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Effect of Seed Treatment and Phosphorus Levels on Growth, Yield and Economics of Cowpea (*Vigna unguiculata* L.)

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Authors' contributions

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

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ABSTRACT

Crop production encounters challenges due to the dearth of nitrogen and phosphorus, while excessive use of chemical fertilizers causes environmental hazards. Use of *Rhizobium* and phosphate solubilizing hazards. The use of *Rhizobium* and phosphate solubilizing bacteria can be a sustainable strategy to overcome these problems.

The present investigation was conducted during *Kharif* season of 2022 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction with EC in safer range, medium in organic carbon, available nitrogen, potassium and high in available phosphorus. The field experiment was laid out in a

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factorial randomized block design comprising sixteen treatments with three replications. The experiment consists of four levels of bio-fertilizer *i.e.,* (S_0) Control, (S_1) *Rhizobium* 10 ml kg^{-1} seed, (S_2) PSB 10 ml kg^{-1} seed and (S_3) *Rhizobium* + PSB both 10 ml kg^{-1} seed as first factor and four levels of phosphorus *i.e.,* (P_0) control, (P_1) 20 kg ha^{-1}, (P_2) 40 kg ha^{-1} and (P_3) 60 kg ha^{-1} as second factor. Recommended dose of nitrogen and potassium (20:20 kg ha^{-1}) was applied through urea and MOP at the time of sowing. Himlobia-2 variety of cowpea was used for sowing. Other crop management practices were followed as per the recommendation of the area.
Results indicated that among the seed treatments, seed inoculation with (S_3) *Rhizobium* + PSB both 10 ml kg^{-1} of seed recorded significant improvement in growth, yield and economics of cowpea, over single inoculation of *Rhizobium* and PSB which was statistically at par with (S_1) *Rhizobium* over rest of the treatments. Application of 60 kg P ha^{-1} resulted significantly higher growth, yield and quality of cowpea and was on par with 40 kg ha^{-1}. Economically, (S_3) *Rhizobium* + PSB both 10 ml kg^{-1} of seed along with application of 0 kg P ha^{-1} resulted in higher gross returns, net returns and B:C ratio under Mid-hills of Himachal Pradesh.

Keywords: Cowpea; PSB; rhizobium; phosphorus; minerals; bacteria.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is an important legume vegetable crop that is grown during the summer and rainy seasons. The pods of cowpea are rich in quality protein and minerals. People cultivate certain varieties for their grains, as fodder, and for green manure. Cowpea is becoming increasingly popular among vegetable growers due to its short growth duration, fast growth rate, ability to enrich the soil, higher yield, and greater profitability per unit of land. This is causing a shift away from other traditional summer vegetable crops.

However, in Himachal Pradesh, the productivity of cowpea is quite low. This is mainly because farmers there don’t use enough fertilizers and lack access to improved farming methods. Cowpea responds well to nitrogen, which encourages the growth of leaves, stems, and other vegetative parts. Phosphorus, on the other hand, helps *Rhizobium* (a type of bacteria) work better and increases the formation of root nodules. These nodules play a key role in capturing nitrogen from the air and making it available to the plant [1].

Unfortunately, most of the soil under the Mid-hill condition of Himachal Pradesh is acidic in nature and contains low amounts of available nitrogen and phosphorus. When farmers add soluble inorganic phosphate to the soil, a large portion of it quickly turns into insoluble forms, which the plants can’t use. In acidic soils, certain compounds called free oxides can also affect plant growth. This combination of factors makes it challenging to grow productive cowpea crops in this region [2,3]. Aluminum and iron hydroxides lock up phosphorus in the soil, making it hard for crops to access. This means that the plants can’t use much of the available phosphorus [4]. To improve this situation, bio-fertilizers are very important. Some research suggests that when seeds are treated with *rhizobium* and phosphate solubilizing bio-fertilizers (PSB), the growth of plants improves a lot. This includes better root growth, more nodules (which help with nitrogen uptake), and ultimately, more cowpea pods are produced [5].

2. MATERIALS AND METHODS

The experiment was conducted during June to September month of 2022 at the Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan. Geographically, Chamelti Agriculture Farm is situated 30 km away from Solan city at an elevation of 1,270 meters above mean sea level lying between latitude 30º 85’67.30 N and longitude 77º 13’20.38 E. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction with EC in safer range, medium in organic carbon, available nitrogen, potassium and high in available phosphorus. The field experiment was laid out in factorial randomized block design. The soil in the experimental field was sandy loam and had a pH of 6.82.

The experiment included sixteen different treatments for cowpea variety “Himlobia-2”. These treatments combined recommended amounts of nitrogen (20 kg ha^{-1}), potassium (20 kg ha^{-1}) and bio-fertilizers, (*Rhizobium* 10 ml kg^{-1}

seed, PSB 10 ml kg seed^{-1}, *Rhizobium* + PSB 10 ml kg^{-1} seed). The experiment followed a Factorial randomized block design with three replications. Levels of phosphorus was spread out in the field a day before sowing with recommended dose of nitrogen and potassium. Seeds were treated with liquid bio-fertilizer, then planted at a depth of 2.5 cm with spacing of 30 cm between rows and 20 cm between plants.

Various measurements were taken from ten randomly selected plants in each plot, including plant height, number of branches plant^{-1}, number of pods plant^{-1}, total dry matter, and pod yield. Soil were collected at the end of the experiment to assess soil pH, organic carbon, EC and phosphorus using standard methods.

The collected data was analyzed using SPSS. Treatment means were compared using a test called the least significant difference (LSD) at a significance level of 0.05.

3. RESULTS AND DISCUSSION

3.1 Effect of Seed Treatment

Seed inoculation with *Rhizobium* + PSB significantly increased plant height (149.25 cm), number of branches plant^{-1} (8.45), total dry matter (23.51 g plant^{-1}) at the harvesting stage of crops, number of pods (9.50), seed pod^{-1}, seed yield (1117.93 kg ha^{-1}), stover yield (4591.63 kg ha^{-1}) and B:C Ratio (3.15) over single inoculation of *Rhizobium* and PSB (Table 1).

Inoculation of seed with symbiotic nitrogen fixers increases the concentration of a beneficial and healthy strain of *Rhizobium* in the rhizosphere, which in turn resulted in higher fixation of atmospheric nitrogen in soil to use by the plants and consequently increases plant growth. Rasool and Singh [6] also reported similar results in lentil. The growth of the plants, both their roots and above-ground parts, might have been improved because they absorbed more nutrients and could carry out photosynthesis more efficiently. This increase in nutrient uptake and photosynthesis led to taller plants, more branches, and more plant material in cowpea. The outcomes of this study are consistent with the findings of Lone et al. [7], who discovered that using biofertilizers could make cowpea plants grow better.

3.2 Effect of Phosphorus Levels

Phosphorus level (60 kg P ha^{-1}) significantly increased plant height (148.35 cm), number of branches plant^{-1} (8.20), total dry matter (24.02 g plant^{-1}) at harvesting of cowpea, number of pods (8.93), seeds pod^{-1} (9.03), seed yield (1119.35 kg ha^{-1}) and stover yield (4587.27 kg ha^{-1}) over control (Table 1). In economics, control (0kg P ha^{-1}) resulted in higher B:C ratio (3.41).

Table 1. Effect of seed treatment and phosphorus levels on Growth and yield of cowpea

Treatment	Plant height	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Dry matter plant^{-1} (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Factor 1 (seed treatment)							
S_0	128.53	6.10	7.58	7.09	22.01	1024.01	4286.51
S_1	141.25	7.83	8.76	8.29	22.91	1087.11	4502.33
S_2	136.37	6.65	8.22	7.88	22.61	1064.52	4430.40
S_3	149.25	8.45	9.50	9.08	23.51	1117.93	4591.63
SEm±	3.50	0.31	0.24	0.26	0.20	12.90	33.34
LSD (p = 0.05)	10.52	0.93	0.74	0.80	0.62	37.27	100.04
Factor 2 (Phosphorus levels)							
P_0	127.76	6.03	6.82	6.68	22.25	1010.62	4293.93
P_1	135.01	6.60	7.52	7.49	22.85	1070.54	4430.69
P_2	140.18	7.34	8.23	8.28	23.45	1093.05	4498.98
P_3	148.35	8.20	8.93	9.03	24.02	1119.35	4587.27
SEm±	3.50	0.31	0.24	0.26	0.20	12.90	33.34
LSD (p = 0.05)	10.52	0.93	0.74	0.80	0.62	37.27	100.04
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of seed treatment and phosphorus levels on physico-chemical properties of soil after harvesting of cowpea

Treatment	pH	EC (dS m^{-1})	OC (%)	Available phosphorus (kg ha^{-1})
Factor 1 (Seed treatment)				
S_0	6.91	0.21	0.55	42.89
S_1	6.87	0.23	0.56	38.81
S_2	6.89	0.23	0.55	40.38
S_3	6.86	0.24	0.57	36.73
SEm±	0.02	0.01	0.01	1.25
LSD (p = 0.05)	NS	NS	NS	3.60
Factor 2 (Phosphorus levels)				
P_0	6.87	0.21	0.56	13.54
P_1	6.88	0.23	0.56	30.92
P_2	6.89	0.24	0.57	48.52
P_3	6.90	0.24	0.57	65.85
SEm±	0.02	0.01	0.01	1.25
LSD (p = 0.05)	NS	NS	NS	3.60
Interaction	NS	NS	NS	NS
Initial	6.82	0.22	0.55	27.53

Table 3. Economics (₹ ha^{-1}) of cowpea as influenced by seed treatment and phosphorus levels

Treatments	Economics (₹ ha^{-1})			B:C Ratio
	Cost of Cultivation	Gross Return	Net Return	
Factor 1 (Seed Treatment)				
S_0: Control	19745	75966	56221	2.84
S_1: Rhizobium	19831	80599	60768	3.06
S_2: PSB	19831	78946	59115	2.98
S_3: Rhizobium + PSB	19917	82846	62929	3.15
Factor 2 (Level of Phosphorus)				
P_0: 0 kg ha^{-1}	17014	75037	58023	3.41
P_1: 20 kg ha^{-1}	18889	79368	60479	3.20
P_2: 40 kg ha^{-1}	20782	81012	60230	2.90
P_3: 60 kg ha^{-1}	22639	82941	60302	2.66

Phosphorus doesn't just contribute to root development and growth; it also enhances the process of nodulation and nitrogen fixation by providing necessary nutrients to the roots. Applying phosphorus to soils that are lacking in it could improve nutrient availability, leading to increased nutrient uptake. The energy obtained from processes like photosynthesis and the breakdown of stored carbohydrates (ATP and ADP) is used for growth, which ultimately leads to robust plant development. These findings agree with the results of Nkaa *et al.* [8] and Singh *et al.* [9] in cowpea, Ali *et al.* [10] in chickpea, and Rasool and Singh (2016) in lentil.

4. CONCLUSION

Among the seed treatments, seed inoculation with (S_3) *Rhizobium* + PSB both 10 ml kg^{-1} of seed resulted significant improvement in growth, yield and economics of cowpea, which was statistically at par with (S_1) *Rhizobium* over rest of the treatments.

Application of 60 kg P ha^{-1} resulted significantly higher growth, yield and economics of cowpea and was on par with 40 kg ha^{-1}.

Economically, (S_3) *Rhizobium* + PSB both 10 ml kg^{-1} of seed along with application of 0 kg P ha^{-1} resulted in higher gross returns, net returns and B:C ratio under Mid-hills of Himachal Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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