J. Asiat. Soc. Bangladesh, Sci. 43(1): 49-60, June 2017

EFFECTS OF GIBBERELLIC ACID (GA3) ON GROWTH AND YIELD PARAMETERS OF FRENCH BEAN (PHASEOLUS VULGARIS L.)

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Abstract

A field study was conducted during the Rabi season of 2009-2010 in the research field of Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka. Six levels of GA_3, *viz*. 0, 30, 50, 70, 90 and 110 ppm were sprayed at 18 days after sowing (DAS). GA_3 treatments significantly increased plant height than the control plants. GA_3 with 30 to 90 ppm significantly increased number of branches and leaves, leaf area, leaf area index (LAI), leaf dry matter and total dry matter at different growth stages. GA_3 at 30 to 70 ppm gradually increased crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR) and declined advanced growth stages. Number of dry pods /plant, number of seeds /pod, 1000 seed weight, fresh fodder, fresh pod, dry seed yield and harvest index also significantly increased. Positive significant correlations were found among growth parameters and as well as yield contributing characters.

Key words: French bean, GA_3, LAI, NAR, yield, HI

Introduction

French bean is best known and widely cultivated as field crop. Its green pods and grains are consumed as vegetables and dry seeds as a pulse. Fresh leaves along with shoot also have fodder value. It is widely cultivated in tropical and subtropical region. In Bangladesh, it is grown in Sylhet, Chittagong, Chittagong Hill Tracts, Cox's Bazar and Comilla (Rashid 1999).

French bean plays a key role in crop rotation due to their ability to fix nitrogen through symbiotic association with bacteria, *Rhizobium* forms nitrogen fixing root nodules, which are agronomically significant (Burns and Hardy 1975). Some Kharif crops like Aus paddy HYV (mid March to August), jute, sun hemp, Lady's finger, bitter gourd, snake gourd, white gourd and sesame can easily cultivated as alternate crops (BBS 2011). It is a new crop in Bangladesh. The production quality of it is low in this country due to lack of modern agricultural practices.

Gibberellic acid (GA_3) is the most widely used plant growth regulator which increases stem elongation along with plant height, growth, dry matter accumulation as well as yield in various crops (Harrington *et al*. 1996, Akter *et al*. 2007 and Emongor 2007). However, very few works have been done on the application of GA_3 on French bean in Bangladesh (Noor 2014). Therefore, the present investigation was undertaken to study the effect of GA_3 on plant growth, dry matter and yield parameters of French bean.

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Materials and Methods

A field experiment was conducted in the Rabi season during the period from November 2009 to February 2010 at the research field of Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka. The field is located at latitude 23°44′23.3″ N and longitude 90°23′03.8″ E at altitude of 4 m above the sea level. The soil sample was tested at Soil Research and Development Institute (SRDI), Dhaka. The soil was a silty loam having pH 7.3, and low amount of chemical composition, *i*. e., 1.05% organic matter, including 0.056% total N, 10.17, 3.1and 0.25 meq/100g soil Ca, Mg and K respectively. Other elements like P, S B, Cu, Fe, Mn and Zn were 20.9, 10.3, 0.27, 5.7 ,147.6, 76.1and 3.1 µ.g/g soil respectively. Based on the organic and elemental condition N, P, K, S and B were applied at the rate of 90, 35, 30, 10 and 1Kg /ha in the form of urea, triple super phosphate, muriate of potash, gypsum and borax, respectively as per the recommendation of Fertilizer Recommendation Guide (2005). Among these fertilizers, P, B and S were applied entirely as basal doses. One third of N and K were applied as basal doses, rest two third were added as top dressing at 20 and 40 days after sowing (DAS), respectively. Furrow irrigation was given at an interval of 7 days. Thinning and weeding were done at an interval of 10 days.

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 2.0 m × 1.5 m. Seeds of French bean cv. BARI bush bean-1 were sown on 15 November, 2009. The distance between line and seed were 30 and 15 cm, respectively. The six treatments applied were as follows; Control (distilled water spray) and 30, 50, 70, 90 and 110 ppm GA_3. The treatments were applied as foliar spray at 18 DAS.

Ten plants selected at random were cut at the above ground level. Data on growth parameters were collected at 5 different growth stages, *i.e*. 18, 28, 38, 48 and 58 DAS for 4 leaves, budding, flowering, pod setting and pod filling, respectively. Leaf area index (LAI) was calculated by the formula of Hunt (1981). Whole aerial parts of plants were oven dried at 70°C till constant weight and then the dry weights were taken and used as leaf dry matter and total dry matter (TDM). CGR, NAR and RGR were calculated according to Brown (1984) and Radford (1967), respectively. Young pods from 10 sampled plants of each treatment was collected from 48 to 68 DAS at an interval of 7 days for measurement of fresh pod yield/plant. After harvesting of pods at 68 DAS, the remaining whole green shoot along with leaves were harvested for fresh fodder yield/plant. Number of dry pods/plant, number of seeds/pod, seed yield/plant and harvest index (HI) were measured from the demarcated areas according to Ullah (2006) and Noor (2014). Data were statistically analyzed by Duncan's Multiple Range Test (DMRT) and LSD test at 5% level of significance (Gomez and Gomez 1984).

Results and Discussion

The height of French bean (cv. BARI bush bean 1) plant treated with GA_3 significantly increased. The magnitude of increase of plant height was found to be more pronounced in treatment with 50 ppm GA_3, followed by 70 to 110 ppm of the same (Table 1). At 58 DAS, the highest plant height, 59.40 cm was recorded for 50 ppm GA_3, whereas the lowest plant height 38.67 cm was found for the control.GA_3 enhances growth activities of plant, stimulates the rate of cell division, cell elongation, and thus, also contributes to internode and stem elongation (Taiz and Zeiger 2002). The results of the present study are in agreement with those of mustard plant reported by Akter *et al*. (2007). They recorded the highest plant height (95.77 cm) with the application of 50 ppm GA_3, which was statistically similar to 75 ppm GA_3 treatment and, the lowest (77.63 cm) was found for the control.

Table 1. Effects of GA_3 on plant height (cm) and number of leaves/plant of French bean at different growth stages.

Treatments	Plant height (cm)					Number of leaves/plant				
	Days after sowing (DAS)					Days after sowing (DAS)				
	18	28	38	48	58	18	28	38	48	58
Control	9.97c	25.30c	34.63c	36.73c	38.67d	4.000	9.00b	10.33c	11.33c	10.33c
30 ppm GA_3	10.05b	33.10b	43.63b	48.63b	51.17c	4.000	10.00a	11.67ab	12.67b	12.00b
50 ppm GA_3	10.06a	45.43a	56.40a	57.90a	59.40a	4.000	10.33a	12.00a	14.00a	13.00a
70 ppm GA_3	10.05b	45.47a	56.33a	57.62a	59.04a	4.000	10.00a	11.67ab	13.00ab	12.00b
90 ppm GA_3	10.05b	45.47a	56.30a	57.50a	58.93a	4.000	9.67ab	11.67ab	12.67b	11.67b
110 ppm GA_3	10.05b	45.50a	56.27a	57.23a	57.80b	4.000	9.67ab	11.00bc	12.33bc	11.67b
LSD (0.05)	0.00	0.53	1.88	0.92	0.34	0.00	0.24	0.32	0.56	0.24
CV (%)	0.31	20.58	17.41	15.34	14.24	0.00	5.61	6.13	7.66	7.46

*Mean in a vertical column followed by same letter do not differ significantly at 5% level.

A gradual increase in number of leaves was observed from 18 to 48 DAS and thereafter it was found to decline for all treatments (Table 1). The maximum number of leaves per plant was recorded for 50 ppm GA_3, followed by 70 and 30 ppm. 50 ppm GA_3 treated plants produced 14.81, 16.13, 23.53 and 25.81% more leaves per plant compared to those of the controls at 28, 38, 48 and 58 DAS, respectively. Similarly, Sarkar *et al*. (2002) observed that GA_3 at 100 ppm concentration in treated soybean plants produced higher number of leaves at the later stages of 60 and 80 DAS. It might be due to GA_3 promote cell enlargement and cell division that enhance plant height, number of branches and number of leaves.

Number of branches /plant gradually increased from 18 to 48 DAS and reached a steady condition (Fig. 1). GA_3 with 30 to 110 ppm concentrations significantly increased number branches per plant at 28 to 48 DAS. The highest number of branches per plant was obtained for 50 ppm GA_3 treated plants, which was 21.43 to 23.08 % more at 28 to 48 DAS over the control. The results were in consonance with the works of Abdul *et al*.

(1988) who noticed significantly increased number of branches per plant by increasing the concentration of GA_3 (50 to 100 ppm) in pepper.

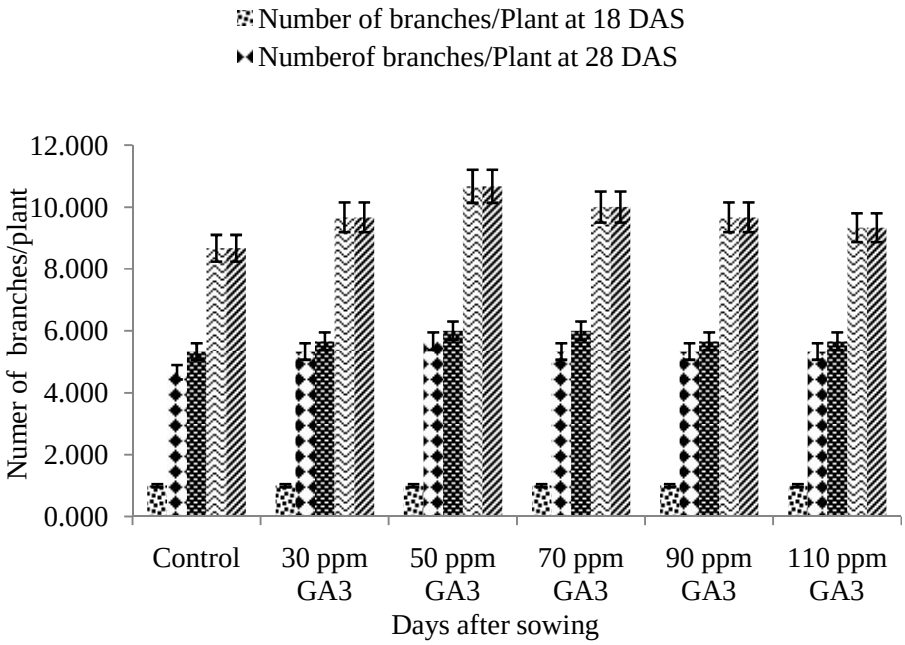

Fig. 1. Effects of GA_3 on number of branches /plant of French bean at different growth stages.

Results presented in Table 2 revealed that leaf area gradually increased from 18 to 48 DAS for all the treatments. Leaf area significantly increased over the control following all the GA_3 treatments at different growth stages. 50 ppm GA_3 increased the leaf area by 22.66, 31.17, 22.88 and 22.67% over those of the control at 28, 38, 48 and 58 DAS, respectively.

Results presented in Table 2 revealed that leaf area gradually increased from 18 to 48 DAS for all the treatments. Leaf area significantly increased over the control following all the GA_3 treatments at different growth stages. 50 ppm GA_3 increased the leaf area by 22.66, 31.17, 22.88 and 22.67% over those of the control at 28, 38, 48 and 58 DAS, respectively.

Leaf area index (LAI) varied from 1.27 to 1.56, 2.52 to 3.31, 2.81 to 3.45 and 2.68 to 3.28 at 28, 38, 48 and 58 DAS, respectively (Table 2). Among the treatments, 50 ppm GA_3 showed significantly highest LAI, whereas the lowest was found for the control. GA_3 induced higher leaf area and LAI were reported in tomato plants (Khan *et al*. 2006) and in rice plants (Liu *et al*. 2012).

Table 2. Effects of GA_3 on Leaf Area (cm^2/plant) and Leaf Area Index (LAI) of French bean at different growth stages.

Treatments	Leaf Area (cm^2/plant)					Leaf Area Index (LAI)				
	Days after sowing (DAS)					Days after sowing (DAS)				
	18	28	38	48	58	18	28	38	48	58
Control	81.80	572.33f	1134.89f	1263.67f	1204.67f	0.18	1.27f	2.52e	2.81f	2.68f
30 ppm GA_3	81.81	632.19c	1277.57c	1442.79c	1403.46c	0.18	1.41c	2.84c	3.21c	3.12c
50 ppm GA_3	81.82	702.00a	1488.62a	1552.75a	1477.75a	0.18	1.56a	3.31a	3.45a	3.28a
70 ppm GA_3	81.81	657.44b	1356.59b	1480.82b	1417.82b	0.18	1.46b	3.02b	3.29b	3.15b
90 ppm GA_3	81.81	618.86d	1266.66d	1393.19d	1334.19d	0.18	1.38d	2.82c	3.10d	2.97d
110 ppm GA_3	81.81	607.52e	1255.00e	1334.52e	1295.19e	0.18	1.35e	2.79d	2.97e	2.88e
LSD (0.05)	0.00	26.30	53.50	43.17	41.64	0.00	0.0001	0.0003	0.0002	0.0002
CV (%)	0.01	6.63	8.56	6.91	6.80	0.00	6.63	8.56	6.91	6.80

*Mean in a vertical column followed by same letter do not differ significantly at 5% level.

Results presented in Table 3 showed that leaf dry matter gradually increased from 18 to 58 DAS. GA_3 significantly increased leaf dry matter from 17.61 to 40.65% at 58 DAS in comparison to the control. Among the treatments, GA_3 at 50 ppm level produced the highest leaf dry matter. For 50 ppm GA_3 treatment, the leaf dry matter was found to increase by 36.24, 50.50, 44.00, and 40.65 % over those of the control at 28, 38, 48 and 58 DAS, respectively. These findings are in agreement with those reported by Ali *et al*. (2012) for *Hibiscus sabdariffa* L. where application of GA_3 increased the shoot and root dry weight compared to other treatments.

Total dry matter was found to increase gradually by GA_3 from 18 to 58 DAS (Table 3). All the GA_3 treatments significantly increased it at 28, 38, 48 and 58 DAS. The highest total dry matter of 36.15 g/plant was obtained for 50 ppm GA_3, whereas, the lowest of 21.19 g/plant was found for the control at 58 DAS. GA_3 at 50 ppm increased the total dry matter by 35.71, 51.37, 60.99 and 70.61 % over the control at 28, 38, 48 and 58 DAS, respectively and it was found to be significantly different from all other treatments. These results are more or less similar to the findings of Akter *et al*. (2007), who observed a significant variation in total dry matter due to the application of different levels of GA_3 in mustard. The exogenous application of GA_3 increased growth parameters like plant height, number of branches, number of leaves, leaf area, leaf dry matter, and along with total dry matter.

Table 3. Effects of GA_3 on Leaf dry matter (g/plant) and total dry matter (g/plant) of French bean at different growth stages.

Treatments	Leaf dry matter (g/plant)					Total dry matter (g/plant)				
	Days after sowing (DAS)					Days after sowing (DAS)				
	18	28	38	48	58	18	28	38	48	58
Control	0.289b	3.132f	6.418e	7.624e	5.746d	0.765	4.21d	9.38f	16.37f	21.19f
30 ppm GA_3	0.292a	3.347c	7.051c	8.375c	7.570b	0.769	4.53c	10.52c	19.09c	25.46c
50 ppm GA_3	0.292a	4.267a	9.659a	10.979a	8.082a	0.771	5.71a	14.20a	26.36a	36.15a
70 ppm GA_3	0.292a	3.486b	7.446b	8.781b	7.599b	0.770	4.73b	11.19b	20.31b	27.52b
90 ppm GA_3	0.292a	3.298d	6.932d	7.901d	7.066c	0.768	4.44c	10.32d	18.38d	24.47d
110 ppm GA_3	0.292a	3.261e	6.929d	7.897d	6.758c	0.768	4.39c	10.19e	17.91e	23.74e
LSD (0.05)	0.000	0.000	0.000	0.002	0.065	0.000	0.01	0.00	0.00	0.01
CV (%)	0.394	11.098	14.608	13.551	11.099	0.260	10.96	14.46	16.63	18.48

*Mean in a vertical column followed by same letter do not differ significantly at 5% level.

Data from Table 4 showed that Crop growth rate (CGR) gradually increased from 18 – 28 to 38- 48 DAS and thereafter decreased in advanced growth stages. The highest CGR was registered for 50 ppm GA_3, followed by 70 ppm GA_3, and these were significantly different from all other treatments. However, the lowest was found for the control. It was found to significantly increased by 43.46, 64.10, 73.92 and 103.31 % for 50 ppm GA_3 in comparison with the control at 18 - 28, 28 - 38, 38 - 48 and 48 - 58 DAS, respectively. The data on net assimilation rate (NAR) was highest at 18 – 28 DAS, and thereafter started to decrease in advanced growth stages (Table 4). NAR was found to be highest for 50 ppm GA_3 among all the treatments and increased significantly by 25.38, 28.86, 37.06 and 65.60 % over the control.

Table 4. Effects of GA_3 on crop growth rate ($g/m^2/day$), net assimilation rate ($g/m^2/day$) and relative growth rate (g/g/day) of French bean at different growth stages.

Treatments	Crop growth rate ($g/m^2/day$)				Net assimilation rate ($g/m^2/day$)				Relative growth rate (g/g/day)			
	Days after sowing (DAS)				Days after sowing (DAS)				Days after sowing (DAS)			
	18-28	28-38	38-48	48-58	18-28	28-38	38-48	48-58	18-28	28-38	38-48	48-58
Control	7.65d	11.50e	15.53f	10.70f	13.65c	6.30c	5.83f	3.90d	0.170d	0.080c	0.056d	0.026e
30 ppm GA_3	8.36c	13.30c	19.06c	14.14c	13.97bc	6.53b	6.32c	4.47c	0.177c	0.084b	0.060b	0.029c
50 ppm GA_3	10.98a	18.87a	27.00a	21.76a	17.12a	8.12a	7.99a	6.46a	0.200a	0.091a	0.062a	0.032a
70 ppm GA_3	8.80b	14.36b	20.27b	16.01b	14.33b	6.70b	6.43b	4.97b	0.181b	0.086b	0.060b	0.030b
90 ppm GA_3	8.16c	13.07cd	17.91d	13.54d	13.83bc	6.51bc	6.06d	4.47c	0.176c	0.084b	0.058c	0.028d
110 ppm GA_3	8.06c	12.89d	17.15e	12.96e	13.83bc	6.50bc	5.96e	4.44c	0.174c	0.084b	0.056d	0.028d
LSD (0.05)	0.06	0.06	0.004	0.03	0.16	0.02	0.001	0.003	0.000	0.000	0.000	0.000
CV (%)	13.08	17.20	19.40	24.02	8.82	9.39	11.63	17.46	5.584	4.443	3.932	6.599

*Mean in a vertical column followed by same letter do not differ significantly at 5% level.

Relative growth rate (RGR) was found to range from 0.170 - 0.200, 0.080 - 0.091, 0.056 - 0.062 and 0.026 - 0.032 g/g/day at 18 - 28, 28 - 38, 38 - 48 and 48 - 58 DAS, respectively (Table 4). The highest RGR were observed for 50 ppm GA_3 treated French bean plants at all the growth stages, which were significantly different from all other treatments. GA_3 at 50 ppm increased it by 17.42, 13.75, 10.71 and 23.08 % over the control at 18 - 28, 28 - 38, 38 - 48 and 48 - 58 DAS, respectively. These were found to be in agreement with the results in a number of crops where CGR, NAR and RGR are increased in early growth and juvenile stages and thereafter began to decline. Maske *et al*. (1998) reported that for soybean GA_3 effectively increased CGR from 30 - 45 to 45 - 60 DAS and enhanced the yield contributing components. They also reported that the foliar application of GA_3 at 30 DAS had the most regulatory effect in increasing root, stem, leaf and total dry matter, LAI, CGR, RGR and NAR in soybean (cv. PB - 1). Sarkar *et al*. (2002) reported that soybean plants treated with GA_3 significantly increased CGR, RGR and NAR at 60 DAS compared to the control. Similarly, GA_3 treatments (50 - 200 ppm) on either seeds or leaves increased TDM, LAI, RGR and NAR (Rahman *et al*. 2004).

Fresh fodder yield /plant varied from 56.20 to 73.40 g (Table 5). Significantly highest fodder yield/plant was recorded for 50 ppm GA_3 and the increase was 30.61% over the control. On the other hand, the lowest value was found for the control plants. GA_3 increased vegetative growth which can be used as fodder (Emongor 2007, Sarkar *et al*. 2002, Rahman *et al*. 2004, Azizi *et al*. 2012 and Liu *et al*. 2012).

Table 5. Effects of GA_3 on yield attributes of French bean .

Treatments	Fresh fodder yield/plant (g)	Number of dry pods/plant	Number of seeds/ pod	1000 seed weight (g)	Fresh pod yield/plant (g)	Seed yield/plant (g)	Harvest index (%)
Control	56.20f	12.40d	5.81b	213.50d	69.26e	13.22d	54.18c
30 ppm GA_3	66.67c	14.00c	6.00a	232.27b	123.35c	17.60bc	60.55ab
50 ppm GA_3	73.40a	16.23a	6.10a	235.47a	158.37a	20.87a	63.76a
70 ppm GA_3	70.60b	14.62b	6.02a	232.58b	130.41b	18.60b	62.00a
90 ppm GA_3	62.67d	13.90c	6.00a	227.15c	117.63d	16.86c	59.82b
110 ppm GA_3	58.47e	13.90c	5.97a	216.37c	115.53d	16.65c	59.77b
LSD (0.05)	0.02	0.10	0.10	2.7	6.89	0.841	1.96
CV (%)	9.84	7.35	1.53	3.78	22.88	10.98	4.11

*Mean in a vertical column followed by same letter do not differ significantly at 5% level.

It was observed that number of dry pods per plant ranged from 12.40 to 16.23 (Table 5). It was significantly higher for 50 ppm GA_3 (16.23), followed by 70 ppm GA_3 (14.62) and 30 ppm GA_3 (14.00). Number of dry pods per plant increased by 12.07 to 30.88 % over the control following different GA_3 treatments. Enhanced number of fruits /plant due to GA application were reported by Sarkar *et al*. (2002) in soybean and Khan *et al*. (2006) in tomato.

Number of seeds per pod was highest for 50 ppm GA_3 which was statistically at par with 70, 30, 90 and 110 ppm GA_3 (Table 5). These results are in agreement with those of Akter *et al*. (2007), who reported that number of seeds per siliqua was significantly influenced by different levels of GA_3 treatments and, the highest number of seeds/siliqua was obtained for 50 ppm GA_3.

Thousand seed weight ranged from 213.50 to 235.47 g (Table 5). Significantly maximum 1000 seed weight was registered for 50 ppm GA_3 which was 10.29% higher compared to the control. It was found that all the GA_3 treatments significantly increased 1000 seed weight, which is in agreement with the studies of Emongor (2007) for cowpea and Tiwari *et al*. (2011) for rice.

Data from Table 5 showed that fresh pod yield /plant ranged between 69.26 and 158.37g and the maximum was recorded due to 50 ppm GA_3. All the GA_3 treatments significantly increased fresh pod yield/plant by 66.82 to 128.67% compared to the control. Significant increase of fruit yield in many crops due to the application of different concentrations of GA_3 was reported by many investigators *viz.* Hye *et al*. (2002) in onion and Khan *et al*. (2006) in tomato. This might be due to an inhibition of vegetative growth and thus making available the food reserves for developing fruits, which was evident from the significantly increased number of pods per plant and fresh pod yield of French bean.

Seed yield /plant ranged from 13.22 to 20.87 g (Table 5). Significantly the highest seed yield/plant was obtained from 50 ppm GA_3 followed by 70 ppm. That GA_3 with different concentrations significantly enhanced the seed yield in many crops were reported by a number of researchers *viz.* Sarkar *et al*. (2002) for soybean and Tiwari *et al*. (2011) for rice. GA_3 may induce the development of xylem and phloem and in turn, increase the flow and deposition of assimilation products in seeds (Secer 1989).

Harvest index (HI) varied from 54.18 to 63.76 % (Table 5). All the GA_3 treatments significantly increased HI by 10.31 to 17.68% where 50 ppm GA_3 treated plants produced maximum over the control. Positive influences of GA_3 on HI was reported by Emongor (2007) for cowpea .

The results of correlation study showed that there were positive and significant correlations among growth and yield parameters of French bean (Table 6). The ‘r’ values of LAI, CGR, NAR, fresh pod yield/plant and fresh fodder yield/plant with TDM were 0.902**, 0.999**, 0.948**, 0.881**and 0.876**, respectively. And the ‘r’ values of LAI, TDM, CGR, NAR and fresh fodder yield/plant with fresh pod yield/plant were 0.939**, 0.881**, 0.875**, 0.741** and 0.881**, respectively.

Positive correlation among yield parameters like number of seeds/pod, 1000 seed weight, seed weight /plant and seed yield/ha were reported by Ullah *et al*. (2007) in cowpea and Azizi *et al*. (2012) in soybean. Hasanuzzaman *et al*. (2007) found positive relationship among plant height, number of branches /plant, number of pods /plant, 1000 - seed weight and yield of chickpea.

Table 6. Correlation among leaf area index (LAI), total dry matter (TDM), crop growth rate (CGR), net assimilation rate (NAR), fresh pod yield/plant, fresh Fodder yield/plant.

Parameters	Leaf Area Index at 48 DAS	Total Dry Matter at 58 DAS	Crop Growth Rate at 38-48 DAS	Net Assimilation Rate at 18- 28 DAS	Fresh pod yield/plant	Fresh fodder yield/plant at 68 DAS
Leaf Area Index at 48 DAS	1	0.902 **	0.908 **	0.753 **	0.939 **	0.986 **
Total Dry Matter at 58 DAS		1	0.999 **	0.948 **	0.881 **	0.876 **
Crop Growth Rate at 38-48 DAS			1	0.945 **	0.875 **	0.885 **
Net Assimilation Rate at 18- 28 DAS				1	0.741 **	0.730 **
					**	**
Fresh Pod yield/plant					1	0.881 **
Fresh fodder yield/plant at 68 DAS						1

** Significant at 1 % level.

The regression value of R^2= 0.9628, showed that there was a significant, positive and linear relationship between number of dry pods/plant and seed yield/plant (Fig. 2). Moreover, significant, positive and linear relationship (R^2= 0.9685) was found between harvest index (HI) and seed yield/plant (Fig. 3). Similar trend was reported by Hasanuzzaman *et al*. (2007) in chickpea. Linear regression with positive significant relationship for yield and GA_3 concentrations in cowpea was reported by Emongor (2007).

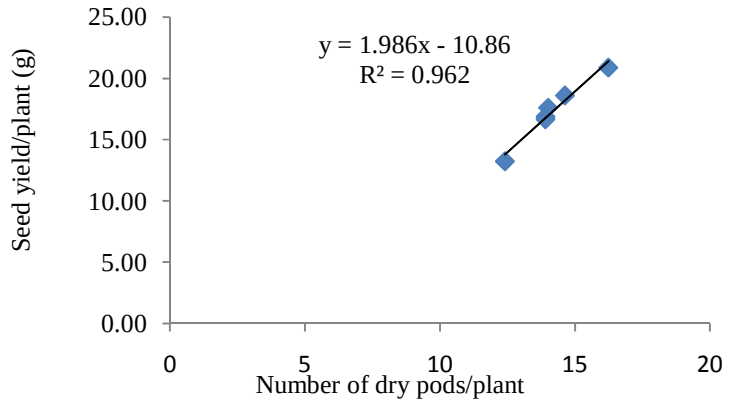

Fig. 2. Relationship between seed yield /plant and seed yield/plant of French bean.

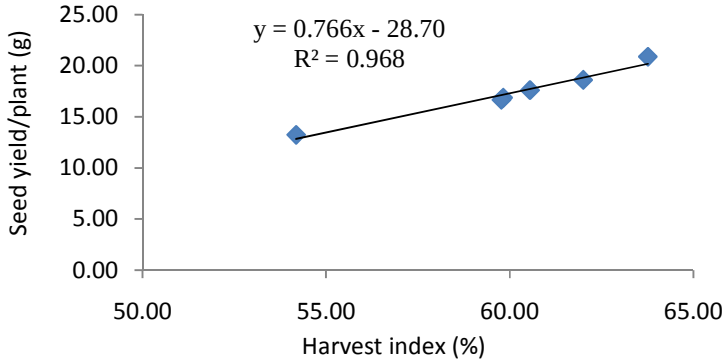

Fig. 3. Relationship between seed yield /plant and harvest index (%) of French bean.

From the results of the study it is apparent that GA_3 had significant effect on growth and yield parameters of French bean. GA_3 at 50 ppm was found to be optimum concentration for the highest growth and yields (fresh pod, dry seed and fodder yield /plant) of French bean.

Acknowledgements

The authors would like to acknowledge the financial support given by the University Grant Commission (UGC fellowship), Bangladesh, for this research. Gratitude and thanks are also to the Chairman, Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, for providing research field, technical and laboratory support.

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(Revised copy received on 1/2/2017)