Original Research Article

Effect of Photosynthetic bacteria, Vermiwash and Phosphorus Solubilizing Bacteria on growth, Yield and Quality of French bean (*Phaseolus vulgaris* L.)

ABSTRACT

Aim: To study the effect of photosynthetic bacteria, vermiwash and phosphorus solubilizing bacteria on growth, yield and quality of French bean (*Phaseolus vulgaris* L.).

Study design: Randomized block design (RBD).

Place and duration of study: The present investigation was carried out at the Central Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during the 2021-22.

Methodology: The experiment was laid in Randomized block design with 7 treatments and 3 replications with different combination in Biofertilizers and application of organic nutrition. Under this experiment, overall, 7 treatment was taken T_1 (Photosynthetic Bacteria @ 30 ml/ m^2 (PSB-1)), T_2 (Vermiwash @ 40 ml/ m^2 (VW)), T_3 (Phosphate Solubilizing Bacteria (30 ml/ m^2) (PSB-2)), T_4 (PSB-1 + VW (40 each ml/ m^2)), T_5 (PSB-1 + PSB-2 (30 ml/ m^2)), T_6 (PSB-2 + VW (40 ml/ m^2)) and T_0 (Control).

Results: From the above experimental finding it was concluded that the treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2) was found to be best in the terms of growth parameters like plant (240.51 cm), plant spread (1984.64 cm^2), earliness parameters like days to first flowering (54.33 days), days to 50% flowering (64.67 days), days to first pod setting (59.78 days) and days to first pod picking (67.47 days). T_5 (PSB-1 + PSB-2 (30 ml/ m^2) was also found best in terms of yield parameters like number of pods per plant (132.33 pods), pod length (13.73 cm), pod width (10.11 mm), individual pod weight (7.99 g), yield per plant (1.04 kg/plant) and yield per hectare (12.53 t/ha) of French bean.

Conclusion: Therefore, Treatment combination of biofertilizers T_5 (PSB-1 + PSB-2 (30 ml/ m^2) can be suggested for better yield achievement in cowpea.

Keywords: *Phosphorus Solubilizing Bacteria (PSB), Vermiwash, French bean, biofertilizer.,*

1. INTRODUCTION

The French bean, scientifically named *Phaseolus vulgaris* L., is a popular herbaceous plant cultivated worldwide for its delectable dry seeds and immature green pods. It belongs to the Fabaceae family, which includes other Phaseolus species. Rhizobia, nitrogen-fixing bacteria, form a symbiotic relationship with common beans, like many legumes, to acquire nitrogen. Cultivation of common beans has a long history, with wild species exhibiting climbing traits while cultivars are classified as either bush or climbing beans. Prominent cultivar groups include kidney beans, navy beans, pinto beans, and wax beans. Commercially grown beans also encompass runner beans and broad beans. Beans thrive on every continent except Antarctica, with approximately 27 million tonnes of dried and

24 million tonnes of green beans produced globally in 2016. The wild French bean species originates from the Americas and genetic studies confirm its initial domestication in Mesoamerica, later spreading alongside maize and squash. French beans display variability, with pole types growing as 2–3-meter vines and bush types as 20-60 cm tall erect bushes. The plants bear three oval, smooth-edged leaflets of green or purple colour, while their blossoms give rise to pods ranging from 8-20 cm long and 1-1.5 cm wide. These pods contain 4-6 beans in green, yellow, black, or purple hues, often speckled with multiple colours. The beans themselves are kidney-shaped, smooth, plump, and up to 1.5 cm long. It's important to note that raw or undercooked beans may contain a toxic protein called phytohemagglutinin. French bean plays a major role in human nutrition, fruit contain high nutritive value constituting high amount of carbohydrates (4.5 g), protein (1.7 g), fat (0.1 g), Phosphorous (28 mg) Calcium (50 mg), Magnesium (29 mg), iron (1.7 mg), Potassium (120 mg) and other mineral matters. Apart from this, it also contains Vitamin A (221 I.U.), Vitamin C (14 mg) per 100 g fruit (Choudhury, 2013) [2]. India is also responsible for the large production of French beans, accounting for 37.52% of total production worldwide. In India, one of the most common, popular, and important vegetable crops grown throughout India, French bean accounting to area under production to be 4.62 lakh hectare with production of 21.18 million metric tonnes in year 2021-22. Gujarat ranks first in area and production of French bean in year 2021-22 followed by Bihar, Jharkhand, Karnataka. Uttar Pradesh ranks 5th in French bean production in India with area under production is 1.72 thousand hectares while production is estimated to be 1.62 million metric tonnes for year 2021-22. (Source: NHB, Ministry of Agriculture & Farmers Welfare, Government of India, 2021-22.) [10]. Research on the effects of photosynthetic bacteria, vermiwash, and phosphorus solubilizing bacteria on the growth, yield, and quality of French beans is crucial for several reasons. Firstly, understanding the impact of these biological agents can lead to the development of sustainable agricultural practices that enhance crop productivity while reducing reliance on chemical fertilizers. Secondly, optimizing the use of photosynthetic bacteria, vermiwash, and phosphorus solubilizing bacteria can improve nutrient availability and uptake, thereby boosting the growth and yield of French beans. Lastly, assessing the impact on bean quality ensures that any potential changes in taste, nutritional composition, or other desirable attributes are considered. This research aids in advancing agricultural knowledge, promoting eco-friendly farming practices, and ultimately supporting food security and sustainable agriculture.

2. MATERIAL AND METHODS

The present investigation was done to understand the plant growth, pod yield and quality of French bean using different combinations of treatment using organic manures and bio-fertilizers. The details of the materials used, and the methods adopted in the investigation, which was carried out at Horticultural Research Farm (CRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Rabi* season of 2021. Observations were recorded at different stages of growth periods and studied for growth parameters like plant height, plant spread, earliness parameters like days to first flowering, days to pod setting, days to first pod picking, yield parameters like pod length, pod width, individual

pod weight. The data were statistically analysed by the method suggested by Fisher and Yates, 1963 **[5].** The details of treatment combination used is given in table 1. The height of five randomly selected plants from each plot was measured in cm with of a 100 cm meter scale from ground level to tip of the shoot. Area covered by plant canopy is termed as plant spread. It was measured using the length of shadow of plant from root of plant till shadow tip. The area was calculated using formula $2\pi r^2$, r was length measured. This was done in five random selected plants in each replication. The numbers of days taken from the date of sowing to the date at which first flower appeared in plants or date at which plants start flowering in whole plot were recorded as days to first flowering, similarly, was taken for days to 50% flowering and days to first pod setting. Weight of individual pod was taken from randomly five fruits from randomly selected plants by using physical balance. Average pod length was taken from randomly five fruits from randomly selected plants by using measuring tape and scale.

Table 1 Details of different doses of bio-fertilizers and organic manures used.

Treatment Symbols	**Treatment combination**
T_0	Control
T_1	Photosynthetic Bacteria @ 30 ml/ m^2 (PSB-1)
T_2	Vermiwash @ 40 ml/ m^2 (VW)
T_3	Phosphate Solubilizing Bacteria (30 ml/ m^2) (PSB-2)
T_4	PSB-1 + VW (40 each ml/ m^2)
T_5	PSB-1 + PSB-2 (30 ml/ m^2)
T_6	PSB-2 + VW (40 ml/ m^2)

RESULTS AND DISCUSSION

Growth Parameters

Plant height (cm) and Plant spread (cm^2)

The results pertaining to plant height and plant spread was statistically significant (*p=0.*05). The maximum plant height (240.51 cm) was observed with treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) with 207.07 cm. Minimum plant height (174.30 cm) was observed in T_0 (control), while the remaining treatments were moderate in their growth habit. It was also found that T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) with maximum value i.e., 2637.60 cm^2 followed by T_6 (PSB-2 + VW (40 ml/ m^2)) with 1984.64 cm^2 whereas the minimum score was observed in treatment T_0 (Control) with 1368.23 cm^2. The application of biofertilizers and organic nutrients might have improved the soil physical and chemical properties and leading to the adequate supply of nutrients to the plants which might have promoted the maximum vegetative growth while the minimum plant growth was due to non-availability of nutrients. Similar findings were reported by Anubani and Maniyanan (2002) [1]; Naidu *et al.,* (2002) [8] in brinjal, Ghoname and Shafeek (2005) [6] in sweet pepper; Chuamayani *et al*., (2010) [3]; Kumar *et al*., (2014) [7]; Yeptho *et al*., (2010) [16] in tomato.

Earliness parameter

Days to first flowering, days to 50% flowering, days to first pod setting and days to first pod picking

The results pertaining to flowering, pod setting and pod picking was statistically significant (*p=0.*05).Among the different applications of organic nutrition, the minimum days to first flowering was seen in T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) with 54.33 days, followed by T_6 (PSB-2 + VW (40 ml/ m^2)) with 55.67 days whereas maximum days to first flowering 60.67 days was recorded in T_0 (control). Among the different applications of organic nutrition, the minimum days to 50% flowering was seen in T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) with 64.67 days, followed by T_6 (PSB-2 + VW (40 ml/ m^2)) with 65.67 days whereas maximum days to 50% flowering 71.00 days was recorded in T_0 (control). Among the application of organic nutrients minimum days to first pod setting was seen in T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) with 59.78 days, followed by T_6 (PSB-2 + VW (40 ml/ m^2)) with 59.89 days whereas maximum days to first pod setting 64.67 days was recorded in T_0 (control). Among the applications of organic nutrition, the minimum days to first pod picking was seen in T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) with 67.47 days, followed by T_6 (PSB-2 + VW (40 ml/ m^2)) with 68.06 days whereas maximum days to first pod picking 72.27 days was recorded in T_0 (control). Integration of biofertilizers with organic nutrition favoured vigorous growth and synthesized more the flowering hormones in plants, which might have helped to the translocation as well as more quantity of available phosphorus through the xylem vessels and their accumulation in the axillary buds that would have favoured the plant to enter reproductive phase. Similar findings were reported by Anubani and Maniyanan (2002) [1]; Naidu *et al.,* (2002) [8] in brinjal, Ghoname and Shafeek (2005) [6] in sweet pepper, Chuamayani *et al*., (2010) [3]; Kumar *et al*., (2014) [7]; Yeptho *et al*., (2010) [16] in tomato.

Yield Parameter

Number of pods per plant, weight of individual pods (g), pod length (cm), pod width (mm), fruit weight (g), pod yield per plant (kg/plant) and pod yield per hectare (t/ha).

The results pertaining to yield parameters was statistically significant (*p=0.*05). The maximum Number of pods per plants 132.33 pods were recorded in treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) i.e., 109.93 pods and the lowest pods per plant 84 pods were observed in T_0 (Control). The maximum weight of single pod 7.99 g was recorded in treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) i.e., 7.88 g and the lowest weight of single pod (4.98 g) were observed in T_0 (Control). The maximum pod length 13.73 cm were recorded in treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) i.e., 13.17 cm and the lowest pod length (10.73 cm) were observed in T_0 (Control). The maximum pod width 10.11 mm were recorded in treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) i.e., 9.76 mm and the lowest pod width (7.18 mm) were observed in T_0 (Control). The maximum average yield per plant (1.04 kg/plant) were recorded in treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) i.e., 0.88 kg/plant and the lowest average yield per plant (0.42 kg/plant) were observed in T_0 (Control). The maximum average yield per hectare (12.53 t/ha) were recorded in treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2)) followed by T_6 (PSB-2 + VW (40 ml/ m^2)) i.e., 10.54 t/ha and the lowest average yield per hectare (5.02 t/ha) were observed in T_0 (Control). Maximum number of pods per plant, pod weight, pod length and pod yield per plant increased in T_5 which might be due to increased number of flowers which might have formed into fruits due to adequate availability of major and minor nutrients during its growth and development. Minimum number of pods per plant in T_0 (Control) might be due to non-availability of nutrients during its development. Integration of organic sources favoured vigorous growth and synthesized more these hormones in plants, which might have helped to the translocation as well as more quantity of storage of nutrients enhancing the pods number, length, weight and ultimately yield. Moreover, the combined use of biofertilizers and organic manure can significantly enhance pod length, pod width, and pod yield in cowpea. Biofertilizers, containing beneficial microorganisms, establish a symbiotic relationship with cowpea plants, facilitating nutrient uptake and promoting plant growth. These microorganisms, such as nitrogen-fixing bacteria, increase nitrogen availability, stimulating pod development and resulting in longer and wider pods. Furthermore, the application of organic manure enriches the soil with essential nutrients, improving overall soil fertility and providing a favourable environment for cowpea growth. The synergistic effect of biofertilizers and organic manure enhances nutrient availability, leading to increased pod yield in cowpea cultivation, while also ensuring sustainable and environmentally friendly agricultural practices. Similar findings were reported by Kumar *et al*., (2014) [7]; Samadiya (2012) [11] in tomato, Sharma *et al*., (2014) [12] in okra, Chauhan, and Singh (2017) [4] in chickpea, Wu *et al*., (2019) [15] in tea, Swaminathan *et al*., (2020) [13] in grapes, Reniguntla *et al*., (2021) [9] in cluster bean.

Conclusion

From the above experimental finding it was concluded that the treatment T_5 (PSB-1 + PSB-2 (30 ml/ m^2) was found to be best in the terms of growth parameters like plant (240.51 cm), plant spread (1984.64 cm^2), earliness parameters like days to first flowering (54.33 days), days to 50% flowering (64.67 days), days to first pod setting (59.78 days) and days to first pod picking (67.47 days). T_5 (PSB-1 + PSB-2 (30 ml/ m^2) was also found best in terms of yield parameters like number of pods per plant (132.33 pods), pod length (13.73 cm), pod width (10.11 mm), individual pod weight (7.99 g), yield per plant (1.04 kg/plant) and yield per hectare (12.53 t/ha) of French bean. Therefore, Treatment combination of biofertilizers T_5 (PSB-1 + PSB-2 (30 ml/ m^2) can be suggested for better yield achievement in cowpea.

Table 2 Performance of different treatment of bio-fertilizers and organic manures on growth and yield parameters studied for French bean.

Treatment Notation	Treatment details	Plant height (cm)	Plant spread (in cm^2)	Days to first flowering (DAS)	Days to 50% flowering (DAS)	Days to first pod setting (DAS)	Days to first pod picking (DAS)	No. of pods/plant	Weight of single pod (g)	Pod length (cm)	Pod width (mm)	Pod yield per plant (Kg/plant)	Pod yield per hectare (t/ha)
T_1	Photosynthetic Bacteria @ 30 ml/ m^2 (PSB-1)	195.57	1369.33	55.67	65.67	59.78	68.62	109.29	6.73	12.55	9.63	0.74	8.86
T_2	Vermiwash @ 40 ml/ m^2 (VW)	178.48	1526.54	56.67	67.33	61.00	68.51	106.17	6.51	12.66	9.48	0.69	8.30
T_3	Phosphate Solubilizing Bacteria (30 ml/ m^2) (PSB-2)	195.64	1832.90	54.33	65.67	60.44	68.28	101.67	5.94	12.95	9.54	0.61	7.27
T_4	PSB-1 + VW (40 each ml/ m^2)	182.73	1900.23	56.33	67.33	60.78	68.95	105.50	6.82	12.49	9.62	0.72	8.65
T_5	PSB-1 + PSB-2 (30	240.51	2637.60	54.33	64.67	59.78	67.47	132.33	7.99	13.73	10.11	1.04	12.53

	ml/ m^2)												
T_6	PSB-2 + VW (40 ml/ m^2)	207.07	1984.64	55.67	65.67	59.89	68.06	109.93	7.88	13.17	9.76	0.88	10.54
T_0	Control	174.30	1368.23	60.67	71.00	64.67	72.27	84.00	4.98	10.73	7.18	0.42	5.02
'F' test		**S**	S	S	S	**S**	S	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%		**0.96**	**8.08**	**1.47**	**1.58**	**0.75**	**1.64**	**12.16**	**0.82**	**0.62**	**0.49**	**0.15**	**1.81**
S.E. (m) ±		**0.31**	**2.59**	**0.47**	**0.50**	**0.24**	**0.52**	**3.90**	**0.26**	**0.20**	**0.16**	**0.05**	**0.58**
C.V.		**7.27**	**0.24**	**1.45**	**1.32**	**0.69**	**1.32**	**6.32**	**6.82**	**2.74**	**2.97**	**11.61**	**11.49**

References

1. Anburani, A. and Manivannan, A. K., (2004) Effect of Integrated Nutrient Management on growth in chilli (*Capsicum annuum* L.). *South Indian Hort*iculture., 84: 636-640.

2. Choudhary, B. (2013). Vegetables-Cucurbits, Cucumber nutritional quality. *National Book Trust India. Reprint edition*. 142 pp.

3. Chumyani, S. P., Kanaujia, S., Singh, V. B. and Singh, A. K. (2010) Effect of Integrated Nutrient Management on growth, yield and quality of tomato. *Journal of Soil & Crop.*, 22 (1): 67-71.

4. Chauhan, S.V.S. and Singh, B. R. (2017). Effect of phosphorus and phosphate solubilizing bacteria on growth, yield and quality of chickpea (Cicer arietinum). *Annals of Plant and Soil Research.* 19(3): 303-306.

5. Fisher, R. A. and Yates, F. (1963). Statistical Tables for Biological, Agricultural and Medical Research. *Oliver and Boyd, London*: 143 p.

6. Ghoname, A. and Shafeek, M. R. (2005) Growth and productivity of sweet pepper (Capsicum annuum L.) grown in plastic house as affected by organic, mineral and bio-fertilisers. *Journal of Agronomy.* 4 (4): 369-372.

7. Kumar, S., Rakesh, K., Sutanu, M., Devendra, K. and Manoj, K. (2014). Effect of organic manures and bio-fertilizers on growth, flowering, yield and quality of tomato cv. Pusa Sheetal. *International Journal Agricultural Sciences.*, 10 (1): 329-332.

8. Naidu, A. K., Kushwah, S. S. and Dwivedi, Y. C. (2002) Influence of organic manures, chemical and bio-fertilizers on growth, yield and economics of brinjal. *South Indian Hort*iculture. 50 (4-6): 370-376.

9. Reniguntla, C., Chaurasia, A. K., Dega, D., Sekhar, M and Macherla, S. (2021). Effect of vermiwash, panchagavya and weed extract on growth, yield and seed quality parameters of cluster bean (Cyamopsis tetragonoloba (L).). *International Journal of Chemical Studies*. 9(1): 2002-2004.

10. National Horticultural Board, Ministry of Agriculture & Farmers Welfare (DAC & FW), Government of India, 2020-21.

11. Samadhiya, H., Dandotiya, P., Chaturvedi, J. and Agrawal, O. P. (2013). Effect of vermiwash on the growth and development of leaves and stem of tomato plants. *International Journal of Current Research.* 5(10): 3020-3023.

12. Sharma, D. P., Lal, J. P. and Tiwari, A. (2014). Effect of NPK, vermicompost and vermiwash on growth and yield of Okra. *International Journal of Basic and Applied Agricultural Research*. 12(1): 5-8.

13. Swaminathan, A. G., Hariprasad, K. P., Suryawanshi, A. V., Kadam, G. B. and Vilas, S. G. (2020). Effect of Phosphorus Solubilizing Bacteria on Growth, Yield, Quality and Nutrient Uptake in Nanasaheb Purple Grapes Grown under Semi-Arid Condition. *International Journal of Current Microbiology and Applied Sciences*. 9(7): 1274-1283.

14. Vavilov, N. I. (1935) Origin and geography of cultivated plants. *Archives of natural history*, 21(1): 142.

15. Wu, F., Jianrong, L., Yanliu, C., Linping, Z., Yang, Z., Shu, W., Xin, S., Lei, L. and Junsheng, L. (2019). Effects of Phosphate Solubilizing Bacteria on the Growth, Photosynthesis, and Nutrient Uptake of Camellia oleifera Abel. *Forests*. 10(348): 1-10.

16. Yeptho, V., Kanaujiasingh, V. B. and Amod, S. (2010) Effect of Integrated Nutrient Management on growth, yield and quality of tomato under poly house condition. *Journal of Soils and Crops.* 22 (2): 246-252.