Himachal Journal of Agricultural Research 34 (1):30-33, 2008

Effect of phosphate solubilizing microorganisms and *Azotobacter* inoculations on yield and quality of pea (*Pisum sativum* L.)

G. P. Upadhyay and Rajesh Kaushal
Department of Soil Science and Water Management
Dr. Y. S. Parmar University of Horticulture and Forestry, Solan-173 230, India.

Abstract

A field experiment was conducted for two consecutive Rabi seasons of the year 2005-06 and 2006-07 on gravelly loam soil (Typic Eutrochrept) at departmental research farm of UHF, Nauni, Solan (H.P.) to work out the effectiveness of phosphate solubilizing microorganisms (PSM) and *Azotobacter* inoculation alone and in combination with farmyard manure (FYM) on yield and quality of green peas (Azad P-I) and soil properties. The results revealed that the PSB and *Azotobacter* inoculation with FYM application significantly improved soil properties, microbial counts and yield and quality of green peas. Keeping in view the contribution of soil organic matter for productivity and soil quality, the FYM application with inoculants played a significant role in building up of organic carbon content which increased from 12.3 to 14.9 g kg^{-1} of soil. Green pod yield of peas was found the highest (40.63 and 41.04 q ha^{-1}, during 1st and 2nd year of experimentation, respectively) in treatment comprising *Azotobacter* + PSM + FYM, compared to control treatment (9.25 and 9.29 q ha^{-1}, respectively). Total soluble sugar (TSS) also increased significantly under this treatment. Total microbial count recorded under this treatment was 603 and 604 x 10^4 cfu g^{-1} soil during the year 2005-06 and 2006-07, respectively, compared to control (357 and 360 x10^4 cfu g^{-1} soil).

Key words: Green peas, *Azotobacter*, phosphate solubilizing microorganisms, microbial counts.

Introduction

Himachal Pradesh is almost wholly mountainous and undulating hilly terrain occupying an area of 55,673 sq kms and only 65 per cent of the total geographical area is available for cultivation. Out of this area, "net area sown" and "current fallow" account for only 21 per cent. There is hardly any scope for mechanized farming due to preponderance of small holding (average 1.21 ha) and terraced fields. Against all these odds, the farmers of state are constantly endeavouring to fully exploit the agricultural potential to increase food production and also to supplement the income by producing quality cash crops like potato, ginger and off-season vegetables viz. green peas, cabbage, cauliflower and capsicum etc. Green pea is the major vegetable crop of the state and is grown in an area of 10,300 hectares with a production of 85 thousand metric tones (average 8.25 metric tones ha^{-1}) with all possible inputs of fertilizers and manures according to the estimates of 1996-97 (Department of Agriculture, Government of Himachal Pradesh). An approach involving the inputs of organic manure and bio-fertilizers to boost the organic production of peas keeping the socio-economic aspects of the farmers is the only viable alternative. Since organic P has been identified as a major source of bio-available phosphate (Tarafdar *et al.*, 2001 and 2002), therefore, the experiment was conducted to study the effect of organic manure and bio-fertilizers (PSM and *Azotobacter*) on soil properties, yield and quality of green peas.

Material and Methods

A field experiment was conducted at departmental research farm of Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan ($30^0$50'30" to 30^0 52'0" N latitude; $77^0$8'30" to $77^0$11'30" E longitude; 1150m asl) for two consecutive Rabi seasons of the year 2005-06 and 2006-07. The soil was deep alluvial loam (Typic Eutrochrept) containing gravels and other properties are mentioned in table 1. About 75% of mean annual rainfall of 1150 mm is generally received during summer months from late June to September. The remaining rain is received during water-deficit winter months from January to March with occasional snowfall and hails. Rest of the months receives no rain and found completely dry.

The five treatments; T_1 (Control), T_2 (*Azotobacter*), T_3 (PSM), T_4 (*Azotobacter* + PSM + FYM) and T_5 (FYM 20 t ha^{-1}) consisting of combinations of organic sources of nutrients and seed treatment with phosphate solubilizing microorganisms (PSM) and *Azotobacter* in peas were tested in a randomized block design. The seeds were properly treated with both the cultures by making thick slurry in pure water with 20% gur jaggery and dried in shade before sowing. No chemical fertilizers were applied in the experiment keeping in view to the concepts of organic farming. Green pod yield and quality parameter (TSS) recorded periodically at the time of each harvest. Soil pH and EC (soil/water ratio 1:2.5) were determined by a glass electrode and a conductivity bridge, respectively, while organic C, available N, P and K were analyzed by using procedures as described by Jackson (1973). Microbial counts were assayed by serial dilution and pour plate method as outlined by Subba Rao (1999) by using nutrient agar (NA), potato dextrose agar (PDA), Jensen's medium for *Azotobacter* and Pikovsakaya's medium for PSM.

Table 1. Initial characteristics of the experimental soil

Parameters	Quantity	
	2005-06	2006-07
Texture	Gravelly loam	Gravelly loam
pH (Soil : Water, 1:2.5)	6.95	7.01
Electrical conductivity (dSm^{-1})	0.35	0.36
Organic C ($g\ kg^{-1}$)	12.6	12.3
Available N ($kg\ ha^{-1}$)	256.4	266.8
Available P ($kg\ ha^{-1}$)	59.2	63.4
Available K ($kg\ ha^{-1}$)	286.4	291.5
Microbial counts in different growth medium: ($x\ 10^4$ cfu g^{-1} soil)		
Nutrient agar (NA)	170	165
Potato dextrose agar (PDA)	28	31
Jensen's medium (*Azotobacter*)	59	51
Pikovsakaya's medium (PSM)	105	110

Results and Discussion

Soil properties

The influence of various treatments on soil pH was although not significant but it was found slightly lower than the control treatment. However, electrical conductivity of the soil was significantly influenced and ranged between 0.34 to 0.82 and 0.37 to 0.83 dSm^{-1} during the year 2005-06 and 2006-07, respectively, and recorded the highest value under treatment comprising of *Azotobacter* + PSM + FYM (Table 2). Application of FYM @ 20 t ha^{-1} has significant contribution in organic C buildup during both the years and recorded the highest values of 14.4 and 14.9 g kg^{-1} soil during the year 2005-06 and 2006-07, respectively. Available N (334 and 339 kg ha^{-1}) was also recorded the highest values under the treatment *Azotobacter* + PSM + FYM during both the years and was found highly significant compared to other treatments. The treatment receiving manure and microbial inoculation coupled with favourable soil conditions might have helped in mineralization of soil N leading to building up of available N content (Santhy *et al.*,1998; Verma *et al.* , 2000).

Table 2. Effect of phosphate solubilizing bacteria and Azotobactor inoculation on soil properties

Treatments	2005-06						2006-07					
	pH (1:2.5)	EC (dSm^{-1})	Org C ($g\ kg^{-1}$)	Avail N ($kg\ ha^{-1}$)	Avail P ($kg\ ha^{-1}$)	Avail K ($kg\ ha^{-1}$)	pH (1:2.5)	EC (dSm^{-1})	Org C ($g\ kg^{-1}$)	Avail N ($kg\ ha^{-1}$)	Avail P ($kg\ ha^{-1}$)	Avail K ($kg\ ha^{-1}$)
T_1- Control	6.75	0.366	12.4	271.2	57.6	285.8	6.72	0.369	12.4	269.9	56.8	286.0
T_2- *Azotobacter*	6.52	0.651	12.2	299.5	73.9	419.7	6.53	0.652	12.3	304.5	75.1	320.3
T_3- PSM	6.61	0.629	12.3	317.8	89.6	321.9	6.66	0.627	12.3	319.7	90.8	322.6
T_4-Azoto+PSM+ FYM	6.52	0.820	11.8	334.1	110.8	333.4	6.52	0.829	11.9	339.8	110.6	335.2
T_5-FYM @ 20 t/ ha	6.65	0.544	14.4	285.4	69.1	318.0	6.64	0.549	14.9	287.8	71.0	317.5
CD (P=0.05)	NS	0.054	1.1	11.9	9.6	7.1	NS	0.050	0.8	12.5	11.1	9.3

The available P status of soil remarkably increased with the inoculation of *Azotobacter* + PSM and FYM over the values (57.6 and 56.8 kg ha^{-1}) under control treatment. The highest

available P (110.8 and 110.6 kg ha^{-1}) was recorded in this treatment combination during the year 2005-06 and 2006-07, respectively. Application of FYM in combination of *Azotobacter* and PSM, on decomposition solubilizes insoluble inorganic P through release of various organic acids, thus resulted in a significant improvement in available P status of the soil. The organic materials form chelates with essential plant nutrients and reduce their fixation; which favours the availability of nutrient to the crop (Dahama 2003; Singh *et al,*. 2004). The available K status of soil also followed the similar trend as in case of organic C, available N and P. Combined inoculation of *Azotobacter* and PSM was found more efficient in improving soil properties compared to application of inoculants alone.

Microbial counts

The microbial counts recorded under different medium as presented in table 3 showed significant increase under the inoculated plots compared to the control. Microbial population was recorded the highest value under treatment *Azotobactor* + PSB + FYM and was found in the tune of 235, 40, 139 and 189 x 10^4 cfu g^{-1} soil in NA, PDA, Jensen's and Pikovsakaya's medium, respectively, during the year 2005-06 and the respective values were 236, 40, 140, and 188 x 10^4 cfu g^{-1}soil during the year 2006-07. Combined application of both the inoculants with FYM was found to be the best in building up of total microbial population (603 and 604 x 10^4 cfu g^{-1} soil, during the year 2005-06 and 2006-07, respectively) as compared to single inoculation (Fig.1).

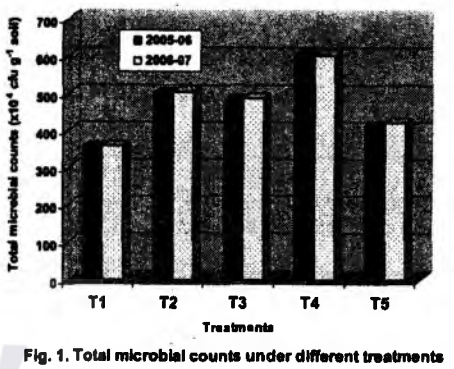


Fig. 1. Total microbial counts under different treatments

Table 3. Effect of phosphate solubilizing microorganisms and *Azotobacter* inoculation on microbial counts under different medium (x 10^4 cfu g^{-1} soil)

Treatments	2005-06				2006-07			
	NA	PDA	JEN	PKB	NA	PDA	JEN	PKB
T_1- Control	161	28	63	105	162	28	61	109
T_2- *Azotobacter*	215	36	111	139	219	36	110	141
T_3- PSM	201	36	93	154	202	36	92	157
T_4-*Azotobacter* + PSM + FYM	235	40	139	189	236	40	140	188
T_5- FYM @ 20 t ha^{-1}	188	33	75	118	193	34	75	120
CD (P=0.05)	10	4	10	7	10	3	10	9

NA = Nutrient agar, PDA = Potato dextrose agar, JEN = Jensen's medium for *Azotobacter*, PKB = Pikovsakaya's medium for PSM

Yield and quality of pea

There was a significant influence of different treatments of inoculation on pod yield and total soluble sugar (TSS) contents (Table 4). The minimum yield (9.25 and 9.29 q ha^{-1}) was recorded under control treatment during both the years, whereas, the plots treated with *Azotobacter* + PSM+FYM gave the highest pod yield (40.62 and 41.04 q ha^{-1}) during the years 2005-06 and 2006-07, respectively. The TSS content in this treatment was also significantly higher as compared to other treatments. Although, FYM alone did not perform well for obtaining better yield and quality of peas but inoculation with *Azotobacter* and PSM alone and in combination gave significantly better yield compared to the control and FYM treated plots.

Table 4. Effect of phosphate solubilizing bacteria and *Azotobactor* inoculation on yield and quality of pea

Treatments	2005-06		2006-07	
	Pod yield (q ha^{-1})	TSS (%)	Pod yield (q ha^{-1})	TSS (%)
T_1- Control	9.25	8.13	9.29	8.60
T_2- *Azotobacter*	35.13	8.97	35.90	9.03
T_3- PSM	28.63	8.93	29.33	8.93
T_4-*Azotobacter* + PSM + FYM	40.63	9.87	41.04	9.80
T_5- FYM @ 20 t ha^{-1}	18.63	8.53	20.74	8.60
CD (P=0.05)	6.77	0.98	7.49	0.90

Conclusion

From the foregoing discussion, it could reasonably be concluded that combined inoculation of *Azotobacter*, PSM and FYM application proved better for improving soil physico-chemical and biological properties, yield and quality of green peas. Application of FYM alone did not perform well as compared to inoculation with *Azotobacter* and PSM.

References

Dahama AK 2003. *Organic Farming for Sustainable Agriculture*. 2nd edition. Agrobios (India), Jodhpur, pp 91-124.

Jackson ML 1973. *Soil Chemical Analysis*. Prentice-Hall of India Private Limited, New Delhi.

Santhy P, Muthuvel P, Murugappan, V and Selvi D 1998. Long-term effects of continuous cropping and fertilization on crop yield and fertility status. J. Indian Soc. Soil Sci. **46**:391-95.

Singh TR, Singh S, Singh, SK and Singh, MP 2004. Influence of integrated nutrient management on properties of a Mollisol (sandy loam) under okra-pea-tomato cropping sequence. Agropedology **14** (2):92-95.

Subba Rao NS 1999. *Soil Microbiology*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Tarafdar JC, Yadav, RS and Meena SC 2001. Comparative efficiency of acid phosphatase originated from plant and fungal sources. J. Plant Nutr. Soil Sci. **164**:279-82.

Tarafdar JC, Yadav, RS and Ram Niwas 2002. Relative efficiency of fungal intra-and extra cellular phosphatases and phytase. J. Plant Nutr. Soil Sci. **165**:17-19.

Verma OP, Sangeeta Paul and Rathi MS 2000. Synergistic effect of co-inoculation of *Azotobactor chroococcum* and *Rhizobium* on pea (*Pisum sativum*). Annals Agric. Res. **21**(3):418-20.