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CONTENTS

Effect of integrated nutrient management on growth, yield, and quality traits in garden pea (*Pisum sativum* L.) under sub-tropical conditions of Garhwal hills

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ABSTRACT: The present study was conducted to find out the effect of integrated nutrient management on growth, yield and quality parameters in garden pea (Var. Azad Pea-3) during winter season (2020-21). The treatments were a sole or combination of organic fertilizers (Farmyard manure, vermicompost), biofertilizer (*Rhizobium*) and inorganic fertilizers (Nitrogen, phosphorus and potassium). With respect to plant growth, yield, and quality parameters, T_4 (100% NPK + seed treatment with *Rhizobium*) recorded the best result in terms of days taken to first emergence of seed, 50% emergence of seeds, first flower emergence, first pod emergence, number of pods per plant, pod weight (g), pod length (cm), pod width (mm), yield per plot (kg), yield per hectare (t), total soluble solids (Brix) and dry matter content (%) followed by T_5 (75% NPK + FYM). The present investigation indicated that the application of 100% recommended dose of fertilizers along with seed treatment using *Rhizobium* before sowing was found to be the most effective and promising in enhancing the growth, yield and quality related characters in Azad Pea-3 (AP-3) variety of garden pea under sub-tropical conditions of the Garhwal hills.

Key words*:* Garden pea, farm yard manure, Rhizobium, Total soluble solids, integrated nutrient management

Garden pea (*Pisum sativum* var. *hortense* L.) is a cool-season crop that is grown for its green pods or seeds all over the world. It is one of the popular winter vegetable crops commercially grown during *Rabi* season in India and provides a variety of protein-rich vegetarian dishes for humans. It is grown in the plains as a winter crop and in the high mountains as a summer and fall crop. Pea is produced as an off-season crop in high-altitude regions in hilly areas, where it eventually fetches high prices and provides a significant source of revenue for farmers. Because of its low water demand, it is a key cash crop in water-stressed areas.

Uttar Pradesh, Bihar, Haryana, Punjab, Himachal Pradesh, Odisha, and Karnataka are the major pea-growing states in India. India produced about 5791 ('000MT) of peas annually from an area of 568 ('000 Ha). Uttar Pradesh alone produces approximately 46 per cent of the total national production, followed by Madhya Pradesh, Punjab, and Jharkhand. In Uttarakhand, pea occupies an important position as a leading off-season vegetable grown over an area of 16.80 thousand ha with a production of 93.40 thousand tons (Anonymous, 2020). Currently, the decreasing fertility of soil due to intensive crop production practices of crops and heavy uses of chemical fertilizers has raised concern about the sustainability of crop production. Also, to fulfil the food requirement of an increasing human population, no single source of nutrient is sufficient to meet the nutrient requirement of crops (Das *et al*., 2015).

The basic principle of integrated nutrient management is to maintain and improve soil fertility by integrating multiple nutrient supplies and fertilizers in order to preserve agricultural productivity over time. This can be accomplished by combining the utilisation of all available nutrient sources and scientifically managing them for the best growth, production, and quality of various crops and cropping systems (Das *et al*., 2015). The integrated nutrient supply, including judicious use of chemical fertilizers with organic manures like farmyard manure, vermicompost, etc., and bio-fertilizers, not only helps in reducing the gap between nutrient removal and supply but also ensures a balanced nutrient proportion by enhancing nutrient response

efficiently and maximizing crop productivity of desired quality without any harmful residual effect on soil. The production and productivity of the crop garden pea can be enhanced by adopting integrated nutrient management practices through the application of inorganic fertilizers, organic manure, and biofertilizers. However, the information on the requirements for an appropriate combination of nutrients through various sources is meagre under sub-tropical conditions of the Garhwal hills. Hence, the present investigation was conducted with the objectives to study the effect of various integrated nutrient management treatments on the growth, yield attributes and quality in garden pea (variety AP-3) and to access the best combination of nutrients for AP-3 variety of garden pea under present materials and environmental conditions.

MATERIALS AND METHODS

The experiment was conducted at the Horticultural Research Centre, Department of Horticulture, Hemwati Nandan Bahuguna Garhwal University, Chauras Campus, Srinagar (Garhwal), Uttarakhand. The Horticultural Research Centre is located at 30.22°N and 78.78°E on the bank of Alaknanda River. The experimental site exhibits a dry summer and rigorous winter with occasional dense fog in the morning up to 10 am from December to mid-February. Except during rainy season, the rest of the year is usually dry, with the exception of occasional showers during winter or early spring. The climate of Horticulture Research Centre is humid sub-tropical, with minimum and maximum temperatures ranging between 11.51°C to 21.79°C and 17.85°C to 23.32°C, respectively, during experimentation. The data pertaining to temperature, relative humidity, and rainfall were collected from Nano observatory section situated at Horticultural Research Centre, Chauras Campus, during the course of investigation, *i.e.,* October to January of 2020-21. The data for different weather variables during the investigation are presented in Table 1.

The present experiment comprised of 12 treatments, which were carried out in a randomized block design along with three replications. The details of experimental site and materials used in the present study are presented in Table 2. The tested variety of garden pea, *viz.*, Azad Pea-3 (Open pollinated), was obtained from G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The present experiment comprised 12 treatments consisting of different doses of inorganic fertilizers, organic manure, and biofertilizers along with their combinations as depicted in Table 3.

Three crisscross tractor ploughings followed by harrowing were used to prepare the experimental field. The field was later levelled with a levelling board and the area was cleared from stones, pebbles and unwanted materials before being split into 36 beds of similar size as per the layout plan. The beds were prepared in an equal size of 1.80 x 1.20 m with a spacing of 30 x10 cm. The recommended doses of various organic manures, namely FYM @ 25 t/ha, and vermicompost @ 8 t/ha, were incorporated during the final field preparation. The recommended dose of fertilizers, i.e., nitrogen, phosphorus, and potassium @ 30:60:60 kg/ha were applied in the form of urea, SSP and MOP, respectively, during the experiment. A full dose of SSP and MOP with half dose of urea was applied as basal dose before sowing of seeds. The remaining half dose of urea was applied in two split doses at 30 and 45 days after sowing. The seeds were inoculated with *Rhizobium* before sowing. The *Rhizobium* solution was prepared by mixing jaggery and water. 50 g of Jaggery was heated in 100 ml of water to form a thick, consistent solution. After cooling down the solution, 5g of *Rhizobium* was mixed with jaggery solution, and the solution was poured on seeds. The seeds with biofertilizer were thoroughly mixed to form a thick coat on seed and left to shade dry for 24 hours.

Observations recorded: During the experiment, various growth, yield and quality characteristics were documented. Ten plants were chosen randomly and tagged for each treatment per replication to record the data. The average mean was computed for each character and utilised for statistical analysis. Ranganna's (2015) methodology was used to estimate the quality analysis. The different growth,

yield and quality attributes that were recorded are as follows:

Growth parameters: Days taken to first emergence of seeds, days taken to 50% emergence of seeds, plant height at 40 days after sowing, plant height at full bloom stage and number of primary branches per plant.

Yield parameters: Days taken to first flower emergence, days taken to first pod emergence, average number of pods per plant, average pod weight (g), average pod length (cm), average pod width (mm), average number of seeds per pod, shelling percentage (%), yield per plot (kg) and yield per hectare (t) were recorded.

Quality parameters

Total soluble seeds (°Brix): Five grams of seeds from randomly selected pods of each plot were used to extract the juice and it was passed through a double layer of fine mesh cheese cloth. Further, a drop of extracted juice was placed in hand refractometer (0-32%) and the reading was noted. A mean of three reading was taken in every replication of each entry and was expressed in °Brix.

Dry matter content of seed (%): The dry weight of seed was estimated by taking ten grams of seeds which was randomly taken from each plot per replication. Each sample was oven dried at 60° C for 8-10 hrs. Dry weight of seed is expressed in percentage and estimated by using the formula given below:

$$\text{Dry matter content} = \frac{(Fresh\ weight - Moisture\ \%)}{Fresh\ weight} \times 100$$

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 (Snedecor and Cochran, 1961). 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.

RESULTS AND DISCUSSION

The data pertaining to the effect of different doses of inorganic, organic, and biofertilizers on various growth, yield attributing and quality parameters are presented in Tables (4 to 7). The minimum (6.33) days taken to first emergence of seeds were observed in treatment T_4 (100% NPK + Seed treatment with *Rhizobium*), which was superior to all other treatments, followed by 6.66 days to first emergence recorded in treatment T_5 (75% NPK + FYM) and T10 (50% NPK + seed treatment with Rhizobium) whereas, maximum (9.33 days) was recorded in Control.

The minimum (10.33) days taken to 50% emergence of seeds was again recorded in T_4 (100% NPK + Seed treatment with *Rhizobium*) followed by T_5 (75% NPK + FYM) with 10.66 days while maximum (13.33 days) was recorded in Control followed by treatment T_{11} (FYM + Vermicompost + seed treatment with *Rhizobium*) with 12.66 days. It is apparent from the data that for plant height at 40 days after sowing, maximum (12.9 cm) was recorded in treatment T_2 (100% NPK + FYM) as revealed in Fig. 1., which was found superior to all other treatments followed by treatment T_4 (100% NPK + seed treatment with *Rhizobium*) with plant height of 12.10 cm and T_{11} (FYM + Vermicompost + seed treatment with *Rhizobium*) with 12.00 cm, while minimum (6.33 cm) plant height was observed in Control. Data also revealed that at full bloom stage (Fig. 2), the maximum (86.66 cm) plant height was recorded in treatment T_2 (100% NPK + FYM) followed by the treatment T_4 (100% NPK + Seed treatment with *Rhizobium*) with 86.33 cm and T_3 (100% NPK + Vermicompost) with 85.00 cm plant height. The minimum (58 cm) plant height at full bloom stage was recorded again in Control in case of the studied open pollinated variety.

A critical examination of the data presented in Table 5 indicated the maximum (3.12) number of primary branches per plant in treatment T_2 (100% NPK + FYM) followed by 2.30 and 2.18 number of branches in treatments T_4 (100% NPK + Seed treatment with Rhizobium) and T_5 (75% NPK + FYM), respectively

Table 1: Monthly meteorological data during the period of investigation (October 2020-March 2021)

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
October, 2020	21.27	19.17	70.14	65.78	.0026
November, 2020	17.85	16.43	67.29	61.13	.0027
December, 2020	12.91	11.51	72.13	66.15	.0024
January, 2021	13.07	11.69	72.69	66.82	.021
February, 2021	17.59	16.08	63.84	57.34	.020
March, 2021	23.32	21.79	47.02	40.86	.0059

Source: Nano observatory section situated at Horticultural Research Centre, Chauras Campus, Srinagar, Uttarakhand

while lowest (1.68) was observed in Control. The minimum (66.0) days taken to first flower emergence was recorded in treatment T_4 (100% NPK + seed treatment with Rhizobium) which was found superior to all other treatments followed by 67.00 and 67.33 days recorded in treatments T_5 (75% NPK + FYM) and T_2 (100% NPK + FYM), respectively. On the other hand, maximum (74.33) days was recorded Control. It is apparent from the data given in Table 5 that, T_4 (100% NPK + Seed treatment with Rhizobium) showed the minimum (75.33) days to first pod emergence followed by 75.66 and 76.33 days observed from treatments T_5 (75% NPK + FYM) and T_{10} (50% NPK + seed treatment with Rhizobium) respectively, whereas the maximum (80.83) days to first pod emergence was recorded in Control. Not much significant difference was observed for days to first pod emergence between different treatments.

A close review of data as shown in Table 5 indicates that the treatment T4 showed maximum (33.66) number of pods per plant the followed by treatment T5 and T3 with 32.33 and 32.00 number of pods per plant respectively, while minimum (20.33) number of pods was observed in Control followed by treatment T_1 (100% RDF of NPK) with 24.66 number of pods per plant. Upon close review of the data given in the Table 6 on the effect of integrated nutrient management on pod length, significant difference among the studied treatments was estimated. The maximum (10.43 cm) pod length was recorded in treatment T4 followed by 9.59 cm and

Table 2: Details of experimental site and materials used in the present study

S.No.	Particulars	Details
1.	Crop	Garden pea *(Pisum sativum* var. *hortense*)
2.	Variety	Azad Pea-3 (OP variety)
3.	Experimental design	Randomized Block Design
4.	Number of treatments	12
5.	Number of replications	3
6.	Spacing	30 x 10 cm
7.	Plot size	1.8 x 1.2 m = 2.16m^2
8.	Total number of plots	36
9.	Net area	77.76 m^2
10.	Total experimental area	97.78 m^2

Table 3: Details of experimental treatments and their doses

Treatments	Concentration	Notation
100% NPK	30:60:60 kg NPK/ha	T_1
100% NPK + FYM	30:60:60 kg NPK/ha + 25 t/ ha FYM	T_2
100% NPK + Vermicompost	30:60:60 kg NPK/ha + 8 t/ha	T_3
100% NPK + Seed treatment with *Rhizobium*	30:60:60 kg NPK/ha + 200g/10kg seeds	T_4
75% NPK + FYM	22.5:45:45 kg NPK/ha + 25 t/ ha FYM	T_5
75% NPK + Vermicompost	22.5:45:45 kg NPK/ha + 8 t/ha	T_6
75% NPK + Seed treatment with *Rhizobium*	22.5:45:45 kg NPK/ha + 200g/10kg seeds	T_7
50% NPK + FYM	15:30:30 kg NPK/ha + 25 t/ ha FYM	T_8
50% NPK + Vermicompost	15:30:30 kg NPK/ha + 8 t/ha	T_9
50% NPK + Seed treatment with *Rhizobium*	15:30:30 kg NPK/ha + 200g/10kg seeds	T_{10}
FYM + Vermicompost + Seed treatment with *Rhizobium*	25 t/ ha FYM + 8 t/ha + 200g/10kg seeds	T_{11}
Control	No treatment	T_{12}

Table 4: Effect of organic, inorganic and bio-fertilizers on days taken to emergence and plant height of garden pea (Var. Azad Pea-3)

Notation	Treatment	Days taken to first emergence of seed	Days taken to 50% emergence of seed	Plant height at 40 DAS (cm)	Plant height at FBS (cm)
T_1	100% NPK	8.33	12.33	7.66	76.00
T_2	100% NPK + FYM	8.00	11.66	12.90	86.66
T_3	100% NPK + Vermicompost	7.66	11.00	8.90	85.00
T_4	100% NPK + seed treatment with *Rhizobium*	6.33	10.33	12.10	86.33
T_5	75% NPK + FYM	6.66	10.66	11.13	82.33
T_6	75% NPK + Vermicompost	7.66	11.00	6.46	65.00
T_7	75% NPK + seed treatment with *Rhizobium*	7.33	11.00	6.60	61.00
T_8	50% NPK + FYM	9.33	13.00	9.96	72.66
T_9	50% NPK + Vermicompost	8.66	12.33	10.06	68.00
T_{10}	50% NPK + seed treatment with *Rhizobium*	6.66	11.00	9.36	71.66
T_{11}	FYM + Vermicompost + seed treatment with *Rhizobium*	9.00	12.66	12.00	80.00
T_{12}	Control	9.66	13.33	6.33	58.00
	C.D.	1.548	1.902	1.593	6.830
	SE(m)	0.525	0.644	0.540	2.314
	SE(d)	0.742	0.911	0.763	3.272
	C.V.	11.557	9.545	9.883	5.385

Table 5: Effect of organic, inorganic and bio-fertilizers on number of branches, pod emergence and number of pods in garden pea (Var. Azad Pea-3)

Notation	Treatment	Number of primary branches per plant	Days taken to first flower emergence	Days taken to first pod emergence	Average number of pods per plant
T_1	100% NPK	1.80	67.66	77.66	24.66
T_2	100% NPK + FYM	3.12	67.33	76.66	31.33
T_3	100% NPK + Vermicompost	1.87	72.00	80.00	32.00
T_4	100% NPK + seed treatment with *Rhizobium*	2.30	66.00	75.33	33.66
T_5	75% NPK + FYM	2.18	67.00	75.66	32.33
T_6	75% NPK + Vermicompost	1.76	69.00	76.50	29.66
T_7	75% NPK + seed treatment with *Rhizobium*	2.12	69.66	76.83	27.33
T_8	50% NPK + FYM	2.00	68.66	76.66	28.66
T_9	50% NPK +Vermicompost	1.79	68.33	76.83	29.00
T_{10}	50% NPK + seed treatment with *Rhizobium*	1.73	67.66	76.33	32.00
T_{11}	FYM + Vermicompost + seed treatment with *Rhizobium*	2.17	67.33	76.83	29.66
T_{12}	Control	1.68	74.33	80.83	20.33
	C.D.	0.617	2.882	N/A	1.319
	SE(m)	0.209	0.976	1.166	0.447
	SE(d)	0.296	1.381	1.649	0.632
	C.V.	17.688	2.459	2.616	2.649

9.46 cm of pod length recorded in treatment T5 and T10 respectively, whereas lowest (7.78 cm) pod length was measured in Control followed by treatment T11 with pod length of 8.16 cm.

After thorough analysis of data, it was observed that application of different sources of organic nutrient along with chemical and biofertilizer significantly influenced the width of pods of garden pea. The maximum (12.73 mm) pod width was recorded in the treatment T_4 followed by 12.50 mm and 12.33 mm pod widths recorded in treatments T5 and T10 respectively, while minimum (11.04 mm) pod width was recorded in Control.

A critical analysis of the data presented in Table 6

Table 6: Effect of organic, inorganic and bio-fertilizers on pod characteristics in garden pea (Var. Azad Pea-3)

Notation	Treatment	Average pod length (cm)	Average pod width (mm)	Average number of seeds per pod	Shelling percentage (%)
T_1	100% NPK	9.43	12.17	7.35	43.66
T_2	100% NPK + FYM	8.22	12.19	6.89	45.70
T_3	100% NPK + Vermicompost	9.37	12.06	7.85	46.22
T_4	100% NPK + seed treatment with *Rhizobium*	10.43	12.73	9.14	47.88
T_5	75% NPK + FYM	9.59	12.50	9.06	47.23
T_6	75% NPK + Vermicompost	9.21	11.65	7.62	44.55
T_7	75% NPK + seed treatment with *Rhizobium*	9.45	11.52	8.27	45.27
T_8	50% NPK + FYM	9.41	11.18	7.82	43.86
T_9	50% NPK + Vermicompost	9.37	11.53	8.00	46.36
T_{10}	50% NPK + seed treatment with *Rhizobium m*	9.46	12.33	8.77	46.66
T_{11}	FYM+ Vermicompost + seed treatment with *Rhizobium*	8.16	11.79	8.03	45.73
T_{12}	Control	7.78	11.04	7.03	41.22
	C.D.	0.368	0.512	0.368	2.233
	SE(m)	0.125	0.174	0.125	0.757
	SE(d)	0.176	0.245	0.176	1.070
	C.V.	2.360	2.528	2.706	2.889

Table 7: Effect of organic, inorganic and bio-fertilizers on biochemical and yield attributes of garden pea (Var. Azad Pea-3)

Notation	Treatment	Yield per plot (kg)	Yield per hectare (t)	T.S.S. content(°Brix)	Dry matter content (%)
T_1	100% NPK	2.87	10.52	23.79	27.60
T_2	100% NPK + FYM	3.43	12.65	24.56	29.31
T_3	100% NPK + Vermicompost	4.20	15.66	24.02	28.18
T_4	100% NPK + seed treatment with *Rhizobium*	4.48	17.97	24.10	29.04
T_5	75% NPK + FYM	4.22	15.77	23.63	27.49
T_6	75% NPK + Vermicompost	3.81	14.88	23.79	27.37
T_7	75% NPK + seed treatment with *Rhizobium*	3.36	12.80	23.30	26.31
T_8	50% NPK + FYM	3.55	13.65	22.87	27.14
T_9	50% NPK + Vermicompost	3.66	14.19	23.40	28.80
T_{10}	50% NPK + seed treatment with *Rhizobium m*	4.20	15.66	23.79	27.26
T_{11}	FYM + Vermicompost + seed treatment with *Rhizobium*	3.66	14.19	23.41	26.66
T_{12}	Control	2.50	8.79	22.82	25.1
	C.D.	0.184	0.627	0.936	1.449
	SE(m)	0.062	0.213	0.317	0.491
	SE(d)	0.088	0.301	0.448	0.694
	C.V.	2.945	2.649	2.326	3.088

revealed that there was significant difference in number of grains per pod in different treatments (Fig. 3). The maximum (9.14) number of grains per pod was recorded in treatment T4 followed by 9.06 and 8.77 grains per pod recorded in treatments T5 and T10, respectively while the lowest (7.03) was recorded in Control. A thorough examination of data presented in Table 6 showed that, maximum (47.88%) shelling percent was recorded in treatment T4 followed by 47.23% and 46.66% recorded in treatment T5 and T10 respectively, whereas minimum (41.22%) shelling percentage was recorded in Control. A critical examination of data presented in Table 7 revealed that, application of different combination of organic, inorganic and biofertilizers had influenced yield per plot. Maximum (4.48 kg) green pod yield per plot was recorded in treatment T4 followed by 4.22 kg and 4.20 kg green pod yield per plot was calculated in treatments T5 and T10, respectively. On the other hand, minimum (2.5 kg) yield per plot was recorded in Control followed by treatment T2 with 2.87 kg

yield per plot.

Data presented in Table 7 revealed that the maximum (17.97 t) green pod yield per hectare was recorded in treatment T4 followed by 15.77 t and 15.66 t green pod yield per hectare in treatments T5 and T10, respectively. The minimum (8.79 t) green pod yield per hectare was again recorded in Control. The data pertaining to total soluble solids revealed that the maximum (24.56 °Brix) T.S.S was recorded in treatment T2 followed by 24.10 °Brix in treatment T4 (100% NPK + seed treatment with Rhizobium) whereas, minimum (22.82 °Brix) T.S.S was recorded in Control. With respect to dry matter content, maximum (29.31 %) was recorded in treatment T2 followed by T4 with 29.04% dry matter whereas, minimum (25.1%) dry matter content was recorded in plants without any treatment (Control).

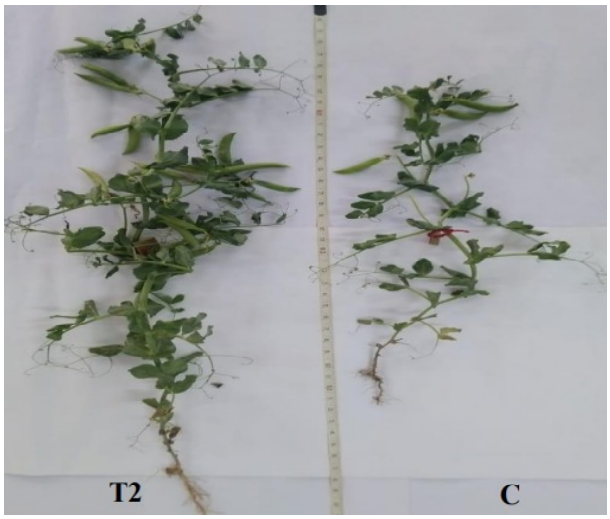

Fig. 1. Plant height of garden pea (Azad Pea-3) under T2 (100% NPK + FYM) and Control (C)

Fig. 2. Field view of crop garden pea (Azad Pea-3) at full bloom stage

Fig. 3. Effect of treatment T_4 (100% NPK + seed treatment with *Rhizobium*) on number of seeds per pod in garden pea (Azad Pea-3) when compared to Control (C)

In the present experiment which was conducted to analyse the effect of integrated nutrient management on growth, yield and quality traits in garden pea (*Pisum sativum* L.) using various sources of plant nutrients such as organic manure (FYM and vermicompost), inorganic fertilizers (N, P and K) and biofertilizer (*Rhizobium*), results revealed that the best treatment for enhancing the growth and yield parameters was T_4 (100% NPK + seed treatment with *Rhizobium*) when compared to other treatments and the control plot. These findings are also in close agreement with the findings of various research workers who reported similar results as Sharma and Chauhan (2011) in an experiment on pea revealed that integrated nutrient management was the best option for maximum yield and quality produce. This might be due to the fact that the biofertilizers play a major role in increasing the nutrient availability to the plants, which in turn reflects in the quality of the produce and yield maximization. The biofertilizers, in the presence of organic manures result in both better quality of the produce and a higher yield, since the manures provide a favourable environment for the activity of the microorganisms. Jyoti and Swaroop (2016) also reported similar results and concluded that inorganic fertilizers and biofertilizers significantly influenced the physical and chemical properties of soil and gave the best results in terms of growth and yield parameters in field pea. The possible reason for increased yield could possibly be due to the fact that combined use

of different sources of nutrients acted differently and provided the required amount of mineral nutrients that improved the physical conditions of the soil, making it favorable for the growth of the plant. Jaipaul *et al*. (2011) also found that the maximum growth and yield were recorded when an integration of recommended dose of NPK along with FYM and biofertilizers was given to the crops. The differences in the management of soil fertility under organic practices affect soil dynamics and plant metabolism, which result in differences in plant composition and nutritional quality (Worthington, 2001).

Significant variation in qualitative characters such as dry matter content and total soluble solids in pea was also observed in the present investigation under different treatments. From the results of present study, it was found that the highest enhancement in qualitative characters was shown by the treatment T_2 (100% NPK + FYM) as compared to the control, which reported the lowest values. Improvement in qualitative characters in pea with farmyard manure may be because of the slow but continuous supply of all major and micro-nutrients, which might have helped in the assimilation of dry matter content and in turn enhanced the total soluble solids in pea seeds. Also, they helped in improving the physical conditions of soil and thus created favourable conditions for the growth of plants. These results are also in agreement with the previous findings of Zaghloul *et al*. (2015), who showed that the application of biofertilizers in combination with a spray of nutrients enhanced the growth and yield of pea crops. Similar findings were also reported by Mishra *et al.* (2010), Bunker *et al.* (2018), Sharma *et al.* (2015), Sepehya *et al.* (2012), Kurbah and Thomas (2017), and Sakya *et al.* (2018) in pea crops and Parween *et al.* (2019) in French bean.

CONCLUSION

It is concluded that T_4 (100% NPK + Seed treatment with 200 g *Rhizobium* /10 kg seeds) along with the application of the 100% recommended dose of NPK showed superior effects on the plant and yield performance of peas. While T_2 (100% NPK + vermicompost, 8 t/ha) showed more effectiveness for certain growth parameters such as plant height at 40 days after sowing, at full bloom stage, number of primary branches, total soluble solids, and dry matter content. Although inorganic chemical fertilizers can fulfil the nutrient requirements of the plant, continuous and excessive use of these chemical fertilizers can severely affect the soil's health and, in the long run, make the soil infertile. Hence, it would be beneficial to use combined applications of manure and fertilizers. Therefore, treatment T_4 was found to be promising for obtaining higher growth and yield responses under the present materials and environmental conditions. Moreover, further research work is needed to find better combinations of different sources of nutrients and to explore new and better sources of plant nutrients that can fulfil the nutrient requirements of crops and are safer to use.

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