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Effect of inorganic fertilizer, organic manures and biofertilizers on growth, yield and yield attributing characters of garden pea (*Pisum sativum* var. *hortense* L.)

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Abstract
A field experiment was conducted at Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* season 2022-23 and 2023-24. A randomized block design with three replications was used to set up this experiment. Eleven treatments combination of FYM and vermicompost @ 1 q/ha and three biofertilizers i.e. *Rhizobium*, PSB and *Azotobacter* @ 500 ml/ha and 1 l/ha through enrichment and soil application technique, including control (without organic manures, inorganics and bio-fertilizers) had laid out. The experiment were comprised of twelve treatment i.e., 100% RDF, organic manures sole and biofertilizers and organic manures in different combination were made. According to the study, garden pea result revealed that the growth parameters, yield and yield contributing characters were increased significantly due to application of inorganic, organic and biofertilizers. The maximum plant height (cm), number of branches per plant, root length (cm), days to initiation flowering, days to marketable maturity, number of pods per plant, pod length (cm), green pod yield per plant (g), green pod yield per hectare (q/ha) and 100 seed weight (g) were all found to be superior when 100 percent RDF was applied, followed by enriched vermicompost (1 q VC and 1 l *Rhizobium*, PSB and *Azotobacter* culture) while the maximum number of nodules recorded with the enriched vermicompost (1 q VC and 1 l *Rhizobium*, PSB and *Azotobacter* culture). Minimum growth, yield and yield contributing characters were recorded with the control (T_0).

Keywords: Inorganic fertilizer, organic manures, biofertilizers growth, yield, PSB

Introduction

Garden pea (*Pisum sativum* var. *hortense* L.) is an important vegetable crop belongs to family leguminaceae (Rabbi *et al.*, 2011) [13]. It is grown all over the world for fresh and processed (canned, frozen or dehydrated) forms. As a leguminous crop, it increases the soil fertility by biological nitrogen fixation in association with symbiotic *Rhizobium* present in its root nodules and leave residual nitrogen of about 50-60 kg/ha in the soil (Negi *et al.*, 2006) [9]. Cultivation of this crop is highly profitable and attractive to the farmers for its short durability. Pea responds greatly to major essential nutrient elements like nitrogen, phosphorous and potassium in respect of its growth and yield. Nitrogen is a constituent of protoplasm, chlorophyll “a”, “b” and nucleic acids. One of the main functions of nitrogen is the initiation of meristematic activity of plant. The cell division and enlargement are also accelerated by ample supply of nitrogen. Thus, the growth of plant by and large depends on nitrogen. Phosphorus plays a vital role in cell division in plants, flowering and fruiting, including seed formation, crop maturation, root development, improvement of crop quality and so on. Potassium helps to regulate the opening and closing of stomata, which regulates the exchange of water vapour, oxygen and carbon dioxide. If K is deficient or not supplied in adequate amounts, it stunts plant growth and reduces yield.

The soil application of organic manures with biofertilizers improved the yield and quality of pea, enhance the fertilizer use efficiency, nutrient cycling and microbiological activity (Sangma *et al.*, 2018) [16]. Organic manure is generally applied to maintain soil health and sustainability in intense cropping systems (Singh *et al.*, 2010) [19].

In this context, attention is given to increase the utilization of different kinds of organic wastes as organic sources of nutrition through farm yard manure, vermicompost etc. Application of vermicompost increases nutrient content, enhances soil respiration and different enzymatic activities and activates microorganisms in soil (Arancon *et al.*, 2006; Tejada *et al.*, 2010) [1, 20]. Pramanik *et al.*, (2007) [12] demonstrated that the presence of several enzymes in vermicompost ultimately lead to improvement in health of the soil. Vermicompost contains 'plant-available nutrients' and appears to increase & retain more of them for longer period of time. Vermicompost also increases 'biological resistance' in plants and protect them against pest and diseases either by repelling or by suppressing them (Edwards and Arancon, 2004 and Rodriguez *et al.*, 2000) [4, 15]. Application of FYM increased soil physical fertility, mainly by improving aggregate stability and decreasing soil bulk density (Diacono and Montemurro 2010) [3]. Application of bacterial inoculants as bio fertilizers improves plant growth, plant available P, increase yield and also release indole acetic acid and gibberellic acid that cause growth and elongation of plant cell (Rashmi *et al.*, 2018) [14].

Materials and Methods

A field experiment was conducted in Horticultural Research cum Instructional Farm, College of Agriculture, IGKV, Raipur (21.16^0 N Latitude, 81.36^0 E Longitude and 289.56 m above mean sea level), Chhattisgarh, India. Raipur is located in the sub-humid region with hot summer and cold winters having a mean annual rainfall of 1300 mm of which 80 percent received during June-September. The soil of the experimental site was well drained clay loam texture. Taxonomically, the soil having pH 7.1 and electrical conductivity 0.17 ds/m, initial soil organic carbon was 0.48%, available N low, P medium and K high were recorded as high. Application of FYM @ 8 t/ha and vermicompost @ 2 t/ha and 40 N: 60 P: 60 K fertilizers according to the treatments plot. The source of primary nutrients used were urea (46% N) for nitrogen, single super phosphate (16% P) for phosphorus and murate of potash (60% K) for potash requirements in treatment T_3. In case of all other treatments, nitrogen, P_2O_5 and K_2O requirement is fulfilled through vermicompost or FYM and remaining P_2O_5 through rock phosphate.

The field experiment was conducted in 2022-23 and 2023-24 with treatments consisting of different organic (FYM, vermicompost) and inorganic (N, P, K) sources of nutrition including biofertilizers (*Rhizobium*, PSB and *Azotobacter*).The experiment was laid out with garden pea cv. Kashi Nandini which is planted at a spacing of 30 × 10 cm in a randomized block design with three replications. The treatments comprised T_0- Control, T_1-Farm Yard Manure, T_2-Vermicompost, T_3-RDF (N,P,K), T_4-Enriched vermicompost (1 q VC and 500 ml *Rhizobium* culture), T_5-Enriched vermicompost (1 q VC and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_6-Enriched vermicompost (1 q VC and 1l *Rhizobium* culture), T_7-Enriched vermicompost (1 q VC and 1l *Rhizobium*, PSB and *Azotobacter* culture), T_8-Enriched FYM (1 q FYM and 500 ml *Rhizobium* culture), T_9-Enriched FYM (1 q FYM and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_{10}-Enriched FYM (1 q FYM and 1l *Rhizobium* culture), T_{11}-Enriched FYM (1 q FYM and 1l *Rhizobium*, PSB and *Azotobacter* culture) were applied during November. The treatments were applied at the time of sowing and appropriate intercultural practices were followed. For all parameters, data were analyzed by analysis of variance (ANOVA) procedure for a randomized block design. Growth and yields attributes sampling was measured during course of investigation. In order to get representative samples, five plants were randomly selected and tagged. Mean values were worked out for the following observation.

Results and Discussion

Growth attributes

Statistically analysed data on growth attributes are presented in Table 1. On the basis of pooled data, the plant height of garden pea at 90 DAS recorded highest with treatment T_3 (55.96 cm) which was statically similar with all the treatments except T_2 (44.80 cm), T_1 (42.97 cm) and control. The lowest result on plant height at 90 DAS recorded with T_0 (39.10 cm) control. The maximum number of branches per plant was observed with treatment T_3 (3.72) which were statistically similar with T_7 (3.53). It was further followed by treatment T_6 (3.43), T_5 (3.37), T_4 (3.32) and T_{11} (3.25) while the lowest were recorded under the treatment T_0 i.e. control (2.52). The pooled analysis revealed that the maximum root length at harvest recorded under treatment T_3 (16.77 cm) which was statistically at par with treatment T_7 (14.72 cm). However, the minimum root length recorded under control (10.76 cm) which was statistically inferior to all other treatments.

Plant height, number of branches and root length was increased possibly due to the fact that nitrogen promotes plant growth, increases the number of internodes and length of the internodes which results in progressive increase in growth factors. The results of this investigation similar with the findings reported in pea by Jyoti and Swaroop (2016) [6]. Phosphorus and potassium helps in establishment and better root development of plants at early growth stage (Uddin *et al.*, 2014) [21].

Yield and yield attributes

Statistically analysed data on yield and yield attributes are presented in Table 2 and 3. Pooled data of days to initiation flowering found non-significant under this experiment while maximum was recorded under the treatment T_0 (control) 32.56 and minimum in treatment T_3 (100% RDF sources) 29.23. The pooled data of days to marketable maturity, showed that the treatment T_3 significantly recorded minimum (49.33) followed by T_7 (50.17). The maximum days to marketable maturity was recorded under T_0 (59.83). The maximum number of green pods per plant recorded with treatment T_3 (20.77) and found significant differences with all other treatments. However, the minimum pods per plant recorded under the treatment T_0 i.e. control (12.68) which were statistically inferior to all other treatments. The significantly maximum pod length were recorded in T_3 (8.74 cm) which was at par with all the treatments except T_1 (7.19 cm) and control. However, the minimum pod length obtained in T_0 (control) 6.49 cm. Pooled analysis revealed that the highest green pod yield per plant was obtained in T_3 (53.47 g) which was statistically at par with T_7 (50.47 g) and T_6 (48.40 g). Significantly minimum green pod yield per plant of 28.27 g was observed under control as compared to rest of the treatments. Maximum pod yield per hectare was obtained under the treatment T_3 (111.67 q/ha) which was at par with T_7 (107.17 q/ha) and T_6 (99.34 q/ha). The minimum pod yield per hectare 43.83 q/ha were observed under the control. The pooled data showed that the maximum 100 seed weight was obtained with treatment T_3 (36.81 g) which was similar with T_7 (35.05 g). It was further followed by T_6 (33.52 g), T_5 (32.80 g) and T_4 (32.43 g). However, minimum 100 seed weight was observed with the control T_0 (24.84 g). The pooled analysis revealed that the maximum number of nodules at 50% flowering stage recorded with treatment T_7-(1 q vermicompost and 1 l-*Rhizobium*, PSB and *Azotobacter*) 39.00 followed by treatment T_6 (34.65) which was statistically similar with T_7. However, the minimum number of nodules at 50% flowering stage was recorded under the treatment T_0 (28.87).

The reason for an increase in yield due to the fact that nitrogen helped the maximum utilization of sunlight and other growth factors which ultimately resulted in production of more photosynthates and translocation from leaves to reproductive parts which leads to increase the yield. These results also reported by Mandloi *et al.*, 2020 [8] Sharma *et al*., 2022 [18]; Shalu and Rattan, 2023 [17] in garden pea. Phosphorus plays an important role in flowering and fruiting, nodule initiation, root proliferation and PSB and *Rhizobium* increases the availability of soluble phosphate and enhances the root growth Prakash and Gupta (2000) [11] and significantly increased the number of nodules in pea. Similar results were also reported by Jeetarwal *et al.* (2014) [5], Devi *et al.* (2013) [2] and Pargi *et al.* (2018) [10].

Table 1: Effect of inorganic fertilizer, organic manures and biofertilizers on growth characters of garden pea

Treats	Plant height (cm) 90 DAS			Number of branches per plant			Root length (cm)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_0	38.69	39.51	39.10	2.37	2.67	2.52	10.55	10.96	10.76
T_1	42.89	43.05	42.97	2.80	2.70	2.75	11.21	11.57	11.39
T_2	44.62	44.98	44.80	2.97	2.87	2.92	11.47	12.03	11.75
T_3	55.41	56.51	55.96	3.70	3.73	3.72	16.64	16.90	16.77
T_4	50.23	51.95	51.09	3.23	3.40	3.32	13.34	14.13	13.73
T_5	50.43	52.67	51.55	3.27	3.47	3.37	13.67	14.47	14.07
T_6	51.11	52.50	51.81	3.33	3.53	3.43	13.85	14.67	14.26
T_7	52.42	53.93	53.18	3.47	3.60	3.53	14.43	15.01	14.72
T_8	47.98	49.86	48.92	3.03	2.90	2.97	12.11	12.78	12.45
T_9	49.20	50.54	49.87	3.10	3.03	3.07	13.29	12.84	13.07
T_{10}	49.25	51.09	50.17	3.17	3.10	3.13	13.52	13.71	13.61
T_{11}	49.55	51.73	50.64	3.20	3.30	3.25	13.82	14.08	13.95
SEm (±)	2.68	3.25	2.98	0.16	0.17	0.17	0.86	0.87	0.87
CD (5%)	7.86	9.52	8.48	0.48	0.50	0.48	2.54	2.56	2.48

Treatment: T_0- Control, T_1-Farm Yard Manure, T_2-Vermicompost, T_3-RDF (N,P,K), T_4-Enriched vermicompost (1 q VC and 500 ml *Rhizobium* culture), T_5-Enriched vermicompost (1 q VC and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_6-Enriched vermicompost (1 q VC and 1 l *Rhizobium* culture), T_7-Enriched vermicompost (1 q VC and 1 l *Rhizobium*, PSB and *Azotobacter* culture), T_8-Enriched FYM (1 q FYM and 500 ml *Rhizobium* culture), T_9-Enriched FYM (1 q FYM and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_{10}-Enriched FYM (1 q FYM and 1 l *Rhizobium* culture), T_{11}-Enriched FYM (1 q FYM and 1 l *Rhizobium*, PSB and *Azotobacter* culture)

Table 2: Effect of inorganic fertilizer, organic manures and biofertilizers on yield and yield attributing characters of garden pea

	Days to initiation flowering			Days to marketable maturity			Number of pods plant^{-1}			Pod length (cm)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_0	32.16	32.96	32.56	59.67	60.00	59.83	12.30	13.07	12.68	6.44	6.53	6.49
T_1	31.81	32.48	32.14	58.33	57.00	57.67	12.87	13.23	13.05	7.09	7.28	7.19
T_2	32.00	32.42	32.21	57.00	56.33	56.67	12.83	13.47	13.15	7.80	7.40	7.60
T_3	29.13	29.33	29.23	49.67	49.00	49.33	20.10	21.43	20.77	8.85	8.64	8.74
T_4	30.62	30.41	30.52	51.00	51.33	51.17	14.00	16.97	15.48	8.43	7.94	8.18
T_5	29.82	30.58	30.20	51.33	50.67	51.00	14.87	17.30	16.08	8.49	8.07	8.28
T_6	29.69	30.26	29.98	51.00	50.33	50.67	15.80	18.13	16.97	8.50	8.22	8.36
T_7	29.33	29.88	29.61	50.67	49.67	50.17	17.50	18.63	18.07	8.65	8.40	8.53
T_8	32.00	32.38	32.19	54.33	54.00	54.17	13.27	14.17	13.72	8.07	7.53	7.80
T_9	31.33	31.77	31.55	53.00	53.33	53.17	13.47	14.40	13.93	8.28	7.65	7.97
T_{10}	31.12	31.62	31.37	52.33	52.67	52.33	13.13	15.60	14.37	8.33	7.77	8.05
T_{11}	30.71	31.44	31.08	52.00	52.33	52.50	13.93	15.97	14.95	8.38	7.87	8.12
SEm (±)	1.69	1.78	1.73	2.10	2.20	2.15	0.80	0.88	0.84	0.45	0.44	0.44
CD (5%)	NS	NS	NS	6.15	6.45	6.12	2.35	2.57	2.39	1.32	1.28	1.26

Treatment: T_0- Control, T_1-Farm Yard Manure, T_2-Vermicompost, T_3-RDF (N,P,K), T_4-Enriched vermicompost (1 q VC and 500 ml *Rhizobium* culture), T_5-Enriched vermicompost (1 q VC and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_6-Enriched vermicompost (1 q VC and 1 l *Rhizobium* culture), T_7-Enriched vermicompost (1 q VC and 1 l *Rhizobium*, PSB and *Azotobacter* culture), T_8-Enriched FYM (1 q FYM and 500 ml *Rhizobium* culture), T_9-Enriched FYM (1 q FYM and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_{10}-Enriched FYM (1 q FYM and 1 l *Rhizobium* culture), T_{11}-Enriched FYM (1 q FYM and 1 l *Rhizobium*, PSB and *Azotobacter* culture)

Table 3: Effect of inorganic fertilizer, organic manures and biofertilizers on yield and yield attributing characters of garden pea

	Pod yield/plant			Pod yield/hectare			100 seed weight (g)			Number of nodules		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T_0	27.90	28.63	28.27	43.17	44.50	43.83	25.25	24.44	24.84	28.73	29.00	28.87
T_1	32.10	33.77	32.93	64.11	65.89	65.00	27.44	26.62	27.03	28.93	29.13	29.03
T_2	34.10	36.97	35.53	74.22	75.44	74.83	29.87	27.01	28.44	29.00	29.67	29.33
T_3	52.30	54.63	53.47	110.67	112.67	111.67	36.69	36.94	36.81	29.20	32.27	30.73
T_4	43.87	45.53	44.70	87.50	90.39	88.94	32.14	32.73	32.43	33.07	34.07	33.57
T_5	45.60	46.60	46.10	90.00	95.44	92.72	32.36	33.24	32.80	33.60	34.20	33.90
T_6	47.90	48.90	48.40	96.95	101.72	99.34	33.28	33.76	33.52	33.93	35.37	34.65
T_7	49.80	51.13	50.47	105.22	109.11	107.17	34.24	35.85	35.05	38.40	39.60	39.00
T_8	37.87	40.20	39.03	76.39	79.11	77.75	30.05	29.34	29.70	30.53	31.27	30.90
T_9	38.77	41.43	40.10	78.89	80.67	79.78	30.52	30.15	30.34	31.40	31.80	31.60
T_{10}	39.70	43.33	41.52	81.22	85.61	83.42	30.39	30.44	30.41	31.07	32.77	31.92
T_{11}	42.00	44.67	43.33	85.22	88.45	86.83	31.88	31.47	31.67	32.07	33.73	32.90
SEm (±)	2.59	2.51	2.55	5.56	5.57	5.56	1.57	1.70	1.63	1.64	1.79	1.71
CD (5%)	7.60	7.35	7.26	16.31	16.32	15.86	4.60	4.98	4.66	4.81	5.24	4.89

Treatment: T_0- Control, T_1-Farm Yard Manure, T_2-Vermicompost, T_3-RDF (N,P,K), T_4-Enriched vermicompost (1 q VC and 500 ml *Rhizobium* culture), T_5-Enriched vermicompost (1 q VC and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_6-Enriched vermicompost (1 q VC and 1l *Rhizobium* culture), T_7-Enriched vermicompost (1 q VC and 1l *Rhizobium*, PSB and *Azotobacter* culture), T_8-Enriched FYM (1 q FYM and 500 ml *Rhizobium* culture), T_9-Enriched FYM (1 q FYM and 500 ml *Rhizobium*, PSB and *Azotobacter* culture), T_{10}-Enriched FYM (1 q FYM and 1l *Rhizobium* culture), T_{11}-Enriched FYM (1 q FYM and 1l *Rhizobium*, PSB and *Azotobacter* culture)

Conclusions

The data obtained from the present study revealed that the application of 100% RDF increase the growth [plant height (cm), number of branches per plant, root length (cm)] and yield components [days to initiation flowering, days to marketable maturity, number of pods per plant, pod length (cm), green pod yield per plant (g), green pod yield per hectare (q/ha) and 100 seed weight (g)] of garden pea. In case of number of nodules combination of organics and biofertilizers found to be superior because it secrets organic acids during solubilization process and increases the availability of soluble phosphate and enhances the growth and number of nodules. The results made it concluded that the application of 100% RDF is better for increasing yield as compared to combination of organic manure and biofertilizers but to sustain soil fertility and to maintain soil health for the future crop planning combination of organic manure and biofertilizers are superior.

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