

Quantification of contribution of PSB in reducing the requirement of P fertilizer in potato production in mid hill of Himachal Pradesh

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Abstract

Application of 100 kg P₂O₅/ha (100% dose of recommended P) along with PSB inoculation gave highest tuber yield (216 q/ha) which was statistically at par with 100% P (206 q/ha). Application 100% P was statistically was at par with 75% P + PSB (203 q/ha). Higher mean of yield, phosphorus uptake, phosphorus use efficiency and apparent nutrient recovery were observed with seed inoculation with PSB as compare to without PSB. The results of this study indicated the beneficial effects of PSB inoculation on tuber yield and 11 to 18% of recommended dose of P can be saved with the seed inoculation by PSB.

Key Words: Quantification, PSB, Potato, fertilizer

Introduction

Phosphorus is one of the key nutrients required for higher and sustained productivity of potato and its influence on tuber yield is very well established. Phosphatic fertilizers are expensive and in developing countries like India, they are either imported or manufactured using imported raw material. The soils of North-Western Himalayas are acidic in nature and therefore, more P fixation take place due to presence of Al and Fe compounds which convert it into insoluble form. As a result most of the P applied is rendered in fixed form and unavailable for crop uptake. Thus, soils commonly have large reserves of 'fixed' P that could support long term crop requirements which could be mobilized through use of phosphate solubilizing bacteria (PSB) which converts insoluble forms of phosphorus to an accessible form and make the phosphorus available to plants from soil (Singh & Kapoor, 1994).

Materials and Methods

Field experiments were conducted at Shimla during 2008 - 2011 to investigate the role of phosphorus solubilizing bacteria on P economy in potato. The crop was grown during April following recommended package of practices. The eight manurial treatments involving different levels of P through inorganic fertilizer *viz.*, control, 25% P, 50% P, 75% P and 100% P with and without PSB inoculation were tried in randomized block design with three

replications. Seed tubers were inoculated by dipping seed tuber in PSB solution and dried in shade before planting. Nitrogen was applied in two splits as per recommendation *i.e.* half at planting and rest at earthing up (at 40 days after planting). Basal application of P and K was done using single super phosphate and muriate of potash, respectively, as per treatments at the time of planting. Crop was harvested at maturity and tuber yield and numbers were recorded. Three year pooled tuber yield at varying levels of P with or without PSB were fitted in quadratic response model ($Y = ax^2 + bx + c$) and amount of P required (%) for target yield (T) was calculated using the relationship in absence and presence of PSB:

% P of recommended dose required in presence of PSB to obtain a target yield (T)

$$= \frac{-b \pm \sqrt{b^2 - 4a(c - T)}}{2a}$$

Where a, b and c are regression co-efficient of the quadratic equation

Results and Discussion

Application of 100 kg P₂O₅/ha (100% dose of recommended P) along with PSB inoculation gave highest tuber yield (216 q/ha) which was 10 q/ha higher as compare to 100% dose of recommended P (Table 1). The tuber yield obtained with 100% P (206 q/ha) was statistically at par with that of under 75% P + PSB (203 q/ha). Similarly, yield under 75% P was statistically at par with that of 50% P + PSB. 6.5% higher mean yield (185 q/ha) was observed with seed inoculation with PSB as compare to without PSB (173 q/ha). Maximum per cent increase (14.9%) in potato tuber yield was observed by inoculation of seed tuber with PSB only compare to absolute control (no P was applied). The soils of mid-hill region of Himachal Pradesh are medium to high in organic matter which is favourable for the microbes. This is due to phosphate solubilizing Bacteria (PSB) are capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds and PSB produce phosphatase like phytase that hydrolyse organic forms of phosphate compounds efficiently (Zehra 2010; Rodriguez & Fraga 1999). The beneficial effect and saving of P fertilizer using PSB was reported by Singh (2000) and Singh (2002) in north-eastern hills and under East Khasi hill conditions of Meghalaya.

Table 1. Effect of phosphorus and PSB inoculation on yield, uptake, per cent yield respons, P use efficiency (PUE) and apparent nutrient recovery (ANR) by of potato crop.

Treatments	Pooled yield (q/ha)		P uptake (kg/ha)		Yield response (%)		PUE (kg tubers/kg P)		ANR (%)	
	Without PSB	With PSB	Without PSB	With PSB	Without PSB	With PSB	Without PSB	With PSB	Without PSB	With PSB
Control	121	139	6.2	8.8	-	15.1	-	-	-	-
25% P	166	175	10.3	11.3	37.2	44.6	180	216	16.2	20.1
50% P	181	190	10.7	12.5	49.6	57.0	120	138	9.0	12.5
75% P	192	203	12.1	14.0	58.7	67.8	95	109	7.9	10.3
100% P	206	216	13.2	15.2	70.3	78.5	85	95	7.0	9.1
Mean	173	185	10.5	12.3	-	-	119.9	139.0	9.7	13.0
CD (0.05)	14.8		1.9		-	-	-	-	-	-

Among the various treatments, mean P uptake (12.3 kg/ha) and per cent yield response was

higher in the PSB inoculated treatment (Table 1) as compare to without PSB inoculation. Maximum uptake (15.2 kg/ha) was observed at 100% P along with seed treatment with PSB. The results revealed that P uptake at 100% P was statistically at par with treatment receiving 75% P + PSB. This may be due to the fact that in presence of PSB more phosphorus was solubilized from native source. However, yield response was 7, 7, 9 and 6% higher at 25, 50, 75 and 100% P application along with seed inoculation with PSB as compare to without PSB inoculation.

Phosphorus use efficiency (kg tubers/kg P) showed considerable variation. Higher mean phosphorus use efficiency (140 kg tubers/kg P) was observed with seed inoculation with PSB as compare to without PSB (120 kg tubers/kg P). Phosphorus use efficiency (PUE) was maximum (216 kg tubers/kg P) under lower dose of P with PSB (25% P + PSB) as compared to only 25% P application without PSB (180 kg tubers/kg P) and maximum PUE was observed when minimum dose of P was applied. In general, increasing dose of P decreased the P use efficiency in all the treatments. Whereas, per cent decrease in PUE was more when only graded dose of P was applied as compared to seed inoculation with PSB. Similar results were followed in case of apparent nutrient recovery. Mean apparent nutrient recovery (ANR) was higher (3%) when seed inoculation with PSB was done as compared to without PSB. Maximum ANR (21.3%) was observed at 25% P with PSB as compared to only 25% P (15.5%).

For target yield, P required in presence and absence of PSB was calculated (Table 2 & Fig. 1). For producing 150 to 200 q/ha target yield of potato tubers, 17.98 to 81.41% P is required without PSB inoculation (Table 2). Whereas, for same target yield 6.8 to 63.1 % P is required with PSB inoculation. Maximum yield (210 q/ha) was not achievable with recommended dose of P, whereas, this yield target can be achieved by 87% P with PSB. The results of this study indicated the beneficial effects of PSB inoculation on tuber yield and 11 to 18% of recommended dose of P can be saved to get yield from 150 to 210 q/ha with the seed inoculation by PSB.

Table 2. Contribution of PSB to phosphorus nutrition of potato crop as derived from quadratic ($y = ax^2 + bx + c$) model.

Treatments	Quadratic equation	P requirement (%) for different target yield (q/ha)						
		150	160	170	180	190	200	210
Without PSB	$y = -0.0074x^2 + 1.5238x + 124.99$	18.0	26.3	35.7	46.7	60.4	81.4	NA
With PSB	$y = -0.0054x^2 + 1.2665x + 141.63$	6.8	15.5	25.1	35.7	48.0	63.0	87.0
Saving of P requirement for different target yield by the seed inoculation of PSB (%)		11.2	10.8	10.7	10.9	12.3	18.4	-

NA*=Not achievable

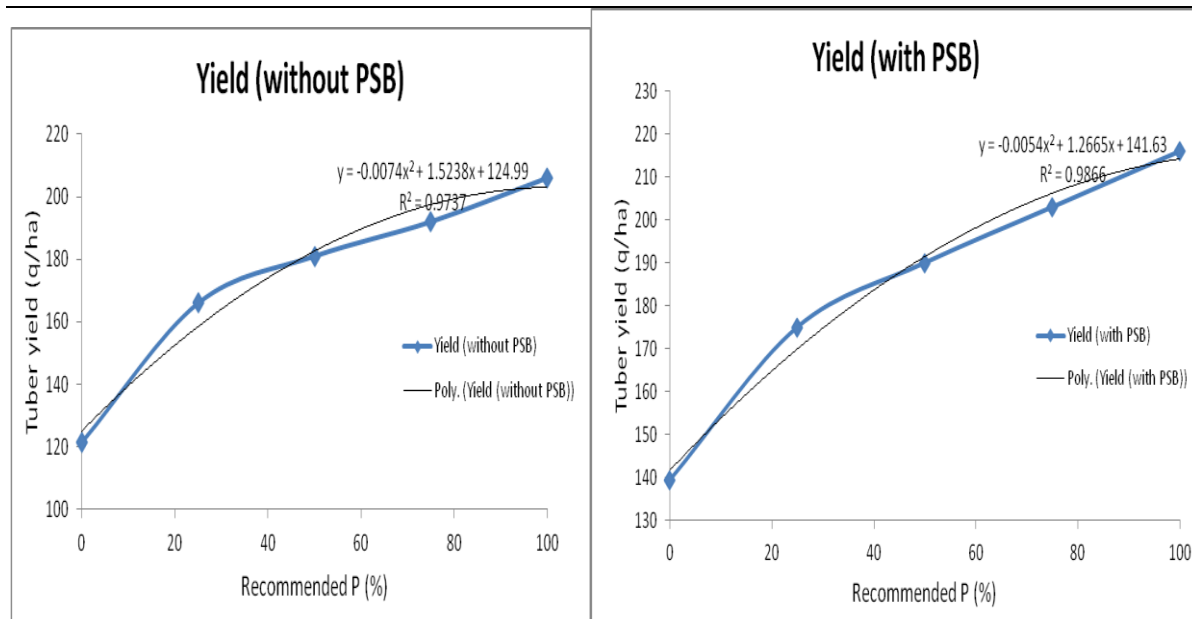


Fig. 1. Yield response of potato with and without PSB application.

It may be concluded that combined application of P along with tuber inoculation with PSB can be effective in reducing the inorganic P dose by approximately 18%. Besides saving fertilizer, this treatment also showed increased phosphorus use efficiency, apparent nutrient recovery and per cent yield response.

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