Bangladesh J. Environ. Sci., Vol. 43, 66-73, 2022 @ BAED ISSN 1561-9206

INFLUENCES OF DIFFERENT PLANT SPACING AND APPLICATION TIMES OF GROWTH REGULATOR (MEPIQUAT CHLORIDE) ON THE INTERNODE LENGTH OF COTTON

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ABSTRACT

An experiment was conducted at Cotton Seed Multiplication, Training and Research Farm, Sreepur, Bangladesh during 2016-2018 to evaluate the response of cotton plant height to different plant spacing, concentration as well as time of application of mepiquat chloride (MC) as growth regulator. Plant spacing were like 45 cm × 30 cm, 60 cm × 20 cm, 60 cm × 30 cm, 60 cm × 40 cm, 75 cm × 30 cm, 75 cm × 40 cm, 90 cm × 10 cm and 90 cm × 45 cm; MC was sprayed @ 1.0 ml L^{-1} water at 25, 50, 75, 100 and 125 days after emergence (DAE) in 2016 whereas @ 1.0, 2.0, 3.0 and 4.0 ml L^{-1} water at 25, 50 and 75 DAE for each conc. in 2017. During 2008 MC sprayed @ 2.0 and 4.0 ml L^{-1} water at 25 DAE, 2.0 and 4.0 ml L^{-1} water at 50 DAE, 2.0 ml L^{-1} water at 25 as well as 50 DAE in 2018 along with water sprayed as control. The shortest internodes (3.00 cm) was obtained from 1ml MC L^{-1} water at 25 DAE with medium plant spacing 60 cm × 30 cm and the longest (6.67) was from water treatment with 90 cm × 45 cm spacing. So, cotton cultivation in Sreepur, Gazipur areas may be accelerated with foliar application of mepiquat chloride @ 1 ml L^{-1} water at 25 DAE along with plant spacing of 60 cm x 30 cm for higher yield and quality.

Key words: MC, spacings, foliar application, internode length.

Introduction

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 28484 ton seed cotton from 43050 hectare of land per year (CDB, 2018). 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). Baumhardt *et al.* (2018) reported that plant height increased significantly with increased row spacing in cotton. 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. Their time of use extends from early season when they are applied in-furrow or as seed treatments at planting to late season in preparing the crop for harvest. Timing the first application of plant growth regulators (mepiquat chloride-MC) 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 internode length control (Livingston *et al.*, 1996). Copur *et al.* (2010) studied that the applied PGRs had significant positive effects on the seed cotton yield, internode length. Use of plant growth retardant 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. Kumar *et al.* (2005) had found reduced internodes with MC (50 ppm) sprayed at 90 DAS as compare to Chlormequat Chloride (CCC)

application in cotton plant. Kataria and Khanpara (2012) reported that the applied Cycocel @ 40 ppm at 90 DAS had significantly decreased internodes in cotton. Zhao *et al*. (2019) reported that application of MC reduced internodes 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. Systematic and comprehensive research effort on blending plant spacing, concentration and time of application of 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

Cotton plants were given different plant spacings, time of application and concentration of growth regulator (mepiquat chloride, MC) during 2016 to 2018 in different treatment combinations to evaluate the response of growth, yield and quality of cotton. The experimental field belongs to the agro-ecological zone of Modhupur Tract (AEZ-28). Cotton inbred cultivar CB 14 was selected as early maturing (short duration) and high yielding cultivar. The experiment was laid out in a split plot design with three replications. Spacing or plant density was assigned to the main plots and growth regulators in the subplots. The size of each plot was 3.6 m × 4.5 m and the distance between replication to replication was 2.0 m. The distance between intra-plot and main plot were maintained 1.0 m. A factorial experiment was conducted with five levels of plant spacing and six times of Mepiquat Chloride (MC) @ 1.0 ml L^{-1} water foliar application during 2016; three levels of plant spacing and twelfth concentrations of mepiquat chloride with time of application according to the experimental treatment were maintained during 2017; three levels of plant spacing and nine concentrations of mepiquat chloride with time of application according to the experimental treatment were followed during 2018;

The experimental variables were:

<u>During Year 1(2016)</u>

Factor A: Level of plant spacings (5)

i. S = 90 cm × 45 cm (24, 691 plants ha
ii. S2 = 60 cm × 30 cm (55,555 plants ha
iii. S3 = 60 cm × 40 cm (41,666 plants ha
iv. S4 = 75 cm × 30 cm (44,444 plants ha
v. S5 = 75 cm × 40 cm (33,333 plants ha

Factor B: Foliar application times of MC (6)

i. FS0 = water spray (control)
ii. FS1 = Foliar spray at 25 days after emergence (DAE)
iii. FS2 = Foliar spray at 50 DAE
iv. FS3 = Foliar spray at 75 DAE
v. FS4 = Foliar spray at 100 DAE
vi. FS5 = Foliar spray at 125 DAE

<u>During Year 1(2017)</u>

Factor A: Plant spacings (3):

i. S1A = 60 cm × 30 cm as check from first year experiment as promising treatment
ii. S2A = 45 cm × 30 cm (74,074 plants ha^{-1})
iii. S3A = 75 cm × 30 cm (44,444 plants ha^{-1})

Factor B: MC concentrations along with time of spraying (13)

i. MC0A =Water spray (control)
ii. MC1A = Mepiquat Chloride spray @ 1.0 ml L^{-1} water at 25 DAE
iii. MC2A= Mepiquat Chloride spray @ 2.0 ml L^{-1} water at 25 DAE
iv. MC3A= Mepiquat Chloride spray @ 3.0 ml L^{-1} water at 25 DAE
v. MC4A = Mepiquat Chloride spray @ 4.0 ml L^{-1} water at 25 DAE
vi. MC5A = Mepiquat Chloride spray @ 1.0 ml L^{-1} water at 50 DAE
vii. MC6A = Mepiquat Chloride spray @ 2.0 ml L^{-1} water at 50 DAE
viii. MC7A= Mepiquat Chloride spray @ 3.0 ml L^{-1} water at 50 DAE
ix. MC8A = Mepiquat Chloride spray @ 4.0 ml L^{-1} water at 50 DAE
x. MC9A = Mepiquat Chloride spray @ 1.0 ml L^{-1} water at 75 DAE
xi. MC10A = Mepiquat Chloride spray @ 2.0 ml L^{-1} water at 75 DAE
xii. MC11A = Mepiquat Chloride spray @ 3.0 ml L^{-1} water at 75 DAE
xiii. MC12A = Mepiquat Chloride spray @ 4.0 ml L^{-1} water at 75 DAE

During Year 1(2018)

Factor A: Plant spacings (3)

i. S1B = 60 cm × 30 cm as check, selected from 1st and 2nd year's experiments
ii. S2B = 90 cm × 10 cm (1,11,111 plants ha^{-1})
iii. S3B = 60 cm × 20 cm (83,333 plants ha^{-1})

Factor B: Application time and concentration of Mepiquat Chloride (9)

i. MC1B = Water spray as control at 25 DAE
ii. MC2B = Mepiquat Chloride spray @ 2.0ml L^{-1} water at 25 DAE
iii. MC3B = Mepiquat Chloride spray @ 4.0 ml L^{-1} water at 25 DAE
iv. MC4B = Water spray as control at 50 DAE
v. MC5B = Mepiquat Chloride spray @ 2.0ml L^{-1} water at 50 DAE
vi. MC6B = Mepiquat Chloride spray @ 4.0 ml L^{-1} water at 50 DAE
vii. MC7B = Water spray as control at 25 and 50 DAE
viii. MC8B = Mepiquat Chloride spray @ 2.0ml L^{-1} water at 25 and 50 DAE
ix. MC9B = Mepiquat Chloride spray @ 4.0 ml L^{-1} water at 25 and 50 DAE

The cotton seeds were sown 5 August, 2016; 17 July, 2018 and 21 August, 2017 whereas total harvest (final) was completed on 24 February, 2017; 28 February, 2018 and 18 January, 2019; respectively. Random selection of ten cotton plants from each treatment plot replicated three times were used to study the increasing or decreasing trend under different treatment combinations. The graduated ruler was used to measure internodes length at the time of final cotton harvest and it was taken from distances between the 4th and 5th leaf from the terminal. The mean plant internodes length was recorded and expressed in cm. The analysis was done 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

The experiment was conducted during 2016-2018 with different levels of plant spacing and times and concentrations of foliar application of mepiquat chloride (MC) at different growth stages. The results obtained in the study have been presented either in table or figure which are followed by discussion.

Effect of p**lant spacing:** There was no significant difference among the plant spacing in respect of internodal length during 2016 (Fig.1). Variation in internodal length due to different plant spacing was statistically significant. Internodal length ranged between 4.46 and 4.94 cm. Plant spacing 90 cm × 45 cm showed the highest internodal length but the lowest being recorded for spacing 60 cm × 30 cm which was at par with 75 cm × 30 cm spacing. Internodal length due to different plant spacing was statistically significant during 2017 (Fig. 2) and ranged between 4.16 and 4.88 cm. Plant spacing 75 cm × 30 cm showed maximum internodal length (4.88 cm) while the minimum (4.16 cm) was in 60 cm × 30 cm spacing followed by 45 cm × 30 cm plant spacing. It varied from 4.51 to 4.74 cm during 2018, plant spacing 60 cm × 30 cm had the highest (4.74 cm) internodes length which was statistically similar with 60 cm × 20 cm spacing and the lowest (4.51 cm) being recorded from 90 cm × 10 cm spacing. Baumhardt *et al.* (2018) narrated that internodes increased significantly with increased row spacing in cotton. Similar information was reported by Singh *et al.* (2017) in tomato.

Effect of time of application and concentration of MC growth regulator: MC level and its application time had significant influence on internodal length during 2016 (Fig. 4). Internodal length was maximum (6.14 cm) in plants grown in control and the lowest (3.76 cm) was obtained from 25 DAE spray. Intermediate internodes length was recorded when MC sprayed from 50 to 125 DAE. Internodal length reduced as MC sprayed compared to control. Significant variation in internodal length was also observed due to different times and concentrations of MC application during 2017 (Fig. 5). Internodal length was maximum (4.8 cm) in control and the minimum (3.21cm) was from 2 ml MC L^{-1} water sprayed at 25 DAE. Intermediate internodal length was recorded when MC sprayed at early (25 and 50 DAE) or late (75 DAE). Internodal length reduced as MC sprayed compared to control during 2018 (Fig. 6). Priyanka and Dalvi (2019) reported that internodal length reduced as MC sprayed compared to control. Application of mepiquat chloride (mc @ 15ml and 10 ml 10 L^{-1} of water) at square and flower formation stage was found effective in reducing internodes length in cotton. This finding was in agreement with the findings of other researchers, Shahr *et al.* (2015) in cotton; Gu *et al.* (2014) as well as Eveleigh *et al. (*2010) in cotton.

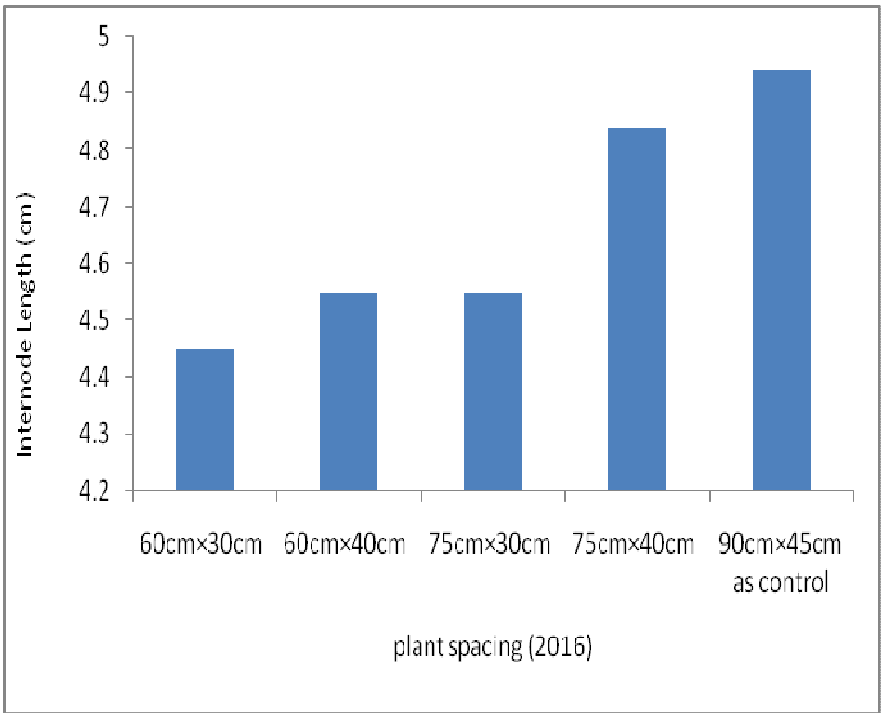

Fig.1. Influence of plant spacing on internodes length of cotton (LSD $_{(0.05)}$ = 0.325)

Fig. 2. Influence of plant spacing on internodes length of cotton (LSD $_{(0.05)}$ = 0.668)

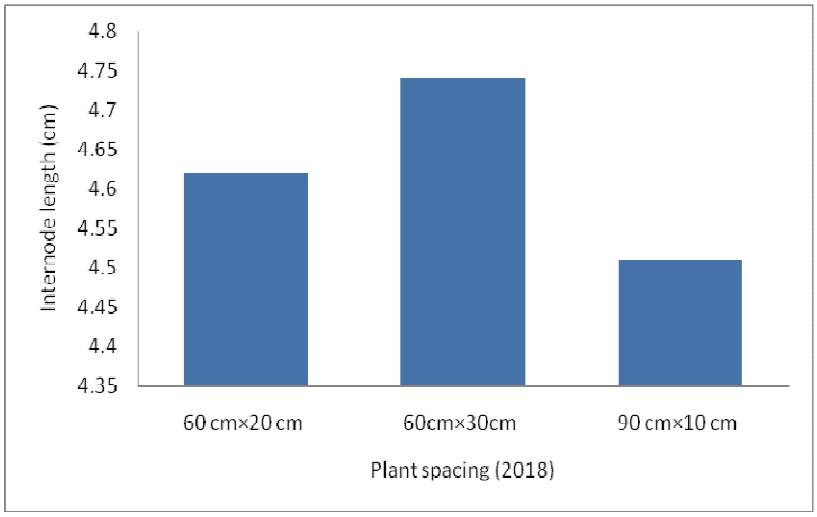

Fig. 3. Influence of plant spacing on internodes length of cotton (LSD $_{(0.05)}$ = 0.271)

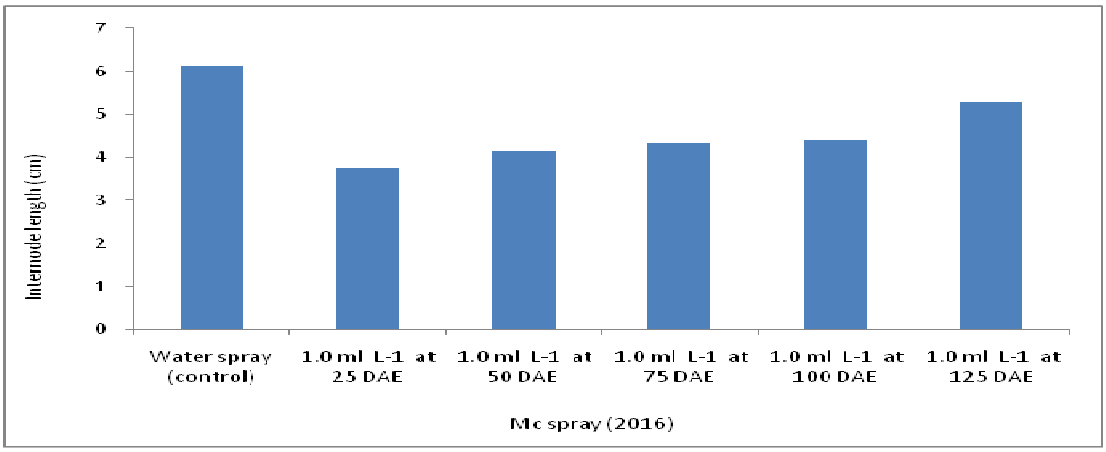

Fig. 4. Influence of time of application of MC on internodes length of cotton (LSD $_{(0.05)}$ = 0.569).

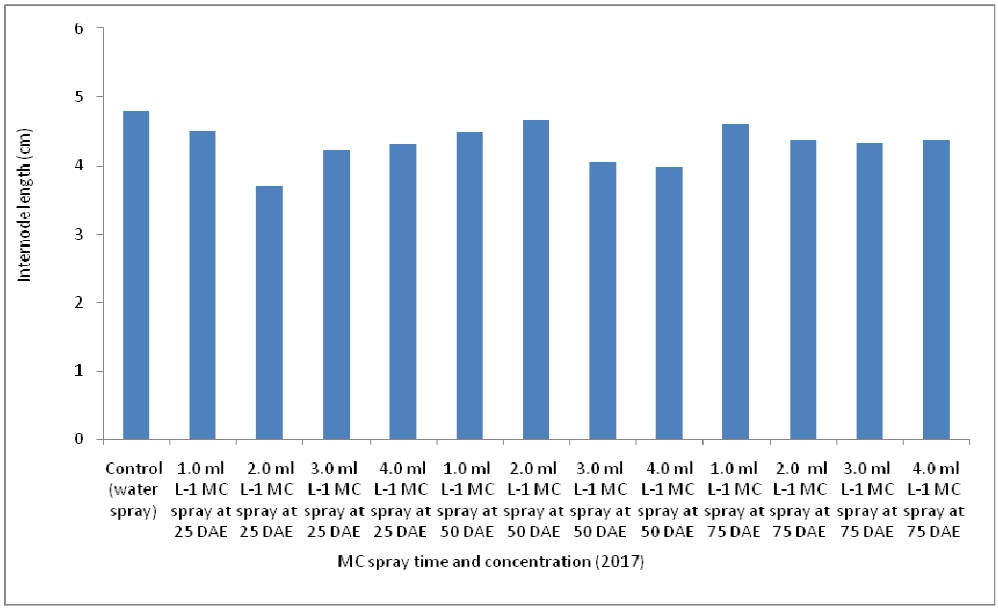

Fig. 5. Influence of time of application and concentration of MC on internode length (LSD $_{(0.05)}$ = 0.673)

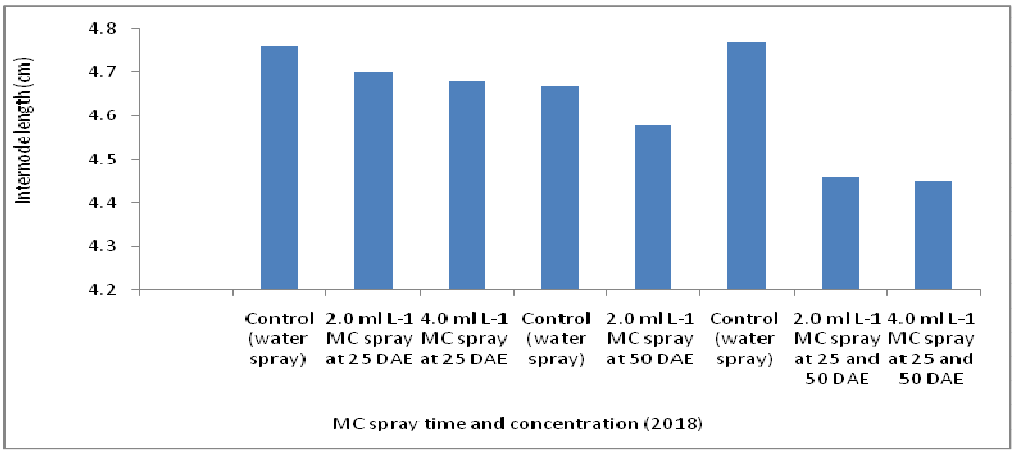

Fig. 6. Influence of time of application and concentration of MC on internode length (LSD $_{(0.05)}$ = 0.30)

The combined effect of plant spacing along with time of application and concentration of growth regulator: Combined effect of plant density and MC level had significant variation in internodal length during 2016. Ultimately the study remarked 1ml MC L^{-1} water at 25 DAE with 60 cm × 30 cm spacing as top most combination amongst the set combinations (82 nos.) from three years trials tested at Training and Research Farm, Sreepur, Bangladesh during 2016-2018. Internodal length increased progressively and significantly irrespective of treatment combinations. Internodes of cotton plant became highest (6.67 cm) from water sprayed (control) with 90 cm × 45 cm spacing and it was marked lowest (3 cm) at 25 DAE foliar sprayed with 60 cm × 30 cm spacing. Combined effect of plant spacing and MC levels at different time of application of growth regulator significantly affected internodal length during 2017. The highest internode (5.50 cm) recorded from water sprayed with 75 cm × 30 cm spacing. The shortest (3.33 cm) was marked at 2 ml MC L^{-1} water at 25 DAE with 60 cm × 30 cm spacing. During 2018, internodal length decreased as plant population increased and internodal length reduced with MC sprayed compared to

control, it was marked highest (5.13 cm) from foliar sprayed with 90 cm × 10 cm spacing. The lowest (4.3 cm) was obtained from foliar sprayed with 2 ml MC L^{-1} water at 25 DAE in 60 cm × 30 cm spacing. Iqbal *et al.* (2007) observed short internodal length in narrow plant spacing with MC sprayed in cotton.

Table 1. Combined effect of plant spacing and MC mepiquat chloride (MC) spray on the internode length of cotton

Internode length in 2016		Internode length in 2017		Internode length in 2018	
Combination	Length (cm)	Combination	Length (cm)	Combination	Length (cm)
S1 x FS0	6.67 a	S1A x MC0A	4.82 a-d	S1B x MC1B	4.82 a-f
S1 x FS1	4.21 d-j	S1A x MC1A	3.47 fg	S1B x MC2B	4.30 f
S1 x FS2	4.22 d-i	S1A x MC2A	3.33 g	S1B x MC3B	4.80 a-f
S1 x FS3	4.00 e-j	S1A x MC3A	3.50 fg	S1B x MC4B	4.95 a-c
S1 x FS4	4.78 c-e	S1A x MC4A	4.65 a-e	S1B x MC5B	4.83 a-e
S1 x FS5	4.61 c-f	S1A x MC5A	4.82 a-d	S1B x MC6B	4.87 a-d
S2 x FS0	4.94 b-e	S1A x MC6A	3.67 e-g	S1B x MC7B	5.12 ab
S2 x FS1	3.00 j	S1A x MC7A	5.00 a-c	S1B x MC8B	4.47 c-f
S2 x FS2	3.06 ij	S1A x MC8A	3.86 d-g	S1B x MC9B	5.12 ab
S2 x FS3	4.19 d-j	S1A x MC9A	4.33 b-g	S2B x MC1B	4.77 a-f
S2 x FS4	4.28 d-h	S1A x MC10A	4.15 b-g	S2B x MC2B	4.42 d-f
S2 x FS5	4.72 c-e	S1A x MC11A	4.67 a-e	S2B x MC3B	4.33 ef
S3 x FS0	5.50 a-c	S1A x MC12A	3.98 c-g	S2B x MC4B	4.47 c-f
S3 x FS1	4.01 e-j	S2A x MC0A	5.22 ab	S2B x MC5B	4.43 c-f
S3 x FS2	4.00 e-j	S2A x MC1A	4.50 a-f	S2B x MC6B	4.45 c-f
S3 x FS3	4.00 e-j	S2A x MC2A	3.33 g	S2B x MC7B	5.13 a
S3 x FS4	4.44 c-g	S2A x MC3A	4.82 a-d	S2B x MC8B	4.50 c-f
S3 x FS5	6.11 ab	S2A x MC4A	4.82 a-d	S2B x MC9B	4.47 c-f
S5 x FS0	6.06 ab	S2A x MC5A	4.50 a-f	S3B x MC1B	4.60 b-f
S5 x FS1	3.47 f-j	S2A x MC6A	4.30 b-g	S3B x MC2B	4.57 c-f
S5 x FS2	3.23 g-j	S2A x MC7A	3.99 c-g	S3B x MC3B	4.58 c-f
S5x FS3	3.22 h-j	S2A x MC8A	4.28 b-g	S3B x MC4B	4.68 a-f
S5 x FS4	4.33 c-h	S2A x MC9A	4.37 b-g	S3B x MC5B	4.60 b-f
S5 x FS5	5.11 b-e	S2A x MC10A	4.00 c-g	S3B x MC6B	4.62 a-f
S5 x FS0	5.34 b-d	S2A x MC11A	4.33 b-g	S3B x MC7B	4.75 a-f
S5 x FS1	4.03 e-j	S2A x MC12A	4.99 a-c	S3B x MC8B	4.70 a-f
S4 x FS2	4.08 e-j	S3A x MC0A	5.50 a	S3B x MC9B	4.70 a-f
S4 x FS3	4.06 e-j	S3A x MC1A	4.83 a-d		
S4 x FS4	4.50 c-f	S3A x MC2A	3.67 e-g		
S4 x FS5	5.11 b-e	S3A x MC3A	3.63 e-g		
		S3A x MC4A	3.50 fg		
		S3A x MC5A	4.67 a-e		
		S3A x MC6A	4.17 b-g		
		S3A x MC7A	4.48 a-f		
		S3A x MC8A	3.83 d-g		
		S3A x MC9A	5.00 a-c		
		S3A x MC10A	4.00 c-g		
		S3A x MC11A	4.00 c-g		
		S3A x MC12A	4.17 b-g		
$LSD_{(0.05)}$	1.205		1.12		0.5203
CV (%)	9.23		14.31		7.76

Means having same letters in the same column indicates no significant difference at $P \leq 0.05$.

Conclusion

The highest internode length (4.94 cm) identified from plant spacing 90 cm x 45 cm and the lowest (4.46 cm) from 60 cm × 30 cm whereas the highest internode length (6.14 cm) observed in water sprayed and the lowest was from 2 ml MC L^{-1} water sprayed at 25 DAE. But in combination, the highest internode

length (6.67 cm) was remarked in control and the lowest was observed from 1ml MC L^{-1} water at 25 DAE treatment when MC concentration was not variable whereas with different concentrations, combined influence of plant density and time of application and concentration of growth regulator developed the higher internode length (5.50 cm) from only water sprayed with 75 cm × 30 cm spacing but the shortest internode length obtained from 2 ml MC L^{-1} water at 25 DAE with 60 cm × 30 cm spacing that confirmed the profitable cotton cultivation in Sreepur, Gazipur areas of Bangladesh

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