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Influence of biofertilizers on growth and yield of winged bean (*Psophocarpus tetragonolobus* (L.) DC.)

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Abstract
The present investigation was carried out during the kharif season of 2018-19 at Horticultural Research Farm, Department of Horticulture, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou. Experiment was laid out in Completely Randomized Design (CRD). Local seeds of winged bean collected from market were taken for the experimental trial and ten treatments were used. After selection, the seeds were sown at the spacing of 90cm x45cm. From the present investigation biofertilizer mixtures of *Rhizobium*, vermicompost, Vesicular Arbuscular Mycorrhiza (VAM) and Phosphate solubilizing bacteria (PSB) (T_{10}) was found significantly superior in terms of yield attributes *viz*., secondary branches (8.9), pod length (13.4cm), seed per pod (11.6) and pod fresh weight per plant (14.88g). Treatment consisting of *Rhizobium* only (T_2) gave maximum (3467.00 mg) pod dry weight, while T_8 (*Rhizobium* + PSB) produced maximum (17.25 ft.) plant height. Maximum weight of tuber (167.53 g) was recorded with treatment T_9 (*Rhizobium*+ vermicompost + VAM). Least performance in terms of growth and yield of winged bean was recorded with control treatment. Statistical analysis of variance (p=0.05) showed that use of different biofertilizers significantly increased in all growth and yield parameters of winged bean. Hence, the results suggest that biofertilizers enhance the growth and yield of winged bean which should be encouraged for future crop improvement programme.

Keywords: Winged bean, *Rhizobium*, VAM, vermicompost, PSB

1. Introduction
Winged bean is one of the most consumed crops in Manipur for its nutritious value and luscious taste (Rahman *et al.*, 2013; Marlene and Valio, 1996) [15, 12]. It has high nutritious value and cultivated for its importance as a protein rich multipurpose crop, thus it is also known as Goa bean, four angled bean, God-sent vegetable and princess pea (Ray *et al.*, 2012) [17]. Winged bean (*Psophocarpus tetragonolobus* (L.) DC.) is a dicotyledonous plant belongs to the genus *Psophocarpus*, which is part of the Fabaceae family, Papilionoideae subfamily having a diploid genome ($2n = 2x = 18$) (Harder, 1992; Vatanparast *et al.* 2016) [6, 22]. It is regarded as a crop with cleistogamous floral system which perform autogamy, with self-pollination before the large flowers open in the morning hours (Karikari 1972; Erskine and Bala 1976; Erskine 1980) [9, 4, 5]. Winged bean plant grows as a vine with climbing stems and leaves. It is a herbaceous perennial, but can be grown as an annual in hot, humid equatorial countries such as Papua New Guinea, Indonesia, Malaysia, Thailand, Philippines, India, Vietnam, Burma, Sri Lanka and Madagascar. It is commonly grown in southern and north-eastern region, *i.e.* Tripura, Manipur, Mizoram and adjoining areas of India and is consumed by local peoples (Kant and Nandan, 2018) [8]. All parts of winged bean are rich in protein (Mnembuka and Eggum, 1995) [13], vitamins and minerals (Mahto and Dua, 2009) [11] and were once identified as the future soybean (National Academy Press, 1981) [4]. Winged bean is a multipurpose crop that can be grown as a pulse, as a vegetable (leaves and pods) and as a root tuber crop (National Academy Press, 1981) [4]. Each part of the plant contains a different nutritional composition; the leaves and pods, commonly used as a vegetable, are a rich source of vitamins, minerals and fibre, the seed are high in protein and the tuber provides a rich source of carbohydrate (Wong *et al.*, 2015) [23]. It is well documented that higher level of nitrogen application not only seems to be uneconomic, but also endanger the basic production system. This situation warrants for a sustainable agro technology, through integrated plant nutrient supply system involving chemical, organic and biofertilizers.
Soil is the important and fundamental component of the biosphere that supports all the living and since there is a concerning factor of land degradation observing the production of food and

maintenance of environmental quality, there is an increasing awareness. Soil health refer to soil quality as the continued capacity of soil to function as a vital living ecosystem that sustains agricultural productivity with minimal environmental impact Soil Thus, soil health provides an ultimate condition of soil functionality (Arias *et al.*, 2005) [2]. Nutrient supplies and soil fertility are the parameter of soil quality and value of agriculture organic soil. Biofertilizers affect microbiological and chemical properties of soil which indirectly is responsible for the growth of crop. (Arancon *et al.*, 2006) [1]. Organic nutrition is the main factor of soil fertility and inadequate organic nutrition even in a bit may alter the yielding of crop. Organic farming is the best solution for preventing soil degradation (Rajeev *et al*. 2010) [16]. Therefore, keeping these facts in view, present study was undertaken to evaluate the influence of biofertilizers on growth and yield of Winged bean.

2. Materials and Methods

Investigation on the effect of biofertilizers on growth, yield and quality of winged bean (*Psophocarpus tetragonolobus*) was carried out at the Horticulture Research Station, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur during the year 2018 - 2019.Seeds of winged bean variety were procured from local market having well developed good quality seeds, free from pest and disease attack were selected and sown. The Horticulture unit is located at an altitude of 776 Meters above mean sea level (MSL) with a geographical bearing $24^0$43'28.06"N latitude and $93^0$51'29.20"E longitude in the North eastern agro-climatic Zone of Manipur. The experimental plot was laid out separately in Completely Randomized design (CRD) with a single local variety of winged bean and ten treatments replicated thrice. The different types of biofertilizers *viz*., *Rhizobium*, Vermicompost, VAM, PSB were obtained from Green Biotech, Imphal. The effect of different biofertilizers on Plant height (ft), Number of branches per plant, Number of pods per plant, Number of seeds per plot, Length of pod (cm), Pod yield plant (g), Tuber weight (g), Fresh weight of pod (g), Dry weight of pod (mg) were recorded.

3. Results and Discussion

3.1. Plant height (ft)

Data pertaining to Table 1 shows that treatment comprising of *Rhizobium* and PSB (T_8) produced the tallest plant (17.25 ft), while T_1 (Control) recorded the least (11.27 ft) plant height. It may be due to higher amount of organic matter to improve soil structure so that plants could get higher amount of nutrients of biofertilizer along with water because water holding capacity of soil increased with the presence of organic matter contributed by biofertilizer which is responsible for enhancing microbial activity. A similar result was also reported by Kushwaha *et al*. (2007) [10] and Togay *et al*. (2008) [21].

3.2. Number of branches per plant

The effect of all treatment on number of branches per plant was found significant (Table 1). Winged bean with treatment comprising of *Rhizobium* + PSB + Vermicompost +VAM (T_{10}), produced significantly higher number of branches per plant (8.9), while the least was observed in T_9 (3.7) which was statistically similar to that of control (4.2). The reason might be due to the sufficient supply of nutrients to the plants because of biofertilizers that fixes essential nutrients for growth and development of the plants. The finding is in line with that of Singh and Singh (2010) [18] and Yadav *et al*. (2017) [24]

3.3. Pod length (cm)

Data obtained from Table 3 showed that treatment T_{10} (R+ VC+ VAM + PSB) produced the longest pod (13.4 cm) found statistically at par with T_2 (11.8 cm), T_4 (12.1cm), T_8 (12.4cm) and T_9 (12.1cm). Shortest (9.6 cm) pod length was observed under the treatment without any biofertilizers (T_1). The beneficial effect of all the biofertilizers (R+VC+VAM+PSB) might play its role in nutrient adequate supply which enhance the mobilization of nutrients, activation of beneficial soil microbes, biological activities (N-fixation) and improved physical and biochemical condition of winged bean which provide good nutrient content.

3.4. Number of seeds per pod

The effect of biofertilizer on the number of seed per pod of winged bean (Table 3) was recorded highest (11.6) in T_{10} (R+VC+VAM) which was found statistically at par with T_2 (*Rhizobium*) (10.1). Least number of seeds per pod (7.0) was observed under Control treatment. The results are in close conformity with the findings of Jarande *et al*. (2006).

3.5. Number of pod per plant

The number of pod per plant is an important yield contributing character, which signifies the efficiencies of treatment and influence the crop yield. The effect of biofertilizer on the number of pod per plant of winged bean (Table 3) was found highest in T_9 (R+VC+VAM) (34.0), found statistically at par with T_{10} (R+VC+VAM) (32.5). Least number of pods per plant (20.9) was recorded in T_1 (Control). Yield of highest number of pods per plant in the treatment consisting of R+VC+VAM might be due to the specific roles of the biofertilizers that supply sufficient nutrients to the plants and enable to produce greater number of pods per plant. A similar result was also reported by Singh and Singh (2010) [18] and Yadav *et al*. (2017) [24].

3.6. Fresh weight of pod per plant (g)

Results obtained from Table 3 indicate that application of biofertilizers significantly increased pod fresh weight. Treatment T_{10} (R+VC+VAM+PSB) recorded significantly higher pod fresh weight (14.88g), found statistically at par with T_8 (R+PSB) (14.54g) and T_9 (R+VC+VAM) (14.69g). It might be due to presence of higher organic matter that increases the water holding capacity of soil and hence, plants get more soluble nutrients which ultimately improve the pod. Similar result was also reported by Asewar *et al*. (2003) [3] and Singh and Prasad (2008) [19].

3.7. Dry weight of pod per plant (mg)

The data on dry weight of pod is shown in Table 3. Results revealed that seeds treated with *Rhizobium* (T_2) recorded significantly higher pod dry weight (3467.00 mg), which was found statistically at par with T_3 (vermicompost) (2717.20 mg), T_7 (R+VAM) (2783.67 mg), and T_{10} (R+VC+VAM+PSB*)* (2483.60 mg). It might be due to different character of the biofertilizer used. The finding is in agreement with the results of Jarande *et al*. (2006) [7].

3.8. Tuber weight (g)

The data from Table 4 revealed that the maximum tuber weight (167.53g) was recorded in the treatment T_9 (R+ VC + VAM), found statistically at par with the treatments T_3 (161.57g), T_4 (119.72g), T_7 (119.00g), T_8 (124.51g) and T_{10} (148.45g). Minimum tuber weight (82.09g) was observed in the treatment T_1 (Control). It may be due to balanced nutrient supply to the plant which ultimately enhances the growth of tubers. The results are in conformity with finding of Theuna *et al*. (2010) [20] and Jarande *et al.* (2006) [7].

3.9. Total yield per plant (g)

Effect of biofertilizers on total yield per plant (Table 4) was found highest in T_9 (673.9g) while the least was observed in T_2 (343.5g). It might be due to the presence of rich amount of organic matter in the soil and different character of the treatment used. The present finding is in agreement with result of Asewar *et al.* (2003) [3] and Singh and Prasad (2008) [19].

4. Conclusion

Biofertilizers have significant role on growth and yield of winged bean. From the present investigation it may be concluded that seed treatment of winged bean with *Rhizobium* prior to planting improves the crop and also use of different biofertilizers in combination boosts the growth, development and yield of winged bean. Hence, application of biofertilizers should be encouraged for better crop yield and also restores the degraded soil because of its eco-friendly in nature.

Table 1: Treatment details of the Experiment

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

Table 2: Biofertilizers and its effect on vegetative growth of winged bean

Treatment	Plant height(ft) at 90 DAS	No. of secondary branches at 90 DAS
T_1	11.27	4.2
T_2	11.94	7.0
T_3	12.83	6.8
T_4	12.74	7.2
T_5	12.03	6.3
T_6	12.25	6.2
T_7	11.46	6.6
T_8	17.25	6.5
T_9	11.56	3.7
T_{10}	14.16	8.9
CD 5%	1.99	2.09
SEd±	0.96	1.00

Table 3: Biofertilizers and its effect on pod parameters of winged bean

Treatment	Pod length (cm)	No. of pods per plant	No. of seeds per pod	Pod fresh weight (g)	Pod dry weight (mg)
T_1	9.6	20.9	7.0	11.94	2036.87
T_2	11.8	24.5	10.1	11.68	3467.00
T_3	11.5	25.2	7.9	10.78	2717.20
T_4	12.1	24.3	8.7	11.04	1770.33
T_5	11.4	28.8	7.9	10.49	1850.00
T_6	11.4	27.9	8.7	10.82	2173.73
T_7	11.3	27.5	8.7	11.12	2783.67
T_8	12.4	30.2	8.7	14.54	1413.73
T_9	12.1	34.0	8.6	14.69	1980.33
T_{10}	13.4	32.5	11.6	14.88	2483.60
CD 5%	1.61	3.5	2.16	2.32	1119.16
SEd±	0.77	1.7	1.04	1.11	536.52

Table 4: Effect of biofertilizers on tuber weight and yield of winged bean

Treatment	Tuber weight (g)	Yield per plot (g)
T_1	82.09	408.6
T_2	117.22	343.5
T_3	161.57	416.6
T_4	119.72	382.4
T_5	117.79	442.5
T_6	102.09	470.2
T_7	119.00	476.0
T_8	124.51	527.8
T_9	167.53	673.9
T_{10}	148.45	581.5
CD 5%	49.41	19.2
SEd±	23.69	9.2

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