Effects of the Application of Combination Treatments of Growth Regulators on Physiological and Pigments Parameters of French Bean (Phaseolus Vulgaris L.)

Ferdowsi Noor*

Abstract: The experiment was carried out to study the physiological parameters and leaf pigments amount of French bean (Phaseolus vulgaris L.) cv. BARI bush bean 1. The study includes seasonal experiment using growth regulators, GA_3 and NAA of different concentrations of nine combination treatments, *viz*., T1 (10 ppm GA_3 + 10 ppm NAA), T2 (20 ppm GA_3 + 20 ppm NAA), T3 (30 ppm GA_3 + 30 ppm NAA), T4 (10 ppm GA_3 + 30 ppm NAA), T5 (30 ppm GA_3 + 10 ppm NAA), T6 (10 ppm GA_3 + 40 ppm NAA), T7 (40 ppm GA_3 + 10 ppm NAA), T8 (10 ppm GA_3 + 50 ppm NAA) and T9(50 ppm GA_3 + 10 ppm NAA) with distilled water as T0 (control). In general, plant height continued to increase up to pod filling stage (18 to 58 DAS) and then reached a steady state. The highest plant height (54.23 cm) was recorded from T2 (20 ppm GA_3+20 ppm NAA). Irrespective of treatments, the total dry matter (TDM) accumulation in French bean started slowly at the beginning of crop growth (18 to 28 DAS) and thereafter it began to increase rapidly, and the trend continued up to maturity. The highest total dry matter was recorded for T2. The partitioning of dry matter into different plant parts indicated that dry matter of the main stem, petiole and lamina increased up to 48 DAS and after that began to decrease. The pod dry matter contributed the highest percentage of 58.35 % to the total dry matter at 58 DAS growth stage. The decrease of dry matter due to main stem, petiole and lamina were 14.18, 15.19 and 18.53 % respectively after 48 DAS. The translocation of photo assimilates and metabolites increased the weight and number of the pods at the maturity stage. The different combination treatments significantly increased leaf area, LAI, TDM, CGR, NAR and RGR. The highest days to 90% flowering, pod setting and maturation were

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found in T8 whereas the lowest were observed in T9 treatment. All the treatments significantly increased total chlorophyll and carotenoids content.

Keywords: TDM, LAI, CGR, NAR , RGR , Pigments, DAS.

1. Introduction

French bean is a widely cultivated field crop. There are many different varieties of French bean, which are popular for their different qualities[1]. Some varieties are grown for pods, whereas some are grown for seeds. Its tender leaves are occasionally used as leaf vegetables and the straw used as forage. It is a leguminous crop. Its green pods and grains are consumed as vegetables and dry seeds as a pulse (dal) like black eyed beans, Lima beans and Toor or pigeon peas and other pulse crops. It is an important crop food containing high protein and essential amino acids. Protein from beans and seeds are easily transportable and absorbed in human body than animal proteins. French bean is a major source of dietary protein in South America and many other third world countries as it is easily available and cheaper in price than the animal sources. It plays a key role in crop rotation, to improve cropping system and soil fertility because of their ability to fix nitrogen through symbiotic association with bacteria, *Rhizobium leguminosarum*. After harvesting French bean, some Kharif crops like Aus paddy HYV, jute, sun hemp, Lady's finger, bitter gourd, snake gourd, white gourd and sesame can easily be cultivated as alternate crops[2].

In Bangladesh, total population is increasing rapidly but there is no parallel increase in the area of pulse cultivation. Considering the cultivable areas, pulse crop area (3.30 %) was the third major cropping area after rice and wheat which were 75.40 and 5.80 %, respectively[2].

Different varieties of French beans have low fat and 20 to 25% protein by dry weight, which is double the protein content of wheat and three times that of rice[3].

The nutrition status of Bangladeshi people has become unbalanced. In order to meet the balance diet for increasing population, it is urgent to select a high yielding variety of food crop such as French bean and judiciously application of growth regulators, which can increase yield of fresh bean and dry seed. Plant growth regulators (PGRs), natural or synthetic are biochemical substances, which control the physiological functions of plants at a site remote from its place of production and are active in minute amounts[4]. Five major groups of phytohormones are generally used in higher plants.

Amongst them, the auxins, gibberellins and cytokinins are plant growth promoters, whereas abscisic acid and ethylene are plant growth retardants. The PGRs in specific doses have a great potential for growth, development and yield of crops. Specific application of some growth regulators increase the vegetative growth, photosynthetic area and pigments, decreases the abscission of flowers and immature pods and consequently maximizes the total yield of crops. There are many synthetic growth regulators (SGRs) such as, NAA, Cycocoel (CCC), IBA, Potassium naphthaenate (Knap) which also have great impact on the biochemical processes of crops and improve the quality of yield and the physiological processes that give the maximum crop yield .

Most PGRs applied exogenously are known to change endogenous occurring hormones level to modify the physiological processes, like seed germination, nutrient uptake from soil, photosynthesis, respiration, flowering, pod setting, partitioning of assimilates, defoliation, postharvest ripening, crop yield and growth retardants[5]. It is now well established that application of different growth regulators in crop field help to increase both vegetative and reproductive parameters as well as biochemical properties of crop plants[6,7,8]. It also helps to increase the nutritive qualities of the edible portions (fruits and seeds) of the cultivated species. The PGRs act at the gene level, profoundly stimulate the transcriptional and translational mechanisms of protein synthesis. It increases the level of mRNA, tRNA and rRNA, which played an important role to enhance protein synthesis in bush bean plant. Crop yield was determined to be correlated with some biochemical parameters of seed[9]. The PGRs must be used in specific concentration at specific ontogenic stage. A large number of PGRs are environment friendly and some amongst them are easily available in the local market at a cheap price. They have now become popular[10]. They are used at very low concentration and are not harmful for human health. If the PGRs are used extensively in crops then the price will come down.

In the late 1950s, plant physiologists applied gibberellic acid to a wide range of crops. It promotes cellular elongation by synthesizing enzymes and controlling the effect of inhibitors. It stimulates seed germination and breaks seed dormancy. It also develops parthenocarpic fruit and induces maleness in flower. GA^3 application resulted in bolting and flowering to the environmentally limited rosette form of cabbage and spinach[11,12]. It increased plant height by shoot elongation and removed genetic dwarfism in maize[13]. Gibberellins stimulate to produce α - amylase and protease, which digest the starchy endosperm and help in germination. GA^3 applied on many crops and

was found to have increased internodal length, plant height, as well as yield and protein contents.

Naphthalene acetic acid (NAA) is one kind of synthetic auxin, which plays an important role in stimulating cellular elongation in shoot, apical bud dominance and root initiation. It has been used to prevent abscission in apple and pear, inducing respiration and parthenocarpic fruit in banana, orange, tomato, apple, pineapple and cucumber, thinning of different fruits like pear and peaches, delaying break of grape bud, changing sex of cucurbits, and also stimulating protein[14]. NAA was found to influence vegetative, reproductive growth, yield attributes and biochemical parameters in a number of crops[15,16,17,18]. There are many works on physiological, biochemical and yield attributes of different crops applying single dose of PGRs. Whereas, the works on combination of PGRs are rare. However, the objectives of the study are as follows,

1. To study the physiological activities of French bean;
2. To determine the total chlorophyll and carotenoids content of French bean;

Materials And Methods

Experiment was conducted at the research field of Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka on the 15 November 2009. The field is located at latitude 23°44′23.3″ N and longitude 90°23′03.8″ E. The field is moderately high land and well drained. The climatic condition of the site is subtropical in nature. Most of the rainfall occurs during the period of June to September. During the Rabi seasons covered by the present experiments, the crop received the following total rainfall of 8.1 mm in 2009 – 2010. Seeds were sown at the rate of 60 kg/ha with a spacing of 30 cmx15 cm having a depth of about 3.0 cm[19]. The seeds were covered with pulverized soil just after sowing and pressed gently with hand. Then the plots were slightly watered to provide sufficient moisture in the soil for quick germination.

Furrow irrigation was given at an interval of 7 to 10 days depending on soil moisture content. Excess water was drained out immediately after irrigation. Four days after irrigation, soil was loosened by spade. Thinning and weeding were done at an interval of 10 days. Thinning of seedling was done by discarding the seedlings with uneven growth at each plot. The plot was kept weed free using Nirani, a local weeding tool. The crop was protected from the attack of aphids, which are the vectors of virus, by spraying Malathion 57 EC at 2ml/L as recommended by BARI[20]. Gibberellic acid (GA_3) and naphthalene acetic acid (NAA) were applied at 18 DAS (Days After

Sowing) at 4 leaves stage as foliar spray. The required concentrations of GA_3 and NAA for application were obtained by diluting with distilled water. The both stock of 5000 ppm was used for preparing treatment solution.

Application of treatments

Both GA_3 and NAA growth regulators were applied as foliar spray at 18 DAS. The foliage of the crop was sprayed with the respective treatments of growth regulators till drip with a manual spray machine. During spraying each plot was separated by a thick polythene sheet in order to prevent a particular treatment given to a plot crossing over the other plots. Control plants were sprayed with distilled water only. During Rabi season 2009 – 2010, the experiment were consisted of ten treatments which were as follows: To (Control: Distilled water spray), T1 (10 ppm GA_3+10 ppm NAA), T2(20 ppm GA_3+20 ppm NAA), T3 (30 ppm GA_3+30 ppm NAA), T4(10 ppm GA_3+30 ppm NAA), T5 (30 ppm GA_3+10 ppm NAA), T6 (10 ppm GA_3+40 ppm NAA), T7 (40 ppm GA_3+10 ppm NAA), T8 (10 ppm GA_3+50 ppm NAA) and T9 (50 ppm GA_3+10 ppm NAA).

Data collection for experiment

Ten plants of each treatment with three replications were taken from the rows of each plot for collecting data. The plant parts were oven dried separately at 70°C till constant weight. The dried separated plant parts were weighed by an automatic digital balance (SCALTEC SPB31) and then averaged. The CGR value was calculated according to the formula of Brown [21] which was as follows:

$$CGR\ (g/m^2/day) = (W2 - W1)/(T2 - T1)) \times 1/GA$$

Where,

W1= Weight of dry matter (g) per plant at time T1

W2= Weight of dry matter (g) per plant at time T2

GA = Ground area (m^2).

The relative growth rate (RGR) of a plant is the increase in dry matter per unit of material present per unit of time and is calculated by the following formula of Radford [22].

$$RGR\ (g/g/day) = ((LnW2 - LnLA1))/((T2 - T1))$$

Net assimilation rate (NAR) is the dry matter accumulation per unit of leaf area per unit of time. NAR was measured by the formula given by Radford[22] .

$NAR\ (g/m^2/day) = (LnLA2 - LnLA1)/(LA2 - LA1)\times(W2 - W1)/(T2 - T1)$

Where,

LA1 = Leaf area (cm2) per plant at time T1

LA2 = Leaf area (cm2) per plant at time T2

W1= Weight of dry matter (g) per plant at time T1

W2 = Weight of dry matter (g) per plant at time T2

Ln = Natural logarithm.

The amount of chlorophyll a and b were calculated by using specific absorption coefficient method of McKinney[23] and the formula of Maclachalan and Zalik[24]. The amount of carotenoid was determined by the equation of Von Wettstein[25].

Statistical analysis

Data were subjected to analysis of variance in all experiments to determine significance of growth regulator treatments. Treatment means for all parameters were compared by co - efficient of variation (CV %) and Least Significant Difference (LSD) at 5% level of significance were done according to Gomez and Gomez[26].

Results and discussion

Plant height

In 2009 - 2010 Rabi season, plant height ranged from 38.67 to 54.23 cm at 58 DAS (Table 1). The highest plant height was recorded for T2 (20 ppm GA_3+20 ppm NAA) while the lowest was for the control (T0). Number of branches per plant Among the combination treatments, T1, T5 and T6 treated plants produced highest number of branches per plant (10.67). On the other hand, lowest number was obtained for T0 (8.67) at 28 to 58 DAS (Table 2). Number of leaves per plant In the case of combination treatments, the highest number of leaves per plant (12.67) was found for the T2 .and T7 treated plants (Figure 1). The lowest number was found for T0 and T4 at all growth stages except at 18 DAS.

Table 1. Effect of GA3 and NAA on plant height (cm) of French bean (Phaseolus vulgaris L.) cv. BARI bush bean - 1 at different growth stages.

Treatments	18 DAS	28 DAS	38 DAS	48 DAS	58 DAS
T_o	9.97	25.30	34.63	36.73	38.67
T_1	10.00	28.67	41.17	42.68	43.05
T_2	10.06	35.97	45.87	51.20	**54.23**
T_3	10.05	34.90	43.79	48.73	51.27
T_4	10.04	31.69	43.20	46.53	48.33
T_5	10.05	35.27	44.13	49.67	52.40
T_6	10.06	35.80	45.56	50.21	53.47
T_7	10.06	35.89	45.82	50.82	54.10
T_8	10.06	35.67	44.20	49.80	52.47
T_9	10.06	35.77	44.90	50.13	53.17
LSD (0.05)	NS	1.09	1.87	1.70	1.63
CV %	0.27	16.97	13.41	11.74	11.38

***Means in a column followed by the same letter do not differ significantly at 5% level;**

Leaf area /plant

Among all the treatments, leaf area /plant ranged from 1204.67 to 1436.02 cm2/plant (Figure 2).

It was highest for T2 and lowest for T0 at 58 DAS which was 19.20% more than that of the control.

Leaf area index (LAI)

Table 3 shows that leaf area index (LAI) was maximum for T2 (3.191) and minimum for T0 (2.677).

Table 2. Effect of GA_3 and NAA on number of branches per plant of French bean (*Phaseolus vulgaris* L.) cv. BARI bush bean - 1 at different growth stages.

Treatments	18 DAS	28 DAS	38 DAS	48 DAS	58 DAS
T_o	1.00	4.67	5.33	8.67	8.67
T_1	1.00	4.67	5.33	9.00	10.67
T_2	1.00	5.67	6.00	10.67	9.67
T_3	1.00	5.33	6.00	9.67	9.33
T_4	1.00	4.67	5.33	9.33	10.33
T_5	1.00	5.33	6.00	10.00	10.67
T_6	1.00	5.33	6.00	10.67	10.67
T_7	1.00	5.67	6.00	10.67	10.33
T_8	1.00	5.33	6.00	10.00	10.33
T_9	1.00	5.33	6.00	10.33	10.33
LSD (0.05)	NS	0.95	0.66	0.82	0.97
CV %	0.00	11.32	7.54	7.94	8.5

***Means in a column followed by the same letter do not differ significantly at 5% level;**

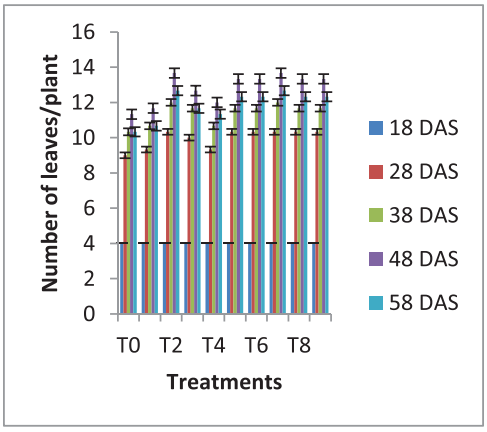

Figure1. Effect of GA_3 and NAA on number of leaves per plant of French bean (*Phaseolus vulgaris* L.) cv. BARI bush bean - 1 at different growth stages.

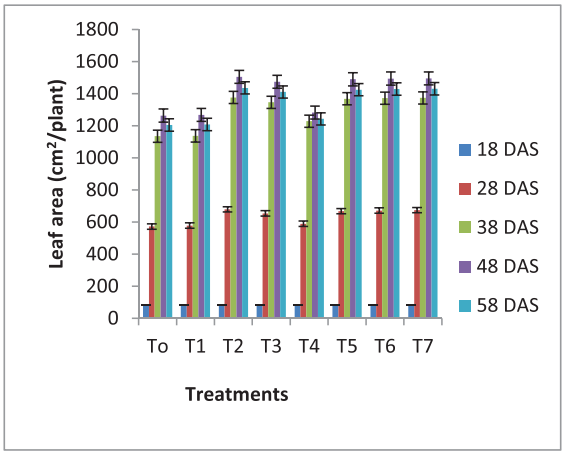

Figure 2. Effect of GA_3 and NAA on leaf area (cm^2/plant) of French bean (*Phaseolus vulgaris* L.) cv. BARI bush bean – 1.

Table 3. Effect of GA_3 and NAA on leaf area index (LAI) of French bean (*Phaseolus vulgaris* L.) cv. BARI bush bean - 1 at different growth stages.

Treatments	18 DAS	28 DAS	38 DAS	48 DAS	58 DAS
T_o	0.182	1.272	2.522	2.808	2.677
T_1	0.182	1.285	2.527	2.81	2.685
T_2	**0.182**	**1.509**	**3.06**	**3.343**	**3.191**
T_3	0.182	1.453	2.991	3.275	3.135
T_4	0.182	1.310	2.730	2.849	2.762
T_5	0.182	1.484	3.040	3.310	3.166
T_6	0.182	1.493	3.048	3.320	3.176
T_7	0.182	1.498	3.053	3.323	3.179
T_8	0.182	1.488	3.044	3.315	3.170
T_9	0.182	1.492	3.047	3.318	3.174
LSD (0.05)	NS	0.020	0.021	0.0194	0.0193
CV %	0.000	6.574	7.775	7.257	6.984

***Means in a column followed by the same letter do not differ significantly at 5% level;**

Total dry matter (g/plant)

The data on total dry matter (g/plant) determined during the Rabi season 2009 - 2010 presented in Tables 4. Total dry matter ranged from 21.19 to 33.95 g/plant at 58 DAS. Among all the treatments, TDM was highest for T2 and lowest for T0. It was 60.22% increased than that of the control. Second highest TDM was found in T7 (33.24 g/plant).

Table 4. Effect of GA_3 and NAA on total dry matter (g/plant) of French bean (*Phaseolus vulgaris* L.) cv. BARI bush bean - 1 at different growth stages.

Treatments	18 DAS	28 DAS	38 DAS	48 DAS	58 DAS
T_o	0.765	4.21	9.38	16.37	21.19
T_1	0.767	4.24	9.46	16.47	21.54
T_2	0.771	5.54	13.51	24.74	33.95
T_3	0.769	4.70	10.98	19.97	26.61
T_4	0.767	4.30	9.85	17.23	22.71
T_5	0.770	4.96	11.76	21.41	29.25
T_6	0.770	5.28	12.65	22.99	31.55
T_7	0.770	5.49	13.21	24.21	33.24
T_8	0.770	4.98	11.82	21.52	29.45
T_9	0.770	5.14	12.15	22.07	30.37
LSD (0.05)	0.001	0.09	0.07	0.07	0.17
CV %	0.25	10.28	13.34	15.29	17.15

***Means in a column followed by the same letter do not differ significantly at 5% level;**

Dry matter partitioning into different plant parts

Cumulative dry matter accumulation by different plant parts at different growth stages were calculated by averaging the values of all treatments. Contributions of different plant parts to total dry matter at different growth stages were calculated in terms of its percentage irrespective of

treatments. The partitioning of dry matter of the main stem, petiole and lamina increased up to 48 DAS and thereafter began to decline for all treatments.

However, the dry matter of branch and pod increased progressively up to maturity, whereas flower dry matter increased up to 58 DAS. The cumulative dry matter of main stem, branch, petiole, lamina, flower and pod were found to be 2.01, 2.23, 1.09, 7.61, 0.03 and 7.15 g dm/plant at 48 DAS and 1.73, 2.40, 0.93, 6.20, 0.03 and 15.80 g dm/plant at 58 DAS, respectively (Figure 3).

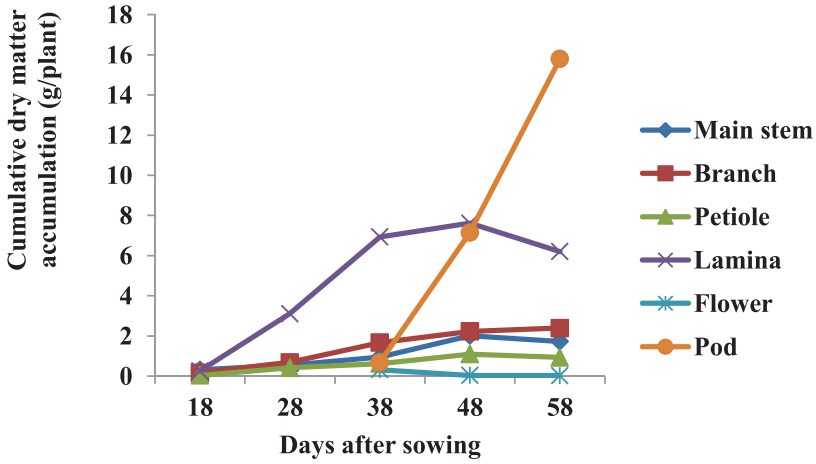

Figure3. Cumulative dry matter accumulation by different parts of French bean *(Phaseolus vulgaris L.)* cv. BARI bush bean - 1 at different growth stages.

The contributions of different plant parts to the total dry matter at different growth stages showed a decrease in dry matter of main stem, petiole and lamina, which, however, did not have any impact on the general trend of continued increase in the total dry matter. The dry matter of lamina contributed 33.25, 65.40, 62.08, and 37.84 % to the total dry matter (100%) at 18, 28, 38 and 48 DAS respectively (Figure 4). However, the pod dry matter contributed the highest percentage of 58.35 % to the total dry matter at 58 DAS growth stage. The decrease of dry matter due to main stem, petiole and lamina were 14.18, 15.19 and 18.53 % respectively, after 48 DAS.

Crop growth rate (g/m^2/day)

It was found that, the crop growth rate ranged from 7.65 - 10.59, 11.50 - 17.71, 15.53 - 24.96 and 10.70 - 20.47 g/m^2/day at 18 - 28, 28 - 38, 38 - 48 and 48 - 58 DAS respectively (Figure 5).

The highest CGR was recorded for T2 (20 ppm GA_3+ 20 ppm NAA) followed by

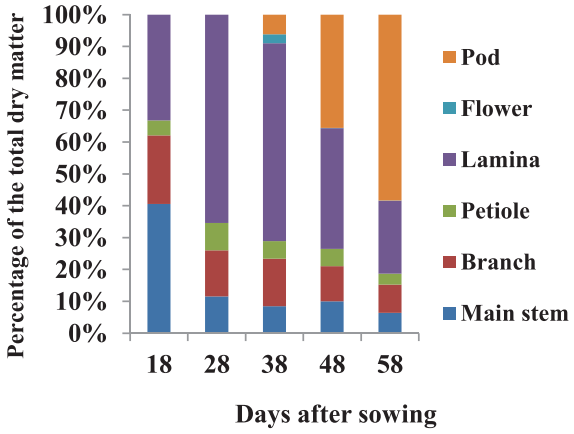

Figure 4. Contribution of different plant parts to total dry matter accumulation ast different growth stages of French bean *(Phaseolus vulgaris L.*) cv. BARI bush bean – 1.

T7 (40 ppm GA3+ 10 ppm NAA), but it was significantly different from all other treatments. However, the lowest was found for T0 (control).

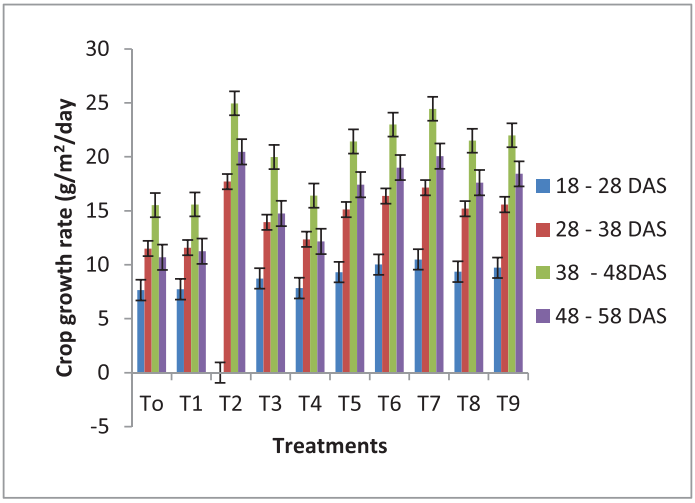

Figure 5. Effect of GA3 and NAA on crop growth rate (g/m2/day) of French bean (Phaseolus vulgaris L.) cv. BARI bush bean - 1 at different growth stages. Net assimilation rate (g/m^2/day)

In 2009 - 2010 Rabi season, NAR ranged from 13.65 - 16.89, 6.30 - 8.08, 5.83 - 7.80 and 3.90 - 6.27 g/m^2/day at 18 - 28, 28 - 38, 38 - 48 and 48 - 58 DAS respectively (Figure 6). Among the treatments, it was the highest for T2 (20 ppm GA3+20 ppm NAA) which was at par with T7 (40

ppm GA_3+10 ppm NAA) , Whereas, the lowest was for T0.

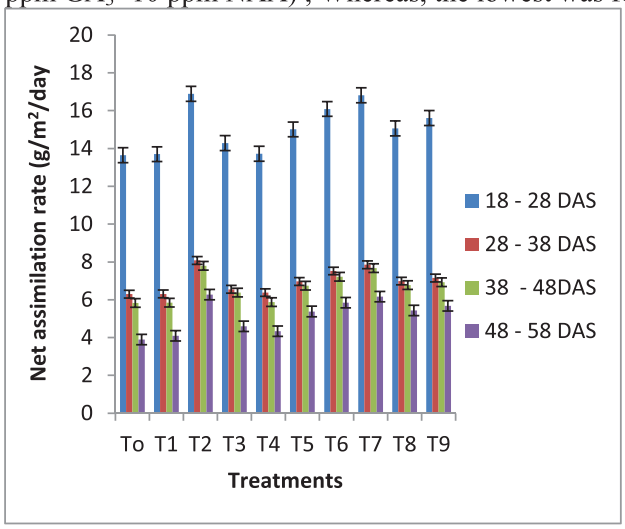

Figure 6. Effect of GA3 and NAA on net assimilation rate (g/m²/day) of French bean (Phaseolus vulgaris L.) cv. BARI bush bean - 1 at different growth stages. Relative growth rate (g/g/day)

Like NAR, the relative growth rate (RGR) for Rabi seasons of 2009 - 2010 indicated that the application of GA3 and NAA combination treatments increased it at 18 - 28 DAS and decreased with the advanced growth stages (Figure 7). RGR were the highest for T2 and T7 treated French bean plants at all the growth stages, which were significantly different and superior to all other treatments. However, the lowest value of it was observed in T0 (control). Flowering and pod setting Irrespective combination treatments of GA^3 and NAA, it was found to have significant influence on flowering and pod setting of French bean. NAA with different concentrations delayed flowering and pod setting, while GA^3 brought those forward (Table 5). It was highest for T8 and lowest for T9.

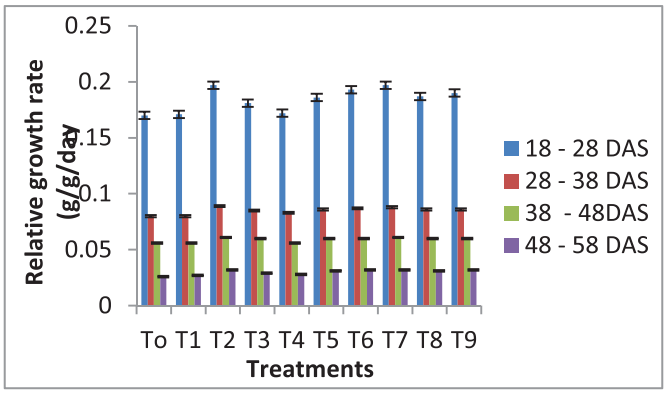

Figure 7. Effect of GA3 and NAA on relative growth rate (g/m²/day) of French bean *(Phaseolus vulgaris L.)* cv. BARI bush bean - 1 at different growth stages.

Table 5. Effect of GA_3 and NAA on flowering and pod setting of French bean *(Phaseolus vulgaris L.)* cv. BARI bush bean - 1.

Treatments	Days to first flowering	Days to 50% flowering	Days to 90% flowering	Days to first pod setting	Days to 50% pod setting	Days to 90% pod setting
T_0	31.00	33.00	35.33	33.33	36.00	39.00
T_1	31.00	33.00	35.33	33.33	36.00	39.00
T_2	31.33	33.33	35.67	33.67	36.00	39.33
T_3	31.33	33.33	36.00	33.67	36.00	39.67
T_4	32.00	34.00	36.67	34.00	36.67	40.33
T_5	30.67	32.67	34.67	33.00	35.33	38.33
T_6	32.00	34.33	37.00	34.33	37.00	40.67
T_7	30.67	32.67	35.00	33.00	35.67	38.67
T_8	**32.33**	**34.67**	**37.33**	**34.67**	**37.33**	**41.00**
T_9	**30.67**	**32.67**	**34.67**	**33.00**	**35.00**	**38.00**
LSD (0.05)	0.79	0.82	0.79	0.74	0.71	0.93
CV %	3.06	3.6	4.49	3.49	4.03	5.45

***Means in a column followed by the same letter do not differ significantly at 5% level;**

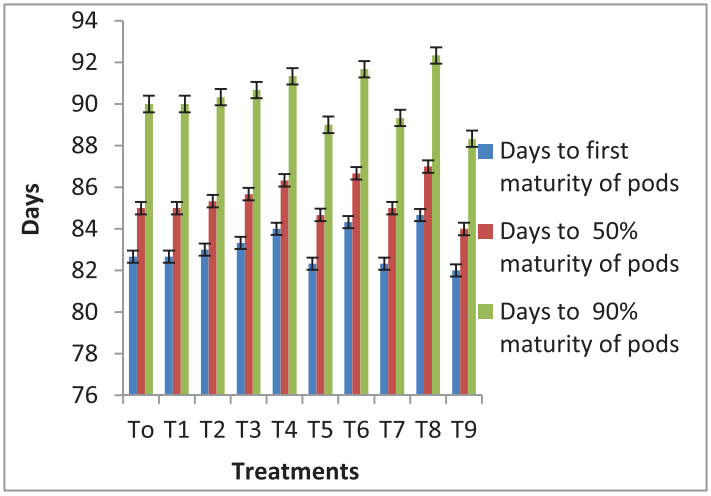

Figure 8. Effect of GA_3 and NAA on maturity of French bean (Phaseolus vulgaris L.) cv. BARI bush bean – 1.

Table 6. Effect of GA^3 and NAA on total chlorophyll (mg/g) of French bean (Phaseolus vulgaris L.) cv. BARI bush bean - 1 leaf at different growth stages.

Treatments	Days after sowing				
	18	28	38	48	58
T_o	**1.16**	**1.47**	**1.37**	**1.18**	**1.07**
T_1	1.16	1.53	1.42	1.21	1.09
T_2	**1.16**	**1.87**	**1.61**	**1.35**	**1.21**
T_3	1.16	1.68	1.53	1.28	1.16
T_4	1.16	1.55	1.44	1.23	1.12
T_5	1.16	1.84	1.57	1.32	1.19
T_6	1.16	1.85	1.59	1.33	1.20
T_7	1.16	1.86	1.61	1.34	1.21
T_8	1.16	1.84	1.58	1.32	1.19
T_9	1.16	1.85	1.58	1.33	1.19
LSD (0.05)	0.001	0.008	0.006	0.005	0.007
CV %)	0.599	7.311	6.823	5.827	5.519

***Means in a column followed by the same letter do not differ significantly at 5% level;**

Maturity

Like flowering and pod setting, the data on maturity of pods of French bean for Rabi seasons of 2009 - 2010 indicated that GA3 and NAA combination treatments with different concentrations had significant effect (Figure 8). It was lowest for T9(88.33 days) and highest for T8 (92.33days).

Leaf pigments

Total chlorophyll (Chlorophyll a and chlorophyll b) and carotenoids (mg/g) were performed rise to maximum from 28 to 38 DAS in all combination treatments during 2009 - 2010 Rabi seasons, then started to decline (Tables 6 and 7).

Table7. Effect of GA3 and NAA on carotenoids (mg/g) of French bean (Phaseolus vulgaris L.) cv. BARI bush bean - 1 leaf at different growth stages.

Treatments	Days after sowing				
	18	28	38	48	58
T_0	**0.89**	**1.995**	**1.712**	**1.306**	**0.892**
T_1	0.89	2.022	1.73	1.314	0.897
T_2	**0.895**	**2.31**	**1.952**	**1.449**	**0.974**
T_3	0.8943	2.167	1.846	1.352	0.917
T_4	0.89	2.035	1.737	1.318	0.899
T_5	0.8943	2.258	1.926	1.402	0.95
T_6	0.895	2.272	1.937	1.414	0.96
T_7	0.895	2.291	1.94	1.43	0.966
T_8	0.8947	2.26	1.928	1.403	0.952
T_9	0.8947	2.262	1.931	1.405	0.954
LSD (0.05)	0.003	0.009	0.005	0.008	0.01
CV %)	0.239	4.8	4.468	3.81	3.369

*Means in a column followed by the same letter do not differ significantly at 5% level;

It was similar for respective pigments at 18 DAS growth stage before hormone spray. Combination treatments of GA_3 and NAA with different concentrations significantly enhanced the amount of total chlorophyll and carotenoid (mg/g) up to 28 to 58 DAS growth stages, compared to the respective controls. These were the highest for T2 (1.87 and 2.31 mg/g, respectively) while the lowest was for T0(1.47 and 1.995 mg/g, respectively) at 28 DAS.

The results of the present study are in agreement with those of mustard plant reported by Akter *et al.*[27]. They recorded the highest plant height (95.77 cm) with the application of 50 ppm GA_3. Moreover, Adam and Jahan[28] (2011) found for rice that NAA with different concentrations increased and also decreased the plant height. In respect of number branch/plant, Arun *et al.*[29] reported that GA3 at 100 ppm resulted in the more number of branches per plant compared to the control in brinjal. Begum[30] also observed that NAA at 50 ppm treated plants produced maximum number of branches per plant in rapeseed. In respect of number leaves/plant, Sarkar *et al.*[31] observed in soybean that GA3 treated plants showed highest number of leaves at the later stages (60 and 80 DAS) over the control. In this study, T2 (20 ppm GA) + 20ppm NAA) treated

plants produced highest leaf area and LAI. Similarly, Jeyakumar *et al.* [32] also observed for black gram that maximum LAI (2.84) was produced by spraying NAA at 40 ppm at pre - flowering stage whereas the minimum was found for the control (1.80). In the present study, combination treatments significantly increased TDM, CGR, NAR and RGR. These findings are similar to Akter et al.[27] in mustard; Deotale *et al.*[33] in soybean; Ullah[34] (2006) in cowpea. In respect of dry matter partitioning into different plant parts, it was reported that increased total dry matter production resulted in the increase of grain yield in cereals. It was evident that partioning of more photosynthates towards seeds resulted in higher crop productivity[35].

In case of flowering, pod setting and maturity, similar findings were reported by Ullah[34] for cowpea, Begum[30] for rapeseed and Symons *et al.*[36] for strawberry. In the present study, the combination treatments of GA_3 and NAA significantly increased total chlorophyll and carotenoids indicated that the increase in chlorophyll must be associated with an increase in the quantity of enzymes and coenzymes, which are necessary for reduction of the products of photorespiration and increase photosynthesis[37].

In this study, total chlorophyll and carotenoid contents of leaf became the maximum at a certain growth stage, and then started to decrease till the maturity of crops. In rapeseed, chlorophyll a and b contents were increased with 70 ppm NAA treatments at all growth stages in comparison with the control and the maximum was found at 50 DAE, whereas in the case of carotenoid content, the maximum was found for 70 ppm NAA treated plants at 60 DAE[30]. Similar results were reported in bell pepper[38].

Conclusion

The findings of the experiment revealed that different combination treatments of GA3 and NAA significantly increased physiological parameters and leaf pigments of French bean. Plant height, number of branches, number of leaves, leaf area, LAI, total dry matter, dry matter partitioning, CGR, NAR, RGR, flowering, pod setting and maturation were significantly influenced by 20 ppmGA_3 and 20 ppm NAA treatment. The highest amount of total chlorophyll and carotenoids of leaf were recorded by same treatment. Moreover, the combination treatments of PGRs develop quantitative and qualitative characters of several crops.

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