

RESPONSE OF COTTON TO DIFFERENT PLANT SPACING ALONG WITH CONCENTRATIONS OF GROWTH REGULATOR (MEPIQUAT CHLORIDE) AND TIME OF FOLIAR APPLICATION ON LEAF AREA INDEX

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ABSTRACT

Plant growth regulators (PGRs) are used in cotton production to optimize yield and quality and even suppressing excess growth whenever necessary. Experiments were conducted in 2017 at Cotton Seed Multiplication, Training and Research Farm, Sreepur, Bangladesh to study the response of cotton yield and quality to different plant spacings, concentration and time of application of mepiquat chloride (MC) growth regulator. Plant spacings like 45 cm × 30 cm, 60 cm × 30 cm and 75 cm × 30 cm; MC spray @ 1.0, 2.0, 3.0 and 4.0 ml L⁻¹ water at 25, 50 and 75 DAE for each concentration along with water spray as control, were the treatment variables. The maximum LAI (0.80) was obtained from 75 cm × 30 cm spacing and the minimum LAI (0.74) was from 60 cm × 30 cm spacing. LAI was maximum (0.90) for plants grown without MC. Plants grown with application of MC 2 ml L⁻¹ water at 25 DAE produced the minimum (0.64) Leaf area index evaluated highest (1.06) from 2 ml MC L⁻¹ water sprayed at 25 DAE with 60 cm × 30 cm spacing and lowest (0.52) from 2 ml MC L⁻¹ water at 25 DAE with 45 cm × 30 cm spacing treatment combinations. So, cotton cultivation in Sreepur, Gazipur areas may be accelerated with foliar application of mepiquat chloride @ 2 ml L⁻¹ water at 25 DAE along with plant spacing of 60 cm × 30 cm for higher yield and quality.

Key words: Plant spacing, growth regulator, time of foliar, leaf area index, cotton.

Introduction

Optimum plant population or spacing is important for crop production through efficient utilization of light, nutrients and water uptake by the plants. In some cases, higher plant populations adversely affect yield per unit area simultaneously vegetative and reproductive growth of plants but is important to compensate yield loss due to short canopy of plant (Wright *et al.*, 2008; Silvertooth, 1999 and Hake *et al.*, 1991). Upland cotton (*Gossypium hirsutum* L.) is a leading cash crop in many countries of the world. Bangladesh produces 156,509 bale or 28,328 ton lint and 82484 ton seed cotton from 43050 hectare of land per year (CDB, 2018). Sowmiya and Sakthivel (2018) reported that the closer plant spacing of 60 cm × 15 cm recorded significantly higher leaf area index in cotton. The highest leaf area index was found at 8 plants dripper⁻¹, while the lowest was found at 4 plants dripper⁻¹ in faba bean (Al-Suhaibani, 2013). Optimizing cotton yield through manipulation of plant spacing has been reported by many researchers that increasing plant population density (number of plants per unit ground area) consistently increases leaf area index (LAI) and light interception but its effects on yield have been inconsistent. Understanding how the arrangement of plants in the field affects cotton growth requires consideration of many interacting factors, such as genetics, physiology, and canopy structure (Heitholt and Sassenrath-Cole, 2010). Stewart *et al.* (1997) suggested that decreasing row spacing increased relative leaf area and light interception by the canopy in peanuts. Alterations in plant spacing through row spacing and plant population have a significant effect on canopy development and yield components.

Application of plant growth regulator (either auxin or retardant) can also lead to improve the growth, flowering and yield of many crops. Plant growth regulators are organic compounds, other than nutrients, that affect physiological processes of plants when applied in small concentrations. These compounds represent diverse chemistries and modes of action and provide numerous possibilities for altering crop growth and development. Timing the first application of mepiquat chloride has caused concerns among cotton producers in that too much applied too soon can result in serious damage to plant structure and subsequent lint yields. However, too little material applied too late can increase production costs and still

leave the grower with a rank plant and difficult harvest. Application timing and concentration that worked well in one production year may be useless or impractical in a subsequent year, for almost two decades the decision of when and how much mepiquat chloride to apply has been accomplished through the experienced eye of those who have worked extensively with the product and have come to understand the factors affecting its usage, a better understanding of the physiology of the cotton plant, its water requirements and the influence of its environment (temperature and rainfall) resulted in new capabilities to prescribe accurate mepiquat chloride doses for use in cotton grown in regions normally requiring plant height control (Livingston *et al.*, 1996). Overall benefits from plant growth regulator use in cotton include yield enhancement, improved fiber quality, and greater ease of harvest; more specific responses include alteration of C partitioning, greater root: shoot ratios, enhanced photosynthesis, altered nutrient uptake, improved water status, and altered crop canopy; these responses are a reflection of the interaction of heritable characteristics, cultural inputs, and environment (Cothren *et al.*, 1983). Use of PGR is an eye-catching technology today which improves seed cotton yield through increased number of sympodia by controlling undesirable vegetative development of cotton plant thus giving a short statured plant canopy.

Zhao *et al.* (2019) reported that application of MC reduced plant height, fruit branch length and fruiting branch under different plant densities, resulting in a lower and more compact plant canopy in cotton. Rademacher (2016) opined that growth retardants reduce shoot elongation, thereby lowering the risk of lodging in cereals, rice and oilseed rape, and making ornamentals more compact. Gu *et al.* (2014) narrated that canopy structure became more compact with the decrease of leaf area index and internode length due to the application of MC in cotton. The changes in plant structure and canopy development with altered plant spacing observed in cotton canopies result, at least in part, from photomorphogenetic responses to the altered light quality within the canopy, the photomorphogenetic responses are mediated via the phytochrome system which provides a mechanism for plants to sense and respond to the light environment of the canopy as suggested by Ballare *et al.* (1992) in cucumber. Edgerton (1983) observed that the application of BA (benzlamino-purine), or the BA + GA₄ + A₇ (gibberellins) formulation has also been beneficial in promoting a more desirable branching and canopy development in young spur type 'Delicious' and 'McIntosh' cultivars of apple tree. Ponnuswami and Rani (2019) obtained that the treatment combination of 40 cm x 20 cm with organic compound 20 kg ha⁻¹ recorded the better canopy size under high density planting system. Systematic and comprehensive research effort on blending plant spacing, concentration and time of application of mepiquat chloride (MC) in order to increase yield of cotton are inadequate or absent at home or abroad. Keeping these views in mind, the present research programme was undertaken with the objectives to determine optimum plant density of cotton and to optimize time of application and concentration of MC as foliar spray on cotton to have a restructured plant lowering plant height shortening internode that switch over the reproductive growth achieving the desired yield from cotton in Bangladesh.

Materials and Methods

The experimental field belongs to the agro-ecological zone of Modhupur Tract (AEZ-28). Cotton inbred cultivar CB 14 was selected as it is early maturing (short duration) and high yielding cultivar. A factorial experiment with three levels of plant spacing and thirteen different concentrated MC foliar applications along with time of spraying was as Factor A: level of Plant spacings (3): 60 cm × 30 cm (55,555 plants ha⁻¹) as check selected from first year experiment as promising treatment, 45 cm × 30 cm (74,074 plants ha⁻¹), 75 cm × 30 cm (44,444 plants ha⁻¹); and Factor B: MC concentrations along with time of spraying (13): Water spray (control), Mepiquat Chloride spray @ 1.0, 2.0, 3.0 and 4.0 ml L⁻¹ water at 25 DAE, Mepiquat Chloride spray @ 1.0, 2.0, 3.0 and 4.0 ml L⁻¹ water at 50 DAE and Mepiquat Chloride spray @ 1.0, 2.0, 3.0 and 4.0 ml L⁻¹ water at 75 DAE respectively. MC was sprayed around the crop canopy on 20 September (25 DAE), 20 October (50 DAE) and 14 November, 2017 (75 DAE). The crop was finally harvested on 28 February, 2018. Leaf area index of cotton were analyzed with the help of computer package MSTAT-C. Least Significant Difference (LSD) was used for mean separation at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Effect of plant spacing: Influence on leaf area index was not found significant by plant density (Fig. 1). LAI was increased with the increase of plant density and the maximum LAI (0.80) was obtained from 75 cm × 30 cm spacing and the minimum LAI (0.74) was from 60 cm x 30 cm spacing which was at par with wider spacing 45 cm × 30 cm. Sowmiya and Sakhivel (2018) reported that the narrow plant spacing of 60 cm x 15 cm had significantly higher leaf area index in cotton (Pengcheng *et al.*, 2015 in cotton; Darawsheh and Aivalakis, 2009a in cotton). Ricaurte *et al.* (2016) argued that sowing density is a major management factor that affects growth and development of crops by modifying the canopy light environment and interplant competition for water and nutrients in bean.

Effect of time of application and concentration of MC growth regulator: Application time and concentration of MC had a significant influence on LAI (Fig. 2). LAI was maximum (0.90) for plants grown without MC (control plants) and ranged between 0.64 to 0.90 across the treatments. Plants grown with application of MC 2 ml L⁻¹ water at 25 DAE produced the minimum (0.64) LAI. Intermediate leaf area was recorded when MC sprayed at early (25 and 50 DAE) or late (75 DAE). Amit *et al.* (2016) reported that application of MC @ 300 ppm, TIBA @ 100 ppm and MH @ 250 ppm reduced leaf area index than control in cotton. Leaf area index of cotton was decreased as MC sprayed compared to control (Kumar *et al.*, 2005).

Combined effect of plant spacing and time of application and concentration of MC growth regulator: Leaf area index was significantly affected by the combined effect of plant density and time and concentration of MC application. Leaf area index of cotton was found to be increased with increasing plant density but decreased as MC sprayed compared to control (Table 1). Leaf area index enumerated highest (1.06) from 2 ml MC L⁻¹ water sprayed at 25 DAE with 60 cm x 30 cm spacing and it was marked lowest (0.52) at from 2 ml MC L⁻¹ water at 25 DAE with 45 cm × 30 cm spacing treatment combinations.

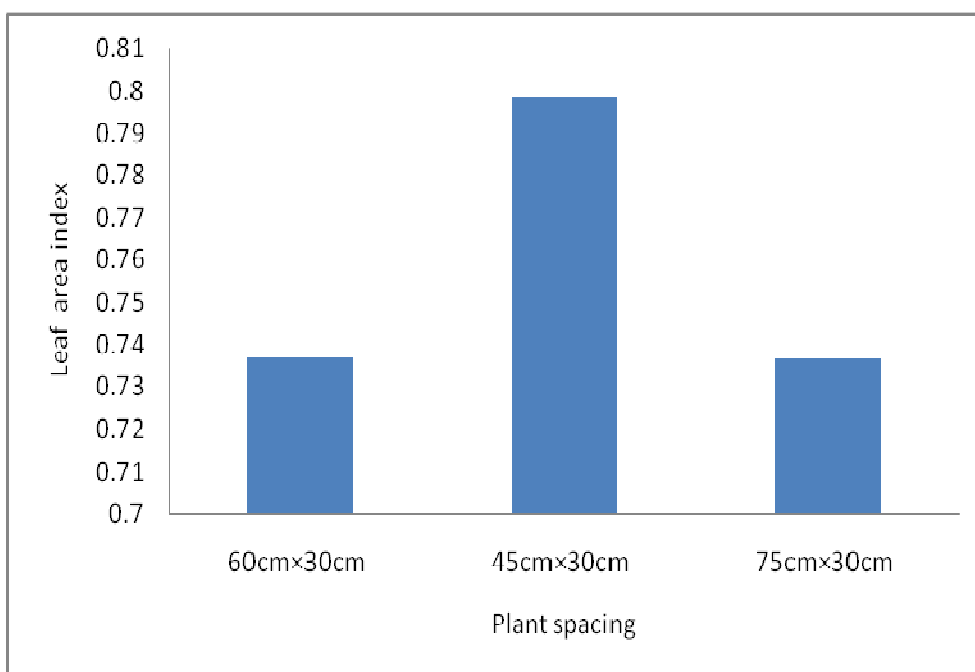


Fig. 1. Influence of plant spacing on LAI of cotton (LSD_(0.05) = 0.101)

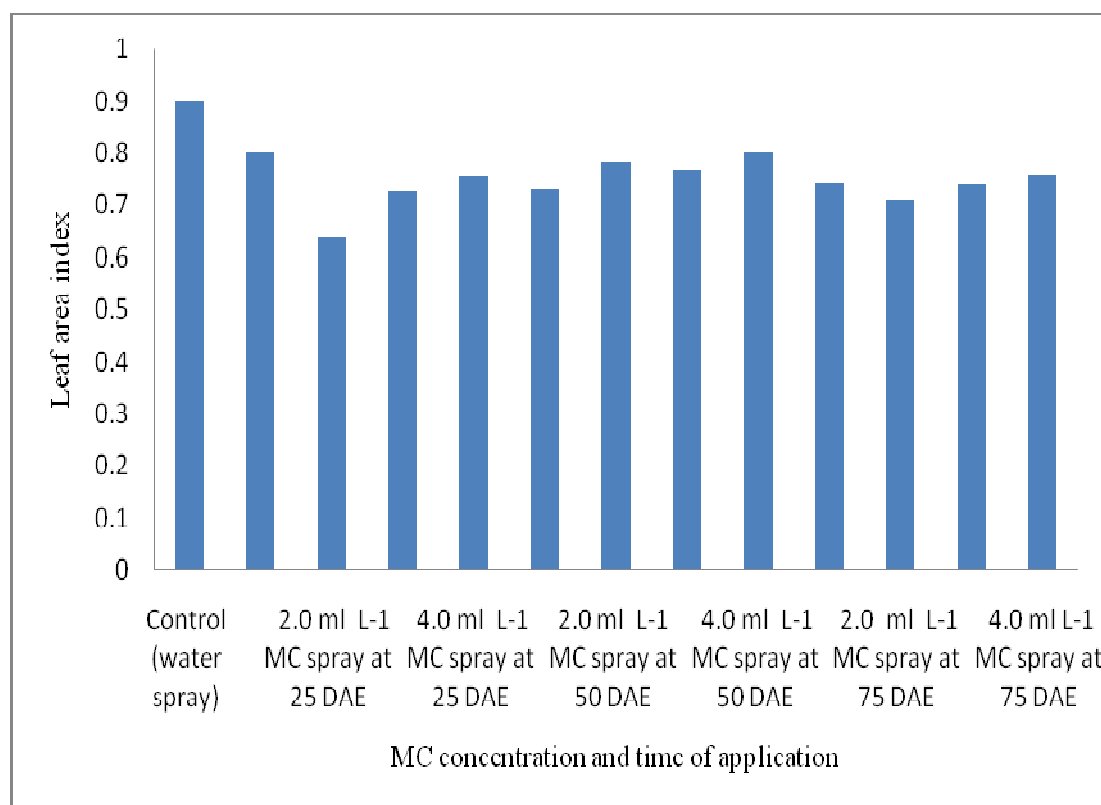


Fig. 2. Effect of different times of application and concentrations of MC on LAI of cotton (LSD_(0.05) = 0.21)

Table 1. Combined effect of plant spacing and MC level along with application time on leaf area index (LAI) of cotton

Treatments	Leaf area index
60 scm×30cm × Control (water spray)	0.79 a-f
× 1.0 ml L ⁻¹ MC spray at 25 DAE	0.78 a-f
× 2.0 ml L ⁻¹ MC spray at 25 DAE	1.06 a
× 3.0 ml L ⁻¹ MC spray at 25 DAE	0.79 a-f
× 4.0 ml L ⁻¹ MC spray at 25 DAE	0.76 a-f
× 1.0 ml L ⁻¹ MC spray at 50 DAE	0.78 a-f
× 2.0 ml L ⁻¹ MC spray at 50 DAE	0.78 a-f
× 3.0 ml L ⁻¹ MC spray at 50 DAE	0.77 a-f
× 4.0 ml L ⁻¹ MC spray at 50 DAE	0.75 a-f
× 1.0 ml L ⁻¹ MC spray at 75 DAE	0.73 b-f
× 2.0 ml L ⁻¹ MC spray at 75 DAE	0.77 a-f
× 3.0 ml L ⁻¹ MC spray at 75 DAE	0.73 b-f
× 4.0 ml L ⁻¹ MC spray at 75 DAE	0.73 b-f

Treatments	Leaf area index
45 cm×30cm × Control (water spray)	0.72 c-f
× 1.0 ml L ⁻¹ MC spray at 25 DAE	0.53 f
× 2.0 ml L ⁻¹ MC spray at 25 DAE	0.52 f
× 3.0 ml L ⁻¹ MC spray at 25 DAE	0.56 ef
× 4.0 ml L ⁻¹ MC spray at 25 DAE	0.65 d-f
× 1.0 ml L ⁻¹ MC spray at 50 DAE	0.66 d-f
× 2.0 ml L ⁻¹ MC spray at 50 DAE	0.67 c-f
× 3.0 ml L ⁻¹ MC spray at 50 DAE	0.62 d-f
× 4.0 ml L ⁻¹ MC spray at 50 DAE	0.62 d-f
× 1.0 ml L ⁻¹ MC spray at 75 DAE	0.66 d-f
× 2.0 ml L ⁻¹ MC spray at 75 DAE	0.59 d-f
× 3.0 ml L ⁻¹ MC spray at 75 DAE	0.70 c-f
× 4.0 ml L ⁻¹ MC spray at 75 DAE	0.72 c-f
75 cm×30cm × Control (water spray)	1.04 ab
× 1.0 ml L ⁻¹ MC spray at 25 DAE	0.63 d-f
× 2.0 ml L ⁻¹ MC spray at 25 DAE	0.80 a-f
× 3.0 ml L ⁻¹ MC spray at 25 DAE	0.98 a-c
× 4.0 ml L ⁻¹ MC spray at 25 DAE	0.81 a-f
× 1.0 ml L ⁻¹ MC spray at 50 DAE	0.85 a-e
× 2.0 ml L ⁻¹ MC spray at 50 DAE	0.89 a-d
× 3.0 ml L ⁻¹ MC spray at 50 DAE	0.83 a-f
× 4.0 ml L ⁻¹ MC spray at 50 DAE	0.82 a-f
× 1.0 ml L ⁻¹ MC spray at 75 DAE	0.80 a-f
× 2.0 ml L ⁻¹ MC spray at 75 DAE	0.88 a-d
× 3.0 ml L ⁻¹ MC spray at 75 DAE	0.84 a-f
× 4.0 ml L ⁻¹ MC spray at 75 DAE	0.89 a-d
LSD _(0.05)	0.316
CV (%)	11.15

In a column, figure (s) followed by same letter do not differ significantly at 5% level.

Conclusion

Foliar application of mepiquat chloride @ 2 ml L⁻¹ water at 25 DAE along with plant spacing of 60 cm x 30 cm can be practiced for profitable cotton production in Gazipur areas of Bangladesh.

References

- Al-Suhaibani , N., El-Hendawy, S. and Schmidhalter U. 2013. Influence of varied plant density on growth, yield and economic return of drip irrigated faba bean (*Vicia faba* L.). *Turkish J. Field Crops.* 18(2): 185-197.

- Amit, K., Deol, J. S. and Brar, A. S. 2016. Response of different *Bt* cotton (*Gossypium hirsutum* L.) hybrids to canopy modification practices. *J. Appl. Nat. Sci.*, 8 (3): 1188- 1197.
- Ballare, C. L., Scopel, A. L., Radosevich, S. R. and Kendrick, R. E. 1992. "Phytochrome-mediated phototropism in deetiolated seedlings: occurrence and ecological significance." *Plant Physiol.*, 100(1): 170-177.
- CDB. 2018. Cotton Extension and Research Report. Cotton Development Board, Khamarbari, Farmgate, Dhaka, Bangladesh. pp. 10-125.
- Cothren, J. T., Albers, D. W., Urwiler, M. J. and Guthrie, D. S. 1983. Comparative growth analysis of mepiquat chloride-treated cotton cultured under controlled environment. Proc. Tenth Ann. Meet. *Plant Growth Regulator Soc. Am., Lake Alfred. FL.*, 253-261.
- Darawsheh, M. K., Khah, E. M., Aivalakis, G., Chachalis, D. and Sallaku, F. 2009. Cotton row spacing and plant density cropping systems I. Effects on accumulation and allocation of dry mass and LAI. *J. Food Agric. Environ.*, 7(3 and 4): 258-261.
- Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. 2nd Edn., pp. 13-175.
- Gu, S., Jochem, B. E., Zhang, L., Mao, L., Zhang, S., Zhao, X. and Liu, S. 2014. Part of a special issue on functional-structural plant modelling, Modelling the structural response of cotton plants to mepiquat chloride and population density. *Ann. Bot.*, 114: 877-887.
- Hake, K., Burch, T., Harvey, L., Kerby, T. and Supak, J. 1991. Plant population In: Cotton Physiology. Today Newsletter. *Natl. Cotton Counc. Am., Memphis, TN.* 2: 4.
- Heitholt, J. J. and Sassenrath-Cole, G. F. 2010. Inter-plant competition: growth responses to plant density and row spacing. *Physiol. of Cotton.* Pp. 179-186.
- Livingston, S.D., Stichler, C.R. and Landivar, J.A. 1996. Using mepiquat chloride on the Texas coast too reduce cotton plant height. Texas Agricultural Extension Service. The Texas A and M University System. College Station. Texas. B-6042. pp 1-7.
- Pengcheng L., Helin, D., Aizhong, L., Jingran, L., Miao, S., Guoping, W., Shaodong, L., Xinhua Z. and Yabing, L. 2015. Effects of planting density and nitrogen fertilizer interaction on yield and nitrogen use efficiency of cotton[J]. *Transactions of the Chinese Society of Agricultural Engineering.* 1(23): 122-130.
- Ponnuswami, V. and Rani, E. A. 2019. Organic leaf production of moringa (*Moringa oleifera* Lam.) cv. PKM-1 for higher leaf yield and quality parameters under ultra high density planting system. *Adv. Plants Agric. Res.*, 9(1): 206-214.
- Rademacher, W. 2016. Chemical regulators of gibberellin status and their application in plant production. *Ann. Plant Reviews*, 49: 359-403.
- Ricaurte, J. J., Clavijo, M. J. A., Sinclair, T. R., Rao, I. M. and Beebe, S. 2016. Sowing density effect on common bean leaf area development. *Crop Sci.* 56: 1-9.
- Silvertooth, J. C. 1999. Row spacing, plant population, and yield relationships. Arizona cotton comments. Cooperative Extension, The University of Arizona. USA.
- Sowmiya, R. and Sakthivel, N. 2018. Effect of planting geometry on growth and yield of cotton. *Madras Agric., J.* 105(1-3): 30-32.
- Stewart, S. D., Bowen, K. L., Mack, T. P. and Edwards, J. H. 1997. Impact of row spacing and planting date on the canopy environment, abundance of lesser cornstalk borer and other arthropods, and incidence of aflatoxigenic fungi in peanuts. *Peanut Sci.*, 24: 52-59.
- Wright, D. L., Marois, J. J., Sprenkel, R. K. and Rich, J. R. 2008. Production of ultra narrow row cotton. Publ. SS-AGR-83, Inst, Food And Agric. Sci. Agron. Deptt. Florida Cooperative Extension Service, Univ. Florida. USA.
- Zhao, W., Yan, Q., Hongkun, Y., Xiaoni, Y., Leran, W., Binglin, C., Yali, M. and Zhou, Z. 2019. Effects of mepiquat chloride on yield and main properties of cotton seed under different plant densities. *J. Cotton Res.*, 2: 1-10.