International Journal of Chemical Studies 2019; 7(3): 946-950

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 946-950

Received: 28-03-2019
Accepted: 30-04-2019

Satish A Raut
Department of Biological Sciences, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Dr. Jayant H Meshram
ICAR- Central Institute for Cotton Research, Post Bag No2, Shankar Nagar Post, Nagpur, Maharashtra, India

Eugenia P Lal
Department of Biological Sciences, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Correspondence
Dr. Jayant H Meshram
ICAR- Central Institute for Cotton Research, Post Bag No2, Shankar Nagar Post, Nagpur, Maharashtra, India

Effect of mepiquat chloride on cotton var Suraj shoot and root growth behaviour

Satish A Raut, Dr. Jayant H Meshram and Eugenia P Lal

Abstract
The growth regulator mepiquat chloride (1, 1-dimethyl-piperidinium chloride) is globally used in cotton (*Gossypium hirsutum* L.) for canopy manipulation to avoid excess vegetative growth. The pot culture experiment was conducted at Division of Crop Production, ICAR-CICR, Nagpur during summer- 2018 to study the "Effect of mepiquat chloride on cotton var Suraj shoot and root growth behaviour". The experiment was arranged in a Completely Randomized Block Design with four replications and seven treatments such are T_0 was control, T_1, T_2, T_3, T_4, T_5 and T_6 (300, 600, 900, 1200, 1500 and 1800 mg litre^{-1} respectively at squaring stage 45 DAS). Foliar application of highest concentration of mepiquat chloride in treatment (T_6) being 1800 mg litre^{-1} reduced cotton plant height, height to node ratio, number of main stem node, stem diameter, leaf area and shoot dry weight whereas, root length and root dry weight are increased as compared to control (T_0). Biochemical parameter like chlorophyll (a, b and total) and carotenoid content increased in same concentration of MC significantly on other hand starch content and nitrate reductase activity significantly higher in treatment T_4 (1200 mg litre^{-1}) compare to control.

Keywords: Cotton, mepiquat chloride, vegetative growth, foliar application

1. Introduction

Cotton (*Gossypium hirusutum* L.) is one of the most important commercial cash crop and important fiber crop of global significance cultivated in more than seventy countries. It is an important raw material of economy in term of both employment generation of foreign exchange and hence it is popularly known as "White gold or friendly fiber". Cotton is used not only for weaving of cloth but also for other purposes like preparation of edible oil from its seeds (16-24 %). American cotton contains more percentage of oil as compared to *desi* cotton varieties (*arboreum*). From the modest yield level of 88 kg ha^{-1} at the time of Independence of the country, today the average productivity is touching around 568 kg ha^{-1} (Anonymous, 2017) [1].

India is the largest cotton growing country in the world. The top five producers in the world are India, China, USA, Pakistan and Uzbekistan. India occupies first rank in area and having first position in production. In India cotton is grown over an area 105 lakh hectares with production 351 lakh bales and productivity 568 kg lint ha^{-1} (Anonymous, 2017) [1]. In Maharashtra, cotton is cultivated over an area 38.06 lakh hectares with production of 89 lakh bales and having productivity 398 lint kg ha^{-1} (Anonymous, 2017) [1].

Cotton plant has a perennial and indeterminate growth habit which is very sensitive to environmental changes and management. Sufficient supply of fertilizer and irrigation sometime results in extensive vegetative growth, excessive vegetative growth can lead to undesirable shade within the plant canopy, fruit abscission and yield reduction (Zhao and Oosterhuis, 2000). Much labor is required to cut the top buds of main stem and branches to control excessive growth in cotton. Hence plant growth retardants are needed to enhance cotton productivity by transforming canopy structure, adjusting plants hormonal balance and improved source-sink ratio (Rosolem *et al*., 2013) [18].

Mepiquat chloride (MC), 1,1dimethylpiperidinium chloride, is a water soluble organic molecule, which is absorbed by the green parts and redistributed throughout the plant, and has been most successful and worldwide used to control plant canopy size in cotton production. MC inhibits gibberellic acid synthesis by stopping the conversion of geranlgeranyldiphosphate to ent-kaurene, consequently reducing cell enlargement and cell division rate (Srivastava, 2002) [19]. The decreased cell elongation after MC application may eventually result in lower cotton leaf area and number of reproductive branches (Kerby, 1985) [10].

Cotton plants treated with MC are typically more compact, with fewer nodes (Reddy *et al*., 1990) [17], shorter internodes and fewer reproductive branches (Bogiani and Rosolem, 2009) [2]. As a result, MC controls plant height and earliness, thus facilitating crop management and harvest. Application of MC reduces leaf area per plant more than boll load; therefore, the number of bolls per leaf area unit is increased. Mepiquat chloride also concentrates boll set on lower sympodia, increasing the synchrony of boll maturation and demand for photosynthate (Gwathmey and Clement, 2010) [7].

Therefore, the aim of present study is to investigate the effect of foliar spray of mepiquat chloride at squaring stage (45 DAS) on cotton shoot growth pattern and biochemical parameter.

Materials and Methods

The experiment was arranged in a Completely Randomized Block Design with four replications and seven treatments such are T_0 was control (distilled water instead of MC applied) and T_1, T_2, T_3, T_4, T_5 and T_6 (300, 600, 900, 1200, 1500 and 1800 mg litre^{-1}, respectively, applied at squaring stage 45 DAS). Mepiquat chloride was applied by foliar application using handheld sprayer with adjustable tip. Surface soil sample were collected from the experimental plot of ICAR-CICR farm. Cotton stubbles, weed roots, pebbles and trash were cleaned. Soil sample were processed using 2mm sieve and each pot filled with 10 kg soil. Compost (20 g) and vermicompost (20 g) were applied and mixed well with the soil. Sowing was done on January 28, 2018, with 5 seeds per pot. After 2 weeks of emergence thinning of cotton seedlings was done to obtain desired plant population. Fertilization was done at the rate of 60:30:30 kg ha^{-1}. Half dose of nitrogen and full dose of phosphorus and potash are given at the time of sowing and remaining dose of nitrogen are given 30 days after sowing according to this recommend suphala (15:15:15) was given at the time of sowing 5g per plant and 3g of urea applied 30 days after sowing. All other management and cultural practices such as weeding, irrigation and pesticide application (neem oil @ 30ml lit^{-1}) were implemented according to local demand in order to reduce competition for nutrient, light and water for a better crop stand. Observation on plant height, number of main stem node plant^{-1}, height to node ratio, leaf area, stem diameter recorded at 50, 80 and 110 DAS. Root length, shoot and root dry weight recorded at 120 DAS. Observation on biochemical parameters like chlorophyll and carotenoid content recorded at 7 and 15 DAT, while starch and nitrate reductase activity recorded at 60 DAS.

Results and Discussion

Growth parameters

The plant height was found significantly low in treatment T_6 (1800 mg litre^{-1}) (33.2, 36.5, 40.9 cm) compare to T_0 (control) (43, 52.2, 57.4 cm) at 50, 80 and 110 DAS respectively, (Table 1). Overall the spray of MC retarded the plant height over control. Similar results were found in different cotton variety at various locations. Higher concentration of MC and maximum temperature inhibits the cotton growth (Rosolem *et al*., 2013) [18]. It decreased the endogenous gibbrellic acid metabolism and signaling which impels to lowers plant height (Wang *et al*., 2014) [23].

The number of main stem node was found non-significantly increased with increasing level of mepiquat chloride, excepting treatment T_6 (Table 1). Highest number of nodes on main stem recorded in treatment T_1, T_2, T_3, and T_4 (9.6, 9.6, 9.6, and 9.6) than T_0 (control) (9.2) and lowest number of nodes were recorded in the treatment T_6 (1800 mg litre^{-1}) (8.9) at 50 DAS. At 80 DAS Higher number of nodes were recorded in the treatment T_1, T_3, T_5 (13.8, 13.8, 13.8 respectively) than control (13.6) and lowest number of nodes were recorded in the treatment T_6 (12.0). At 110 DAS Higher number of nodes were recorded in the treatment T_1 and T_5 (17.8 and 17.8) than control (16.0) and lowest number of nodes were recorded in the treatment T_6 (15.0). From this data, it is clear that higher concentration of MC spray at square initiation (45DAS) stage had reduced the cotton main stem node. Higher dose (2 litre ha^{-1}) of pix reduced nodes number than control (Niakan and Habibi, 2013) [14].

Height to node ratio was found significantly high in treatment T_0 (control) (4.6, 3.9, 3.6) at 50, 80, and 110 DAS respectively, and lowest height to node ratio recorded in treatment T_5 (3.6) at 50 DAS and in treatment T_6 (3.0, 2.7) at 80 and 110 DAS respectively (Table 2). This indicated that decreased height to node ratio was mainly due to reduced plant height and increased number of main stem node. The height-to-node ratio at 4 wk after phs was highest in plots receiving no mepiquat chloride (Nichols *et al*., 2003) [15].

Leaf area was found non-significantly high in treatment T_0 (control) (63.9, 71.2, 75.3 cm^2) at 50, 80, 110 DAS respectively. Similarly the lowest leaf area recorded in treatment T_6 (40.3, 44.2, 45.9 cm^2) at 50, 80, 110 DAS respectively (Table 2). Overall the spray of mepiquat chloride retarded the leaf area over control. MC application modified the canopy structure through reduction of leaf area (Gu *et al*., 2014). Nagashima *et al*., (2005, 2010) who found that MC reduced the shoot length and leaf area. The authors explained that this compound inhibits leaf expansion, consequently lending plants a more compact architecture.

Stem diameter was found non-significantly high in treatment T_0 and T_2 (2.75 and 2.75 mm) and lowest stem diameter recorded in treatment T_5 and T_6 (2.00 and 2.00 mm) at 50 DAS. Similarly at 80 DAS higher stem diameter was recorded in treatment T_2 (3.50 mm) and lowest stem diameter recorded in treatment T_5 (2.25 mm) compare to T_0 (3.0 mm). At 110 DAS higher stem diameter was recorded in treatment T_2, T_3 and T_4 (3.75 mm) and lowest stem diameter recorded in treatment T_5 and T_6 (3.00 and 3.00 mm) compare to T_0 (3.50 mm) (Table 3). From this data, it is clear that higher concentration of MC spray at square initiation (45DAS) stage had reduced the stem diameter. Similar results were reduced the petiole and internode diameter (Gu *et al*., 2014) [6]. Conversely, seed inoculation reduced the stem diameter (mm) than foliar application (Ferrari *et al*., 2015) [4].

Root length was found non-significantly high in treatment T_6 (40.8 cm) compare to T_0 (control) (28.6 cm) (table 3). Overall the spray of mepiquat chloride increased root length over control. Present findings were in close agreement with the Iqbal *et al*., (2005) [9] who observed that root length increased with increasing doses of MC. Taiz and Zeiger (2009) [21], gibberellins as well as auxins and cytokinins are important for root growth. Though MC inhibits gibberellin synthesis, in the present experiment, the hormonal imbalance did not significantly influence this variable.

Dry matter accumulation:

Shoot dry weight was found non-significantly low in treatment T_6 (9.7 gm) compare to T_0 (14.7 gm). Overall the spray of mepiquat chloride decreased shoot dry weight over control (table 3). Similarly, Desouza and Rosolem (2007) [3] reported that MC reduced overall dry matter when applied to seeds. This reduction in dry matter accumulation could be due to disturbance in source-sink ratio under MC application (Rosolem *et al*., 2013). While Higher root dry weight was recorded in the treatment T_6 (2.5 gm) compare to T_0 (1.3 gm) (table 3). This could be due to maximum root length and more number of lateral roots. Present findings were in close agreement with the Iqbal *et al*. (2005) [9] who reported that maximum dry weight were recorded in high dose treatment of mepiquat chloride.

Biochemical parameters

Chlorophyll ‘a’ content was found high in treatment T_6 (29.6 mg g^{-1}fw) and (29.9 mg g^{-1}fw) compare to T_0 (control) (25.9 mg g^{-1}fw) and (19.8 mg g^{-1}fw) at 7 and 15 DAT respectively. Similarly, chlorophyll ‘b’ content was found high in treatment T_5 (12.4 mg g^{-1}fw) compare to T_0 (9.1 mg g^{-1}fw) at 7 DAT and at 15 DAT significantly higher chlorophyll ‘b’ content was recorded in treatment T_6 (11.2 mg g^{-1}fw) compare to T_0 (control) (7.6 mg g^{-1}fw). Similarly, total chlorophyll content was found high in treatment T_5 (44.2 mg g^{-1}fw) compare to T_0 (control) (36.7 mg g^{-1}fw) at 7 DAT and at 15 DAT significantly higher total chlorophyll content was recorded in treatment T_6 (43.4 mg g^{-1}fw) compare to T_0 (29.9 mg g^{-1}fw) (table 4). Chl a, the reaction center pigment, is able to convert light energy into electrical energy, and Chl b plays a vital role in absorbing blue violet light, which is important to improve the plant’s light-trapping ability (Wang *et al*., 2011) [22]. MC application has a significant impact on chlorophyll contents in cotton leaves. Our data are in agreement with Reddy *et al*., (1996) [16] who observed that MC-treated plants increased the chlorophyll contents, which resulted in dark green leaves. Similarly, increased chlorophyll contents were also reported by Xu and Taylor (1992) [24], Zhao and Oosterhuis (2000) in MC-treated plants; these authors suggested that this increment might be associated with higher specific leaf weight due to the fact that MC application up-regulated the chlorophyll contents.

Carotenoid content was found non-significantly high in treatment T_6 (7.8 mg g^{-1}fw), (11.0 mg g^{-1}fw) compare to T_0 (6.0 mg g^{-1}fw), (7.7 mg g^{-1}fw) at 7 and 15 DAT respectively (table 5). Similar traint was observed by Gabiery and Ata Allah, (2017) [5] who reported that foliar application of mepiquat chloride at 3cm^3/L increased carotenoid content in cotton.

Starch content was found significantly high in treatment T_4 (375.84 mg g^{-1}fw) compare to T_0 (176.40 mg g^{-1}fw) (table 5). Under MC application, reduced photosynthesis resulted in limited production of photoassimilates. In the current study, starch were more accumulated in leaves, thereby creating an imbalance between photoassimilate accumulation and utilization. This imbalance further reduced the photoassimilate synthesis and translocation toward sink tissues. Similar findings were reported by Hummel *et al*. (2010) [8], who suggested that increased carbohydrate contents in leaves created an imbalance between source and sink tissues. Higher leaf starch concentrations for both PGR (mepiquat chloride and Pix) treatments were associated with a higher leaf CO_2 exchange rate because starch accumulation in chloroplasts was primarily a mechanism for storing carbon when the rate of photosynthesis exceeded the capacity of the leaf to export saccharides (Stitt 1984) [20].

Nitrate reductase activity was found significantly high in treatment T_4 (739.77 μ mol NO_2 $g^{-1}h^{-1}$fw) compare to T_0 (127.27 μ mol NO_2 $g^{-1}h^{-1}$fw) (table 5). Nitrate reductase, a key enzyme in control of nitrogen assimilation is target of several regulatory process. Present findings were in close agreement with the Kiran kumar *et al.,* (2005) [11] who observed that application of MC (50 ppm) sprayed at 90 DAS resulted in higher nitrate reductase activity (85.52 µg NO_2/g fresh wt.) over control.

Table 1: Effect of mepiquat chloride on plant height (cm) and number of main stem node of cotton var Suraj

Treatments	Plant height (cm)			Number of main stem nodes plant^{-1}		
	50 DAS	80 DAS	110 DAS	50 DAS	80 DAS	110 DAS
T0 – Control	43.07 ± 0.41	52.27 ± 0.88	57.40 ± 0.72	9.25 ± 0.25	13.50 ± 0.50	16.00 ± 0.70
T1 – 300 mg litre^{-1}	36.25 ± 1.23	43.40 ± 1.49	50.80 ± 2.02	9.50 ± 0.28	13.75 ± 0.25	17.75 ± 0.75
T2 – 600 mg litre^{-1}	39.40 ± 2.25	45.92 ± 1.00	51.92 ± 0.76	9.50 ± 0.50	13.50 ± 0.28	16.75 ± 0.75
T3 – 900 mg litre^{-1}	37.92 ± 1.21	43.30 ± 1.54	49.60 ± 1.63	9.50 ± 0.28	13.75 ± 0.85	17.25 ± 0.75
T4– 1200 mg litre^{-1}	36.40 ± 0.81	40.95 ± 0.76	47.75 ± 1.05	9.50 ± 0.50	13.25 ± 0.94	17.50 ± 1.04
T5– 1500 mg litre^{-1}	33.55 ± 2.13	41.97 ± 1.88	49.30 ± 2.93	9.25 ± 0.47	13.75 ± 0.47	17.75 ± 0.85
T6 – 1800 mg litre^{-1}	33.17 ± 1.23	36.52 ± 1.56	40.87 ± 1.99	8.75 ± 0.25	12.00 ± 0.57	15.00 ± 0.40
C.D.	S	S	S	NS	NS	NS
SE(m)	1.465	1.364	1.756	0.382	0.607	0.772
SE(d)	2.071	1.929	2.484	0.540	0.859	1.091
C.V.	7.894	6.274	7.073	8.194	9.096	9.154

Table 2: Effect of mepiquat chloride on height to node ratio per plant and leaf area (cm^2) of cotton var Suraj

Treatments	Height to node ratio plant^{-1}			Leaf area (cm^2)		
	50 DAS	80 DAS	110 DAS	50 DAS	80 DAS	110 DAS
T0 – Control	4.67 ± 0.13	3.90 ± 0.17	3.60 ± 0.17	63.97 ± 8.89	71.23 ± 10.32	75.30 ± 10.48
T1 – 300 mg litre^{-1}	3.85 ± 0.15	3.17 ± 0.07	2.87 ± 0.14	62.58 ± 6.73	66.68 ± 6.42	69.90 ± 7.93
T2 – 600 mg litre^{-1}	4.20± 0.21	3.45 ± 0.13	3.10 ± 0.12	58.58 ± 7.13	63.14 ± 8.38	64.58 ± 8.33
T3 – 900 mg litre^{-1}	4.00 ± 0.17	3.17 ± 0.14	2.87 ± 0.07	52.99 ± 3.33	56.90 ± 3.60	59.81 ± 3.33
T4– 1200 mg litre^{-1}	3.85 ± 0.17	3.12 ± 0.18	2.75 ± 0.15	51.16 ± 3.10	55.93 ± 2.65	57.77 ± 2.65
T5– 1500 mg litre^{-1}	3.62 ± 0.13	3.07 ± 0.06	2.77 ± 0.04	47.99 ± 8.01	52.21 ± 9.39	53.15 ± 9.43
T6 – 1800 mg litre^{-1}	3.80 ± 0.20	3.05± 0.16	2.72 ± 0.18	40.36 ± 1.19	44.28 ± 2.29	45.95 ± 2.29
C.D.	S	S	S	NS	NS	NS
SE(m)	0.171	0.143	0.141	6.116	6.882	7.118
SE(d)	0.242	0.202	0.199	8.650	9.733	10.067
C.V.	8.548	8.704	9.508	22.673	23.477	23.366

Table 3: Effect of mepiquat chloride on stem diameter, root length, shoot and root dry weight of cotton var Suraj

Treatments	Stem diameter (mm)			Root length (cm)	Shoot dry weight (gm)	Root dry weight (gm)
	50 DAS	80 DAS	110 DAS			
T0 – Control	2.75 ± 0.25	3.00 ± 0.00	3.50 ± 0.28	28.52 ± 2.95	14.67 ± 0.54	1.34 ± 0.14
T1 – 300 mg litre^{-1}	2.25 ± 0.25	3.25 ± 0.47	3.50 ± 0.28	34.17 ± 6.10	10.55 ± 0.18	1.42 ± 0.14
T2 – 600 mg litre^{-1}	2.75 ± 0.25	3.50 ± 0.28	3.75 ± 0.25	36.32 ± 5.33	13.82 ± 3.01	1.56 ± 0.15
T3 – 900 mg litre^{-1}	2.25 ± 0.25	3.25 ± 0.25	3.75 ± 0.25	33.42 ± 2.60	12.52 ± 1.45	1.60 ± 0.27
T4– 1200 mg litre^{-1}	2.50 ± 0.50	2.75 ± 0.47	3.75 ± 0.25	38.55 ± 2.66	10.52 ± 0.98	1.78 ± 0.40
T5– 1500 mg litre^{-1}	2.00 ± 0.00	2.25 ± 0.25	3.00 ± 0.40	35.42 ± 4.01	10.80 ± 1.82	1.80 ± 0.30
T6 – 1800 mg litre^{-1}	2.00 ± 0.00	2.50 ± 0.28	3.00 ± 0.00	40.72 ± 5.28	9.72 ± 1.64	2.55 ± 0.32
C.D.	NS	NS	NS	NS	NS	NS
SE(m)	0.267	0.327	0.273	4.349	1.627	0.268
SE(d)	0.378	0.463	0.386	6.151	2.301	0.380
C.V.	22.677	22.354	15.748	24.637	27.572	31.099

Table 4: Effect of mepiquat chloride on chlorophyll a, chlorophyll b and total chlorophyll content of cotton var Suraj

Treatments	Chlorophyll a (mg g^{-1}fw)		Chlorophyll b (mg g^{-1}fw)		Total chlorophyll (mg g^{-1}fw)	
	7 DAT	15 DAT	7 DAT	15 DAT	7 DAT	15 DAT
T0 – Control	25.92 ± 0.56	19.72 ± 2.26	9.15 ± 0.44	7.57 ± 0.54	36.65 ± 1.12	29.92 ± 3.27
T1 – 300 mg litre^{-1}	26.65 ± 1.72	22.27 ± 1.32	10.62 ± 0.66	8.35 ± 0.44	39.05 ± 2.67	34.27 ± 1.48
T2 – 600 mg litre^{-1}	26.70 ± 1.10	26.27 ± 1.27	10.42 ± 0.33	8.30 ± 0.70	38.87 ± 1.35	34.12 ± 3.05
T3 – 900 mg litre^{-1}	27.67 ± 0.59	26.02 ± 2.32	9.97 ± 0.32	8.02 ± 0.66	39.37 ± 0.89	31.57 ± 1.90
T4– 1200 mg litre^{-1}	26.65 ± 1.55	24.47 ± 1.38	10.12 ± 0.86	9.02 ± 0.53	38.40 ± 2.55	30.12 ± 2.04
T5– 1500 mg litre^{-1}	27.57 ± 1.96	26.70 ± 3.47	12.42 ± 1.57	10.87 ± 1.15	44.20 ± 1.24	39.47 ± 5.02
T6 – 1800 mg litre^{-1}	29.52 ± 1.10	29.87 ± 0.54	10.07 ± 0.83	11.20 ± 0.33	39.65 ± 3.18	43.45 ± 0.93
C.D.	NS	NS	NS	S	NS	S
SE(m)	1.331	2.068	0.828	0.673	2.044	2.833
SE(d)	1.882	2.925	1.171	0.952	2.890	4.006
C.V.	9.771	16.514	15.921	14.880	10.358	16.324

Table 5: Effect of mepiquat chloride on carotenoid, starch and nitrate reductase activity of cotton var Suraj

Treatments	Carotenoid content (mg g^{-1}fw)		Starch content (mg g^{-1}fw)	Nitrate reductase activity (μ mol NO_2 g^{-1} fw h^{-1})
	7 DAT	15 DAT		
T0 – Control	6.07 ± 0.41	7.60 ± 0.30	176.40 ± 26.70	127.27 ± 59.86
T1 – 300 mg litre^{-1}	6.22 ± 0.49	7.85 ± 0.61	224.64 ± 26.81	245.47 ± 71.65
T2 – 600 mg litre^{-1}	6.15 ± 0.41	8.40 ± 0.38	234.54 ± 12.08	420.47 ± 126.88
T3 – 900 mg litre^{-1}	7.27 ± 0.73	9.70 ± 1.20	348.12 ± 16.09	608.52 ± 142.14
T4– 1200 mg litre^{-1}	6.32 ± 0.38	9.50 ± 0.84	375.84 ± 12.06	739.77 ± 216.11
T5– 1500 mg litre^{-1}	6.75 ± 0.70	9.90 ± 1.29	309.42 ± 12.53	709.62 ± 103.21
T6 – 1800 mg litre^{-1}	7.77 ± 1.34	11.00 ± 0.24	280.26 ± 17.08	540.35 ± 55.55
C.D.	NS	NS	S	S
SE(m)	0.715	0.804	18.639	122.748
SE(d)	1.011	1.138	26.360	173.591
C.V.	21.496	17.610	13.387	50.670

Conclusion

From the present investigation it was concluded that foliar application of mepiquat chloride at squaring stage (45 DAS) on cotton var Suraj, manipulate cotton plant architecture. Among the treatments, T_6 (1800 mg litre^{-1}) was found better to reduced plant height, height to node ratio, number of main stem nodes, leaf area, stem diameter and increased in root length whereas biochemical parameters such as chlorophyll, carotenoid, starch content and nitrate reductase activity was increased in same concentration of mepiquat chloride compare to T_0 (control).

Acknowledgement

The author is greatly thankful to the advisor Dr. Eugenia P. Lal (Associate Professor, Dept. of Biological Sciences, SHUATS Allahabad) to give this opportunity to do this research work and also thankful to co-advisor Dr. J. H. Meshram (Sr. Scientist Plant Physiology, ICAR-CICR Nagpur) to give full of knowledge related to this research work.

References

1. Anonymous. Annual progress report of cotton. 2017, www.cab.com.
2. Bogiani JC, Rosolem CA. Sensibility of cotton cultivars to mepiquat chloride. Pesquisa Agropecuaria Brasileira. 2009; 44:1246-1253.
3. Desouza FS, Rosolem CA. Rainfall intensity and mepiquat chloride persistence in cotton. Scientia Agricola. 2007; 64:125-130.
4. Ferrari JV, Furlani JE, Ferrari S, APPG Luques. Vegetative growth response of cotton plants due to growth regulator supply via seeds. Acta Scientiarum. Agronomy. 2015; 37:361-366.
5. Gabiery AE, Ata Allah YFA. Response of Cotton Plant to Foliar Application with Mepiquat Chloride (Pix) and Kaolin. Journal Plant Production. 2017; 8:1037-1043.
6. Gu S, Evers JB, Zhang L, Mao L, Zhang S, Zhao X, Li Z. Modelling the structural response of cotton plants to mepiquat chloride and population density. Annals of Botany. 2014; 114:877-887.

7. Gwathmey CO, Clement JD. Alteration of cotton source-sink relations with plant population density and mepiquat chloride. Field Crops Research. 2010; 116:101-107.
8. Hummel I, Pantin F, Sulpice R, Piques M, Rolland G, Dauzat M *et al*. Arabidopsis plants acclimate to water deficit at low cost through changes of carbon usage: an integrated perspective using growth, metabolite, enzyme, and gene expression analysis. Plant Physiology. 2010; 154:357-372.
9. Iqbal M, Nisar N, Khan RSA, Hayat K. Contribution of mepiquat chloride in drought tolerance in cotton seedlings. Asian Journal of Plant Sciences. 2005; 4:530-532.
10. Kerby TA. Cotton response to mepiquat chloride. Agronomy journal. 1985; 77:515-518.
11. Kiran Kumar KA, Patil BC, Chetti MB. Effect of plant growth regulators on physiological components of yield in hybrid cotton. Indian Journal of Plant Physiology. 2005; 10:187-190.
12. Nagashima GT, Maurur CJ, Yamaoka RS, Miglioranza E. Development of cotton plant from seeds soaked with mepiquat chloride. Pesquisa Agropecuária Brasileira. 2005; 40:943-946.
13. Nagashima GT, Migloranza E, Maurur CJ, Yamaoka S, Silva JGR. Development of cotton in response to mode of application and doses of mepiquat chloride in seeds. Ciência Rural. 2010; 40:7-11.
14. Niakan M, Habibi A. Effect of pix regulator on vegetative growth of cotton plant. Annals of Biological Research. 2013; 4:53-58.
15. Nichols SP, Snipes CE, Jones MA. Evaluation of row spacing and mepiquat chloride in cotton. Journal of cotton science. 2003; 7:148-155.
16. Reddy AR, Reddy KR, Hodges HF. Mepiquat chloride (Pix)-induced changes in photosynthesis and growth of cotton. Plant Growth Regulation. 1996; 20:179-183.
17. Reddy VR, Baker DN, Hodges HF. Temperature and mepiquat chloride on cotton canopy architecture. Agronomy Journal. 1990; 82:190-195.
18. Rosolem CA, Oosterhuis DM, Desouza FS. Cotton response to mepiquat chloride and temperature. Scientia Agricola. 2013; 70:82-87.
19. Srivastava LM. Plant growth and development. Academic Press, New York, NY, USA, 2002, 172-181.
20. Stitt M. Degradation of starch in chloroplast: a buffer to sucrose metabolism. In: Lewis DH, editor. Storage carbohydrates in vascular plants. Cambridge: Cambridge University Press, 1984, 205-229.
21. Taiz L, Zeiger E. Plant physiology. Porto Alegre, Artmed, 2009, 719p
22. Wang J, Ren S, Shi B, Liu B, Zhou Y. Effects of shades on the photosynthetic characteristics and chlorophyll fluorescence parameters of Forsythia suspensa. Acta Ecol. Sin. 2011; 31:1811-1817.
23. Wang L, Mu C, Du M, Chen Y, Tian X, Zhang M et al. The effect of mepiquat chloride on elongation of cotton (*Gossypium hirsutum* L.) internode is associated with low concentration of gibberellic acid. Plant Science. 2014; 225:15-23.
24. Xu X, Taylor HM. Increase in drought resistance of cotton seedlings treated with mepiquat chloride. Agronomy Journal. 1992; 84:569-574.
25. Zhao D, Oosterhuis DM. Pix plus and mepiquat chloride effects on physiology, growth, and yield of field-grown cotton. Journal of Plant Growth Regulation. 2017; 19:415-422.