



Growth and Yield Comparison of French Bean as Influenced by Three Varieties and Nutrients

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Authors' contributions

This work was carried out in collaboration among all authors. Authors TM and KK planned the experiment and lead the research. Authors MA, TM and KK designed and carried out the research. Authors MAS and MEH performed the statistical analysis. Authors MA, AB carried out the research on the field. Authors SSR, ASAS and MEH collected the data. Authors MA and MAS wrote the manuscript. Authors AB, SSR and ASAS managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh with aim to find out the suitable variety, optimum nutrients and suitable combination variety and optimum nutrients for maximum growth, yield of French bean in Bangladesh. The experiment consisted of two factors. Factor A: different varieties as V_1 = BARI French bean-1, V_2 = BARI French bean-2, V_3 = BARI French bean-3 and Factor B: different level of nutrients as N_1 = cowdung (5 t/ha) + vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) + $N_{90} P_{30} K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) + vermicompost (2 t/ha) + $N_{90} P_{30} K_{45}$ kg/ha. The experiment was laid out in a Randomized Complete Block Design with three replications. In case of different varieties of French bean the maximum number of flowers (27.83), the highest number of pod harvested per

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plant (22.14) and the highest pod yield (15.95 t/ha) were found from V_2 , whereas the lowest was from V_3 . For the different levels of nutrients₁ the highest number of flowers (25.58), the highest number of pod per plant (20.60) and the highest pod yield (14.10 t/ha) were recorded from N_2 treatment, while the lowest was from N_1 treatment. Due to the combined effect, the maximum number of flowers (32.02), the maximum number of pod harvested per plant (26.50), the highest pod yield (18.92 t/ha) were observed from V_2N_2 treatment combination, while the lowest were from V_3N_1 treatment combination. Therefore, the V_2N_2 treatment combination appeared to be the best for achieving the higher growth and yield of French bean.

Keywords: Cowdung; French bean; varieties; vermincompost and yield.

1. INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is a herbaceous annual plant. It is a short duration high yielding legume crop and it can be utilized both as a vegetable and pulse. It belongs to the family Leguminosae and subfamily Papiolionaceae [1]. It is widely cultivated in temperate, tropical, subtropical regions of the world [2]. The green pods and mature seeds are used as a cooked vegetable in Bangladesh. Although the crop is not extensively grown in Bangladesh, it has great export potentiality. Hortex foundation exported 330 metric tons of fresh French bean during the year 2012-2013 [3]. French bean is nutritionally rich in both pods and seeds. French bean production depends on many factors such as variety, quality of seed, time of sowing, irrigation schedule, fertilizer and proper management practices, etc. One of the most important factors that influences on the productivity and profitability of French bean is variety. A few well adted local varieties such as Sylhet local, Chittagong local), are cultivated by local farmers in limited areas of Bangladesh. But there is no available recommended variety of French bean. Bangladesh Agricultural Research Institute (BARI) has developed three varieties viz. BARI bush bean-1, BARI bush bean-2 and BARI bush bean-3 and have so far has been released [4]. The performances of all varieties do not produce the same quantity and quality of pod.

Another factor of low productivity of French bean is due to inadequate fertilization. Organic manure such as vermicompost is an eco-friendly, cost-effective, and ecologically sound bio-fertilizer. The use of vermicompost has a significant positive influence on seed germination and seedling vigor, plant growth, flowering, fruiting, root development, color, shelf-life and quality of vegetables [5]. French bean responds considerably to major essential elements like N, P and K in respect to its growth and yield [6].

Sultana S [7] found that the organic manure had a significant effect on the plant height, number of branches, leaf size, number of flowers, number of pod per plant and pod yield per hectare. Nitrogen fertilizer management plays a significant role in maximizing the production of French bean. French bean requires nitrogen in quite a high amount in the first stage of development for the emergence of the nodules and builds up of the symbiotic nitrogen fixation. Phosphorus is one of the most significant determinants of plant growth [8]. Robinson HF [9] reported the effect of phosphorus in stimulating root and plant growth. Phosphorus improves the fertilization, quality of fruits, vegetable and grain crops and increases their resistance to diseases, drought and adverse environmental conditions. It is a major component of compounds whose functions relate to growth, root development, flowering, and ripening [10]. Potassium application influence vegetative growth, pod and seed yields and the quality of seeds, measured in terms of germinability [11]. It enhances plants ability to resist diseases, cold and other adverse conditions such as poor flower development and poor pod setting. Few works have been conducted regarding the performance and characterization of bush bean varieties but we do not know which one gives the best result under a balanced nutrient system. A detailed and systematic study is needed to find out the suitable variety, optimum nutrients and suitable combination variety and optimum nutrients for maximum growth, yield of French bean in (Bangladesh.)

2. MATERIALS AND METHODS

2.1 Experimental Site

The research was conducted during the period from November, 2018 to January, 2019 at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka1207, Bangladesh. The experiment

was carried out during rabi season. The location of the experimental site is situated at 90° 22' E longitude and 23°41'N latitude. The altitude of the site is 8.6 meters above sea level. The texture of soil is sandy loam with pH and organic matter 5.47–5.63 and 0.83%, respectively.

2.2 Experiment Frame Work

The experiment consisted of two factors. Factor A: Different variety, viz. V_1 = BARI French bean 1, V_2 = BARI French bean 2 and V_3 = BARI French bean 3; Factor B: Different levels of nutrient, viz. N_1 = cowdung (5 t/ha) + vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) + $N_{90}P_{30}K_{45}$ kg/ha and N_3 = cowdung (5 t/ha) + vermicompost (2 t/ha) + $N_{90}P_{30}K_{45}$ kg/ha. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was 18.1 m x 3.6 m which was divided into three blocks. Each block was again divided into 9 plots and hence there were 27 (9 x 3) unit plots. The treatments were assigned randomly in each block separately. The size of the unit plot was 1.2 m x 0.9 m. The distance between two adjacent blocks and plots were 1.0m and 0.5 m respectively.

2.3 Planting Materials

The seeds of variety BARI French bean-1, BARI French bean-2 and BARI French bean-3 were collected from the Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

2.4 Manure and Fertilizer Application

The fertilizer and manures for French bean was applied in the following way. Total amount of well composed cow dung (5 t/ha), vermicompost (2 t/ha), triple super phosphate (TSP) (150 Kg/ha) and half of muriate of potash (MP) (as per treatment) were during final land preparation and rest of MP (as per treatment) was used after 35 DAS. Urea (196 kg/ha) was used as equal three splits. 1/3rd amount of urea was used during final land preparation and rest amount was applied in two installments at 15 and 30 days after sowing (as per treatment). The fertilizers which were applied mixed in appropriate portion with the plot soil.

2.5 Statistical Analysis

The recorded data on different parameters were statistically analyzed using Statistic 10 software. The significance of the difference among the

treatment means was estimated by the least significant difference test (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Different varieties showed a significant variation on plant height of French bean at 15, 30, 45 days after sowing (DAS) Fig. 1. At 15, 30, 45 DAS, the longest plant (31.57, 48.56, 50.21 cm) was found from V_3 (BARI French bean-3) and the shortest plant (22.89, 31.83, 36.17 cm) from V_1 (BARI French bean-1). Optimum plant height can be achieved through proper management practices during the growth and development stage. A study was conducted by [12] with 13 cultivars of French bean. They reported that plant height showed wide variability except for pod length. This result is in agreement with the findings of [13], they reported that the longest plant height was obtained from BARI French bean-3 and shortest from BARI French bean-1. Plant height of French bean was significantly influenced by different levels of nutrients at 15, 30, 45 (DAS) Fig. 2. Results revealed that the longest plant height (28.66, 43.15 and 45.78cm) was observed from N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the shortest plant height (24.43, 35.27 and 39.55 cm) was observed from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment at 15, 30 and 45 DAS respectively. It revealed that cowdung, vermicompost and $N_{90}P_{30}K_{45}$ had increased plant height, which might be due to the effect of nitrogen. Rahman MA et al. and Thriveni V et al. [14,15] observed similar trend of results. Significant variation was observed due to the combined effect of different varieties and levels of nutrients in terms of plant height of French bean at 15, 30, 45 days after sowing Table 1. At 15, 30, 45 DAS, the maximum plant height (33.45, 50.60 and 53.13cm) was recorded from treatment combination of V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha), while the minimum plant height (20.55, 28.07 and 33.40cm) from V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

3.2 Number of Leaves Per Plant

The number of leaves per plant is an important parameter of crop plant because of its physiological role in photosynthetic activities. The

effect of different varieties on the number of leaves of French bean was statistically significant Fig. 3. The highest (3.43, 21.54 and 27.05) number of leaves per plant was recorded from V₃ (BARI French bean-3) and the minimum (2.64, 15.22 and 18.39) number of leaves per plant was obtained from V₁ (BARI French bean-1) at 15, 30, 45 DAS respectively. This variation might be due to the difference in genetic constituents as well as environmental effects. The result is similar to the findings of [13,7]. Application of different levels of nutrients exhibited a significant influence on the number of leaves of French bean plants at 15,30,45 (DAS) days after sowing Fig. 4. At 15 DAS, the maximum number of leaves (3.21) was found from N₃ (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment and the minimum number of leaves (2.82) from N₁ (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment which is statistically identical with N₂ (cowdung @ 5 t/ha + N₉₀ P₃₀ K₄₅ kg/ha). At 30, 45 DAS, the maximum number of leaves (19.73 and 24.66) was found from N₃ (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment and the minimum number of leaves (16.95 and 20.72) from N₁ (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. It was revealed that the number of leaves increased with the increase in the number of days after sowing (DAS) i.e., 15, 30, 45 DAS. Cowdung, vermicompost, N₉₀P₃₀K₄₅ kg/ha is rich in its nitrogen and nutrient content.

This favorable condition creates better nutrient absorption for vegetative growth and consequently, the maximum number of leaves was found by cowdung, vermicompost, N₉₀P₃₀K₄₅. Rahman MA et al [14] reported a similar trend of results. The combined effect of different varieties and levels of nutrients showed significant differences for the number of leaves per plant of French bean at different days after sowing Table 1. At 15 DAS the maximum (3.68) number of leaves per plant was recorded from treatment combination of V₃N₃ (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + N₉₀P₃₀K₄₅ kg/ha), while the treatment combination of V₁N₁ (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) gave the minimum (2.48) number of leaves per plant which is statistically similar with V₁N₂ and V₂N₁ (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination. At 30,45 DAS significant differences in terms of the number of leaves per plant were observed among the treatment combination and the maximum (22.90 and 28.63) number of leaves per plant was recorded from the treatment combination of V₃N₃ (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + N₉₀P₃₀K₄₅ kg/ha) whereas the minimum (13.53 and 16.36) was recorded from the treatment combination of V₁N₁ (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

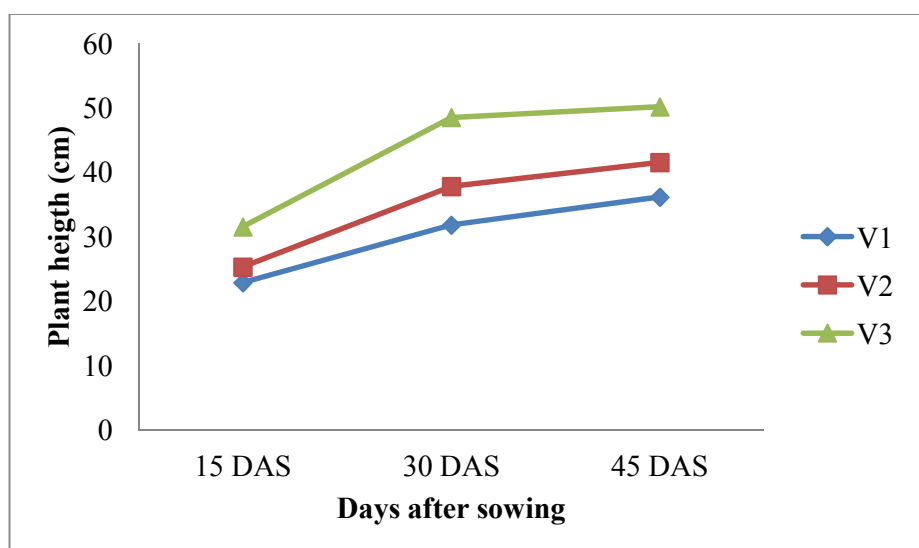


Fig. 1. Varietal difference in plant height of French bean at different days after sowing
Where, V₁= BARI French bean-1, V₂= BARI French bean-2, V₃= BARI French bean-3

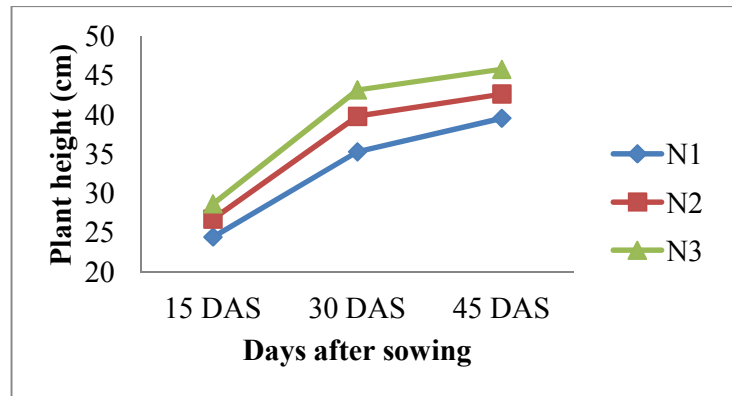


Fig. 2. Effect of different levels of nutrients on plant height of French bean at different days after sowing

Where, N₁= cowdung (5 t/ha) and vermicompost (2 t/ha), N₂= cowdung (5 t/ha) and N₉₀ P₃₀ K₄₅ kg/ha, N₃= cowdung (5 t/ha) and vermicompost (2 t/ha) and N₉₀ P₃₀ K₄₅ kg/ha

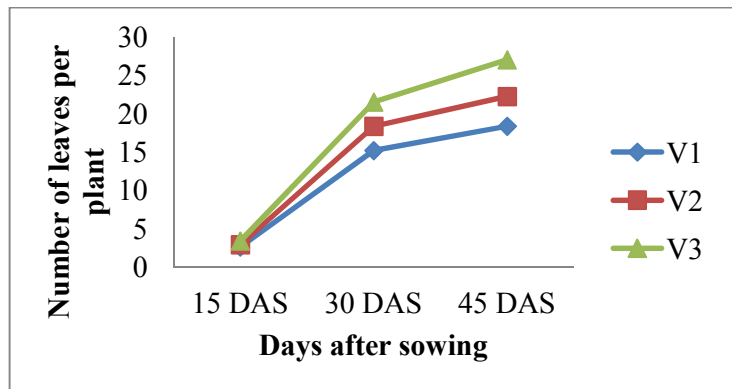


Fig. 3. Varietal differences on the number of leaves per plant of French bean at different days after sowing

Where, V₁= BARI French bean-1, V₂= BARI French bean-2, V₃= BARI French bean-3

Table 1. Combined effect of different varieties and levels of nutrients on plant height and number of leaves per plant of French bean at different days after sowing

Treatment combinations	Plant height (cm)			Number of leaves per plant		
	15 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS
V ₁ N ₁	20.55 g	28.07 h	33.40 h	2.48 f	13.53 g	16.36 g
V ₁ N ₂	23.16 f	31.69 g	35.69 g	2.61 ef	14.97 f	18.01 f
V ₁ N ₃	24.98 e	35.75 f	39.43 f	2.83 de	17.17 e	20.79 e
V ₂ N ₁	23.15 f	31.20 g	37.93 f	2.74 def	17.01 e	19.85 e
V ₂ N ₂	25.29 e	39.15 e	42.02 e	2.98 cd	19.02 d	22.45 d
V ₂ N ₃	27.55 d	43.10 d	44.78 d	3.12 bc	19.12 d	24.55 c
V ₃ N ₁	29.59 c	46.54 c	47.33 c	3.25 bc	20.30 c	25.96 b
V ₃ N ₂	31.69 b	48.53 b	50.16 b	3.36 b	21.43 b	26.57 b
V ₃ N ₃	33.45 a	50.60 a	53.13 a	3.68 a	22.90a	28.63 a
LSD(0.05)	1.5313	1.7781	1.9672	0.2890	0.9931	1.3416
CV%	3.33	2.61	2.66	5.55	3.12	3.43

In a column, means with the similar letter (s) are not significantly different and those having a dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V₁= BARI French bean-1, V₂= BARI French bean-2, V₃= BARI French bean-3. Where, N₁= cowdung (5 t/ha) and vermicompost (2 t/ha), N₂= cowdung (5 t/ha) and N₉₀ P₃₀ K₄₅ kg/ha, N₃= cowdung (5 t/ha) and vermicompost (2 t/ha) and N₉₀ P₃₀ K₄₅ kg/ha

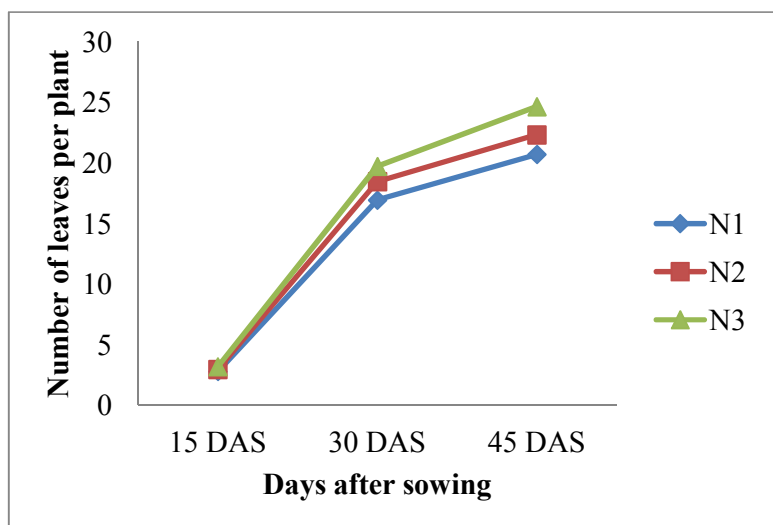


Fig. 4. Effect of different levels of nutrients on the number of leaves per plant of French bean at different days after sowing

Where, N_1 = cowdung (5 t/ha) and vermicompost (2 t/ha), N_2 = cowdung (5 t/ha) and $N_{90}P_{30}K_{45}$ kg/ha, N_3 = cowdung (5 t/ha) and vermicompost (2 t/ha) and $N_{90}P_{30}K_4$ kg/ha

3.3 Days Required to First Flowering

Significant influence was observed in terms of days required to first flowering of French bean affected by different varieties Table 2. It was observed that maximum days (37.63) to first flowering was required in V_2 (BARI French bean-2) treatment whereas minimum days to first flowering (26.81) was required in V_3 (BARI French bean-3) treatment. Korla BN et al. [16] reported that days required to first flowering showed little differences among the various cultivars of French bean. The result is similar to the findings of [17]. The data on days required to first flowering was found to be significant in terms of different levels of nutrients on French bean (Table 3). Results showed that maximum days (33.46) to first flowering was required in N_3 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment whereas minimum days (30.44) to first flowering was required in N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Rahman MA et al., Thriveni V et al and Bipradas A et al. [14,15,18] observed a similar trend of results. The combined effect between different varieties and levels of nutrients showed a statistically significant variation in consideration of the number of days to the first flowering of French bean Table 4. The maximum days to first flowering (38.89) was recorded from the treatment combination of V_2N_3 (BARI French bean-2 and cowdung @ 5 t/ha + vermicompost

@ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the minimum days to first flowering (25.67) was recorded from a combination treatment of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

3.4 Number of Flowers Per Plant

The number of flowers per plant of French bean was significantly influenced by the three varieties Table 2. The highest number of flowers per plant (27.83) was recorded for the V_2 (BARI French bean-2) treatment and the lowest number of flowers (15.47) was recorded for the V_3 (BARI French bean-3) treatment. Kakon SS et al. [17] observed that BARI French bean-2 produced the highest number of flowers per plant while BARI French bean-1 produced the lowest number. The number of flowers per plant showed significant differences due to the application of different levels of nutrients Table 3. The maximum number of flowers per plant (25.58) was recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment and the minimum number of flowers per plant (18.33) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Rahman MA et al., Thriveni V et al and Bipradas A et al. [14,15,18] observed a similar trend of results. The combined effect between different varieties and levels of nutrients showed significant variation in consideration of the number of flower per plant of French bean Table 4. The maximum number of

flowers per plant (32.02) was recorded from the treatment combination of V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the minimum number of flower per plant (13.33) was recorded from a combination treatment of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha).

3.5 Number of Pods Per Plant

Significant variation was observed in number of pods per plant of French bean among varieties Table 2. The maximum number of pods per plant (22.14) was recorded from V_2 (BARI French bean-2), while the minimum (11.22) was counted from V_3 (BARI French bean-3). [19] found significant variation in the number of pods per plant with an experiment of seven French bean genotypes. The number of pods per plant differed significantly due to the application of different levels of nutrients on French bean Table 3. The maximum number of pods per plant (20.60) was recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) and the minimum number of pod per plant (13.66) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. It was revealed that the number of pods per plant increased by using cowdung and $N_{90}P_{30}K_{45}$ kg/ha. This might be the caused that cowdung and $N_{90}P_{30}K_{45}$ supply a high amount of nitrogen which increased the number of leaves, cell division and cell enlargement. Rahman MA et al., Thriveni V et al. [14,15] observed a similar trend of results. The variation was found due to the combined effect of different varieties and levels of nutrients on the number of pods per plant of French bean (Table 4). The maximum number of pods per plant (26.50) was recorded from the treatment combination of V_2N_2 (BARI French bean-2 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the treatment combination of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) performed the minimum number of pods per plant (9.32).

3.6 Length of the Green Pod (cm)

A variation on length of green pod differed significantly among different varieties of French bean Table 2. Results revealed that highest length of the green pod (13.70 cm) was observed from V_3 (BARI French bean-3) treatment and the minimum length of the green pod (12.09 cm) was found from V_1 (BARI French bean-1) treatment. It is similar to the result of [7]. Significant influence was observed in terms of length of the green pod of French bean influenced by different levels of

nutrients Table 3. Result signified that maximum length of green pod (13.13 cm) was observed from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment which is statistically similar with N_3 (cowdung @ 5t/ha and vermicompost @ 2 t/ha and $N_{90} P_{30} K_{45}$ kg/ha) treatment and minimum length of green pod (12.57 cm) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The above result revealed that the application of cowdung and $N_{90}P_{30}K_{45}$ kg/ha increases the length of the green pod. Rahman MA et al. [14] observed similar trend of results. The combined effect of different varieties and levels of nutrients showed a statistically significant variation on the length of the green pod of French bean Table 4. The result showed that the maximum length of the green pod (14.22 cm) was recorded from treatment combination V_3N_2 which is statistically similar with V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination and the minimum length of green pod (11.58 cm) was found from the treatment combination of V_1N_1 which is statistically similar with V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) and V_1N_3 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination.

3.7 Diameter of Green Pod (cm)

There was a significant variation in the diameter of the green pod for the effect of different varieties of French bean Table 2. The maximum diameter of the green pod (0.76 cm) was recorded from V_3 (BARI French bean-3), while the minimum (0.65 cm) was counted from V_1 (BARI French bean-1). Remarkable variation was found on the diameter of the green pods due to the application of different levels of nutrients on French bean Table 3. The highest diameter of green pod (0.72 cm) was achieved from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment which is statistically identical with N_3 (cowdung @ 5 t/ha and vermicompost @ 2 t/ha and $N_{90} P_{30} K_{45}$ kg/ha) treatment where the lowest diameter of green pod (0.67 cm) was achieved from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Significant variation was remarked on the diameter of the green pods of French bean as influenced by combined effect of different varieties and levels of nutrients Table 4. Results exposed that the highest diameter of green pod (0.78 cm) was obtained from the treatment combination of V_3N_2 (BARI French bean-3 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) which is

statistically similar to V_3N_3 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination. The lowest diameter of the green pod (0.63 cm) was obtained from the treatment combination of V_1N_1 (BARI French bean-1 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) which is statistically similar to V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment combination.

3.8 Number of Seeds Per Green Pod

There was a significant variation in the number of seeds per green pod for the effect of different varieties of French bean Table 5. The maximum number of seeds per green pod (6.28) was recorded from V_1 (BARI French bean-1), while the minimum (4.82) was counted from V_3 (BARI French bean-3) treatment. It is similar to the result of [17]. Significant variation was recorded on the number of seeds per green pod for the effect of different levels of nutrients on French bean (Table 6). The maximum number of seeds per green pod (5.82) was recorded from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) and the minimum number of seeds per green pod (5.42) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. The variation was found due to the combined effect of different varieties and levels of nutrients on the number of seeds per green pod of French bean Table 7.

The maximum number of seeds per green pod (6.47) was recorded from the treatment combination of V_1N_2 (BARI French bean-1 and cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) while the treatment combination of V_3N_1 (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) performed the minimum number of seeds per green pod (4.60).

3.9 Pod Yield Per Plant (g)

Significant variation was observed on the pod yield per plant among different varieties of French bean Table 5. The highest (71.78 g) yield was recorded from V_2 (BARI French bean-2) and the lowest (27.51 g) yield was obtained from V_3 (BARI French bean-3) treatment. Similar observations were recorded by [7]. The yield per plant of French bean was significantly varied due to different levels of nutrients Table 6. It was examined that the highest yield per plant (63.46 g) was observed from N_2 (cowdung @ 5 t/ha + $N_{90}P_{30}K_{45}$ kg/ha) treatment while the lowest yield per plant (41.78 g) was found from N_1 (cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment. Rahman MA et al., Thriveni V et al. and Bipradas A, Taheri RAE [14,15,18,20] observed similar trend of results. The combined effect between different varieties and levels of nutrients showed significant variation for yield per plant of French bean Table 7.

Table 2. Effect of different varieties on days to first flowering, number of flowers, number of pods per plant, length of green pod and diameter of green pod of French bean

Treatment	Days required to first flowering	Number of flowers per plant	Number of pods per plant	Length of green pod (cm)	Diameter of green pod (cm)
V_1	31.89 b	23.88 b	18.67 b	12.09 c	0.65 c
V_2	37.63 a	27.83 a	22.14 a	12.69 b	0.70 b
V_3	26.81 c	15.47 c	11.22 c	13.70 a	0.76 a
LSD(0.05)	0.6562	0.7653	0.9898	0.4745	0.0173
CV%	2.04	3.42	5.71	3.70	2.47

Table 3. Effect of different levels of nutrients on days to first flowering, number of flowers, number of pods per plant, length of green pod and diameter of green pod of French bean

Treatment	Days required to first flowering	Number of flower per plant	Number of pods per plant	Length of green pod (cm)	Diameter of green pod (cm)
N_1	30.44 c	18.33 c	13.66 c	12.57 b	0.67 b
N_2	32.42 b	25.58 a	20.60 a	13.13 a	0.72 a
N_3	33.46 a	23.26 b	17.77 b	12.78 ab	0.71 a
LSD(0.05)	0.6562	0.7653	0.9898	0.4745	0.0173
CV%	2.04	3.42	5.71	3.70	3.43

Table 4. Combined effect of different varieties and levels of nutrients on days to first flowering, number of flowers, number of pods per plant, length of green pod and diameter of green pod of French bean

Treatment combinations	Days required to first flowering	Number of flower per plant	Number of pods per plant	Length of green pod (cm)	Diameter of green pod (cm)
V ₁ N ₁	29.33 e	20.03 f	15.79 e	11.58 d	0.63 g
V ₁ N ₂	32.67 d	27.17 c	22.20 c	12.38 cd	0.65 fg
V ₁ N ₃	33.67 d	24.45 d	18.01 d	12.32 cd	0.66 f
V ₂ N ₁	36.33 c	21.63 e	15.87 e	12.79 bc	0.67 ef
V ₂ N ₂	37.67 b	32.02 a	26.50 a	12.80 bc	0.74 bc
V ₂ N ₃	38.89 a	29.83 b	24.06 b	12.47 c	0.70 de
V ₃ N ₁	25.67 g	13.33 i	9.32 h	13.34 b	0.72 cd
V ₃ N ₂	26.93 f	17.57 g	13.09 f	14.22 a	0.78 a
V ₃ N ₃	27.83 f	15.50 h	11.25 g	13.55 ab	0.77 ab
LSD(0.05)	1.1365	1.3255	1.7145	0.8219	0.03
CV%	2.04	3.42	5.71	3.70	2.47

In a column, means with the similar letter (s) are not significantly different and those having a dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V₁=BARI French bean-1, V₂= BARI French bean-2, V₃= BARI French bean-3. Where, N₁= cowdung (5 t/ha) and vermicompost (2 t/ha), N₂= cowdung (5 t/ha) and N₉₀ P₃₀ K₄₅ kg/ha, N₃= cowdung (5 t/ha) and vermicompost (2 t/ha) and N₉₀ P₃₀ K₄₅ kg/ha

The result indicated that the highest yield per plant (85.13 g) was observed from V₂N₂ (BARI French bean-2 and cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment combination while the lowest yield per plant (18.68 g) was found from V₃N₁ (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

3.10 Pod Yield Per Plot (g)

Significant difference was noted on pod yield per plot of French bean affected by different varieties of French bean Table 5. The highest pod yield per plot (1722.70 g) was found from the V₂ (BARI French bean-2) treatment where the lowest pod yield per plot (660.20 g) was found from the treatment V₃ (BARI French bean-3). Pod yield per plot of French bean varied significantly due to different levels of nutrients Table 6. The highest pod yield per plot (1523.00 g) was achieved from N₂ (cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment where the lowest pod yield per plot (1002.60 g) was achieved from the treatment of N₁ (cowdung @ 5 t/ha + vermicompost @ 2 t/ha). Significant variation was remarked on pod yield per plot of French bean as influenced by the combined effect of different varieties and levels of nutrients Table 7. The highest pod yield per plot (2043.00 g) was recorded from the treatment combination of V₂N₂ (BARI French bean-2 and cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) which was significantly different from all other treatment combinations. The lowest pod yield per plot

(448.20 g) was recorded from the treatment combination of V₃N₁ (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) which was significantly different from other treatment combinations.

3.11 Pod Yield per Hectare (t)

The variation on pod yield per ha of French bean was noted to be significantly influenced by different irrigation levels Table 5. The highest pod yield per ha (15.95 t) was achieved from V₂ (BARI French bean-2) treatment whereas the lowest pod yield per ha (6.11 t) was achieved from the treatment of V₃ (BARI French bean-3). The recorded data on pod yield per ha of French bean was significant due to the effect of different levels of nutrients Table 6. The highest pod yield per ha (14.10 t) was achieved from N₂ (cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment whereas the lowest pod yield per ha (9.28 t) was achieved from the treatment of N₁ (cowdung @ 5 t/ha + vermicompost @ 2 t/ha). The combined effect between different varieties and levels of nutrients showed a statistically significant variation for pod yield per hectare of French bean Table 7. The result indicated that the highest pod yield per hectare (18.92 t) was observed from V₂N₂ (BARI French bean-2 and cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment combination while the lowest pod yield per hectare (4.15 t) was found from V₃N₁ (BARI French bean-3 and cowdung @ 5 t/ha + vermicompost @ 2 t/ha) treatment combination.

Table 5. Effect of different varieties on number of seeds per green pod, pod yield/plant, pod yield/plot and pod yield/ha of French bean

Treatment	Number of seeds per green pod	Pod yield per plant (g)	Pod yield per plot (g)	Pod yield per hectare (t)
V ₁	6.28 a	61.16 b	1467.70 b	13.59 b
V ₂	5.71 b	71.78 a	1722.70 a	15.95 a
V ₃	4.82 c	27.51 c	660.20 c	6.11 c
LSD(0.05)	0.0939	3.4525	82.861	0.7672
CV%	1.68	6.46	6.46	6.46

Table 6. Effect of different levels of nutrients on number of seeds per green pod, pod yield/plant, pod yield/plot and pod yield/ha of French bean

Treatment	Number of seeds per green pod	Pod yield per plant (g)	Pod yield per plot (g)	Pod yield per hectare (t)
N ₁	5.42 c	41.78 c	1002.60 c	9.28 c
N ₂	5.82 a	63.46 a	1523 a	14.10 a
N ₃	5.57 b	55.21 b	1325 b	12.27 b
LSD(0.05)	0.0939	3.4525	82.861	0.7672
CV%	1.68	6.46	6.46	6.46

Table 7. Effect of different varieties and levels of nutrients on number of seeds per green pod, pod yield/plant, pod yield/plot and pod yield/ha of French bean

Treatment combinations	Number of seeds per green pod	Pod yield per plant (g)	Pod yield per plot (g)	Pod yield per hectare (t)
V ₁ N ₁	6.13 b	52.56 e	1261.40 e	11.68 e
V ₁ N ₂	6.47 a	69.48 c	1667.50 c	15.44 c
V ₁ N ₃	6.23 b	61.43 d	1474.20 d	13.65 d
V ₂ N ₁	5.51 e	54.09 e	1298.20 e	12.02 e
V ₂ N ₂	5.93 c	85.13 a	2043 a	18.92 a
V ₂ N ₃	5.69 d	76.13 b	1827 b	16.92 b
V ₃ N ₁	4.60 h	18.68 h	448.20 h	4.15 h
V ₃ N ₂	5.06 f	35.78 f	858.60 f	7.95 f
V ₃ N ₃	4.80 g	28.08 g	673.90 g	6.24 g
LSD(0.05)	0.1626	5.9800	143.52	1.3289
CV%	1.68	6.46	6.46	6.46

In a column, means with the similar letter (s) are not significantly different and those having a dissimilar letter (s) are significantly different by LSD at 5% level of significance. Where, V₁= BARI French bean-1, V₂= BARI French bean-2, V₃= BARI French bean-3. Where, N₁= cowdung (5 t/ha) and vermicompost (2 t/ha), N₂= cowdung (5 t/ha) and N₉₀ P₃₀ K₄₅kg/ha, N₃= cowdung (5 t/ha) and vermicompost (2 t/ha) and N₉₀ P₃₀ K₄₅kg/ha.

4. CONCLUSION

Considering the above result of this experiment, the following conclusion can be drawn: In the experiment, treatment V₂ (BARI French bean-2) was superior to the others. Balanced nutrients play a significant role in maximizing the production of French bean. In respect of all, the N₂ (cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) treatment showed better performance than others. The treatment combination of V₂N₂ (BARI French bean-2 and cowdung @ 5 t/ha + N₉₀P₃₀K₄₅ kg/ha) showed the best potentiality of yield 18.92 t/ha.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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