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Effect of Biofertilizers on Growth and Yield of Winged Bean (*Psophocarpus tetragonolobus* (L.) DC.)

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Abstract: The study was conducted during the kharif season of 2023 and 2024 at experimental farm of ICAR-National Bureau of Plant Genetic Resources, New Delhi, using a Completely Randomized Design with ten biofertilizer treatments. Indira Winged Bean-2 variety was sown at a spacing of 90 cm × 45 cm. Among the treatments, the combined application of Rhizobium, vermicompost, Vesicular Arbuscular Mycorrhiza (VAM), and Phosphate Solubilizing Bacteria (PSB) produced the best yield attributes, recording the highest number of secondary branches (8.9), pod length (13.4 cm), seeds per pod (11.6), and fresh pod weight per plant (14.88 g). The maximum pod dry weight (3467 mg) was observed with Rhizobium alone, while Rhizobium + PSB resulted in the greatest plant height (17.25 ft). The control treatment exhibited the poorest growth and yield performance. Analysis of variance ($p \leq 0.05$) revealed significant improvements in all growth and yield parameters with biofertilizer application. The findings demonstrate that biofertilizers can substantially enhance the growth and productivity of winged bean and may be effectively utilized in sustainable crop improvement programmes.

Keywords: Winged bean, Rhizobium, VAM, Vermicompost, PSB

INTRODUCTION

Winged bean (*Psophocarpus tetragonolobus* (L.) is a highly nutritious tropical legume belonging to the family Fabaceae. It is widely cultivated in several tropical and subtropical countries, including India, Indonesia, Malaysia, Thailand, the Philippines, Sri Lanka, and Papua New Guinea. The crop is valued for its high protein content and versatility, as almost all plant parts, including leaves, flowers, pods, seeds, and tubers, are edible and rich in nutrients (Ray et al., 2012). Winged bean is a climbing herbaceous plant with a predominantly self-pollinating nature. It is considered a multipurpose crop that can be utilized as a vegetable, pulse, forage, and tuber crop. The tender leaves and pods are rich sources of vitamins, minerals, and dietary fibre, while the seeds contain high-quality protein and the tubers are rich in carbohydrates. Owing to its exceptional nutritional value and multiple uses, winged bean has been recognized as a promising crop for improving food and nutritional security (National Academy Press, 1981). Sustainable crop production requires balanced nutrient management practices that maintain soil fertility while ensuring optimum crop growth and yield. Excessive dependence on chemical fertilizers may adversely affect soil health and increase production costs. In this context, biofertilizers offer an eco-friendly and sustainable alternative by enhancing nutrient availability, improving soil microbial activity, and promoting plant growth. They contribute to the maintenance of soil health

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and help reduce the dependence on chemical fertilizers. Soil health is an important indicator of sustainable agricultural productivity. The application of biofertilizers improves the biological and chemical properties of soil, resulting in better nutrient uptake and enhanced crop performance. Therefore, the use of biofertilizers has gained considerable importance in modern agriculture as a means of improving crop productivity while preserving environmental quality. Keeping these facts in view, the present investigation was undertaken to evaluate the influence of biofertilizers on the growth and yield of winged bean.

MATERIALS AND METHODS

An investigation on the effect of biofertilizers on the growth and yield of winged bean (*Psophocarpus tetragonolobus* (L.) DC.) was conducted at the experimental farm of ICAR–National Bureau of Plant Genetic Resources (NBPGR), New Delhi, during the kharif seasons of 2023 and 2024. The experimental field soil was sandy clay loam in texture and slightly alkaline in reaction (pH 8.1), with an electrical conductivity of 0.36 dS m^{-1}. The soil was low in organic carbon (0.37%) and available nitrogen (206.2 kg ha^{-1}), while available phosphorus (13.6 kg ha^{-1}) and potassium (236.0 kg ha^{-1}) were in the medium range. The experiment was laid out in a Completely Randomized Design (CRD) using the variety 'Indira Winged Bean-2', comprising ten treatments with three replications. The biofertilizers, namely *Rhizobium*, vermicompost, vesicular-arbuscular mycorrhiza (VAM), and phosphate-solubilizing bacteria (PSB), were procured from ICAR–Indian Agricultural Research Institute (IARI), New Delhi. Observations were recorded on plant height (ft), number of branches per plant, number of pods per plant, number of seeds per pod, pod length (cm), pod yield per plant (g), fresh pod weight (g), and dry pod weight (mg) to assess the effect of different biofertilizer treatments on growth and yield attributes of winged bean.

RESULTS AND DISCUSSION

Plant height (ft)

Data presented in Table 1 revealed that the treatment comprising **Rhizobium + PSB** produced the tallest plants (17.25 ft), whereas the **control** recorded the lowest plant height (11.27 ft). The increase in plant height under **Rhizobium + PSB** may be attributed to improved nutrient availability and enhanced microbial activity in the rhizosphere due to biofertilizer application. Biofertilizers improve soil health, nutrient uptake, and water availability, thereby promoting better plant growth. Similar findings have been reported by **Kushwaha (2007).**

Number of branches per plant

The effect of different biofertilizer treatments on the number of branches per plant was found to be significant (Table 1). The treatment comprising **Rhizobium + PSB + Vermicompost + VAM** produced the highest number of branches per plant (8.9). In contrast, the lowest number of branches (3.7) was recorded under **Rhizobium + Vermicompost + VAM,** which was statistically at par with the control (4.2). The increase in the number of branches may be attributed to improved nutrient availability and uptake resulting from the combined action of biofertilizers, which enhance nutrient fixation, mobilization, and overall plant growth. Similar findings have been reported by Singh and Singh (2010) and Yadav et al. (2017).

Pod length (cm)

Data presented in Table 3 revealed that treatment **Rhizobium + Vermicompost + VAM + PSB** produced the longest pods (13.4 cm), which was statistically at par with Rhizobium (R) (initial treatment of seed with 5 g of R /kg **(11.8 cm),** Vesicular Arbuscular

Mycorrhiza (VAM) (initial treatment of seed @8 g/kg) **(12.1 cm),** Rhizobium (R) + Phosphate Solubilizing Bacteria (PSB) @ 2.5 kg ha^{-1} **(12.4 cm), and** Rhizobium (R) + Vermicompost (VC) + Vesicular Arbuscular Mycorrhiza (VAM) @ 2kg ha^{-1} **(12.1 cm).** The shortest pod length (9.6 cm) was recorded under the control treatment, where no biofertilizers were applied. The increased pod length under Rhizobium (R) + Vermicompost (VC) + Vesicular Arbuscular Mycorrhiza (VAM) @ 2kg ha^{-1} + Phosphate Solubilizing Bacteria (PSB)@ 2.5kg ha^{-1} may be attributed to the synergistic effect of the combined biofertilizer application, which enhanced nutrient availability and uptake, stimulated beneficial microbial activity, improved biological nitrogen fixation, and promoted better physical and biochemical conditions of the soil. These factors collectively contributed to improved plant growth and pod development in winged bean**.**

Number of pod per plant

The number of pods per plant is an important yield-contributing trait that reflects the effectiveness of different treatments and directly influences crop yield. The effect of biofertilizer treatments on the number of pods per plant in winged bean was found to be significant. The highest number of pods per plant (34.0) was recorded under the treatment comprising **Rhizobium + Vermicompost + VAM + PSB,** which was statistically at par with **Rhizobium + Vermicompost + VAM** (32.5). The lowest number of pods per plant (20.9) was observed in the control treatment. The increased number of pods per plant under the combined biofertilizer treatments may be attributed to improved nutrient availability, enhanced nutrient uptake, and greater biological activity in the rhizosphere, resulting in better plant growth and reproductive development. Similar findings have been reported by Singh and Singh (2010) and Yadav et al. (2017).

Number of seeds per pod

The effect of biofertilizer treatments on the number of seeds per pod in winged bean was found to be significant. The highest number of seeds per pod (11.6) was recorded under **Rhizobium + Vermicompost + VAM + PSB,** which was statistically at par with **Rhizobium** (10.1). The lowest number of seeds per pod (7.0) was observed in the control treatment. The increase in the number of seeds per pod under biofertilizer treatments may be attributed to improved nutrient availability and enhanced physiological activities, resulting in better flowering, fertilization, and seed development. Similar results were reported by Jarande et al. (2006).

Fresh weight of pod per plant (g)

Results presented in Table 3 indicate that the application of biofertilizers significantly increased pod fresh weight in winged bean. The highest pod fresh weight (14.88 g) was recorded under **Rhizobium + Vermicompost + VAM + PSB,** which was statistically at par with **Rhizobium + PSB** (14.54 g) and **Rhizobium + Vermicompost + VAM** (14.69 g). The increase in pod fresh weight may be attributed to improved nutrient availability and uptake, enhanced microbial activity, and the addition of organic matter through vermicompost, which improves soil structure and water-holding capacity. These factors promote better plant growth and pod development, resulting in increased fresh pod weight. Similar findings were reported by Singh and Prasad (2008).

Total yield per plant (g)

The effect of biofertilizers on total yield per plant revealed that the highest yield was recorded in Rhizobium (R) + Vermicompost (VC) + Vesicular Arbuscular Mycorrhiza (VAM) @ 2 kg ha^{-1} (673.9 g per plant), whereas the lowest yield was observed in Rhizobium (R) (initial treatment of seed with 5 g of R / kg) (343.5 g per plant). The increase in yield

Table 1: Treatment Details of the Experiment

Treatment	*Treatment Details*
T_1	Absolute control (without any fertilizer or manure)
T_2	Rhizobium (R) (seed treatment with 5 g kg^{-1} seed)
T_3	Vermicompost (VC)
T_4	Vesicular Arbuscular Mycorrhiza (VAM) (seed treatment @ 8 g kg^{-1} seed)
T_5	Phosphate Solubilizing Bacteria (PSB) @ 2.5 kg ha^{-1} and seed treatment with 5 g kg^{-1} seed
T_6	Rhizobium (R) + Vermicompost (VC)
T_7	Rhizobium (R) + Vesicular Arbuscular Mycorrhiza (VAM) @ 2 kg ha^{-1}
T_8	Rhizobium (R) + Phosphate Solubilizing Bacteria (PSB) @ 2.5 kg ha^{-1}
T_9	Rhizobium (R) + Vermicompost (VC) + Vesicular Arbuscular Mycorrhiza (VAM) @ 2 kg ha^{-1}
T_{10}	Rhizobium (R) + Vermicompost (VC) + Vesicular Arbuscular Mycorrhiza (VAM) @ 2 kg ha^{-1} + Phosphate Solubilizing Bacteria (PSB) @ 2.5 kg ha^{-1}

Table 2: Effect of Biofertilizers on Growth and Yield of Winged Bean

Treatment	*Plant height (ft) at 90 DAS*	*No. of secondary branches at 90 DAS*	*Pod length (cm)*	*No. of pods per plant*	*No. of seeds per pod*	*Pod fresh weight (g)*	*Yield per plot (g)*
T1	11.27	4.2	9.6	20.9	7.0	11.94	408.6
T2	11.94	7.0	11.8	24.5	10.1	11.68	343.5
T3	12.83	6.8	11.5	25.2	7.9	10.78	343.5
T4	12.74	7.2	12.1	24.3	8.7	11.04	382.4
T5	12.03	6.3	11.4	28.8	7.9	10.49	442.5
T6	12.25	6.2	11.4	27.9	8.7	10.82	470.2
T7	11.46	6.6	11.3	27.5	8.7	11.12	476.0
T8	17.25	6.5	12.4	30.2	8.7	14.54	527.8
T9	11.56	3.7	12.1	34.0	8.6	14.69	673.9
T10	14.16	8.9	13.4	32.5	11.6	14.88	581.5
CD 5%	1.99	2.09	1.61	3.5	2.16	2.32	19.2

may be attributed to the higher availability of nutrients resulting from enhanced organic matter content in the soil and the beneficial effects of the biofertilizer treatments. The present findings are in agreement with those reported by **Singh and Prasad (2008).**

CONCLUSION

Biofertilizers play a significant role in the growth and yield of winged bean. Based on the present investigation, it may be concluded that seed treatment of winged bean with **Rhizobium** prior to planting improves crop performance, while the combined application of different biofertilizers further enhances growth, development, and yield. Therefore, the use of biofertilizers should be encouraged to achieve higher crop productivity and restore soil health, as they are environmentally friendly and contribute to the sustainable management of degraded soils.

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