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Productivity and profitability of pea-summer squash cropping system regarding integrated nutrient management under high hill cold desert conditions

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Abstract

A field experiment was conducted during 2006 and 2007 to evaluate the effect of organic sources of plant nutrients viz. FYM (Farmyard manure), *Rhizobium* (P-HP-3 strain), Phosphate solubilizing bacteria (PSB), FYM+*Rhizobium* and FYM+PSB along with chemical fertilizers in pea-summer squash cropping system. Application of FYM @ 2.5t/ha+*Rhizobium* resulted in significantly superior yield contributing characters of pea as well as summer squash crop. Hence, productivity of pea was highest in this treatment giving 131.6 q/ha of green pod yield. Residual effect on summer squash with FYM @ 2.5t/ha+*Rhizobium* when applied to pea produced 142.9 q/ha summer squash crop which consequently resulted in significantly higher pea equivalent yield (PEY) of 203 q/ha and system productivity of 1.11 q/ha/day. This effect was manifested in getting higher gross and net returns of the system (Rs. 246085 and 180350/ha, respectively). Application of 150% NPK through chemical fertilizers in pea and no application of fertilizers to summer squash resulted in significantly higher green pod yield of pea (141.0 q/ha) and summer squash 167.2 q/ha and higher PEY of 224.6 q/ha giving net profit of Rs. 205198/ha in the system.

Key words: Pea, summer squash, FYM, *Rhizobium,* phosphate solubilizing bacteria, chemical fertilizers.

Introduction

The cold desert (dry temperate) zones of Himachal Pradesh come under the trans-Himalayan zone, which lies in rain shadow of the main Himalayan range and is usually described as high altitude cold desert (snowbound). These areas remain covered with snow for about six months during winter season i.e. October to March and remain cut off from rest of the world. Hence crops can be grown only in summer season i.e. April to September. Farmers get only one growing season and monocropping system is followed in these areas. Peculiar climate of this zone enables farmers to grow all *kharif* and *rabi* season crops simultaneously in the same season same fields. Crop intensification is possible either through intercropping or crop sequences in the short period of six months. The agro- climatic conditions are most congenial for the production of disease free commercial high value off-season vegetable cash crops. Being single seasoned areas, farmers have to depend upon the integrated farming systems to harness the natural resource managements. Pea is the main commercial off-season vegetable crop. In some places farmers adopt pea-pea, pea-buckwheat or pea-sarson crop sequences. Variety 'Palam priya' of pea is performing very well in the valley (Sharma *et al.* 2007). However, with continuous growing of pea as monocropping some diseases may appear resulting in low productivity. As in the valley the only source of other fresh vegetables is lower parts of Himachal Pradesh and Punjab. There is immense demand in the valley itself and also in lower parts of H.P. being off-season vegetables and lack of package of practices of growing pea using organic sources in these cold desert areas of H.P., the present study was conducted to evaluate different sources of plant nutrients along with chemical fertilizers on pea-summer squash (summer squash - a new introduction) cropping system.

Materials and Methods

A field experiment was conducted at CSK Himachal Pradesh Krishi Vishvavidyalaya, Highland Agricultural Research and Extension Centre, Kukumseri (Lahaul and Spiti) during 2006 and 2007. Fifteen treatment combinations of five organic sources of plant nutrients *viz.* FYM @ 5 t/ha (Oven dry weight basis) (FYM having 0.5 N, 0.2 P and 0.5 K), *Rhizobium* (Indigenous strain from Lahaul and Spiti (Jhalma) P-HP-3) (@200g/10 kg seed), Phosphate Solubilizing Bacteria(PSB) (Indigenous strain from Kangra)

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(@200g/10 kg seed), FYM @ 2.5 t/ha + *Rhizobium* and FYM @ 2.5 t/ha + PSB and three fertility levels *viz.* 50, 100 and 150 per cent of the recommended (20:60:30 kg/ha) N,P_2O_5 and K_2O were studied on pea crop and their residual effect on summer squash crop. Half dose of nitrogen and full doses of phosphorus and potassium were used at sowing time of pea and remaining half dose of nitrogen was applied after hoeing (40-50 DAS). The experiment was laid out in Split-plot design with three replications. In Pea (*Pisum sativum* L.) – Summer squash (*Cucurbita pepo* L.) crop sequence, pea (var. Palam Priya) was sown on May 4 and May 11 during 2006 and 2007 with 30 X 5 cm spacing and Summer Squash (var. Australian green) was transplanted on July 26 and August 9 during 2006 and 2007 respectively using 90 cm X 60 cm spacing. The nursery of summer squash was raised in poly tubes under the poly house conditions. The plot size was 3.0 m X 2.7 m = 8.1 m^2 during both the years of study. For weed management in pea, pendimethalin @ 1.2 kg a.i. /ha was used as pre emergence herbicide and one hoeing was done 40-50 days after sowing. Irrigation was done as and when required by sprinkler irrigation system using the glacier gravity water. Field experiment was conducted at Highland Agricultural Research and Extension Centre, Kukumseri (2772 m above mean sea level), Lahaul and Spiti during *kharif* seasons of 2006 and 2007. The soil was sandy loam in texture and neutral in reaction (pH 6.9). The initial soil contained 2.3% organic carbon, available nitrogen 248 kg/ha, phosphorus 46.3 kg/ha and potassium 171 kg/ha, respectively. Plant height (cm) was recorded before first picking. Number of pods/plant, Number of grains/pod and pea shelling percentage was recorded at the time of picking, following formula was used for the calculation of pea shelling percentage.

$$\text{Shelling percentage} = \frac{\text{Weight of grain}}{\text{Total weight of pod}} \times 100$$

Number of leaves/plant, number of fruits/plant, fruit weight (g), fruit diameter (cm^2) were recorded at the time of picking. Following formulae were used for calculating various parameters:

$$\text{Pea equivalent yield (q/ha.)} = \frac{\text{Sale rate of summer squash (Rs.)}}{\text{Sale rate of pea (Rs.)}} \times \text{Yield of summer squash (q/ha)}$$

$$\text{Productivity (q/ha/day)} = \frac{\text{Yield (q/ha)}}{\text{No. of days taken by crop in half year (182.5 days)}}$$

Gross return (Rs.) was calculated on the basis of sale rate of crop. Total cost was calculated at the purchase sources. Net return (Rs.) per ha was worked out on the basis of following formula:

$$\text{Net returns (Rs./ha)} = \text{Gross Return (Rs/ha)} - \text{Total Cost (Rs./ha)}$$

$$\text{Economic Efficiency (Rs./ha/day)} = \frac{\text{Net Returns (Rs./ha)}}{\text{No. of days taken by crop in half year (182.5 days)}}$$

$$\text{Benefit: Cost ratio} = \frac{\text{Gross Returns (Rs./ha)}}{\text{Total Cost (Rs./ha)}}$$

***Method used for seed inoculation*:** Ten per cent gur solution was prepared, which served as a sticker for *Rhizobium* and PSB cells to seeds. Then *Rhizobium* and PSB cultures (@200g /10 kg seed) were added to sticker solution and mixed thoroughly. This culture slurry was poured on seeds and again mixed thoroughly. Treated seeds were spread uniformly for drying on a gunny bag in shaded place. Now these inoculated seeds were ready for sowing.

Results and Discussion

Yield attributes of pea

Application of FYM @ 2.5 t/ha + *Rhizobium* resulted in significantly more number of pods per plant, number of grains per pod and higher shelling percentage of pea. In case of plant height, application of FYM @ 5 t/ha produced significantly taller plants than all other treatments. Whereas, FYM @ 2.5 t/ha + *Rhizobium* and FYM @ 2.5t/ha+PSB remaining at par with each other followed it (Table 1).

Effect of NPK levels on yield attributes of pea in Table 1 showed that the entire yield attributes were significantly affected by applying increased doses of NPK beyond recommended dose. Application of 150% NPK was followed by 100% NPK. Significantly lower values of all the yield attributes were recorded with the application of 50% NPK doses. The increase to the range of 5.5 to 8.2% was observed in the yield attributes with the application of 150% over 100% NPK. Bindra and Thakur (2005) and Rana *et al.* (2006) also observed similar findings in pea and crop sequences with pea.

Table 1. Effect of organic/bio-fertilizers and NPK levels on yield attributes of pea (Pooled over 2006 and 2007)

Treatment	Plant height (cm)	No. of pods/plant	No. of grains/ pod	Shelling (%)
Organic/bio-fertilizers				
FYM @ 5 t/ha	69.8	11.1	7.1	56.4
Rhizobium	66.3	11.0	7.3	57.9
PSB	66.0	10.1	6.6	54.4
FYM @ 2.5t/ha+*Rhizobium*	68.2	11.7	7.6	59.1
FYM @ 2.5 t/ha + PSB	68.1	10.9	7.0	55.6
CD (P=0.05)	0.65	0.13	0.11	0.52
NPK-Levels				
50%	61.0	9.5	6.5	51.7
100%	69.1	11.3	7.2	56.7
150%	72.9	12.0	7.6	61.7
CD (P=0.05)	0.6	0.2	0.1	0.6

Yield attributes of summer squash

Yield contributing characters of summer squash were influenced by the residual effect of treatments imposed on pea crop. FYM @ 2.5 t/ha + *Rhizobium* applied to pea crop significantly increased the height of summer squash plants bearing more number of leaves per plant , more number of fruits per plant, more fruit diameter and more fruit weight (Table 2). However, application of *Rhizobium* alone to pea and its residual effect on summer squash also remained at par with this treatment in case of number of fruits /plant. FYM @ 5 t/ha to pea remained at par with these two treatments in case of leaf diameter and number of fruits/plant.

It was observed that 150% NPK levels when applied to pea crop resulted in more residual effects than 100% and 50% NPK doses. All the yield attributes of summer squash were significantly influenced with 150% NPK (Table 2). Plants were significantly taller having higher number of leaves per plant with larger leaf diameter, more number of fruits per plants, more fruit diameter and fruit weight with 150% NPK to pea as compared to other levels of NPK under study. The increase in all the yield attributes with 150% NPK was in the range from 8.6 to 33.3 % over 100% NPK application.

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Table 2. Residual effect of organic/bio-fertilizers and NPK levels on yield attributes of summer squash in pea-summer squash cropping system (Pooled over 2006 and 2007)

Treatment	Plant height (cm)	No. of leaves/plant	Leaf diameter(cm)	No. of fruits/plant	Fruit diameter (cm)	Fruit weight (g)
Organic/bio-fertilizers						
FYM @ 5 t/ha	16.7	17.7	315.4	1.9	290.9	868.9
Rhizobium	17.2	18.6	298.4	2.1	275.0	840.4
PSB	15.4	16.7	271.8	1.6	262.5	754.6
FYM @ 2.5t/ha+*Rhizob.*	18.4	21.2	306.7	2.1	298.1	936.3
FYM @ 2.5 t/ha + PSB	17.3	17.4	282.7	1.7	280.1	834.9
CD (P=0.05)	0.3	0.3	7.4	0.2	4.5	20.3
NPK-Levels						
50%	14.2	16.0	233.2	1.5	197.7	619.5
100%	17.3	18.6	314.9	1.8	308.7	899.4
150%	19.5	20.2	336.8	2.4	337.6	1022.2
CD (P=0.05)	0.3	0.4	6.8	0.1	4.8	14.5

Productivity of pea-summer squash cropping system

It was observed that pea green pod yield was significantly highest in the treatment receiving FYM @ 2.5 t/ha + *Rhizobium* (131.6 q/ha) than all other treatments of organics and bio-fertilizers. This treatment was followed by FYM @ 5 t/ha (128.4 q/ha). Whereas, *Rhizobium* alone and FYM @ 2.5 t/ha + PSB treatments remained statistically at par with each other but resulted in lower green pea yields (Table 3 & Fig.1). Rana *et al.* (2006) studied the positive response of *Rhizobium* strains in the soils of these areas, resulting in higher crop yields than no inoculation. Similarly, Danielle *et al.* 2003 observed the encouraging effects of *Rhizobium* on pea crop. Decreasing FYM to 2.5t/ha but adding *Rhizobium* gave up to 2.5% more pea green pod yield compared to FYM @ 5t/ha alone. Similarly, compared to application of *Rhizobium* alone, the increase in pea green pod yields to the tune of 9.3% was observed with the addition of FYM @ 2.5t/ha along with *Rhizobium.* Whereas, when PSB was applied in place of *Rhizobium* along with FYM @ 2.5t/ha the green pod yields decreased to the tune of 8.13& on the pooled data basis of two years.

Table 3. Effect of organic/bio-fertilizers and NPK levels on productivity of pea - summer squash cropping system (Pooled over 2006 and 2007)

Treatment	Yield (q/ha)		Pea equivalent yield (q/ha)	System Productivity (q/ha/day)
	Pea	Summer squash		
Organic/bio-fertilizers				
FYM @ 5 t/ha	128.4	127.6	192.2	1.05
Rhizobium	120.4	124.8	182.8	1.00
PSB	115.3	114.6	172.6	0.95
FYM @ 2.5t/ha+*Rhizobium*	131.6	142.9	203.0	1.11
FYM @ 2.5 t/ha + PSB	121.7	127.6	185.5	1.02
CD (P=0.05)	2.2	3.0	3.1	0.02
NPK-Levels				
50%	94.4	78.0	133.4	0.73
100%	135.0	137.4	203.7	1.12
150%	141.0	167.2	224.6	1.23
CD (P=0.05)	2.3	3.5	2.9	0.02

Residual effect of organic and bio-fertilizers was studied on succeeding summer squash crop in the same season. It was observed that application of FYM @ 2.5 t/ha + *Rhizobium* to pea crop resulted in significantly highest yield of summer squash (142.9 q/ha) followed by FYM @ 5 t/ha and FYM @ 2.5 t/ha + PSB. The later two treatments remained at par with each other. Residual effect with the application of *Rhizobium* along with FYM @ 2.5t/ha was more and its positive effect was manifested in getting significantly higher summer squash yields. Reducing FYM to 2.5t/ha from 5t/ha but adding *Rhizobium* resulted in 12.0% higher summer squash yields than application of only 5t/ha FYM. When compared with application of only *Rhizobim* to pea, it gave 14.5% less yields of summer squash than adding FYM @ 2.5t/ha to *Rhizobium*. Comparing residual effect of PSB instead of *Rhizobium* along with 2.5t/ha FYM, it again reduced summer squash yields to the tune of 12.0%. In case of pea equivalent yield the treatment receiving FYM @ 2.5 t/ha + *Rhizobium* resulted in significantly higher pea equivalent

yield (203.0 q/ha) followed by FYM 5t/ha. Application of PSB alone resulted in lowest PEY. Similar trend of results were observed for system productivity as that obtained for pea equivalent yield.

Effect of NPK showed that application of 150% of recommended NPK to pea crop resulted in significantly highest green pod yield of pea (141.0 q/ha) followed by recommended dose of NPK. The yield advantage of 4.44% was observed over 100% NPK. Significantly lowest green pod yield was recorded with application of 50% NPK levels (Table 3 & Fig.2). Similarly, the residual affect of 150% NPK to pea resulted in significantly higher summer squash yields. The yield advantage of 21.69% was recorded while increased the NPK level by 50% over recommended. Further, pea equivalent yield and system productivity were also significantly higher with the application of 150% NPK doses to pea crop. With incremental doses of 50% over recommended increased the pea equivalent yields by 10.26% and system productivity by 9.82%, respectively.

Profitability of pea - summer squash cropping system

Application of FYM @ 2.5 t/ha + *Rhizobium* to pea and residual effect on summer squash resulted in significantly higher gross returns (Rs.246085/ha), net returns (Rs.180350/ha), economic efficiency (Rs.988.2/ha/day) and B: C ratio Rs.3.74 for pea - summer squash cropping system. *Rhizobium* alone has followed this treatment except in case of B: C ratio (Table 4) (Fig. 3). However, application of only *Rhizobium* to pea significantly decreased net returns which were 14.08% less compared to addition of FYM @ 2.5t/ha along with *Rhizobium*. Similarly, net returns decreased by 11.91% with the application of only FYM @ 5t/ha compared to half quantity of FYM along with *Rhizobium*.

Fig.1 Effect of Organic/Bio-fertilizers on Pea Equiv
Yield of Pea - Summer Squash Cropping Syster

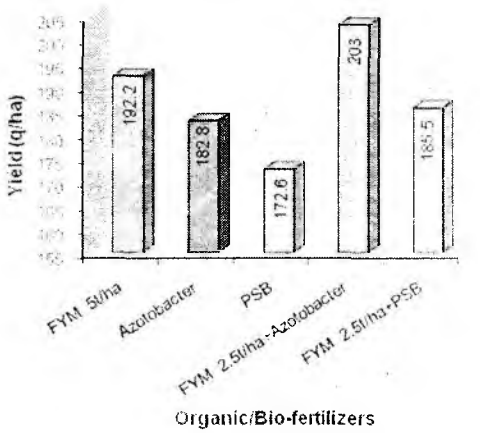
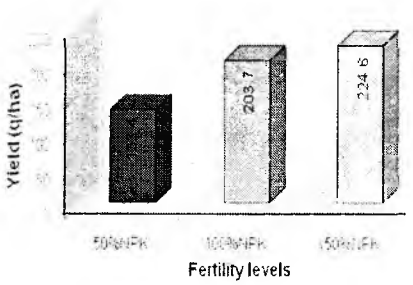


Table 4. Effect of organic/bio-fertilizers and NPK levels on profitability of pea - summer squash cropping system (Pooled over 2006 and 2007)

Treatment	Gross returns (Rs./ha)	Net returns (Rs./ha)	Economic efficiency (Rs./ha/day)	B:C ratio (Rs.)
Organic/bio-fertilizers				
FYM @ 5t/ha	233063	161153	883.0	3.24
Rhizobium	221695	158085	866.2	3.48
PSB	209283	145682	798.2	3.28
FYM @ 2.5t/ha+*Rhizobium*	246085	180350	988.2	3.74
FYM @ 2.5 t/ha + PSB	224908	159173	872.2	3.42
CD (P=0.05)	3794.8	3791.7	20.8	0.06
NPK-Levels				
50%	162000	96677	529.7	2.48
100%	246911	180791	990.6	3.74
150%	272109	205198	1124.3	4.07
CD (P=0.05)	3535.9	3541.1	19.4	0.05

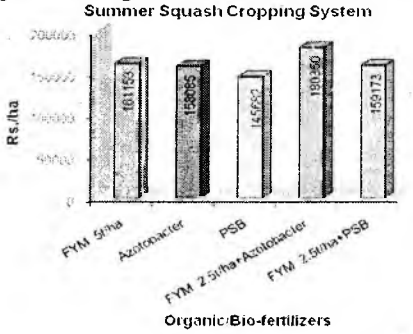
Sale rate : Rs./kg Summer squash= 6.0 Pea = 12.0
Cost : Rs./kg Summer squash= 500.0 Pea = 44.0 IFFCO= 8.48

Fig.2 Effect of Fertility levels on Pea Equivalent Yield of Pea - Summer Squash Cropping System



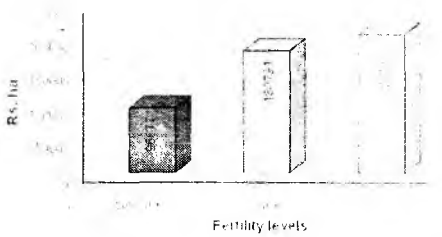
Observations recorded for economics parameters of pea-summer squash cropping system as influenced by levels of NPK showed (Table 4 & Fig. 4) that increasing doses of NPK from 100 to 150% significantly increased the gross and net returns, economic efficiency and B: C ratio. Significantly lowest values were recorded

Fig.3 Effect of Organic/Bio-fertilizers on net returns of Pea - Summer Squash Cropping System



with the application of 50% NPK. Accordingly 13.5% higher net returns were obtained with the increase of 50% NPK over recommended in pea-summer squash system as whole. Economic efficiency and B:C ratio of the system were also

Fig.4 Effect of Fertility levels on Net Returns of Pea - Summer Squash Cropping System



increased to the tune of 13.5 and 8.82% with 150% NPK as against recommended dose of NPK. Hence for obtaining higher returns of Pea-summer squash cropping system under high hill cold desert conditions application of FYM @ 2.5t/ha along with *Rhizobium* and 150% NKP were found to be quite effective.

Conclusion

Pea green pod yields were significantly higher with FYM @ 2.5 t/ha + *Rhizobium*. Residual effect of organic/bio-fertilizers on summer squash showed that same treatment resulted in higher summer squash yields. Pea crop fertilized with 150% NPK gave significantly higher pea green pod yields, and higher succeeding crop summer squash yields. Hence, pea - summer squash crop sequence with growing of pea by applying FYM @ 2.5 t/ha + *Rhizobium* along with 150% NPK followed by summer squash on residual fertility is the most remunerative cropping system.

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