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Response of vermicompost and levels of nitrogen on growth, yield and yield attributes in pea (*Pisum sativum* L.) rhizosphere

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Abstract
The present investigation **"**Effect of vermicompost and levels of nitrogen on growth, yield and yield attributes in pea (*Pisum sativum* L.) rhizosphere" Pot experiment was conducted in completely randomized design with eight treatments and three replications. Details of treatments are as under T_1 -Control, T_2 -N_{40}:P_{60}:K_{50} (Kg ha^{-1}), T_3 -N_{20}:P_{60}: K_{50} (Kg ha^{-1}), T_4 -Vermicompost @ 5 t ha^{-1}, T_5-enriched Vermicompost @5 t ha^{-1}, T_6-N_{20}:P_{60}:K_{50} + vermicompost @ 2.5tha^{-1}, T_7-N_{20}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}, and T_8- N_{10}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}. Based on the experimental results, it may said that enriched vermicompost contained higher mineral element content than normal vermicompost. Treatment T_7- (N_{20}:P_{60}:K_{50}+enriched vermicompost @ 2.5 t ha^{-1}) was found to be superior to all other treatments in increasing growth, nodulation and yield of the pea. Nodule count and pod yield with this treatment were 12.09% and 7.33% higher than those recorded with RDF.

Keywords: Pisum sativum, enriched vermicompost, NPK, yield

Introduction
Pea (*Pisum sativum* L.) is one of the worlds' top 10 vegetable crops and ranks among the top 10. Pea is widely used worldwide in human diets and is rich in protein (21 -25%), carbohydrates, vitamin A and C, Ca, phosphorous and has high levels of amino acids lysin and trypophan (Bhat *et al.*, 2013) [3]. Its cultivation maintains soil fertility through biological nitrogen fixation in association with symbiotic rhizobium prevalent in its root nodules and thus play a vital role in fostering sustainable agriculture (Negi *et al.*, 2006) [17].
Nitrogen (N) is necessary for life. The ultimate source of nitrogen used by plants is N_2 gas, which constitutes 78% of the earth's atmosphere. Higher plants, unfortunately, can not directly metabolized N_2 into protein. The quantities of NH_3 and NO_3^- available to plants depend largely on the amounts applied as N fertilizers and mineralized from organic soil N. The amount released form organic N, and to some extent those existing in the soil after the addition of NH_4^+ or NO_3^- depend on factors affecting nitrogen mineralization, immobilization, and losses from the soil (Tisdale *et al.*, 1993) [28]. Sustainable agriculture relies greatly on renewable resources like biologically fixed nitrogen or product prepared from waste and residues. Vermicompost is one of the potential renewable resources which can offer sustainability in agriculture. But, due to lesser NPK content in recycled waste and residues these are not becoming popular among farming community. However, use of these renewable resources in agriculture is essential on sustainability consideration. Thus, these renewable resources are required to be enriched. Vermicompost has been proved important agricultural input having potential to sustain fertility of the soil. Its nutritional content can further be increased by enriching it with nitrogen fixing and phosphate solubilizing bacteria (Kumar and Singh, 2001) [12]. Enrichment of vermicompost with rock phosphate, phosphogypsum, *Azolla, Azotobacter* and phosphate solubilizing bacteria also improves nutritional status of vermicompost (Rani and Jha, 2018) [21]. The vermicompost (The compost made from organic matter with the use of earth worm) has gained impetus in organic farming to boost agricultural production to its important multifarious features for example they are rich in nutrients, vitamins, growth regulators, pathogen- free and contain immobilized micro flora.

Materials and Methods

To study the Effect of vermicompost and levels of nitrogen on growth, yield and yield attributes in pea (*Pisum sativum* L.) rhizosphere soil, different types vermicompost were prepared at vermicompost production unit and pot experiment was established at pot house of Bihar Agricultural University Sabour, Bhagalpur, Bihar during the year 2017-18. This college is located in Agro-climatic Zone III A of south Bihar at 25°50' N latitude, 87°19' E longitude and at an altitude of 52.73 meters above mean sea-level. Hot desiccating summer, cold winter and moderate rainfall are the characteristic climatic feature of Sabour. May is the hottest month with an average maximum temperature of 35 to 39˚C. However, January is the coldest month of the year with mean minimum temperature varies from 5 to 10˚C. The average annual rainfall is 1380 mm, precipitating mostly between mid- June to mid-October. For determination of pH, electrical conductivity, total organic carbon, nitrogen, phosphorus and potash in both, normal and enriched vermicompost, methods proposed by fertilizer control order (FCO, 1985) were employed. The characteristics of top soil (0–15 cm layer) at the start of experiment was neutral in reaction (pH 7.84), electrical conductivity 0.20 dSm^{-1}, soil organic carbon 0.34%, available N 73.13 mg kg^{-1} (Subbiah and Asija 1956) [25], available P_2o_5 11.46 mg kg^{-1} (Olsen *et al*. 1954) [19], available K_20 97.20 mg kg^{-1} (Jackson 1976) [10] and available micronutrient (Lindsay and Norvell 1978) [14]. Each set of pot experiment consisted eight treatments and three replications. The experiment was carried out in a fully randomized design (CRD). Details of the treatments are as under T_1 - Control, T_2 -N_{40}:P_{60}:K_{50} (Kg ha^{-1}), T_3 -N_{20}:P_{60}: K_{50} (Kg ha^{-1}), T_4 - Vermicompost @ 5 t ha^{-1}, T_5-enriched Vermicompost @5 t ha^{-1}, T_6-N_{20}:P_{60}:K_{50} + vermicompost @ 2.5tha^{-1}, T_7-N_{2O}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}, and T_8- N_{10}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}.

Results and Discussion

Effect of vermicompost and levels of nitrogen on growth and nodulation in Pea

Growth attributes

Garden pea (*Pisum sativum* L. var. *hortense*) is an important leguminous vegetable crop grown chiefly for its fresh, unshelled green seeds rich in proteins, vitamins, and minerals. Green, smooth and slightly curved at distal end is the characteristic feature of the pods of Azad Pea 3 cultivar of garden pea. Methods adopted for measuring growth attributes have been presented below: Data on growth contributing characters have been presented in table 1.

Plant height (cm)

The highest plant height at 40 DAS is evident from the data presented in Table 1 (35.83 cm) and 90 DAS (55.80cm) was recorded in T_7 (N_{2O}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}) treated plots. However, these values in RDF treated plots were 37.47 cm and 53.57cm respectively. These findings are similar to the results reported by Muddukumar (2007) and Chauhan *et al*. (2010) [18, 4].

Root length (cm)

The observation recorded on root length of a garden pea after 40 and 90 days of sowing as influenced by vermicompost and levels of nitrogen have been presented in table 1. On the basis of statistical analysis, the highest root length (9.93 cm) was observed at 40 days after sowing (DAS) in plot treated with recommended dose of fertilizer (RDF) and the lowest in (6.70 cm) in control plot. Root length in T_7 (N_{2O}: P_{60}: K_{50}+ enriched vermicompost @ 2.5 t ha^{-1}) treated plant after 40 days of sowing was 9.30 cm. These data clearly indicate that mineral nutrition played vital role on root elongation. At 90 DAS maximum root length (11.73 cm) was observed in T_7 and minimum (9.07 cm) in control (Without fertilizers). But, the impact of the treatment on root elongation was statistically not significant. Reddy *et al*. (1998) [22] also recorded maximum plant height at harvest, root length, days to first flowering and branches per plant with the application of Vermicompost – 10 t/ha and recommended dose of NPK 27.5:60:50 kg/ha in garden pea.

Number of nodules per plant

The observation recorded on a number of nodules per plant of garden pea as influenced by vermicompost and levels of nitrogen have been presented in Table 1. It is evident from the data that vermicompost played vital role in increasing nodule count at 40 day stage of plant growth. Combination of enriched vermicompost and half dose of recommended N resulted the highest number of root nodule (12.33 $plant^{-1}$), however, the lowest number of nodule per plant (10.0) was recorded in untreated plant. Recommended dose of fertilizer along with seed inoculation with *Rhizobium* resulted into 11.0 nodules per plant. Similar trends were found at 90 DAS but the influence of treatment on root nodulation was non-significant. Nodulation was enhanced by both, normal vermicompost (NVC) and enriched vermicompost (EVC). Integrated nutrient management through vermicompost and chemical fertilizers resulted higher number of nodules probably due to high demand of phosphorus for root nodulation and biological N_2 fixation. Smaller dose of nitrogen is required to increase the photosynthetic area in the early stage of plant growth, because biological N_2 fixation starts only after 3-4 weeks of sowing of leguminous crop. Role of organic matter on nodulation and biological nitrogen fixation has also been established by Peoples *et al*., (1995) [20].

Fresh weight (g $plant^{-1}$)

It is evident from data presented in Table 1 that the significantly highest fresh biomass (173.83 g $plant^{-1}$) was recorded with treatment T_7 (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare) and the lowest (142.18 g $plant^{-1}$) with treatment T_1 (Control) at 90-day stage of plant growth. The fresh biomass in T_2 (RDF) treated plot was 152.07 g $plant^{-1}$. Similar trend of fresh biomass production was recorded at 40-day stage of plant growth. But, at this stage of plant growth, influence of the treatment on fresh biomass production was found non-significant. Fresh and dry matter accumulations were the highest in ½RDN + enriched vermicompost treated pots. Improvement in dry weight per plant at nutrient supplied through organic sources was also reported by Mahto and Yadav (2005) [15].

Dry weight (g $plant^{-1}$)

It is obvious from data presented in Table 1 that the highest dry matter (23.49 g $plant^{-1}$) was recorded with treatment T_7 (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare) and the lowest (18.55 g $plant^{-1}$) with treatment T_1 (Control) particularly at 90-day stage of plant growth. The dry weight of the plant treated with T_2 (RDF) was 20.60 g $plant^{-1}$. Similar trend of dry matter accumulation was recorded at 40-day stage of plant growth. But, at this stage of plant growth, impact of the treatment on fresh biomass production was found non-significant. Similar findings were reported by Mahto and Yadav (2005) [15].

Effect of vermicompost and levels of nitrogen on yield and attributes in Pea

Number of pods per plant

The data pertaining to a number of pods per plant of garden pea as influenced by different levels of nitrogen and vermicompost has been presented in Table 2. It is evident from the data presented in table 2 that the highest number of pod per plant (14) was obtained with treatment T_7 (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare) and the lowest (9.67) in control. But, the influence of treatments on number of pod was found non- significant. Similar results were also reported by Jat and Ahlawat (2004) [11] and Devi and Singh (2005) [5].

Pod length (cm)

It is evident from the data presented in Table 4.3 that the treatment influenced the pod length. The longest pod (7.7 cm) was obtained in T*7* (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare) treated plant; however, the shortest pod (6.30 cm) was recorded in untreated plant. But, the influence of treatment on pod length was found non-significant. In their experiments, Mishra *et al* (2010) [16] reported similar findings.

Pod diameter (cm)

It is obvious from the data presented in Table 4.3 that the treatment influenced the pod diameter. The highest pod diameter (1.22 cm) was obtained in T_7 (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare) treated plant; however, the lowest pod diameter (1.19 cm) was recorded in untreated plant. Average diameter of pods obtained from RDF treated plant was 1.21 cm. But, the influence of treatments on pod length was found non-significant.

Proper nutrients promote vigorous growth of the plant which ultimately increase the diameter of pod as well as seed which confirms the observation of Waseem *et al*., (2008) [29].

Number of seed per pod

The data on Number of seed per pod has been presented in Table 4.3. It is vivid from the data that the highest number of seeds plant (14.33) was obtained with treatment T_7 (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare), where as the lowest number of seeds plant (9.33) was obtained with treatment T_1 (Control). But, the influence of treatments on number of seed per pod was found non-significant. Jat and Ahlawat (2004) [11] have also reported similar results.

Pod Yield (g/plant)

The data indicating the effect of treatments on pod yield of garden pea has been presented in table 4. It is obvious from the data that integrated nutrient management system was found superior to chemical fertilizer alone to increase pod yield of garden pea. The highest pod yield (54.31 g plant^{-1}) was recorded with treatment T_7 (½ RDN + enriched vermicompost @ 2.5 tonnes per hectare) and the lowest (35.41 g plant^{-1}) with T_1 (control). Treatment T_7 was found significantly superior over all other treatments in increasing pod yield of garden pea. Pod yield recorded with recommended dose of fertilizer was 50.60 g plant^{-1}. Similar result had been reported by Chauhan *et al*. (2010) [4].

Effect of vermicompost and levels of nitrogen on Soil after harvesting of garden pea

pH (1:2.5): Table 3 represents the effect of vermicompost and levels of nitrogen on soil pH. Most of the soil was neutral to slightly alkaline in reaction. The highest pH (7.61) was recorded in control pots and the lowest (7.37) in ½ RDN + enriched vermicompost @ 2.5 tonnes per hectare treated soil. It indicated the tendency of enriched vermicompost to lower the pH towards neutrality. The addition of vermicompost in soil resulted in decrease in soil pH (Ilker *et al.,* 2016) [9].

EC (1:2.5): Effect of vermicompost and different doses of nitrogen on soil electrical conductivity (EC) has been presented in Table 3. The highest value of electrical conductivity (0.123 dS m^{-1}) was recorded in vermicompost and chemical N treated soil and the lowest (0.112 dS m^{-1}) in untreated soil.

Organic carbon (%): The data pertaining to an organic carbon as influenced by different levels of nitrogen and vermicompost has been presented in Table 3. Organic carbon content were found significantly higher (0.46%) in enriched vermicompost treated plot followed by T_4 (0.45%), T_7 (0.44%), T_8 (0.43%), T_6 (0.42%), T_2 (0.41%) and lower (0.38%) in T_1 (control) pots. Elvira *et al.* (1996) [6] reported that the change in organic carbon percentage in vermicompost was due to the medication of the substrate conditions by earthworms. Addition of vermicompost in soil and root development due to fertilizer application may be the probable reasons of increase of organic carbon content in vermicompost and fertilizer treated soils.

Available Nitrogen (mg kg^{-1})

Table 3 represents the effect of vermicompost and level of nitrogen on available nitrogen. Pot under integrated nutrient management system (T_7) was containing the highest amount of available nitrogen (75.53 mg kg^{-1}), however, the lowest content (67.38 mg kg^{-1}) was recorded with control. Progressive increase in availability and major nutrients with increased nitrogen levels and vermicompost over RDF and control was mainly because of the release of these nutrient by mineralization during the crop growth period. Bellakki and Badanur (1997) [2] reported increase in available nitrogen with addition of organic materials to the greater multiplication of soil microbes. Higher mineralization with the application of vermicompost leading to the release of significant amount of NH_4-N was reported by Lavalle and Martin (1992) [13].

Available P_2O_5 (mg kg^{-1}): The effect of vermicompost and chemical N on phosphorus availability in rhizospheric soil of pea has been presented in Table 3. It is vivid from the data that all the treatments differed significantly to influence the availability of phosphorus in rhizospheric soil of of pea after harvesting of the crop. The available phosphorus content was recorded the highest (13.17 mg kg^{-1}) in ½ RDN + enriched vermicompost @ 2.5 tonnes per hectare treated soil followed by enriched vermicompost @ 5 tonnes per hectare treated soil. However, it was minimum (10.94 mg kg^{-1}) in control plot. Higher availability of soil phosphorus was might be due to presence of phosphate solubilizing bacteria (PSB) and release of carbon dioxide and organic acids which solubilized the native soil phosphorus (Singh *et al*., 2008). Vermicompost treated pots showed higher residual Phosphorus than FYM (Barik *et al*., 2006) [1].

Available K_2O (mg kg^{-1})

The data indicating the effect of vermicompost and levels of nitrogen on Availability of K_2O has been presented in Table 3. It is obvious from the data that treatment T_7 was found to be superior to control and T_5 to increase available K_2O content of the soil. The highest content of K_2O (102.47 mg kg^{-1}) was recorded in T_7 treated soil, however the lowest (96.05 mg kg^{-1}) in control plot. The beneficial effect of levels of nitrogen and vermicompost on available potassium could be ascribed the reduction of potassium fixation, solubilisation and release due to the interaction of organic matter with clay besides the direct potassium addition to the potassium pool of soil (Tandon, 1987) [27].

Effect of vermicompost and levels of nitrogen on available micronutrient (Fe, Mn, Cu, and Zn) (mg kg^{-1})

Impact of vermicompost and levels of nitrogen on available concentrations of micronutrient (Fe, Mn, Cu, and Zn) has been presented in Table 4. It is vivid from the data that organic treatments and levels of nitrogen had a non-significant difference in available micronutrient. The highest concentration of iron (11.21 mg kg^{-1}) was found with ½ RDN + enriched vermicompost @ 2.5 tonnes per hectare treated soil. However, the lowest concentration of DTPA extract actable Fe (10.82 mg kg^{-1}) after harvesting of the crop was recorded in the soil collected from control plot. The similar trends of Mn, Cu, and Zn availability were recorded in experimental soil. The complexing properties of organic manures which prevented the precipitation and fixation and keep them in soluble form was also reported by Gopal and Suryanarayana (1998) and Suvarna and Sankara (2001) [8, 26]. Increase in extractable micronutrient in organic manure treated soil was due to reduction of cations in experimental soil (Singh *et al*., 1992) [23].

Table 1: Effect of vermicompost and levels of nitrogen on growth and nodulation in Pea

Treatment	Plant height (cm)		Root length (cm)		No. of Nodule plant^{-1}		Fresh biomass (g plant^{-1})		Dry weight (g plant^{-1})	
	40 DAS	90 DAS	40 DAS	90 DAS	40 DAS	90 DAS	40 DAS	90 DAS	40 DAS	90 DAS
T1	31.27	49.93	6.70	9.07	10.00	4.00	121.39	142.18	14.54	18.55
T2	37.47	53.57	9.93	11.10	11.00	6.00	152.37	170.37	17.15	20.60
T3	32.20	52.17	8.10	9.97	10.67	6.00	146.84	167.63	16.84	19.85
T4	31.53	51.60	7.90	10.43	11.33	7.33	128.30	149.09	15.48	19.98
T5	32.27	52.17	8.53	10.90	11.33	7.33	139.52	160.31	16.76	20.66
T6	33.37	53.40	8.70	11.33	12.00	7.33	151.48	172.27	17.14	21.80
T7	35.83	55.80	9.30	11.73	12.33	7.67	152.07	173.83	17.89	23.49
T8	31.53	51.50	7.87	10.10	12.00	6.67	128.81	159.54	16.11	20.75
SEM	0.72	0.61	0.81	1.11	0.67	1.28	11.16	10.56	1.42	1.20
CD (0.05)	1.52	1.28	1.70	NS	1.40	NS	NS	22.16	NS	2.53

Table 2: Effect of vermicompost and levels of nitrogen on yield and attributes in pea

Treatment	No. of pod per plant	Pod length (cm)	Pod diameter (cm)	No. seed per pod	Pod yield (g plant^{-1})
T1	9.67	6.30	1.19	9.33	35.41
T2	13.00	7.33	1.21	13.33	50.60
T3	12.33	7.03	1.20	11.67	44.55
T4	12.33	6.63	1.20	12.00	45.21
T5	12.67	6.66	1.21	12.33	46.51
T6	13.00	7.33	1.21	13.00	49.60
T7	14.00	7.77	1.22	14.33	54.31
T8	12.33	7.13	1.21	12.00	45.77
SEM	1.14	0.601	0.01	1.28	0.79
CD (0.05)	NS	NS	NS	NS	1.67

Table 3: Effect of vermicompost and levels of nitrogen on soil properties after pea crop

Treatment	pH (1:2.5)	EC (d S m^{-1}) (1:2.5)	OC (%)	Available N (mg kg^{-1})	Available P_2O_5 (mg kg^{-1})	Available K_2O (mg kg^{-1})
T1	7.61	0.115	0.38	67.38	10.94	96.05
T2	7.51	0.123	0.41	74.11	12.08	100.00
T3	7.49	0.120	0.42	73.90	11.99	100.00
T4	7.37	0.116	0.45	73.90	11.24	100.23
T5	7.37	0.112	0.46	72.80	12.52	99.64
T6	7.41	0.122	0.42	73.34	11.68	100.91
T7	7.37	0.121	0.44	75.53	13.17	102.47
T8	7.38	0.122	0.43	73.82	12.74	101.79
SEM	0.08	0.014	0.02	2.06	0.57	1.64
CD (0.05)	NS	NS	0.03	4.32	1.20	3.44

Table 4: Effect of vermicompost and levels of nitrogen on micronutrient availability after harvesting of pea crop

Treatment	Available Fe (mg kg^{-1})	Available Mn (mg kg^{-1})	Available Zn (mg kg^{-1})	Available Cu (mg kg^{-1})
T1	10.82	8.82	1.00	1.29
T2	11.03	9.58	1.02	1.40
T3	11.11	9.39	1.04	1.41
T4	11.07	9.38	1.04	1.48
T5	11.12	9.40	1.06	1.49

T6	11.04	9.36	1.05	1.43
T7	11.21	9.74	1.12	1.53
T8	11.02	9.26	1.09	1.48
SEM	0.417	1.92	0.07	0.94
CD (0.05)	NS	NS	NS	NS

Conclusion

The characteristics of enriched vermicompost (EVC) were found better than that of the normal vermicompost (NVC). Integrated nutrient management system (INMS) especially, ½RDN+EVC@2.5t ha^{-1} was found superior over fertilizers and vermicompost alone to augment growth, nodulation, dry matter and pod yield of garden pea. This treatment was also beneficial to increase organic carbon, available N, Available P_2O_5 and available K_2O availability of the soil. Content of all these forms of nitrogen increased up to 40 day stage of plant growth and then decreased which indicates that INMS is suitable to increase nitrogen availability at flowering and pod filling stages and as a result production of crop increased.

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