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Study on Growth, Yield and Quality of Pea under the Influence of Different Combinations of Biofertilizers and Organic Manures

Himani Rawat [a*], K.C. Singh [b] and S.C. Pant [c]

[a] *Department of Vegetable Science, College of Horticulture, VCSGUUHF, Uttarakhand, India.*
[b] *Department of NRM, College of Horticulture, VCSGUUHF, Uttarakhand, India.*
[c] *Department of Crop Improvement, College of Horticulture, VCSGUUHF, Uttarakhand, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Pea (*Pisum sativum*) belongs to group of the legume family (Fabaceae). The immature green seeds are eaten raw, cooked, dehydrated, or as the main ingredient in frozen vegetable dishes. The present investigation was carried out at Vegetable Research & Demonstration Block, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar Pauri Garhwal during Rabi season (2023-2024) to access the performance of pea to different organic cultivation practices. The experiment was laid out in Randomized Complete block Design (RCBD) with 13 treatments and 3 replications. The treatments were a combination of different doses of biofertilizers i.e. (*Rhizobium leguminosarum*) and PSB along with application of organic manures (FYM,

Corresponding author: E-mail: himani26rawat@gmail.com;

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Vermicompost and Compost). Parameters like germination (93.333 %), plant height (67.813 cm), leaf count (60.333), RLWC % (80.963 %), number of cluster/plant (13.633), number of root nodules (27.433), root active nodules (14.217), pod length (10.267 cm), pod yield/plant (77.230), seed yield/plant (60.760 g), shelling percentage (48.920 %) and 100 seed weight (46.470 g), TSS (14.0 °Brix) and Ascorbic acid (25 mg/100g) also found highest in T_9. The data depicted best results in T_9 for all the treatments which was found statistically at par with T_5. But considering economic point of view Cost benefit ratio (1:1.73) was found to be maximum under treatment T_5 [*Rhizobium leguminosarum* (20ml) + PSB (20ml) +FYM (10 t/ha)] and should be recommended to the farmers as for deriving maximum profit for organic cultivation of pea. Therefore, the current study concludes that organic sources of nutrients are more environment friendly and sustainable than chemical fertilizers. They also have an advantage over inorganic synthetic fertilizers, which pollute the environment and may accumulate in the soil and lead to health risk of living surrounding beings.

Keywords: Pea; FYM; rhizobium; PSB; yield; quality.

1. INTRODUCTION

The most significant vegetable crop among legumes, garden peas (*Pisum sativum* L.) have a long history of domestication and are cultivated all over the world as a valuable export oriented cash crop (Devi et al., 2023). It is a diploid (2n=14), short-duration and cleistogamous crop belonging to the family Fabaceae. The young green seeds can be consumed raw, cooked, dehydrated or as the main ingredient in frozen vegetable recipes. It is one of the top ten vegetable crops and one of the most significant vegetable globally. There are two subspecies of pea: garden pea (*Pisum sativum* var. hortense) and field pea (*Pisum sativum* var. arvense), which are used in a variety of food processing sectors and can be eaten as a pulse or as a raw vegetable (Mohan et al., 2011).

Pea is a native of South West Asia and is widely grown in temperate countries like USA, China, France, Holland and Hungary. Cool climates with cardinal temperatures between 10-18° degrees Celsius are ideal for pea growth. (Kumar and Choudhary, 2014). In India, it is grown as a winter vegetable in the plains of North India and as summer vegetable in the hills. Pea may be cultivated in nearly all kind of soils that has sufficient drainage. The ideal pH range for pea cultivation is between 5.5 to 6.5 for silt loam and clay loam. (Srivastava et al., 2020).

Garden peas are highly nutritive and rich source of protein, sugar, carbohydrates, vitamins and minerals. It is used as vegetable in the form of cooked, soup, canned, frozen or dehydrated. It is an important off- season cash crop besides having ecological advantage due to fixation of atmospheric nitrogen through root nodules. The stovers are used as fodder. 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, 13 mg phosphorous, 0.23 mg copper, 1.5 mg iron, 0.01 mg riboflavin, 0.8 mg nicotinic acid and 9.0 mg vitamin C per 100g of edible portion (Khichi et al*.,* 2016) and (Sepehya et al., 2015).

The extensive use of chemical fertilizers leaves toxic residues that have a devastating long-term impact on the health of humans, animals, and soil and utilization of these artificial inputs has resulted in a decline in soil fertility, soil microbiological activity, and crop nutritional status (Shukla et al., 2022). Adding organic sources like FYM, compost, vermicompost, etc. has made it possible to reduce the usage of chemical fertilizers in order to maintain a healthy and sustainable agro-ecosystem. A judicious use of organic manures and biofertilizers may be effective not only sustaining crop productivity and in soil health, but also in supplementing chemical fertilizers of crop (Jaipaul et al., 2011). They fix nitrogen from the atmosphere and mobilize different micro and macronutrients in the soil, increasing their availability and effectiveness. (Kaushal and Kukreja, 2020). There are several reports, which show that the combined and sole application of organic manures and biofertilizers increase the yield and quality attributes in vegetables (Rather et al., 2010).

2. MATERIALS AND METHODS

The experiment was conducted at Vegetable Demonstration Block, College of Horticulture, Veer Chandra Singh Garhwali, Uttarakhand University of Horticulture and Forestry, Bharsar, District Pauri Garhwal, Uttarakhand, Pauri Garhwal is one of the thirteen districts of Uttarakhand and is located between 29° 20' –

29° 75' N latitude and 75° 10' – 78° 80' E longitude. Bharsar is situated at about 57 km from the district headquarter of Pauri Garhwal, situated at an altitude of about 1900 meters above mean sea level. The meaning of Bharsar in local dialect is flourished with natural wealth. Since the ancient time it is famous for its vast reserve of biodiversity and geographically the temperature, climate conditions of the region are quite congenial for the horticulture. The farm area falls in the high mid zone of Uttarakhand (Bisht and Sharma, 2014). Before laying out the experiment random sample was collected from the different spots with the help of khurpi in 'V' shaped manner from the furrow slice (0-15 cm depth) of each plots from which a composite sample was prepared for the determination of different soil characteristics. The entire analysis of soil was carried out in the laboratory of Natural Resource Management College of Horticulture, VCSG UUHF, Bharsar, Pauri Garhwal, Uttarakhand.

The present experiment comprised of 13 treatments, which were carried out in a randomized complete block design along with 3 replications. The details of experimental site and materials used in the present study are presented in Table 1 and 2. Cultivar "Arkel" of garden pea was selected for the present study. The cultivar has recommended for different agro-climatic zones. Seeds of Garden Pea were obtained from the "Uttrakhand beej Bhandar store" market of Dehradun. Different organic inputs were used in the experiment viz., FYM, Vermicompost, Compost and *Rhizobium leguminosarum*. FYM was obtained through Organic Block, College of Horticulture, Veer Chandra Singh Garhwali, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal (Uttarakhand). The Vermicompost, Compost and *Rhizobium leguminosarum*, PSB were obtained from the "Uttrakhand beej Bhandar store" market of Dehradun.

The experimental field was once ploughed by power tiller. The clods were crushed and weeds were removed manually. The land was divided into 39 plots of required size (1m×0.6 m). After preparation of experimental plots each of the plots was tagged according to the layout and different treatments were applied. Garden pea was normally sown directly by scattering the seeds along drill at a depth of 3-5cm and spacing of 30cm × 10cm and cover with soil using a rake after sowing. Before dibbling the seeds were treated with *Rhizobium leguminosarum* and Phosphate solubilizing bacteria (PSB) culture as per treatments. 100g of Jaggery was dissolved in 100ml of warm water. Seeds were soaked in Jaggery solution for 15-20 minutes and seeds were dried under shade. Thereafter, these seeds were coated with *Rhizobium leguminosarum* culture with different concentration and Phosphate Solubilizing Bacteria with different concentration and with mixed culture of *Rhizobium leguminosarum* and Phosphate Solubilizing Bacteria as per the treatments. Treated seeds were dried in shade before planting. Data were collected on different growth, yield and quality contributing characters. Five plants were selected randomly and tagged for identification. The plants in the outer rows and at extreme end of the middle rows were excluded from the random selection top avoid the border effect. The following observations were made regarding plant growth, yield and quality contributing characters as affected by different types of biofertilizers and organic manures. The following parameters were recorded:

2.1 Observations Recorded

Data were collected on different growth, yield and quality contributing characters. Five plants were selected randomly and tagged for identification. The plants in the outer rows and at extreme end of the middle rows were excluded from the random selection top avoid the border effect. The following observations were made regarding plant growth, yield and quality contributing characters as affected by different types of biofertilizers and organic manures. The following parameters were recorded:

2.2 Growth Parameters

Germination (%): number of seedlings germinated from the plot were counted from date of sowing and expressed in per cent.

Plant height (cm): The height of the plant was measured from the ground level to the maximum apical bud (top most leaf) with the help of meter scale from the 5 tagged plants at 15, 30,45,65 and 90 days interval till the harvesting done and average plant height was expressed in centimeter.

Number of leaves per plant: The number of leaves was counted from the 5 tagged plants at 15,30,45,65and90 days interval till the harvesting done and expressed as average number of leaves per plant.

RLWC (%): The RLWC was estimated by the method of Barrs and Weatherly (1962). Ten leaf discs were collected randomly in each treatment label and were wrapped immediately in aluminum foil, put in a plastic bag and kept in a cool place, weighed accurately upto third decimal on a single pan analytical balance. This was considered as fresh weight (FW). The weighed leaf discs were allowed to float on distilled water in a petridish and allowed to absorb water for four hours. After four hours, the leaf discs were taken out and their surface was blotted gently and weighed. This was referred to as turgid weight (TW). After drying in box air oven at 60̊ C for 48 hours, the dry weight (DW) was recorded and RLWC %) was calculated by using the following formula:

$$RLWC = \frac{Fresh\ weight - dry\ weight}{Turgid\ weight - dry\ weight} \times 100$$

2.3 Number of Branches Per Plant

The number of branches per plant of tagged five plants were counted at maturity and mean value were expressed as number of branches per plant.

2.4 Number of Cluster Per Plant

Number of cluster per plant were recorded randomly from the tagged 5 plant and mean values were determined.

2.5 Days Taken for First Flowering

On the appearance of flower in 50% plant population in each plot, the date was noted and days taken for flowering were worked out from the sowing date.

2.6 Total Number of Nodules Per Plant

The total and effective number of nodules per plant was counted at 60 DAS. Five plants were selected randomly in sample rows of each plot and uprooted carefully. The soil mass embedding the roots of the plant was washed off with water and total nodules were counted to record average number of nodules per plant.

2.7 Root Active Nodules

Effective number of nodules was counted from same plant as taken for total number of nodules. Healthy, pink colored nodules were counted and mean value recorded as effective number of nodules.

2.8 Fresh Weight of Nodules

From the 5 sample plants after removing the roots the nodules were washed with clean water to remove all the soil particles and air dried. The fresh weight of nodules were taken with the help of a weighing balance and average value was taken and expressed as mg /plant.

2.9 Dry Weight of Root Nodules

The nodules were shade dried for an hour and later dried at 60°C in the oven till the constant dry weight was obtained. The final dry weight was recorded using electronic weighing balance and the average value was expressed as mg /plant.

2.10 Pod Length (cm)

Fresh 5 pod were selected after harvesting and the pod length was measured using measuring scale. The mean value was calculated and expressed in centimeter (cm).

2.11 Pod Girth (cm)

Fresh 5 pods were selected after harvesting and the pod girth was measured at the centre of the fruit by using Vernier calliper. The mean value was calculated and expressed in centimeter.

2.12 Yield Parameters

2.12.1 Number of pods/plants

In each net plot, the pods borne by the randomly selected five plants were counted at each picking. The average number of pods per plant per plant was obtained by dividing the total number of pods by five.

2.12.2 Number of seeds/pods

At the time of picking five whole pods were taken out randomly. The pods were shelled for counting the seeds per pod. The seeds per pod were determined by dividing the total number of seeds with corresponding number of pods.

2.12.3 Pod yield/ plant (g)

Mean weight of pod from five selected plants from each plot was measured in gram.

2.12.4 Pod yield/plot (kg/0.6m2)

The weight of pods was recorded for each picking in each plot and summed up to determine the total pod yield per plot in kilograms for all the treatment combinations in all replications.

2.12.5 Seed yield/plant (g)

Five randomly selected plant from each plot were harvested then weighed and average seed yield per plot was recorded for each treatment.

2.12.6 Seed yield/plot (kg/0.6m2)

The weight of seeds was recorded for each picking in each plot and summed up to determine the total seed yield per plot in kilograms for all the treatment combinations in all replications.

2.12.7 Shelling (%)

Shelling percent in each treatment in each replication were recorded out by given formula:

$$Shelling\ per\ cent = \frac{Weight\ of\ green\ seeds\ from\ 20\ pods}{Weight\ of\ 20\ pods} \times 100$$

2.12.8 100 seed weight (g)

A random sample of 100 seeds from each treatment was weighed to work out 100 seed weight in grams for all the treatment combinations in all replications.

2.13 Quality Parameters

2.13.1 Total soluble solids (°Brix)

Total soluble solids of the fruit was recorded with the help Erma off hand Refractometer (range 0-32°Brix) and the values were correlated to the room temperature using suitable correction factor. Five fully ripened fruits were picked at random from each treatment in a replication and TSS was determined, mean values were adopted for comparison.

2.13.2 Ascorbic acid (mg/100 g)

Ascorbic content in pea was determined as per standard AOAC method (AOAC, 1995) using 2,6 -dichlorophenol indophenol dye. A known volume of the sample extracted in 3% meta phosphoric acid was titrated with the dye to an end point of pink color. Results were expressed as mg per 100 g of sample and calculated by using the following formula:

$$Ascorbic\ acid\ (mg/100g) = \frac{Titrate\ value \times dye\ factor \times volume\ made\ up}{aliquot\ of\ extract\ taken \times weight\ of\ soil\ sample} \times 100$$

2.13.3 Starch content (%)

The starch was extracted from pea using water steeping method. In this method, 50g of pea seeds were crushed with the help of mortar and pestle, followed by blending with water (1:2 w/v) in a blender. The slurry was agitated for 90 min at 200 rpm, followed by sieving consecutively through 150 um and 80 um pore size sieves. The residual flesh on the sieves was further washed with water to drag the remaining starch. The filtrate was left for 24 hour at 4°C to allow the starch sedimentation. The starch was separated by decantation and washed twice with water. Finally, the NS was dried in a hot air oven at 40 °C for 48 h. The dried starch was stored in zip-lock bags for further analysis (Ali et al. 2023).

2.13.4 Dry matter content (%)

Random sample of hundred grams of green seeds were taken from each plot and each sample was dried in an oven at 60 °C till constant weight. The dry weight of the seed expressed as percentage of corresponding fresh weight.

$$Dry\ matter\ content\ (\%) = \frac{dry\ weight}{fresh\ weight} \times 100$$

2.14 Statistical Analysis

Statistical analysis was performed on the observations collected for various characters. The data were analysed using the analysis of variance technique for Randomized Block Design with three replications (Gomez and Gomez, 1984). The significance of variance among treatments was determined using the Analysis of Variance (ANOVA) and Critical Difference (C.D) tests at a 5% probability level.

3. RESULTS AND DISCUSSION

The result involved in present study recorded maximum germination per cent (93.333%) in treatment T_9. However, treatment T_1 Control (Untreated) had the lowest germination per cent (71.667). *Rhizobium leguminosarum* strains secrete growth hormones like Indole acetic acid (IAA), which shows positive influence on plant growth and also plays an important role in the formation and development of root nodules. The results are in strong conformity with the Anandrao and Arshiya (2022) in certain leguminous plant including pea, Sneka et al. (2022) in green gram and Mandale et al*.* (2021) in mung bean.

Fastest days taken to initial germination (6.667) was recorded in treatment T_9, similar in T_8 (6.667) and T_5 (6.667). On the other hand, treatment T_1 Control (Untreated) exhibited the most delayed initial germination (9.000). It might be due to organic nutrient sources which are rich in humus, gibberellins, and humic acids in vermicompost hence enable nitrogen fixation by microbes, microbial decomposition regulates nitrogen supply to the plants which created better condition. These favorable conditions seemed to have created better nutrient absorption and favors faster and better germination, growth and development of root system which in true reflects of better vegetative growth and photosthetic activity. Biofertilizers and organic manure also improved the water holding capacity of soil and moisture helps in germination rapid cell elongation leading to longer root formulation. Similar results have been reported by Chauhan et al. (2010) in pea and Shalu and Rattan (2023) in pea.

The tallest plant height 30.120 cm, 49.010 cm, 58.680 cm, 67.813 cm at 45, 60, 75 and 90 DAS observed was in treatment T_9 except at 15 and 30 DAS the tallest plant height (6.687 cm and 16.237 cm) was recorded in T_5 and T_8. Similar finding were also recorded by Bunker et al. (2022) in garden pea and Siddiqui and Debbarma (2022) in pea.

The highest number of leaf 45, 60, 75 and 95 DAS, respectively except at 15 and 30 DAS where the highest number of leaf count i.e., (10.267 and 20.100) was recorded in T_{13} and T_5. observing (10.267, 20.100). Similar results were observed by Negi et al. (2006) in garden pea who noticed increased plant height with co-inoculation of biofertlizers viz., *Rhizobium* and PSB. Similar results have been reported by Verma et al*.* (2019) in chickpea.

The highest leaf area index 0.2.317, 3.553, 4.310 and 4.357 at 45, 60, 75 and 90 DAS observed under T_9 and 0.560, 0.787 at 15 and 30 DAS observed in T_5. Similar results have been reported by Samsurahman et al. (2021) in mung bean and Verma et al*.* (2019) in chickpea.

The RLWC values 78.987 %, 78.503 % and 80.63 % at 30, 60 and 90 DAS was found to be highest under T_9. At the harvest maximum number of branches (3.567) was recorded in treatment T_5. Similar results were also obtained Kazeminasab et al. (2016) in lemon balm and Hafez et al. (2020) in wheat.

At the harvest maximum number of branches (3.567) was recorded in treatment T_5 which was found statistically at par with treatment T_9 (3.533, T_8 (3.500), T_{13} (3.400), T_4 (3.367), T_7 (3.333), T_3 (3.333) and T_{12} (3.267) respectively. While, the minimum number of branches (2.633) was recorded with treatment T_1 Control (Untreated). Lakshmipathy et al. (2011) in cluster bean, who reported that number of branches per plant was significantly increased with the application of FYM + *Rhizobium* + PSB inoculation as compare to un-inoculated one.

Maximum number of cluster per plant (13.633) was recorded with treatment T_9 which was found statistically at par with treatment T_5 (13.427), T_4 (13.100), T_{13} (13.067), T_7 (12.713), T_3 (12.713) and T_{12} (12.763) respectively. However, minimum number of cluster (9.667) with treatment T_1 Control (Untreated). Similar results have been recorded by Ramana et al. (2010) in French bean, Chauhan et al. (2016) in cowpea.

Among different treatments fastest flowering (45.333) was noticed in treatment T_5 and it was found statistically at par with treatment T_9 (45.667), T_8 (46.000) T_4 (46.333) and T_{13} (46.667) respectively. On the other hand, delayed flowering (49.667) was recorded in treatment T_1 Control (Untreated) Similar results were reported by Kothyari et al. (2017) in pea Soniya et al. (2023) in pea.

Highest number of root nodules (27.433), root active nodules (14.217), maximum fresh weight (1,257.807 mg) and dry weight (146.467 mg) of root nodules observed under treatment T_9. Similar results were noticed by Negi et al. (2006) in garden pea who reported that number of root nodules increased with the application of biofertilizers viz., *Rhizobium* and PSB. Lakshmipathy et al. (2017) in cluster bean reported increase in root nodules per plant with organic manure and biofertilizers viz., *Rhizobium* and PSB.

The longest pod length (10.267 cm) was observed in T_9 which was found statistically at par with T_5 (10.030 cm).Where, the shortest pod length (6.820 cm) was obtained from the treatment T_1 Control (Untreated). Similar finding were noticed by Teli et al. (2016), in pea, Khan et al. (2017) in pea.

Pod girth was affected significantly by different combinations of biofertilizers and organic manures. The highest pod girth (1.477cm) was observed in T_5 (which was found statistically at par with T_9 (1.463 cm), T_8 (1.440 cm) and T_{13} (1.433 cm) and T_4 (1.463 cm) respectively. However, the shortest pod girth (1.190 cm) was obtained under the treatment T_1 Control (Untreated). The accumulation of carbohydrates and increase in metabolic activities gives better vegetative growth which leads to manufacture of food materials, which are then translocated to the developing pod and ultimately led to increase in diameter of pod. The result are in strong conformity with Gupta et al. (2017) in pea and Bhutia et al. (2019) in pea.

The maximum number of pods per plant (16.167) was observed in T_8 and it was found statistically at par with T_9 (16.133), T_5 (16.067) respectively. Similar results were also reported by Harireddy and Dawson (2021) in cowpea and Pandey et al. (2017) in field pea.

The highest number of seeds per pod (9.667) was observed in T_9 and it was found statistically at par with T_5 (9.467) and T_{13} (9.367) respectively. Increase in number of seeds per pod might be due to application of *Rhizobium*, Phosphate Solubilizing Bacteria and FYM that enhanced the availability of nutrients in soil, which in turn encouraged more vegetative growth, metabolic activities and chlorophyll content and increased accumulation of more amounts of carbohydrates in the pods and thereby increasing the number of seeds per pod. Similar results were observed by Meena et al. (2014) in cowpea.

The maximum pod yield per plant (77.230g) observed in T_9 (and it was statistically at par with treatment T_5 (75.703 g) and T_{13} (74.657 g). All the treatments were found statistically significant as compared to T_1 Control (Untreated). These results are in line with the finding of Lakshmipathy et al. (2017) in cluster bean and Ram et al (2021) in pea.

The highest pod yield per plot (1.400 kg/0.6m^2), was recorded in T_9 and it was statistically at par with treatment T_5 (1.363 kg/0.6m^2). Composite inoculation with Bacteria might have increased the growth, yield attributes and ultimately the yield, due to increased nitrogenase activity and available phosphorus status in soil as reported by Negi et al. (2006) in garden pea. Similar finding were also reported by Jaipaul et al. (2011) in pea and Bunker et al. (2018) in pea.

The highest seed yield per plant (60.760 g) was recorded in T_9 which was statistically at par with T_5 (60.557 g) and T_{13} (59.157 g) respectively. While, the lowest seed yield per plant (41.560 g) was observed in treatment T_1 Control (Untreated). The increase in seed yield is due to more availability of nutrients, which in turn encourages more vegetative growth metabolic activities and chlorophyll content thereby increasing the number of seeds per pod. Similar results were reported by Reeturaj and Chil (2021) in cowpea.

The highest seed yield per plot (1.133 kg), was observed in T_9 which was statistically at par with T_5 (1.110 kg/0.6m^2), seed yield per hectare (18.478 tonnes /ha). Rapid synthesis and translocation of photosynthates from source (leaves) to sink (roots) might have contributed to increase fresh weight and dry weight of root. Similar results were reported by Ganesh et al. (2021) in cowpea and Mohanty et al. (2017) in French bean.

The maximum shelling percent was recorded (48.920%) in T_9 and it was statistically at par with treatment T_5 (47.683 %), T_8 (46.697 %) and T_{13} (46.137 %) respectively. The minimum shelling percent (40.177%) was observed in the treatment T_1 Control (Untreated). These results are in conformity with the findings of Singh et al. (2019) who reported maximum shelling per cent with the application of *Rhizobium* in garden pea. Similar results were reported by Rajput et al. (2022 and Shalu and Rattan (2023) in pea.

The maximum 100g seed weight (46.470g) was observed in T_9 and it was statistically at par with treatment T_5 (45.457 g). The similar results are in Shah and Kataria (2019) in soyabean and Gaharwar et al. (2023) in pea.

Table 1. Detail of experimental site conducted during December, 2023 – March, 2024

Crop	Garden Pea
Variety	Arkel
Experimental site	Vegetable Demonstration Block, CoH, Bharsar
Growing condition	Natural ventilated polyhouse condition
Design	Randomized complete Block Design (RCBD)
Number of Replications	03
Number of Treatments	13
Number of plots	39
Spacing	30 cm × 10 cm
Plot size	1 m × 0.6m
Number of plants/ plots	20
Total number of plants	780
Area of one plot	0.6 m^2
Net experimental area	23.4 m^2

Table 2. Details of treatments

Treatment	Treatment details
T_1	Control
T_2	*Rhizobium leguminosarum*(5ml)+ PSB (5ml) + FYM (10 t/ha)
T_3	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + FYM (10 t/ha)
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)
T_5	*Rhizobium leguminosarum* (20ml)+ PSB(20ml) +FYM (10 t/ha)
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)
T_7	*Rhizobium leguminosarum* (10ml)+ PSB(10ml) +Vermicompost (10 t/ha)
T_8	*Rhizobium leguminosarum*(15ml)+ PSB (15ml) + Vermicompost (10 t/ha)
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5 ml) +Compost (10 t/ha)
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) +Compost (10 t/ha)
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)

The highest TSS (15.083°Brix) was recorded in the treatment T_9 and it was found statistically at par with T_{13} (14.707 °Brix) and T_5 (14.630 °Brix). The lowest TSS (10.433°Brix) was recorded in T_1 Control (Untreated). Similar finding were reported by and Sangma et al. (2018) and Kumari et al. (2023) in pea.

The maximum ascorbic acid (34.387mg/100g) was recorded in the treatment T_9 and it was found statistically at par with T_{12} (33.863mg/100g), T_4 (33.743mg/100g) and T_8 (32.683 mg/100g).While, the minimum ascorbic acid (28.783 mg/100g) was recorded in T1 Control (Untreated). Increase in ascorbic acid might be due to the availability of nitrogen leading to balanced C: N ratio enhancing the vegetative growth resulting in high photosynthetic activity Vermicompost 10 t/ha). While, the minimum ascorbic acid (10.433) was recorded in T_1 Control (Untreated). These results are in conformity with the result obtained and. (Gayathri and Krishnaveni (2015) in okra and Verma et al. (2024) in pea and garlic.

The highest starch content (25.445 %) was recorded in the treatment T_8 and it was found statistically at par with T_{12} (25.287 %) and T_3 (24.363 %). However, the lowest starch content (21.110) was recorded in T1 Control (Untreated). These results are in conformity with the result obtained by Sepheya et al. (2015) in pea.

The highest dry matter content of seed (30.487%) was observed in T_{10} (*Rhizobium leguminosarum* (5ml) + PSB (5 ml) +Compost (10 t/ha) and found statistically at par with T_4 (30.433 %), T_5 (30.270 %), T_8 (30.070%), T_3 (29.427%), T_6 (29.103%),T_7 (30.070)and T_{13} (29.303 %). While, the lowest dry matter content of seed (28.133 %) was observed from T_5. These results are conformity with the result obtained by Chauhan et al. (2023) in pea.

Table 3. Influence of different combinations of biofertilizers and organic manures on Germination per cent (%) and number of days taken to initial germination

Treatment	Treatment details	Germination Percent ±S.E	No of days taken to initial germination ±S.E
T_1	Control	71.667 ±1.667	9.000± 0.577
T_2	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + FYM (10 t/ha)	83.333*±3.333	7.667* ±0.333
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	85.000*±2.887	7.333* ±0.333
T_4	*Rhizobium leguminosarum* (15ml) + PSB (15ml) + FYM (10 t/ha)	88.333*±1.667	7.333*±0.333
T_5	*Rhizobium leguminosarum* (20ml) + PSB (20ml) + FYM (10 t/ha)	91.667*±1.667	6.667*±0.333
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	85.000*±2.887	7.333*±0.333
T_7	*Rhizobium leguminosarum* (10ml) + PSB(10ml) + Vermicompost (10 t/ha)	86.667*±1.667	7.000* ±0.577
T_8	*Rhizobium leguminosarum* (15ml) + PSB (15ml) + Vermicompost (10 t/ha)	88.333*±1.667	6.667*±0.333
T_9	*Rhizobium leguminosarum* (20ml) + PSB (20ml)+ Vermicompost (10 t/ha)	93.333*±1.667	6.667*±0.333
T_{10}	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Compost (10 t/ha)	83.333*±3.333	7.000*±0.577
T_{11}	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) + Compost (10 t/ha)	81.667±3.333	7.667*±0.333
T_{12}	*Rhizobiumleguminosarum* (15ml) + PSB (15ml) + Compost (10 t/ha)	86.667*±3.333	7.333*±0.333
T_{13}	*Rhizobium leguminosarum* (20ml)+ PSB (20 ml) + Compost (10 t/ha)	88.333*±4.410	7.000*±0.577
	S.E(d)	3.307	0.561
	$C.D_{(0.05)}$	6.865	1.165

Table 4. Influence of different combinations of biofertilizers and organic manures on plant height (cm) at different time interval

Treatments		Plant height (cm) ±S.E					
		15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**
T_1	Control	3.013±0.338	9.760±0.086	21.727±0.777	41.533±0.786	46.197±0.381	54.633±1.217
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	4.473*±0.324	13.027*±0.315	23.703±0.922	44.463*±0.515	52.543*±0.138	60.423*±0.547
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	4.563*±0.313	14.237*±0.532	25.363*±0.103	45.123*±0.951	54.020*±0.365	62.800*±0.361
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	4.723*±0.451	15.400*±0.934	28.490*±0.644	46.607*±1.191	54.930*±0.470	64.230±0.416
T_5	*Rhizobium leguminosarum* (20ml) + PSB (20ml) + FYM (10 t/ha)	6.687*±0.631	16.090*±0.059	29.663*±0.602	48.250*±0.616	58.113*±0.412	66.823*±0.742
T_6	*Rhizobium leguminosarum* (5 ml) + PSB (5ml) + Vermicompost (10 t/ha)	5.113*±0.561	13.050*±0.257	24.283*±0.419	46.153*±0.467	52.713*±0.127	61.783*±1.117
T_7	*Rhizobium leguminosarum* (10ml) + PSB (10ml) +Vermicompost (10 t/ha)	4.967*±0.355	14.287*±0.394	27.763*±0.805	46.520*±1.121	54.123*±0.354	63.347*±0.676
T_8	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Vermicompost (10 t/ha)	5.860*±0.156	16.237*±0.540	28.530*±0.629	48.773*±0.632	55.163*±0.453	64.060*±0.331
T_9	*Rhizobium leguminosarum*(20ml) + PSB (20ml)+ Vermicompost (10 t/ha)	6.527*±0.518	16.053*±0.479	30.120*±0.741	49.010*±0.757	58.680*±0.130	67.813*±0.817
T_{10}	*Rhizobium leguminosarum*(5 ml) + PSB (5ml) + Compost (10 t/ha)	4.197*±0.724	13.083*±0.289	24.497*±1.225	44.153*±0.725	51.840*±0.687	60.007*±0.407
T_{11}	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + Compost (10 t/ha)	3.863*±0.398	14.183*±0.217	25.130*±0.755	44.770*±1.290	53.933*±0.335	62.710*±0.374
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) + Compost (10 t/ha)	4.517*±0.323	14.860*±0.360	26.197*±0.4*59	46.580*±0.601	54.827±0.544	64.693*±0.269
T_{13}	*Rhizobium leguminosarum*(20ml) + PSB (20ml) + Compost (10 t/ha)	6.430*±0.377	15.800*±0.379	28.323*±0.549	47.193*±0.425	57.540*±0.653	65.960*±1.017
	S.E(d)	0.413	0.511	1.016	1.075	0.486	0.823
	$C.D_{(0.05)}$	0.858	1.060	2.110	2.231	1.010	1.709

Table 5. Influence of different combinations of biofertilizers and organic manures on leaf area index at different time period

Treatments		Leaf area index ±S.E					
		15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**
T_1	Control	0.317±0.009	0.587±0.012	1.153±0.018	1.457±0.041	2.697±0.015	2.767±0.024
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	0.353*±0.009	0.637±0.019	1.197±0.023	1.847±0.026	3.140*±0.345	3.533*±0.290
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	0.397*±0.009	0.767*±0.015	1.283±0.023	2.447*±0.048	3.183*±0.359	3.753*±0.094
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	0.393*±0.018	0.787*±0.018	1.387±0.023	2.730*±0.386	3.620*±0.012	3.657*±0.020
T_5	*Rhizobium leguminosarum* (20ml) + PSB (20ml) +FYM (10 t/ha)	0.560*±0.012	0.950*±0.020	2.267*±0.121	3.410*±0.015	4.280*±0.012	4.307*±0.018
T_6	*Rhizobium leguminosarum* (5 ml) + PSB (5ml) + Vermicompost (10 t/ha)	0.480*±0.012	0.767*±0.033	1.417±0.009	2.073*±0.349	2.883±0.009	3.120*±0.026
T_7	*Rhizobium leguminosarum* (10ml) + PSB (10ml) +Vermicompost (10 t/ha)	0.517*±0.015	0.853*±0.037	1.813*±0.343	2.560*±0.136	2.947±0.018	3.250*±0.021
T_8	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Vermicompost (10 t/ha)	0.550*±0.015	0.900*±0.030	1.943*±0.347	3.513*±0.01	3.637*±0.020	3.500*±0.115
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	0.553*±0.019	0.947*±0.015	2.317*±0.133	3.553*±0.018	4.310*±0.021	4.357*±0.018
T_{10}	*Rhizobium leguminosarum*(5 ml) + PSB (5 ml) +Compost (10 t/ha)	0.353*±0.015	0.603±0.015	1.173±0.035	1.707±0.023	2.777±0.015	3.827*±0.015
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)	0.387*±0.007	0.733*±0.015	1.203±0.017	2.180*±0.230	2.837±0.020	3.900*±0.017
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) +Compost (10 t/ha)	0.403*±0.024	0.697*±0.012	1.387±0.020	2.263*±0.257	3.583*±0.009	3.600*±0.012
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20ml) + Compost (10 t/ha)	0.427*±0.030	0.763*±0.012	1.750*±0.325	3.410*±0.015	4.240*±0.023	4.347*±0.018
	S.E(d)	0.015	0.026	0.236	0.243	0.187	0.133
	$C.D_{(0.05)}$	0.031	0.055	0.490	0.504	0.388	0.277

Table 6. Influence of different combinations of biofertilizers and organic manures on RLWC (%)

Treatments	Relative leaf water content (%) ±S.E			
	Treatment details	**At 30 DAS**	**At 60 DAS**	**At 90 DAS**
T_1	Control	62.543±1.183	66.467±0.579	66.613±1.250
T_2	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + FYM (10 t/ha)	66.033±1.924	70.500*±1.066	72.400*±1.098
T_3	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) + FYM (10 t/ha)	72.807*±1.462	72.257*±1.551	73.993*±0.918
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	71.817*±1.395	73.050*±1.556	74.767*±1.321
T_5	*Rhizobium leguminosarum* (20ml)+ PSB(20ml) +FYM (10 t/ha)	78.070*±2.278	77.627*±1.173	77.793*±1.386
T_6	*Rhizobium leguminosarum* (5 ml) + PSB (5ml) + Vermicompost (10 t/ha)	68.323*±1.705	70.653*±1.157	72.410*±1.111
T_7	*Rhizobium leguminosarum* (10ml)+ PSB(10ml) + Vermicompost (10t/ha)	70.333*±1.453	73.887*±1.024	76.080*±1.028
T_8	*Rhizobium leguminosarum* (15ml) + PSB (15ml) + Vermicompost (10 t/ha)	75.427*±1.188	76.300*±1.190	76.537*±1.191
T_9	*Rhizobium leguminosarum* (20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	78.987*±2.619	78.503*±1.796	80.963*±1.267
T_{10}	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Compost (10 t/ha)	64.600±1.249	66.400±0.488	68.013±0.888
T_{11}	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) + Compost (10 t/ha)	75.500*±0.604	69.580±0.511	70.037±1.389
T_{12}	*Rhizobiumleguminosarum* (15ml) + PSB (15ml) + Compost (10 t/ha)	70.610*±0.583	72.217*±0.993	71.970*±1.386
T_{13}	*Rhizobium leguminosarum* (20ml) + PSB (20ml) + Compost (10 t/ha)	74.737*±1.122	76.017*±1.524	77.897*±1.405
	S.E(d)	2.153	1.742	1.727
	$C.D_{(0.05)}$	4.470	3.617	3.586

Table 7. Influence of different combinations of biofertilizers and organic manures on number of branches, number of cluster and days taken to first flowering

Treatment	Treatment details	Number of branches per plant ±S.E	Number of cluster per plant ±S.E	Days taken to first flowering ±S.E
T_1	Control	2.633±0.285	9.667±0.291	49.667± 0.333
T_2	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + FYM (10 t/ha)	2.867±0.384	11.847*±0.439	48.000*±0.577
T_3	*Rhizobium leguminosarum* (10ml) + PSB (10ml) + FYM (10 t/ha)	3.267*±0.240	12.680*±0.591	47.667*±0.333
T_4	*Rhizobium leguminosarum* (15ml) + PSB (15ml) + FYM (10 t/ha)	3.367*±0.338	13.100*±0.379	46.333*±0.333
T_5	*Rhizobium leguminosarum* (20ml)+PSB(20ml) +FYM (10 t/ha)	3.567*±0.120	13.427*±0.757	45.333*±0.333
T_6	*Rhizobium leguminosarum* (5 ml) + PSB (5ml) + Vermicompost (10 t/ha)	3.233*±0.418	11.733*±0.533	47.333*±0.333
T_7	*Rhizobium leguminosarum* (10ml)+ PSB(10ml) +Vermicompost (10 t/ha)	3.333*±0.273	12.713±0.582	47.000*±0.577
T_8	*Rhizobium leguminosarum* (15ml)+ PSB (15ml) + Vermicompost (10 t/ha)	3.500*±0.153	13.277±0.357	46.000*±0.577
T_9	*Rhizobium leguminosarum* (20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	3.533*±0.167	13.633*±0.636	45.667*±0.667
T_{10}	*Rhizobium leguminosarum* (5ml) + PSB(5 ml) +Compost (10 t/ha)	2.900±0.351	11.697±0.353	48.333±0.667
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)	3.200*±0.306	11.730*±0.221	47.667*±0.333
T_{12}	*Rhizobiumleguminosarum* (15ml) + PSB (15ml) +Compost (10 t/ha)	3.250*±0.340	12.763*±0.739	47.000*±0.577
T_{13}	*Rhizobium leguminosarum* (20ml)+ PSB (20 ml) + Compost (10 t/ha)	3.400*±0.115	13.067*±0.219	46.667*±0.667
	S.E(d)	0.206	0.664	0.744
	$C.D_{(0.05)}$	0.428	1.378	1.546

Table 8. Influence of different combinations of biofertilizers and organic manures on total no of root nodules, root active nodules, fresh weight of root nodules (mg) and dry weight of root nodules (mg)

Treatment	Treatment details	Total no of root nodules ±S.E	Root active nodules±S.E	Fresh weight of nodules (mg) ±S.E	Dry weight of root nodules (mg) ±S.E
T_1	Control	19.167±1.129	10.333±0.882	537.050±0.647	118.827±0.612
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	23.057*±1.851	11.217±0.707	717.777*±1.417	134.480*±1.851
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	23.553*±1.25	11.243±0.338	817.143*±6.255	127.760*±2.344
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	25.310*±0.955	12.190*±0.766	948.64*±6.943	130.397*±2.593
T_5	*Rhizobium leguminosarum* (20ml) + PSB (20ml) + FYM (10 t/ha)	27.693*±1.553	14.180*±0.448	1,155.16*±2.961	144.157*±2.053
T_6	*Rhizobium leguminosarum* (5 ml) + PSB (5ml) + Vermicompost (10 t/ha)	23.857*±0.823	11.133±0.458	734.407*±3.171	141.723*±2.523
T_7	*Rhizobium leguminosarum* (10ml) + PSB (10ml) + Vermicompost (10 t/ha)	22.260*±1.044	10.220±0.032	847.370*±4.066	143.743*±2.070
T_8	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Vermicompost (10 t/ha)	25.750*±1.554	12.317*±0.745	1155.113*±3.104	141.563*±3.882
T_9	*Rhizobium leguminosarum*(20ml) + PSB (20ml) + Vermicompost (10 t/ha)	27.433*±0.977	14.217*±0.911	1,257.807*±7.358	146.467*±2.408
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5 ml) + Compost (10 t/ha)	21.510*±0.665	10.890±0.459	723.773*±1.798	135.587*±0.695
T_{11}	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + Compost (10 t/ha)	25.120*±1.036	11.850*±0.675	816.320*±0.589	123.600*±0.541
T_{12}	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Compost (10 t/ha)	24.893*± 1.658	12.527*±0.514*	943.357*±0.623	132.057*±0.872
T_{13}	*Rhizobium leguminosarum*(20ml) + PSB (20 ml) + Compost (10 t/ha)	27.373*±1.010	13.353*±0.340	1055.797*±0.910	134.200*±2.120
	S.E(d)	1.087	0.716	5.638	2.269
	$C.D_{(0.05)}$	2.258	1.486	11.705	4.711

Table 9. Influence of different combinations of biofertilizers and organic manures on podlength (cm) and pod girth (cm)

Treatment	Treatment details	Pod length (cm) ±S.E	Pod girth (cm)±S.E
T_1	Control	6.820±0.133	1.190±0.006
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	7.380*±0.242	1.260±0.038
T_3	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + FYM (10 t/ha)	8.060*±0.399	1.333*±0.035
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	8.433*±0.145	1.463*±0.045
T_5	*Rhizobium leguminosarum*(20ml)+ PSB(20ml) +FYM (10 t/ha)	10.030*±0.395	1.477*±0.033
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	7.667*±0.291	1.353*±0.037
T_7	*Rhizobium leguminosarum* (10ml)+ PSB(10ml) +Vermicompost(10t/ha)	8.200*±0.173	1.380*±0.038
T_8	*Rhizobium leguminosarum*(15ml)+ PSB (15ml) + Vermicompost (10 t/ha)	8.450*±0.104	1.440*±0.031
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	10.267*±0.203	1.463*±0.020
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5 ml) +Compost (10 t/ha)	7.093±0.411	1.243±0.032
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)	7.940±0.271	1.290*±0.032
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) +Compost (10 t/ha)	8.313*±0.104	1.380*±0.015
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)	9.473*±0.093	1.433*±0.0035
	S.E(d)	0.247	0.043
	$C.D_{(0.05)}$	0.513	0.089

Table 10. Influence of different combinations of biofertilizesr and organic manureson number of pods/plant and number of seeds /pods

Treatment	Treatment details	Number of pods/plant± S.E	Number of seeds /pods ±S.E
T_1	Control	10.167 ± 0.145	6.200 ± 0.115
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	13.267* ± 0.353	7.800* ± 0.306
T_3	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + FYM (10 t/ha)	14.267*± 0.546	8.000* ± 0.306
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	15.167* ± 0.145	8.467* ± 0.145
T_5	*Rhizobium leguminosarum*(20ml)+ PSB(20ml) +FYM (10 t/ha)	16.067* ± 0.467	9.467* ± 0.145
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	13.600*±0.116	7.467*±0.318
T_7	*Rhizobium leguminosarum* (10ml)+ PSB(10ml) +Vermicompost(10t/ha)	15.050*±0.355	8.067*±0.240
T_8	*Rhizobium leguminosarum*(15ml)+ PSB (15ml) + Vermicompost (10 t/ha)	16.167*±0.484	8.767*±0.318
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	16.133*±0.418	9.667*±0.176
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5 ml) +Compost (10 t/ha)	13.067*±0.296	6.667±0.481
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)	14.233*±0.426	7.667*±0.033
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) +Compost (10 t/ha)	14.876*±0.437	8.233*±0.219
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)	15.600*±0.265	9.367*±0.186
	S.E(d)	0.235	0.247
	$C.D_{(0.05)}$	0.487	0.512

Table 11. Influence of different combinations of biofertilizers and organic manures on pod yield/plant (g) and pod yield/plot (kg/0.6m^2)

Treatment	Treatment details	Pod yield/plant (g) ±S.E	Pod yield/plot (kg/0.6m^2) ±S.E
T_1	Control	62.123 ± 0.767	0.877 ± 0.027
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	65.540*±0.701	1.083*±0.058
T_3	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + FYM (10 t/ha)	67.097* ± 0.819	1.133*±0.050
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	72.957* ± 1.433	1.313*±0.027
T_5	*Rhizobium leguminosarum*(20ml)+ PSB(20ml) +FYM (10 t/ha)	75.703* ± 1.252	1.363*±0.047
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	68.853* ± 0.987	1.163*±0.052
T_7	*Rhizobium leguminosarum* (10ml)+ PSB(10ml) +Vermicompost(10t/ha)	71.333* ± 0.946	1.223*±0.039
T_8	*Rhizobium leguminosarum*(15ml)+ PSB (15ml) + Vermicompost (10 t/ha)	73.627* ± 1.225	1.277*±0.012
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	77.230* ± 0.807	1.400*±0.051
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5 ml) +Compost (10 t/ha)	64.363 ± 0.637	1.063*±0.039
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)	68.837* ± 0.842	1.117*±0.030
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) +Compost (10 t/ha)	70.907* ± 0.780	1.213*±0.037
T_{13}	*Rhizobium leguminosarum*(20ml) + PSB (20ml) + Compost (10 t/ha)	74.657* ± 1.254	1.353* ± 0.007
	S.E(d)	1.345	0.042
	C.D$_{(0.05)}$	2.792	0.088

Table 12. Influence of different combination of biofertilizers and organic manures on seed yield per plant (g) and seed yield per plot (kg/0.6m²)

Treatment	Treatment details	Seed yield/plot (g) ±S.E	Seed yield/plot (Kg/0.6 m²) ±S.E
T_1	Control	41.560 ± 0.668	0.590±0.017
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	49.127* ± 1.174	0.807*±0.057
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	53.623* ± 0.905	0.903* ± 0.043
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	56.440* ± 0.803	1.013* ± 0.032
T_5	*Rhizobium leguminosarum*(20ml)+ PSB (20ml) + FYM (10 t/ha)	60.557* ± 0.738	1.110*±0.031
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	48.840*±1.354	0.827*±0.049
T_7	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) + Vermicompost (10t/ha)	54.187*±0.593	0.930*±0.025
T_8	*Rhizobium leguminosarum*(15ml)+ PSB (15ml) + Vermicompost (10 t/ha)	57.427*±0.624	1.010*±0.015
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	60.760*±0.826	1.133*±0.033
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + Compost (10 t/ha)	43.430*±0.715	0.713*±0.030
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + Compost (10 t/ha)	45.683*±1.926	0.797*±0.111
T_{12}	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Compost (10 t/ha)	54.627*±1.221	0.940*±0.060
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)	59.157*±0.763	1.073*±0.030
	S.E(d)	0.794	0.051
	$C.D_{(0.05)}$	1.649	0.106

Table 13. Influence of different combination of biofertilizers and organic manures on shelling percent (%) and 100 seed weight (g)

Treatment	Treatment details	Shelling Percent (%) ±S.E	100 seed weight (g) ±S.E
T_1	Control	40.177±1.172	38.757±0.809
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	42.220±1.064	40.640±0.405
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	44.777*±1.042	42.753*±1.455
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	45.493*±1.401	44.807*±0.841
T_5	*Rhizobium leguminosarum*(20ml)+ PSB (20ml) + FYM (10 t/ha)	47.683*±1.114	45.457*±0.638
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	42.660±1.210	40.507±1.051
T_7	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) + Vermicompost (10t/ha)	45.550*±0.951	42.403*±0.561
T_8	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Vermicompost (10 t/ha)	46.697*±0.882	44.230*±1.798
T_9	*Rhizobium leguminosarum*(20ml) + PSB (20ml)+ Vermicompost (10 t/ha)	48.920*±1.286	46.470*±1.189
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + Compost (10 t/ha)	41.403±0.887	39.200±1.293
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + Compost (10 t/ha)	43.747*±0.703	42.110*±0.390
T_{12}	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Compost (10 t/ha)	44.413*±1.225	41.653±1.202
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)	46.137*±0.993	43.627*±1.228
	S.E(d)	1.343	1.432
	$C.D_{(0.05)}$	2.789	2.973

Table 14. Influence of different combinations of biofertilizers and organic manures on TSS (°Brix), ascorbic acid (mg/100g), starch content (%) and dry matter content (%)

Treatment	Treatment details	TSS (°Brix) ±S.E	Ascorbic acid (mg/100g)±S.E	Starch content (%) ±S.E	Dry matter content (%) ±S.E
T_1	Control	10.43±0.145	28.783±0.363	21.110±0.770	28.397±0.969
T_2	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + FYM (10 t/ha)	11.467*±0.564	29.763±0.366	21.857±0.729	28.133±0.297
T_3	*Rhizobium leguminosarum*(10ml) + PSB (10ml) + FYM (10 t/ha)	13.067*±0.285	30.670*±0.365	24.363±1.139	29.427±0.178
T_4	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + FYM (10 t/ha)	13.203*±0.370	32.893*±0.826	23.707*±0.301	30.433*±0.097
T_5	*Rhizobium leguminosarum*(20ml)+ PSB (20ml) + FYM (10 t/ha)	14.630*±0.137	33.743*±0.158	22.747*±0.297	30.270*±0.186
T_6	*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Vermicompost (10 t/ha)	11.473*±0.411	29.827±0.324	23.417±0.554	29.103±0.540
T_7	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) + Vermicompost (10t/ha)	13.200*±0.306	32.333*±1.180	22.920±*0.353	29.097±0.368
T_8	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Vermicompost (10 t/ha)	13.620*±0.607	32.683*±0.028	25.440±0.577	30.070*±0.447
T_9	*Rhizobium leguminosarum*(20ml) + PSB (20ml)+ Vermicompost (10 t/ha)	15.083*±0.225	34.387*±0.397	23.497±0.509	29.080±0.345
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5ml) + Compost (10 t/ha)	11.227±0.318	29.557±0.532	22.397±1.080	30.487*±0.952
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + Compost (10 t/ha)	12.023*±0.313	30.320±0.031	25.287±0.253	28.587±0.209
T_{12}	*Rhizobium leguminosarum*(15ml) + PSB (15ml) + Compost (10 t/ha)	12.787*±0.311	33.863*±1.402	23.180*±0.642	28.210±0.614
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)	14.707*±0.058	32.493*±0.057	23.217*±0.784	29.303±0.388
	S.E(d)	0.483	0.907	0.605	0.674
	$C.D_{(0.05)}$	1.003	1.882	1.256	1.400

Table 15. Effect of different treatments on economics of treatments

Treatments	Treatment details	Cost of cultivation (₹)	Gross return (₹)	Net returns(₹)	C:B
T_1	Control	1,47,003	2,92,222	1,45,219	1:0.99
T_2	*Rhizobium leguminosarum*(5ml)+ PSB (5ml) + FYM (10 t/ha)	1,64,038	3,61,111	1,96,182	1:1.20
T_3	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) + FYM (10 t/ha)	1,64,771	3,77,780	2,13,009	1:1.29
T_4	*Rhizobium leguminosarum* (15ml) + PSB (15ml) + FYM (10 t/ha)	1,65,504	4,37,780	2,72,276	1:1.64
T_5	*Rhizobium leguminosarum* (20ml)+ PSB(20ml) +FYM (10 t/ha)	1,66,237	4,54,440	2,88,203	1:1.73
T_6	*Rhizobium leguminosarum*(5 ml) + PSB (5ml) + Vermicompost (10 t/ha)	3,04,038	3,87,780	83,742	1:0.28
T_7	*Rhizobium leguminosarum* (10ml)+ PSB (10ml) +Vermicompost (10 t/ha)	3,04,771	4,07,780	1,03,009	1:0.34
T_8	*Rhizobium leguminosarum*(15ml)+ PSB (15ml) + Vermicompost (10 t/ha)	3,05,504	4,25,560	1,20,056	1:0.39
T_9	*Rhizobium leguminosarum*(20ml)+ PSB (20ml)+ Vermicompost (10 t/ha)	3,19,162	4,66,660	1,47,498	1:0.46
T_{10}	*Rhizobium leguminosarum*(5ml) + PSB (5ml) +Compost (10 t/ha)	2,74,038	3,54,440	80,402	1:0.29
T_{11}	*Rhizobium leguminosarum*(10ml)+ PSB (10ml) +Compost (10 t/ha)	2,74,771	3,72,220	97,449	1:0.35
T_{12}	*Rhizobiumleguminosarum*(15ml) + PSB (15ml) +Compost (10 t/ha)	1,58,673	4,04,440	2,45,767	1:1.54
T_{13}	*Rhizobium leguminosarum*(20ml)+ PSB (20 ml) + Compost (10 t/ha)	2,76,237	4,51,120	1,74,883	1:0.63

4. CONCLUSION

From the present study it can be concluded that treatment T_9 (*Rhizobium leguminosarum* (20ml) + PSB (20ml) + Vermicompost (10t/ha) was found effective in improving growth, yield and quality attributes of pea (*Pisum sativum* L.) which was found statistically at par with treatment T_5 (*Rhizobium leguminosarum* (20ml) + PSB (20ml) + FYM (10 t/ha) except in growth parameter with respect to number of branches per plant, number of days taken for fastest flowering, pod girthT_5 was found to be more significant and for number of pods/plant T_8 (*Rhizobium leguminosarum* (15ml) + PSB (15ml) + Vermicompost (10 t/ha) showed best result. In case of quality characters, treatment T_8 (*Rhizobium leguminosarum* (15ml) + PSB (15ml) + Vermicompost (10 t/ha) recorded highest starch content and T_{10} (*Rhizobium leguminosarum* (5ml) + PSB (5ml) + Compost (10 t/ha) recorded maximum dry matter content. But, considering economic point of view T_5 (*Rhizobium leguminosarum* (20ml) + PSB (20ml) +FYM (10 t/ha) was found most profitable because of high yield and low investment and should be recommended to the farmers for generating profitable returns.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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