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EFFECT OF PHOSPHORUS AND BIO-FERTILIZERS ON YIELD OF PEA (*PISUM SATIVUM* L.)

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ABSTRACT

The experiment was conducted during the *rabi* season of 2014-15 at Horticulture farm of Rajasthan College of Agriculture, Udaipur (Rajasthan) to study the effect of phosphorus and bio-fertilizers on yield and quality of pea. Treatments consisted of four levels of phosphorus (0, 50, 100 and 150 per cent RDP) and bio fertilizers (control, PSB, *Rhizobium* and PSB + *Rhizobium*). The total 16 treatment combinations were tested in randomized block design with three replications. Results revealed that application of 100 per cent RDP to the pea crop significantly increased the plant height (74.28 cm), number of nodules per plant (67.16 total and 46.31 effective), chlorophyll content in leaves. Seed inoculation with PSB + *Rhizobium* significantly increased the plant height (74.13cm), chlorophyll content in leaves (2.453mg/g), number of pickings (3.44), pod length (8.11cm), fresh weight per pod (6.75g), green pod yield (5.51 kg $plot^{-1}$ and 91.91 q ha^{-1}), total phosphorus uptake (19.13 kg ha^{-1}) and available P_2O_5 (23.32 kg ha^{-1}) in soil after harvest. The combined application of 100 per cent RDP with PSB + *Rhizobium* as seed inoculation proved to be effective treatment combination in terms of green pod yield (6.28 kg $plot^{-1}$ and 104.74 q ha^{-1}), grain yield (37.59 q ha^{-1}), total nitrogen uptake (191.37 kg ha^{-1}) and phosphorus uptake by grain (17.79 kg ha^{-1}).

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INTRODUCTION

Pea (*Pisum sativum* L.) is an important crop grown throughout the world. In India, it is grown mainly as winter vegetable in the plains of North India and as summer vegetable in the hills. Peas are utilized mainly as a vegetable and consumed as pulses. It is used as fresh vegetable, canned, processed or dehydrated (Thamburaj and Singh, 2005). The field pea is also grown for forage and green manure. It is highly nutritive, containing high percentage of digestible protein, carbohydrate and vitamins. It is also very rich in minerals. Its pod contains 7.2 per cent protein, 19.8 per cent carbohydrate, 0.8 per cent mineral matter, while dried pea grain contains 19.7 per cent protein, 56.6 per cent carbohydrate, 2.1 per cent mineral matter and 4.4 per cent iron, besides being a rich source of vitamins A, B and C (Choudhary, 1967).

Growing of pulses without application of phosphatic fertilizer is an important factor for low yield. An adequate supply of phosphorus has been reported beneficial for better growth, yield, quality and enormous nodule formation in legumes (Sammauria *et al.*, 2009). It acts as a structural component of membrane system of cells, chloroplasts and mitochondria. Phosphorus play important role in root development, nodulation, flowering, fruiting and is usually a constituent of phospholipids, nucleic acids, protein, coenzymes, NAD, NADP, and ATP. (Murade *et al.*, 2014). It plays an important role in cell division, carbohydrate break down for energy release, transfer of inherited characteristics and hastening the maturity of plants. In areas where legumes are traditionally grown without phosphorus, poor nodulation was observed with low yield. Biofertilizers are widely accepted as low cost supplements to chemical fertilizers and have no deleterious effects either on soil health or environment. Populations of beneficial microorganisms present in the soil have been reduced due to excessive use of chemicals during production and protection of the crops. The status of nutrient thus declines. This might be one of the major reasons of less productivity in Indian vegetable crops as compare to world average (Sharma *et al.*, 2014). The benefit of *Rhizobium* inoculation on plant growth and efficiency of N incorporation were demonstrated for two isolates, P.SOM and P.1236. In contrast, pea root inoculation with P.SOM and P.1236 isolates led to a reduced root infection by *Orobanche crenata*, resulting from a lower *Orobanche* germination rate close to pea roots and a limited capacity of the parasitic seedlings to develop tubercles (Mabrouk *et al.,* 2007). Hence, keeping in view the above facts the experiment was conducted to study the effect of phosphorus and bio-fertilizers on yield and quality of pea (*Pisum sativum* L.) at Horticulture farm, Rajasthan College of Agriculture, Udaipur (Rajasthan).

MATERIALS AND METHODS

The present study was conducted during the *rabi* season of 2014-15 at Horticulture farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur (Rajasthan). The experiment was conducted in "Factorial Randomized Block Design" with three replications. All the treatments and their combinations were randomly distributed among the plots. Detail of the treatments is given in table 1. The fertilizer single super phosphate (SSP) containing 16% P_2O_5 as basal dose was drilled as phosphorus source at sowing as per treatments. Recommended dose of phosphorus was 80 kg ha^{-1} and its levels *i.e.* 0, 50, 100 and 150% dose (0, 40, 80 and 120 kg ha^{-1}, respectively) were applied. Seeds were inoculated with PSB and *Rhizobium* culture as per the treatments. Uniform cultural practices were adopted during the experimentation. Observations were recorded for plant height, number of nodules per plant, chlorophyll content in leaves (mg/g), days to flower initiation, days to first harvest, duration of fruiting, number of pods per plant, number of seeds per pod, pod length (cm), fresh pod weight (g), green pod yield (kg/plot), green pod yield (q/ha), nitrogen content, phosphorus content, total soluble solids (°B), protein content and total sugar content. Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop colour. Phosphorus content in seed was determined by "Vanadomoloybdo" phosphoric acid yellow colour method. Protein content in dry grain was calculated by multiplying nitrogen per cent in grain by the factor 6.25. Total sugars content was determined by using anthrone reagents method (Dubois *et al*., 1951). The experimental data were statistically analyzed for analysis of variance using the standard method as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Phosphorus level

Table 1: Detail of treatments with their symbols

Treatments		Symbols
(A) Phosphorus levels		
Control	:	P_0
50% RD (40 kg ha^{-1})	:	P_1
100% RD (80 kg ha^{-1})	:	P_2
150% RD (120 kg ha^{-1})	:	P_3
(B) Bio-fertilizers		
Control (No inoculation)	:	B_0
PSB inoculation	:	B_1
Rhizobium inoculation	:	B_2
PSB + *Rhizobium* inoculation	:	B_3

PSB = Phosphorus solublizing bacteria; RD = Recommended dose (FYM @ 20 t ha^{-1}, NPK 30,80 and 50 kg ha^{-1}, respectively)

All the growth parameters *viz*. plant height, number of nodules per plant (total and effective) and chlorophyll content in leaves increased linearly with the corresponding increase in levels of recommended dose of phosphorus up to 150% RDP. However, 100% RDP was found statistically at par with 150% RDP and have favorable effect on growth and bio mass production. Phosphorus has been considered as an essential constituent of all living organisms and plays an important role in the conservation and transfer of energy in the metabolic reactions of living cells including biological energy transformation. In terms of significance, phosphorus is more indispensable mineral nutrient for pulse crops as it helps in better root growth and development and thereby making them more efficient in biological N_2 fixation (BNF). The results obtained in this investigation are in close conformity with those of Kumar (2011), Puniya (2011) and Bhat *et al*. (2013) who reported significantly higher plant height, nodules per plant and chlorophyll content in pea.

Application of 100% RDP (80 kg P_2O_5 ha^{-1}) showed significantly higher flowering and yield attributes *viz*., days to flowering initiation, number of pods per plant, pod length (cm), fresh pod weight (g) and number of seeds per pod. Further, an increase in green pod yield kg per plot and q ha^{-1} was observed due to application of 150% RDP as compared to lower levels but remained statistically at par with 100% RDP.

A significant increase in N content and their total uptake, protein content as well as TSS content in seeds was observed due to application of phosphorus up to 150% RDP. While, 100% RDP found at par with 150% RDP in respect to P content in seed and their total uptake. These results are in close conformity with finding of Rathore *et al*. (2007), Rathore *et al*. (2010), Dar *et al*. (2011) and Puniya (2011). The results find support from the work of Dass *et al*. (2005) in vegetable pea.

Biofertilizers

A significant increase in plant height, number of nodules (total and effective) and total chlorophyll content in leaves was observed due to seed inoculation with PSB and *Rhizobium* alone as well as their combined inoculation over uninoculated control. However, combined inoculation (PSB + *Rhizobium*) recorded higher growth parameters. *Rhizobium* inoculation also plays significant and unique role in phosphate mobilization and uptake of phosphorus, zinc, sulphur and water by plant.

Table 2: Effect of phosphorus and bio-fertilizers on growth and yield of pea

Treatment	Plant height (cm)	Total nodules /plant	Effective nodules /plant	chlorophyll content in leaves (mg/g)	Days to flower initiation	Days to first harvest	Duration of fruiting	Number of pods/ plant	Pod length (cm)	Fresh pod weight (g)	Number of seeds / pod	Green pod yield (kg $plot^{-1}$)	Green pod yield (q ha^{-1})
Phosphorus levels													
Control	52.30	51.94	33.39	1.796	46.91	78.40	29.79	18.61	3.99	4.81	5.57	3.88	64.61
50 %	66.34	60.45	41.32	2.186	46.89	77.12	29.99	23.31	7.87	5.91	6.75	4.40	73.29
100 %	74.28	67.16	46.31	2.411	47.68	77.28	30.04	25.05	8.69	6.79	7.71	5.22	87.03
150 %	75.01	70.52	46.44	2.455	47.18	76.60	30.87	25.42	8.93	6.74	7.55	5.31	88.46
SEm±	1.45	1.22	0.72	0.036	0.53	0.52	0.69	0.51	0.17	0.15	0.10	0.13	2.10
CD (P=0.05)	4.20	3.51	2.07	0.104	NS	NS	NS	1.48	0.49	0.44	0.28	0.36	6.06
Biofertilizers													
Control	59.21	55.05	36.61	1.954	48.04	78.35	28.89	20.43	6.60	5.29	6.16	3.96	65.96
PSB	68.91	63.61	43.19	2.266	46.21	77.63	31.08	23.88	7.55	6.25	7.05	4.84	80.60
Rhizobium	65.68	60.96	41.38	2.175	47.74	76.78	29.44	22.71	7.22	5.95	6.69	4.50	74.93
PSB+*Rhizobium*	74.13	70.45	46.28	2.453	46.68	76.64	31.27	25.37	8.11	6.75	7.68	5.51	91.91
SEm±	1.45	1.22	0.72	0.036	0.53	0.52	0.69	0.51	0.17	0.15	0.10	0.13	2.10
CD (P=0.05)	4.20	3.51	2.07	0.104	NS	NS	NS	1.48	0.49	0.44	0.28	0.36	6.06

Table 3: Effect of phosphorus and bio-fertilizers on N and P content, protein, TSS and total sugar content

Treatment	Nutrient content (%)		Protein (%)	TSS (°B)	Total Sugar (%)
	N	P			
Phosphorus levels					
Control	2.696	0.323	16.85	15.44	11.09
50 %	3.186	0.391	19.91	17.08	12.26
100 %	3.590	0.429	22.43	17.67	12.68
150 %	3.682	0.434	23.01	18.91	13.56
SEm ±	0.029	0.002	0.18	0.16	0.21
CD (P=0.05)	0.084	0.007	0.52	0.46	0.61
Biofertilizers					
Control	2.954	0.350	18.46	15.71	11.28
PSB	3.397	0.405	21.23	16.81	12.07
Rhizobium	3.217	0.389	20.10	17.84	12.80
PSB+*Rhizobium*	3.586	0.434	22.41	18.73	13.44
SEm ±	0.029	0.002	0.18	0.16	0.21
CD (P=0.05)	0.084	0.007	0.52	0.46	0.61

There are only few field experiments with *Rhizobium* inoculation mainly due to difficulty in producing clean pure inoculation on a large scale as the fungi are obligatory symbiont and have to be maintained and multiplied on living plant. Similar results were also reported by Bahadur *et al.* (2006) in pea, Biswas and Patra (2007) in green gram, Djebali *et al.* (2010) in common bean, pea, alfalfa and Ramana *et al.* (2010) in french bean, who observed significantly higher plant height, root nodules and other growth attributes due to inoculation with *Rhizobium* over uninoculated control. Inoculation of seeds with PSB also recorded significantly higher values of growth parameters over no inoculation. It is obvious because of the fact that PSB produce organic acids like gluconic, guccinic, lactic, oxalic, citric and ketogluconic acid which convert the insoluble phosphate to soluble one (Stevenson, 1967) and increase the synthesis growth promoting substances which augment plant growth (Gaind and Guar, 1992). The results obtained in present investigation are in line with the findings of Shrivastava and Ahlawat (1993) in pea and Dadhich *et al.* (2006) and Chavan *et al.* (2008) in soybean who reported more growth parameters and nodulation in pea due to application of biofertilizers.

Seed inoculation with PSB + *Rhizobium* significantly enhanced number of pickings, number of pods per plant, pod length (cm), fresh pod weight, number of seeds per pod, green pod yield and grain yield over no inoculation. The significantly higher values of yield attributes were registered under PSB + *Rhizobium* followed by PSB inoculation.

Inoculation of seed with PSB also significantly enhanced the yield and yield attributes. The beneficial effect of phosphate solubilizing bacteria as explained earlier increased the availability of phosphorus. Greater root extension under higher availability of phosphorus might have helped in greater uptake of other nutrients especially micronutrient and secondary nutrients, enhanced photosynthesis, production of photosynthates and their partitioning between vegetative and reproductive structure might have helped in improving the yield attributes (days to flower initiation, number of pickings, number of pods per plant, number of seeds per pod, fresh pod weight and finally the green pod yield). These findings corroborate the results of Shrivastava and Ahlawat (1993) and Yadav (2009).

Seed inoculation with PSB + *Rhizobium* significantly enhanced the nitrogen and phosphorus content and its total uptake and protein content in grains over control. TSS content in seed also increased significantly due to inoculation of PSB, *Rhizobium* and PSB + *Rhizobium* over control. *Rhizobium* increased nutrient uptake through reduction of the distance that nutrient must diffuse to plant roots by accelerating the rate of nutrient absorbing surface and finally by chemically modifying the availability of nutrient for uptake by plant through *mycorrhizal hyphae* (Somani, 2004). Since protein content of grain is essentially a manifestation of N content. Increased N content due to seed inoculation with PSB or *Rhizobium* resulted in higher protein content because of their beneficial role in enhancing N content in seed. Finding of Shrivastava and Ahlawat (1993) and Kristek *et al.* (2005) in pea also provide support to the results of present investigation. Significantly increase in nitrogen, phosphorus and TSS content in seeds of the crop was also observed with PSB inoculation. PSB enhance the availability of phosphorus to plant which might have been utilized by the crop for greater root development and nodulation which in turn resulted in high nitrogen fixation in the soil by nodules. Thus increased availability of nitrogen and phosphorus might have resulted in greater uptake by the plant for proper development and ultimately increased their content in plant. Sinde and Saraf (1992) in chick pea, Moduk *et al.* (1993) in pigeonpea, Shrivastava and Ahlawat (1993) in pea and Chalka (1999) in cowpea reported similar kind of results. Thus application of 100 percent RDP (80kg P ha^{-1}) as basal and seed inoculation with PSB + *Rhizobium* (both 2.0 kg ha^{-1}) proved to be effective treatment in terms of growth, yield and nutrient, TSS and sugar content in grain of pea.

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