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Comparative analysis of NPK with *Rhizobium* and PSB on the growth and yield of field pea under the sub-tropical regions of Punjab, India

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ABSTRACT

A field study was presided in Rabi season to estimate the effect of different sources of nutrients on the growth, yield, and economics of field peas. The experiment was performed at Agriculture Research Farm, at Lovely Professional University, Phagwara, Punjab during 2022-23 from October to March. Seven different treatments were used to check the result of growth of pea and its yield. The experiment was laid out in a randomized complete block design with three replications. Results demonstrated that the treatment which comprise of NPK with 100% RDF + Rhizobium + PSB gave the highest growth in terms of plant height (66.85 cm), number of leaves/ plant (87.4), number of branches/plant (44.5), leaf area index (32.93), chlorophyll (63.24), plant dry weight (31.24 gm), number of nodules/plant (38.3), and dry weight of nodules (0.84g) respectively. Among the yield attributes pod length (10.48 cm), number of pods/plants (16.65), number of seeds/pod (9.84), 100-grain weight (18g), and yield of grain and straw of field pea were increased by combined application of NPK 100% RDF and bio-fertilizers. However, combined application of 100% RDF+PSB gave at par results with respect to other treatments. The single inoculation of PSB produced promising results as compared to the Rhizobium and control. Therefore, it is recommended that field pea seeds must be inoculated with Rhizobium and PSB along with the full recommended amount of fertilizer to achieve the crop's maximum yield and net profit.

***Key words**: Field pea, Recommended dose of fertilizer (RDF), Phosphate solubilizing bacteria (PSB), Rhizobium, Inoculation.*

Introduction

Pea crop is a popular and versatile cool season Legume crop that is grown for its edible seeds. Peas are widely cultivated around the world for their nutritional value, culinary uses, and versatility. Field pea is a hardy crop that can tolerate cold temperatures and drought conditions, making it suitable for cultivation in a wide range of regions. They grow in well-drained soil and can be grown in both garden plots and containers. Garden peas are seeded on the northern plains during the Rabi season, which runs from early October to late November Shabir *et al.* (2010). Peas grow best in a temperature range of 13 to 18 ^{0}C and are frost-resistant in their early stages of development (Vimla and Natrajan, 2000). One of the earliest cultivated crops is the pea. Due to its high nutritional content, par-

ticularly the proteins at 7.2 g/100 g, it is also a significant vegetable crop Singh *et al.* (2005). It is a major source of protein in many developing countries for the local population, especially in rural areas where other sources of protein may be expensive. Field pea is widely cultivated in many parts of the world, including Europe, North America, Asia, and Australia. Field peas have many health benefits, including reducing the risk of heart disease, improving digestion, and aiding in weight loss. Field pea is also an important crop for soil health, as they can fix nitrogen from the atmosphere and improve soil fertility Peas are typically sown in the spring, depending on the climate and growing conditions. The total global field pea production in the 2019-2020 season was 14.4 million metric tons, with a harvested area of 12.8 million hectares. According to the Food and Agriculture Organization of the United Nations (FAO), the total global field pea production in the 2019-2020 seasons was 14.4 million metric tons, with a harvested area of 12.8 million hectares. The total area under pea cultivation in India during 2019-2020 was 0.23 million hectares. The production of peas during the same period was around 3.10 million metric tonnes (Anonymous, 2020). Nitrogen phosphorus, and potassium (often abbreviated as NPK) are three essential nutrients that play critical roles in the healthy growth and development of pea crops. By providing these nutrients through fertilizers or the use of beneficial microorganisms, pea growers can help ensure optimal crop yields and high-quality harvests. Field peas may naturally fix between 30 and 80 percent of their N requirements, according to (Ali Khan and Zimmer, 1996) and Bowren *et al.* (1986). Field pea plants require a steady supply of nitrogen throughout their growing cycle to develop healthy leaves, stems, and pods. Nitrogen is a vital component of chlorophyll, which is required for photosynthesis. Nitrogen also plays a role in protein synthesis, which is important for the development of high-quality peas. Nitrogen can be applied to pea crops as a fertilizer or using nitrogen-fixing bacteria. Pea plants also require phosphorus to promote flower and pod development. Phosphorus is essential for the development of strong root systems, which are critical for the uptake of water and nutrients Phosphorus can be applied to pea crops as a fertilizer or with phosphorus-solubilizing bacteria. Potassium is necessary for the overall health and vigour growth of pea plants. It regulates water uptake, improves disease resistance, and promotes overall growth and yield. Therefore, there is a need for research to identify the best nutrient sources and management practices to improve the productivity and profitability of field pea production. Biofertilizers are organic fertilizers made of microorganisms that help in productivity growth by biologically fixing nitrogen or solubilizing insoluble phosphate with vitamins and other growth-promoting compounds (Bhattacharya, 2000). Biofertilizers can play a significant role in improving the production and quality of pea crops. Legume plants, including peas, form symbiotic relationships with some strains of bacteria, such as Rhizobium. Biofertilizers help in increasing the uptake of essential nutrients, such as nitrogen, phosphorus, and potassium, by pea plants which can significantly increase the plant's NPK content and promote growth. In addition to enhancing biological nitrogen fixation and phosphorus availability to crops, biofertilizers are recognized to play a significant impact in raising nitrogen and phosphorus availability Bhat *et al.* (2013). The growth, yield, and general health of the plants may all be increased because of this better nutrient uptake. Enhancing pea crop yield with the use of biofertilizers may be sustainable and productive. Fundamental roles in the biogeochemical cycling of phosphorus in natural and agricultural ecosystems are played by phosphate-solubilizing microorganisms. By means of acidification, chelation, exchange processes, and the creation of polymeric compounds, phosphorus-solubilizing microorganisms can convert insoluble phosphorus to the soluble forms HPO_2^{-4} and H_2PO^{-4} Delvasto *et al.* (2006). The availability of P restricts Field pea production by more than 30% of the world's arable land Tesfaye *et al.* (2007). Phosphorus-solubilizing bacteria can solubilize phosphorus in the soil, making it more available to plants. To address the twin concerns of nutrient excess and nutrient depletion, integrated nutrient management entails maintaining soil fertility to an ideal level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients-organic as well as inorganic-in an integrated manner, which is a crucial step. Thus, an integrated approach to nutrient supply using chemical and bio-fertilizers is becoming more and more important because it not only reduces the overuse of inorganic fertilizers but also sustains crop productivity by enhancing soil health in addition to being an environmentally friendly strategy. Field peas had superior growth, production, and nutrient uptake

because of the integration of inorganic fertilizers and biofertilizers Pandey *et al.* (2002).

Materials and Methods

Field experiment was conducted in the Research field of the School of Agriculture, Lovely professional university, Phagwara, Punjab in Rabi season 2022-2023. The location of experiment site isin the northern plain zone at 31.2690°N latitude and 75.7021°E longitude. The soil of the research site was sandy loam having ph 7.7; average content of organic carbon (0.38%), available N (186.63 kg/ha), medium in available P (28.4kg/ha) and K (209.84 kg/ha). The variety was PB-89 selected for this study. The experiment was conducted in randomized block design with three replications comprises of 7 treatments on gross plot size of 5 × 4m^2 and net plot size of 15.05 m^2 with crop geometry of 45X20cm.

The sowing of crop was done on 30th October 2022. The plots were used for control, 100% RDF, *Rhizobium,* PSB, 100% RDF + *Rhizobium*, 100% RDF + PSB, and 100% RDF + *Rhizobium* + PSB. Sowing of inoculated seed as per treatment of field pea was done on ridges by the kera method using seed at 75 kg ha^{-1}. The full dose of fertilizer as per treatments was applied into the field at the time of sowing. Spraying of pendimethalin @1lha^{-1} was done after 48hrs to control the weed growth, and the first weeding was done at 50 DAS. The harvesting of crop was done on 26th Feburary, 2023.

Data were recorded for plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, leaf area index, number of pods plant^{-1}, pod length (cm pod^{-1}), number of seeds pod^{-1}, 100 seed weight, and seed yield (t ha^{-1}) respectively. Height of plant, number of branches plant^{-1} were recorded randomly by selecting the labelled plants from each plot and the average number of plants were recorded. Number of nodules plant^{-1} were measured when it was pulled and these were put in plastic buckets with water so that the adhered soil was loosened from roots to the plant. Afterwards, roots and shoots were separated from the plants when it was cut from the first node of plants which was unable in nature. The roots were washed with tap water with screen lying below so to catch the nodules which were separated. Tesfaye *et al.* (2007). The separated nodules with scalpel were figured up and it was oven dried for 48hrs at 60 ^{o}C till constant weight were achieved. Thereafter the average weight of nodule was determined in terms of gplant^{-1}. Economics of the crop was calculated by checking prevailing sale price of field pea and its cost of cultivation. The data was collected and was analysis with technique of variance as suggested Cox *et al.* (1963).

Results and Discussion

Combined application of NPK 100% RDF + *Rhizobium* + PSB showed maximum plant height (63.9 cm) at maturity as compared to 100% RDF+PSB which is par with NPK 100% RDF+Rhizobium+PSB, but significantly superior over control and rhizobium or PSB (Table 1). Similar findings were obtained by (Mukherjee, 2016) whostated that plant height of field pea increased significantly with a full dose of NPK with *Rhizobium* and PSB. The phosphorus-solubilizing bacteria havethe capacity to dissolve the unavailable soil phosphorus and as a result the yield of crops is increased Adesemoye *et al.,* (2009). The study found that the flow of assimilates was from source to sink andit was found highest and it causes for more seeds per pod in plant. This revealed that the more number of branches and leaves plant^{-1} at maturity were found with integrated application of NPK 100%RDF + *Rhizobium* + PSB over control, *Rhizobium*, or PSB. This result is same as with 100% recommended dose of fertilizer with the use of *Rhizobium* and PSB that was obtained as the highest dry matter plant $^{-1}$(20.8g and 31.2g) at reproductive and maturity as contrast to control, *Rhizobium* and PSB. Similar findings were obtained by Bhat *et al.,* (2013) stated that the inoculation of *Rhizobium* and PSB demonstrated the highest drymatter plant^{-1}. The findings are in line with (Mukherjee, 2016). The nodule dry weight at 60DAS was highest in the NPK (100% RDF) + Rhizobium+ PSB (0.84 g), followed by NPK (100% RDF) + PSB (0.80 g) and NPK (100% RDF) + *Rhizobium* (0.76 g) respectively. It showed a significant increase in the nodule dry weight compared to control, *Rhizobium,* or PSB. The CGR from 90DAS was also highest in the NPK (100% RDF) + *Rhizobium* + PSB treatment (0.45), followed by NPK (100% RDF) + PSB (0.41) and NPK (100% RDF) + *Rhizobium* (0.38) and showed a significant increase in crop growth rate (CGR) compared to control, *Rhizobium* or PSB. The leaf area index at harvest was highest in the NPK (100% RDF) + *Rhizobium* + PSB treatment (32.9), followed by NPK (100% RDF+PSB). The result obtained in this investigation are in close conformity

with those of Mishra *et al.* (2016); Singh *et al.* (2008). More vegetative growth in crop with unite application of chemical fertilizers and bio fertilizers are because of high soil fertility, greater attainability and uptake of nutrients like (N, P, and K). This leads to more vegetative growth in field pea. Along with it the bio fertilizer like *Rhizobium* also fix nitrogen. In study it was found that combined application of nutrients also increased significantly with number and dry weight of nodules plant[1] at flowering stages (Table 1). The data revealed that full dose of fertilizer along with inoculation of *Rhizobium* and PSB showed maximum number and dry weight of nodules of roots per plant at 90 days after sowing (38.3 and 0.84 g) respectively. Number and dry weight of nodules were increased significantly with integrated application which is due to Rhizobium and PSB. These bio fertilizers are needed for proper functioning of bacteria like nitrogen fixing and made an optimum effect on number and weight of effective nodule formation on the plant root system.The application of all fertilizers and biofertilzers increases the number with dry weight of nodules per crop which can be observed at flowering stage. The nodulation was declined after the vegetative stage because of increment of nitrogenase activity at flowering stage. *Rhizobium* and PSB play vital role in activity of nodule by the formation and accessibility of Adenosine Triphosphate (ATP) Bhat *et al.*,(2013). The impact of different bio inoculations on the quantity and dry weight of nodules per plant similarly supported Martins *et al.* (2002) findings. The significant increase with application of 100% RDF +Rhizobium + PSB on the root nodules dry weight of plant' was 0.84g at flowering stage over control. However, the application of NPK 100% RDF+ PSB (36 and 0.80g) alone remained par but significantly superior over control. Arif *et al*. (2014) noted that the combined use of phosphorous and inoculants enhances the number of nodules plant^{-1}. This is attributed to an increased number of Rhizobia and PSB in the rhizosphere due to inoculation, which synergistically increased the number and dry weight of the plant (Tiwari *et al*., 2007).

Attributes of yield like number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, and 100-seed weight were impacted by the recommended dose of fertilizer and seed inoculation (Table 2). 100 percent of NPK and combined inoculation of *Rhizobium* + PSB recorded the highest number of pods plant^{-1} (16.7), seeds pod^{-1} (9.8), length of a pod (10.5 cm), and 100-seed weight (18g) at harvest as compared to

Table 1. Effect of the recommended dose of fertilizers and biofertilizers on growth attributes of field Pea

Treatments	Plant height (cm) at harvest	No. of leaves plant^{-1} at harvest	No. of branches plant^{-1} at harvest	Nodule at 60DAS	Nodule dry weight (g) at 60 DAS	CGR at 90 DAS	LAI at harvest	Chlorophyll content
T1	53.4	65.1	27.8	15.33	0.44	0.24	15.6	47.5
T2	61.4	80.3	40.3	32.67	0.75	0.36	28.9	57.1
T3	56.4	71.9	32.9	22.33	0.47	0.28	18.8	50.5
T4	59.1	74.1	35.6	25.67	0.51	0.29	22.3	52.9
T5	62.1	81.8	41.8	33.67	0.76	0.38	29.7	58.2
T6	64.1	84.1	43.2	36.00	0.80	0.41	30.4	62.0
T7	66.9	87.4	44.5	38.33	0.84	0.45	32.9	63.2

Table 2. Effect of the recommended dose of fertilizers and biofertilizers on yield attributes of field pea

Treatments	Number of pods	Number of seeds per pod	Pod length (cm)	100 seed weight	Grain yield (qt)	Harvest index (%)
T1	8.8	6.3	6.8	10.90	11.4	35.35
T2	14.4	8.7	9.5	15.30	27.0	42.14
T3	10.9	7.0	7.3	12.13	14.1	38.22
T4	11.8	7.9	7.7	13.02	16.7	40.58
T5	14.8	8.9	9.9	15.99	28.2	42.84
T6	15.6	9.0	10.0	17.03	33.0	45.19
T7	16.7	9.8	10.5	18.00	34.6	45.62

100% RDF+PSB, which is par with NPK 100%RDF + *Rhizobium* + PSB, but significantly superior over control and rhizobium or PSB respectively. Similar findings were obtained by Bhat *et al.* (2013) who stated that recommended dose of phosphorus and seed inoculation with *Rhizobium* + PSB resulted in the highest yield attributes. 100 percent recommended dose of NPK with alone inoculation of *Rhizobium* recorded the highest number of pods plant^{-1} (14.8), seeds pod^{-1} (8.9), length of a pod (9.9 cm), and 100-seed weight (15.99g) respectively at harvest as compared to NPK 100%RDF, which is par with NPK, NPK 100% RDF + *Rhizobium*, but significantly superior over control and *Rhizobium* or PSB. It could be attributed to greater nutrient availability at crucial growth stages, which permitted higher crop growth,

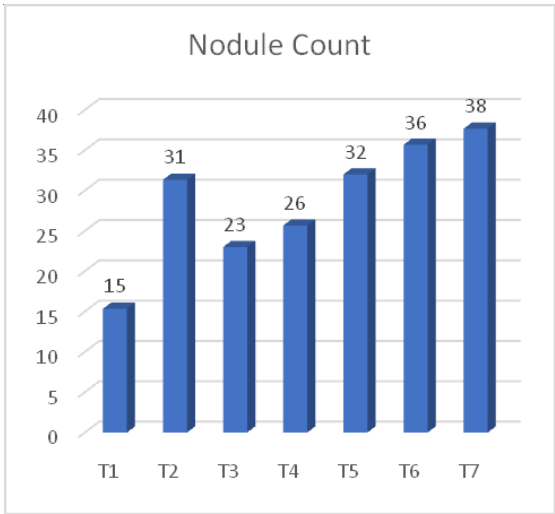

Fig. 1. Nodule count

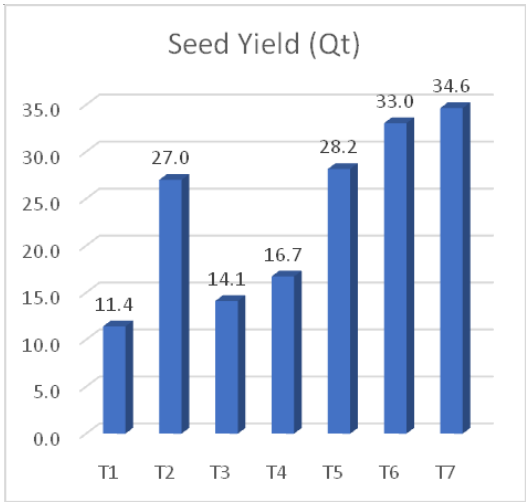

Fig. 2. Seed Yield in Quintal

yield characteristics, and further nutrient translocation that ultimately affects pod formation which results in increase of seed per pod and seed test weight. Similar results were obtained by Qureshi *et al.* (2015) and Pandey *et al.* (2002). Seed inoculation by PSB alone remained significantly superior over the control and it raises the harvest index as compared to control. The application of 100% RDF with inoculation of *Rhizobium* + PSB recorded a maximum harvest index (45.19%). The remarkable improvement in attributes of yield, seed yield, stover yield, and harvest index due to the integrated use of chemical fertilizers and bio-fertilizers could be predicted to high and balanced availability of N, P_2O_5, and K_2O. Same findings were obtained by Rudresh *et al.* (2005) stated that combined application of Nitrogen and phosphorous with inoculation of *Rhizobium* and PSB recorded the highest seed yield plant^{-1}. The results are in line with the findings of Shamad *et al*. (2019), and Rather *et al*. (2010) inpea. An adequate supply of NPK along with biofertilizers plays a crucial role in the process of photosynthesis, hence improving the number of pods plant^{-1}, seeds pod^{-1}, length of pod, and test weight. Higher values of the harvest index recorded with NPK 100% RDF and combined inoculation of bio fertilizers results the production of more photosynthates Martin *et al.* (2002).

Conclusion

Integrated use of bio fertilizer and chemical fertilizers gave the highest value of growth and yield attributing characters over control. When only chemical fertilizers were used for plants, they gave higher performance than only with biofertilizers. However, the combination of Biofertilizer and chemical fertilizer showed higher yield performances. It can be concluded that integrated management with 100% RDF application and usage of both *Rhizobium* + PSB is an effective way to increase field pea (*Pisum sativum* L.) production to achieve the greatest grain yield and profit.

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