IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 13, Issue 7 Ser. II (July 2020), PP 20-28
www.iosrjournals.org

Effect of Gibberellic Acid (GA3) on Morpho-physiological Traits and Yield Performance of Chickpea (*Cicer arietinum* L.)

M. S. Reja, S. Sikder*, M. A. Hasan and S. K. Pramanik
Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University Dinajpur, Bangladesh
**Corresponding author: E-mail: srisikder@gmail.com*

***Abstract**: Response of chickpea to gibberellic acid (GA3) regarding morpho-physiology and yield was investigated in this experiment. The experiment consisted of two factors: a) two growing conditions viz.; control and foliar application of GA3 and b) four chickpea varieties viz.; Deshi, BARI Chola-3, BARI Chola-5 and BARI Chola-9. The experiment was laid out in Randomized Complete Block Design with three replications. Plant height, leaf dry weight and shoot and root dry weight plant^{-1} at different days after sowing maintained a typical sigmoid pattern in all chickpea varieties under both control and GA3 applied condition. The percentage of increasing in maximum plant height, leaf dry weight plant^{-1}, shoot dry weight plant^{-1} and root dry weight plant^{-1} were 6.21%, 9.59%, 12.00% and 9.05% in Deshi variety; 4.54%, 3.06%, 4.89% and 4.76% in BARI Chola-3; 5.21%, 9.28%, 8.25% and 10.07% in BARI Chola-5 and 8.31%, 13.44%, 9.80% and 9.58% in BARI Chola-9, respectively under foliar application of GA3. The combined effect of growing condition and chickpea variety significantly influenced number of flowers plant^{-1} number of pods plant^{-1}, 100-seed weight, biological yield and seed yield. BARI Chola-9 produced the maximum seed yield under both control and foliar application of GA3 (2.45 and 2.71 t h^{-1}, respectively) on the contrary BARI Chola-3 produced the minimum seed yield (1.86 and 1.97 t h^{-1}, respectively). Foliar application of GA3 resulted increasing in all traits of chickpea varieties but the magnitude of increasing was not similar to all varieties. BARI Chola-9 performed better compared to other three varieties in relation to foliar application of gibberellic acid (GA3).*

***Key Words**: Chickpea, Gibberellic Acid, Morpho-physiology, Yield*

Date of Submission: 13-06-2020 Date of Acceptance: 28-07-2020

I. Introduction

Chickpea (*Cicer arietinum* L.) is a legume of the family Fabaceae, subfamily Faboideae. It is one of the important legume cultivated throughout the world. Chickpeas have a protein digestibility corrected amino acid score of about 0.76, which is higher than many other legumes and cereals (Jukanti *et al.* 2012). Cooked chickpeas have 60% water, 27% carbohydrates, 9% protein, 3% fat and 75% lipid (El-Adawy 2002). In Bangladesh, chickpea is the third major pulse crop after grass pea and lentil and stands 5th in respect of area (14615 ha) and production (6237 tons), and 2nd in consumption priority (BBS 2017). The average production of chickpea in the country is about 746 kg ha^{-1}, which is much lower than India and some other countries of the world. This is mainly due to the use of traditional or low yielding varieties as well as adoption of poor management practices. In Bangladesh, cultivable land area is decreasing year after year for rapid growth of population. So, there is no scope to increase production of pulses as well as chickpea horizontally. In this situation there is only a way of increasing production vertically by means of using of high yielding varieties and improved technologies. Agricultural research, till now, has been primarily concerned with increasing crops yield by use of fertilizers, pesticides, irrigation, better crop management coupled with variety development and genetic improvement. Exogenous application of growth regulators and micronutrient also offer unique opportunities of scaling plant and quality. Plant growth substances have key role in different physiological processes related to growth and development of crops and significantly increased all physiological and yield characters (Meera and Poonam 2010). Plant growth regulators have potentiality to increase chickpea yield and may also increase protein levels of legume crops (Ma *et al.* 1994). Plant growth regulators play role in manipulating physiological processes in crop production include germination, vigour, nutrient uptake from soil, photosynthesis, respiration, partitioning of assimilate, growth suppression, defoliation and post-harvest ripening (Rahman and Nath 1993; Kathiresan and Balasubramanian 1995). Active gibberellins show many physiological effects, each depending on the type of gibberellin present as well as the species of plant. Due to the diversified use of productive land, it is necessary to increase the food production and gibberellic acid (GA3) may be a contributor in achieving the desired goal. Considering the present situation, the research work was carried out to investigate the effect of gibberellic acid (GA3) on morpho-physiological traits and yield of chickpea.

II. Materials and Methods

2.1 Location and duration

The experiment was conducted at Research field and Laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during December, 2017 to April, 2018.

2.2 Experimental site, soil and climate

The experimental site is located at 25º39′ N latitude and 88º41′ E longitude with an elevation of 37.58 m above the sea level. It is medium high land and belonging to the agro-ecological zone named Old Himalayan Piedmont Plain (AEZ-I). The experimental field is under subtropical climate characterized by rainfall during the month of last April to October and scanty rainfall during December.

2.3 *Experimental design, layout and treatments*

The experiment was laid out in a Randomized Complete Block Design with three replications. The unit plot size was 2 m × 2 m having plot to plot and block to block distance of 0.50 m and 1 m, respectively. There were eight treatment combinations and they were distributed randomly in twenty-four plots. The experimental treatments consisted of two factors; **Factor a**: Two growing conditions (control and foliar application of 300 ppm GA3) and **Factor b:** Four chickpea varieties (Deshi; collected from local market, BARI Chola -3, BARI Chola -5 and BARI Chola -9).

2.4 Land preparation, seed sowing and intercultural operations

The land was ploughed by a tractor drawn disc plough and leveled by harrowing carefully. The weeds and stubbles were removed and the land was leveled to obtain a desirable tilt for sowing of seed. Finally, the experimental plot was divided into twenty-four plots as stated earlier. Seeds were sown in the morning of 5th December 2018 following line sowing method maintaining line to line distance 25 cm. Seeds were sown on the furrow and the furrow were covered by soil soon after seeding. The depth was maintained at about three centimeters from the soil surface. The production technology of chickpea recommended by Bangladesh Agricultural Research Institute (BARI) was followed and necessary intercultural operations such as fertilization, irrigation, weeding, thinning, crop protection etc. were done when and as necessary.

2.5 Preparation of gibberellic acid (GA3) solution and application

300 ppm solution of GA3 was prepared by dissolving 300 mg of GA3 in small quantity of ethanol prior to dilution with distilled water. Then distilled water was added to make the volume 1 liter to get 300 ppm. The prepared solution was applied at 30 and 60 days after sowing at late morning by using a hand sprayer.

2.6 Sampling and data collection

2.6.1 Collection of data on morpho-physiological traits

The selected representative plants from each plot were uprooted carefully by a 'khurpi' and washed in running tap water to remove the soil. Three plant samples from each plot were taken and mean was calculated. Plant height was measured from the base to the tip of the plant. For measuring leaf dry weight plant^{-1}, Shoot dry weight plant^{-1} and root dry weight plant^{-1} samples were collected from selected uprooted plants from each treatment and the samples were oven dried at 70°C for 48 hours and dry weight was taken by an electrical balance. Sampling was continued at an interval of 10 days *viz.* 40, 50, 60, 70, 80, 90 and 100 days after sowing. Number of nodules plant $^{-1}$ was recorded from five selected plants from each treatment at 40, 60 and 80 days after sowing and mean was calculated.

2.6.2 Collection of data on yield and yield components

Number of flowers plant^{-1} was recorded from five selected plants from each plot at 75 days after sowing and the mean was calculated. Number of pods plant^{-1} was counted at the time of harvest from five selected plants from each plot and the mean was calculated. 100 seeds were counted and weighted by using an electric balance and the mean was calculated. Seeds were separated by threshing plot wise then sun dried and weighed. Biological yield (seed yield + stover yield) was also calculated on dry weight basis. Seed yield and biological yield were converted into ton hectare^{-1}. Harvest index was calculated with the following formula-

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

2.7 Statistical analysis

The collected data were analyzed by partitioning the total variance with the help of a computer using STATA program and the mean differences were adjusted by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

III. Results and Discussion

3.1 Plant height

Plant height of all chickpea varieties maintained a typical sigmoid pattern at different days after sowing under both control and GA3 applied condition (Figure 1). Plant height of all chickpea varieties at both control and GA3 applied condition started from a lower value and increased gradually with the advancement of growth stage (days after sowing) and reached their peak at certain stage of growth. Under control condition, plant height was observed to be increased up to 82.33 cm in Deshi variety, 51.55 cm in BARI Chola-3, 53.33 cm in BARI Chola-5 and 55.70 cm in BARI Chola-9 at 90 days after sowing and decline there after slowly. Under GA3 applied condition, plant height was increased in all chickpea varieties at different days after sowing. The increasing in maximum plant height was 6.21% in Deshi variety, 4.54% in BARI Chola-3, 5.21% in BARI Chola-5, and 8.31% in BARI Chola-9. However, under GA3 applied condition, plant height was observed to be increased up to 87.44 cm in Deshi variety, 53.89 cm in BARI Chola-3, 56.11 cm in BARI Chola-5 and 60.33 cm in BARI Chola-9 at 90 days after sowing and decline there after slowly. Number of days required to attain maximum plant height was similar in all varieties under both control and GA3 applied condition. The results observed by Iqbal *et al.* (2001) and Nabi *et al.* (2016) on spraying with gibberellic acid in chickpea support the result of the present study regarding plant height.

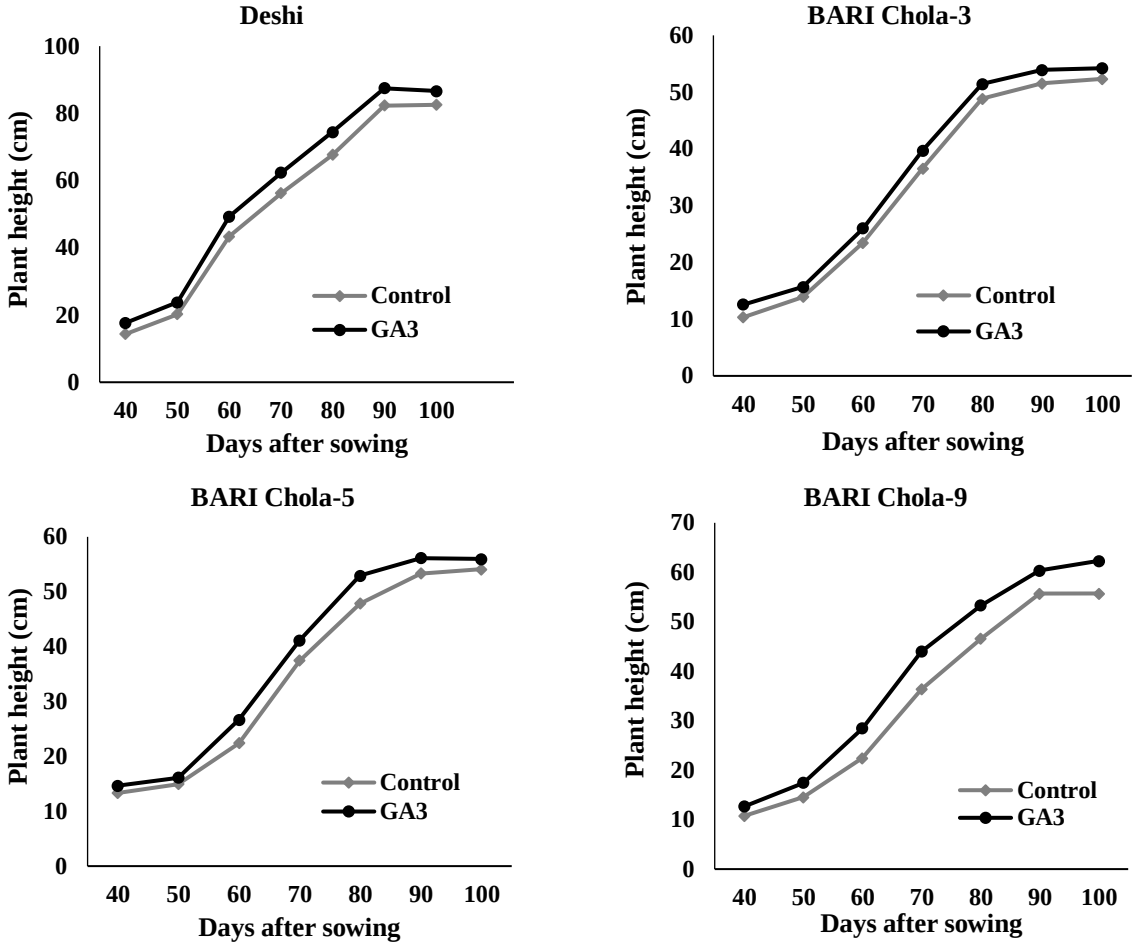

Figure 1. Plant height of chickpea varieties at different days after sowing as influenced by GA3.

3.2 Leaf dry weight plant^{-1}

Leaf dry weight plant^{-1} at different days after sowing maintained a typical sigmoid pattern in all chickpea varieties under both control and GA3 applied condition (Figure 2). Leaf dry weight of all chickpea varieties at both control and GA3 applied condition started from a lower value and increased gradually with the advancement of growth stage (days after sowing) and reached their peak at certain stage of growth. Under control condition, leaf dry weight plant^{-1} was observed to be increased up to 3.44 g in Deshi variety, 3.27 g in BARI Chola-3, 3.45 g in BARI Chola-5 and 2.53 g in BARI Chola-9 at 90 days after sowing and decline there after slowly. Under GA3 applied condition, root dry weight plant^{-1} was increased in all chickpea varieties at different days after sowing. The increasing in maximum leaf dry weight plant^{-1} was 9.59% in Deshi variety,

3.06% in BARI Chola-3, 9.28% in BARI Chola-5, and 13.44% in BARI Chola-9. However, under GA3 applied condition, leaf dry weight plant^{-1} was observed to be increased up to 3.77 g in Deshi variety, 3.37 g in BARI Chola-3, 3.77 g in BARI Chola-5 and 2.87 g in BARI Chola-9 at 90 days after sowing and decline there after slowly. Number of days required to attain maximum root dry weight plant^{-1} was similar in all varieties under both control and GA3 applied condition.

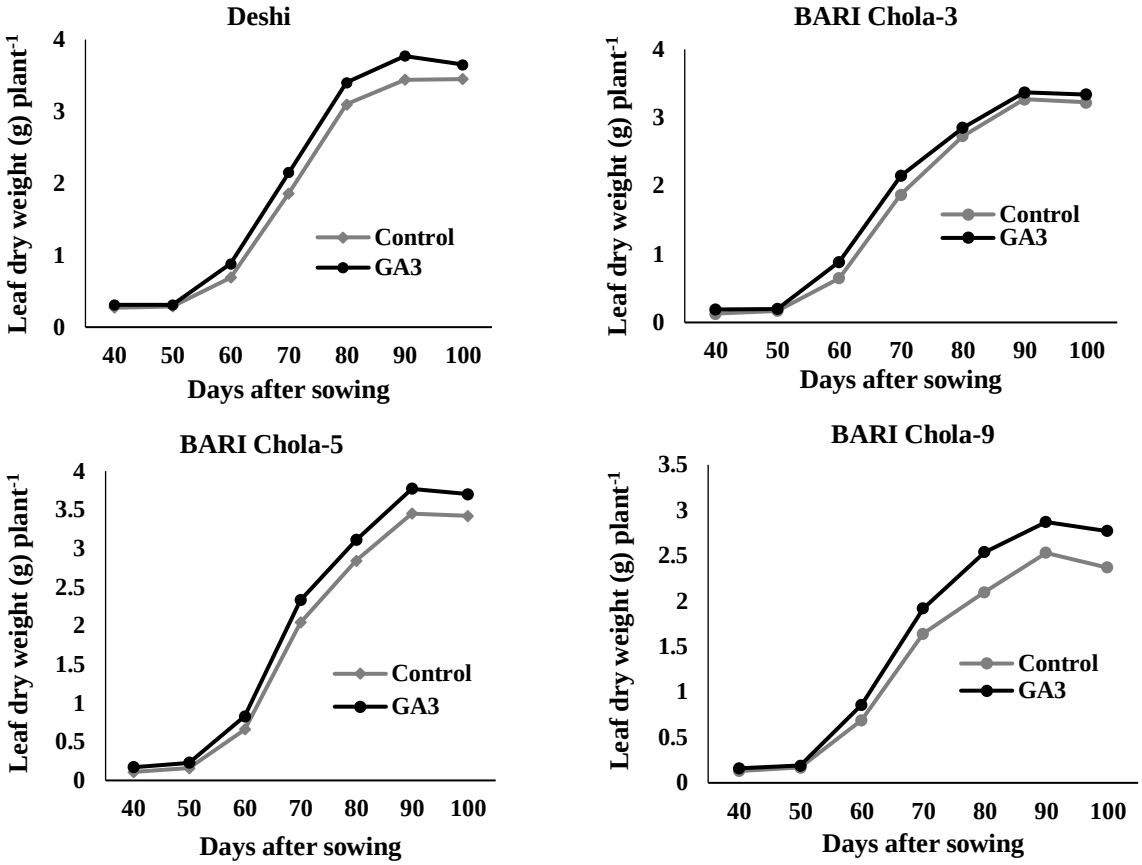

Figure 2. Leaf dry weight of chickpea varieties at different days after sowing as influenced by GA3.

3.*3 Shoot dry weight plant^{-1}*

Shoot dry weight plant^{-1} at different days after sowing maintained a typical sigmoid pattern in all chickpea varieties under both control and GA3 applied condition (Figure 3). Shoot dry weight of all chickpea varieties at both control and GA3 applied condition started from a lower value and increased gradually with the advancement of growth stage (days after sowing) and reached their peak at certain stage of growth. Under control condition, shoot dry weight plant^{-1} was observed to be increased up to 7.83 g in Deshi variety, 5.11 g in BARI Chola-3, 4.00 g in BARI Chola-5 and 6.63 g in BARI Chola-9 at 90 days after sowing and decline there after slowly. Under GA3 applied condition, shoot dry weight plant^{-1} was increased in all chickpea varieties at different days after sowing. The increasing in maximum shoot dry weight plant^{-1} was 12.00% in Deshi variety, 4.89% in BARI Chola-3, 8.25% in BARI Chola-5, and 9.80% in BARI Chola-9. However, under GA3 applied condition, shoot dry weight plant^{-1} was observed to be increased up to 8.77 g in Deshi variety, 5.36 g in BARI Chola-3, 4.33 g in BARI Chola-5 and 7.28 g in BARI Chola-9 at 90 days after sowing and decline there after slowly. Number of days required to attain maximum shoot dry weight plant^{-1} was similar in all varieties under both control and foliar application of GA3.

3.4 Root dry weight plant^{-1}

Root dry weight plant^{-1} at different days after sowing maintained a typical sigmoid pattern in all chickpea varieties under both control and GA3 applied condition (Figure 4). Root dry weight of all chickpea varieties at both control and GA3 applied condition started from a lower value and increased gradually with the advancement of growth stage (days after sowing) and reached their peak at certain stage of growth. Under control condition, root dry weight plant^{-1} was observed to be increased up to 1.99 g in Deshi variety, 1.68 g in BARI Chola-3, 1.49 g in BARI Chola-5 and 1.67 g in BARI Chola-9 at 90 days after sowing and decline there after slowly. Under GA3 applied condition, root dry weight plant^{-1} was increased in all chickpea varieties at different days after sowing.

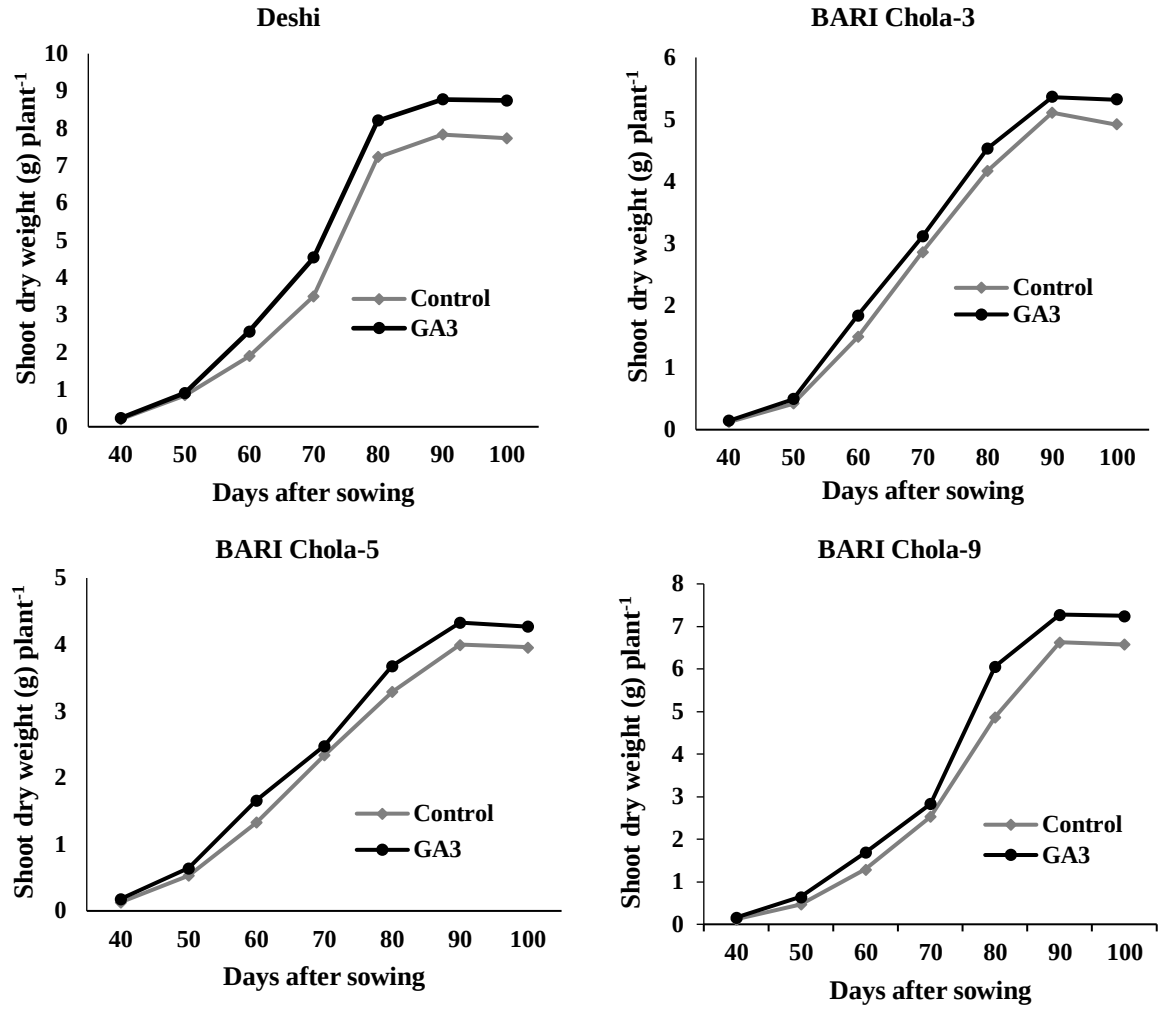

Figure 3. Shoot dry weight of chickpea varieties at different days after sowing as influenced by GA3.

The increasing in maximum root dry weight plant^{-1} was 9.05% in Deshi variety, 4.76% in BARI Chola-3, 10.07% in BARI Chola-5, and 9.58% in BARI Chola-9. However, under GA3 applied condition, root dry weight plant^{-1} was observed to be increased up to 2.17 g in Deshi variety, 1.76 g in BARI Chola-3, 1.64 g in BARI Chola-5 and 1.83 g in BARI Chola-9 at 90 days after sowing and decline there after slowly. Number of days required to attain maximum root dry weight plant^{-1} was similar in all varieties under both control and GA3 applied condition. The declining tendency in shoot and root dry weight after attaining the maximum level might be due to respiratory loss and usage of stored photosynthates. Increasing in shoot and root growth is the result of more cell division and cell enlargement, as plant growth regulators directly promote growth by increasing cell division and elongation. Plant growth regulators also increase the reserve utilization during growth and development which contributed to higher shoot and root dry weight of chickpea. Significant increasing in term of shoot and root dry weight among the varieties might be attributed to their differential response in term of plant growth regulator (GA3). %). The results of the present study are in agreement with the results observed by Khan *et al.* (2000) regarding shoot and root dry weight under foliar application of GA3.

3.5. Number of nodules plant^{-1}

The combined effect of growing condition and variety was significant on number of nodules plant^{-1} of chickpea at 40, 60 and 80 days after sowing (Table 1). At 40 days after sowing, the maximum nodules number (4.37) was recorded from the variety BARI Chola-9, whereas the minimum nodules number (2.64) was recorded in variety BARI Chola-3 under control condition. At 60 days after sowing the maximum nodules number (11.19) was recorded from BARI Chola-3, while the minimum nodules number (7.65) was recorded from Deshi variety under control condition. At 80 days after sowing, the highest nodules number (13.14) was found in variety BARI Chola-5, whereas the lowest nodules number (5.18) was recorded from the Deshi variety under control condition. Application of GA3 increased nodule number in all chickpea varieties at 40, 60 and 80 days after sowing (3.56 to 5.36; 8.42 to 11.72 and 6.36 to 13.36, respectively) compared to control condition (2.64 to

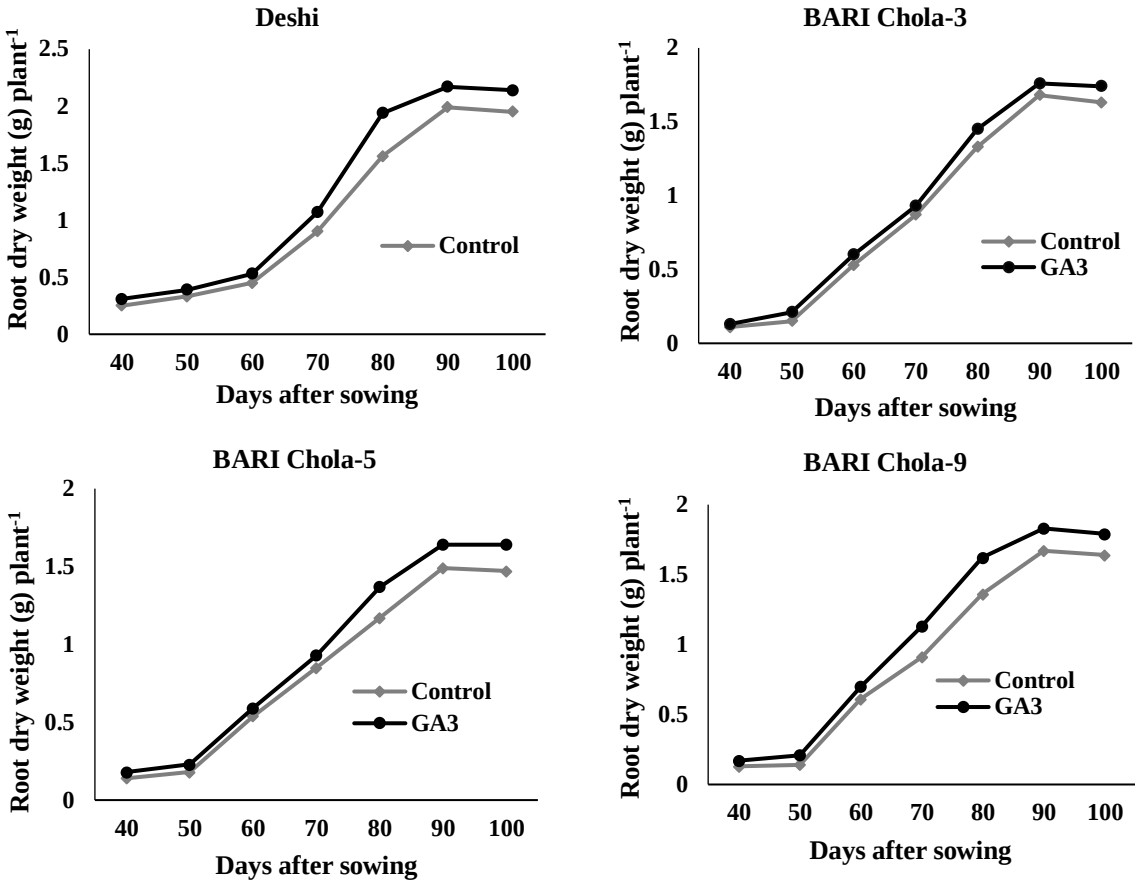

Figure 4. Root dry weight of chickpea varieties at different days after sowing as influenced by GA3.

4.37; 7.65 to 11.19 and 5.18 to 13.14, respectively). However, under GA3 applied condition, the maximum nodules number (5.36) was observed in BARI Chola-9, whereas the lowest nodules number (3.56) was obsereved in Deshi variety at 40 days after sowing. At 60 days after sowing, maximum nodules number (11.72) was found in BARI Chola-3, whereas minimum nodules number (8.42) was found in BARI Chola-5 under application of GA3. At 80 days after sowing the maximum nodules number (13.36) was observed in BARI Chola-5 and the lowest nodules number (6.36) was observed in Deshi variety under application of GA3. From the results of the present study, it was observed that the number of nodules plant^{-1} was higher in all chickpea varieties at 60 days after sowing than at 40 days after sowing. At 80 days after sowing, the number of nodules plant^{-1} increased for the varieties BARI Chola-5 and BARI Chola-9 but decreased for the varieties Deshi and BARI Chola-3.

Table 1. Effect of gibberellic acid (GA3) on number of nodules plant^{-1} of chickpea varieties at different days after sowing

Chickpea varieties	Growing conditions	Number of nodules plant^{-1} at		
		40 DAS	60 DAS	80 DAS
Deshi	Control	3.36 c	7.65 d	5.18 f
	GA3	3.56 c	9.34 b	6.36 e
BARI Chola-3	Control	2.64 d	11.19 a	7.71 d
	GA3	4.49 b	11.72 a	8.38 d
BARI Chola-5	Control	3.59 c	7.72 d	13.14 ab
	GA3	3.79 c	8.42 c	13.36 a
BARI Chola-9	Control	4.37 b	9.68 b	9.36 c
	GA3	5.36 a	11.15 a	12.36 b
Level of significance		**	**	**
CV)%(		8.95	1.92	1.78

*In a column, means followed by the same letter)s(did not differ significantly at the 5% level by DMRT. ** Significant at the 1% probability level*. DAS = Days after sowing.

3.6 Number of flowers plant^{-1}

Number of flowers plant^{-1}of chickpea was significantly influenced by the combined effect of growing condition and variety (Table 2). However, under control condition, BARI Chola-9 produced the maximum

number of flowers plant^{-1} (31.26) and the minimum number of flowers plant^{-1} (21.82) was recorded in Deshi variety. Foliar application of GA3 increased the number of flowers plant^{-1} in all chickpea varieties but the degree of increasing was different for different varieties. Under GA3 applied condition, maximum increasing in number of flowers plant^{-1} (25.16%) was recorded in Deshi variety, whereas the minimum increasing in number of flowers plant^{-1} (16.53%) was recorded in BARI Chola-3. BARI Chola-5 and BARI Chola-9 showed moderate increasing in number of flowers plant^{-1} (20.27% and 21.14%) under application of GA3. However, Under GA3 applied condition, again the highest number of flowers plant^{-1}(37.87) was found in BARI Chola-9, whereas the lowest number of flowers plant^{-1} (27.31) was found in Deshi variety. Differential degree of flowering among the chickpea varieties might be due to genetic variability of chickpea. Increased flowering under GA3 applied condition might be due to promotion of production and translocation of stimulus for flowering from leaves to the flower forming region by the foliar application of GA3.

Table 2. Effect of gibberellic acid (GA3) on number of flowers plant^{-1} and number of pods plant^{-1} of chickpea varieties at 75 days after sowing

Chickpea varieties	Number of flowers plant^{-1}			Number of pods plant^{-1}		
	Control	GA3	% change over control	Control	GA3	% change over control
Deshi	21.82 d	27.31 c	+25.16	43.51 bc	50.48 b	+16.02
BARI Chola-3	28.31 c	32.99 b	+16.53	30.26 c	32.80 c	+6.68
BARI Chola-5	27.09 c	32.58 b	+20.27	45.32 bc	50.46 b	+11.34
BARI Chola-9	31.26 b	37.87 a	+21.14	49.16 b	58.97 a	+19.96
Level of significance	**			**		
CV (%)	2.90			3.18		

*In a column, means followed by the same letter)s(did not differ significantly at the 5% level by DMRT. ** Significant at the 1% probability level.*

3.7 Number of pods plant^{-1}

The combined effect of growing condition and variety significantly influenced the number of pods plant^{-1} of chickpea (Table 2). However, under control condition, maximum number of pods plant^{-1} (49.16) was recorded in BARI Chola-9 and minimum number of pods plant^{-1} (30.26) was recorded in BARI Chola-3. Foliar application of GA3 increased number of pods plant^{-1} in all chickpea varieties but the degree of increasing was not similar for all chickpea varieties. Under GA3 applied condition, maximum increasing in number of pods plant^{-1} (19.96%) was recorded in BARI Chola-9, whereas the minimum increasing in number of pods plant^{-1} (6.68%) was recorded in BARI Chola-3. Moderate increasing in number of pods plant^{-1} was recorded in Deshi variety (16.02%) and BARI Chola-5 (11.34) under GA3 applied condition. However, Under GA3 applied condition, again the maximum number of pods plant^{-1} (58.97) was observed in BARI Chola-9 and the minimum number of pods plant^{-1} (32.80) was observed in BARI Chola-3. Other two varieties produced more or less similar number of pods (50.48 and 50.46). The results of the present study are in a line with the results observed by Mazid (2014).

3.8 100-seed weight

Table 3 shows that 100-seed weight of chickpea was significantly varied by the interaction effect of growing condition and variety. Under control condition, the highest 100-seed weight (18.69 g) was recorded from BARI Chola-9 and lowest 100-seed weight (10.43 g) was recorded from BARI Chola-5. Under GA3 applied condition, again the highest 100-seed weight (20.76 g) was recorded from BARI Chola-9, whereas the lowest 100-seed weight (11.16 g) was recorded from BARI Chola-3. Foliar application of GA3 increased the 100-seed weight in all chickpea varieties at different magnitude. However, foliar application of GA3 increased 100-seed weight by 11.08% in BARI Chola-9, 2.41% in BARI Chola-3, 5.21% in Deshi variety and 7.00% in BARI Chola-5. GA3 increased seed weight via acceleration of reserve mobilization in seed. It also stimulated the source capacity as well as sink size resulted in increasing of seed weight. The results are in a line with the results observed by Singh *et al.* (2013) and Danesh *et al.* (2014).

3.9 Biological yield

The combined effect of growing condition and variety was significant on biological yield of chickpea (Table 3). Under control condition, BARI Chola-9 produced the highest biological yield (7.88 t ha^{-1}) and Deshi variety produced the lowest biological yield (6.38 t ha^{-1}) which was statistically similar to the that of BARI Chola-3 (6.51 t ha^{-1}). The second highest biological yield (6.95 t ha^{-1}) was observed in BARI Chola-5. Under GA3 applied condition, again the BARI Chola-9 produced the highest biological yield (8.96 t ha^{-1}), whereas BARI Chola-3 produced the lowest (6.97 t ha^{-1}). Foliar application of GA3 increased biological yield in all chickpea varieties at different magnitude. However, application of GA3 increased biological yield by 13.70% in BARI Chola-9, 7.07% in BARI Chola-3, 12.07% in Deshi variety and 11.65% in BARI Chola-5. Foliar application of GA3 during stem elongation positively affected straw dry matter production as GA3 has a

positive regulatory effect on vegetative growth of plant. The increased biological yield might be due to increase of leaf area results in increased photosynthesis rate. Findings concluded by Nabi *et al.* (2016) and Singh *et al.* (2015) support the results of the present study.

Table 3. Effect of gibberellic acid (GA3) on 100-seed weight and biological yield of chickpea varieties

Chickpea varieties	100-seed weight (g)			Biological yield (t h^{-1})		
	Control	GA3	% change over control	Control	GA3	% change over control
Deshi	18.20 b	19.15 b	+5.21	6.38 de	7.15 bc	+12.07
BARI Chola-3	18.22 b	18.66 ab	+2.41	6.51 de	6.97 cd	+7.07
BARI Chola-5	10.43 d	11.16 c	+7.00	6.95 cd	7.76 b	+11.65
BARI Chola-9	18.69 ab	20.76 a	+11.08	7.88 b	8.96 a	+13.70
Level of significance	*			*		
CV%	2.22			4.15		

*In a column, means followed by the same letter)s(did not differ significantly at the 5% level by DMRT. * Significant at the 5% probability level.*

Table 4. Effect of gibberellic acid (GA3) on seed yield and harvest index of chickpea varieties

Chickpea varieties	Seed yield (t h^{-1})			Harvest index (%)		
	Control	GA3	% change over control	Control	GA3	% change over control
Deshi	1.95 de	2.13 c	+9.23	30.56	29.79	-2.52
BARI Chola-3	1.86 e	1.97 de	+5.91	28.57	28.26	-1.09
BARI Chola-5	1.88 e	2.03 cd	+7.98	27.05	26.16	-3.29
BARI Chola-9	2.45 b	2.71 a	+10.61	31.09	30.25	-2.70
Level of significance	*			NS		
CV (%)	2.70			4.59		

*In a column, means followed by the same letter)s(did not differ significantly at the 5% level by DMRT. *Significant at the 5% probability level. ^{NS}Not significant at the 5% probability level.*

3.10 Seed yield

The combined effect of growing condition and variety significantly interacted on seed yield of chickpea (Table 4). Under control condition, BARI Chola-9 produced the maximum seed yield (2.45 t ha^{-1}) and BARI Chola-3 produced the minimum (1.86 t ha^{-1}) which was statistically similar to that of (1.88 t ha^{-1}) produced by BARI Chola-5. The second highest seed yield (1.95 t ha^{-1}) was recorded in Deshi variety. Seed yield was increased under GA3 application (1.97 to 2.71 t ha^{-1}) compared to control (1.86 to 2.45 t ha^{-1}). However, under GA3 application, again the BARI Chola-9 produced the highest seed yield (2.71 t ha^{-1}), while the lowest (1.97 t ha^{-1}) was recorded from BARI Chola-3. Foliar application of GA3 increased seed yield by 10.61% in BARI Chola-9, 5.91% in BARI Chola-3, 9.23% in Deshi variety and 7.98% in BARI Chola-5. It could be stated that the beneficial effect of GA3 on improving yield might be due to the translocation of more photo assimilates to the seeds. Results published by Khan *et al.* (2000) and Iqbal *et al.* (2001) regarding seed yield under GA3 are in line and support the results of the present study.

3.11 Harvest index

Harvest index of chickpeas was not significantly influenced by the interaction effect of varieties and GA3 levels but significantly influenced by the main effect (Table 4). However, under control condition, the highest harvest index (31.09%) was found in BARI Chola-9, whereas the lowest harvest index (27.05%) was found in BARI Chola-5. GA3 application reduced the harvest index in all varieties (26.16 to 30.25%) compared to control condition (27.05 to 31.09%). However, under GA3 applied condition, again the highest harvest index was recorded in BARI Chola-9 (30.25%) and the lowest was found in BARI Chola-5 (26.16%). The order of reduction in harvest index under GA3 applied condition was BARI Chola-5 > BARI Chola-9 > Deshi > BARI Chola-3. Application of GA3 influenced biological yield and seed yield consequently harvest index. Harvest index was higher at control condition compared to GA3 applied condition because GA3 had more positive regulatory effect on straw dry matter production than seed yield. GA3 increased the both stover yield and seed yield but the increasing rate was more in stover yield than seed yield.

IV. Conclusions

Considering the findings of the present experiment, it can be concluded that foliar application of gibberellic acid (GA3) appeared to be an effective way to improve the yield and yield contributing characters of chickpea. Among the four varieties the BARI Chola-9 was found as better under foliar application of GA3 followed by Deshi variety, BARI Chola-5 and BARI Chola-3 accordingly. The present findings are from one year and one location. So, it needs further trails and multiplications to recommend the practice.

References

[1]. BBS. Bangladesh Bureau of Statistics, Statistical Year Book of Bangladesh, Ministry of Planning, Government of the People's Republic of Bangladesh. 2017.

[2]. Danesh TS, Mehrafarin A, Naghdi BH, Khalighi SF.Changes in growth and trigonelline/mucilage production of fenugreek)*Trigonella foenum-graecum* L.(under plant growth regulators application. Journal of Medicinal Plants. 2014;13)51(:15-25.

[3]. El-Adawy TA. Nutritional composition and antinutritional factors of chickpeas (*Cicer arietinum* L.) undergoing different cooking methods and germination. Plant foods for human nutrition. 2002;57(1):83-97. DOI: 10.1023/A:1013189620528.

[4]. Iqbal MZ, Shafiq M, Syed KA. Toxic effects of lead and cadmium individually and in combination on germination and growth of *Leucaena leucocephala* (Lam.) de wit. Pakistan Journal of Botany. 2001;33:551-557.

[5]. Jukanti AK, Gaur PM, Gowda CLL, Chibbar RN. Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): A review. British Journal of Nutrition. 2012;108(1):11-26. DOI: 10.1017/S0007114512000797.

[6]. Kathiresan G, Balasubramanian TN. Influence of growth regulatory substance on the germination of clip and single budded sets of different age cane. Cooperative Sugars. 1995;26:695-699.

[7]. Khan MR, Qureshi AS, Hussain SA. Biological Effects of Gamma Irradiation and its Modulation with Gibberellic Acid in M1 Generation of Chickpea (*Cicer arietinum* L.). Pakistan Journal of Biological Sciences. 2000;3:993-995. DOI: 10.3923/pjbs.2000.993.995.

[8]. Ma BL, Leibovitch S, Smith DL. Plant growth regulator effects on protein content and yield of chickpea (*Cicer arietinum*). Journal of Agronomy and Crop Science. 1994;72(1):9-18.

[9]. Mazid M. Seed priming application of gibberellic acid on growth, biochemical, yield attributes and protein status of chickpea (*Cicer arietinum* L. cv. DCP 92-3). International Journal of Genetic Engineering and Biotechnology. 2014;5(1):17-22.

[10]. Meera S, Poonam S. Response of growth regulators on some physiological traits and yield of chickpea (*Cicer arietinum*). Progressive Agriculture. 2010;10(2):387-388.

[11]. Nabi AJMN, Hawlader MHK, Hasan MM, Haque MZ, Rahaman ML. Growth and yield difference due to application of various levels of gibberellic acid in local and BARI falon-1. Progressive Agriculture. 2016;27)2(:94-100. DOI: 10.3329/pa.v27i2.29317.

[12]. Rahman MA, Nath KK. Effect of seed treatment of IAA and GA3 on sex expression, fruit character and yield of bottle gourd. Bangladesh Journal of Science. 1993;5(2):57-63.

[13]. Singh M, John SA, Rout S, Patra SS. Effect of GA_3 and NAA on growth and quality of garden pea)*Pisum sativum* L.) CV Arkel. The Bioscan. 2015;10)3(:381-383.

[14]. Singh M, Singh PK, Agrawal V. Effect of various levels of seed treatment and field spray on growth and seed yield of chickpea)*Cicer arietinum* L.(. The Journal of Rural and Agricultural Research. 2013;13)2(:57-59.

M. S. Reja, S. Sikder, *et. al.* "Effect of Gibberellic Acid (GA3) on Morpho-physiological Traits and Yield Performance of Chickpea (*Cicer arietinum* L.)." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 13(7), 2020, pp. 20-28.