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RESPONSE OF ORGANIC MANURE AND BIO-FERTILIZERS ON THE GROWTH AND YIELD OF BROAD BEAN (*Vicia faba* L.)

Vishwa Nath[1], Gauri Shanker[1], Anuradha Singh[2]* and Brijesh Kumar[1]

[1]Department of Horticulture, R.B.S. College, Bichpuri, Agra (Affiliated with Dr. Bhimrao Ambedkar University), Agra, U.P., India.

[2]Department of Botany, Meerut College (C.C.S. Uniersity), Meerut, U.P., India.

*Corresponding author E-mail : sinanuradha@gmail.com

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ABSTRACT

The present field experiment was conducted at Agricultural Research Farm, Department of Horticulture, Raja Balawant Singh College, Bichpuri Agra, during *Rabi* season of 2024-25 to evaluate the Effect of organic manures and bio-fertilizer on the growth and yield of broad bean (*Vicia faba* L.). The variables involved in this study were various levels of RDF, FYM, Azotobacter and Rhizobium *viz.*; T_0 (Absolute control), T_1 (100% RDF), T_2 (100% RDF+Rhizobium), T_3 (100% RDF+Azotobacter), T_4 (80% RDF+20% FYM), T_5 (80% RDF+20% FYM+Rhizobium), T_6 (80% RDF+20% FYM + Azotobacter), T_7 (60% RDF+40% FYM), T_8 (60% RDF+40% FYM+Rhizobium) and T_9 (60% RDF+40% FYM+Azotobacter). In all 10 treatment combinations were tested in Randomized Block Design with three replications. The result revealed that the maximum vegetative growth and yield (115.23 q/ha) was recorded in treatment T_5 (80% RDF + 20% FYM + Rhizobium), while the minimum (69.21 q/ha) was observed in the treatment T_0 (control).

Key words : Azotobacter, Broad bean, FYM, INM, RDF, Rhizobium.

Introduction

Broad bean botanically known as *Vicia faba* L. having chromosome number (2n=2x=12), belongs to family Fabaceae. It is an important winter legume crop grown on approximately three million hectare worldwide and is known for various names as ‘faba bean’, ‘horse bean’, ‘pigeon bean’, ‘field bean’ and ‘bell bean’. In India, it’s popularly known as Kala matar and Bakla. It is basically self pollinated crop but natural outcrossing was also done by insects/honeybee. Broad bean origin has been reported to be in the West Asia or Afghanistan and then spread throughout the world. Broad bean is bushy annual herb have typical tap root with branched secondary roots and nodules due to *Rhizobium leguminosarum* stem growth is indeterminate with 0.5 to 2 m tall coarse and upright stems, having innately compound leaves and alternate phyllotaxy. Flowers are white with brown or black tinge on wings, it blooms between the 5th and 10th node on pedicels in clusters of 1-5. From each flower cluster there is development of 1-4 pods which contain 3 to 6 flat, oval seeds.

Bio fertilizers like *Azotobacter*, are enormously cost effective than the chemical fertilizers and increases crop productivity by 20-30%, replaces chemical nitrogen and phosphorus by 25% and accelerate plant growth, provide protection against biotic and abiotic stresses. *Azotobacter* species are free living bacteria which grow well on a nitrogen free medium and are an important source of bio-fertilizers. These bacteria utilize atmospheric nitrogen gas for their cell protein synthesis. This cell protein is then mineralized in soil after the death of the *Azotobacter* cells thereby contributing towards the nitrogen availability of the crop plants thus resulting in a strong symbiotic relationship They also secrete some compounds like auxins, cytokinin and antibiotics improving growth and productivity of the crops (Valencia *et al.*, 2024). Biofertilizer is a substance which contains living micro organisms which, when applied to the seed or plant surfaces or soil colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.

Farm yard manure being bulky organic material,

releases the soil compactness and improves the aeration in addition to the supply of essential plant nutrients and organic matter and increase soil microbial establishment along with accumulation of excess humus content. It acts directly for increasing crop yield by accelerating the respiratory process through cell permeability or by hormones through growth action. It supplies nitrogen, phosphorus and sulphur in available form to the plants through biological decomposition. Indirectly it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Jagadeesh *et al*., 2018).

Most of the leguminous plants bearing nodules in their roots are responsible for fixing atmospheric nitrogen. The bacteria responsible for the formation of root nodules in legumes belong to the genus *Rhizobium*/ *Brady rhizobium*. Success of introduced *Rhizobium* strains in soil depends upon its ability to compete over native rhizobial flora for nodule occupancy. Secretions of extra cellular polysa ceharides and lipopolysaccharides by *Rhizobium* has been associated with mechanism of nodule formation. As influenced by various biotic and abiotic factors, the magnitude of nitrogen fixation by legume crops/free microbes are variable from as low as 30 kg N ha^{-1} in black gram/green gram to as high as 300 kg N ha^{-1} in *Leucacna leucouphala*. *Rhizobium* inoculation is a simple and cost effective technology to increase the pulse crop productivity. In India, the survey conducted on *Rhizobium* showed poor nodulation in about half the area for one reason or the other, though the legumes are grown in the area for a long time. The nitrogen fixing process and its contribution to total nitrogen can be enhanced by selection and use of efficient strains of N fixing micro organism suited to the local environmental conditions coupled with proper amendments. *Rhizobium* can play a vital role in minimizing our dependence or inorganic nitrogenous fertilisers. *Rhizobium* inoculation not only increases the yield and improves the quality of legumes but also leaves behind substantial amount of residual nitrogen in soil for subsequent crops (Prasad *et al.*, 2024).

Materials and Methods

A field experiment was conducted during *Rabi* season of 2024-25 at Agricultural Research Farm, Department of Horticulture, R.B.S. College, Bichpuri, Agra (U.P.), India. The research farm is situated at about 11 km to the west of Agra on Agra-Bharatpur Road at latitude of 2702' N and longitude of 7709' E with an elevation of 163.4 m above the mean sea level. This region falls under south-western semi-arid zone of Uttar Pradesh. The soil of experimental field was moderately fertile, being low in organic carbon (0.31%), available nitrogen (181.50 kg ha^{-1}), available phosphorus (27.5 kg P_2O_5 ha^{-1}) and rich in available potassium (285.0 kg K_2O ha^{-1}). The variables involved in this study were various levels of RDF, FYM, Azotobacter and Rhizobium *viz.*; T_0 (Absolute control), T_1 (100% RDF), T_2 (100% RDF+ Rhizobium), T_3 (100% RDF+Azotobacter), T_4 (80% RDF+20% FYM), T_5 (80% RDF+20% FYM+ Rhizobium), T_6 (80% RDF+20% FYM + Azotobacter), T_7 (60% RDF+40% FYM), T_8 (60% RDF+40% FYM+Rhizobium) and T_9 (60% RDF+40% FYM+Azotobacter). In all 10 treatment combinations were tested in Randomized Block Design with three replications.

The experimental field was prepared by one deep ploughing followed by two harrowings and planking, and the treatments were randomly allotted within each replication as per the Randomized Block Design. The gross and net plot sizes were 3.0 m × 2.4 m and 2.4 m × 1.8 m and healthy seeds were dibbled at 45 cm × 20 cm spacing in the second fortnight of November, 2024. Gap filling, thinning, irrigation and weeding were done uniformly.

Well decomposed FYM was incorporated 15 days before sowing in the plots where 20 and 40 per cent of the nitrogen was substituted through the organic source, its quantity worked out on nitrogen equivalent basis. The recommended dose of N, P_2O_5 and K_2O was supplied through urea, single super phosphate and muriate of potash; full P and K with half of the N were applied basally and the remaining N top dressed at 30 DAS. Seeds were inoculated with *Rhizobium* and *Azotobacter* @ 20 g kg^{-1} seed using 10 per cent jaggery solution as sticker, while the control plots received no manure, fertilizer or bio-fertilizer.

Five plants were randomly selected and tagged in the net plot of each treatment. Plant height (cm) was measured from the ground level to the tip of the main shoot with a metre scale at 30, 60 and 90 DAS, and the data of 90 DAS are presented. Number of branches and leaves $plant^{-1}$ were counted at 90 DAS, days to 50 per cent flowering were counted from sowing to flowering in half the plants and pod length (cm) was recorded on ten randomly selected pods. At harvest, pods $plant^{-1}$, seeds pod^{-1}, pod weight $plant^{-1}$ (g), 100-seed weight (g) and fresh pod yield (q/ha) were recorded.

Composite soil samples (0-15 cm) drawn before layout were analysed for organic carbon (Walkley and Black), available N (alkaline permanganate), P (Olsen's method) and K (ammonium acetate, flame photometer).

The data were analysed by the analysis of variance for Randomized Block Design (Panse and Sukhatme) and the treatment means were compared with SEm± and CD at 5 per cent level of significance.

Results and Discussion

Growth studies

Data presented in Table 1 reveal that plant height was significantly influenced by different treatments of integrated nutrient management at 90 days after sowing (DAS). The maximum plant height (76.14 cm) was recorded in T_5 (80% RDF + 20% FYM + Rhizobium), which was significantly superior to all other treatments. This enhanced growth may be attributed to the synergistic effect of FYM and Rhizobium in improving soil structure, increasing microbial activity, and enhancing nutrient availability especially nitrogen fixation, which directly influences vegetative growth. The second highest plant height was recorded in T_8 (60% RDF + 40% FYM + Rhizobium) with 74.82 cm, followed by T_7 (60% RDF + 40% FYM) and T_2 (100% RDF + Rhizobium) with 73.14 cm and 72.10 cm, respectively. These treatments also showed statistically significant improvements over the control. Similar findings have also been reported by (Jagadeesh *et al.*, 2018).

The data in Table 1 show that the number of branches per plant was significantly influenced by different integrated nutrient management treatments at 90 DAS. The maximum number of branches (8.01) was recorded under T_5 (80% RDF + 20% FYM + Rhizobium), which was significantly superior to all other treatments. This increase in branching may be attributed to improved soil fertility, microbial activity, and better nitrogen availability resulting from the combined use of FYM and Rhizobium, which promote cell division and vegetative growth. The second highest number of branches (7.40) was recorded in T_7 (60% RDF + 40% FYM), followed by T_6 (80% RDF + 20% FYM + Azotobacter) with 6.93 branches and T_9 (60% RDF + 40% FYM + Azotobacter) with 6.90 branches. These treatments also showed statistically significant improvement over the control and most other treatments. The minimum number of branches per plant (4.96) was observed in T_0 (Absolute Control), where no nutrients were applied, indicating the crucial role of nutrient management in promoting branching. Similar findings have also been reported by Kumar and Pandita (2016), Panda *et al.* (2017), Shubhashree *et al*. (2018)

The data presented in Table 1 indicate that the number of leaves per plant was significantly affected by various integrated nutrient management (INM) treatments at 90 DAS. The highest number of leaves (62.23) was recorded under the treatment T_5 (80% RDF + 20% FYM + Rhizobium), which was significantly superior to all other treatments. This increase may be attributed to the positive interaction between organic manure and biofertilizers, especially Rhizobium, which enhances root development and nutrient uptake, thereby stimulating leaf formation. The second highest number of leaves (56.91) was recorded under T_8 (60% RDF + 40% FYM + Rhizobium), followed closely by T_9 (60% RDF + 40% FYM + Azotobacter) with 56.11 leaves and T_7 (60% RDF + 40% FYM) with 55.97 leaves per plant. These results suggest that even with reduced chemical fertilizer input, the combination with organic and microbial sources can maintain or enhance vegetative growth. In contrast, the minimum number of leaves per plant (43.40) was observed in T_0 (Absolute Control), indicating the adverse effect of nutrient deficiency on foliage development. Most agricultural soils contain larger amount of fixed form of P than available P, a considerable part of which has accumulated as a consequence of regular applications of P fertilizers. (Ramesh *et al.*, 2023; Sonia *et al.*, 2023 and Sonia *et al.*, 2023).

The data in Table 1 indicate that the effect of integrated nutrient management treatments on the days taken for 50% flowering was non-significant, as also supported by the statistical analysis. However, notable numerical variations were observed among the treatments. The earliest flowering was recorded in T_7 (60% RDF + 40% FYM) with 69.11 days, followed closely by T_9 (60% RDF + 40% FYM + Azotobacter) with 69.23 days and T_0 (Absolute Control) with 69.09 days. Early flowering in these treatments may be attributed to balanced nutrient availability and improved soil health due to the inclusion of organic manures, which promote early physiological maturity. On the other hand, delayed flowering was observed in T_3 (100% RDF + Azotobacter) and T_1 (100% RDF), with 72.90 and 72.60 days, respectively. This delay could be due to an imbalance in the nitrogen-to-carbon ratio or the absence of organic components, which may have influenced the hormonal balance responsible for floral initiation.

The data in Table 1 reveal that pod length was significantly influenced by different integrated nutrient management (INM) treatments at 90 days after sowing (DAS). The maximum pod length (6.51 cm) was recorded under T_5 (80% RDF + 20% FYM + Rhizobium), which was significantly superior to all other treatments. The increase in pod length under this treatment could be attributed to improved nutrient uptake, particularly nitrogen and phosphorus and enhanced biological nitrogen fixation due to Rhizobium inoculation, which supports

Table 1 : Growth characters as influenced by different treatments of integrated nutrient management at 90 DAS stages.

Treatments	Plant height (cm)	Number of branches /plant	Number of leaves/ plant	Days taken for 50% flowering	Pod length (cm)
T_0 Absolute control	67.76	4.96	43.40	69.09	4.31
T_1 100% RDF	68.11	5.97	48.32	72.60	5.41
T_2 100% RDF + Rhizobium	72.10	6.32	49.40	72.00	5.49
T_3 100% RDF + Azotobacter	69.29	6.50	47.71	72.90	5.38
T_4 80% RDF + 20% FYM	70.10	6.10	49.81	70.11	5.41
T_5 80% RDF + 20% FYM + Rhizobium	76.14	8.01	62.23	70.68	6.51
T_6 80% RDF + 20% FYM + Azotobacter	72.11	6.93	54.34	69.91	5.55
T_7 60% RDF + 40% FYM	73.14	7.40	55.97	69.11	4.59
T_8 60% RDF + 40% FYM + Rhizobium	74.82	6.30	56.91	70.17	4.91
T_9 60% RDF + 40% FYM + Azotobacter	71.51	6.90	56.11	69.23	4.89
SEm±	0.81	0.36	0.96	1.84	0.257
CD at 5%	2.41	0.94	2.79	NS	0.761

better pod development. This was followed by T_2 (100% RDF + Rhizobium) and T_6 (80% RDF + 20% FYM + Azotobacter) with pod lengths of 5.49 cm and 5.55 cm, respectively. These treatments also performed significantly better than the control, indicating the positive influence of integrating biofertilizers with inorganic and organic nutrient sources. The minimum pod length (4.31 cm) was recorded in the absolute control (T_0), which received no nutrient input, demonstrating the negative impact of nutrient deficiency on reproductive parameters. These findings confirm that integrated application of organic, inorganic, and biological sources of nutrients improves pod development and ultimately the yield attributes of the crop. Similar findings have also been reported by Kumar and Pandita (2016), Panda *et al*. (2017), Shubhashree *et al*. (2018)

Yield characters

The data presented in Table 2 show that the number of seeds per pod was significantly influenced by different integrated nutrient management (INM) treatments. The maximum number of seeds per pod (4.76) was recorded under the treatment T_7 (60% RDF + 40% FYM), which was significantly superior to all other treatments. This enhanced seed setting may be due to improved nutrient availability, especially phosphorus and micronutrients, from the well-decomposed FYM, which plays a crucial role in flower and seed development. The second highest number of seeds per pod was noted in T_3 (100% RDF + Azotobacter) with 4.45 seeds, followed by T_2 (100% RDF + Rhizobium) with 4.37 seeds and T_8 (60% RDF + 40% FYM + Rhizobium) with 4.34 seeds. These treatments, involving either biofertilizers or organic components with RDF, also performed significantly better than the control. The minimum number of seeds per pod (2.98) was observed in the absolute control (T_0), which received no nutrient inputs. This result confirms that nutrient deficiency adversely affects reproductive parameters such as seed setting. Similar findings have also been reported by Meena *et al.* (2018), Basdemir *et al.* (2020), Alhammad and Seleiman (2023) and Virendra *et al*. (2024).

The data in Table 2 reveal that pod weight per plant was significantly influenced by different integrated nutrient management (INM) treatments. The maximum pod weight per plant (85.35 g) was recorded in T_5 (80% RDF + 20% FYM + Rhizobium), which was significantly superior to all other treatments. The enhanced pod weight in this treatment may be attributed to the combined effect of chemical fertilizers, organic manure, and Rhizobium, which improve soil fertility, enhance root nodulation and increase nutrient uptake, especially nitrogen and phosphorus elements for pod development and filling. The next best performance was recorded in T_2 (100% RDF + Rhizobium) and T_9 (60% RDF + 40% FYM + Azotobacter) with pod weights of 76.03 g and 72.11 g, respectively. These treatments also showed significant improvement over the absolute control and other lower-performing treatments. The lowest pod weight (59.23 g) was observed under the absolute control (T_0), which received no nutrient input, improved soil biological activity and sustained nutrient release during the crop growth period. Similar findings have also been reported by Kumar

Table 2 : Yield characters as influenced by different treatments of integrated nutrient management.

Treatments	Number of seeds pod^{-1}	Pod weight plant^{-1} (g)	No. of pods plant^{-1}	100 seed weight (g)	Fresh pod yield (q/ha)
T_0 Absolute control	2.98	59.23	46.51	15.06	69.21
T_1 100% RDF	3.53	65.78	56.76	21.06	75.56
T_2 100% RDF + Rhizobium	4.37	76.03	57.11	19.79	82.12
T_3 100% RDF + Azotobacter	4.45	66.35	61.10	22.09	88.64
T_4 80% RDF + 20% FYM	4.25	55.20	60.96	19.09	90.23
T_5 80% RDF + 20% FYM + Rhizobium	4.28	85.35	65.77	25.06	115.23
T_6 80% RDF + 20% FYM + Azotobacter	3.61	67.83	60.81	18.06	101.54
T_7 60% RDF + 40% FYM	4.76	70.71	60.28	19.79	95.11
T_8 60% RDF + 40% FYM + Rhizobium	4.34	70.16	59.25	24.09	102.45
T_9 60% RDF + 40% FYM + Azotobacter	3.11	72.11	60.93	18.09	102.64
SEm ±	1.03	1.13	6.345	0.13	8.06
CD at 5%	3.09	3.39	18.562	0.39	24.17

and Pandita (2016), Panda *et al.* (2017), Shubhashree *et al*. (2018).

The data presented in Table 1 reveals that the number of pods per plant was significantly influenced by different integrated nutrient management (INM) treatments at 90 days after sowing (DAS). The maximum number of pods per plant (65.77) was recorded with treatment T_5 (80% RDF + 20% FYM + Rhizobium), which was statistically at par with all treatment recorded T_0 (control). The lowest number of pods per plant (46.51) was observed in T_0 (absolute control). The substantial increase in the number of pods per plant under integrated treatments, particularly with T_5, could be attributed to the synergistic effect of organic manure (FYM), chemical fertilizers (RDF) and biological inoculants (Rhizobium), which together enhanced nutrient availability and uptake. FYM improves soil physical properties and microbial activity, while Rhizobium contributes to nitrogen fixation and growth-promoting substances. These factors collectively result in better vegetative growth, more flowering sites and ultimately a higher number of pods per plant.

The 100-seed weight was significantly influenced by different integrated nutrient management treatments at 90 DAS (Table 2). The highest 100-seed weight (25.06 g) was recorded under T_5 (80% RDF + 20% FYM + Rhizobium), which was significantly superior over all other treatments. This was followed by T_1 (100% RDF) with 21.06 g, and T_2 (100% RDF + Rhizobium) with 19.79 g, both of which were statistically at par with each other. The lowest 100-seed weight (15.06 g) was observed under the T_0 (absolute control) treatment. The maximum 100-seed weight observed in T_3 (100% RDF + Azotobacter) may be due to the improved nutrient uptake, especially nitrogen, facilitated by Azotobacter, along with the immediate availability of nutrients from the full recommended dose of fertilizers (RDF). Nitrogen plays a key role in protein synthesis and seed development, thereby enhancing seed size and weight. The combined effect of chemical fertilizers and Azotobacter likely contributed to more efficient metabolic activities and seed filling. Similar results were also reported by Singh *et al.* (2022), Harish *et al.* (2023) and Singh *et al.* (2024).

The data presented in Table 2 indicate that fresh pod yield per hectare was significantly affected by various integrated nutrient management treatments. The highest fresh pod yield (115.23 q/ha) was recorded with T_5 (80% RDF + 20% FYM + Rhizobium), which was followed by T_9 (60% RDF + 40% FYM + Azotobacter) with 102.64 q/ha, T_8 (60% RDF + 40% FYM + Rhizobium) with 102.45 q/ha, and T_6 (80% RDF + 20% FYM + Azotobacter) with 101.54 q/ha. The lowest fresh pod yield (69.21 q/ha) was obtained in T_0 (absolute control). The maximum fresh pod yield per hectare recorded in T_5 can be attributed to the synergistic effect of inorganic fertilizers (RDF), organic manures (FYM) and Rhizobium biofertilizer. Rhizobium enhances nitrogen fixation, FYM improves soil health and nutrient availability and RDF ensures an immediate and balanced supply of essential nutrients. This integrated approach likely improved plant vigor, pod formation, and seed filling, thereby increasing overall yield. Treatments involving a combination of FYM and biofertilizers (T_6, T_8, T_9) also showed significantly higher yields, highlighting the importance of organic and

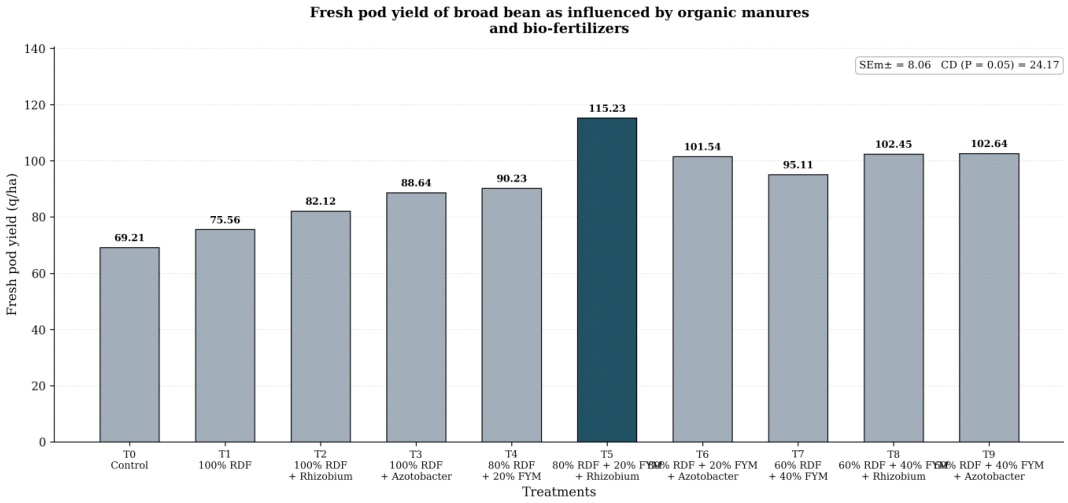


Fig. 1 : Fresh pod yield (q/ha) of broad bean as influenced by different treatments of integrated nutrient management.

biological components in sustainable nutrient management. The significantly lower yield in T_0 (control) clearly reflects the impact of nutrient deficiency on crop performance. Similar findings have also been reported by Panda *et al.* (2017), Meena *et al.* (2018), Basdemir *et al.* (2020), Alhammad and Seleiman (2023).

Conclusion

The present investigations indicate that the integrated application of organic manures, biofertilizers and chemical fertilizers significantly enhances the growth, yield and profitability of broad bean cultivation. Among all treatments, T_5 (80% RDF + 20% FYM + Rhizobium) recorded the maximum plant height, number of branches and leaves per plant, pod length, number of pods and seeds per plant, 100-seed weight (25.06 g), and fresh pod yield per plant (0.651 kg) and per hectare (115.23 q/ha).

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