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Influence of Nitrogen Levels and Biofertilizers on the Growth and Yield of French Bean (*Phaseolus vulgaris* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Influence of Nitrogen levels and Biofertilizers on the growth and yield 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 treatment consisted of two factors, Factor-1 levels of Nitrogen (75,100,125 kg/ha) and factor-2 Biofertilizers (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 Biofertilizers had a significant effect on Growth , yield, and yield parameters. Treatment-6 [Nitrogen 100 kg/ha + *Rhizobium* (10 g/kg of seed) + PSB (10 g/kg of seeds)] recorded maximum plant height (46.19 cm), dry weight (26.39 g), number of pods/plant (19.73), number of seeds/pod (5.08), seed yield (22.47 q/ha) and stover yield (50.08 q/ha).

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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 family Fabaceae known by common 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 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 this plant is rich in elements like potassium, calcium, iron and phosphorus and it contains 18-32 percent of protein in every grain averagely" [5]."The plant is also rich in vitamins like A, B and D" [6].

French bean is considered as a nitrogen responsive crop due to its high responsiveness to fertilizer while it is noticed that increased nutrition has a negative impact on yield [7]. "Nitrogen is so vital in every crop because it is a major component of chlorophyll, amino acids and the building blocks of proteins. Without proteins, plants wither and die. Application of N increases leaf N and chlorophyll content. Leaf N, chlorophyll and photosynthetic rate are closely related and high leaf N and chlorophyll increase the photosynthetic rate. Therefore, application of N increases the leaf area and photosynthetic rate and thus increases dry matter production" [8]. "Prolonged use of chemical fertilizers degrades the soil health and affects crop yield" [9]. "Application of higher doses of nitrogen especially for seed crop of French bean is imperative for realizing its potential yield" [10]. "There is also report that French bean is in sufficient in trapping atmospheric nitrogen due to lack of nodulation in north Indian plains" [4]. Therefore, it requires large quantity of nitrogenous fertilizer. 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, bio fertilizer viz., Phosphorus solubilizing bacteria, *Rhizobium* along with inorganic fertilizers.

"Biofertilizer is required to restore the fertility of the soil. Biofertilizers enhance the water holding capacity of the soil and add essential nutrients such as nitrogen, vitamins, and proteins to the soil. Microbes in biofertilizers provide atmospheric nitrogen directly to plants. They aid in solubilization and mineralization of other plant nutrients like phosphates. Better synthesis and availability of hormones, vitamins, auxins, and other growth - promoting substances improves plant growth. The interaction of biofertilizer along chemical fertilizer the requirement of inorganic fertilizer will reduced will be better for ecosystem, as the use of fertilizer is one most important factor to increase all growth parameters and yield of crop" [11,12].

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 25^0 39" 42" N latitude, 81^0 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 T_1-Nitrogen 75 kg/ha + *Rhizobium* (20 g/kg of seeds), T_2-Nitrogen 75 kg/ha + PSB (20 g/kg of seeds), T_3-Nitrogen 75 kg/ha + *Rhizobium* (10 g/kg of seeds)+ PSB (10 g/kg of seeds), T_4-Nitrogen 100 kg/ha + *Rhizobium* (20 g/kg of seeds), T_5-Nitrogen 100 kg/ha + PSB (20 g/kg of seeds), T_6-Nitrogen 100 kg/ha + *Rhizobium* (10 g/kg of seeds) + PSB (10 g/kg of seeds), T_7-Nitrogen 125 kg/ha + *Rhizobium (*20 g/kg of seeds), T_8-Nitrogen 125 kg/ha + PSB (20 g/kg of seeds), T_9 -Nitrogen 125 kg/ha + *Rhizobium* (10 g/kg of seeds) + PSB (10 g/kg of seeds), T_{10}-Control (NPK 100-80-60 kg/ha). Experiment was laid out in 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 split dose one month after sowing. The sources of nitrogen, phosphorus and potash were urea, SSP and MOP, respectively. Sowing of healthy seed was done with 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 crops, *viz.,* growth, yield and yield parameters were subjected to statistical analysis by analysis of variance method" [13] and economic data analysis mathematical method.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

There were significant differences in growth parameters among treatments due to application of nitrogen at different rates in the presence of biofertilizers (Table 1). All the growth parameters increased with N levels up to 100 kg N/ha and declined at 125 kg N/ha. Combined application of PSB and *Rhizobium* recorded higher growth parameters compared to individual application in the presence of N. The tallest plant height (46.19 cm), dry weight (26.39 g/plant) and CGR (8.25) with Treatment-6 [Nitrogen 100 kg/ha + *Rhizobium* (10 g/kg of seed) + PSB (10 g/kg of seeds)] and was comparable with T9, T8 an T3 but significantly superior to rest of the treatments. The best treatment caused 14.9%, 21.83%and 18.66% increase in plant height, dry weight of plant and CGR over control.

Significant increase in growth parameters with *Rhizobium* and PSB might be due to increase in uptake of N and P by the plants, which can be result of more N-fixation and P-solubilization through micro-organisms Singh et al. [14]. Above results are also in agreement with the findings of Singh et al*.* [15], Singh et al*.* [16], Ramana et al*.* [17] and Singh et al*.* [18]. While significantly declined growth parameters observed at 125 kg N/ha might be due to presence of nutrient in soil more than plant requirement, the nutrient is absorbed in higher amounts which causes imbalance of nutrients or disorder in physiological processes (Reddy & Reddi, [19], Moniruzzaman et al*.* [20]. However, T1 and T2 recorded lower growth parameters compared to RDF which resulted from decreased availability of nitrogen as compared to control with decreased Nitrogen application. These findings are in line the results of Namvar et al*.* [7] who also reported that growth parameters increase with increasing rate of N.

3.2 Yield attributes and Yield

As depicted in Table 2 the statistically analyzed data pertaining to pods/plant, seeds/pod, seed yield, stover yield indicated that significant differences observed 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 100kg N/ha along with seed inoculation with PSB and *Rhizobium* (T6) significantly increased number of pods/plant over all the treatments except T3 and T9. The best treatment caused 28.68% increase over control. Similarly, T6 recorded maximum no. of seeds/plant (19.70) and significantly superior over rest of treatments. The best treatment caused 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*.* and Singh et al*.* [18] also reported significant effect of Fertilizer and Biofertilizers on pods/plant. However, to a certain limit, beyond that N level no further increase was observed with increasing rate of N. Namvar et al. [7] also observed same results. Significant increase in 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 (Barcchiya et al*.* [11].

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 rest of the treatments. However, T9 (21.16 q) was found statistically at par to 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. Significant increase in seed yield might be due to the Dual inoculation of *Rhizobium* and PSB. *Rhizobium* can increase seed yield in pulse crop up to 10 to 15% while PSB increase availability of insoluble phosphorous into soil. Results were similar to Singh et al*.* [18] and increased yield with nutrient levels might be due to the direct role of nitrogen

to seed growth and indirectly help in accommodating osmotic imbalances present during final stage of seed filling. Higher seed yield may be due to better expression of growth and yield parameters through higher number of pods/plant, number of seeds/pod and pod length(cm).These results agree with Manivannan et al. [14] and Ramana et al. [17]. Behura et al. [21], Uddin Jamil et al., [8] and Wange et al., [12] were 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 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 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

Table 1. Influence of Nitrogen levels and Biofertilizers on growth of French bean

S.No.	Treatment combinations	At 80 DAS		
		Plant height (cm)	Dry weight (g/plant)	Crop growth rate(g/m^2/day))
1.	Nitrogen 75kg + *Rhizobium*	37.14	19.13	5.226
2.	Nitrogen 75 kg + PSB	39.54	20.86	6.100
3.	Nitrogen 75 kg + *Rhizobium* + PSB	44.63	23.91	6.719
4.	Nitrogen 100 kg + *Rhizobium*	40.73	22.82	6.983
5.	Nitrogen 100 kg + PSB	41.43	23.06	7.169
6.	Nitrogen 100 kg + *Rhizobium* + PSB	46.19	26.39	8.253
7.	Nitrogen 125 kg + *Rhizobium*	42.38	23.58	7.202
8.	Nitrogen 125 kg + PSB	44.07	23.88	6.799
9.	Nitrogen 125 kg + *Rhizobium* + PSB	45.29	25.74	8.117
10.	Control (NPK 100-80-60 kg/ha)	40.20	21.66	6.955
	F-test	S	S	S
	SEm(±)	0.76	0.35	0.51
	CD (p=0.05)	2.24	1.04	1.51

Table 2. Influence of Nitrogen levels and Biofertilizers 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 + *Rhizobium*	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 + *Rhizobium* + PSB	18.27	4.65	20.61	47.65	30.20
4.	Nitrogen 100 kg + *Rhizobium*	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 + *Rhizobium* + PSB	19.70	5.08	22.47	50.08	30.95
7.	Nitrogen 125 kg + *Rhizobium*	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 + *Rhizobium* + 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

increase in P availability through solubilization of insoluble native P and production of plant growth promoting substances, [18,22].

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 rest of the treatments. However, T9, T3, T8 and T7 were found statistically at par to T6. The highest harvest index might be due to the larger seed size with higher sink capacity [23].

4. CONCLUSION

Based on the above findings it can be concluded that French bean with the application of *Rhizobium* and PSB along with the application of Nitrogen 100 kg/ha (Treatment 1) recorded highest plant height, dry weight, no. of pods/plant, no. of seeds/pod, seed yield stover yield and harvest index.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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