



Direct and residual effect of integrated nutrient management on garden pea (*Pisum sativum*) based crop sequence in Lahaul valley of Himachal Pradesh

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ABSTRACT

A field experiment was conducted on a sandy loam soil of Kukumseri (Lahaul & Spiti) on integrated nutrient management in garden pea (*Pisum sativum* L.) under dry temperate high hill conditions of Himachal Pradesh for the two consecutive summer seasons of 2006 and 2007. All six combinations of two crop sequences [Pea-Buckwheat (*Fagopyrum esculentum* Moench) and Pea-Sarson (*Brassica rapa* var. brown sarson)] and three sources of organic fertilizer (FYM @ 5 t/ha, *Rhizobium* inoculation (RI) @ 200 g/10 kg seed and FYM @ 2.5 t/ha + *Rhizobium*) as main plot treatments and three levels of chemical fertilizers (50%, 100% and 150% of recommended NPK i.e. 20:60:30 kg N, P₂O₅ and K₂O/ha, respectively) as sub-plot treatments were evaluated in a split plot design. The highest green pod yield of garden pea was obtained with an application of FYM 2.5 t/ha + *Rhizobium* in integration with 150% of recommended NPK through chemical fertilizers. However, from the view point of economics for the cropping systems (garden pea - buck wheat and garden pea-sarson) as a whole, combined use of FYM + *Rhizobium* (RI) along with 100% of recommended NPK was found to be as good as FYM + RI along with 150 kg N/ha NPK.

Key words : Buckwheat, Farmyard manure, Garden pea, INM, Quality, *Rhizobium*

Garden pea is recognized as a major cash crop in high hill dry temperate areas of Lahul by the growers particularly during summers when it is difficult to grow garden pea in plains. The consumers have a special preference for hill grown peas because of its characteristic flavour, sweetness and freshness. The green pods from the hilly areas of Himachal Pradesh are available at such a time (June-September) when these cannot be grown in the plains due to high temperature. As a result these are sold at a high premium bringing lucrative returns to the growers. There are several factors, which influence the yielding capacity and quality of a crop. Out of these, plant nutrition is very important in deciding the ultimate yield of the crop. The availability of plant nutrients in sufficient quantity is important for successful production of garden pea. Lahaul and Spiti district of Himachal Pradesh is the remotest area situated in north representing high hill temperate zone. There is only one cropping season (April-September/October), from onwards no crop can be grown as the land remains covered with snow. Unawareness among farmers for the judicious use chemical fertilizers in combination with organic and bio-fertilizer is the main cause of low

productivity and poor quality of green pods in this area. Plant nutrients besides increasing yield also plays a vital role in enhancing the quality traits in garden pea crop. Keeping this in view, the present experiment was conducted to optimize the fertility level to get maximum yield under garden pea-buckwheat/sarson cropping system in dry temperate high hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

The present field experiment was conducted during the summer seasons of 2006 and 2007 at Research Farm of Highland Agricultural Research and Extension, Centre Kukumseri (Lahaul & Spiti), CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (Himachal Pradesh) which is located at 2,734 metres amsl (32°44'55"N latitude and 76°41'23"E longitude) in the trans Himalayas where monsoon fails and rainfall is almost negligible. The soil of the experimental field was a sandy loam (62.3% sand, 25.5% silt and 12.2% clay), slightly above neutral in reaction (pH 7.6), had 325 kg/ha available nitrogen (medium), 30 kg/ha available phosphorus (high) and 327 kg/ha available potassium (high) and 7.62 g/kg organic carbon (high). The experiment was laid out in a split-plot design with three replications. Six combinations of two crop se-

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quences [Pea-Buckwheat (*Fagopyrum* spp.) and Pea-Sarson (*Brassica campestris*)] and three sources of organic/bio-fertilizer (FYM @ 5 t/ha, *Rhizobium* @ 200 g/10 kg seed and FYM @ 2.5 t/ha + *Rhizobium*) were the main plot treatments and three levels of chemical fertilizer [50%, 100% and 150% of recommended dose of NPK (20 : 60 : 30 kg N, P₂O₅ and K₂O/ha, respectively)] as sub-plot treatments. The garden pea variety "Palam Priya" was sown on 4th May and 10th May, 2006 and 2007, respectively with a row spacing of 30 cm and was harvested on 25th July and 12th August in 2006 and 2007, respectively. Buckwheat/sarson crops were sown on 1st August and 14th August, 2006 and 2007, respectively and harvested on 11th October and 26th October, 2006 and 2007, respectively. The organics/bio-fertilizers/chemical fertilizers were applied only to the main crop garden pea as per treatment. FYM was applied on oven dry weight basis in the plots as per their respective treatments before the sowing of crop. Seeds were inoculated with *Rhizobium* @ 200 g/10 kg seed. Crops were grown in accordance with the recommended package of practices.

RESULTS AND DISCUSSION

Growth, yield attributes and yield of garden pea

Growth of garden pea crop in terms of plant height and yield attributes like pod length and pods per plant were not significantly affected by crop sequence during both the years of study (Table 1). The highest values for plant

height, pod length, pods/plant, green pod yield and stover yield were obtained with a combined application of FYM and *Rhizobium* inoculation (RI), significantly higher than the application of FYM alone or *Rhizobium* inoculation (RI). FYM application gave significantly taller plants and longer pods than RI, but the two treatments were at par in respect of pods/plant and yield of green pods and stover. This would be expected since RI helps mostly in N fixation, while FYM supplied most plant nutrients. Garden pea responded well to fertilizer application and the increase due to each successive level of fertilizer applied was significant in all the characters studied and in grain and stover yield of garden pea; application of 150% RDF registered the highest values. Rana *et al.* (2009) also reported similar results. Organic/biofertilizer x inorganic fertilizer interaction was significant in respect of green pod yield of garden pea and showed that the difference between 50% and 100% of RDF was not significant with RI alone (Table 4). However, when FYM was applied, each successive level of fertilizer recorded a significant increase. These results bring out the importance of FYM which supplied secondary and micronutrients in addition to NPK. These results also bring out the need for integrated nutrient management in the production of garden pea in Hill soils. Results obtained in the present study are in accord with those of De *et al.* (2006), Reddy *et al.* (1998) and Srivastava and Verma (1984).

Table 1. Effect of crop-sequence, organic/bio-fertilizer and chemical fertilizers on growth, yield attributes, and yield of garden pea (t/ha)

Treatment	Plant height (cm)		Pod length (cm)		Pods per plant		Green pod yield (t/ha)		Stover yield (t/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
<i>Crop-sequence</i>										
Pea-Buckwheat	62.5	59.3	7.9	7.8	14.8	13.0	11.34	10.69	1.60	1.58
Pea-Sarson	62.6	59.4	7.9	7.8	15.2	13.2	11.41	10.71	1.60	1.59
SEm±	0.66	0.73	0.06	0.07	0.55	0.32	0.19	0.18	0.03	0.04
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
<i>Organic/bio-fertilizer</i>										
FYM 5 t/ha	61.8	58.7	7.8	7.7	14.5	12.6	11.18	10.45	1.56	1.54
<i>Rhizobium</i>	58.0	55.5	7.6	7.5	13.9	11.9	10.88	10.26	1.47	1.46
FYM 2.5 t/ha + <i>Rhizobium</i>	67.9	63.9	8.3	8.2	16.7	14.8	12.06	11.39	1.77	1.75
SEm±	0.81	0.89	0.08	0.08	0.67	0.40	0.24	0.22	0.04	0.05
CD (P=0.05)	1.8	2.0	0.2	0.2	1.5	0.9	0.53	0.50	0.09	0.10
<i>Chemical fertilizers</i>										
50% of RDF	53.6	50.7	7.3	7.1	12.1	10.4	10.22	9.60	1.31	1.30
100% of RDF	64.6	61.1	8.0	7.8	15.1	13.6	11.52	10.83	1.63	1.61
150% of RDF	69.6	66.2	8.3	8.4	18.0	15.3	12.39	11.68	18.6	18.4
SEm±	1.11	1.06	0.13	0.13	0.64	0.48	0.23	0.22	0.04	0.04
CD (P=0.05)	2.3	2.2	0.3	0.3	1.3	1.0	0.47	0.45	0.08	0.08

Recommended dose of chemical fertilizers: 20 kg N, 60 kg P₂O₅ and 30 kg K₂O/ha

Table 2. Effect of crop-sequence, organic/bio-fertilizer and chemical fertilizers on pea pod equivalent (PPEs), crude protein (%), total soluble solids (%), cost of cultivation, net returns ($\times 10^3$ ₹/ha) and returns per ₹ invested (₹) in garden pea in garden pea.

Treatment	Pea pod equivalent (PPEs) (t/ha)		Crude protein (%)		Total soluble solids (%)		Cost of cultivation ($\times 10^3$ ₹/ha) 2006 & 2007	Net returns ($\times 10^3$ ₹/ha)		Returns per ₹ invested (₹)	
	2006	2007	2006	2007	2006	2007		2006	2007	2006	2007
<i>Crop-sequence</i>											
Pea-Buckwheat	14.01	13.27	20.90	19.86	13.69	12.21	57.7	113.9	104.9	1.97	1.82
Pea-Sarson	14.08	13.17	20.91	19.83	13.90	12.36	57.4	113.9	103.0	1.98	1.79
SEm \pm	0.19	0.20	0.27	0.12	0.30	0.15		2.3	2.4	0.04	0.04
CD (P=0.05)	NS	NS	NS	NS	NS	NS		NS	NS	NS	NS
<i>Organic/bio-fertilizer</i>											
FYM 5 t/ha	13.77	12.89	19.70	18.47	13.64	12.14	60.4	107.6	97.0	1.78	1.60
<i>Rhizobium</i>	13.26	12.48	21.20	20.21	13.16	11.71	54.7	107.2	97.7	1.96	1.79
FYM 2.5 t/ha+ <i>Rhizobium</i>	15.10	14.29	21.80	20.86	14.58	13.02	57.7	126.8	117.0	2.20	2.03
SEm \pm	0.23	0.24	0.33	0.15	0.37	0.19		2.8	2.9	0.05	0.05
CD (P=0.05)	0.51	0.54	0.74	0.34	0.82	0.42		6.3	6.4	0.11	0.11
<i>Chemical fertilizers</i>											
50% of RDF	12.28	11.53	20.26	19.09	12.16	10.81	56.8	93.0	84.0	1.64	1.48
100% of RDF	14.31	13.46	21.02	20.02	14.18	12.63	57.6	117.1	106.8	2.04	1.86
150% of RDF	15.54	14.67	21.43	20.43	15.04	13.43	58.4	131.5	120.9	2.26	2.07
SEm \pm	0.24	0.21	0.38	0.37	0.24	0.21		2.9	2.5	0.05	0.04
CD (P=0.05)	0.49	0.43	0.78	0.76	0.50	0.44		5.9	5.1	0.10	0.09

Crude protein and total soluble solids in garden pea

Crop-sequences did not significantly affect quality parameters such as crude protein and total soluble solids during both the years (Table 2). As regards crude protein content in garden pea, RI showed its distinct advantage and RI with or without FYM significantly increased crude protein (Table 2). These results show the contribution of RI in augmenting nitrogen supply to garden pea. However, as regards total soluble solids (TSS), combined application of FYM and RI gave significantly higher values than FYM alone or RI. Application of 100% or 150% NPK were at par and gave significantly higher crude protein in garden pea than 50% NPK. However, TSS significantly increased with each successive level of NPK. The present results are in conformity with those of Kanaujia *et al.*, (1997) and Srivastava and Verma (1984).

Economics and productivity

The two cropping systems studied, namely, garden pea-buckwheat and garden pea-sarson did not differ significantly in respect of economics and productivity (Table 3). Combined application of FYM and RI gave the highest net returns and pea pod equivalents (PPEs), significantly higher than FYM and RI applied individually, which were at par. However, in respect of return per rupee invested, FYM alone was least profitable, significantly inferior to R,

which in turn was significantly inferior to the combined application of FYM and RI. As regards NPK, net return, per rupee invested in fertilizer and PPEs were the highest with 150% NPK and the least with 50% NPK.

Residual effects

Combined use of FYM and RI in pea left a significant residual effect on succeeding buckwheat and sarson; significantly more than their individual application (Table 5). In the case of grain yield of buckwheat in both the years and of sarson in 2006, FYM + RI was significantly superior to FYM, which in turn was superior to RI. The highest straw yield of both buckwheat and sarson was also obtained with FYM + RI, significantly more than FYM or RI alone. Residual effect of NPK applied to pea was the highest with 100% NPK and least with 50% NPK; the differences between three levels of NPK were significant. The interaction effects of organic/biofertilizers \times NPK on the cropping systems per se (Table 3) showed that net return, return per rupee invested and pea pod equivalents obtained with FYM + RI + 150% NPK and FYM + RI + 100% NPK were not significantly different.

Hence, it is concluded that 50% NPK can be saved by applying 100% NPK in combination with 2.5 t FYM/ha (dry weight basis) and inoculating the pea seed with *Rhizobium*.

Table 3. Interaction effect of organic/bio-fertilizer and chemical fertilizers on green pod yield (t/ha), pea pod equivalent yield (t/ha), net returns (₹/ha) and returns per ₹ invested (₹) in garden pea based cropping sequence

Treatment	Green pod yield (t/ha)		Pea pod equivalent yield (t/ha)		Net returns ($\times 10^3$ ₹/ha)		Returns per ₹ invested (₹)														
	2006	2007	2006	2007	2006	2007	2006	2007													
FYM 5 t/ha	10.22	10.06	10.38	9.54	9.46	12.29	11.94	11.50	11.21	11.90	90.3	91.6	80.7	82.8	88.4	1.51	1.7	1.71	1.35	1.54	1.56
Rhizo- bium	2.5	2.5	2.5	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha	5 t/ha
FYM 5 t/ha + Rhizo- bium	11.18	10.65	12.74	10.41	10.04	12.04	13.80	13.03	12.89	12.24	15.25	107.9	104.4	139.1	96.9	128.7	1.79	1.91	2.41	1.6	1.74
100% of RDF	12.16	11.95	13.05	11.40	11.29	12.35	15.21	14.82	14.29	13.98	15.73	124.6	125.6	144.2	113.5	133.9	2.03	2.27	2.47	1.85	2.08
150% of RDF																					
CD (P=0.05)																					
Fertilizer levels at the same organic/bio-fertilizer level	0.82		0.78		0.85		0.74		0.81		0.86		10.2		8.9		10.4		9.7		0.18
Organic/bio-fertilizer level at the same or different fertilizer levels			0.81		0.86		0.81		0.86		0.86		10.4		9.7		10.4		9.7		0.17

Table 4. Residual effect of organic/bio-fertilizer and chemical fertilizers on grain and straw yields (t/ha) of buckwheat and sarson

Treatment	Buckwheat grain yield (t/ha)		Buckwheat straw yield (t/ha)		Sarson grain yield (t/ha)		Sarson straw yield (t/ha)	
	2006	2007	2006	2007	2006	2007	2006	2007
<i>Organic/bio-fertilizer</i>								
FYM 5 t/ha	1.709	1.657	2.578	2.381	0.783	0.720	1.601	1.544
Rhizobium	1.524	1.461	2.504	2.302	0.741	0.671	1.520	1.462
FYM 2.5 t/ha + Rhizobium	2.108	2.046	2.945	2.762	0.879	0.819	1.761	1.699
SEm±	0.047	0.043	0.038	0.048	0.005	0.014	0.025	0.013
CD (P=0.05)	0.186	0.167	0.151	0.190	0.021	0.054	0.097	0.050
<i>Chemical fertilizers</i>								
50% NPK	1.324	1.263	2.279	2.108	0.644	0.594	1.410	1.354
100% NPK	1.878	1.810	2.765	2.554	0.828	0.765	1.678	1.608
150% NPK	2.139	2.092	2.983	2.783	0.931	0.852	1.794	1.742
SEm±	0.040	0.047	0.048	0.046	0.015	0.013	0.026	0.028
CD (P=0.05)	0.123	0.145	0.147	0.141	0.046	0.040	0.082	0.086

Note: No organic/bio-fertilizer or chemical fertilizer has been applied in buckwheat/sarson crops

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