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Response of Pea (*Pisum sativum* L.) growth characteristics and quality parameters as influenced by VAM and PSB inoculation

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Abstract: A field experiment was carried out at Crop Research Centre (CRC), School of Agriculture, Uttaranchal University, Dehradun during the Rabi season of 2021 and 2022 to investigate the impact of VAM and PSB inoculation on growth, yield, and quality in Pea (*Pisum sativum* L.) The experimental design was assigned in Randomized Block Design with 3 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). Among these treatments, T_7 (50% RDF + 25% VAM + 25% PSB) found to be the most effective and significant over T_1 (Control) in terms of growth and quality parameters like plant height, numbers of leaves, crop growth rate, leaf area index, chlorophyll content, nitrogen content in dry seeds, protein content in dry seeds.

Index Terms: **Growth, Pea, PSB, Quality, VAM**

INTRODUCTION

Pea (*Pisum sativum* L.) is the most prominent pulse crop and belongs to the family leguminosae. It is widespread in Southern Europe's Mediterranean area, Russia, India, Ethiopia and China which are grown over more than 25 million acres worldwide with 12.2 million tonnes of production, China is by far the world's top producer, followed by India with 4.8 million tonnes **(**FAO, 2020**).** Considering India's contribution, U.P. is the leading pea grower, accounting for more than half of total pea production. Madhya Pradesh, Jharkhand, and Himachal Pradesh ranked second, third, and fourth, respectively. Punjab, Haryana, West Bengal, Maharashtra and Uttarakhand are among the pea-growing states with the least contribution.It is one of renowned legume crops with rich source of carbohydrates, vitamin A, vitamin C, calcium, and phosphorus (Jitendra, 2011). Lutein is also found in abundance in peas which is good for vision and most commonly consumed as a raw vegetable or in canned, processed, or dried form (Thamburaj and Singh, 2005).

In recent years, the positive effects of VAM and PSB in various crop have been thoroughly studied considering phosphorus is one of the most essential nutrients for plants, especially for the legume crops.Vesicular Arbuscular Mycorrhizae (VAM) is extremely important in the phosphorus cycle and plant phosphorus assimilation (Biswas *et al.*, 2001). Moreover, they also helps 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 stress. On the other hand, PSB releases acidic chemicals that solubilize in accessible phosphorus of soil and availability to plants. These microbial inoculants can replace almost 20-25 % of a plant's phosphorus demand. In addition, the use of PSB in agronomic practices would not only balance the high cost of making phosphate fertilizers but it would also mobilize insoluble from fertilizers and soils (Chang and Yang, 2009).

MATERIALS AND METHODS

An experiment was conducted in the field at Crop Research Center (CRC), School of Agriculture, Uttaranchal University, Dehradun. which has longitude and latitude coordinates of 29° 58' to 31° 2' N and 77° 37' to 78° 18' E respectively. It rises approximately 648 metres above mean sea level, having a humid subtropical climate. Soil of this site has a sandy clay loam texture and pH is neutral (7.2). In terms of nutrient availability, the soil had a high level of organic carbon (1.31%) whereas the level of nitrogen is medium (301.5kg ha^{-1}) and that of phosphorus and potassium is low (12.44 kg ha^{-1} and 233.6 kg ha^{-1}).The analysis was assigned in a RBD with 3 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). The seed were sown in line with the spacing of 22.5 cm x 10 cm with a depth of 3-5 cm. Seed rate was 80 kg/ha and the recommended dose of fertilizer were 30: 60: 60 NPK kg/ha. The liquid-form of PSB culture 2.5 liters @ 100kg seeds was used for inoculating seeds thoroughly as per treatments and dried in the shade. Field soil was used as the carrier to apply VAM to the plots at a rate of 2 kg/ha. The data were collected from 5 tagged plants and analyzed statistically. The nitrogen content in dry seeds was calculated using a colourimetric method using Nessler's reagent to create the colour (Snell and Snell, 1949) and represented as a percentage and multiplied by 6.25 to get the protein content in dry seed (A.O.A.C., 1960). The Vanadomoloybdo phosphoric acid yellow colour method was used to test the phosphorus content in dry seeds. Richards (1954) used a tri-acid mixture to digest the samples, and a spectrophotometer was used to detect the intensity of colour.

RESULT AND DISCUSSION:

Growth characteristics

Plant height: Table 1 clearly shows that the treatment T_7 (50% RDF + 25% VAM + 25% PSB) recorded the maximum plant height at all intervals 30 DAS, 60 DAS, 90 and DAS whereas the minimum was observed in T_1 (Control). At 30 DAS the treatment T_2 (75% RDF + 25% PSB) was statistically *at par* with T_5 (50% RDF + 50% VAM) followed by T_3 (50% RDF + 50% PSB) with T_4 (75% RDF + 25% VAM) and T_6 (75% RDF + 12.5% VAM + 12.5% PSB). At 60 DAS treatment T_4 (75% RDF + 25% VAM) was statistically *at par* with T_3 (50% RDF + 50% PSB) and T_6 (75% RDF + 12.5% VAM + 12.5% PSB). Also at 90 DAS treatment T_7 (50% RDF + 25% VAM + 25% PSB) showed positive results and significant followed by T_6 (75% RDF + 12.5% VAM + 12.5% PSB). In all treatments, there was a proportional rise in plant height that interspaced from 30 DAS to 60 DAS. The plant height increased at a faster rate and eventually slowed down at 90 DAS and began to reach its maximum height.

Table 1: Effect of VAM and PSB inoculation on growth characteristics of pea

Treatments	Plant height (cm)			Number of leaves			Crop growth rate (CGR)		Leaf area index
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30-60 DAS	60- 90 DAS	
T_1 (Control)	9.84	49.81	68.28	13.06	50.72	59.18	5.26	6.11	3.02
T_2 (75% RDF + 25 % PSB)	13.04	53.9	71.70	15.40	52.27	61.59	5.31	6.04	3.43
T_3 (50% RDF + 50% PSB)	12.88	52.43	74.31	15.20	50.99	61.65	5.99	6.43	3.95
T_4 (75% RDF + 25% VAM)	12.48	52.93	72.38	14.13	52.63	63.14	5.95	6.55	4.05
T_5 (50% RDF + 50% VAM)	13.5	54.46	73.46	14.4	53.56	63.33	6.18	6.61	4.05
T_6 (75% RDF + 12.5% VAM + 12.5 % PSB)	12.84	52.52	75.06	14.36	52.40	60.99	5.94	6.53	3.99
T_7 (50% RDF + 25% VAM + 25% PSB)	15.32	55.64	76.42	17.09	55.52	65.71	6.31	6.74	4.57
S Em±	0.46	0.87	0.42	0.63	0.76	0.99	0.013	0.014	0.012
CD at 5%	1.21	1.66	1.15	1.41	1.55	1.77	0.20	0.207	0.199

Numbers of leaves: Table 1 shows the information on the highest number of leaves was recorded at T_7 (50% RDF + 25% VAM + 25% PSB) at different phases of crop growth (30 DAS, 60DAS and 90 DAS) while the least was observed in T_1 (Control). At 30 DAS the following treatments T_2 (75% RDF + 25% PSB), T_3 (50% RDF + 50% PSB), T_5 (50% RDF + 50% VAM), T_6 (75% RDF + 12.5% VAM + 12.5% PSB), T_4 (75% RDF + 25% VAM) were statistically at par to each others. At 60 DAS the treatment T_2 (75% RDF + 25% PSB) was statistically *at par* with T_4 (75% RDF + 25% VAM) and T_6 (75% RDF + 12.5% VAM + 12.5% PSB), but T_3 (50% RDF + 50% PSB) showed no significant effect. At 90 DAS the treatment T_2 (75% RDF + 25% PSB), T_3 (50% RDF + 50% PSB), T_4 (75% RDF + 25% VAM), T_5 (50% RDF + 50% VAM) remain statistically *at par* to each others. Therefore, T_7 (50% RDF + 25% VAM + 25% PSB) and others treatment showed significant over control except T_3 (50% RDF + 50% PSB) at 60 DAS.

Crop growth rate (CGR): Table 1 shows that the treatment T_7 (50% RDF + 25% VAM + 25% PSB) has the highest crop growth rate during 30-60 DAS and 60-90 DAS whereas the least was observed in T_1 (Control). The others treatment were also found significant except T_2 (75% RDF + 25 % PSB). At 30-60 DAS, T_7 (50% RDF + 25% VAM + 25% PSB) which is statistically *at par* with treatment T_5 (50% RDF + 50% VAM) was found to be effective and significant over control followed by T_4 (75% RDF + 25% VAM), T_3 (50% RDF + 50% PSB), and T_6 (75% RDF + 12.5% VAM + 12.5 % PSB). Moreover, at 60-90 DAS the following 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) were statistically at par with T_7 (50% RDF + 25% VAM + 25% PSB).

Leaf area index: Table 1 shows that the treatment T_7 (50% RDF + 25% VAM + 25% PSB) has maximum leaf area index (4.57) while minimum was noted in T_1 (Control) with 3.02. The following treatments T_4 (75% RDF + 25% VAM), T_5 (50% RDF + 50% VAM) and T_6 (75% RDF + 12.5% VAM + 12.5 % PSB) were also found significant over control. Simultaneously, use of two different biofertilizers significantly increased LAI was mainly caused by contributing greater meristematic tissue activity, which increases photosynthetic surface and, in return, enhances LAI throughout the crop growth period. Moreover, Rani *et al.* (2017) also concluded their finding with better growth parameters like LAI, considering PSB in their treatments.

Quality parameters

Chlorophyll content: Data (Table 2) presented chlorophyll content with three different pigments viz. chlorophyll a, chlorophyll b and total chlorophyll which was recorded under respective wavelength (645 nm, 663 nm and 652 nm) at 60 days after sowing. The highest chlorophyll content (chlorophyll a, chlorophyll b and total chlorophyll) was observed in treatment T_7 (50% RDF + 25% VAM + 25% PSB) while the least was observed in T_1 (Control). 'Chlorophyll a' content remarks proficiently in enhancing the foliage and quality of pods which was due to influence of using biofertilizer with RDF. Likewise, chlorophyll b and total chlorophyll also enhanced in producing green leaves.

Table 2: Effect of VAM and PSB inoculation on quality parameters of pea

Treatments	Chlorophyll content (mg/g fresh weight)			Nitrogen content in dry seeds (%)	Protein content in dry seeds (%)	Phosphorous content in dry seeds (%)
	Chlorophyll a	Chlorophyll b	Total chlorophyll			
T_1 (Control)	1.014	0.331	1.323	3.08	19.26	0.30
T_2 (75% RDF + 25 % PSB)	1.185	0.351	1.532	3.86	24.12	0.40
T_3 (50% RDF + 50% PSB)	1.268	0.321	1.589	3.70	23.15	0.36
T_4 (75% RDF + 25% VAM)	1.158	0.332	1.49	3.99	24.95	0.41
T_5 (50% RDF + 50% VAM)	1.22	0.355	1.572	3.98	24.90	0.41
T_6 (75% RDF + 12.5% VAM + 12.5 % PSB)	1.245	0.378	1.606	3.95	24.84	0.40
T_7 (50% RDF + 25% VAM + 25% PSB)	1.306	0.431	1.736	4.28	26.75	0.46
S Em±	0.001	0.001	0.003	0.021	0.13	0.10
CD at 5%	0.066	0.059	0.099	0.25	1.6	0.04

Nitrogen content in dry seeds (%): Table 2 reveals that treatment T_7 (50% RDF + 25% VAM + 25% PSB) recorded the highest nitrogen content (4.28%) and the lowest was recorded in T_1 (Control) (3.08%). The following treatment T_6 (75% RDF + 12.5% VAM + 12.5 % PSB), T_5 (50% RDF + 50% VAM), T_4 (75% RDF + 25% VAM), T_3 (50% RDF + 50% PSB) and T_2 (75% RDF + 25 % PSB) were statistically *at par* to each others. The main cause of higher nitrogen content in seeds was due to better N uptake at their developing phase which results in use of biofertilizer that enhanced nutrient availability during their growth and development. Similar findings were observed by Kristek *et al.* (2005) and Senthilkumar *et al.* (2012).

Protein content in dry seeds (%): The data (Table 2) shows that the treatment T_7 (50% RDF + 25% VAM + 25% PSB) was highly significant over control. The highest number of protein content (26.75%) in dry seeds was observed in T_7 (50% RDF + 25% VAM + 25% PSB) while the lowest was recorded in T_1 (Control) (19.26%). The treatment T_2 (75% RDF + 25 % PSB), T_6 (75% RDF + 12.5% VAM + 12.5 % PSB), T_5 (50% RDF + 50% VAM) and T_4 (75% RDF + 25% VAM) were statistically *at par* to each others.The findings was similar to Jaga and Sharma (2015) and Ujjainiya *et al*. (2021)

Phosphorous content in dry seeds (%): Table 2 reveals that the treatment T_7 (50% RDF + 25% VAM + 25% PSB) showed maximum phosphorous content in dry seeds obtaining 0.46% while the minimum was recorded in T_1 (Control) (0.30%). The following treatment 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) were also found significant over control. The amount of phosphorus in dry seeds is significantly increased when two independent phosphorus-giving biofertilizers are used. Insoluble phosphorous is broken down by the bacteria in the biofertilizer and made available to the plants for their vegetative and reproductive stages of growth.

CONCLUSION

According to the results of the experiment, it is possible to conclude that the treatment that comprised 50% RDF + 25% VAM + 25% PSB was ideal in terms of growth characteristics and quality parameters. Utilizing phosphorous giving biofertilizers for legume crops improved crop at different crop growth stages. The findings are just suggestive; more study is required to get a more trustworthy and firm conclusion.

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