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INFLUENCE OF PHOSPHORUS LEVELS AND LIQUID BIOFERTILIZERS APPLICATION ON SOIL HEALTH AND NUTRIENT DYNAMICS IN URDBEAN (*VIGNA MUNGO* L.)

Bineeta Yadav*, M.K. Sharma, R.K. Yadav, RK. Meena, J.P. Tetarwal and V.K. Yadav

College of Agriculture, Ummedganj-Kota, Agricultural University, Kota, Rajasthan, India

*Corresponding author E-mail: Bineetayadav1705@gmail.com

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ABSTRACT

A field experiment was conducted during *Kharif*, 2024 on clay loam soil to study the "influence of phosphorus levels and liquid biofertilizers application on soil health and nutrient dynamics in urdbean (*Vigna mungo* L.)" at the Instructional farm, College of Agriculture, Ummedganj-Kota which was laid out in factorial randomized block design (FRBD) with 2 factors *viz.* phosphorus levels and liquid biofertilizers, 3 replications and 16 treatment combination. The experiment consist of four different phosphorus levels *i.e.* Control, 75 % RDP, 100 % RDP and 125 % RDP applied as basal dose and four different liquid biofertilizer combination *i.e.* No inoculation, PSB, PSB + *Rhizobium* and NPK consortia applied as seed treatment at the time of sowing. Results showed that application of different phosphorus levels and liquid biofertilizers doesn't report any significant effect on the soil physical property *i.e.* BD, PD, porosity and WHC as well as chemical properties *i.e.* pH, EC, OC and CEC and soil available nitrogen and potassium where non-significant whereas there is a substantial rise in the soil available phosphorus and alkaline phosphatase enzyme with 125 % RDP and NPK consortia and statistically remained at par with 100 % RDP and PSB + *Rhizobium*, respectively and soil available suphur with 125% RDP and remained at par with 100 % RDP and 75 % RDP.

***Keywords*:** Urdbean, Phosphorus, Liquid biofertilizers, RDP, NPK consortia, Rhizobium, PSB.

Introduction

Pulses are integral to sustainable agriculture, largely due to their natural ability to improve soil fertility. Through a symbiotic relationship with *Rhizobium* bacteria in root nodules, these crops fix atmospheric nitrogen, thereby reducing the need for synthetic fertilizers and contributing to healthier soils (Harika *et al.*, 2023). Urdbean (*Vigna mungo* L.), also referred to as black gram, is one of the most significant pulse crops in India. Nutritionally, it is composed of about 60% carbohydrates and 25% protein, along with small amounts of fats, phosphoric acid and essential B-complex vitamins like riboflavin and thiamine (Lokhande, 2018). Nationally, urdbean is cultivated on around 13% of the area dedicated to pulses and contributes approximately 10% to the total pulse production. In Rajasthan, its cultivation spans nearly 286,786 hectares, yielding 196,359 tonnes, with an average productivity of 685 kg per hectare (Anonymous, 2024). However, in several regions of south-eastern Rajasthan, limited use of fertilizers by farmers has resulted in poor crop performance and declining soil fertility (Laddha *et al.*, 2006).

Phosphorus is a key nutrient in pulse cultivation, crucial for supporting root growth, nodule formation, and energy metabolism (Kant *et al.*, 2017; Jangir *et al.*, 2017). Biofertilizers offer a sustainable alternative to chemical inputs. *Rhizobium*-based inoculants enhance the nitrogen-fixing capacity of pulses (Abdelgani *et al.*, 2003), while phosphate-solubilizing microorganisms (PSMs) make insoluble phosphorus forms more available to plants, thus promoting better nutrient uptake and growth (Sanjotha & Manawadi, 2016). This study is designed to explore how different levels of phosphorus and applications of liquid biofertilizers affect soil health and nutrient availability in urdbean cultivation. The broader objective is to identify sustainable management practices that can improve yield while maintaining soil quality in pulse-based farming systems.

Materials and Method

A field experiment was conducted during *Kharif*, 2024 at Instructional farm, College of Agriculture, Ummedganj-Kota which is located at 23°40' to 24°52' N latitude and 75°29' to 76°56' E longitude at an altitude of 258 m above mean sea level in the humid south-eastern plain zone (agro-climatic zone V) of Rajasthan. The soil of experimental site was clay loam in texture, slightly alkaline in reaction. The experimental soil is medium in available nitrogen, phosphorus and sulphur while high in potassium. Source of nutrients applied were urea for nitrogen, single super phosphate (SSP) for phosphorus, phosphate solubilizing bacteria (PSB), *Rhizobium* and NPK consortia were used as liquid biofertilizers.

The experimental laid out in factorial randomized design (FRBD) with 2 factors *viz.* phosphorus levels and liquid biofertilizers, 3 replication and 16 treatment combination. The treatment comprised of four levels of phosphorus *i.e.* Control, 75 % recommended dose of phosphorus (RDP), 100 % RDP and 125 % RDP applied as basal dose and four different liquid biofertilizer combination *i.e.* No inoculation, PSB, PSB + *Rhizobium* and NPK consortia applied as seed treatment at the time of sowing.

Determination of soil physico-chemical properties and nutrient status

To estimate the fertility status of the soil, the soil sample (0-15 cm depth), from each plot at harvest of crop was taken. The sample was sieved through 2 mm sieve.

Physical properties *i.e.* bulk density (BD) and particle density (PD) estimated by the Pycnometer or RD bottle (Piper, 1950), while the total porosity is determined by the using BD and PD values put in the formula and water holding capacity (WHC) was determined by (Richards. 1954) Soil electrical conductivity (EC) measure by the help of EC meter while pH is the measure by pH meter (Richards, 1954). Soil organic carbon determined by (Walkley and Black, 1934) method and cation exchange capacity (CEC) was analysed by ammonium saturation method (Metson 1956)

N availability was determined by (Subbiah and Asija. 1956). Analysis of Phosphorus content in soil (Olsen *et al.*, 1954) using spectrophotometer. Available potassium estimated by Ammonium Acetate method (Hanway and Heidal, 1952). Sulphur was estimated by Turbidimetric method using spectrophotometer (Williams and Steinberg, 1969) and alkaline phosphatase enzyme analysed by (Tabatabai and Bremner, 1969).

The data of different parameters were recorded for statistically analysed by adopting appropriate method of standard analysis of variance (ANOVA) using technique for factorial randomized block design. The least significant difference test was used to decipher the main and interaction effects of treatments at 5% level of significance ($P < 0.05$) by using least significant test (Gomez and Gomez, 1984).

Result and Discussion

Effect of Phosphorus Levels

Soil Physico-chemical Properties

Data shown in Table 1 revealed that application of phosphorus levels, statistically did not show any significant change in the physico-chemical properties of soil *i.e.* BD, PD, porosity, WHC, pH, EC, OC and CEC after harvest of urdbean crop. Similar results in the bulk density and particle density data also demonstrated that the application of phosphorus fertiliser did not result in a substantial difference between the BD and PD values. (Tian *et al.*, 2020; Manoj *et al.*, 2023). The pH and EC values of the soil were found to be little altered by the application of single super phosphate fertilisers (Singh *et al.*, 2007). Veer *et al.* (2024) and Yadav. (2017) also reported a similar outcome.

Soil Available Nutrient

Data presented in Table 2 and figure 1 revealed that with the application of different phosphorus levels there is no significant increase in the soil available nitrogen and potassium whereas there is a substantial rise in the soil available phosphorus and sulphur. The maximum soil available phosphorus and sulphur was recorded with the application of 125 % RDP (30.58 kg ha^{-1}) and (20.49 kg ha^{-1}), respectively which is statistically at par with 100 % RDP (30.14 kg ha^{-1}) and (19.92 kg ha^{-1}), respectively. Conversely, lowest soil available phosphorus and sulphur (25.62 kg ha^{-1}) and (18.34 kg ha^{-1}), respectively was recorded with control. Applying phosphorus boosted root nodulation, which may have encouraged microbial activity and improved mineralisation of nutrients (Bhatt *et al.*, 2013). Similar findings also reported by Manoj *et al.* (2023), Veer *et al.* (2024), Yadav. (2017).

Soil biological property

Results perceived in Table 2 revealed that there is an imperative effect of various phosphorus levels on soil biological property *i.e.* alkali phosphatase enzyme. It was reported that with the application of 125 % RDP (20.03 μg PNP g^{-1} soil hr^{-1}) the alkaline phosphatase enzyme activity increases rapidly and remained statistically equivalent to 100 % RDP (19.72 μg PNP g^{-1} soil hr^{-1}) and significantly higher than control. It may be because microbes were more active in using the local pool of organic carbon as a carbon source when they were exposed to inorganic nutrient sources. The observation recorded were found similar with Mohammad *et al.* (2017) and Raiger *et al.* (2024).

Effect of Liquid Biofertilizers

Soil Physico-chemical Properties

An analysis of data presented in Table 1 clearly showed that application liquid biofertilizers didn't showed any significant change in the physio-chemical properties of soil. According to Yilmaz and Alagose (2010), Microorganisms enhance soil structure by producing polysaccharides that bind soil particles into stable aggregates, lowering BD and improving aeration and drainage. As they decompose organic matter, they release compounds that stimulate growth and microbial activity, boosting soil health and water use efficiency (Bhardwaj *et al*., 2014). According to Shekhawat *et al.* (2017), Phosphorus and biofertilizers improve soil properties by boosting microbial activity, which releases organic acids that lower soil pH to an optimal range for nutrient availability. Biofertilizer application causes only slight changes in soil pH and EC. (Sharma *et al*., 2019). Similarly, Yadav (2017) reported similar results.

Soil Available Nutrient

Analysis of Table 2 and figure 1indicates that liquid biofertilizer application did not significantly affect soil nitrogen, potassium, or sulphur levels. However, a notable improvement was observed in soil phosphorus availability. The highest phosphorus content (28.48 kg/ha) was recorded with NPK consortia seed inoculation, significantly higher than PSB (26.18 kg/ha) and the uninoculated control (24.49 kg/ha) and remained statistically equivalent to PSB + *Rhizobium* (28.01 kg/ha). This improvement may be attributed to enhanced microbial activity, particularly from *Rhizobium* and PSB, which supports better nutrient mobilization and availability in the rhizosphere (Jangir *et al*., 2017; Shekhawat *et al*., 2017). Similar findings have been reported by Kumawat *et al*. (2024) and Danga *et al*. (2023).

Soil biological property

Data presented in Table 2 reported that soil biological property *i.e.* alkali phosphatase enzyme significantly increases with the application different liquid biofertilizers. Alkali phosphatase enzyme activity reported maximum with the application of NPK consortia (19.99 μg PNP g^{-1} soil hr^{-1}) which was found significantly equivalent to PSB + *Rhizobium* (19.75 μg PNP g^{-1} soil hr^{-1}). The addition of organic manure and biofertilizer increases microbial activity, which in turn boosts the activity of enzymes that are essential for the transformation, recycling, and availability of plant nutrients in soil (Shekhawat *et al.*, 2018). Sreelakshmi *et al.* (2019) and Raiger *et al.* (2024) reported that application of liquid biofertilizers subsequently increases the soil biological property.

Interactive effect

The data presented in Table 3 indicate that the interaction between varying levels of phosphorus and liquid biofertilizer treatments had a significant effect on soil available phosphorus. The highest value (32.07 kg ha^{-1}) was observed in the treatment combining 125% RDP with NPK consortia which was statistically comparable to different treatment combinations *i.e.* 100% RDP + NPK consortia (31.97 kg ha^{-1}), 125% RDP + PSB + *Rhizobium* (32.03 kg ha^{-1}) and 100% RDP + PSB + *Rhizobium* (31.74 kg ha^{-1}) all of which demonstrated similarly enhanced levels of available phosphorus in the soil. similar results were demonstrated by Kant *et al.* (2017).

Conclusion

According to the aforementioned observation, the application of 125% RDP and NPK consortia resulted in a notable increase in soil physio-chemical and biological properties and soil nutrient availability and remained at par with 100 % RDP and PSB + *Rhizobium* and it has shown to be advantageous as it improves soil nutrient availability as well as soil health.

Table 1: Effect of phosphorus levels and liquid biofertilizers on physico-chemical properties of soil

	Physical properties				Chemical properties			
	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)	Water holding capacity (%)	pH	EC (dS m^{-1})	Organic carbon (%)	Cation exchange capacity (C mol (p+) g^{-1})
PHOSPHORUS LEVELS								
Control	1.314	2.329	43.56	39.81	7.83	0.800	0.496	21.58
75 % RDP	1.308	2.328	43.82	41.12	7.79	0.793	0.510	22.00
100 % RDP	1.305	2.325	43.84	41.25	7.80	0.788	0.514	22.54
125 % RDP	1.299	2.318	43.95	41.60	7.78	0.773	0.524	23.02
SEm±	0.009	0.013	0.54	0.72	0.03	0.009	0.01	0.37
C.D. at 0.05	NS	NS	NS	NS	NS	NS	NS	NS
LIQUID BIOFERTILIZER								
No Inoculation	1.317	2.331	43.48	39.77	7.83	0.800	0.498	21.99
PSB	1.312	2.328	43.66	40.32	7.80	0.783	0.505	22.26
PSB + *Rhizobium*	1.303	2.327	43.98	41.15	7.79	0.778	0.518	22.41
NPK Consortia	1.295	2.315	44.05	42.55	7.78	0.793	0.523	22.49
SEm±	0.009	0.013	0.54	0.72	0.03	0.009	0.01	0.37
C.D. at 0.05	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of phosphorus levels and liquid biofertilizers on soil available nutrient N, P, K, S and alkaline phosphatase enzyme

	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	Available Sulphur (kg ha^{-1})	Alkaline phosphatase enzyme (μg PNP g^{-1} soil hr^{-1})
PHOSPHORUS LEVELS					
Control	198.87	20.81	364.73	18.34	17.35
75 % RDP	205.36	25.62	370.43	19.61	18.81
100 % RDP	208.68	30.14	376.41	19.92	19.72
125 % RDP	209.81	30.58	379.67	20.49	20.03
SEm±	2.90	0.24	4.40	0.32	0.29
C.D. at 0.05	NS	0.70	NS	0.91	0.85
LIQUID BIOFERTILIZER					
No Inoculation	199.85	24.49	367.11	19.02	17.42
PSB	205.37	26.18	372.84	19.41	18.76
PSB + *Rhizobium*	206.73	28.01	374.76	19.81	19.75
NPK Consortia	210.79	28.48	376.52	20.12	19.99
SEm±	2.90	0.24	4.40	0.32	0.29
C.D. at 0.05	NS	0.70	NS	NS	0.85

Table 3 : Interactive effect of phosphorous levels and liquid biofertilizers on soil available phosphorus (kg ha^{-1})

Treatment	Control	75 % RDP	100 % RDP	125 % RDP
No inoculation	19.02	24.20	26.72	28.02
PSB	19.23	25.13	30.14	30.21
PSB + *Rhizobium*	22.10	26.17	31.74	32.03
NPK Consortia	22.90	26.96	31.97	32.07
SEm±	0.49			
C.D. at 0.05	1.41			

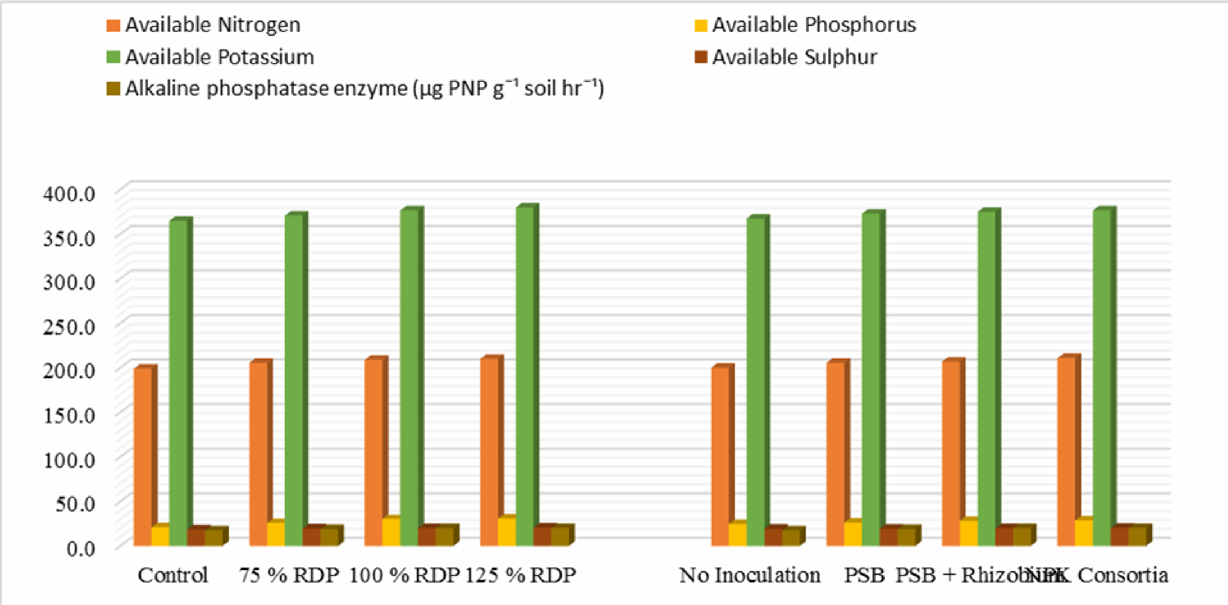

Fig. 1: Effect of phosphorus levels and liquid biofertilizers on soil available nutrient N, P, K, S and alkaline phosphatase enzyme

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