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Development of optimized source-sink relationship, favourable morpho-physiological behaviour and profitability of soybean through detopping and mepiquat chloride application

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ABSTRACT

The influence of detopping and mepiquat chloride on the morpho-physiological and yield attributes of soybean was studied during kharif 2014 and 2015. The investigation was conducted at Punjab Agricultural University, Ludhiana which was laid out in RCBD design with eight treatments viz. control, detopping (50-55 DAS), MC @ 200 ppm (50-55 DAS), MC @ 200 ppm (50-55 + 65-70 DAS), MC 250 ppm (50-55 DAS), MC @ 250 ppm (50-55 + 65-70 DAS), MC @ 300 ppm (50-55 DAS) and MC @ 300 ppm (50-55 + 65-70 DAS) with four replications. Detopping significantly decreased plant height, increased total dry matter accumulation plant^{-1}, flowers and pods plant^{-1}, pod setting percentage and seed yield over control. Mepiquat chloride significantly decreased LAI, abscission of reproductive parts, increased total dry matter accumulation plant^{-1}, pods plant^{-1}, 100-seed weight and seed yield over control. At harvest, an optimum source-sink relationship was developed in detopping and two foliar applications of mepiquat chloride @ 250 ppm by causing partitioning of total dry matter among stem, foliage and pods by 21.6, 17.4, 61.0 and 20.1, 9.2, 70.8 per cent, respectively, which led to increased yield levels (17.90 and 18.05 q ha^{-1}) . Detopping and foliar applications of mepiquat chloride resulted in significant enhancement in the growth indices like CGR, RGR and NAR.

Keywords: Detopping, dry matter partitioning, growth indices, mepiquat chloride, soybean

Soybean [*Glycine max* (L.) Merrill] belonging to family *fabaceae*, has been globally recognized as potential supplementary source of protein, edible oil and functional food (Kaur *et al.*, 2006). In 1925, Japanese-American journalist Kinnosuké Adachi extolled the virtues of soybean by describing it as 'Miracle Bean' (Prodöhl 2010). Soybean seed contains 40 per cent good quality protein and 20 per cent oil comprising of 85 per cent unsaturated fatty acids and is free from cholesterol along with ample mineral elements and thus, highly desirable for human diet. It is an evident that in soybean there is remarkable loss of developing reproductive parts *i.e*., flower and pod abscission ranging from 40-80 per cent. Soybean has immense potential for expressing higher yields if morpho-physiological constraints like excessive vegetative growth, insufficient partitioning of photosynthates towards sink, flower and fruit drop are favourably regulated. Exogenous application of plant growth regulators has been exploited to cause favourable shifts in endogenous hormonal levels by enhancing the flower retention, fruit set, 100-seed weight and yield (Arora *et al.*, 2005). To manage various physiological flaws like excessive vegetative growth in irrigated conditions and flower and pod abscission, application of plant growth regulators can prove propitious.In the physiological studies, PGRs have emerged as magic chemicals that could increase agricultural production and help in removing and circumventing many of the barriers imposed by genetics and environment (Kumar *et al.*, 2005). Improvement in the physiological efficiency of plants in terms of photosynthetic ability of plants and a significant role in realizing higher crop yields under the influence of plant growth regulators have very well known. Sandhu *et al.* (2015) also reported significant effect of mepiquat chloride on dry matter plant^{-1}, pod dry weight, number of pods plant^{-1} and seed yield of summer mungbean. The purpose of detopping is to get good plant architecture so that crop can get required sunlight with reduction of mutual shading and thus the picking efficiency can be increased with the advancement of crop maturity. Singh and Devi (2006) concluded that nipping of *Pisum sativum* at 30 DAS significantly increased number of branches plant^{-1}, number of pods plant^{-1}, seed yield and B:C. In the view of aforementioned, present investigation was undertaken to evaluate the effect of detopping and mepiquat chloride on growth and yield of soybean.

MATERIAL AND METHODS

The investigation was carried out at Punjab Agricultural University, Ludhiana, during *kharif* season of 2014 and 2015. Ludhiana is located in Trans-Gangatic agro-climatic zone and represents the Indo-Gangatic alluvial plains. It is located in 30°56' N latitude and 75°52' E longitude at an altitude of 247 m above the mean sea level. Ludhiana is characterized by sub-tropical semi-arid type of climate with hot summer and cold winters. The experiment was laid-out in randomized

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complete block design (RCBD) having eight treatments *viz.* control, detopping (removal of 4-5 cm apical portion of main stem) at 50-55 DAS, MC @ 200 ppm (50-55 DAS), MC @ 200 ppm (50-55 + 65-70 DAS), MC @ 250 ppm (50-55 DAS), MC @ 250 ppm (50-55 + 65-70 DAS), MC @ 300 ppm (50-55 DAS) and MC @ 300 ppm (50-55 + 65-70 DAS) with four replications. Sowing of soybean (SL 744) was done on 13-06-2014 and on 08-06-2015 through *pora* method using seed rate of 75 Kg ha^{-1} keeping spacing of 45 x 5cm. The fertilizers were applied at the time of sowing @ 32 kg N ha^{-1} and 80 Kg P_2O_5 ha^{-1} through urea and SSP, respectively.

Growth and yield parameters

The periodic plant height was measured from the base of main stem to the base of top most fully opened leaf and was expressed in cm. The periodic leaf area index (LAI) of plants was recorded with the sun scan canopy analyzer. Specific leaf weight was determined as follow:

$$\mathrm{SLW} = \frac{\mathrm{LW}}{\mathrm{LA}}$$

Where,

LW – Leaf Weight (g)

LA – Leaf area (cm^2)

SPAD value was estimated by using hand held Minolta SPAD-502 chlorophyll meter. The photosynthetically active radiation interception (PARI) was calculated by using line quantum sensor as per the following formula:

$$\mathrm{PARI} = \frac{\text{PAR above crop canopy} - \text{PAR at soil surface}}{\text{PAR above the crop canopy}} \times 100$$

For dry matter accumulation, weight of oven dried plant parts was expressed as dry matter accumulation (g plant^{-1}) as well as dry matter partitioning (g). Data on the crop phenology was recorded on the basis of methodology described by Fischer and Fanta (2010).

CGR was calculated by using the formula as follows:

$$\text{Crop growth rate } (\mathrm{CGR}) = \frac{(W_2 - W_1)}{(T_2 - T_1)\,P}$$

Where,

W_1 – Dry matter (g) at time T_1 (days)

W_2 – Dry matter (g) at time T_2 (days)

P – Ground area (m^2)

Relative growth rate it was calculated as follows:

$$\text{Relative growth rate } (\mathrm{RGR}) = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

Where,

W_1 - Dry matter (g) at time T_1 (days)

W_2 – Dry matter (g) at time T_2 (days)

Net assimilation rate was calculated according to following formula:

$$\text{Net assimilation rate } (\mathrm{NAR}) = \frac{(W_2 - W_1)\,(\log_e L_2 - \log_e L_1)}{(T_2 - T_1)\,(L_2 - L_1)}$$

Where,

W_1 - Dry matter (g) at time T_1 (days)

W_2 – Dry matter (g) at time T_2 (days)

L_1 – Leaf area (cm^2) at time T_1 (days)

L_2 – Leaf area (cm^2) at time T_2 (days)

Pod setting percentage was calculated by using the formula as follows:

$$\text{Setting percentage} = \frac{\text{Total no of pods plant}^{-1}}{\text{Total no of flowers plant}^{-1}} \mathrm{x}100$$

The data on the seed yield was recorded by weighing the produce from individual plots and was expressed as q ha^{-1}. From the data of economic and biological yield, harvest index was computed as follows:

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \mathrm{x}\ 100$$

Statistical analysis: The various data were subjected to pooled statistical analysis by general linear model (GLM) procedure (SAS Software 9.2, SAS Institute Ltd., U.S.A.).

RESULTS AND DISCUSSION

Growth Parameters

Detopping led to a significant reduction in plant height (Table 1) while a non-significant effect of mepiquat chloride applications. At 110 DAS, detopping resulted in 15per cent reduction in plant height but MC applications could not bring significant difference over control. Decrease in plant height with detopping may be due to removal of stem apex which acts as a potential source of auxins. The results regarding decrease in plant height owing to detopping are in line with Sharma *et al* (2003). Detopping of soybean had non-significant effect on LAI at all the growth stages. On the contrary, foliar applications of MC resulted in significant decrease in LAI relative to contrast, especially at 80 and 110 DAS except at harvest where LAI of all the treatments was statistically at par. Decrease in LAI by MC application may be due to its anti-gibberellin action. It prevents the conversion of trans-geranyl geranyl diphosphate to ent-copalyl diphosphate, which is the first step in the synthesis of gibberellins in the plants. This decrease in

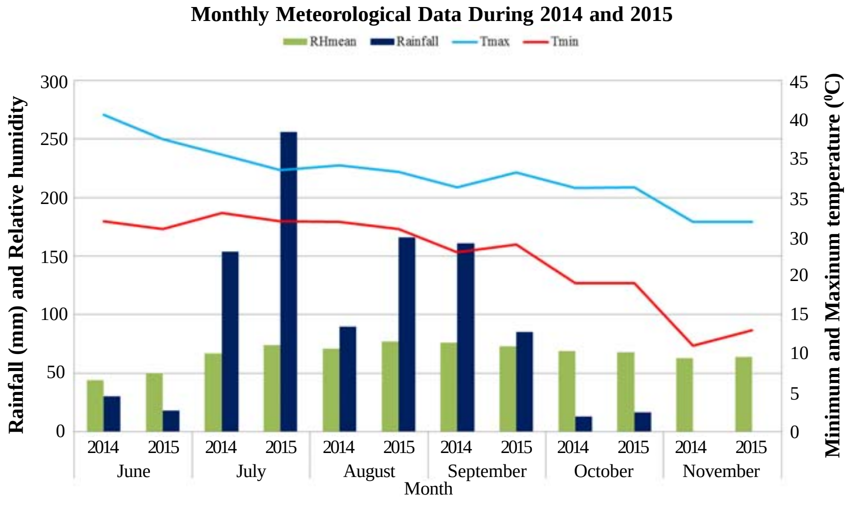

Fig. 1: Monthly meteorological data during 2014 and 2015

the gibberellin level consequently causes drop in leaf cell expansion and finally decrease in LAI. Results on decrease in LAI by MC application are in consonance with Gwathmey and Clement (2010). Detopping and MC applications resulted in significant increase in SLW at all the growth stages. At 80 DAS, two foliar applications of MC @ 200 as well as 250 ppm resulted in 80.5 and 85.7per cent higher SLW than control (7.7 mg cm^{-2}), respectively. Detopping also resulted in significant increase (54.5 %) in SLW in comparison with control which may be due to maintenance of more foliage dry weight [Table 2, 3 and 4]. Cessation of apical dominance leads to promotion of axillary bud growth, more number of leaves leading to enhanced foliage weight. Foliar application of MC increases the chlorophyll content, RuBP activity and decreased cell elongation. Decrease in cell expansion and increase in SPAD (Table 1) resulted in more leaf thickness. This increase in leaf thickness is directly related to the SLW of plant. Results of MC applications are in conformity with Pettigrew and Johnson (2005). Detopping had a non-significant effect on SPAD value at all the growth stages but foliar application of MC significantly enhanced the SPAD value over control at 80 and 110 DAS. At 110 DAS, two foliar applications of MC @ 250 ppm resulted in a significantly higher (40.5%) SPAD value. Outcomes of MC application are in close conformity with Azab *et al.* (1993). A non-significant effect of detopping and MC application on PAR interception by soybean at 80 and 110 DAS was reported. Decrease in PAR interception due to MC may be attributed to decreased LAI, but it was statistically at par with control. Application of MC caused increase in SPAD value, leaf thickness and SLW. These changes resulted in decreased diffusion of incident radiation through crop canopy and decreased amount of radiation reaching at ground level. This efficient utilization of incident radiation through high SLW led to a non-significant variation from control even with low LAI.

Dry matter accumulation and partitioning

At 80 DAS (Table 2), control treatment had lowest dry matter accumulation (12.7 g $plant^{-1}$) while highest dry matter accumulation was recorded in detopping treatment, which was significantly greater (35.9 %) than control. Dry matter accumulation in two foliar applications of MC @ 200 and 250 ppm was 21.4 and 28.3 per cent higher than control, respectively.

Stem dry weight in all the treatments was found statistically at par with each other. Detopping and foliar applications of MC @ 250 ppm at two growth stages resulted in a significantly higher foliage dry weight relative to control. Application of MC as well as detopping resulted in greater percentage of dry matter partitioning to foliage as compared to control. For instance, in control, distribution of total dry matter among stem and foliage was found to be 43.3 and 56.7per cent, respectively whereas in detopping and two foliar applications of MC @ 250 ppm, partitioning of total dry matter to stem and foliage occurred by 33.4 & 66.6 and 33.5 & 63.5 per cent, respectively. At 110 DAS (Table 3), detopping resulted in the highest dry matter accumulation $plant^{-1}$ with 52.4per cent increase as compared to control (23.7 g $plant^{-1}$). Likewise, two foliar applications of MC @ 200 and 250 ppm resulted in a significantly higher (30.8 and 35.1%, respectively) dry matter accumulation per plant as compared to control. MC applications had a non-significant effect on stem dry weight but detopping led to a significant increase in it relative to control. Control had a significantly lower foliage dry weight than rest of the treatments. Highest foliage dry weight was resulted by detopping with 47.2

per cent increase as compared to control (8.9 g plant^{-1}). Two foliar applications of MC @ 250 ppm resulted in 36.0per cent higher foliage dry weight than control. Furthermore, control treatment also had a significantly lower pod dry weight than rest of the treatments. Two foliar applications of MC @ 250 ppm resulted in the highest pod dry weight, although it was statistically at par with detopping. Increase in pod dry weight due to two foliar applications of MC @ 250 ppm was 7.3per cent as compared to control (5.1 g plant^{-1}). Detopping as well as MC application resulted in better partitioning of dry matter towards reproductive parts as compared to control. Likewise in control treatment, allocation of dry matter to pods occurred by 21.6 per cent but on the contrary, detopping and foliar application of MC @ 250 ppm at two growth stages, resulted in partitioning of total dry matter to pods by 24.1 and 27.7per cent, respectively. At harvest, detopping (Table 4) resulted in the highest dry matter accumulation which was 44.0 per cent higher than control (41.4 g plant^{-1}). Increase in dry matter accumulation by two foliar applications of MC @ 250 ppm was 23.9 per cent over control, respectively. Results regarding stem dry weight showed a non-significant effect of MC application as compared to control. However, detopping resulted in a significantly higher (19.4 %) stem dry weight in comparison with control (10.8 g plant^{-1}). Highest foliage dry weight was resulted by detopping with significant increase (90.9 %) as compared to control (5.5 g plant^{-1}). Among all the treatments, highest pod dry weight was recorded in two foliar applications of MC @ 250 ppm which was significantly greater than control but statistically at par with detopping. Detopping and MC application led to optimized source sink relationship though better allocation of photosynthates and dry matter towards reproductive parts *i.e*., pods. For instance, in control treatment, per cent allocation of total dry matter to pods was 60.6 per cent while in detopping and application of mepiquat chloride @ 250 ppm at two growth stages, partitioning to pods occurred by 61.0 and 70.8 per cent, respectively. All mepiquat chloride treatments improved translocation of assimilates to reproductive organs and resulted in higher pod dry weight at 110 DAS and at crop harvest than untreated control. Enhancement of stem, foliage and pod weight in detopping may be the result of abatement in apical dominance, LAI and SLW, causing accumulation of assimilates in stem and foliage. Increase in pod weight with MC may be due to increase in canopy photosynthesis by modifying the growth behavior of crop. Enhanced availability of photosynthates resulted in more flower and pod retention, more setting percentage and higher pod dry weight. The results are also in conformity with the results of Chetti (1991).

Crop phenology

Detopping and foliar application of MC (Table 5) had a non-significant effect on crop phenology. The results on effect of detopping and mepiquat chloride on phenological stages are in consonance with Sandhu *et al.* (2015.

Growth indices

At all growth stages showed a significant increase in crop growth rate (Table 6) by detopping and MC application relative to contrast. During the growth interval between 50-80 DAS, detopping resulted in the highest CGR, which was significantly higher (15.8 %) than control (14.8 g m^{-2} day^{-1}). Similarly, two foliar applications of mepiquat chloride @ 250 ppm resulted in a significantly higher CGR than control (14.8 g m^{-2} day^{-1}). Scrutiny of data on RGR depicted a significant effect of detopping and mepiquat chloride application as compared to control at all the growth stages. Between 80-110 DAS, single foliar application of mepiquat chloride @ 300 ppm resulted in the highest RGR over the years, which was significantly greater (18.5 %) than control (2.92 g g^{-1} day^{-1}) but statistically at par with rest of the treatments.

Increase in RGR due to detopping was 12.4per cent than control. Detopping and foliar application of MC significantly increased NAR of crop as compared to control during all growth intervals. For example, during the growth interval of 110 DAS-harvest, combined analysis showed that two foliar applications of mepiquat chloride @ 250 ppm resulted in the highest NAR , which was 40.0 and 22.8 per cent greater than control (0.50 mg cm^{-2} day^{-1}). Increase in NAR by detopping was reported to be 36.0 per cent as compared to control. Better growth rate due to detopping can be attributed to activation of lateral dormant buds by cessation of apical dominance thereby arresting the terminal growth which resulted in increased number of primary branches and leaves, which further resulted in increased photosynthesis. In case of MC, foliar application resulted in increased SPAD value, specific leaf weight and decreased vegetative growth and mutual leaf shading. Mepiquat chloride enhances activity of RuBP carboxylase so rate of photorespiration in plant can fall from normal and availability of photosynthates increases for storage in reproductive parts without much loss. These manipulations in the physiology and morphology of plant led to more canopy photosynthesis, lesser parasitism, less usage of photosynthates in vegetative development, more availability of assimilates for growth

Table 1: Growth parameters of soybean as influenced by detopping and mepiquat chloride application (Pooled data)

Treatment	Plant height (cm)		Leaf area index			Specific leaf weight (mg cm^{-2})			SPAD value		PAR interception (%)	
	80 DAS	110 DAS	80 DAS	110 DAS	At harvest	80 DAS	110 DAS	Harvest	80 DAS	110 DAS	80 DAS	110 DAS
Control	62.9 a	73.9 a	4.16 a	3.25 a	1.46^{ns}	7.7 c	12.1 f	16.9 b	29.6 d	26.2 d	85.4^{ns}	72.2^{ns}
Detopping	55.8 b	62.8 b	4.26 a	3.30 a	1.45	11.9 b	17.6 e	32.3 a	29.6 d	27.6 d	86.3	72.5
MC @ 200 ppm at 50-55 DAS	61.1 a	73.6 a	3.26 b	2.47 b	1.45	11.1 b	18.5 de	15.2 bc	33.3 c	31.9 c	85.2	72.2
MC @ 200 ppm at 50-55+65-70 DAS	61.9 a	73.6 a	3.14 bc	2.34 c	1.43	13.9 a	22.4 b	15.3 bc	36.4 b	35.0 ab	84.9	70.8
MC @ 250 ppm at 50-55 DAS	62.1 a	73.7 a	3.20 bc	2.38 bc	1.45	11.9 b	19.7 cd	12.8 c	35.1 bc	33.9 bc	85.1	71.7
MC @ 250 ppm at 50-55+65-70 DAS	61.9 a	73.0 a	3.22 bc	2.28 cd	1.40	14.3 a	24.4 a	15.1 bc	38.6 a	36.9 a	84.6	71.1
MC @ 300 ppm at 50-55 DAS	61.7 a	73.4 a	3.15 bc	2.32 c	1.43	11.1 b	19.5 cd	14.4 c	34.8 bc	33.9 bc	85.1	71.7
MC @ 300 ppm at 50-55+65-70 DAS	62.1 a	73.3 a	3.05 c	2.17 d	1.44	11.7 b	20.9 bc	14.2 c	34.8 bc	33.8 bc	81.7	71.5
SEd	**0.83**	**1.22**	**0.09**	**0.06**	**0.02**	**0.7**	**0.9**	**1.1**	**0.99**	**1.18**	**2.09**	**0.81**
SEm(±)	**0.32**	**0.55**	**0.06**	**0.05**	**0.005**	**0.3**	**0.5**	**0.9**	**0.45**	**0.53**	**0.48**	**0.19**
P(F)	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.12**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.57**	**0.44**

Table 2: Dry matter accumulation and partitioning in soybean at 80 DAS in response to detopping and mepiquat chloride application (Pooled data)

Treatment	Total weight plant^{-1} (g)	Stem weight plant^{-1} (g)	Foliage weight plant^{-1} (g)
Control	12.6 c	5.5^{ns} (43.3)	7.1 d (56.7)
Detopping	17.2 a	5.8 (33.4)	11.5 a (66.6)
MC @ 200 ppm at 50-55 DAS	13.2 c	5.1 (38.5)	8.1 cd (61.5)
MC @ 200 ppm at 50-55+65-70 DAS	15.4 b	5.6 (36.3)	9.8 b (63.7)
MC @ 250 ppm at 50-55 DAS	13.7 c	5.1 (37.4)	8.6 c (62.6)
MC @ 250 ppm at 50-55+65-70 DAS	16.3 ab	5.4 (33.2)	10.9 b (66.8)
MC @ 300 ppm at 50-55 DAS	13.2 c	5.3 (40.4)	7.9 cd (59.6)
MC @ 300 ppm at 50-55+65-70 DAS	13.4 c	5.4 (40.0)	8.0 cd (59.9)
SEd	**0.52**	**0.33**	**0.52**
SEm (±)	**0.23**	**0.11**	**0.24**
P(F)	**<0.0001**	**0.46**	**<0.0001**

Table 3: Dry matter accumulation and partitioning in soybean at 110 DAS in response to detopping and mepiquat chloride application (Pooled data)

Treatment	Total weight plant^{-1} (g)	Stem weight plant^{-1} (g)	Foliage weight plant^{-1} (g)	Pod weight plant^{-1} (g)
Control	23.7 d	9.6 b (40.8)	8.9 d (37.6)	5.1 c (21.6)
Detopping	36.1 a	14.4 a (39.6)	13.1 a (36.3)	8.7 ab (24.1)
MC @ 200 ppm at 50-55 DAS	27.6 c	9.5 b (34.5)	10.2 c (36.9)	7.9 ab (28.8)
MC @ 200 ppm at 50-55+65-70 DAS	31.0 b	10.2 b (33.0)	11.8 b (38.1)	8.6 ab (27.8)
MC @ 250 ppm at 50-55 DAS	27.9 c	9.3 b (33.4)	10.5 c (37.6)	8.1 ab (29.1)
MC @ 250 ppm at 50-55+65-70 DAS	32.0 b	10.5 b (32.8)	12.1 b (37.8)	8.8 a (27.7)
MC @ 300 ppm at 50-55 DAS	26.9 c	9.3 b (34.5)	10.1 c (37.5)	7.6 b (28.0)
MC @ 300 ppm at 50-55+65-70 DAS	27.4 c	9.4 b (34.2)	10.2 c (37.3)	7.8 ab (28.4)
SEd	**0.60**	**0.62**	**0.45**	**0.54**
SEm (±)	**0.50**	**0.24**	**0.20**	**0.20**
P(F)	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

Table 4: Dry matter accumulation and partitioning in soybean at crop harvest in response to detopping and mepiquat chloride application (Pooled data)

Treatment	Total weight plant^{-1} (g)	Stem weight plant^{-1} (g)	Foliage weight plant^{-1} (g)	Pod weight plant^{-1} (g)
Control	41.4 e	10.8 b (26.0)	5.5 b (13.3)	25.1 d (60.6)
Detopping	59.8 a	12.9 a (21.6)	10.5 a (17.4)	36.5 a (61.0)
MC @ 200 ppm at 50-55 DAS	44.6 d	10.0 b (22.4)	4.9 bc (10.9)	29.7 c (66.6)
MC @ 200 ppm at 50-55+65-70 DAS	50.6 b	10.4 b (20.6)	4.9 bc (9.7)	35.3 a (69.8)
MC @ 250 ppm at 50-55 DAS	47.0 c	10.1 b (21.5)	4.2 c (8.9)	32.7 b (69.6)
MC @ 250 ppm at 50-55+65-70 DAS	51.3 b	10.3 b (20.1)	4.7 bc (9.2)	36.3 a (70.7)
MC @ 300 ppm at 50-55 DAS	46.4 c	9.9 b (21.3)	4.6 c (9.9)	31.6 b (68.1)
MC @ 300 ppm at 50-55+65-70 DAS	47.0 c	9.9 b (21.1)	4.6 c (9.8)	32.5 b (69.0)
SEd	**0.54**	**0.57**	**0.40**	**0.62**
SEm (±)	**0.68**	**0.18**	**0.28**	**0.51**
P(F)	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

Table 5: Phenology of soybean under the influence of detopping and mepiquat chloride application (Pooled data)

Treatment	Days to emergence	Days to floral initiation	Days to pod initiation	Days to seed development initiation	Days to full seed development	Days to physiological maturity
Control	7.1^{ns}	51.9^{ns}	62.6^{ns}	90.1^{ns}	111.1^{ns}	138.6^{ns}
Detopping	7.2	51.9	62.8	90.9	112.0	138.9
MC @ 200 ppm at 50-55 DAS	7.1	51.8	62.5	89.7	111.2	138.4
MC @ 200 ppm at 50-55+65-70 DAS	7.2	52.2	62.7	92.2	111.7	138.5
MC @ 250 ppm at 50-55 DAS	7.2	51.9	62.8	90.0	112.1	138.2
MC @ 250 ppm at 50-55+65-70 DAS	7.2	51.9	62.9	90.3	110.6	138.6
MC @ 300 ppm at 50-55 DAS	7.2	52.1	62.7	90.9	112.1	138.9
MC @ 300 ppm at 50-55+65-70 DAS	7.2	52.0	62.8	91.5	111.4	138.2
SEd	**0.38**	**0.36**	**0.46**	**2.99**	**2.40**	**0.47**
SEm (±)	**0.08**	**0.08**	**0.10**	**0.66**	**0.53**	**0.11**
P(F)	**1.00**	**0.98**	**0.99**	**0.99**	**0.99**	**0.66**

Table 6: Growth indices of soybean at different growth intervals as affected by detopping and mepiquat chloride application (Pooled data)

Treatment	Crop Growth Rate (g m^{-2} day^{-1})			Relative Growth Rate (g g^{-1} day^{-1})			Net Assimilation Rate (mg cm^{-2} day^{-1})	
	50-80 DAS	80-110 DAS	110 DAS-Harvest	50-80 DAS	80-110 DAS	110 DAS-Harvest	80-110 DAS	110 DAS-Harvest
Control	14.8 c	4.4 c	0.14 d	19.74 d	2.92 b	0.082 d	0.19 c	0.50 c
Detopping	17.1 a	5.1 b	0.18 a	21.13 bc	3.26 a	0.091 ab	0.32 b	0.68 a
MC @ 200 ppm at 50-55 DAS	15.7 bc	5.8 a	0.15 c	20.37 cd	3.45 a	0.086 c	0.33 b	0.57 b
MC @ 200 ppm at 50-55+65-70 DAS	16.6 ab	5.5 ab	0.17 ab	22.18 ab	3.28 a	0.091 ab	0.37 a	0.69 a
MC @ 250 ppm at 50-55 DAS	16.3 ab	5.8 ab	0.16 bc	21.64 b	3.45 a	0.088 c	0.33 b	0.65 a
MC @ 250 ppm at 50-55+65-70 DAS	16.9 a	5.5 ab	0.17 a	22.97 a	3.28 a	0.092 a	0.38 a	0.70 a
MC @ 300 ppm at 50-55 DAS	16.2 ab	5.7 ab	0.16 bc	21.21 bc	3.46 a	0.087 c	0.33 b	0.68 a
MC @ 300 ppm at 50-55+65-70 DAS	16.3 ab	5.7 ab	0.16 bc	21.75 b	3.44 a	0.088 bc	0.35 ab	0.70 a
SEd	**0.46**	**0.28**	**0.005**	**0.58**	**0.11**	**0.001**	**0.02**	**0.03**
SEm (±)	**0.14**	**0.08**	**0.001**	**0.18**	**0.03**	**0.0007**	**0.01**	**0.01**
P(F)	**0.0003**	**0.0001**	**<0.0001**	**<0.0001**	**0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

Table 7: Seed yield and yield attributes of soybean as influenced by detopping and mepiquat chloride application (Pooled data)

Treatment	Flowers plant^{-1}	Abscission of reproductive parts plant^{-1}	Pods plant^{-1}	Pod setting (%)	Seeds pod^{-1}	Pod length (cm)	100-Seed weight (g)	Seed yield (q ha^{-1})	Harvest index (HI)
Control	189.2 b	116.8 a	72.5 c	38.03 c	3.0^{ns}	4.1^{ns}	8.21 f	12.25 d	0.17 c
Detopping	238.9 a	118.9 a	121.6 a	50.06 b	3.1	4.3	8.23 f	17.90 a	0.22 ab
MC @ 200 ppm at 50-55 DAS	198.4 b	98.4 b	100.1 b	50.29 b	2.9	4.0	8.79 de	15.39 c	0.20 b
MC @ 200 ppm at 50-55+65-70 DAS	206.5 b	88.0 b	118.5 ab	57.50 a	2.8	3.9	8.93 b	17.66 ab	0.22 ab
MC @ 250 ppm at 50-55 DAS	200.3 b	94.8 b	105.5 ab	52.75 ab	2.9	4.2	8.87 c	16.05 bc	0.20 ab
MC @ 250 ppm at 50-55+65-70 DAS	214.7 b	92.5 b	122.2 a	56.71 a	2.9	3.9	8.97 a	18.05 a	0.22 a
MC @ 300 ppm at 50-55 DAS	190.8 b	88.1 b	102.2 b	53.76 ab	2.9	4.2	8.76 e	15.58 c	0.20 ab
MC @ 300 ppm at 50-55+65-70 DAS	189.7 b	85.5 b	104.6 ab	54.48 ab	3.0	4.0	8.80 d	15.75 c	0.21 ab
SEd	**11.25**	**6.6**	**8.60**	**2.69**	**0.20**	**0.2**	**0.02**	**0.83**	**0.01**
SEm (±)	**3.22**	**2.2**	**2.72**	**0.94**	**0.05**	**0.1**	**0.04**	**0.30**	**0.003**
P(F)	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.93**	**0.73**	**<0.0001**	**<0.0001**	**<0.0001**

and development. Lowering down of parasitism and competition by shaded leaves for assimilates and their efficient translocation towards the potential sink *i.e.*, pods put the growth indices on higher side than control. The results are in line with results of Singh (2001).

Seed yield and yield attributes

Detopping (Table 7) significantly increased the number of flowers/plant as compared to rest of the treatments with an increase of 26.3per cent over control (189.2). However, foliar application of MC did not affect the number of flowers plant^{-1} as compared to control. Foliar application of MC, irrespective of dose and frequency of application led to a significant reduction in abscission of reproductive parts over the years as compared to control and detopping. Maximum reduction was recorded due to two foliar applications of mepiquat chloride @ 300 ppm which was 26.8per cent lesser than control (116.8). Furthermore, reduction in abscission of reproductive parts by two foliar applications of MC @ 200 and 250 ppm was 24.7 and 20.8per cent as compared to control, respectively. Increase in pods plant^{-1} by two foliar applications of MC @ 200, 250 and 300 ppm was 63.4, 68.6 and 44.3per cent as compared to control, respectively. The results on MC are in line with that of Kaur (1997). Pod setting percentage in the treatments including two foliar applications of mepiquat chloride @ 200 and 250 ppm was found to be 51.2 and 49.1per cent higher than control (38.03 %), respectively. Results of MC application are in accordance with Arora *et al.* (2005). Detopping and MC application had a non-significant effect on number of seeds pod^{-1} and pod length. Results regarding number of seeds pod^{-1} are in line with Islam *et al.* (2010). Increase in 100-seed weight by two foliar applications of MC @ 250 ppm was 9.3 and 8.9 per cent as compared to control (8.21 g) and detopping (8.23 g), respectively. Results of MC application are in line with Reddy *et al.* (2009). Two foliar applications of MC @ 250 ppm resulted in the highest seed yield, which was statistically at par with detopping and two foliar applications of MC @ 200 ppm. Two foliar applications of MC @ 250 ppm resulted in the highest harvest index, which was statistically at par with other treatments except control and single foliar application of MC @ 200 ppm. Detopping also resulted in 29.4 per cent higher HI as compared to control. Results from the MC application are in line with Ravichandran and Ramaswami (1993). Detopping caused cessation of apical dominance, increased SLW, development of more floral buds and ultimately higher number of flowers and pods plant^{-1} which led to enhanced setting percentage and seed yield. Foliar application of MC resulted in decreased LAI, increased SPAD and SLW. Increase in SLW is directly related to photosynthetic capacity and yield in many crops. Thus, posing a favourable impact on the photosynthetic machinery of the plant led to increased photosynthetic rate. Hiked photosynthetic rate and decreased vegetative growth of the crop resulted in abatement in level of competition among vegetative and reproductive parts, better availability and their efficient translocation to developing reproductive parts resulting in higher pod number, setting percentage and seed yield.

Cessation of apical dominance by detopping put favourable effect on plant growth and development which was clearly reflected in terms of decreased plant height, optimized source-sink relationship, enhanced yield attributes and seed yield. Effect of fluctuations in the weather elements especially rain was also recorded in terms of increased stem and foliage weight and decreased seed yield in detopping treatment during 2015 relative to 2014. Mepiquat chloride posed a favorable impact on soybean in terms of decreased leaf area index, enhanced SPAD value, high specific leaf weight, dry matter accumulation, optimized source-sink relationship resulting into better seed yield and yield attributes in comparison to control.

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