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Influence of organic, inorganic and integrated use of nutrients on productivity and quality of pea (*Pisum sativum*) vis-à-vis soil properties

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ABSTRACT

Awareness of food quality has shifted our nutrient management system toward crop production. Integrated nutrient management system resulted in yield improvement and maintenance of soil health, but has least impact on food quality and environment. To study the impact of different nutrient management system, a field experiment was conducted with organic, inorganic and integrated nutrient management practices on pea (*Pisum sativum* L.) with eight treatments for four years at the research farm of CSKHPKV, Palampur. Soil chemical, physical and biological properties and symbiotic parameters of pea found to be better under organic farming, however, integrated nutrient practices increased green pod yield each year whereas yield decreased under chemical treatment.

Key words: Nutrient Management system, *Pisum sativum,* Symbiotic Parameter, Soil Properties, Yield

In present scenario, of crop production, awareness of food quality has shifted our nutrient management system owing to excess and imbalanced use of nutrients and its impact on food quality and environment. The continuous nutrient mining from the soil deteriorated crop productivity and ultimately soil health. It has been revealed from the studies on long-term experiments that organic manures along with chemical fertilizers proved impetus on yield and soil quality. But integrated nutrient management system is conceived with least impact on food quality as well as environment. So there is need to evolve economically attractive and ecologically sound means to reduce external inputs and to improve the renewable sources of energy and it becomes imperative to select the efficient techniques of crop production. However supply of nutrients from organic management is less and spontaneous as compared to integrated management and chemical management. Organic inputs such as farmyard manure and green manures also improve the soil physical properties (Gopinath *et al.* 2008). Crops having low nutrient requirement may emerge as a potential crop under organic management without losing remunerative price to farmers and additional benefits to assess the impact of organic management on soil health and crop quality. Pea (*Pisum sativum* L.), being a legume crop, its nutrient requirement from external sources is less as compared to cereal crops. About 75-80% of the total nitrogen requirements of leguminous crop can be met through symbiotic fixation (Verma 1993). But farmers are applying more and more nitrogen which cause imbalance of nutrients and making crop more susceptible to diseases and insects and pests. Hence the study to assess the impact of different management practices on productivity, quality and soil properties was under taken on pea crop.

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MATERIALS AND METHODS

The field experiment was conducted on pea during the four years since start from 2005-2006 to 2008-2009 at the research farm of CSK HPKV at Palampur (32°N, 76°E, 1260 m asl) representing the wet temperate zone of the western Himalayas. The area received 2443 mm annual rainfall (averaged for 2005-2006 to 2008-2009). Eight treatments were: T_1- Organic (10 tonnes of farmyard manure + nitrogen fixer-A, phosphate solubilizer and chopped crop residues of same plots, T_2- Organic (10 tonnes farm yard manure + nitrogen fixer-B, phosphate solubilizers and chopped crop residues of same plots, T_3-Integrated [5 tonnes of farmyard manure +Nitrogen fixer-A phosphate solubilizer+half P_2O_5,T_4-Integrated [5 tonnes of farmyard manure +Nitrogen fixer-A+half nitrogen + phosphate solubilizer+half of P_2O_5, T_5-Integrated [5 tonnes of farmyard manure+nitrogen fixer-B + phosphate solubilizer+half P_2O_5, T_6-Integrated [5 tonnes of farm yard manure+Nitrogen fixer-B+half nitrogen+ phosphate solubilizer+half P_2O_5 ,T_7-chemical (Recommended NPK), T_8-(control). The recommended dose for pea is 20 kg nitrogen, 60 kg P_2O_5 and 20 kg K_2O. Recommended dose of K_2O was applied in treatment T_3, T_4, T_5 and T_6. These eight treatments were evaluated in a randomized block design with three replications. The full amount of farmyard manure, P and K; whole of N was applied at sowing time. The Rhizobium culture was applied as seed treatment and phosphorus solubilizing bacteria through farmyard manure at sowing. The seeds were sown with the recommended spacing in the 2^{nd} week of Nov each year. Symbiotic parameters were recorded at the flowering stage in each year. The pods were picked at 10 day intervals and yield was calculated by adding the numbers of pickings. Initial and final (after the harvest of crop) soil properties were determined by standard methods.

RESULTS AND DISCUSSION

Symbiotic parameters

Nodule number: The number of nodule differed significantly (Table 1). The maximum nodule number was recorded in T_1 (organic) and minimum was in T_7 (chemical fertilizer) each year. Treatment T_7 recorded lesser nodule number than the absolute control, akin to T_7, application of nitrogenous fertilizers (T_4 and T_6) recorded lesser nodule number than T_3 and T_5. It might be due to fact that application of nitrogenous fertilizer suppresses the activity of nitrogen fixing microorganism owing to readymade supply of nitrogen through chemical fertilizers**,** which resulted poor nodulation in nitrogen fertilizer applied treatments. Results are corroborated with the findings of Pathak *et al.* 1999. Organic treatment (T_1 and T_2) gave higher nodule number than integrated treatments indicates that application of organic sources of nutrients enhanced the microbial activities, however integration of nutrients increased nutrient availability which ultimately resulted higher yield and other yield attributes. The results are in close proximity with Datt *et al.* (2006) who reported that application of organic (FYM) at the rate of 3.0 tonnes on dry weight basis resulted in higher nodule number per plant than inoculated and uninoculted treatments with and without nitrogenous fertilizers, respectively.

Nodule weight: The maximum nodule weight was recorded in the organic management followed by integrated management without nitrogenous fertilizers, with nitrogenous fertilizers, control and application of nitrogenous fertilizers, respectively. Minimum nodule weight was recorded in T_7, favoured our observation that application of nitrogen suppressed the microbial activity. It might be due to fact that application of chemical fertilizers suppressed the nodule formation owing to readymade supply of nitrogen from the soil which resulted in poor symbiosis between the plant and Rhizobia caused poor nodulation in chemical fertilizer applied treatments rather than the control. Results are corroborated with the finding of Dubey and Bindra (2008).

Yield attribute and yield

Number of grains per pod: It is discernible from the pooled data of (Table 1) that the maximum number of grains per pod was recorded in organic treatment (T_2) followed by integrated use of nutrients (T_6), organic treatment (T_1) respectively. The maximum number of grain per pod was recorded in T_2 (organic) and minimum was in T_8 (control). Application of nitrogenous fertilizer in integrated treatments T_4 and T_6 gave numerically more number of grains per pod than T_3 and T_5. Control treatment recorded the lowest number of grain per pod which was significantly at par with other treatments and significantly lower than organic treatments T_2 and T_1 and integrated use of nutrients T_6.

Green pod yield: Data pooled over four years depicted that integrated use of nutrients gave significantly and numerically higher pod yield than other treatments (Table 1). The minimum and significantly lower pod yield was recorded in control than other treatments. Pod yield under organic treatments was significantly at par with the chemical treatment and statistically superior to control and statistically

Table 1 Effect of organic, inorganic and integrated use of nutrients on symbiotic parameter, yield attributes, green pod yield and quality of green pods pea (Data pooled over for four years)

Treatment	Nodule number Pooled Over four years	Nodule weight (mg/plant) Pooled over four years	No. of grains (pod) Pooled over four years	Yield (t/ha) 2005 & 2006	2006 & 2007	2007 & 2008	2008 & 2009	Pooled yield four years (t/ha)	Nitrogen (%) in green pods Pooled-over four years	Protein (%) in green-pod Pooled over four years
T_1	27	35.2	7.2	5.5	6.1	5.6	5.7	5.73	3.9	24.4
T_2	24	32.4	7.5	5.4	6.4	5.7	5.8	5.83	3.8	23.8
T_3	18	20.8	5.8	5.6	7.1	6.1	6.1	6.23	3.6	22.5
T_4	13	24.7	6.2	6.9	7.3	6.3	6.4	6.73	3.6	22.5
T_5	22	21.8	6.5	6.4	7.2	6.5	6.7	6.7	3.7	23.1
T_6	16	26.4	7.4	6.9	7.5	6.9	7.3	7.15	3.8	23.8
T_7	7	4.8	5.6	7	6.1	5	5	5.78	3.7	23.1
T_8	12	10.3	4.8	3.4	3.8	3.7	3.9	3.7	3.4	21.3
CD (P=0.05)	3.62	3.76	1.72	0.64	0.68	0.42	0.485	1.253	0.28	1.86

inferior to integrated use of nutrients. Garden pea is more responsive under organic management owing to better symbiosis with micro organisms and low nutrient requirement as compared to other pulse crops, which may easily mitigate through organic sources. Similar results were reported by Gopinath *et al.* (2011) in their study under different management practices and found that garden pea is more responsive under organic management in comparison to bell pepper and French bean. Both the organic treatments are statistically at par with each other show the nitrogen fixer A and B are considered equally good as for as nitrogen fixation is concerned. An increase in yield during all the years (except 2007-08) has been observed in treatments T_4 and T_6 when farmyard manure was added with chemical fertilizers and bio-fertilizers. The percent increase in yield over control in different treatments, viz. T_1, T_2, T_3, T_4, T_5, T_6 and T_7 was 61.8%, 58.8%, 64.7%, 102.9%, 88.2%, 102.9% and 105.8% during 2005-06. Similarly percent increase in yield over control in different treatments, viz. T_1, T_2, T_3, T_4, T_5, T_6 and T_7 was 60.5%, 68.4%, 86.8%, 102.9%, 89.4%, 97.3% and 67.6% during 2006-07. The per cent increase over control in each treatment decreased during 2007-08. It was 51.4%, 54.0%, 64.8%, 70.3%, 75.7%, 86.5% and 35.1% in treatment from T_1 to T_7 respectively. During 2008-09 the per cent increase over control decreased further. It was 46.1%, 48.7%, 56.4%, 64.1%, 71.8%, 87.1% and 28.2%. It is revealed from the data that maximum reduction in terms of per cent increase was in T_7, i. e. 100% NPK treatment while was lower in integrated treatments. Application of half doses of nitrogen under integrated nutrient management along with bio-fertilizers proved to be more sustenance than organic treatments and integrated treatment without nitrogen. It might be due to fact that the application of nitrogen in presence of organic manures helps the mineralization by minimizing C/N ratio. Organic treatments gave consistently better increase in green pod yield during subsequent years. The higher yield because of farmyard manure along with biofertilizers may be owing to nutrients supplied by farmyard manure and biofertilizers had improved the physico-chemical properties of soil and the results are corroborated with the findings of Veerabhadraiah *et al.* (2006). It is revealed that bio-fertilizers and farmyard may prove important inputs in organic farming.

Quality parameters

Nitrogen and protein content: It is discernable from (Table 1) that maximum nitrogen content was recorded in organic treatments, which was significantly better than rest of treatments except T_3 and T_5. Both the organic treatments were at par with each other. Application of nitrogen through chemical fertilizers decreased nitrogen content in comparison to treatments where nitrogen was not applied through chemical fertilizers. It might be due to fact that the application of nitrogen through fertilizer enhances the nitrogen availability rapidly whereas, nitrogen from organic sources act slow and spontaneous may caused better nitrogen accumulation in plant parts. It is also revealed from the data presented in (Table 1) that protein content in green pod was maximum in organic treatment and minimum in control. Since protein content is a product of nitrogen concentration of green pod and yield of green pod. So it is not merely indicator of single parameter, increase in any one parameter may affect the value of it. However, increased in yield may caused the reduction in nutrient concentration owing to dilution effect. Maximum nitrogen content was observed in T_2 which was at par with T_1. When nitrogen was added through chemical fertilizers as in case of treatments T_7, T_4 and T_6; the nitrogen content and protein content decreased in comparison to T_1 and T_2. Similar findings have been reported by Dubey and Bindra (2008). A numerical decrease in nitrogen content was also observed in T_4 and T_6.

Soil chemical properties

Organic carbon: It is discernible from (Table 2) that organic carbon differed significantly under all the treatments over control. The maximum organic carbon was recorded in organic treatment T_1 and the minimum was recorded in control treatment. Both the organic treatments were significantly at par. The increase in organic carbon might be due to direct addition of organic source of nutrients and less mineralization due to wide C: N ratio material. Results are in accordance with the findings of Kanwar *et al.* (2002) who reported that application of organic manure alone recorded higher organic carbon content than chemical fertilizers (NPK) applied treatments. Organic carbon under integrated treatment did not differ significantly with each other. In control treatment organic carbon increased from its initial status, but was significantly lower than other treatments. Chemical fertilizer applied treatment gave significantly and numerically less organic carbon than the other treatments except control. Increase in doses of organic manures along with decreased doses of chemical fertilizers improved soil organic carbon in comparison to application of chemical fertilizer alone in long term experimentation as revealed from the study of Bedi and Dubey (2009).

Cation exchange capacity (CEC): Integrated treatments and organic treatments were found statistically at par. The organic treatments contained significantly higher values of CEC than control (Table 2). This might be due to release of cations with the decomposition of organic matter which would have increased the CEC. Yagi *et al.* (2003) have also reported similar findings. Integrated treatments are found to be better than chemical fertilizers applied treatment.

Available nitrogen: Available nitrogen differed significantly in all the treatment. Available nitrogen was more in integrated treatments as compared organic treatments (Table 2). It might be due to fact that integration of organic and chemical fertilizer has increased the mineralization owing to narrow C/N ratio as compared to organic treatments. In chemical fertilizers applied treatment low available nitrogen is owing high mineralization and low organic matter caused nutrients mining.

Available phosphorus: Available phosphorus content in control treatment decreased from its initial value (22.2

Tables 2 Effect of organic, inorganic and integrated use of nutrients on soil chemical, physical and biochemical properties after four years

Treat-ment	Chemical Properties					Physical Properties			Biological Properties			
	Organic carbon (g/kg)	Available N kg/ha	Available P kg/ha	Available K kg/ha	Cation exchange carbon (cmol p+kg)	Bulk density (mg/ml^3)	Water Holding capacity (%)	Biomass carbon (μgCg^{-1})	Dehydroge-nase activity (μgTPF g-hr^{-})	Urease activity (μgg^{-1}hr^{-1})	Phosphat-ase activity (μgg^{-1}hr^{-1})	Microbial Respiration (μgg^{-1}hr^{-1})
T_1	13.4	367	29.5	255	13.8	1.38	54.7	235	2.4	4.6	2.7	12.8
T_2	12.8	385	27.8	257	13.2	1.34	53.8	230	2.5	43	2.6	11.8
T_3	11.8	392	28.4	268	13.4	1.3	51.2	210	2.2	5.8	1.9	10.3
T_4	12	410	35.7	284	13.2	1.32	50.9	195	2.1	6.2	2.1	8.2
T_5	12.1	408	33.2	272	13.4	1.33	51.7	225	2.6	6.4	2.2	9.6
T_6	12.4	445	37.6	310	13.7	1.32	51.4	208	2.7	6.8	3.1	9.2
T_7	11.4	335	30.2	265	12.9	1.24	51.1	148	2.3	4.8	1.7	7.2
T_8	10.6	296	22	202	11.3	1.21	50.2	123	1.8	3.6	1.4	5.6
CD (P = 0.05)	0.62	15.6	2.85	12.2	0.46	0.015	2.28	12.6	0.3	0.18	0.22	0.82
Initial	10.4	322	22.2	210.3	11.2	1.22	51.3	134	1.7	3.8	1.3	6.0

kg/ha), whereas the available phosphorus in rest of the treatments increased from its initial levels. The increase in the available P content due to incorporation of organic manures may be attributed to the direct addition of organic manures as well as solubilization of native P through release of various organic acids. The minimum increase was in organic treatments followed by chemical fertilizer applied treatment, respectively. Available phosphorus was more in integrated treatments as compared organic treatments. Build up of phosphorus status in acidic soils generally occurs owing to poor availability of phosphorus and complex formation with iron and aluminium, but better availability under chemical fertilizers applied treatment and integrated nutrient management might be due to more mineralization owing to addition of chemical fertilizers. Similar improvement in available P due to integrated use of manures and chemical fertilizers has been observed by Sharma *et al.* (2009).

Available potassium: The minimum increase in available potassium was recorded in organic treatments followed by integrated treatments, respectively. Available potassium was more in integrated treatments as compared organic treatments. The beneficial effect of integrated use of fertilizers and organic treatments on available K may be ascribed to the direct potassium addition in the potassium pool of the soil. Results are corroborated with the findings of Gopinath *et al.* 2008.

Physical properties

Bulk density: The bulk density in all the treatments has increased from its initial value (1.22 Mg/m) except control, where it has decreased (1.21 Mg/m) numerically, in rest of the treatments, it has increased significantly. The increase in bulk density might be due to increase in organic carbon. The results are corroborated with the findings of Pathak *et al.* (2005). The bulk density in organic treatments was significantly superior to the rest of treatments.

Water holding capacity: It is discernable from (Table 2) that water holding capacity differed significantly. However, it increased in all the treatments from its initial value (51.3%) except in control and chemical fertilizers applied treatment. In these two treatments, it has decreased numerically from its initial value. The maximum water holding was recorded in organic treatment T_1 and the minimum was recorded T_8 treatment. Integrated treatment gave numerically less water holding values than the organic nutrient management treatments. However it did not affect the available water content to the plants. Organic matter content which resulted in the improvement in stable soil aggregates and macro and micro pore spaces caused to increase in free movement of water within the soil might have resulted to increase in water holding capacity of the soil. Similar results were also reported by Walia *et al.* (2010).

Soil biological parameters

Microbial biomass: On the perusal of data from (Table 2), it is revealed that the contents of biomass carbon were the highest under organic treatments followed by integrated nutrient management. The biomass carbon in all the treatment differed significantly. The biomass carbon content was maximum in T_1 and minimum in the control. The highest biomass carbon in organic treatments may be attributed firstly to the fact that the buildup of organic carbon was more which might harbor more microbial population and ultimately resulted in the higher biomass carbon and secondly to the formation of root exudates, mucigel soughed off cells and addition of crop residues (Goyal *et al.* 1992). The content was significantly highest in T_1 but was at par with T_2. Addition of nitrogen decreased the biomass content in T_4 and T_6. The biomass carbon contents in integrated treatments were significantly higher than chemical fertilizer treatment. The biomass carbon contents were significantly lowest in the control.

Dehydrogenase activity: The activity of dehydrogenase was significantly higher in organic and integrated treatments than the chemical fertilizers applied treatment (Table 2). Addition of farmyard manure with crop residues, bio-fertilizers along with chemical fertilizers increased the activity of dehydrogenase enzyme as FYM and crop residues being the major carbon sources, which provided energy for soil microorganisms and increased the number of pores, which are considered important in soil-water-plant relationship and maintained good soil structure accompanied by better dehydrogenase activity (Marinari *et al.* 2000). The results also corroborated with the findings of Verma and Mathur (2009) who reported that integrated use of FYM with chemical fertilizer increased the activity of dehydrogenase enzyme. Further, addition of nitrogen in the farmyard manure and bio-fertilizers increased the dehydrogenase activity than the alone chemical fertilizer treatment might be due to more availability of substrate for dehydrogenase enzyme. Among the Rhizobium strains A and strain B, the strain B performed better than strain A in affecting the dehydrogenase activity. The value was significantly lowest in the control. The value increased in all treatments from the initial value.

Phosphatase activity: The minimum phosphatase activity was recorded in control and maximum was found in integrated nutrient management treatment where each of the organic, inorganic and biofertilizers were used (Table 2). Significantly highest activity was found in T_6 followed by T_5 and T_2. It may be due to that fact that integrated treatment provided narrow and optimum C: P ratio which resulted in fast mineralization from the organic forms of di-and mono-esters. Results are corroborated with the finding of Bedi and Dubey (2009).

Urease activity: The values in the organic treatments were significantly lower than the integrated treatments (Table 2). The higher urease activity in integrated use of nutrients (organic and inorganic together) might be due to maintenance of the continuity of conversion of nutrients from organic to inorganic form owing to that urease enzyme acts on C-N bonds other than the peptide bonds in a linear amides and thus belong to a group of enzymes that include glutominase and amidase. The results are corroborated with the findings of Jaun *et al.* (2008). An increase in values was observed in all treatments from the initial value except in the control.

Microbial respiration: Microbial respiration was minimum in the control and maximum in the organic treatments followed by T_3. This is also an index of higher organic carbon content of the organic treatments. Application of alone fertilizer as in treatment T_7 and other integrated treatments except T_3 resulted in lesser microbial respiration in comparison to organic treatments (Table 2). It might be due to fact that in organic applied treatments, microbial population was more and resulted in more respiration. Results are corroborated with the findings of Liang *et al.* (2003).

CONCLUSION

Bio-fertilizers and farmyard manure has proved potential organic inputs for yield sustenance under these conditions for pea. Nitrogen and phosphorus can be saved around 25 kg/ha and 20 kg/ha respectively in Pea with the use of 5 tonnes of farmyard manure and 50% of nitrogen and phosphorus can be supplied through the use of nitrogen and phosphate fertilizers and bio-fertilizers. Integrated nutrient management found better than organic treatments in terms of pod yield, phosphatase and urease activity and available nutrient status and cation exchange capacity. Organic management increased the quality parameters like nitrogen and protein of green pods, soil biomass carbon, microbial respiration, dehydrogenase activity; physical properties, viz. bulk density and water holding capacity.

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