MC and the untreated control, with more assimilate moving into the fruits (squares and bolls) of MepPlus-treated plants.

Leaf Photosynthesis

At 5 days after foliar application of MepPlus and MC to field-grown plants, both MepPlus- and MC-treated plants exhibited significantly higher single leaf photosynthetic rates than untreated control plants under field conditions (Table 2). Increased leaf photosynthesis from MepPlus and MC was related to higher stomatal conductance. Both treatments also showed a higher leaf transpiration rate than the control, whereas intercellular CO_2 concentration was similar between treatments. No differences were observed in leaf photosynthesis and stomatal properties between MepPlus and MC treatments. Under greenhouse conditions, the untreated control, MepPlus and MC treated plants exhibited single leaf photosynthetic rates of 11.8, 11.3 and 10.9 µmol CO_2 m^{-2} s^{-1}, respectively, with no statistical differences among treatments.

Membrane Leakage

Investigation of leaf discs membrane leakage indicated that the membrane leakage was not different among three treatment at 24 hr after sampling (Table 3). However, after 48 h MepPlus and MC treated-plants showed significantly less leakage (decreased 33 to 50%) compared to the untreated control. MepPlus exhibited the lowest membrane leakage but was not significantly different from MC. Foliar application of both PGRs appeared to increase membrane stability and improve leaf tolerance to the environment.

Sugar Concentrations in Leaf Sap

Under greenhouse conditions, the MepPlus and MC treated-plants showed considerably lower leaf sap sucrose, glucose, fructose and myo-inositol concentrations than untreated-control plants (Table 4). The explanation for the decreased leaf sap sugar concentrations from both PGRs is not clear. It may be associated with improved carbohydrate translocation, i.e. more soluble sugar translocated into reproductive tissues from leaves. This would support the improved dry matter partitioning into the fruit of MepPlus-treated plants. Additional study is needed to determine the effect of MepPlus and MC on cotton carbohydrate metabolism.

Yield and Yield Components

At Clarkedale, lint yield of MC was significantly decreased compared to the control, whereas MepPlus was numerically, but not significantly lower, than the untreated control (Table 5). Slightly decreased lint yields for both PGR treatments might be associated with the extended growing season in 1997. Plants receiving growth retardants (MepPlus and MC) usually cutout earlier than the untreated control plants (Oosterhuis, et. al., 1991) which may, therefore, have been able to continue to mature more late-season bolls than the MepPlus- and MC-treated plants. In Fayetteville, MepPlus treatment showed the highest, and MC lowest, lint yield among the three treatments, although the differences were not significant (Table 5). MepPlus treatments yielded 35 to 55 lb. lint/acre more than MC treatments but the increase was not significant.

Of the three yield components open boll numbers, average boll weight and lint percentage, only boll weight was affected by MepPlus and MC application (Table 5). Average boll weight of the MepPlus treatment was 5.8 g (+13%), and the MC was 5.6 g (+9%), compared to 5.1 g in the untreated control plants. Boll number and lint percentage were unaffected by either PGR treatment.

Analysis of plant mapping indicated that applications of MepPlus and MC increased the fraction of bolls located at fruiting branches 1 to 6, and decreased the fraction of bolls above fruiting branch 10 compared to the untreated control (data not shown). This supports the explanation of higher than expected yields in the untreated control due to more late-season bolls being matured in the extended growing season.

Summary

Application of MepPlus and MC significantly decreased plant height, but had no affect on the number of main-stem nodes. MepPlus and MC also increased leaf stomatal conductance and net photosynthetic rate of field-grown cotton, and improved assimilate partitioning between vegetative and reproductive organs. MepPlus resulted in significantly more dry matter being partitioned into fruit. Both MepPlus and MC increased the stability of leaf cell membranes. In 1997 lint yield was not significantly different between the two PGR treatments. MepPlus treatments yielded 35 to 55 lb. lint/acre more than MC treatments but the increase was not significant. MepPlus and MC treatments had higher average boll weights compared to untreated control.

References

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Table 1. Effect of MepPlus and MC on plant height and main-stem nodes of field-grown cotton† (Clarkedale,1997).

Treatment	Plant height	Main-stem nodes	Height/node ratio
	(Inches)	(no. plant^{-1})	
Control	36.7 a‡	20.7 a	1.77 a
MepPlus	27.0 b	20.3 a	1.33 b
MC	26.4 b	19.9 a	1.33 b

† Measured 3 weeks after first applying .
‡ Means with the same letter within a column are not significant ($P>0.05$).

Table 2. Effects of MepPlus and MC application on leaf photosynthetic rate (Pn), Intercellular CO_2 concentration (c_i), stomatal conductance (g_s) and transpiration rate (E) of field-grown cotton (1997, Fayetteville).

Treatment	Pn	c_i	g_s	E
	µmol CO_2 m^{-2} s^{-1}	ppm	cm s^{-1}	mol m^{-2} s^{-1}
Control	21.3 b†	297 a	2.83 b	0.016 b
MepPlus	29.0 a	291 a	4.10 a	0.020 a
MC	30.0 a	296 a	3.94 a	0.019 ab

† Data with the same letter within a column are not significant ($P>0.05$).

Table 3. Effect of MepPlus and MC application on leaf cell membrane leakage of Field-grown cotton (1997, Fayetteville, AR).

Treatment	24 hours	48 hours
	----------- micro-amps --------------	
Control	17.2 a†	40.3 a
MepPlus	17.8 a	26.9 b
MC	18.2 a	30.3 b

† Data with the same letter within a column are not significant ($P>0.05$).

Table 4. Effect of MepPlus and MC on sugar concentrations of petiole fluids of greenhouse-grown cotton plant (1997, Fayetteville).

Treatment	Sucrose	Glucose	Fructose	Myo-inositol
	------------------- mg ml^{-1} fluid ---------------------			
Control	4.24	1.22	0.21	0.022
MepPlus	3.14	0.43	0.06	0.015
MC	3.13	0.25	0.04	0.009

Table 5. Effect of MepPlus and MC on lint yield and yield components of field-grown cotton (1997).

Treatment	Boll wt.	Boll no.	ginning	Lint yield	
				Clarkedale	Fayetteville
	g boll^{-1}	no. m^{-2}	%	------ lbs acre^{-1} -------	
Control	5.1 b†	78 a	39.8 a	1242 a	1110 a
MepPlus	5.8 a	73 a	38.4 b	1160 ab	1133 a
MC	5.6 a	74 a	38.3 b	1125 b	1078 a

† Data with the same letter within a column are not significant ($P>0.05$).

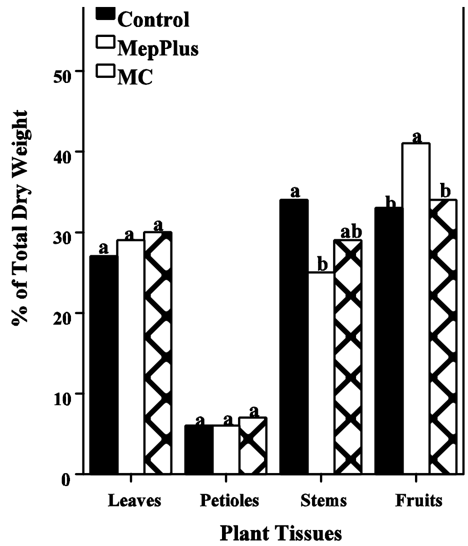

Figure 1. Effect of Mep Plus and MC on dry matter partitioning of field-grown cotton. Measurements were taken at 100 DAP (1997, Clarkedale). Bars with a same letter within a group are not significant. (P>0.05).