Efficacy Of Bio-Fertilizers And Planting Distance On Growth, Quality AndYield Of Pea (*Pisum Sativum*)

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ABSTRACT
The experiment entitled "Efficacy of bio-fertilizers and planting distance on growth, quality and yield of pea (*Pisum sativum*)" was conducted at research's field and laboratories of Uttaranchal University, Department of Agriculture, Dehradun (Uttarakhand). The experiment is carried out during the rabi season of December 2022 to April 2023. The present research investigates at the effects of two bio-fertilizers, VAM (Vesicular Arbuscular Mycorrhiza) and Pseudomonas, as well as two different planting distances, (30×15 cm) and (45×15 cm), on pea (*Pisum sativum*) growth, quality, and yield.The study's goal is to give useful information about the usage of bio-fertilizers andoptimized planting distances to improve pea crop performance. The study used a randomized block design (RBD) with three replications. Data on growth characteristics, quality traits, and yield components were gathered and examined statistically. The results demonstrated significant differences in plant growth, quality, and yield variables between treatments. The results indicate that the use of VAM and Pseudomonas bio-fertilizers, as well as a planting distance, influenced the growth, quality, and yield of the plants.

Keywords: *Pea; bio-fertilizer; VAM; Pseudomonas; Planting distance.*

1. INTRODUCTION

Pea (*Pisum sativum* L.) is a herbaceous annual crop which belongs to the family Fabaceae. It is grown in cool season in many parts of the world. It may be classified in to twoclasses. Pea (*Pisum sativum* L. var. *hortense*) which is used for vegetable purpose and for canning and Field pea (*Pisum sativum* L. var. *arvense*) which on the other hand is used as vegetable, fresh, frozen or canned and is also grown to produce dry peas like the split pea. Mature seeds of this types are also used as '*dal*'. It has long been important in diet due to its content of fibre, protein, starch, trace elements and many phytochemicals substances. It has been shown to possess antibacterial, antibiotic, anti-fungal, anti-inflammatory, antioxidant activities and also shown anticancer property.

Pea covers 2.74 million hectares globally, with a total production of 21.22 million tonnes (FAO, 2018). Pea is one of the world's most important pulse crops, with an estimated
76.26 lakh hectares under cultivation. China, Russia, India, Ethiopia, and the United States are the major field pea producing countries. Canada leads the world in field pea area with
16.97 lakh ha (22%) and production with 46.11 lakh tones (32%). With 10.59 lakh ha (13.89%), India is second in area, followed by Russia (13.64%). India ranks fourth in production, with 21.99 lakh tonnes (7.04%). Ukraine has the highest productivity (3126 kg ha^{-1}) followed by Canada (2717 kg ha^{-1}) and Lithuania (2676 kg ha^{-1}). In India, however, productivity is only 955 kg ha^{-1} (Anonymous, 2018).

Pea is the third most important pulse crop in India, after chickpea and pigeon pea, and is grown for its versatility as a vegetable, pulse, and fodder. Uttar Pradesh, Punjab, Haryana, Rajasthan, Chhattisgarh, and Madhya Pradesh are important field pea growing states. Madhya Pradesh ranks first in terms of acreage, with 3.72 lakh ha (39.81%), followed by Uttar Pradesh (37.47%) and Jharkhand (4.07%). Uttar Pradesh leads the way with 3.86 lakh tonnes (41.22%) in terms of production, followed by Madhya Pradesh (33.27%), and Jharkhand (5.16%). Rajasthan had the highest yield (1858 kg ha-1) followed by Punjab (1333 kg ha^{-1}) and West Bengal (1169 kg ha^{-1}). Currently, the cultivated area in Chhattisgarh exceeds 0.146 lakh ha, with a production of 0.054 lakh tonnes and a productivity of 431 kg ha^{-1} (Anonymous, 2018).

In Uttarakhand, it is grown in an area of 0.011 million hectares, which accounts 0.055 million metric tonnes green pods production annually. Due to lack of awareness about sowingtime, proper spacing requirements and other management practices, the productivity of this crop is only 48.74 q ha^{-1} (Anonymous,2002). The crop has a tremendous scope in Uttarakhand hills, due to its off-season nature of production coupled with great demand for green pods during lean period, particularly, in the metropolitan cities of Northern plains.

Peas have dark green pods, a high chlorophyll content, a high TSS, sugars, and a good flavour and texture. Peas have a high nutritional value and are the best and cheapest source of fibre, vitamins (A, B, and C), minerals (Ca, P, and Mg), and phytochemicals in the vegetarian diet. The vitamin and mineral content of peas can help prevent deficiency-related diseases, particularly those involving folate. Dry pea seeds are being used to extract high-quality starch, proteins, and oligoside isolates (Dhall, 2017).Peas with coloured seed coats contain antioxidants and anticarcinogenic properties. Peas contain pre-biotic sugars and fibre, which can aid digestion (Dahl *et al.*, 2012). Per 100 g of edible portion, garden pea contains 7.2 g protein, 0.1 g fats, 0.8 g minerals, 15.8 g carbohydrates, 20 mg calcium, 34 mg magnesium,
139 mg phosphorus, 0.23 mg copper, 95 mg sulphur, 1.5 mg iron, 0.01 mg riboflavin, 0.8 mg nicotinic acid, and 9.0 mg vitamin C. (Sepehya *et al.*, 2015).

Pea can be grown on many types of soils from light sandy to clay soils. Highly organic soils are unsuitable for cultivation of pea as their moisture reserve leads to excess vegetative growth and poor pod formation. Temperature between 15° C to 18° C. High temperature at flowering stage are harmful and cause yield reduction. Pea is recognized as a major cash crop in hilly dry temperate region. Hill grown peas have different characteristics flavour, sweetness and freshness. Several high yielding varieties are cultivated but average productivity of pea is low (6 MT/ha). The productivity of pea crop can be enhanced by standardizing the production technique to be followed in the field. By providing the most optimum plant population per unit area and supply of adequate and balanced nutrients under field conditions maximum yield can be obtained. These two factors not only enhance the productivity of crop but also decide the commercial success of pod vegetable crop like pea.

According to several research workers, they have found significant increase in pod yield and quality attributing characters such as plant height, days to flowering, higher graded seed yield and days for the first harvest which were influenced when the seed crops were grown under the most optimum plant density per unit area in crops like pea a (Attar *et al.,* 2013). Pea crop removes approximately 50-70 kg of nitrogen, 20-30kg of phosphorous and 40-60 kg of potash in its life cycle. Pea gives good response to nitrogen which is essential for early vegetative growth with increasing functional photosynthetic area and ultimately dry matter production.

(VAM) Vesicular Arbuscular Mycorrhiza play an important role in the uptake of phosphorus and phosphorus cycling by plants (Biswas *et al.,* 2001). VAM as symbiotic association with plant roots helps in mobilization of "P". VAM fungi are beneficial symbiotic micro-organisms that increase the growth and yield of most crop plants through improved P uptake. It also increases tolerance to biotic and abiotic stresses. These microorganisms have extensive mycelial network and can increase the transport of other mineral elements such as zinc and copper. VAM can play an important role in enhancing P availability to plant in P deficient soils. VAM fungi can save P- fertilizer by 25-30% (Somani *et al.*, 1990).

Fluorescent Pseudomonas has the ability to produce anti fungal agents, siderophores, and plant growth promoting substances, and it can be foetal to Fusarium spp., potentially reducing disease in the long run (Gholve *et al.*, 2005). Pseudomonas has increased its PAL and cell wall lysis ability through the secretion of extracellular lytic enzymes (Saikia *et al*., 2004).Thus, Pseudomonas fluorescens can be used as an effective bio control agent for diseases such as chickpea wilt and root rot.

With the safety of food and the environment in mind, organic farming is growing more popular among farmers and consumers in India. Compared to conventional farming, it has no negative effects and increases the soil's long-term fertility. With this in mind, the current experiment is entitled as "**Efficacy of bio-fertilizers and planting distance on growth, quality,yield and of pea (*Pisum sativum*)"** was carried out with the following objectives :

1) To study the effect of different planting on growth, quality and yield of pea.
2) To study the effect of different bio-fertilizer on growth, quality and yield of pea.
3) To work out the economics of all the treatment combination.

2. MATERIALS AND METHODS

The research was conducted at the Field and laboratories of School of Agriculture, Uttaranchal University, Dehradun (Uttarakhand). The experiment is carried out during therabi season of December 2022 to March 2023. The experiment was carried out in Randomized block design (RBD) with 7 treatments and 3 replications included two Bio-fertilizers, (Vesicular Arbuscular Mycorrhiza and Pseudomonas Fluorescens) and two different

planting distance (30×15 cm and 45×15 cm). The following observations were recorded on five randomly selected pant in each treatments and replication. 1) Plant height indifferent growth stage, 2) Number of branches in different growth stages, 3) Number of leaves in different growth stages, 4) Fresh and dry weight of shoot, 5) Number of pods perplant, 6) Number of grains per pods, 7) Pod length, 8) Number of nodules, 9) Fresh and dryroot weight,10) Protein content in seed, 11) Total soluble solids, 12) Crop growth rate(CGR).The pea variety used in this experiment was Arkel. The to gross area of the give field was 224 m^2 and plot area is 10 m^2 respectively. The seeds were treated with the bio-fertilizers (Vesicular Arbuscular Mycorrhiza and Pseudomonas Fluorescens) before sowing for 30-40 minutes in shades. The sowing is done line sowing method manually by hand with two different planting distance or spacing i.e 30 cm (row to row) × 15 cm (plant to plant) & 45cm (row to row) × 15 cm (plant to plant) respectively. Recommended seed rate was 60-80 kg/ha. All the seeds were treated with recommended dose of bio-fertilizer except the control. The following treatment combination were used in this research work:

2.1 Treatment Details

T1 - **Control**
T2 - **30×15 cm + Control**
T3 - **30×15 cm + Pseudomonas Fluorescens**
T4 - **30×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)**
T5 - **45×15 cm + Control**
T6 - **45×15 cm + Pseudomonas Fluorescens**
T7 - **45×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)**

2.2 Statistical Analysis

The data recorded were different characteristics were subjected to statistical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez. Critical difference (CD) values were calculated the 'F' test was found significant at 5% level.

3. RESULTS AND DISCUSSION

Growth, yield and quality attributes showed significant variations with different concentrations of Bio-fertilizers and Planting distance.

3.1 Effect on growth parameters

An experiment was conducted to see the effect of Bio-fertilizers and planting distance on growth, yield and quality of pea (*Pisum sativum*). The pea seeds were treated with Bio- fertilizers (Vesicular Arbuscular Mycorrhiza and Pseudomonas Fluorescens) an they aresown with two different planting distance i.e (30 row to row × 15 plant to plant) cm and (45 row to row ×15 plant to plant) cm. According to Bio-fertilizer treatments the plant height (75 DAS-64cm), number of branches (75 DAS-12.5), number of leaves (75 DAS-57) was higher in treatment having Vesicular Arbuscular Mycorrhiza compare to Pseudomonas Fluorescens
i.e T3, T4,T6 and T7. Control i.e T1,T2 and T5 shows the minimum result. Similar result was observed by Tabassum Yaseen *et al.,* (2011), Biswas and Patra (2007)**.** The plant height (75 DAS-64cm), number of branches (75 DAS-12.3) and number of leaves (75 DAS-57) was higher in treatment having wider planting distance i.e T6, T7 and also T3 and T4. Control shows the minimum results. Similar results were observed in Satodiya *et al.,* (2015), Bitew *et al.,* (2014), Dandile (2017).

3.2 Effect on yield and yield attributes

In yield attributes, the number of pods per plants (13.4), number of grains per pods(9.3), Pod Yield (74 q/ha), pod length (9 cm), fresh (20. 7g) and dry (3.1 g) pod weight, fresh (612.5 mg)and dry (91.9 mg) root weight, number of nodules (40.4) were found to be maximum in treatments having bio-fertilizers (Vesicular Arbuscular Mycorrhiza and PseudomonasFluorescens) which is T3,T4,T6 and T7. The treatment T4,T6 and T7 shows the most highest result of all the treatments. Minimum result was recorded in control treatment T1,T2 and T5. Similar result was also observed by Salehi and Aminpanah (2015), Choudhary *et al.,* (2010)**,** Rathore *et al.,* (2010). For planting distance, the number of pods per plants (13.2), number of grains per pods(9.4), Pod Yield (74.4 q/ha), pod length (9.7 cm), fresh (25.6 g) and dry (4 g) pod weight, fresh (612.6 mg) and dry (91.9 mg) root weight, number of nodules (60 DAS- 45.4) were found to be maximum in treatments having wider planting distance (45×15 cm) i.e T6 and T7. Minimum result was found in control treatment T1,T2 and T5. Similar case were observed by Rahman *et al.,* (2020), Gurjar *et al.,* (2018), Khamis *et al.,* (2018), Murade *et al.,*(2014).

3.3 Effect on quality

The quality parameters includes protein content in grains, Total Soluble Solid (TSS) and nutrient percentage in pea. According to planting distance the protein content was in medium level. However maximum protein content was found in wider planting distance i.e T6 (22.5 %) and T7 (24.2 %) including T4 (24.7%). TSS level was also found

to be maximum in wider planting distance T6 (7.46 ^{o}Brix) and T7 (6.7 ^{o}Brix). And the nutrient content (NPK) was found in maximum in wider planting distance (Nitrogen -1.24 %) (phosphorous - 0.61 %)(Potassium - 0.75 %). All the quality parameters was found to be minimum in control T1 and T5. According to bio-fertilizer the protein content was somewhat similar in all the treatment i.c T3 (23.1 %) ,T4 (24.7 %) ,T6 (22.5 %) and T7 (24.2 %) except control T1,T2 and T5.

Total Soluble Solid (TSS) was also high in all treatment having bio-fertilizers i.e T3 (5.2 ^{o}Brix),T4 (5.5 ^{o}Brix),T6 (7.6 ^{o}Brix) and T7 (6.7 ^{o}Brix). Minimum was recorded in control treatment T1, T2 and T5. And the nutrient percentage (NPK) was found to have high in all treatment having bio-fertilizers. However maximum nutrient was found in T6 (Nitrogen - 1.25%)(Phosphorous - 0.62 %)(Potassium -0.82 %) and T7 (Nitrogen - 1.25%) (Phosphorous - 0.63 %) (Potassium -0.80 %).

Table 1. Mean performance of treatments according to different planting distance inpea before harvesting

Treatment	Treatments	Plant height (cm) 30 DAS	Plant height (cm) 45 DAS	Plant height (cm) 60 DAS	Plant height (cm) 75 DAS	Number of branches 60 DAS
T1	Control	15.200	31.063	41.983	52.297	5.877
T2	30×15 cm + Control	15.500	32.387	43.663	53.413	5.843
T3	30×15 cm + Pseudomonas Fluorescens	15.663	31.983	45.477	57.410	6.377
T4	30×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)	15.363	32.463	46.090	63.057	6.837
T5	45×15 cm + Control	15.337	31.733	45.423	54.720	5.523
T6	45×15 cm + Pseudomonas Fluorescens	15.173	32.570	48.197	64.010	7.467
T7	45×15 cm + Vesicular Arbuscular Mycorrhiza(VAM)	15.407	31.663	47.283	61.880	8.887

Table 2. Mean performance of treatments according to different bio-fertilizers in peabefore harvesting

Treatment	Treatments	Plant height (cm) 30 DAS	Plant height (cm) 45 DAS	Plant height (cm) 60 DAS	Plant height (cm) 75 DAS	Number of branches 60 DAS
T1	Control	15.163	30.160	42.007	53.113	5.120
T2	30×15 cm + Control	15.533	30.123	42.297	53.187	5.510
T3	30×15 cm + Pseudomonas Fluorescens	15.517	31.257	47.623	57.557	6.473
T4	30×15 cm + Vesicular Arbuscular Mycorrhiza(VAM)	15.430	32.480	46.227	63.157	7.623
T5	45×15 cm + Control	15.170	30.103	42.333	53.100	5.057
T6	45×15 cm + Pseudomonas Fluorescens	15.900	35.370	48.397	64.727	7.387
T7	45×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)	15.570	33.233	49.413	62.147	8.770

Table 3. Mean performance of treatments according to different planting distance inyield and quality of pea after harvesting

Treatment	Treatments	Number of pods per plant	Number of grains per pod	Pod yield per plot (kg)	Pod yield per hectare (q)	Protein %	Total Soluble Solid (TSS ^{o}Brix)
T1	Control	8.093	5.397	3.543	35.433	20.233	3.467
T2	30×15 cm + Control	9.937	5.437	4.167	41.533	21.197	3.600
T3	30×15 cm + Pseudomonas Fluorescens	11.330	6.507	5.420	54.200	23.133	5.200
T4	30×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)	11.117	7.327	5.633	56.333	24.733	5.500
T5	45×15 cm + Control	9.023	5.367	4.260	42.600	20.667	3.300
T6	45×15 cm + Pseudomonas Fluorescens	12.843	8.803	6.487	64.867	22.500	7.467
T7	45×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)	13.220	9.407	7.440	74.400	24.267	6.700

Table 3. Mean performance of treatments according to different bio-fertilizers in yieldand quality of pea after harvesting

Treatment	Treatments	Number of pods per plant	Number of grains per pod	Pod yield per plot (kg)	Pod yield per hectare (q)	Protein %	Total Soluble Solid (TSS ^{o}Brix)
T1	Control	8.130	5.183	3.543	35.433	20.233	3.467
T2	30×15 cm + Control	8.157	6.133	4.167	41.533	21.197	3.600
T3	30×15 cm + Pseudomonas Fluorescens	10.157	8.373	5.420	54.200	23.133	5.200
T4	30×15 cm + Vesicular Arbuscular Mycorrhiza(VAM)	11.270	9.103	5.633	56.333	24.733	5.500
T5	45×15 cm + Control	8.087	6.067	4.260	42.600	20.667	3.300
T6	45×15 cm + Pseudomonas Fluorescens	12.743	9.810	6.487	64.867	22.500	7.467
T7	45×15 cm + Vesicular Arbuscular Mycorrhiza (VAM)	13.410	9.327	7.440	74.400	24.267	6.700

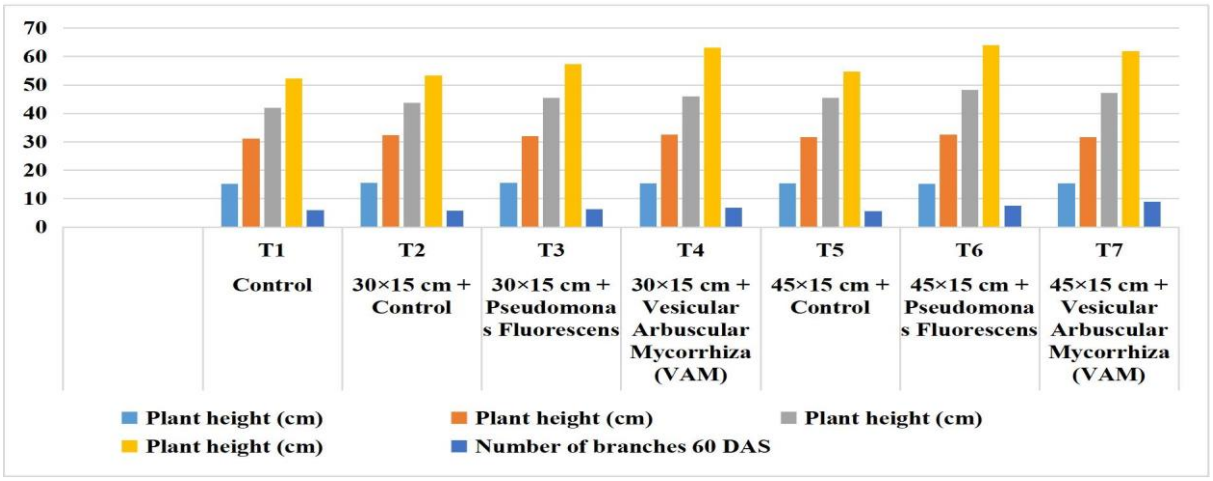

Fig 1. Performance of treatments according to different planting distance in pea beforeharvesting

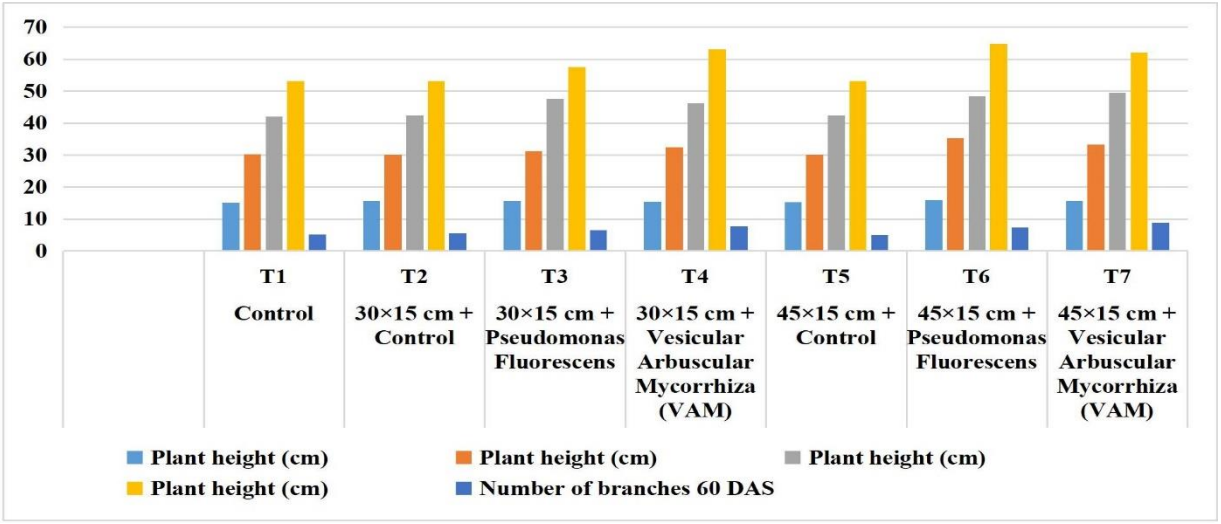

Fig 2. Performance of treatments according to different bio-fertilizers in pea before harvesting

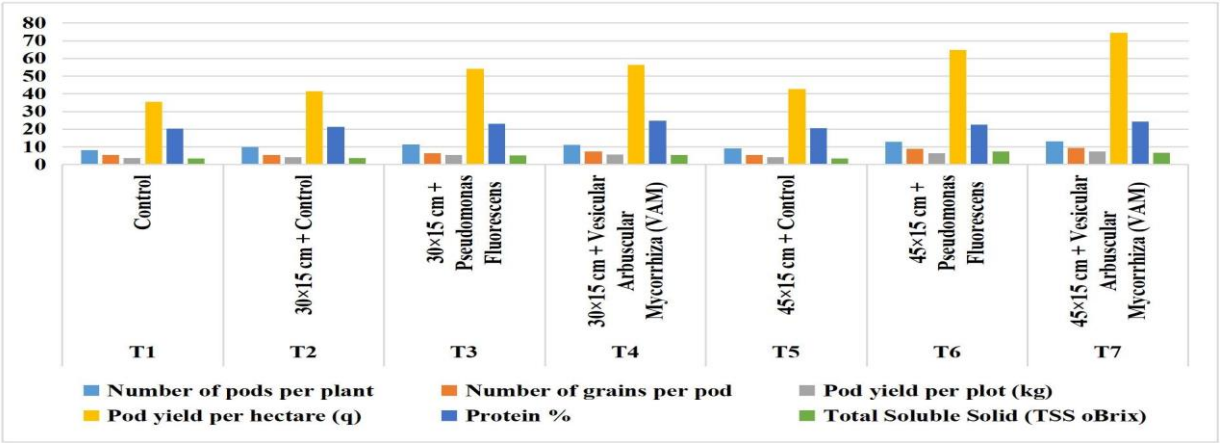

Fig 3. Performance of treatments according to different planting distance in yield andquality of pea after harvesting

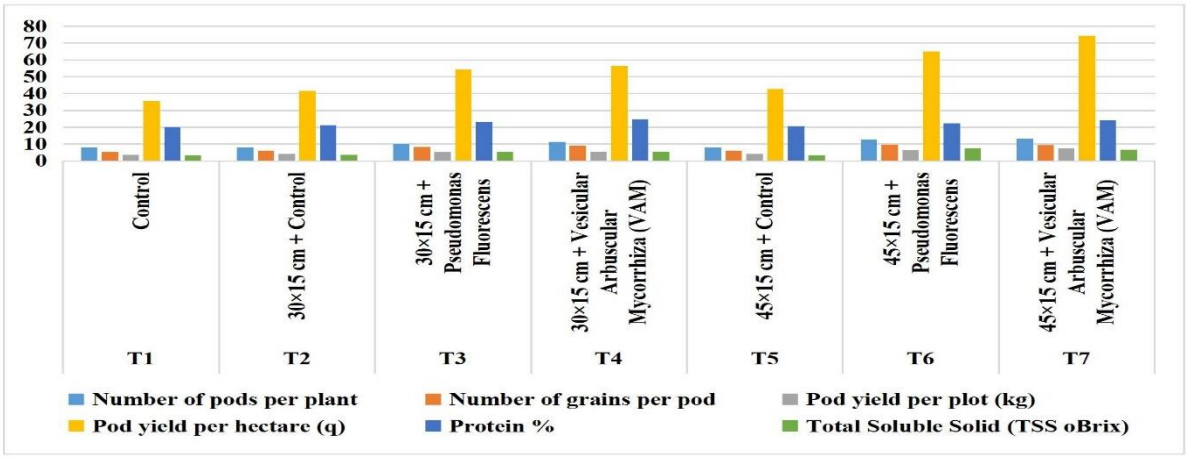

Fig 4. Performance of treatments according to different bio-fertilizers in yield andquality of pea after harvesting

4. CONCLUSION

It was concluded from the present investigation that the bio-fertilizers and planting distance have significant effect in growth, yield and quality of pea (*Pisum sativum*). Treatment havingbio-fertilizers (Vesicular Arbuscular Mycorrhiza and Pseudomonas Fluorescens) i.e, T3,T4,T6 & T7 shows better result in terms of pea growth, yield and quality compared to control treatment. Treatment having wider planting distance (T6 and T7) have much better plant height, number of branches, number of leaves and yield compare to control treatment.

5. ACKNOWLEDGMENT:

This research is supported by Division of Research & Innovation, Uttaranchal University, Dehradun, India.

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