Effect of organic manures on agronomic and economic performance of garden pea (Pisum sativum) and on soil properties

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Effect of organic manures on agronomic and economic performance of garden pea (*Pisum sativum*) and on soil properties

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ABSTRACT

A field experiment was conducted during 2005-07 at Almora, Uttarakhand to evaluate the effect of different organic manures (farmyard manure, poultry manure and vermicompost) and biofertilizers [*Rhizobium leguminosarum* + phosphorus-solubilizing bacteria (*Pseudomonas* sp.)] on yield of organically, grown garden pea [*Pisum sativum* subsp. *hortense* (Neilr.) Asch & Graebn] and on soil properties. Pod yields for all the treatments were significantly higher than the control. In both the years, application of farmyard manure 10 tonnes/ha + poultry manure and vermicompost each 1.5 tonnes/ha + biofertilizers gave the highest pod yields (7.02 and 7.52 tonnes/ha) and it was significantly superior to other treatments except farmyard manure 20 tonnes/ha + biofertilizers and application of farmyard manure 10 tonnes/ha + recommended NPK (20:26:33 kg/ha) through fertilizers. Application of farmyard manure 20 tonnes/ha + biofertilizers resulted in the lowest soil bulk density (1.19 Mg/m^3) compared to other treatments. The soil *p*H increased in all the treatments compared to control. Similarly, soil organic C was significantly higher in all the treatments (1.21–1.30%) except in poultry manure 5 tonnes/ha + biofertilizers compared to control (1.06%). Application of farmyard manure 10 tonnes/ha + recommended NPK, however, recorded significantly higher available N than plots under organic manures. Application of farmyard manure 10 tonnes/ha + recommended NPK being at par with application of farmyard manure 10 tonnes/ha + poultry manure and vermicompost each 1.5 tonnes/ha + biofertilizers registered significantly higher available P and K contents in soil compared to other treatments. Application of farmyard manure 10 tonnes/ha + recommended NPK gave highest net returns (₹ 63 295 /ha) compared to other treatments. However, all organic treatments except vermicompost 7.5 tonnes/ha + biofertilizers gave higher net returns (₹ 64 148 – 75 498/ha) than application of farmyard manure 10 tonnes/ha + recommended NPK, when a price premium (10–15%) was assigned to organic garden pea.

Key words: Biofertilizers, Economics, Garden pea, Organic farming, Organic manures, Soil properties

The concept of organic agriculture is receiving more attention, and organic food markets are also expanding rapidly in many countries including India. India has about 8 65 323 ha land under organic management (Yadav 2008). Agriculture in hills of Uttarakhand has largely remained organic by default. Majority of rural households in these hills lack the financial means to shift to intensive modern agricultural practices. For many (especially small and marginal) farmers the purchase of fertilizers and pesticides is constrained by their high costs. Furthermore, systems that depend upon sustainable use of locally available natural resources and farmers' knowledge and labour are far more likely to meet the needs and aspirations of resource-poor farmers than those which require costly or scarce external inputs (Parrott *et al*. 2006). As productivity of traditional systems in hills is often very low, organic agriculture could provide a solution to the food needs of poor farmers while relying on natural and human resources. However, there are no serious attempts so far to develop a package of practices for large-scale adoption of organic farming in these areas. Furthermore, there is a need for research on effect of organic manures on soil properties as many of the issues of sustainability are related to soil quality. Garden pea (*Pisum sativum* sub sp. *Hortens* L.) is an important vegetable of north-western Himalayan states occupying about 24 000 ha area with an annual production of 0.17 million tonnes. This trial assessed the effect of different organic manures and biofertilizers on the growth and yield of garden pea and on soil properties.

MATERIALS AND METHODS

The field experiment was conducted during the winter (*rabi*) seasons of 2005–07 at the experimental farm, Hawalbagh (29° 36' N, 79° 40' E and 1250 m above mean level), Almora, Uttarakhand. The soil was loamy clay having bulk density of 1.30 Mg/m^3, organic C content of 1.05%, available N 403 kg, available P 19.2 kg, available K 217 kg/

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ha and a *p*H of 6.7. This experiment included six treatments: T_1, farmyard manure 20 tonnes/ha + biofertilizers [*Rhizobium leguminosarum* + phosphorus-solubilizing Bacteria (*Pseudomonas* sp.)]; T_2, poultry manure 5 tonnes/ha + biofertilizers; T_3, vermicompost 7.5 tonnes/ha + biofertilizers; T_4, farmyard manure 10 tonnes/ha + poultry manure and vermicompost each 1.5 tonnes/ha + biofertilizers; T_5, integrated nutrient management (farmyard manure 10 tonnes/ha + recommended NPK – 20:26:33 kg/ha); and T_6, control. The experiment was laid out in a randomized complete block design with four replications. Composite samples of each manure were collected one week before application to plots and were analyzed for moisture and nutrient composition (Table 1). All the organic manures were applied on dry weight basis. Organic manures were applied by hand two weeks before sowing and were incorporated within 24 hr of application with a spade. The fertilizers were applied in integrated nutrient management plots at the time of sowing through urea, diammonium phosphate and muriate of potash.

Seeds of 'VL Ageti matar 7' garden pea were treated with biofertilizers (*Rhizobium leguminosarum* and *Pseudomonas* sp. each at 10 g/kg seed) before sowing in the plots as per treatment. The crop was sown at a seeding rate of 100 kg/ha and a row spacing of 30 cm on 13 November 2005 and 17 November 2006. Crop was irrigated four times. No chemical insecticides, fungicides or herbicides were used in keeping with organic standards. Weeds were managed by hand weeding once, followed by two hoeings using a manually operated wheel-hoe. The crop was not infested by any major insect-pests and diseases in both the years. However, azadirachtin [a *neem* (*Azadirachta indica*)-based formulation] and *Trichoderma viridae* were sprayed three times each as a prophylactic measure against insect-pests and diseases, respectively. The pods of garden pea were harvested in three pickings at weekly intervals. The crop received 55 mm and 237 mm rainfall during 2005–06 and 2006–07, respectively. The mean weekly maximum and minimum temperatures ranged between 28.9 and –2.1°C during 2005–06 and 29.1 and –2.9°C during 2006–07.

Soil samples were collected from the surface layer (0–15 cm) of all the plots before treatment applications and immediately after garden pea harvest in April 2007. Five random cores were taken from each plot with 5 cm diameter tube auger and bulked. Bulk density was determined by calculating the soil's dry weight (dried at 110°C) and volume of the soil sample. The soil *p*H was determined in 1:2.5 soil:water suspension. Oxidizable soil organic C was determined by the method of Walkley and Black, Kjeldahl N with a FOSS Tecator analyzer (Model 2200), and available P by the method of Olsen. Available K was determined with 1 N NH_4OAc and a flame photometer.

Economics of garden pea cultivation, as influenced by organic manures and integrated nutrient management, were calculated by considering the prevailing market price of garden pea (₹ 15/kg). A price premium ranging from 10 to 100% higher than that for conventional produce is already being realized in many organically produced crops in India (Chadha and Choudhary 2007). Therefore, economic evaluation of organic garden pea cultivation was also done by assuming different price premiums (0 to 15%) for the produce to assess whether garden pea can be profitably grown under organic farming conditions in comparison with integrated nutrient management.

RESULTS AND DISCUSSION

Crop growth

Plant height was significantly greater for all the treatments than those for the control (Table 2). In the first year, integrated nutrient management resulted in significantly higher plant height than other treatments. Among the organic manures, poultry manure 5 tonnes/ha + biofertilizers being at par with combined application of organic manures (T_4) and vermicompost 7.5 tonnes/ha + biofertilizers gave significantly higher plant height compared to farmyard manure 20 tonnes/ha + biofertilizers. In 2006–07, however, all the organic and integrated nutrient management treatments had similar effect on plant height. All the treatments improved yield attributes such as pods/plant, pod lengh and grains/pod significantly compared to control. Combined application of organic manures (T_4) being at par with other treatments gave significantly higher number of pods/plant and pod length in

Table 1 Moisture and nutrient contents of organic manures used in the experiment

Organic manure	Year	Moisture (%)	Total nutrient content						
			g/kg				mg/kg		
			N	P	K	Fe	Zn	Cu	Mn
Farmyard manure	2005–06	54	11.0	4.4	6.7	4.2	293	56	320
	2006–07	56	10.6	4.6	7.0	4.5	296	54	334
Poultry manure	2005–06	45	17.2	16.1	8.2	4.6	352	79	400
	2006–07	49	16.8	16.6	7.7	4.2	357	83	405
Vermicompost	2005–06	53	15.4	6.4	5.8	5.0	126	37	322
	2006–07	52	15.2	6.1	5.7	5.1	132	45	317

Table 2 Effect of treatments on growth and yield of garden pea

Treatment	Plant height (cm)		Pods/plant		Pod length (cm)		Grains/pod		Pod yield (tonnes/ha)		
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Mean
FYM 20 tonnes/ha + BF	56.9	75.3	7.6	7.8	7.0	7.6	5.6	4.5	+.72	7.35	7.04
PM 5 tonnes/ha + BF	64.1	72.2	7.3	7.0	7.0	7.4	5.4	4.2	5.76	6.45	6.11
VC 7.5 tonnes/ha + BF	59.8	74.8	6.7	6.6	6.7	7.3	4.7	4.4	5.06	6.06	5.56
FYM 10 tonnes/ha + PM and VC each 1.5 tonnes/ha + BF	62.4	75.1	8.0	8.1	7.2	7.7	5.8	5.0	7.02	7.52	7.24
FYM 10 tonnes/ha + 100% NPK	69.8	73.1	7.2	8.0	6.9	7.6	5.3	4.4	6.99	7.16	7.08
Control	42.6	5.30	5.4	3.0	6.0	6.4	3.6	3.3	2.99	1.41	2.20
LSD (*P*=0.05)	5.3	5.0	1.1	1.0	0.4	0.3	0.6	0.4	0.41	0.44	-

Y_1, 2005–06; Y_2, 2006–07; FYM, Farmyard manure; PM, poultry manure; VC, vermicompost; BF, biofertilizers

both years and grains/pod in 2005–06 compared to vermicompost 7.5 tonnes/ha + biofertilizers. However, in 2006–07, combined application of organic manures (T_4) resulted in significantly more number of grains/pod than other treatments. Pandey *et al*. (2006) also reported better crop growth and yield attributes of garden pea under organic management. Other organic (T_1, T_2 and T_3) and integrated nutrient management treatments had similar effect on number of grains/pod.

Green pod yield

There were significant differences among treatments with respect to pod yield in both years (Table 2). Pod yields for all the treatments were significantly higher than the control. In both the years, combined application of organic manures (T_4) gave the highest pod yields (7.02 and 7.52 tonnes/ha) and was significantly superior to other treatments except integrated nutrient management (T_5) and farmyard manure 20 tonnes/ha + biofertilizers. Increase in green pod yield may be attributed to better availability of nutrients, improved soil bulk density (Table 3) and marked improvement in crop growth and yield attributes (Table 2). The results obtained here are comparable with Pandey *et al*. (2006). Application of poultry manure 5 tonnes/ha + biofertilizers gave about 10% higher pod yield than vermicompost 7.5 tonnes/ha + biofertilizers. This might be due to higher P input (82 kg/ha) through poultry manure than vermicompost (47 kg/ha), as the P requirement of garden pea is higher (26 kg/ha) compared to N and K.

Soil properties

The soil bulk density was reduced significantly in all the treatments compared to control (Table 3). Application of farmyard manure 20 tonnes/ha + biofertilizers resulted in the lowest bulk density (1.19 Mg/m^3) closely followed by combined application of organic manures (T_4) which was mainly due to incorporation of organic manures with low bulk density. Similar results have also been reported by Pandey *et al*. (2006) and Gopinath *et al*. (2008). The soil *p*H also increased in all the organic treatments as compared to control. These results are similar to those in earlier studies of Gopinath *et al.* (2008) and Saha *et al.* (2010) where organic systems had higher *p*H levels in mildly acidic soils than their conventional counterparts. Soil organic C was also significantly increased in all the treatments except poultry manure 5 tonnes/ha + biofertilizers compared to control. Application of farmyard manure 20 tonnes/ha + biofertilizers resulted in the highest soil organic C (1.30%) closely followed by combined application of organic manures (T_4). Plots under integrated nutrient management (T_5), however, had significantly higher levels of available N than the treatments under organic manures (Table 3). Lower availability of plant nutrients in plots applied with organic manures was expected, due to the slower release rates of organic manures (Stockdale *et al*. 1993). Integrated nutrient management (T_5) being at par with combined application of organic manures (T_4) and farmyard manure 20 tonnes/ha +

Table 3 Effect of different treatments on soil properties after two years

Treatment	BD (Mg/m^3)	*p*H	Organic C (%)	Available nutrients (kg/ha)		
				N	P	K
FYM 20 tonnes/ha + BF	1.19	7.1	1.30	446	23.4	252
PM 5 tonnes/ha + BF	1.26	6.9	1.16	432	21.2	239
VC 7.5 tonnes/ha + BF	1.22	6.9	1.22	430	20.5	237
FYM 10 tonnes/ha + PM and VC each 1.5 tonnes/ha + BF	1.20	7.0	1.27	471	23.5	256
FYM 10 tonnes/ha + 100% NPK	1.22	6.9	1.21	492	24.4	259
Control	1.33	6.8	1.06	409	18.7	215
LSD (*P*=0.05)	0.05	0.1	0.13	16	1.7	11

FYM, Farmyard manure; PM, poultry manure; VC, vermicompost; BF, biofertilizers;
BD, bulk density

Table 4 Effect of different treatments on cost of cultivation and economic returns at different price premiums for the organic produce

Treatment	Cost of cultivation (₹/ha)	Net returns (₹/ha) at different price premiums				Benefit: cost ratio
		O%	5%	10%	15%	
FYM 20 tonnes/ha + BF	51 930	53 595	58 871	64 148	69 424	2.0
PM 5 tonnes/ha + BF	35 200	56 375	60 954	65 533	70 111	2.6
VC 7.5 tonnes/ha + BF	62 370	21 030	25 200	29 370	33 540	1.3
FYM 10 tonnes/ha + PM and VC each 1.5 tonnes/ha + BF	49 910	59 140	64 593	70 045	75 498	2.2
FYM 10 tonnes/ha + 100% NPK	42 830	63 295	63 295	63 295	63 295	2.5
Control	26 410	6 590	8 240	9 890	11 540	1.2

FYM, Farmyard manure; PM, poultry manure; VC, vermicompost; BF, biofertilizers;
₹ 400/tonne farmyard manure; ₹ 450/tonne poultry manure; ₹ 2 000/tonne vermicompost; ₹ 80/man-day

biofertilizers registered significantly higher levels of available P and K than other treatments.

Economics

In general, the cost of garden pea cultivation was higher with the use of different organic manures (T_1, T_3 and T_4) except poultry manure 5 tonnes/ha + biofertilizers compared to integrated nutrient management (Table 4). This was mainly due to higher costs of organic manures and more manual labour involved in transportation, spreading and incorporation of organic manures. The cost of cultivation was highest with vermicompost 7.5 tonnes/ha + biofertilizers due to higher input cost of the manure (₹ 2 000/tonne). Integrated nutrient management (T_5) gave the highest net returns compared to other treatments. These findings were in close conformity with the observations of Russo and Taylor (2006) where higher gross margin was reported for conventionally produced crops than for organic crops. Among the organic treatments, combined application of organic manures (T_4) gave higher net returns closely followed by poultry manure 5 tonnes/ha + biofertilizers. The latter treatment also gave higher benefit:cost ratio (2.6) compared to other treatments. This was mainly due to lower cost of cultivation with the use of poultry manure.

Combined application of organic manures (T_4) gave slightly higher net returns (₹ 64 593/ha) than integrated nutrient management (T_5) when 5% price premium was assumed for organic garden pea (Table 4). At 10% price premium for organic garden pea, combined application of organic manures (T_4) and poultry manure 5 tonnes/ha + biofertilizers gave higher net returns whereas, farmyard manure 20 tonnes/ha + biofertilizers gave similar net returns as that of integrated nutrient management. At 15% price premium for organic garden pea, all the treatments except vermicompost 7.5 tonnes/ha + biofertilizers gave 10–19% higher net returns than integrated nutrient management (T_5). This clearly suggests that organic garden pea cultivation may not be as profitable as that grown with integrated crop management practices, articularly during initial years when no price premium is available for organic garden pea. Russo and Taylor (2006) also opined that the costs of production could be mitigated if a price premium is assigned to the value of organically grown crops.

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