Evaluation of variable-rate application of growth regulator in cotton

Beatriz Costalonga Vargas[1]; Marconi Ribeiro Furtado Junior[2]; Gabriel de Oliveira Paula[2]; Andre Luiz de Freitas Coelho[2]; Michel Castro Moreira[2]; Flaviane Ribeiro Carvalho[2]

[1]EPAMIG, Pitangui Institute of Agricultural Technology (ITAP), Brazil; [2]Federal University of Viçosa (UFV), Brazil

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Abstract.

The application of plant growth regulators in cotton is widely used to control excessive vegetative growth and improve plant architecture. However, the spatial variability present in agricultural fields may reduce the efficiency of conventional fixed-rate applications, making variable-rate applications (VRAs) a promising alternative. The objective of this study was to evaluate the effect of fixed-rate and variable-rate application of the growth regulator mepiquat chloride on plant height, leaf area index (LAI), and chlorophyll index (SPAD) at the final stage of the cotton growing cycle. The experiment was conducted in Viçosa, Minas Gerais, Brazil, using the cultivar FM 985GLTP, in a randomized complete block design with eight replications and three treatments: control (no application), fixed rate (FR), and variable rate (VR). The variable-rate application was performed using an automated system adjusted according to plant height. The evaluation was carried out on May 29, 2024, when the crop was at the end of its cycle. The growth regulator was applied six times throughout the growing season. Plant height was measured in 20 plants per plot; LAI was determined using a ceptometer, and the SPAD index was measured with a portable chlorophyll meter. The data were subjected to analysis of variance and Tukey's test at a 5% probability level. In the final evaluation, treatments with the growth regulator (FR and VR) showed a significant reduction in plant height compared to the control, confirming the product's effectiveness in managing vegetative growth. There was no statistical difference between fixed and variable rates for this variable, indicating that both strategies were equally effective in limiting plant height. For the SPAD index, significantly higher values were observed in the treatments with the growth regulator compared to the control, indicating higher chlorophyll content in the leaves of treated plants. This result suggests improved physiological balance and a possible increase in photosynthetic capacity. No differences were found between FR and VR for this variable. The leaf area index showed a distinct response: variable-rate application resulted in a significantly higher LAI compared to both the control and the fixed-rate treatment in the final evaluation. This finding indicates that VRA promoted a more efficient plant architecture, combining height control with maintenance or expansion of the active leaf area. The fixed-rate treatment did not differ from the control for this variable. It is concluded that the application of the growth regulator was effective in controlling plant height and increasing chlorophyll content in cotton. Variable-rate application stood out by promoting a higher leaf area index at the final evaluation, demonstrating superior potential for optimizing plant architecture and improving physiological efficiency. The results reinforce the feasibility of variable-rate technology as a more precise management strategy

adapted to the spatial variability of the crop.

Keywords.
Mepiquat chloride, plant architecture, leaf area index, SPAD index.

INTRODUCTION

The application of plant growth regulators in cotton (Gossypium hirsutum L.) is essential for controlling vegetative growth, promoting a balance between plant development and yield, and facilitating crop management and harvesting operations (Simões et al., 2021; Dharani et al., 2022). In this context, variable-rate application has emerged as an alternative strategy to adjust application rates according to the specific needs of the crop, contributing to greater efficiency in input use (Reis et al., 2020; Inacio and Cortez, 2023). In addition to plant height control, parameters such as the chlorophyll index obtained with a SPAD meter and the leaf area index are widely used to assess cotton growth and vigor (Alves et al., 2020). Therefore, the objective of this study was to evaluate the effects of fixed-rate and variable-rate applications of plant growth regulators on plant height, SPAD index, and leaf area index in cotton.

MATERIAL AND METHODS

The experiment was conducted using the cotton cultivar FM 985GLTP (FiberMax®, Bayer Crop Science, São Paulo, Brazil), with row spacing of 0.90 m and plant spacing of 0.12 m. Sowing was performed on January 30, 2024. The evaluated treatments consisted of applications of plant growth regulators at fixed and variable rates, in addition to an untreated control. A randomized complete block design (RCBD) with eight replications was adopted. For the fixed-rate treatment, an application rate of 106.0 L ha^{-1} was used. The variable-rate treatment was implemented using an automated sensing and flow-control system. In this system, sensors monitored plant height, and an algorithm calculated the application rate in real time.

For both fixed-rate and variable-rate applications, the commercial plant growth regulator Sponsor® (FMC Agrícola®, Campinas, São Paulo, Brazil), containing mepiquat chloride as the active ingredient, was used. Data collection was performed on May 29, 2024.

Field Evaluations

Plant height was assessed by measuring 20 plants per treatment within each block using a measuring tape (Starrett STS12-3ME, Itu, São Paulo, Brazil), recording the distance from the soil surface to the insertion point of the uppermost leaf. Leaf area index (LAI) was evaluated using a ceptometer (AccuPAR LP-80®, Decagon Devices, Pullman, WA, USA). Ten readings were taken per plot, and the average value was subsequently calculated.

Leaf chlorophyll content was measured using a portable chlorophyll meter SPAD-502 Plus (Konica Minolta Sensing®, Osaka, Japan). Measurements were performed on the lower, middle, and upper canopy sections, totaling 15 plants per plot. The average of the 45 readings was used to represent the SPAD index for each plot. All evaluations were conducted between 11:00 a.m. and 1:00 p.m. under stable light conditions.

Statistical Analysis

The experimental data were subjected to analysis of variance (ANOVA). When significant effects were detected, treatment means were compared using Tukey's test at the 5% significance level. All statistical analyses were performed using RStudio® software (Posit Software, PBC, Boston, MA, USA).

RESULTS AND DISCUSSION

Field Evaluation

The fixed-rate and variable-rate treatments resulted in shorter plants and differed significantly from the untreated control. The method of applying the plant growth regulator did not affect the leaf area index and chlorophyll content. No significant differences in plant height were observed between the fixed-rate and variable-rate application strategies (Table 1).

Tab. 1. Statistical analysis of plant height, leaf area index (LAI), and SPAD chlorophyll meter readings.

Variable	Control	Fixed Rate	Variable Rate	CV (%)
Plant height (cm)	136,34	105,00 $A^{\#}$	105,76 $A^{\#}$	10,37
Leaf area index (m^2 m^{-2})	2,74	2,74 A^{ns}	2,74 A^{ns}	28,03
Chlorophyll meter (SPAD)	52,34	54,58 A^{ns}	51,88 A^{ns}	5,85

CV = coefficient of variation; # = significant at the 5% probability level by Dunnett's test; ns = not significant. Means followed by the same letter within a row do not differ significantly according to Tukey's test at the 5% probability level.

The results confirm the effectiveness of the plant growth regulator in controlling cotton plant height. Height reduction is an important agronomic practice that improves light penetration into the canopy, facilitates crop management and harvesting operations, and promotes a better balance between vegetative and reproductive growth (Simões et al., 2021). The absence of significant differences between fixed-rate and variable-rate applications indicates that both strategies were equally effective in controlling plant height, demonstrating the potential of precision application technologies to achieve results comparable to conventional management practices.

No significant differences were observed among treatments for leaf area index or SPAD chlorophyll readings. These findings indicate that the application of the growth regulator did not negatively affect canopy development or leaf chlorophyll content. Maintaining similar leaf area and chlorophyll levels across treatments suggests that plant growth regulation was achieved without impairing physiological characteristics associated with photosynthetic capacity and crop vigor.

CONCLUSION

The application of the plant growth regulator significantly influenced cotton development by reducing plant height compared with the untreated control, regardless of the application strategy adopted. However, no significant differences were observed among treatments for SPAD chlorophyll readings, indicating that the use of the growth regulator did not affect leaf chlorophyll content.

The growth regulator’s fixed-rate or variable-rate applications did not significantly affect the leaf area index. These results demonstrate that plant growth regulation effectively controlled plant height without negatively impacting leaf area development or chlorophyll content, maintaining important physiological characteristics associated with cotton growth and vigor.

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