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Effect of Phosphorus and Bio-fertilizers on Growth and Yield of Urdbean [*Vigna mungo* (L.) Hepper]

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *kharif* season of 2014 on loamy sand soil to study the effect of phosphorus levels and bio-fertilizers on growth and yield of urdbean. Experiment consisted of four treatments of phosphorus levels (0, 20, 40 and 60 kg/ha) and four treatments of bio-fertilizers (control, PSB, VAM and PSB + VAM) thereby making sixteen treatment combinations tested in randomized block design with three replications. Result indicated that application of phosphorus up to 40 kg/ha significantly increased the growth and yield determining characters *viz*., plant height, number of branches/plant, dry matter accumulation/m row length, number and weight of root nodules/plant, CGR, RGR, number of pods/plant, grains/pod, test weight, grain yield, straw yield, biological yield, harvest index and net returns and its remain at par with 60 kg/ha. Seed and soil inoculation with PSB + VAM significantly enhanced the growth and yield attributing characters over PSB, VAM and control.

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1. INTRODUCTION

Pulses are the main source of dietary protein particularly for vegetarians and contribute about 14 per cent of the total protein of average Indian diet. Urdbean [*Vigna mungo* (L.) Hepper] is among the major pulses grown throughout the country during both in summer and rainy season. It is a self pollinated leguminous crop containing 24% protein. The duration of the crop is very short; it fits well in various multiple and intercropping systems. After removing pods, its plant may be used as good quality green or dry fodder or green manure. Being a legume, it also enriches soil by fixing atmospheric nitrogen. Phosphorus is a universally deficient plant nutrient in most of the soils of Rajasthan, particular in light textured soils. Application of phosphorus to pulse crop has been found very effective and used as master key element for increasing yield. Its play a vital role in growth and development of roots. Phosphorus is also necessary for growth of *Rhizobium* bacteria responsible for biological fixation of N to increase the efficiency of pulses as soil renovator and serves the dual purpose of increasing yield of main as well as succeeding crop. An adequate supply of phosphorus has been reported for better growth, yield, quality and enormous nodule formation in legumes [1]. It acts as a structural component of membrane system of cells, chloroplasts and mitochondria. It is a constituent of energy phosphates like ADP and ATP, nucleic acids (DNA and RNA), nucleic proteins, purines, pyrimidine, nucleotides and several coenzymes. About 93-99 per cent of the total phosphorus is insoluble and hence directly not available to plants. Inoculation of P solubilizing microorganisms in the rhizosphere of crop and soil increases the availability of P from insoluble sources of phosphate, desorption of fixed phosphates and also increases the efficiency of phosphatic fertilizers through secreting acidic substances [2]. Symbiosis between plant roots and certain soil fungi *e.g.* Vesicular Arbuscular Mycorrhiza (VAM) plays an important role in phosphorus cycling and its uptake by plants [3]. These symbiotic micro-organisms have extensive mycelia network and can increase the transport of other mineral elements such as zinc and copper. Vascular Arbuscular Mycorrhiza fungi can play an important role in enhancing P availability to plants in deficient soils and can save P-fertilizer by 25-30% [4].

2. MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of 2014 at the Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan). Soil of the experimental field was loamy sand in texture and alkaline in reaction (pH 8.2), low in organic carbon (0.14%) and available nitrogen (137.4 kg/ha), medium in available phosphorus (16.2 kg/ha) and potassium (154.2 kg/ha). Experiment was laid out in randomized block design with sixteen treatment combinations comprised of four phosphorus levels (0, 20, 40 and 60 kg/ha) and four treatments of bio-fertilizers *viz*., (control, PSB, VAM and PSB + VAM). The urdbean variety T-9 was sown using seed rate 15 kg/ha with a row spacing of 30 cm at the depth of 4-5 cm. Seeds were treated with PSB culture using three packets (200 g each) for 15 kg of seed of urdbean needed for sowing for one hectare and VAM was applied as per treatments to the open furrow using field soil to bulk the carrier. Uniform dose of nitrogen 25 kg/ha was applied to all the plots by adjusting the nitrogen supplied by di-ammonium phosphate and remaining through urea at the time of sowing. Whereas, phosphorus was applied as per treatments through DAP. The CGR of crop was calculated with the following formula from the crop dry matter recorded at periodic intervals.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \ (g/m^2/day)$$

Where,

W_1 = Total crop dry matter/m^2 at time t_1
W_2 = Total crop dry matter/m^2 at time t_2
t_1 = Time at first observation
t_2 = Time at second observation

The mean relative growth rate (RGR) of the crop was calculated by the following formula.

$$RGR\ (mg/g/day) = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where,

W_1 = Total crop dry matter at time t_1
W_2 = Total crop dry matter at time t_2
t_1 = Time at first observation
t_2 = Time at second observation
Log_e = Natural log

Net return was calculated by deducting cost of cultivation from gross return and B: C ratio was calculated by dividing the net return by cost of cultivation. Harvest index was computed by using the formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

N concentration was determined by modified kjeldhal method while total P determined using sulphuric-nitric-perchloric acid digest procedure. K was determined by tri acid digestion procedure on flame photometer.

3. RESULTS AND DISCUSSION

3.1 Effect of Phosphorus Levels and Bio-fertilizers on Growth Parameters

3.1.1 Effect of phosphorus levels

Successive addition in level of phosphorus from 0 to 40 kg/ha significantly increased the growth attributes *viz*., plant height, number of branches/plant, dry matter accumulation/m row length (at harvest stage), number and weight of root nodules, crop growth rate and relative growth rate over 20 kg/ha and control. Further increase in level of phosphorus to 60 kg/ha attained highest values yet, it showed statistical equivalence with 40 kg/ha (Table 1). Its might be due to the better nutritional environment in root zone for growth and development. Phosphorus is a vital component of ADP and ATP, its play an important role in conservation and transfer of energy in metabolic reaction and also improve nodulation and N fixation by roots. Similar findings were reported by [5] in greengram.

3.1.2 Effect of bio-fertilizers

Results indicated in Table 1 that individual as well as combined inoculation with PSB and VAM had significant influence on plant height, number of branches/plant, dry matter accumulation/m row length (at harvest stage), number and weight of root nodules, CGR and RGR. However, dual inoculation with PSB + VAM registered the maximum values of this parameter than rest of the treatments. This might be due to PSB produce organic acids like, gluconic, succinic and lactic acid etc. that solubilize insoluble phosphates from stable complex such as Ca^{++} and Mg^{++} phosphates. So increase the availability of phosphorus which in turn better growth and development of roots, increase photosynthesis and production of assimilates which led to increased plant height, number of nodules and dry matter accumulation. These results are in close conformity with the findings of [6] in urdbean, [7,8] and [9] in mungbean. VAM inoculation plays important in phosphate mobilization and uptake of P, Zn, S and water.

3.2 Effect of Phosphorus Levels and Bio-fertilizers on Yield Attributes

3.2.1 Effect of phosphorus levels

Seed or soil inoculation with bio-fertilizers (PSB, VAM and PSB + VAM) significantly enhanced the number of pods/plant, number of grains/pod, test weight as well as grain yield, straw yield, biological yield of urdbean over no inoculation and no significant effect on harvest index. The highest values of these parameters were recorded under combined inoculation with PSB + VAM that was accompanied by PSB and VAM, alone. This could be ascribed to the greater availability and uptake of phosphorus due to additive effect of these two bio-fertilizers in improving nutritional environment enhanced the growth in terms of branches and dry matter, photosynthetic area, production of assimilates and their translocation to reproductive structures, thereby increasing the yield attributes and ultimately, yields of the crop. Significant increase in straw yield due to bio-fertilizer inoculation could be attributed to the increased vegetative growth possibly as a result of effective utilization of nutrients absorbed through extensive root system and prolific shoot development on account of improved nourishment. These results are in close conformity with the findings of [10] in greengram and [11] in urdbean. Dual use of PSB +VAM fetched significantly highest net returns (Rs. 46087/ha) and B: C ratio in comparison to rest of the treatments. PSB and VAM also gave 16.2 and 21.5 per cent more return than control and thus found the next better and equally effective treatments.

3.2.2 Effect of bio-fertilizers

Application of phosphorus at 40 kg/ha recorded significantly higher number of pods/plant, number of grains/pod, test weight, grain yield, straw yield and biological yield, and no significant effect was observed on harvest index (Table 2). This could be attributed due to better root proliferation, higher root development, increased availability and uptake of nutrients, energy transformation and metabolic processes in plant. The higher

Table 1. Effect of phosphorus fertilization and bio-fertilizers on growth attributing characters

Treatments	Plant height	Branches/plant	Dry matter accumulation (g/m row length)	CGR (g/m^2/day)	RGR (mg/g/day)	Number of nodules/plant		Weight of nodules/plant (mg)	
						Total nodules	Effective nodules	Fresh weight	Dry weight
A. Phosphorus levels (kg/ha)									
Control	44.20	6.20	91.60	2.45	9.31	28.30	26.50	102.50	57.20
20	50.90	7.80	119.60	3.71	11.08	32.40	28.90	111.50	62.50
40	55.80	8.90	133.40	3.99	10.61	35.50	31.10	120.56	67.10
60	58.20	9.20	136.50	4.03	10.45	36.80	31.60	123.20	68.20
SEm±	1.42	0.22	2.80	0.07	0.29	0.97	0.70	2.91	1.55
CD (P=0.05)	4.10	0.62	8.09	0.21	0.84	2.80	2.01	8.39	4.47
B. Bio-fertilizers									
Control	45.06	6.95	106.32	2.98	9.76	29.93	27.22	104.07	58.48
PSB	52.35	8.08	121.69	3.63	10.55	33.15	29.63	114.47	64.07
VAM	52.55	8.08	120.17	3.50	10.24	33.45	29.53	115.27	63.87
PSB + VAM	59.14	9.00	132.92	4.08	10.90	36.47	31.73	123.95	68.57
SEm±	1.42	0.22	2.80	0.07	0.29	0.97	0.70	2.91	1.55
CD (P=0.05)	4.10	0.62	8.09	0.21	NS	2.80	2.01	8.39	4.47
CV (%)	9.40	9.31	8.07	7.24	9.69	10.10	8.18	8.80	8.42

Table 2. Effect of phosphorus fertilization and bio-fertilizers on yield attributing characters, grain, straw, biological yield, harvest index and net returns

Treatments	Number of pods/plant	Number of grains/pod	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net returns (Rs/ha)	B: C ratio
A. Phosphorus levels (kg/ha)									
Control	16.60	5.90	34.20	784	1561	2345	33.46	27489	1.60
20	22.70	7.10	37.10	1041	2062	3103	33.93	41021	2.25
40	27.20	7.80	38.60	1160	2340	3500	33.17	47003	2.44
60	28.80	8.20	39.85	1186	2394	3580	33.27	47458	2.34
SEm±	0.62	0.18	0.93	25	49	78	1.13	1113	0.06
CD (P=0.05)	1.80	0.52	2.68	71	141	226	NS	3213	0.16
B. Bio-fertilizers									
Control	19.23	6.54	34.46	926	1882	2808	33.13	34606	1.87
PSB	24.01	7.18	37.29	1062	2114	3176	33.69	42047	2.26
VAM	23.90	7.37	37.62	1039	2080	3119	33.51	40231	2.10
PSB + VAM	28.15	7.92	40.38	1144	2281	3425	33.51	46087	2.40
SEm±	0.62	0.18	0.93	25	49	78	1.13	1113	0.06
CD (P=0.05)	1.80	0.52	2.68	71	141	226	NS	3213	0.16
CV (%)	9.04	8.66	8.57	8.15	8.1	8.67	11.70	9.46	8.84

crop growth with more supply of phosphorus might regulate starch/sucrose ratio in source leaves and reproductive organs. The beneficial effect of phosphorus on fruiting of plants and better translocation of desired metabolites to the yield contributing parts of the plant might attributed to more grain yield. The improvement in straw yield might be due to the fact that phosphorus tends to increased growth and development in terms of plant height, branches and dry matter by improving nutritional environment of rhizosphere and plant system leading to higher plant metabolism and photosynthetic activity. These findings corroborate the results of [12,13] and [14] in urdbean. The application of phosphorus 40 kg/ha recorded the significantly higher net returns (Rs. 47003/ha) and B: C ratio over proceeding levels and remained at par with 60 kg/ha. The increase in net returns might be due to higher grain and straw yield obtained under the treatment.

4. CONCLUSION

Based on the results of one year experimentation, it may be concluded that phosphorus fertilization at 40 kg/ha in conjunction with PSB + VAM was found the most superior treatment combination for obtaining higher grain yield and net returns in mungbean.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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