# Effect of Chemical Fertilizers, *Rhizobium* and Phosphate Solubilizing Bacteria on Growth, Yield and Quality of French Bean (*Phaseolus vulgaris* L.)

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**Abstract: -** The investigation was carried out during 2019-20 at HRS, Mondouri, BCKV, Nadia, West Bengal to find out the effect of biofertilizers with different levels of inorganic fertilizers. The experiment was laid out in RBD with three replications. Two biofertilizers (*Rhizobium phaseoli* and PSB) and four levels (100%, 75%, 50% and 25%) of RDF were included in this experiment along with recommended dose of NPK (100:60:50 kg $ha^{-1}$). Among different treatments, highest plant height (35.10 cm), number of primary branches $plant^{-1}$ (4.20), number of pods $plant^{-1}$ (8.00), length of pod (15.44 cm), total pod yield (12.51 t $ha^{-1}$), and crude protein content (3.19 %) was recorded when seeds were treated with *Rhizobium phaseoli* biofertilizer @10 g $Kg^{-1}$ seeds and soil application of PSB @2.5 Kg $ha^{-1}$ along with application of 75% RDF.

**Key Words:** ***Biofertilizers, French Bean, Inorganic Fertilizers, PSB, Rhizobium.***

## I. INTRODUCTION

French bean is the most widely grown bean among all beans due to its short lifespan and nutritional benefits (Ramana et al. 2011). It is eaten as dry beans (Rajmah), tender pods, and shelled green beans. In USA, it is grown in large scale for processing purpose while, in India, it is mostly grown for tender vegetable. On a surface of 227.78 thousand hectares, India produced 2356 thousand tonnes of beans. Gujarat is the state that produces the most beans in India, followed by West Bengal, Bihar, Karnataka, and Jharkhand (NHB 2018-19).

Continuous application of chemical fertilizers has a negative impact on the soil's texture and structure, diminishes the amount of organic matter present, and reduces microbial activity (Alam et al., 2007).

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Green bean development and output are positively impacted by the use of organic nutrients (Abdel Mawgoud, 2006), and the reduction of chemical residues results in higher-quality products for human consumption (Saikia et. al., 2018).

In this context, biofertilizer is one of the essential elements of sustainable farming and organic French bean production can be a realistic solution to get through the current worrying situation. In addition, they do not harm the ecosystem or the health of the soil. In addition to their function in atmospheric nitrogen fixation and phosphorus solubilization, they aid in the stimulation of plant growth hormones, which improves nutrient absorption and increases tolerance to moisture and drought stress.

A minimal dose of the fertilizer is adequate to produce desired effects, because each gram of bio-fertilizers includes at least 10 million viable cells of a particular strain. Bio-fertilizers a cost-effective renewable energy source play a crucial role in reducing the inorganic fertilizer level and at the same time increasing the crop yield besides maintaining the soil fertility. It can help in reducing the application of inorganic fertilizers up to 25 per cent for obtaining the same or higher yield.

Rhizobium is a gram-negative bacterium that lives in soil. It is the most extensively used bio-fertilizer, colonizing the roots of

particular legumes to produce tumor-like growth called root nodules. These nodules serve as factories of ammonia production in plants. In one crop season, the Rhizobium legume association can fix up to 50–300 Kg of nitrogen per hectare (Kumar et al., 2017), and in some circumstances, it can leave behind significant nitrogen for subsequent crops (Dahama, 1997). Rhizobium showed a considerable impact on legume vegetable crops, leading to a yield increase of 4–13%. (Mishra et al., 1996).

Phosphorus is a macronutrient that is crucial for the growth and development of crops (Soetan *et al.,* 2010). The plants are unable to use it. It can be found in the soil in two different forms: organic and inorganic. Chemical fertilizers supply inorganic phosphorus in precipitated form, which plants cannot absorb. Phospho-bacteria have the ability of converting the insoluble form of phosphorus to a soluble form and make it available to plant by releasing various organic acids (succinic acid, oxalic acid, glutamic acid, citric acid, malic acid and fumaric acid). All vegetables can be treated with PSB via soil application, seedling dipping, or seed treatment. The application of PSB would be most beneficial to plants with limited root systems (Lattief, 2016).

Keeping all these points in view the present study was undertaken to observe the effect of biofertilizer on growth, yield and quality of French bean with the objective, to study the effect of biofertilizer on growth, yield and quality of French bean.

## II. Materials And Methods

The present investigation was done with a bushy type French bean variety Sunheri during Rabi season 2019-20 at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, located on 22º946' North latitude, 88º516' East longitude and 9.75 m above sea level. The experiment was conducted on sandy loam soil with pH 6.5, organic carbon 0.57%, available N, $P_2O_5$ and $K_2O$ was 175.40, 30.10 and 115.70 Kg $ha^{-1}$ respectively. The experiment consisting of ten treatments was laid in randomized block design with three replications in individual plot size of 2.25m × 1.5 m where sowing done at the spacing of 45cm × 15cm. The treatments comprised of four levels of recommended dose of fertilizer (RDF– Recommended Dose of Fertilizer is N: $P_2O_5$: $K_2O$ @ 100:60:50 Kg $ha^{-1}$) (Chattopadhyay *et al*., 2007), viz. 100%, 75%, 50%, and 25% along with two levels of biofertilizer *i.e*. PSB @2.5 Kg $ha^{-1}$ as soil application and *Rhizobium* @10 g $Kg^{-1}$ seeds as seed treatment.

The treatments included $T_1$- 100% RDF, $T_2$- 25% RDF + PSB @2.5 Kg $ha^{-1}$, $T_3$- 25% RDF + *Rhizobium* @10 g $Kg^{-1}$ seeds, $T_4$- 25% RDF + PSB @2.5 Kg $ha^{-1}$ + *Rhizobium* @10 g $Kg^{-1}$ seeds, $T_5$- 50% RDF + PSB @2.5 Kg $ha^{-1}$, $T_6$- 50% RDF + *Rhizobium* @10 g $Kg^{-1}$ seeds, $T_7$- 50% RDF + PSB @2.5 Kg $ha^{-1}$ + *Rhizobium* @10 g $Kg^{-1}$ seeds, $T_8$- 75% RDF + PSB @2.5 Kg $ha^{-1}$, $T_9$- 75% RDF + *Rhizobium* @10 g $Kg^{-1}$ seeds and $T_{10}$- 75% RDF + PSB @2.5 Kg $ha^{-1}$ + *Rhizobium* @10 g $Kg^{-1}$ seeds. Inorganic fertilizer (half N + full $P_2O_5$ + full $K_2O$) were applied one week ahead of biofertilizer application as per the treatments as basal dose during land preparation to get better result and to maintain the caution regarding biofertilizer application. Seeds were sown during first week of December. Irrigation was given as per requirement and all other cultural operations were followed which were necessary to raise a good crop of French bean. The data collected at different growth stages were analyzed by adopting the method of analysis of variance outlined by Panse and Sukhatme (1967) using the mean values of random plants in each replication from all treatments to find out the significance of treatment effect. The significance was tested by referring to the values of F table (Fisher and Yates, 1963).

## III. Results And Discussion

### *3.1 Plant height (cm)*

From the data presented in Table 1 it is revealed that, the Plant height was markedly influenced by inorganic fertilizers and biofertilizers. Significantly maximum plant height was recorded in the treatment $T_{10}$ (35.10 cm) *i.e.* application of 75% RDF along with biofertilizers like PSB@ 2.5 Kg $ha^{-1}$ and *Rhizobium*@10 g $Kg^{-1}$ of seeds, followed by $T_1$ (34.31 cm), $T_9$ (33.73 cm) and $T_8$ (32.78 cm) which were statistically *at par* with each other. While, the minimum plant height was recorded in $T_2$ (27.83 cm) which was *at par* with $T_3$. Treatment $T_{10}$ recorded maximum plant height for better and quicker availability of the necessary amount of nutrients from the inorganic form of fertilizers at the early stage of growth. *Rhizobium* and PSB inoculation plays a significant role in boosting plant height, that was might be due to solubilization of phosphorus in soil and to make available for plant use, which enhanced the root system of the French bean and helped in assimilation of nutrients resulting in better cell division. Thakur *et al.* (2018) conducted an experiment in Himachal Pradesh in French bean var. Contender, they also found maximum plant height (48.42 cm) in treatment with *Rhizobium* + PSB + FYM. Seed inoculation with *Rhizobium* significantly increased plant

height, which was also supported by the findings of Rana *et al.* (2006) and Mfilinge *et al.* (2014).

Table.1. Effect of biofertilizers on growth of French bean

| Treatment | Plant height (cm) | No. of primary branches plant$^{-1}$ | No. of secondary branches plant$^{-1}$ |
|---|---|---|---|
| $T_1$ | 34.31 | 3.73 | 5.47 |
| $T_2$ | 27.83 | 3.40 | 5.87 |
| $T_3$ | 29.46 | 3.40 | 5.87 |
| $T_4$ | 30.66 | 3.40 | 5.93 |
| $T_5$ | 30.71 | 3.60 | 6.07 |
| $T_6$ | 30.51 | 3.93 | 6.07 |
| $T_7$ | 31.07 | 3.60 | 6.13 |
| $T_8$ | 32.78 | 3.80 | 6.27 |
| $T_9$ | 33.73 | 3.93 | 6.20 |
| $T_{10}$ | 35.10 | 4.20 | 6.40 |
| **SEm (±)** | 0.88 | 0.15 | 0.20 |
| **LSD (0.05)** | **2.62** | **0.46** | **N.S.** |

### *3.2 Number of branches plant$^{-1}$*

Effect of biofertilizer on number of branches (both primary and secondary) plant$^{-1}$ was illustrated in Table 1 significant difference observed among the treatments with respect to number of primary branches plant$^{-1}$ but in case of secondary branches, there was no significant differences. Maximum number of primary branches plant$^{-1}$ (4.20) was recorded in treatment $T_{10}$ *i.e.* application of 75% RDF with PSB@2.5 Kg ha$^{-1}$ and *Rhizobium*@10 g Kg$^{-1}$ of seeds, followed by $T_9$, $T_6$ (3.93) and $T_8$ (3.80). Minimum number of primary branches plant$^{-1}$ (3.40) were recorded in treatment $T_2$, $T_3$ and $T_4$ which were statistically at par with rest of the treatments. Datta *et al.* (2018) found the similar trend in French bean. Due to presence of readily available nutrients in recommended dose of fertilizer along with biofertilizers significantly increased the number of primary as well as secondary branches. PSB plays an important role in increasing number of branches by conversion of inaccessible forms to accessible in early stage of growth, also by synthesizing growth promoting substances like vitamin $B_{12}$ and auxins. Seed treatment with *Rhizobium* increased the number of branches due to increased uptake of available nitrogen by fixing of atmospheric nitrogen.

### *3.3 Days to 50% flowering*

Significant difference among the treatments under trial was observed for days to 50 per cent flowering in Table 2. Minimum days (54.89) for 50% flowering was recorded in $T_{10}$ (75% RDF + PSB@2.5 Kg ha$^{-1}$ + *Rhizobium*@10 g Kg$^{-1}$ of seeds) which was statistically at par with $T_9$ (56.11). While maximum number of days taken for 50% flowering (58.78) was recorded in $T_2$ (25% RDF + PSB@2.5 Kg ha$^{-1}$) followed by $T_4$ (57.67), $T_3$ (57.56) and $T_7$ (57.44). Application of inorganic fertilizer (RDF) along with biofertilizers showed significantly influence on days to 50% flowering in French bean. Application of biofertilizers might have increased the nutritional status of the plant and ultimately induced early initiation of flower.

### *3.4 Number of pods plant$^{-1}$*

The highest number of pods plant$^{-1}$ was found in $T_{10}$ (8.00) *i.e.* application of 75% RDF along with biofertilizers like PSB@ 2.5 Kg ha$^{-1}$ and *Rhizobium*@10 g Kg$^{-1}$ of seeds (Table 2), followed by $T_8$ (7.73) and $T_9$ (7.53) which were statistically *at par* with each other and superior over rest of the treatments. The lowest number of pod plant$^{-1}$ was recorded in $T_4$ (6.53) and $T_6$ (6.53) which were *at par* with $T_1$, $T_2$, $T_3$, $T_5$ and $T_7$. This might be due to combine use of chemical fertilizers and biofertilizers which increased the availability of nutrient and helps the plant to bear more number of flowers and reduce the chance of flower and fruit drop, as a result, more number of pods plant$^{-1}$ are obtained. This result was in consonance with the findings of Ramana *et al.* (2010) and Sayma (2019) in French bean.

### *3.5 Length of pod (cm)*

Data pertaining to length of the pod (cm) as influenced by different biofertilizers, presented in Table 2, showed significant difference among the treatments under trial. Maximum length of the pod (15.44 cm) was recorded in $T_{10}$ (75% RDF + PSB@2.5 Kg ha$^{-1}$ + *Rhizobium*@10 g/Kg of seeds) which was significantly higher than all other treatments except with $T_9$ (15.12 cm) and $T_8$ (14.70 cm) where it was statistically *at par*. While, minimum length of the pod (12.97 cm) was recorded in

$T_3$ (25% RDF + *Rhizobium*@10 g $Kg^{-1}$ of seeds). Optimum application.

of inorganic fertilizers and biofertilizers (PSB + *Rhizobium)* create a synergistic effect between them and increased the availability of nutrient to the plants, which is the chief constituent of cell division as a result increased accumulation of carbohydrates, balanced C: N ratio, increased vegetative growth and might have enhanced the pod length. This finding was in consonance with the observations of Sayma (2019) recorded (7.73) with 75% RDF + 25% (N) Vermicompost (1.25 t $ha^{-1}$) + Biofertilizer (*Rhizobium* + PSB) in French bean.

Table.2. Effect of biofertilizers on growth of French bean

| Treatments | Days to 50% flowering | No. of pods $plant^{-1}$ | Length of pod (cm) |
|---|---|---|---|
| **$T_1$** | 56.78 | 6.67 | 14.30 |
| **$T_2$** | 58.78 | 6.67 | 13.24 |
| **$T_3$** | 57.56 | 6.60 | 12.97 |
| **$T_4$** | 57.67 | 6.53 | 13.77 |
| **$T_5$** | 57.22 | 6.87 | 13.54 |
| **$T_6$** | 56.45 | 6.53 | 14.45 |
| **$T_7$** | 57.44 | 6.60 | 14.56 |
| **$T_8$** | 56.67 | 7.73 | 14.70 |
| **$T_9$** | 56.11 | 7.53 | 15.12 |
| **$T_{10}$** | 54.89 | 8.00 | 15.44 |
| **SEm (±)** | 0.46 | 0.28 | 0.28 |
| **LSD (0.05)** | **1.37** | **0.85** | **0.84** |

### *3.6 Yield $plant^{-1}$ (g)*

From the data presented in Table 3 it is revealed that, significantly highest yield $plant^{-1}$ (84.00 g) was obtained from $T_{10}$ *i.e.* application of 75% RDF along with biofertilizers like PSB@ 2.5 Kg $ha^{-1}$ and *Rhizobium*@10 g $Kg^{-1}$ of seeds. Higher yield $plant^{-1}$ was also recorded in $T_8$ (78.37 g) followed by $T_9$ (74.21 g) which was statistically at par with $T_7$ (72.20 g) and $T_1$ (71.25 g). Minimum yield $plant^{-1}$ (62.84 g) was obtained in $T_2$ *i.e.* application of 25% RDF along with PSB@2.5 Kg $ha^{-1}$ followed by $T_5$ and $T_3$ which were statistically at par with each other. Application of biofertilizers along with inorganic fertilizers increased soil fertility, availability of nutrient, which in turn resulted maximum reproductive parameter like increased number of pods per plant and pod length, etc. Seed inoculation with rhizobium might have increased the nitrogen fixation, more solubilisation of natural phosphorus and production of secondary metabolites by the bacteria (Rudresh *et al*., 2005). These altogether recorded higher yield of French bean.

### *3.7 Total pod yield (t $ha^{-1}$)*

After threadbare perusal of the data from the Table 3, pertaining to the total pod yield per hectare was noticed that application of biofertilizers along with different percent of RDF exerted significant influence among the treatments. Significantly highest pod yield per hectare (12.51 t $ha^{-1}$) was recorded in the treatment $T_{10}$ *i.e.* application of 75% RDF along with biofertilizers like PSB@ 2.5 Kg $ha^{-1}$ and *Rhizobium*@10 g $Kg^{-1}$ of seeds. Followed by 11.67 t $ha^{-1}$ in $T_8$ *i.e.* application of 75% RDF along with PSB@2.5 Kg $ha^{-1}$, and 11.05 t $ha^{-1}$ in the treatment $T_9$ *i.e.* application of 75% RDF and seed treatment with *Rhizobium*@10 g $Kg^{-1}$ of seeds, which was statistically *at par*. Lowest pod yield per hectare (9.36 t $ha^{-1}$) was recorded from the treatment $T_2$ that is application of 25% RDF along with PSB@2.5 Kg $ha^{-1}$ which was statistically *at par* with $T_5$ and $T_3$ which produced the pod yield of 9.44 t $ha^{-1}$ and 9.52 t $ha^{-1}$ respectively. This result might be due to increased absorption of nitrogen and phosphorus by the plants, which was made possible by nitrogen fixation and phosphate solubilization by the microorganisms. At the early stage of growth, biofertilizers did not affect the plant, this may have been due to the slower rate of nutrient mineralization, since microorganisms may have multiplied and established themselves at an early stage of growth. However, as they progress, they may increase their mineralization activity and increase nutrient availability, which will promote plant growth, produced higher number of flowers or higher number of pods per plant, ultimately, increase yield. Similar observations also obtained by Ramana *et al.* (2010) in the treatment $B_3$ (75% RDF + VAM @2 Kg $ha^{-1}$ + PSB @2.5 Kg $ha^{-1}$) in French bean.

### *3.8 Crude protein content (%)*

From the data presented in Table 3, it is revealed that, maximum percentage of crude protein (3.19) was recorded

from the treatment $T_{10}$ *i.e.* application of 75% RDF along with biofertilizers like PSB@ 2.5 Kg $ha^{-1}$ and *Rhizobium*@10 g $Kg^{-1}$ of seeds out of all the treatments except $T_9$ (75% RDF + *Rhizobium*@10 g $Kg^{-1}$ of seeds) where it was showed the value of 3.09 % followed by the treatment $T_8$ (application of 75% RDF along with PSB@2.5 Kg $ha^{-1}$) with a crude protein value of 3.04%. Minimum crude protein content (1.90%) was found in treatment $T_1$ *i.e.* application of 100% RDF only which was closely preceded by the treatment $T_3$ and $T_2$, which recorded the values of 2.19 % and 2.23 % respectively. Application of higher dose of fertilizer especially nitrogen along with biological fixation by *Rhizobium* have increased the availability and uptake of more nitrogen. As nitrogen is the main constituent of protein, the treatment like $T_{10}$ or $T_9$ recorded maximum content of crude protein in French bean. Similarly Ramana *et .al*. (2010) also recorded maximum protein content of 3.22% in Arka Suvidha variety by application of 75% RDF + VAM @ 2 Kg $ha^{-1}$ + PSB @ 2.5 Kg $ha^{-1}$.

Table.3. Effect of biofertilizers on yield and quality of French bean

| Treatments | Yield plant$^{-1}$ (g) | Total pod yield (t $ha^{-1}$) | Crude protein (%) | Crude fibre (%) |
|---|---|---|---|---|
| $T_1$ | 71.25 | 10.61 | 1.90 | 2.22 |
| $T_2$ | 62.84 | 9.36 | 2.23 | 1.95 |
| $T_3$ | 63.92 | 9.52 | 2.19 | 2.10 |
| $T_4$ | 68.96 | 10.27 | 2.34 | 1.97 |
| $T_5$ | 63.41 | 9.44 | 2.48 | 2.05 |
| $T_6$ | 70.33 | 10.47 | 2.65 | 1.77 |
| $T_7$ | 72.20 | 10.75 | 2.78 | 1.40 |
| $T_8$ | 78.37 | 11.67 | 3.04 | 1.06 |
| $T_9$ | 74.21 | 11.05 | 3.09 | 0.70 |
| $T_{10}$ | 84.00 | 12.51 | 3.19 | 0.66 |
| SEm (±) | 1.15 | 0.17 | 0.04 | 0.04 |
| **LSD (0.05)** | **3.44** | **0.51** | **0.13** | **0.13** |

### *3.9 Crude fibre content (%)*

Statistical data on effect of biofertilizer on crude fibre content of French bean, presented in Table 3, which showed significant difference among the treatments. The treatment $T_{10}$ *i.e.* application of 75% RDF along with PSB@2.5 Kg $ha^{-1}$ + *Rhizobium*@10 g $Kg^{-1}$ of seeds recorded significantly lowest crude fibre content (0.66%) of French bean over all the treatments except $T_9$ (*i.e.* application of 75% RDF and seed treated with *Rhizobium*@10 g $Kg^{-1}$ of seeds) where it was statistically *at par* (0.70%) with the treatment $T_8$ (75% RDF + PSB@2.5 Kg $ha^{-1}$) with a value of 1.06%. Maximum crude fibre content (2.22%) was recorded in treatment $T_1$ i.e. 100% RDF only, closely preceded by $T_3$ and $T_5$ with crude fibre content of 2.10 % and 2.05 % respectively. Quality of pod can be judge by the amount of crude fibre content in pod. Lower levels of crude fibre and higher levels of crude protein content in pods are the best quality parameters, which can be achieved by application of biofertilizers along with inorganic forms of fertilizers. Similar type of obvervation also recorded in French bean by Ramana *et al*. (2010) through the application of 75% RDF + VAM @2 Kg $ha^{-1}$ + PSB @2.5 Kg $ha^{-1}$ and also by vimala *et al.* (2000) in pea.

## IV. Conclusion

Based on the findings of this study, it was found that the combination of biofertilizers and inorganic sources of fertilizers had an impact on French bean growth, yield, and quality. The application of biofertilizers in some treatments performed better with suitable nutrient combination. It can be concluded that application of 75% RDF along with PSB@2.5 Kg $ha^{-1}$ and seed treated with *Rhizobium*@10 g $Kg^{-1}$ of seeds produced better growth, yield (12.51 t $ha^{-1}$) and quality of French bean as compared to other treatments.

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