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Research Article

EFFICACY OF BIOFERTILIZER INOCULATION ON PHOSPHORUS LEVELS OF INDIAN BEAN (*Lablab purpureus L. var. typicus*) UNDER SEMI ARID REGIONS OF RAJASTHAN

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Abstract- A field experiments on Indian bean green pod yield was assessed for effectiveness of inoculation with biofertilizer sunder various levels of phosphorus application. The data revealed that inoculation significantly increased the Indian bean pod yield at all levels of phosphorus application including control. Application of 50 kg P/ha along with PSB + VAM + Rhizobium inoculation maximized Indian bean pod yield (43.67 q/ha) which was 42.67 % higher and significantly better than the yield obtained at same level of P application without biofertilizer inoculation. However, yield obtained with 50 kg P/ha (43.67 q/ha) was statistically at par with that of 50 kg P/ha with or without biofertilizers, 37.5 kg P/ha with VAM, Rhizobium and PSB + VAM + Rhizobium. Higher value yield, phosphorus use efficiency and apparent nutrient recovery were optimized under inoculation with PSB + VAM + Rhizobium as compared to non-inoculation. The results depicted the beneficial effects of PSB + VAM + Rhizobium inoculation on Indian bean pod yield resulting in saving of 6.50 to 14.70 kg/ha phosphorus and an enhanced pod yield ranging from 26 to 44 q/ha.

Keywords- Indian bean, Phosphorus, biofertilizers, pod yield, semiarid regions

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Introduction

Pea Being a leguminous crop, Indian bean is highly responsive to nitrogenous and phosphatic fertilizers especially in early stage. Phosphorus is second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby atmospheric nitrogen fixation. An adequate supply of phosphorus fertilizer has been reported beneficial for better growth and yield, better quality and enormous nodule formation in legumes [1]. The added phosphorus is reported to serve dual purpose in legumes by increasing the yield of current as well as succeeding crop. About 93-99 percent of the total phosphorus is insoluble and hence directly not available to plants. Only about a quarter of water soluble phosphate is taken up by plants in the season of the application and the remaining is converted into insoluble forms [2].

Bio-fertilizers play a vital role in maintaining long term soil fertility and sustainability, increasing yield of crops by 10- 30 percent. Similarly, inoculation of bio-fertilizers also plays an important role in increasing fertilizers use efficiency. When the seed of legumes crops are inoculated with biofertilizers and sown, it increases microbial population in the rhizosphere, thereby increasing the amount of microbiologically fixed nitrogen and increase unlocking and absorption of phosphorus for the plant growth. VAM can play an important role in enhancing phosphorus availability to plant in phosphorus deficient soils. VAM fungi can save phosphorus fertilizer by 25-30%. The roots of the most common crops like potatoes, beans, alfalfa etc. have VAM association [3]. The PSB culture proved broad spectrum bio-fertilizer which may increase yield of crops (Legumes, vegetables *etc.*) by 10-30 percent and supplement phosphorus upto 30 kg P_2O_5 ha^{-1} [4].

The soils of arid and semi-arid regions are generally deficient in organic matter and the problem of nutrient drain from the soil is becoming so acute that it is beyond the capacity of any single fertilizer to accept the challenge of appropriate nutrient supply. Hence, the present study was undertaken to assess the effectiveness of biofertilizers for improving yield performance of Indian bean under fertilized conditions.

Materials and Methods

The field experiment was conducted on Indian bean *cv.* Arka vijay at Horticulture farm, S.K.N. College of Agriculture, Jobner, Jaipur during kharif season 2013-14. The experimental soil belongs to loamy sand (entisol) with pH 8.2, ECe 1.35 dSm^{-1}, organic carbon 0.15 %, Available nitrogen 135 kg ha^{-1}, available phosphorus 16.25 kg ha^{-1} and available potassium 148.6 kg ha^{-1}. The experiment was laid out in split plot design with 4 replications, nutrient management treatments comprised of four NP levels (0, 50, 75&100 % RDF as 0, 25, 37.5 & 50 kg p/ha) in main plots and five bio-fertilizer inoculants viz. No inoculation as control (B0), PSB (Bp), VAM (Bv), Rhizobium (Br) and PSB + VAM + Rhizobium (Bpvr) in sub plots, thus making a total of 20 treatments in all. The recommended dose of N, P and K is 30, 50 and 50 kg ha^{-1}, respectively. Nitrogen and phosphorus were applied through urea and single super phosphate (SSP) as per treatments and K as muriate of potash as basal dose uniformly in all plots. To apply biofertilizers, weigh 30 g jaggery and boiled in half litre of water to prepare jaggery solution, cooled it and added 50 g of each Rhizobium (*Rhizobium phaseoli*) or PSB (*Bacillus sp.*) cultures in it. The required quantity of seed was thoroughly mixed with paste of culture to inoculate with Rhizobium or PSB culture as per treatments and dried in shade. The VAM (Vasicular Arvuscular Mycorrhizae) was applied to the respective plots @ 2 kg/ha as soil application using field soil to bulk the carrier. All the recommended package of practices was followed to raise the crops during the course of study as per recommendation for the crop in the region. Irrigations were applied as and when needed to obtain a satisfactory crop stand. Data was statistically analyzed as per Gomez and Gomez, [5]. Indian bean crop was harvested as pickings of green pods at enough tenderness stage time to time and green pod yield was recorded. Indian bean green pod yield at varying levels of P with or without biofertilizers were fitted in quadratic response model ($Y = ax^2 + bx + c$) and amount of P required (kg/ha) for target yield (T) was calculated using the relationship in absence and presence of biofertilizers: P (kg/ha) required in presence or absence of biofertilizers to obtain different-target yields (T)

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Where a, b and c are regression coefficient of the quadratic equation

Percent yield response and phosphorus use efficiency (PUE) was computed [6] using the yield data and rates of fertilizer nutrients applied for Indian bean as given below:

Yield Response:

$$\frac{\text{Yield in fertilized plot} - \text{Yield in unfertilized plot}}{\text{Yield in unfertilized plot}}$$

Phosphorus use efficiency (PUE):

$$\frac{(\text{Yield in fertilized plot} - \text{Yield in unfertilized plot})}{\text{Quantity of total nutrient applied}}$$

Results and Discussion

Yield and yield response

Inoculation of Indian bean with PSB, VAM & Rhizobium + 50 kg P/ha gave highest green pod yield followed by inoculation with VAM + 50 kg P/ha as compared to other treatment combinations. Saving of P requirement for different target yields by inoculation of PSB + VAM + Rhizobium ranged in between 6.50 –14.70 kg/ha P in the present study. Effect of graded dose of P application increased the yield of the Indian bean with or without inoculation of biofertilizers. Application of 50 kg P/ha along with inoculation with PSB, VAM &Rhizobium gave highest green pod yield (43.67 q/ha) which was 14.83 percent q/ha more as compared to 50 kg P/ha application without inoculation with biofertilizers [Table-1]. This treatment gave 218 and 126.62 % higher yield as compared to absolute control and only PSB + VAM + Rhizobium application, respectively. The yield obtained with 50 kg P/ha (43.67 q/ha) was statistically at par with that of 50 kg P/ha with or without biofertilizers, 37.5 kg P/ha with VAM, Rhizobium alone and combined inoculation of PSB + VAM + Rhizobium. 21.13 % higher mean yield (34.80 q/ha) was observed under inoculation with PSB + VAM + Rhizobium as compared to without biofertilizers (28.73 q/ha). Maximum increment in Indian bean green pod yield was observed in plants which inoculated by PSB + VAM + Rhizobium over absolute control (where no Pand biofertilizers were applied) [7].

Table-1 *Effect of Phosphorus and Bio-fertilizer inoculation on pod yield of Indian bean crop*

Phosphorus level (kg/ha)	Green pod yield (q/ha)					
	Without *Biofertilizer*	With PSB	With VAM	With *Rhizobium*	With PSB+VAM+ *Rhizobium*	Mean
0	13.72	18.49	18.65	18.83	19.27	17.79
25	27.11	30.68	32.04	30.32	34.16	30.86
37.50	36.05	33.23	38.29	37.94	42.08	37.52
50	38.03	38.16	42.21	36.98	43.67	39.81
Mean	28.73	30.14	32.80	31.02	34.80	
CD at 5%	6.72					

Percent rise in yield by the application of 25, 37.50 and 50 kg P/ha was 26.11, 35.05 and 37.03 %, respectively whereas, that of yield with added inoculation by PSB + VAM + Rhizobium was 33.16, 41.08 and 42.67 %, respectively [Table-2]. Application of 25, 37.50 and 50 kg P/ha, the percent increase in yield by the inoculation with PSB + VAM + Rhizobium was 7.05, 6.75 and 5.64 %, respectively and maximum increase in yield (i.e., 7.05%) was underapplication of 25 kg P/ha with PSB + VAM + Rhizobium. Increased yield by the PSB + VAM + Rhizobium could be due to the greater availability of nutrients in the soil and better nodulation under the influence of inoculation resulting in better growth and development which might be attributed to better mobilization of phosphorus and increased allocation of photosynthates towards the economic parts and also hormonal balance on the plant system. This finding corroborates with the findings of Menaria, *et al*., in soybean [8]. The increased availability of nutrients through application of chemical fertilizers and absorption of available P by VAM and PSB and biological nitrogen fixation by Rhizobium, might have favoured the plant growth characters under given treatments. Deshmukh, *et al*., [9] also reported improvement in growth attributes of cluster bean with application of nutrients. Better plant growth led more availability of plant nutrients, which can be resulted an improvement in yield attributes under above treatments. Similar observations by Ganie, *et al*. [10] in garden pea and Sajitha, [11] in cluster bean also confirm the trend in the present experimental setup. From the above results, it is evident that added biofertilizers might have resulted in improvement of soil physical, chemical and biological properties leading to better nutrient absorption by the plants and higher assimilation of photosynthates which resulted in better yield.

Table-2 *Effect of Phosphorus levels and Biofertilizers on percent yield response (%)*

Phosphorus level (kg/ha)	Yield Response (%)					
	Without *Biofertilizer*	With PSB	With VAM	With *Rhizobium*	With PSB+VAM + *Rhizobium*	Mean
25	26.11	29.68	31.04	29.32	33.16	29.86
37.50	35.05	32.23	37.29	36.94	41.08	36.52
50	37.03	37.16	41.21	35.98	42.67	38.81
Mean	32.73	33.02	36.51	34.08	38.97	

Table-3 *Effect of Phosphorus levels and Biofertilizers on P use efficiency (kg pods/ kg P)*

Phosphorus level (kg/ha)	PUE (kg pods/ kg P)				
	Without *Biofertilizer*	With PSB	With VAM	With *Rhizobium*	With PSB+VAM+ *Rhizobium*
25	53.56	67.84	73.28	66.40	81.76
37.50	59.55	52.03	65.52	64.59	75.63
50	48.62	48.88	56.98	46.52	59.90
Mean	53.91	56.25	65.26	59.17	72.43

Phosphorus use efficiency

Phosphorus use efficiency (PUE) is the increase in economic yield obtained per unit increase in nutrient applied. PUE of Indian bean crop was significantly influenced by the graded doses of phosphorus application with or without biofertilizers [Table-3]. PUE (kg pods/kg P) showed considerable variation. Higher mean PUE (72.43 kg pods/kg P) was observed in inoculated plants with PSB + VAM + Rhizobium as compared to non-inoculated (53.91 kg pods/kg P). PUE was maximum (81.76 kg pods/kg P) under lower dose of P(25 kg P/ha) with PSB + VAM + Rhizobium as compared to only 25 kg P/ ha application without biofertilizers(53.56 kg pods/kg P). PUE was inversely related to P application. In general, increasing dose of P decreased the P use efficiency for all the treatments wherein percent decrease in PUE was more when only graded dose of P was applied as compared to its usage on biofertilizers specially under PSB + VAM + Rhizobium inoculated plants. Increase in phosphorus use efficiency by inoculation of PSB, VAM and Rhizobium might be due to increase in availability and absorption of phosphorus and increase in root nodulation, number of leaves and leaf area which determines the photosynthetic efficiency of plants, dry matter production and ultimately the yield and better PUE. Similar results have been reported by Tiwari and Kumar, [12].

Saving of P through inoculation

The pod yield obtained in presence or absence of biofertilizers with respect to varying P levels fitted well in quadratic model. For different target yields, P required in presence and absence of biofertilizer was worked out [Table-4]. For producing 26 to 44 q/ha target yield of Indian bean pods, 5.63 to 29.46 kg P/ha is needed with PSB + VAM + Rhizobium inoculation [Table-4]. Whereas, for same target yield 12.13 to 44.16 kg P/ha is required without biofertilizer inoculation. Maximum yield (44 q/ha) was achievable by 29.46 kg P/ha with PSB + VAM + Rhizobium. Finally, it may be concluded that the beneficial effects of PSB + VAM+ Rhizobium inoculation on green pod yield and 6.50 to 14.70 kg P/ha can be saved to get yield from 26 to 44 q/ha with inoculation by PSB + VAM+ Rhizobium. Inoculation of rhizobia, vam and PSB into the soil found beneficial to increase the availability of native fixed phosphate and to reduce the use of fertilizers and build up significant improvement in residual soil fertility. Significant response to application of phosphorus with inoculation of biofertilizer was reported by Surya kant, *et al*. [13].

Table-4 *Contribution of biofertilizers to P nutrition of Indian bean crop as derived from quadratic ($y= ax^2+bx+c$) model*

Treatments	Quadratic equation	Fertilizer P requirement for different target yield (q/ha)									
		26	28	30	32	34	36	38	40	42	44
Without Bio	$y= -0.0106 x^2+1.159 x +13.489$	12.13	14.42	16.84	19.42	22.21	25.26	28.66	32.58	37.38	44.16
With PSB	$y=-0.0076 x^2 +0.866 x +18.619$	9.28	12.12	15.16	18.43	22.01	26.00	30.59	36.17	43.95	-
with VAM	$y=-0.00839 x^2 +1.044 x +18.595$	7.55	9.78	12.10	14.54	17.11	19.84	22.75	25.9	29.35	33.21
with Rhizo.	$y=-0.0167 x^2 +1.141 x +18.562$	7.30	9.63	12.2	15.13	18.59	23.08	32.41	-	-	-
With P+V+R	$y=-0.0160 x^2 +1.317 x +19.089$	5.63	7.44	9.35	11.38	13.55	15.92	18.53	21.49	24.97	29.46
Saving of P requirement for different target yield by use of PSB+VAM+*Rhizobium* (kg/ha)		6.50	6.98	7.49	8.04	8.66	9.34	10.13	11.09	12.41	14.70

Application of research: This article is important for all those who are growing legumes in saline soils where phosphorus remains in locking conditions and Use of biofertilizers like PSB, Rhizobium and VAM are helpful to make P available to plants in light textured and saline soils.

Research Category: Crop science, Indian bean

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