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Effect of phosphate-rich organic manure (PROM) on nutrient uptake and soil properties after harvest of Rajmah (*Phaseolus vulgaris* L.)

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Abstract
The research study, named "Effect of phosphate-rich organic manure (PROM) on productivity, nutrient uptake and economics in Rajmah bean (*Phaseolus vulgaris* L.)", took place at the Agronomy farm of the College of Agriculture in Pune, Maharashtra, throughout the 2023-24 growing season. The experiment was arranged in a Randomized Block Design (RBD) consisting of seven treatments and three replications. The treatment T_3 (100% phosphorus through single super phosphate) recorded the significantly higher N, P and K content in seeds (3.55%, 0.77% and 0.90%) and stover (1.31%, 0.26% and 1.24%). The significantly higher N, P and K uptake by rajmah bean seeds (58.19 kg ha^{-1}, 12.56 kg ha^{-1} and 14.70 kg ha^{-1}) and stover (31.90 kg ha^{-1}, 6.30 kg ha^{-1} and 30.12 kg ha^{-1}) recorded by treatment T_3 (100% phosphorus through single super phosphate), which ultimately noted higher total uptake by rajmah bean. The highest available N, P, K (266.68, 30.60 and 373.23 kg ha^{-1}, respectively) were observed with the application of treatment T_4 (100% phosphorus through PROM).

Keywords: PROM, nutrient uptake, rajmah bean

1. Introduction
Rajmah bean (*Phaseolus vulgaris* L.) is part of the Fabaceae family and comes from South America. Rajmah bean is a good source of energy; it contains high protein, dietary fibre, and complex carbohydrates and also provides folic acid (Edje *et al.*, 1980) [3]. It is the most important crop cultivated for both purposes i.e. green beans or tender vegetables and dry seeds.
Phosphorus is an important plant nutrient which helps in the growth and development of plants and ultimately improves crop yield. It involves many biochemical functions in the physiological system of plants. It is an essential nutrient as a part of several key plant structure compounds and as catalysis in the conversion of numerous key flower formations and seed production, more uniform and earlier crop maturity, improvements in crop quality and increased resistance to plant diseases. It is an essential part of the skeleton of the plasma membrane, nucleic acid, many coenzymes, organic molecules and phosphorylated compounds in plant systems (Pandey and Sinha, 1986) [7].
All plants require phosphorus, but low phosphorus levels in soil pose a significant challenge for agriculture. To achieve the robust plant growth necessary for agricultural production, phosphorus often needs to be added to the soil. The solubility of phosphorus is affected by soil pH, environmental conditions and the presence of soil bacteria.
PROM (phosphorus rich organic manure) is a slow-release fertilizer that has proven to be more effective in agriculture than synthetic fertilizers like single super phosphate (SSP), diammonium phosphate (DAP), or monoammonium phosphate (MAP). PROM provides three major nutrients: phosphorus, organic carbon, and nitrogen, along with essential micronutrients such as cobalt, copper, and zinc. It also enhances soil physical properties, including structure, porosity, and the binding of soil particles into aggregates. This improves the soil water-holding capacity and increases infiltration rates. Acting as a buffering agent, PROM helps to reduce soil degradation caused by extreme acidity or alkalinity. The presence of organic matter in PROM minimizes

leaching and runoff, thereby improving soil health and fertility. Additionally, it promotes the growth of soil microorganisms that aid in dissolving phosphorus, whether naturally present or applied to the soil. PROM is particularly effective as a phosphatic fertilizer in saline soils, where DAP often fails. Its use can lower fertilization costs for farmers while conserving phosphate minerals, a non-renewable resource, due to its high residual effect. PROM continues to supply P_2O_5 to subsequent crops planted in treated areas just as efficiently as it does to the initial crop. The agronomic efficiency of PROM surpasses that of many complex phosphatic fertilizers currently on the market, leading to increased yields and improved crop quality (Khatik *et al*., 2022) [4].

2. Materials and Methods

The present investigation, "Effect of phosphate rich organic manure (PROM) on productivity, nutrient uptake and economics in rajmah bean (*Phaseolus vulgaris* L.)" was conducted at the, Agronomy Farm, College of Agriculture, Pune, during rabi 2023-24. The experiment was laid out in Randomized Block Design with seven treatments and three replications with gross and net plot sizes 4.00 x 3.00 m^2 and 3.40 x 2.60 m^2 respectively. The seven treatments *viz*., T_1 (Absolute control), T_2 [Control (No P2O5)], T_3 [100% phosphorus through single super phosphate (SSP)], T_4 [100% phosphorus through phosphate rich organic manure (PROM)], T_5 [75% phosphorus through phosphate rich organic manure (PROM) + 25% phosphorus through single super phosphate (SSP)], T_6 [50% phosphorus through phosphate rich organic manure (PROM) + 50% phosphorus through single super phosphate (SSP)], T_7 [25% phosphorus through phosphate rich organic manure (PROM) + 75% phosphorus through single super phosphate (SSP)].

In Nov, 2023 the rajmah variety Phule Rajmah was sown with a row-to-row and plant to plant spacing 30 × 10 cm^2, and it was harvested on February 2024. As per the protocol, the FYM was applied before sowing. The soil of the experimental field was clay loam in texture with strongly alkaline in reaction (pH 8.50). The soil was low in available nitrogen moderately high in available phosphorus and very high in available potassium while medium in organic carbon content. The necessary amount of N and K is applied at the time of sowing. The data and observations recorded in the experiment were statistically analyzed in randomized block design and stated significance at 5%. The standard methods were used for the analysis of N, P and K from soil and from plant. The uptake of nitrogen, phosphorous and potassium by plant was calculated by multiplying per cent N, P and K content in plant with their respective total yield. The total uptake was reported by summing up the respective uptake by grain and stover yield.

3. Results and Discussion

3.1 Nutrient content in seed and stover (%)

Among the different treatments, the application of treatment T_3 (100% phosphorus through single super phosphate) resulted in the highest N, P and K content in seeds (3.55%, 0.77% and 0.90%) and stover (1.31%, 0.26% and 1.24%) respectively. The highest nutrient content was observed in T_3 (100% phosphorus through SSP) might be due the phosphorous in SSP is readily available to plant and which is utilized for seed formation which result in increase in nutrient content in seed and straw. The increased availability of nitrogen and phosphorous in the root zone coupled with improved metabolic activity at cellular level might have increased the nutrient uptake and their accumulation in the vegetative plant parts. The increased accumulation of nutrients in vegetative parts of the plant with improved metabolism led to greater translocation of nutrients to reproductive organs of crop and ultimately the nutrient content if seed and straw of crop plant enhanced at harvest (Dutta *et al*., 2021 and Kumar *et al*., 2022) [2, 5].

3.2 Nutrient uptake in seed and stover (kg ha^{-1})

In comparison to the other treatments under investigation, the application of treatment T_3 (100% phosphorus through single super phosphate) resulted in significantly higher N, P and K uptake by rajmah bean seeds (58.19 kg ha^{-1}, 12.56 kg ha^{-1} and 14.70 kg ha^{-1}) and stover (31.90 kg ha^{-1}, 6.30 kg ha^{-1} and 30.12 kg ha^{-1}). However, it was found to be at par with the application of treatment T_7 (25% phosphorus through PROM + 75% phosphorus through SSP) and T_6 (50% phosphorus through PROM+ 50% phosphorus through SSP).

The highest nutrient uptake by seed and stover were observed in (T_3) 100 per cent phosphorus through SSP might be due the increased phosphorus level which improved nutritional level in rhizosphere as well as plant system and led to higher concentration of phosphorous in seed and stover which ultimately increase its content and uptake in both seed and stover of soybean (Singh *et al*., 2015) [10] and (Meena *et al*., 2021) [6]. The findings are similar to the result of Sanaye *et al*., (2015) and Patel *et al*., (2022) [8, 9].

3.3 Total nutrient uptake by Rajmah bean (kg ha^{-1})

The highest uptake of N, P, and K was observed in treatment T_3 where GRDF was fulfilled by chemical fertilizer, about 90.10 kg N ha^{-1}, 18.86 kg P ha^{-1} and 44.82 kg K ha^{-1}, which was statistically comparable or found to be at par with treatment T_7 (25% phosphorus through PROM + 75% phosphorus through SSP). The increased uptake of N, P and K with PROM + SSP is attributed to enhancements in soil physical conditions, improved root aeration, better water drainage, promotion of cation exchange (N+, P+, K+), consistent nutrient availability and subsequent enhanced nutrient absorption by plants. This leads to improved growth, yield and quality of rajmah bean.

3.4 Available nutrient status in soil after harvest (kg ha^{-1})

The highest available N, P, K (266.68, 30.60 and 373.23 kg ha^{-1}, respectively) was observed with the application of treatment T_4 (100% phosphorus through PROM), which were found to be at par to the treatments T_5 (75% phosphorus through PROM + 25% phosphorus through SSP) and T_6 (50% phosphorus through PROM + 50% phosphorus through SSP). The maximum available phosphorous content at harvest was found in application of T_4 (100% phosphorus through PROM) which is might be due to lower water solubility of PROM due to that it release P after production of organic acids like carbonic, fumic, fulvic etc. and also solubilize by PSB and also maximum available potassium content at harvest was found in application of T_4 (100% phosphorus through PROM) which is might be due the application of potassium fertilizer along with PROM released the potash in soil it increases the available potash in soil (Ali *et al*.,2014) [1].

3.5 Effect on chemical properties of soil after harvest of Rajmah bean

In case of chemical properties of soil like pH, EC and organic carbon (%) were remained unchanged after harvest of rajmah bean under different treatments. The mean pH, EC and organic carbon (%) after harvest of rajmah bean were 8.74, 0.06 d Sm^{-1} and 0.48%, respectively as compared to initial values 8.50, 0.06 d Sm^{-1} and 0.50%, respectively.

Table 1: Nutrient content in seed and stover of Rajmah bean as influenced due to different treatments

Symbol	Treatment	Nutrient content (%)					
		Seed			Stover		
		N	P	K	N	P	K
T_1	Absolute control	3.25	0.53	0.60	0.89	0.14	1.04
T_2	Control (No P_2O_5)	3.30	0.66	0.90	1.07	0.20	1.08
T_3	100% phosphorus through SSP	3.55	0.77	0.90	1.31	0.26	1.24
T_4	100% phosphorus through PROM	3.35	0.69	0.91	1.07	0.20	1.08
T_5	75% phosphorus through PROM + 25% phosphorus through SSP	3.39	0.72	0.93	1.12	0.20	1.09
T_6	50% phosphorus through PROM+ 50% phosphorus through SSP	3.45	0.77	0.93	1.21	0.21	1.13
T_7	25% phosphorus through PROM + 75% phosphorus through SSP	3.50	0.77	0.93	1.26	0.23	1.23

Table 2: Nutrient uptake in seed and stover of Rajmah bean as influenced due to different treatments

Symbol	Treatment	Nutrient uptake (kg ha^{-1})					
		Seed			Stover		
		N	P	K	N	P	K
T_1	Absolute control	22.62	3.66	4.15	8.94	1.44	10.44
T_2	Control (No P_2O_5)	32.82	6.63	8.91	15.72	2.89	15.82
T_3	100% phosphorus through SSP	58.19	12.56	14.70	31.90	6.30	30.12
T_4	100% phosphorus through PROM	46.93	9.63	12.67	22.18	4.10	22.38
T_5	75% phosphorus through PROM + 25% phosphorus through SSP	48.64	10.36	13.36	23.84	4.21	23.17
T_6	50% phosphorus through PROM+ 50% phosphorus through SSP	53.69	11.90	14.50	27.62	4.80	25.70
T_7	25% phosphorus through PROM + 75% phosphorus through SSP	55.49	12.16	14.69	29.76	5.34	29.02
S.E.(m)±		2.02	0.67	0.68	1.96	0.25	0.96
CD at 5%		6.28	2.10	2.10	6.10	0.79	3.00
General mean		45.48	9.56	11.85	22.85	4.16	22.38

Table 3: Total nutrient uptake of Rajmah bean as influenced due to different treatments

Symbol	Treatment	Total nutrient uptake (kg ha^{-1})		
		N	P	K
T_1	Absolute control	31.56	5.09	14.59
T_2	Control (No P_2O_5)	48.55	9.52	24.73
T_3	100% phosphorus through SSP	90.10	18.86	44.82
T_4	100% phosphorus through PROM	69.11	13.74	35.04
T_5	75% phosphorus through PROM + 25% phosphorus through SSP	72.48	14.57	36.53
T_6	50% phosphorus through PROM+ 50% phosphorus through SSP	81.30	16.70	40.20
T_7	25% phosphorus through PROM + 75% phosphorus through SSP	85.26	17.50	43.72
S.E.(m)±		2.72	0.60	1.15
CD at 5%		8.47	1.85	3.58
General mean		68.34	13.71	34.23

Table 4: Available nutrient content (N, P and K) at harvest of Rajmah bean as influenced due to different treatments

Symbol	Treatment	Available nutrient content (kg ha^{-1})		
		N	P	K
T_1	Absolute control	188.05	16.17	325.58
T_2	Control (No P_2O_5)	214.94	20.22	345.84
T_3	100% phosphorus through SSP	224.27	24.65	352.83
T_4	100% phosphorus through PROM	266.68	30.60	373.23
T_5	75% phosphorus through PROM + 25% phosphorus through SSP	241.16	28.37	364.48
T_6	50% phosphorus through PROM+ 50% phosphorus through SS	230.40	26.16	359.51
T_7	25% phosphorus through PROM + 75% phosphorus through SSP	228.77	26.02	353.91
S.E.(m)±		9.48	1.01	6.40
CD at 5%		29.52	3.15	19.93
General mean		227.75	24.60	353.63
Initial		213.48	23.80	358.46

Table 5: Chemical properties of soil after harvest of Rajmah bean as influenced due to different treatments

Symbol	Treatment	pH	E.C. (d Sm^{-1})	O.C. (%)
T_1	Absolute control	8.73	0.05	0.46
T_2	Control (No P_2O_5)	8.75	0.07	0.46
T_3	100% phosphorus through SSP	8.72	0.06	0.47
T_4	100% phosphorus through PROM	8.74	0.06	0.51
T_5	75% phosphorus through PROM + 25% phosphorus through SSP	8.74	0.06	0.50
T_6	50% phosphorus through PROM+ 50% phosphorus through SSP	8.74	0.05	0.49
T_7	25% phosphorus through PROM + 75% phosphorus through SSP	8.73	0.06	0.49
S.E.(m)±		0.03	0.01	0.01
CD at 5%		NS	NS	NS
General mean		8.74	0.06	0.48
Initial		8.50	0.06	0.50

4. Conclusion

The application of 100% phosphorus through single super phosphate outperformed among other fertilizer combinations in nutrient content in seed and stover, nutrient uptake in seed and stover and total nutrient uptake in rajmah bean. Whereas application 100% phosphorus through PROM showed highest available N, P, K after harvest of the rajmah bean. Its performance was comparable to the treatments 75% phosphorus through PROM + 25% phosphorus through SSP and 50% phosphorus through PROM + 50% phosphorus through SSP.

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