



Influence of Nitrogen Levels and Microbial Inoculants on Yield and Economics of French Bean (*Phaseolus vulgaris* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Influence of Nitrogen levels and Microbial inoculants on Yield and Economics of French bean" was conducted during *rabi* season, 2022 at Crop Research Farm in the Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh. The soil in the experimental area was sandy loam with pH (8.0), Organic Carbon (0.42%), Available N (180.58 kg/ha), Available P (15.54 kg/ha), and Available K (198.67 kg/ha). The treatment consisted of two factors, Factor-1 levels of Nitrogen

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(75,100,125 kg/ha) and factor-2 Microbial inoculants (*Rhizobium*, PSB & *Rhizobium* +PSB). The experiment was layout in Randomized Block Design (RBD) with 10 treatments and replicated thrice. It was noticed that application of Nitrogen levels and Microbial inoculants had a significant effect on growth, yield, and yield parameters. The results indicated that the higher seed yield (22.47 q/ha), stover yield (50.08 q/ha), harvest index (30.95%), gross return (133601.00 INR/ha), net return (91333.00 INR/ha) and benefit-cost ratio (2.16) were observed in treatment 6, which involved the seed inoculation of *Rhizobium* and PSB along with the soil application of Nitrogen 100 kg/ha. So, in order to get higher productivity and returns from French bean, application of 100kg N/ha along with seed inoculation with phosphate solubilizing bacteria (PSB) and *Rhizobium* should be followed in sub-humid condition of Prayagraj, UP.

Keywords: French bean; nitrogen; microbial inoculants; yield and economics.

1. INTRODUCTION

“French bean (*Phaseolus vulgaris* L.) is one of the most important commercially grown pulse crops globally. This crop is well adapted to diverse climatic conditions ranging from tropical to temperate regions” [1]. “The French bean (*Phaseolus vulgaris* L.) is a short-duration high yielding legume plant of the family *Fabaceae*. It is commonly known as bean or kidney bean and was considered to have been introduced from Ethiopia in the 16th century by the Portuguese” [2]. “It is one of the most important commercially grown legume crops during winter season in India and it can be used both as a pulse and vegetable. Seed of French bean is highly nutritious containing 21.1 percent protein, 1.7 percent fat and 69.9 percent carbohydrates and minerals viz. calcium (381 mg/100 g of seed), phosphorus (425 mg/100 g of seed) and iron (12.5 mg/100 g of seed)” [3,4]. “It is assumed that beans can play an important role in the enhancement of the level of nourishment because it is rich in elements like potassium, calcium, iron and phosphorus and on average, every grain contains between 18-32 percent of protein” [5]. “The beans are also rich in vitamins like A, B and D” [6].

“It is cultivated in an area of 9.72 million hectares with a production of 4.34 metric tons. The productivity in India is about 447 kg/ha which is against The World average productivity of 669 kg/ha. French bean is newly introduced as a non-traditional winter pulse crop in the plains of India with high yield potential of 2.5-3.5 tons/ha” [7]. Its cultivation in India is mainly confined to northern hilly tracts of Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh as a *Kharif* crop and in some parts of Maharashtra, Andhra Pradesh, Western and Eastern Ghats and the North-eastern plain zone.

The productivity of French beans (*Phaseolus vulgaris* L.) is low in Uttar Pradesh. The inadequate supply of nutrients is one of the most important reasons for its low productivity. Declining soil fertility and high fertilizer cost are major limitations to crop production in smallholder farms [8].

French bean is considered a nitrogen-responsive crop due to its high responsiveness to fertilizer while it is noticed that increased nutrition affect yields [9]. “Nitrogen (N) is so vital in every crop because it is a major component of chlorophyll, amino acids, and the building blocks of proteins. Application of N increases the leaf area and photosynthetic rate and thus increases dry matter production” [10]. “Prolonged use of chemical fertilizers degrades soil health and affects crop yield” [11]. “The application of higher doses of nitrogen especially for seed crop of French bean is imperative for realizing its potential yield” [12]. “While usage of biofertilizers - a category of organic fertilizers is an environmentally secure method of fertilization. Biofertilizers augment the biochemical processes in the soil such as nitrogen fixation, phosphorus solubilization and mobilization, zinc solubilization, production of plant growth-promoting substances and pathogen control. Biofertilizers provide an attractive, ecologically sound means of fertilization and economically judicious”. “Furthermore, they are important for making agriculture more sustainable. *Rhizobium* and phosphate solubilizing bacteria (PSB) assume countless importance on account of their dynamic role in N₂-fixation and P solubilizations. *Rhizobium* and PSB use have been beneficial for increasing French bean productivity” [13].

“There is also report that French bean is insufficient in trapping atmospheric nitrogen due to lack of nodulation in north Indian plains” [4],

[14]. Therefore, it requires a large quantity of nitrogenous fertilizer. The increasing cost of inorganic fertilizers and reduction in soil health with chemical fertilizers there is a need of present are to use of eco-friendly inputs like vermicompost, biofertilizer viz., Phosphorus solubilizing bacteria, *Rhizobium* along with inorganic fertilizers.

2. MATERIALS AND METHODS

This experiment was laid out during the *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25° 39' 42" N latitude, 81° 67' 56" E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design (RBD) consisting of ten treatments with T₁-Nitrogen 75 kg/ha + *Rhizobium*(20 g/kg of seeds), T₂-Nitrogen 75 kg/ha + PSB (20 g/kg of seeds), T₃-Nitrogen 75 kg/ha + *Rhizobium*(10 g/kg of seeds)+ PSB (10 g/kg of seeds), T₄-Nitrogen 100 kg/ha + *Rhizobium*(20 g/kg of seeds), T₅-Nitrogen 100 kg/ha + PSB(20 g/kg of seeds), T₆-Nitrogen 100 kg/ha + *Rhizobium*(10 g/kg of seeds) + PSB (10 g/kg of seeds), T₇-Nitrogen 125 kg/ha + *Rhizobium*(20 g/kg of seeds), T₈-Nitrogen 125 kg/ha + PSB (20 g/kg of seeds), T₉ -Nitrogen 125 kg/ha + *Rhizobium* (10 g/kg of seeds) + PSB (10 g/kg of seeds), T₁₀-Control (NPK 100-80-60 kg/ha). The experiment was laid out in a factorial randomized block design with three replications. Method of application of biofertilizer viz., *Rhizobium* culture and Phosphorus solubilizing bacteria culture was seed treatment. Full dose of phosphorus, potash and ½ dose of nitrogen were applied at the time of sowing. Half dose of nitrogen was applied as a split dose one month after sowing. The sources of nitrogen, phosphorus and potash were urea, Single Super Phosphate (SSP)and Murate Of Potash (MOP), respectively. Sowing of healthy seeds was done with a spacing of 45 cm × 15 cm. All cultural operations were performed as per recommendations. Observations were recorded from five random healthy plants of each treatment on growth, yield, and its attributes. Data recorded on different aspects of crop, viz., growth, yield and yield parameters were subjected to statistical analysis by analysis of variance method [15] and economic data analysis mathematical method.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes and Yield

As depicted in Table 1 the statistically analyzed data of pods/plant, seeds/pod, seed yield, and stover yield indicating significant differences among the treatments. T₆ [Nitrogen 100 kg + *Rhizobium* + PSB] recorded maximum pods/plant, seeds/pod, seed yield, stover yield (19.70, 5.08, 22.47 and 50.08) and least was observed in treatment 1 [Nitrogen 75kg + *Rhizobium*].

Application of 100 kg N/ha along with seed inoculation with phosphate solubilizing bacteria (PSB)and *Rhizobium* (T₆) significantly increased number of pods/plant over all the treatments except T₃ and T₉. The best treatment caused a 28.68% increase over control. Similarly, T₆ recorded maximum no. of seeds/plant (19.70) and was significantly superior over the rest of the treatments. The best treatment caused a 16.25% increase over control. While T₉ (4.81) was found statistically at par to T₆.

Increased pods/plant might be due to increased assimilation of nitrogen and phosphorus which resulted from positive interaction between fertilizer and biofertilizers at 100 kg N/ha. Ramana et al. [16] and Singh et al. [17] also reported significant effects of fertilizer and biofertilizers on pods/plant. However, to a certain limit, beyond that N level no further increase was observed with the increasing rate of N. Namvar et al. [9] also observed similar results. A significant increase in the number of seeds/pods probably may be due to balanced nutrition and proper vegetative growth which later converted into reproductive phase and resulted might in a greater number of seeds. The results were similar to [13].

Application of Nitrogen at 100 kg/ha along with seed inoculation with PSB and *Rhizobium* (T₆) recorded the highest seed yield (22.47 q/ha) and was significantly superior to the rest of the treatments. However, T₉ (21.16 q) was found statistically at par with T₆. Percent increase in seed yield ranged from 4.7 (T₄) to 28.13 % (T₆) over control. However, T₁ and T₂ caused a reduction in seed yield over control. A significant increase in seed yield might be due to the Dual inoculation of *Rhizobium* and PSB. *Rhizobium* can increase seed yield in pulse crops by up to 10 to 15% while PSB increases the availability of

Table 1. Influence of nitrogen levels and microbial inoculants on yield attributes and yield of french bean

S.No.	Treatment combination	Number of pods /Plants	Number of seeds/pod	Seed Yield (q/ha)	Stover Yield (q/ha)	Harvest Index (%)
1.	Nitrogen 75kg + <i>Rhizobium</i>	14.00	3.87	16.00	43.55	26.82
2.	Nitrogen 75 kg + PSB	14.80	4.03	16.33	44.90	26.68
3.	Nitrogen 75 kg + <i>Rhizobium</i> + PSB	18.27	4.65	20.61	47.65	30.20
4.	Nitrogen 100 kg + <i>Rhizobium</i>	15.80	4.37	18.36	46.19	28.44
5.	Nitrogen 100 kg + PSB	16.00	4.44	18.76	46.00	28.97
6.	Nitrogen 100 kg + <i>Rhizobium</i> + PSB	19.70	5.08	22.47	50.08	30.95
7.	Nitrogen 125 kg + <i>Rhizobium</i>	16.67	4.51	19.79	46.03	30.06
8.	Nitrogen 125 kg + PSB	17.13	4.59	19.63	46.05	29.88
9.	Nitrogen 125 kg + <i>Rhizobium</i> + PSB	18.70	4.81	21.16	48.29	30.45
10.	Control (NPK 100-80-60 kg/ha)	15.33	4.37	17.53	45.86	27.69
	F-test	S	S	S	S	S
	SEm(±)	0.82	0.14	0.54	0.75	0.64
	CD (p=0.05)	2.45	0.40	1.62	2.40	1.91

Table 2. Influence of nitrogen levels and microbial inoculants on economics of french bean

S.No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1	Nitrogen 75kg + <i>Rhizobium</i>	41890.00	96710.00	54820.00	1.31
2	Nitrogen 75 kg + PSB	42050.00	98795.00	56745.00	1.35
3	Nitrogen 75 kg + <i>Rhizobium</i> + PSB	41938.00	122885.00	80947.00	1.93
4	Nitrogen 100 kg + <i>Rhizobium</i>	42220.00	110218.00	67998.00	1.61
5	Nitrogen 100 kg + PSB	42380.00	112380.00	70000.00	1.65
6	Nitrogen 100 kg + <i>Rhizobium</i> + PSB	42268.00	133601.00	91333.00	2.16
7	Nitrogen 125 kg + <i>Rhizobium</i>	42550.00	118051.00	75501.00	1.77
8	Nitrogen 125 kg + PSB	42710.00	117175.00	74465.00	1.74
9	Nitrogen 125 kg + <i>Rhizobium</i> + PSB	42598.00	126038.00	83440.00	1.96
10	Control (NPK 100-80-60 kg/ha)	42060.00	105587.00	63527.00	1.51

insoluble phosphorous in the soil. These results were similar to Singh et al. [17] thus increased yield with nutrient levels might be due to the direct role of nitrogen in seed growth and indirectly helping in accommodating osmotic imbalances present during the final stage of seed filling. Higher seed yield may be due to a better expression of growth and yield parameters through higher number of pods/plant, number of seeds/pod and pod length(cm). These results are in agreement with Manivannan et al. [18] and Ramana et al. [19]. Behura et al. [20] and Uddin Jamil *et.al* [10] also reported significant influence of nitrogen levels on seed yield per hectare.

Application of 100kg N/ha plus PSB and *Rhizobium* recorded maximum Stover yield (50.08 Q/ha). It was significantly superior to the rest of the treatments except T9. Percent increase in Stover yield ranged from 0.31% (T5) to 9.21% (T6). Similarly, T1 and T2 caused a reduction in Stover yield over control to the tune of 5.04 and 2.10, respectively. Significant increase in stover yield with Dual inoculation of *Rhizobium*, PSB and increase in nitrogen availability in soil leads to increase in content of nitrogen in seed and increase in P availability through solubilization of insoluble native P and production of plant growth promoting substances [17,21].

Application of Nitrogen at 100 kg/ha along with seed inoculation with PSB and *Rhizobium* (T6) recorded the highest harvest index (30.95) and was significantly superior to the rest of the treatments. However, T9, T3, T8 and T7 were found statistically at par with T6. The highest harvest index might be due to the larger seed size with higher sink capacity [22].

3.2 Economics

A. Gross return (INR/ha)

Maximum (133601.00 INR/ha) (Table 2) gross return was obtained with the application of treatment 6 [Nitrogen 100 kg + *Rhizobium* + PSB] while the lowest (96710.00 INR/ha) gross return was obtained with the application of Treatment 1 [Nitrogen 75kg + *Rhizobium*] as compared to all other treatments.

B. Net returns (INR/ha)

Maximum (91333.00 INR/ha) (Table 2) net return was obtained with the application of treatment 6 [Nitrogen 100 kg + *Rhizobium* + PSB] while the lowest (54820.00 INR/ha) net return was obtained with the application of treatment 1 [Nitrogen 75kg + *Rhizobium*] as compared to all other treatments.

C. Benefit-Cost ratio (B:C)

The benefit Cost ratio (2.16) (Table 2) was found to be highest in treatment-6 [Nitrogen 100 kg + *Rhizobium* + PSB] and the minimum benefit-cost ratio (1.31) was found to be in treatment-1 [Nitrogen 75kg + *Rhizobium*] as compared to all other treatments.

4. CONCLUSION

French bean (*Rhizobium phaseoli*) is less-efficient in nodulation with native rhizobia i.e. nitrogen-fixing bacteria as compared to other leguminous crops and because of this reason it requires nitrogen fertilizer as non-leguminous crops. Due to a wide range in the dosage of nitrogenous fertilizers, the average yield of French beans in farmers' fields is somewhat lower than its actual yield potential. Crop growth and development are hampered by nutrient deficiencies, while hazardous nutrient overuse can also result in poor growth. Furthermore, adding too much nitrogen to the soil is bad for the health of the soil, damaging the crop, and worsens environmental contamination. Hence the use of biofertilizer along with chemical fertilizer the requirement of inorganic fertilizer will be reduced, and which is better for ecosystem. Based on the above findings it can be concluded that French beans with the application of *Rhizobium* and PSB along with the application of Nitrogen 100 kg/ha (T6) recorded the highest seed yield and B:C ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mongi Rose, Tongoona Pangirayi, Shimelis Hussein, Sibiya Julia. Appraisal of

- common bean farming systems under angular leaf spot disease prone environments of the southern highlands of Tanzania. Indian Journal of Agricultural Research. 2016;50(5):428-433.
2. Imru A. Bean production in Ethiopia. In regional workshop on potential for field beans (*Phaseolus vulgaris* L.) in West Asia and North Africa. Aleppo, Syria. 1985;56.
 3. Gopalakrishnan TR. Vegetable crops. New India Publishing Agency, New Delhi (India); 2007.
 4. Kanwar R, Mehta DK, Sharma R, Dogra RK. Studies on genetic diversity of French bean (*Phaseolus vulgaris* L.) landraces of Himachal Pradesh based on morphological traits and molecular markers. Legume Research-An International Journal. 2020; 43:470-479.
 5. Shimelis EA, Rakshit SK. Proximate composition and physico-chemical properties of improved dry bean (*Phaseolus vulgaris* L.) varieties grown in Ethiopia. LWT. 2005;38(2):331-338.
 6. Campos-Vega R, Loarca-Pina G, Oomah BD. Minor components of pulses and their potential impact on human health. Food Res. Int. 2010;43:461-582.
 7. Kumar, R. P., O.N., Singh, Yogeshwar Singh, J. P. Singh. (2009 Effect of integrated nutrient management on growth, yield nutrient uptake and economics of French bean. (*Phaseolus vulgaris* L.) Indian J. of Agric. Sci. 79 (211): 122-128.
 8. Wange SS, Karkeli MS, Patil JD, Meher BB. Effect of rhizobial inoculation and fertilizer nitrogen on French bean varieties. Journal of Soils and Crops. 1996;6(1):132-133.
 9. Namvar A, Sharifi RS, Khanda T. Growth analysis and yield of chickpea (*Cicer arietinum* L.) in relation to organic and inorganic nitrogen fertilization. Ekologija. 2011;57(3):97-108.
 10. Uddin Jamil FM, Molla R, Rashid H, Sarkar K, Karim M. Influence of nitrogen levels on yield of French bean. Research crop. 2022;23(1):163-171.
 11. Caliskan S, Ozkaya I, Caliskan ME, Arslan M. The effect of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean type soil. Field Crops Res. 2008;108:126-132.
 12. Sardana Virender, Dhingra KK, Gill MS, Singh Inder Jit. Production technology of French bean (*Phaseolus Vulgaris* L.) cultivation: A review. Agric. Rev. 2000;21(3):141-154.
 13. Barcchiya J, Kushwah SS. Influence of integrated nutrient management on growth, yield parameters and yield in French bean (*Phaseolus vulgaris*). Legume Research - An International Journal. 2017;40(5):920- 923.
 14. Kushwaha BL. Response of French bean to nitrogen application in North Indian plains. Indian Journal of Agronomy. 1994;39(1):34-37.
 15. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Ed. New York: John Wiley and Sons. 1984;680.
 16. Ramana V, Ramakrishna M, Purushotham K, Reddy K Balakrishna. Effect of biofertilizers on growth, yield attributes and yield of French bean (*Phaseolus vulgaris*). Legume Research. 2010;33(3): 178-183.
 17. Singh R, Pratap T, Singh D, Singh G, Singh KA. Effect of phosphorus, Sulphur and biofertilizers on growth attributes and yield of chickpea (*Cicer arietinum* L.) Journal of Pharmacognosy and Phytochemistry. 2018;7(2):3871-3875.
 18. Manivannan S, Batamurugan M, Parthasarathi K, Gunasekaran G, Ranganathan LS. Effect of vermicompost on soil fertility and crop productivity - beans (*Phaseolus vulgaris*). Journal of Environmental Biology. 2009;30(2):275-281.
 19. Ramana V, Ramakrishna M, Purushotham K, Reddy K Balakrishna. Effect of biofertilizer on growth, yield and quality of French bean. Vegetable Science. 2011;38(1):35-38.
 20. Behura AK, Mahapatra PK, Swain D. Effect of irrigation and nitrogen on yield, water and nitrogen use efficiency in rajmash (*Phaseolus vulgaris* L.). Legume Research. 2008;31(1):40-43.
 21. Tiwari S, Chouhan RK, Singh R, Sukla R, Gaur R. Integrated effect of rhizobium and azatobactor culture on the leguminous

- crop black gram (*Vigna mungo*). Adv Crop Sci Tech. 2017;(5):3.
22. Rajput Pankaj Kumar, Singh ON, Singh Yogeshwar, Singh JP. Integrated nutrient management for quantitative and qualitative yield of French bean (*Phaseolus vulgaris* L.). Vegetable Science. 2006;33 (2):155-159.

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