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Ameriolations with VAM and PSB Inoculation of Growth and Yield Attributes in Pea (*Pisum sativum* L.) cv. Arkel

Maharabam Martina Devi[1], Siddharth Shankar Bhatt[2], Maragani Vamshi[3], Vishwajeet Singh[4], Priya Rani[5], Deen Dayal[6], Ankur Gupta[7], Ashwani Kumar Sanghi[8], Smita Agrawal[9], Nitin Wahi[10], Kundan Kumar Chaubey[11] 10.18805/LR-5123

ABSTRACT

Background: Pea (*Pisum sativum* L.) is one of the most important legume grown all over the world with its varied uses as vegetables and other processed products. Its production and productivity in recent times have witnessed a diminishing graph due to numerous biotic and abiotic stresses. With unexploited use of synthetics in legume crops number of nodule formation have reduced to lowest levels. VAM (Vesicular Arbuscular Mycorrhiza) and PSB (Phosphate Solubilizing Bacteria) inoculation in soil have been observed in enhancing number of nodules, levels of NPK uptake and yield in pea.

Methods: Considering the importance of above facts and experiment was laid in 2022 with RBD with three replications containing 7 treatments *viz*. T_1 (Control), T_2 (75% RDF + 25% PSB), T_3 (50% RDF + 50% PSB), T_4 (75% RDF + 25% VAM), T_5 (50% RDF + 50% VAM), T_6 (75% RDF + 12.5% VAM + 12.5% PSB) and T_7 (50% RDF + 25% VAM + 25% PSB).

Result: Investigations indicated that the treatment T_7 (50% RDF + 25 % VAM + 25% PSB) showed significantly high growth, yield and quality like plant height (113.90 cm), number of leaves (87.09), number of branches (20.2), number of nodules (90.56), numbers of pod/plant (19.1), pod length (8.97 cm), number of seeds per pod (8.23), green pod yield/plot (4.80 kg), green pod yield/ha (80.12 q) compared to control. Hence, T_7 (50% RDF + 25% VAM + 25% PSB) evidently exhibited a conglomeration of bio nutrient uptake enhancers resulting in maximum yield and quality.

Key words: Biofertilizer, Growth, Pea, PSB, VAM, Yield.

INTRODUCTION

Pea (*Pisum sativum* L.) is the most prominent pulse crop with considerable economic importance among all the other pulses belongs to the family Fabaceae. It is an excellent source of digestible protein (21-25%), carbohydrates, vitamin A, C, calcium and phosphorus and is one of the world's most widely grown winter season legume crops (Jitendra, 2011).

Dry-shelled pea consists of higher levels of the amino acids lysine and tryptophan than cereal grains and is marketed as nutrition for both humans and livestock food (Schatz and Endres, 2009). Lutein is also found in abundance in peas, which is good for the eyes. It is commonly consumed as a raw vegetable or in canned, processed, or dried form.

Pulses production in recent time has shown a decline trend due to major constraints ranging from biotic and abiotic stress. Poor soil fertility in mariginal and sub mariginal land has been one of the prominent factors contributing to low yield. Lack of available nutrients in such soils results in stunted growth. Root nodules alone present in the roots of pulses cannot manage to enhance growth. Biofertilizers on the other hand not only increases nodulation percentage but also enhances the availability of nutrients in mariginal soils (Sharma *et al*., 2019). Bio-fertilizers are considered to play a critical role in enhancing nitrogen and phosphorus availability, as well as promoting biological nitrogen fixation and crop phosphorus availability to legumes crops. They are live, ready-to-use formulations of beneficial microorganisms that mobilize the availability of nutrients through biological processes when applied to seed, root, or soil. Also the number of beneficial microorganism

[1]School of Agriculture, Uttaranchal University, Dehradun-248 007, Uttarakhand, India.
[2]Department of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar-400 075, Uttarakhand, India.
[3]Department of Soil Science and Agriculture Chemistry, Tamil Nadu Agriculture University, Coimbatore-641 003, Tamil Nadu, India.
[4]Department of Botany, Dhanauri PG College, Dhanauri, Haridwar-247 667, Uttarakhand, India.
[5]Taqgene Training and Research Institute, Kotra Santoor Road, Dehradun-248 007, Uttarakhand, India.
[6]Department of Biotechnology, GLA University, Mathura-281 406, Uttar Pradesh, India.
[7]Department of Microbiology, School of Life Sciences, Dr. Bhimrao Ambedkar University, Agra-282 004, Uttar Pradesh, India.
[8]School of Allied and Health Sciences, MVN University, Palwal-121 105, Haryana, India.
[9]Department of Horticulture, B.M. College of Agriculture, RVSKVV, Khandwa-450 001, Gwalior, Madhya Pradesh, India.
[10]Department of Bioinformatics, Pathfinder Research and Training Foundation, Greater Noida-201 308, Uttar Pradesh, India.
[11]School of Basic and Applied Sciences, Sanskriti University, Mathura-281 401, Uttar Pradesh, India.

Corresponding Authors: Siddharth Shankar Bhatt; Kundan Kumar Chaubey; Department of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar-400 075, Uttarakhand, India; School of Basic and Applied Sciences, Sanskriti University, Mathura-281 401, Uttar Pradesh, India. Email: siddharthbhatt2714@gmail.com; kundan2006chaubey@gmail.com

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species can enhance crop growth through a variety of mechanisms (Uikey *et al*., 2015). Therefore, the use of VAM-fungi is exploding throughout the country because of its potential advantages in agriculture, forestry, wasteland development and revegetation of damaged biodiversity. In recent years, the positive effects of mycorrhizal fungus in various plants have been thoroughly studied. The phosphorus cycle and plant phosphorus assimilation are both dependent on VAM (Geetha *et al*., 2017). By improving P uptake, these fungi help most field crops growth and their productivity. Also, the VAM biofertilizers have been demonstrated to be effective in increasing plant availability of macro and micronutrients, as well as in preventing pathogenic organisms from invading plant roots, therefore protecting plant roots from biotic and abiotic stresses. On the other hand, the PSB culture used as seed inoculation has a massive effect on the solubilization of various insoluble organic and inorganic phosphates added to the soil as phosphate supplements (Harishkumar *et al*., 2019). These microbial inoculants can replace almost 20-25 per cent of a plant's phosphorus need. Furthermore, introducing PSB into agronomic activities would not only help to offset the high cost of producing phosphate fertilizers, but it would also help to mobilize insoluble nutrients from fertilizers and soils (Chang and Yang, 2009). About 40 per cent pulse growing regions have low to medium population of native rhizobium. Seed inoculation with biofertilizer (Rhizobium and PSB) - low cost inputs - can increase pulse productivity by 10-12 per cent in India (Tiwari and Shivhare, 2016).

MATERIALS AND METHODS

Examination of the effect of VAM and PSB inoculation under pea (*Pisum sativum* L.) was completed at Crop Research Centre (CRC), School of Agriculture, Uttaranchal University, Dehradun in the *rabi* season of 2022-23. The experimental region's soil was sandy clay loam with a pH of 7.2, available N (301.5 kg ha^{-1}), P (12.44 kg ha^{-1}), K (233.6 kg ha^{-1}) and organic carbon (1.31%). The analysis was spread out in a RBD with three replications containing 7 treatments *viz*. T_1 (Control), T_2 (75% RDF + 25% PSB), T_3 (50% RDF + 50% PSB), T_4 (75% RDF + 25% VAM), T_5 (50% RDF + 50% VAM), T_6 (75% RDF + 12.5% VAM + 12.5% PSB) and T_7 (50% RDF + 25% VAM + 25% PSB). *Glomus mosseae* species in VAM and *Pseudomonas spp.* of PSB were predominant in both biofertilizers. Arkel variety was chosen and it was sown in lines in 3 m × 2 m plots at a seed rate of 80 kg/ha for each replication and treatment. Data on various growth and yield parameters were collected from the five tagged plants in each plot and averaged were recorded for statistical analysis.

Finally, crop harvesting was done by hand-picking. The observations were subjected to statistical analysis by using randomized block design (RBD) as per procedure given by Cochran and Cox (1959). Mean differences were tested by 'F' test at 5 per cent level of significance (LOS). Critical difference (CD) at 5 per cent level of probability was used for comparison among treatments and was used for test of significance between the treatments.

RESULTS AND DISCUSSION

Growth parameters

Plant height

Table 1 shows the information about plant height. The treatment T_7 (50% RDF + 25% VAM + 25% PSB) obtained maximum plant height of 113.90 cm which was effective and significant over control. The minimum plant height was observed in T_1 (Control) (80.71 cm). The plant height gradually increased at a faster rate due to better supply of nutrients reached its maximum height till harvest. The supply of nutrients and availability are two different components which determines the growth pattern of legumes. Faster growth rate eventually results in shorter maturity period with maximum yield. Both VAM and PSB collectively might have enhanced the availability of both nitrogen and phosphorus resulting in enhanced plant height. Similar trends were also obtained by Jaga and Sharma (2015), who revealed that VAM and seed inoculation of PSB improved growth parameter. Pramanik and Bera (2012) also concluded his studies on inoculating chickpea plants with PSB and VAM increased growth indices such as plant height.

Number of leaves

The highest number of leaves (87.09) was recorded at treatment T_7 (50% RDF + 25% VAM + 25% PSB) while the least number of leaves (82.73) was shown by T_1 (Control)

Table 1: Effect of growth parameters on pea as influenced by VAM and PSB inoculation.

Treatments	Plant height (cm)	No. of leaves	No. of branches	No. of nodules
T_1 (Control)	80.71 c	82.73 c	18.60 c	80.6 c
T_2 (75% RDF + 25% PSB)	93.32 b	85.40 b	19.53 b	87.02 a
T_3 (50% RDF + 50% PSB)	95.32 b	85.20 b	19.60 b	82.15 b
T_4 (75% RDF + 25% VAM)	97.38 b	84.13 b	19.40 b	85.81 b
T_5 (50% RDF + 50% VAM)	100.81 a	84.44 b	19.33 b	88.95 a
T_6 (75% RDF + 12.5% VAM + 12.5% PSB)	110.21 a	84.36 b	19.06 b	86.18 b
T_7 (50% RDF + 25% VAM + 25% PSB)	113.90 a	87.09 a	20.20 a	90.56 a
SEm	0.91	0.92	0.05	0.07
CD at 5%	1.70	1.70	0.41	0.47

(Table 1). The influence of biofertilizer varied the number of leaves for different growth phases. The perusal of data implies that when applied alone they didn't show any significant results. But both VAM and PSB in integration with other synthetic fertilizers successfully enhanced number of leaves which enhanced amount of photosynthates. PSB have been reported to affect number of leaves in numerous legumes along with pea. Choudhary *et al*. (2017) investigations revealed that among different regime of biofertilizers inoculation of PSB led to greatest, number of leaves per plant**.** Nitrogen and phosphorus are essential elements responsible for growth and development. Their availability in soluble form might have increased number of leaves in pea. Muley *et al.* (2016) also reported similar results with the use of liquid based PSB which produced noticeably greater number of leaves per plant.

Number of branches

Maximum number of branches (20.2/plant) was observed in treatment T_7 (50% RDF + 25% VAM + 25% PSB) which was highly significant over control while the minimum branches (9.86/plant) was noted in T_1 (Control). Number of branches in legumes plays a pivotal role in number of pods and yield. It showed positive correlation with number of pods and yield. Different biofertilizers tend to produce varied branches. Both VAM and PSB collectively increased number of branches in comparison to when applied alone. Among them both biofertilizers with inorganic nitrogen sources has shown positive result in enhancing number of branches (Das *et al.,* 2011).

Number of nodules

The maximum number of nodules (90.56) was observed in treatment T_7 (50% RDF + 25% VAM + 25% PSB) while the minimum number of nodules (80.6) were noted in T_1 (Control). The other treatments T_2 (75% RDF + 25% PSB), T_3 (50% RDF + 50% PSB), T_4 (75% RDF + 25% VAM), T_5 (50% RDF + 50% VAM and T_6 (75% RDF + 12.5% VAM + 12.5% PSB) also showed significant effects over control. The use of biofertilizer greatly affects the root nodules by performing proper N-fixation. VAM is a free living nitrogen fixing bacteria which acts as a saprophyte and enhances number of root nodules. PSB on the other hand helps in solubilizing phosphorus. When used alone both didn't enhanced nodules but collectively applied showed significant increase in number of nodules. These nodules further enhance availability of nutrients in the root zone of legumes. Tomar *et al.* (2001) also concluded his findings that inoculating different biofertilizers resulted in the greatest increase in nodulation with VAM found to observe maximum nodules in pea. Moreover, VAM also considerably increased number of nodules per plant in chickpea (Yaseen *et al*., 2011).

Yield attributes and yield

Numbers of pod/plant

Yield depicts quantitative character which is governed by polygenes. When comparing the number of pods per plant under different treatment to the control, it was observed that pods per plant varied dramatically. Maximum number of pods/plant (19.1) was recorded in T_7 (50% RDF + 25% VAM + 25% PSB) while the least was observed in T_1 (Control) (15.93). All the treatments were found to be significant over control except T_2 (75% RDF + 25% PSB) (16.15). Use of two different biofertilizer (VAM and PSB) with RDF has greater influence on number of pods/plant. As legumes crop needed phosphorous for better yield, the combination of two phosphorous giving biofertilizer (VAM and PSB) showed positive results on number of pods/plant. The similar findings were observed in Kaur and Rawat (2020) examined that the yield-related attributes were judged to be superior with the assessment seed treatment with PSB, resulting in a number of pods per plant (8.23). Additionally, Rajput *et al.* (2022) also investigated the effects of culture, liquid and capsulated biofertilizer on the growth, yield and quality characteristics of vegetable pea. The results showed that PSB dramatically improved the yield parameters like number of pods per plant.

Pod length (cm)

Table 2 showed that the treatment T_7 (50% RDF + 25% VAM + 25% PSB) was effective and significant over control. Maximum pod length (cm) was observed in T_7 (50% RDF + 25% VAM + 25% PSB) obtaining 8.97 cm which was statistically at par with T_2 (75% RDF + 25% PSB), T_3 (50% RDF + 50% PSB). Minimum pod length (7.55 cm) was noted in control in which no biofertilizers was incorporated (Graph 1). Because of their proper uptake of nutrient supply, the application of biofertilizer gradually increased pod length and contributed the positive effect of yield parameters. Moreover VAM and PSB showed positive relation in enhancing pod length in comparison to either VAM or PSB alone. Similar results were found with the findings of Heisnam *et al.* (2017) who reported maximum pod length with the use of different biofertilizer.

Number of seeds per pod

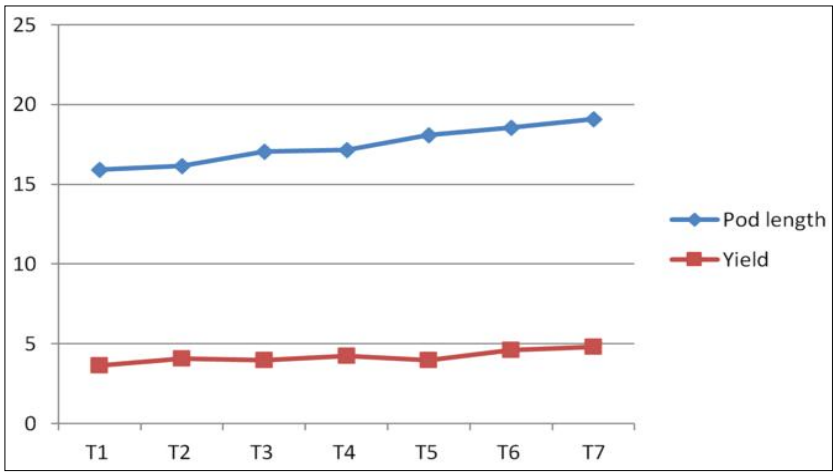
The highest number of seeds per pod (8.23) was observed in T_7 (50% RDF + 25% VAM + 25% PSB) while the least was observed in T_1 (Control) (7.20). The number of seeds per pod indicated how biofertilizers collaborate by enabling the production of more seeds on pods, which leads to better flowering and later fruiting. This can be correlated with how biofertilizer application has a significant impact on the reproductive phase and improves yield. Moreover, seed inoculation with biofertilizers considerably improved number of seeds per pod, which resulted in substantially larger yield properties (Teli *et al*., 2016). Experimentation on the impact of INM on seed yield and characteristics in field pea revealed enhanced number of seeds per pod (Pandey *et al*., 2017). It possessed positive relationship with pod length and no. branches.

Pod yield/plot (kg)

When comparing under different treatment to the control, T_7 (50% RDF + 25% VAM + 25% PSB) has obtained maximum yield of 4.80 kg/ plot while the least was observed

Table 2: Effect of yield parameters on pea as influenced by VAM and PSB inoculation.

Treatments	No. of pods/plant	Pod length (cm)	No. of seeds/pod	Pod yield/plot (kg)
T_1 (Control)	15.93 c	7.55 c	7.20 c	3.63 c
T_2 (75% RDF + 25% PSB)	16.15 b	8.79 a	7.30 c	4.06 b
T_3 (50% RDF + 50% PSB)	17.05 b	8.64 a	7.52 b	3.98 c
T_4 (75% RDF + 25% VAM)	17.14 b	7.94 b	7.67 b	4.23 b
T_5 (50% RDF + 50% VAM)	18.07 a	8.26 a	7.85 b	3.97 c
T_6 (75% RDF + 12.5% VAM + 12.5% PSB)	18.54 a	8.60 a	8.20 a	4.60 a
T_7 (50% RDF + 25% VAM + 25% PSB)	19.1 a	8.97 a	8.23 a	4.80 a
SEm	0.09	0.02	0.02	0.20
CD at 5%	0.54	0.28	0.27	0.85



Graph 1: Correlation between pod length and yield.

in T_1 (Control) (3.63 kg/plot). The treatment T_7 (50% RDF + 25% VAM + 25% PSB) was also statistically *at par* with T_2 (75% RDF + 25 % PSB), T_4 (75% RDF + 25% VAM) and T_6 (75% RDF + 12.5% VAM + 12.5 % PSB). Pod yield depicts interrelation with pod length and number of seeds/pod. VAM and PSB enhanced the available form of major elements required for increased yield. Nodulation increase particularly had a greater impact in surge in yield in Ramana *et al.* (2010) experimented that use of VAM, PSB with measured fertiliser dosages increased yield attributing characteristics and yield like pod yield per plant. Rajput *et al.* (2022) also investigated that use of different biofertilizer with RDF improved yield parameters of pod yield/plot and total pod yield dramatically.

CONCLUSION

Depending on the outcomes of the experiment, it can be concluded that the combination of 50% RDF + 25% VAM + 25% PSB was the most superior treatment in terms of growth and yield parameters. Using biofertilizer for legume crops also enhanced nutrient availability for crop production. As a consequence, the application of 50% RDF + 25% VAM + 25% PSB under various pea varieties is advised for upcoming researchers in order to produce greater outcomes, but VAM and PSB can indeed be recommended for farmers. The results are merely indicative; further research is needed to draw a more reliable and conclusive conclusion.

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Conflict of interest

The authors have no conflict of interest in this manuscript.

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