Influence of Nitrogen levels and Microbial inoculants on Yield and Economics of French bean (*Phaseolus vulgaris* L.)

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 (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.

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" (Singh *et al*., 1999). "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" (Imru, 1985). "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)" (Ali *et al.,* 1987, Gopalkrishnan, 2007 and Kanwar *et al.,* 2020). "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" (Shimelis *et al.,* 2005). "The beans are also rich in vitamins like A, B and D" (Campos-vega *et al.,* 2010).

"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 (Include citation). 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" (Kumar *et al.,* 2009). Its cultivation in India is mainly confined to northern hilly tracts of Jammu and Kashmir, Himachal Pradesh, and Utter 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.

French bean is considered a nitrogen-responsive crop due to its high responsiveness to fertilizer while it is noticed that increased nutrition affect yields (Namvar *et al.,* 2011). "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" (Jamil *et.al* 2022). "Prolonged use of chemical fertilizers degrades soil health and affects crop yield" (Caliskan *et al.,* 2008). "The application of higher doses of nitrogen especially for seed crop of French bean is imperative for realizing its potential yield" (Sardana *et al*., 2000). "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" (Patel *et al.,* 2013). "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 N_2-fixation and P solubilizations. *Rhizobium* and PSB use have been beneficial for increasing French bean productivity" (Barcchiya J. *et.al* 2016).

"There is also report that French bean is insufficient in trapping atmospheric nitrogen due to lack of nodulation in north Indian plains" (Kushwaha, 1994). 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 25^0 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). 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. (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

Result And Discussion

2. 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 100kg 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.* (2010) and Singh *et al.* (2018) 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.,* (2011) 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 (Barcchiya . *et.al* (2016).

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 insoluble phosphorous in the soil. These results were similar to Singh *et al.,* (2018) 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.*, (2009) and Ramana *et al.*, (2010). Behura *et al.*, (2008) and Uddin Jamil *et.al* (2022) 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 (Singh *et al.*, 2014, Chauhan *et al.*, 2017).

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 (Rajput *et al.*, 2006).

3. 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.

CONCLUSION:

c of the soil, damaging to the crop, and worsens environmental contamination. Hence the use of biofertilizer along with chemical fertilizer the requirement of inorganic fertilizer will 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.

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 + *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

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 + *Rhizobium*	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 + *Rhizobium* + PSB	41938.00	122885.00	80947.00	1.93
4	Nitrogen 100 kg + *Rhizobium*	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 + *Rhizobium* + PSB	42268.00	133601.00	91333.00	2.16
7	Nitrogen 125 kg + *Rhizobium*	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 + *Rhizobium* + 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

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