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Soil Nutrient Availability and Profitability as Affected by PROM and Phosphatic Inoculants in Cowpea [*Vigna unguiculata* (L.) Walp]

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ABSTRACT: A field experiment on loamy sand soil was conducted in the *kharif* of 2020, at the Agronomy farm at S.K.N. College of Agriculture, Jobner (Rajasthan). The field experiment included four levels of PROM (Control, PROM equivalent to 20 kg, 40 kg, and 60 kg P_2O_5/ha), as well as four phosphatic inoculants (PSB, VAM, and PSB + VAM) thereby making 16 treatment combinations. The experiment was set up in Factorial Randomized Block Design with three replications. The application of PROM equivalent to 40 kg P_2O_5/ha, according to the results, considerably increased the amount of accessible P in the soil after harvest when compared to lesser levels. The most profitable level was determined to be applying PROM equivalent to 40 kg P_2O_5/ha, which yielded net returns of ₹37184/ha. The application of PSB + VAM led to a considerable increase in accessible N, P, and K in the soil after harvest. With a B:C ratio of 2.38, the dual inoculation of PSB+VAM likewise produced the highest net returns, at ₹43226/ha. The most effective treatment combination for increasing net return (₹52400/ha) was dual phosphatic inoculation of PSB + VAM with application of PROM equivalent to 40 kg P_2O_5/ha, according to the results.

Keywords: Net return, PROM, PSB and VAM.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp], also known as lobia and grown for vegetables, grains, fodder, and green manuring, is one of the major *kharif* pulse crops in India. This crop's short growth period, high yield and quick growth make it extremely significant. The green tender pods of cowpea are used as vegetables. They are high in protein, minerals and vitamins. While fresh seeds and tender pods are the preferred form, dry seeds are also eaten in some regions of the nation. Growing cowpea in rainfed conditions, low soil fertility, conventional growing methods, lack of access to new techniques and the fact that they are mostly cultivated on marginal and sub-marginal soils with poor fertility are some of the main obstacles limiting their output. It is a fact of life that a wide variety of nutrients have a significant impact on the growth and yield of plants. The most lacking element is nitrogen, particularly in Rajasthan's coarse-textured sandy soils. Nitrogen is beneficial to early root advancement, plant growth, yield and produce quality. It is necessary for the transfer of energy throughout the plant system. It is also a basic component of most enzymes, which are essential for the metabolism of fats and carbohydrates as well as for plant respiration (Yawalkar *et al.,* 1996). After nitrogen, phosphorus is the second most important nutrient. The amount of accessible phosphorus in Indian soils is poor. In the year of application, crops only absorb 15–30% of the phosphate fertilizer, with the other portion becoming insoluble phosphorus (Swarup, 2002). Phosphate Rich Organic Manure (PROM), sometimes known as "green chemistry phosphatic fertilizer," is a more cost-effective and efficient source of phosphorus when compared to costly chemical phosphatic fertilizers. Similar to DAP, PROM also exhibits equal residual impact, meaning it is effective for the crop that follows. Its contents are 55–60% organic manure, 14–16% P_2O_5, 15:1 C:N ratio, and 7–7.5 pH. Legume seed inoculation with phosphate solubilizing bacteria (PSB) increases biomass in the roots and shoots, nodulation and the amount of accessible phosphorus in the soil. PSB releases the acidic compounds and transforms the inaccessible phosphorus into a form that plants can use. PSB has the potential to increase crop yields by 10–30% by adding 30 kg of phosphorus per hectare to the soil, namely in the case of vegetables and legumes.

MATERIAL AND METHOD

The Agronomy Farm of the S.K.N. College of Agriculture in Jobner, Rajasthan, was the site of this experiment. Jobner is located 427 meters above mean sea level and 45 kilometers west of Jaipur at 26°05′ North latitude and 75°28′ East longitude. This area of Rajasthan is located in the Semi-Arid Eastern Plains Zone, or Agroclimatic Zone IIIA. The field experiment included four levels of PROM (Control, PROM equivalent to 20 kg, 40 kg, and 60 kg P_2O_5/ha), as well as four phosphatic inoculants (PSB, VAM, and PSB + VAM) thereby making 16 treatment combinations. The experiment was set up in Factorial Randomized Block Design with three replications. The allotment of treatments to various plots in each replication was done by referring random number. After the harvest of the cowpea crop, representative soil samples (0 to 15 cm depth) from each plot were gathered, allowed to air dry, and then run through a 2 mm sieve in order to determine the soil's ultimate fertility state. The amount of nitrogen, phosphorus, and potassium that was accessible in the soil samples was measured. In order to evaluate the profitability of the treatments, comprehensive economics comprising net returns (₹/ha) and the B:C ratio were computed. This allowed the most profitable and efficient treatment to be suggested. Analysis of variance (ANOVA) was used to evaluate the experimental data in accordance with the Factorial Randomized Block Design (Gomez and Gomez, 1984). Significance of the treatments were tested using F test with 5% level of significance ($P< 0.05$) and means were compared using the least significant difference (LSD) test at $\alpha = 0.05$.

Economics

Levels of PROM. Application of different levels of PROM upto PROM equivalent to 40 kg P_2O_5/ha was found the most remunerative level in cowpea. It fetched the net returns of ₹37184/ha thereby indicating a significant increase of 18.1 per cent and 48.9 per cent over PROM equivalent at 20 kg P_2O_5/ha and control, respectively. However, it remained at par with PROM equivalent to 60 kg P_2O_5/ha wherein, the maximum net returns (₹37685 /ha) was recorded. Similar results were also reported by Kumar *et al*. (2018) in mungbean and Kumawat *et al*. (2013) in urdbean.

Phosphatic inoculation. Use of PSB+VAM fetched significantly highest net returns of (₹43226 /ha) over no inoculation and control, respectively. PSB alone was the next better and equally remunerative phosphatic inoculation treatments. PSB also gave 42.7 per cent more return than control (Table 1). As net return is computed by multiplying the seed and straw yields by their market sale prices and subtracting the cost of cultivation including treatment cost, it seems to be directly associated with significantly higher seed and straw yields obtained under these superior treatments as well as comparatively lower additional cost of cultivation over control in comparison to added output. The highest B:C ratio (2.38) was observed with PSB + VAM which might be attributed to the very low cost of treatment. These results are in agreement with the findings of Singh *et al.* (2016) in urdbean and Khandelwal *et al*. (2012) in cowpea.

Effect of Interaction. Interactive effect of varying levels of PROM and phosphatic inoculation on net returns in cowpea was also noted to be influenced significantly. Application of PROM equivalent to 60 kg P_2O_5/ha combined with dual phosphatic inoculation of PSB + VAM ($P_{60}I_{PV}$) was found as the most remunerative treatment combination in obtaining net returns (₹53494/ha) and it was found at par with $P_{40}I_{PV}$. The results of the present investigation corroborate with the findings of Khangarot (2020) in mungbean.

Available soil nutrients

Levels of PROM. Results presented in Table 3 revealed that the application PROM equivalent to 20 kg P_2O_5/ha significantly enhanced the available N and K than control in soil after harvest of the cowpea. However, available P in soil after crop harvest was significantly increased under the application of PROM equivalent to 40 kg P_2O_5/ha. Applying phosphorus to the otherwise low-phosphorus soil had a positive effect on photosynthesis, the production of proteins and phospholipids, and other plant metabolic activities, which improved root growth and proliferation. Applying PROM improved the overall biomass (seed and straw) in cowpea plants by fostering a healthy internal environment and increasing photosynthetic efficiency. After harvest of cowpea crop, phosphorus treatment improved the soil's N, P, and K status (Table 3). As the amount of PROM increased, an increasing trend for the building up of N, P, and K status was seen. Applying organic manure rich in phosphorus boosted root nodulation, which may have encouraged microbial activity and increased mineralization. Furthermore, the availability of nutrients may have been aided by the release of hormones and organic acids brought on by phosphor bacterial activity (Bhatt *et al.,* 2013). Kumar and Yadav (2018) found similar findings on the nutrients that were present in the soil for mungbean.

Phosphatic inoculation. The extraction of acids such as glutamic, succinic, lactic, oxalic, glyoxalic, malic, fumaric, α-ketobutric, propionic and formic is responsible for the solubilization of phosphorus by phosphatic inoculants. Phosphates were successfully soluble in these acids (hydroxyl-acid) by forming chelates with cations like Ca^{++} and Fe^{++}. Apart from solubilizing phosphate, these microorganisms have the ability to mineralize organic phosphorus and produce excess P in the soil solution, which plants can utilize for growth and metabolism. This could be because the PSB + VAM inoculation increased the amount of N, P, and K available in the soil (Table 3), enhanced the N, P, and K content in the seed and increased the amount of N, P, and K uptake in the straw.

Malik *et al.* (2013) reported similar observations. Furthermore, the ability of legume roots to excrete amino acids and promote the growth and multiplication of soil microorganisms has the potential to solubilize soil phosphorus, which in turn allows inaccessible P to be mineralized into available P in the soil. It is a well-known fact that plants N content will increase if their P nutrition is enhanced, whether via fertilization or biological methods such symbiotic N_2 fixation. Increased phosphatase activity has been directly linked to uptake of P by plants. Additionally, it was discovered that one of the most significant characteristics of fungi is their capacity to relocate plant nutrients, particularly N, P, and K. The results were discovered to be similar to those reported by Mondal *et al.* (2015); Tripura (2017).

Table 1: Effect of varying levels of PROM and phosphatic inoculation on net returns and B:C ratio in cowpea.

Treatments	Net returns (₹/ha)	B:C ratio
Levels of PROM		
Control	24959	2.11
PROM equivalent to 20kg P_2O_5/ha	31483	2.12
PROM equivalent to 40kg P_2O_5/ha	37184	2.11
PROM equivalent to 60kg P_2O_5/ha	37685	1.96
SEm±	1124	0.06
CD (P=0.05)	3246	NS
Phosphatic inoculation		
Control	22411	1.77
PSB	34457	2.14
VAM	31217	2.01
PSB + VAM	43226	2.38
SEm±	1124	0.06
CD (P=0.05)	3246	0.17
Interaction (P X I)	Sig.	NS
CV (%)	11.16	9.79

Sig. = Significant, NS= Non Significant

Table 2: Interactive effect of varying levels of PROM and phosphatic inoculation on net returns (₹/ha).

Treatments	Levels of PROM equivalent to			
	P_0-Control	**P_{20}**-20kg P_2O_5/ha	**P_{40}**-40kg P_2O_5/ha	**P_{60}**-60kg P_2O_5/ha
I_0 -Control	21233	22833	23823	21754
I_P-PSB	25768	34074	38171	39816
I_V -VAM	23499	31352	34344	35675
I_{PV}-PSB+VAM	29336	37673	52400	53494
SEm±	2248			
CD (P=0.05)	6491			

Table 3: Effect of varying levels of PROM and phosphatic inoculation on available Nitrogen, phosphorus and potash in soil after harvest of crop.

Treatments	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Levels of PROM			
Control	123.51	16.72	162.35
PROM equivalent to20 kg P_2O_5/ha	132.50	18.46	173.62
PROM equivalent to 40kg P_2O_5/ha	137.56	19.86	181.65
PROM equivalent to 60kg P_2O_5/ha	140.85	20.15	186.92
SEm±	2.93	0.52	3.80
CD (P=0.05)	7.84	1.30	10.97
Phosphatic inoculation			
Control	126.73	16.14	168.48
PSB	135.64	19.40	177.73
VAM	130.08	18.90	176.70
PSB + VAM	141.97	20.75	181.63
SEm±	2.72	0.45	3.80
CD (P=0.05)	7.84	1.30	10.97
CV (%)	7.04	8.28	7.47

CONCLUSIONS

Based on the results of one year experimentation, it may be inferred that application of PROM equivalent to 40 kg P_2O_5/ha combined with dual phosphatic inoculation of PSB + VAM ($P_{40}I_{PV}$) was found the most superior treatment combination for obtaining higher net returns (₹52400/ha) in cowpea.

FUTURE SCOPE

The result of the study will provide the basis for future research to find out the suitable and sustained source of nutrients in standing crop for organic growers in the time of fertilizer crisis.

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Conflict of Interest. None.

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