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Effect of Phosphorus Management through Rock Phosphate Application to Preceding Crops on Yield of Groundnut and Soil Microbial Population under Organic Condition

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A B S T R A C T

Field experiment was carried out during 2014-15 and 2015-16 at Main Agricultural Research Station, UAS, Raichur to study the impact of varied levels of rock phosphate application to preceding sunhemp and bajra crops on growth and yield of groundnut [*Arachis hypogaea* (L.)]. The two years pooled data indicated that soil application of higher levels of rock phosphate at 150 and 200 kg ha^{-1} to preceding sunhemp (1200 and 1226 kg ha^{-1} respectively) and 200 kg ha^{-1} to preceding bajra (1159 kg ha^{-1}) recorded significantly higher kernel yield of groundnut and these treatments were at par with treatment receiving RDF + FYM (1253 kg ha^{-1}) to both bajra and groundnut crops in the system. Number of root nodules and dry weight of root nodules at peak growth stage (90 DAS) recorded with the application of RDF + FYM to both bajra and groundnut crops in the system were significantly higher over all other treatments but it was on par with rock phosphate application @ 150 and 200 kg ha^{-1} to preceding sunhemp and rock phosphate @ 200 kg ha^{-1} to preceding bajra. Bacterial and Actinomycetes population found significantly higher at 60 and 90 DAS with higher levels of rock phosphate application to preceding sunhemp compared to preceding bajra crop whereas population of Phosphorus solubilizers was found significant with the application of RDF + FYM to both the crops in the system over all other treatments except treatments receiving rock phosphate @ 50 and 100 kg ha^{-1} to preceding bajra crop at 60 DAS.

Introduction

Groundnut [*Arachis hypogaea* (L.)] is one of the major oil seed crops of India produced in an area of 4.72 million hectare with the production of 4.70 million tonnes. In Karnataka, it ranks 5th in area with 5.90 lakh hectares with a production of 4.0 lakh tonnes and the productivity of 678 kg per hectare (Anon., 2014). Of the total area under groundnut in the state as much as 49.2 per cent of the area is cropped under irrigation during *rabi* / summer seasons mainly in Northern Karnataka. Groundnut seeds contain 40-50 per cent fat, 20-50 per cent protein, and 10-20 per cent carbohydrate apart from some essential minerals and vitamins (Okello *et al*., 2010). Rock phosphate is one of the important sources of phosphorus and soil amendment that is permitted to use in organic production systems. It is a naturally occurring mineral source of insoluble phosphate and is much

less expensive than soluble phosphatic fertilizers. Among the organic nutrient sources that are used in organic production system rock phosphate contains higher quantity of phosphorus. The residual effect of rock phosphate application on succeeding crops is also distinct. Nazeer and Mohammed (2014) reported that application Hazara rock phosphate (HRP) in wheat-maize system produced a significant residual effect on grain and biomass yield of maize. The variations induced by levels of HRP were mostly similar while the residual levels showed better results in terms of yield and yield components for higher doses compared to lower doses in succeeding maize.

Materials and Methods

Field experiment was conducted to study the effect of phosphorus management through rock phosphate application to preceding crops in organic cultivation of groundnut at Main Agricultural Research Station, University of Agricultural Sciences, Raichur, during *kharif* and *rabi* seasons of 2014-15 and 2015-16. The soil of the experimental site was sandy clay loam in texture with bulk density of 1.34 g per cc, pH of 7.75 with organic carbon content of 0.43%. The soils were low in available N (272.2 kg/ha) and available P_2O_5 (32.5 kg ha^{-1}) and medium in available K_2O (292.4 kg ha^{-1}). The treatments consisted of four levels of rock phosphate 50, 100, 150 and 200 kg ha^{-1} applied to two preceding crops bajra and sunhemp. The treatment with RDF + FYM applied for bajra and groundnut in the system. Bajra and sunhemp taken during *kharif* and succeeding groundnut was sown during *rabi* season. All the organic treatments received recommended dose of nitrogen through compost and vermicompost (50:50). At the time of sowing, recommended dose of fertilizer for bajra 50:25:0 kg N: P_2O_5:K_2O ha^{-1} and for groundnut 25:75:25 kg N: P_2O_5: K_2O ha^{-1} was applied in RDF + FYM treatment and remaining organic treatments received N through Compost and vermicompost (50:50). Mussoorie rock phosphate along with Phosphate Solubilising Bacteria (PSB) was applied to preceding crops in *Kharif* as per the treatments. The experiment was laid out in RCBD with three replications.

The initial soil microbial population like bacteria, actinomycetes and Phosphorus solubilizers (28.6 x 10^7 CFU g^{-1} of soil, 12.2 X 10^3 CFU g^{-1} of soil and 11.2 X 10^3 CFU g^{-1} of soil respectively) in experimental site were analysed with the serial dilution plate count technique (Pramer and Schmidt, 1964) using Nutrient agar for bacteria, Kuster's agar (Kuster and Williams, 1964) for actinomycetes, free living N_2 fixers and P-solubilizer's.

The number of nodules per plant at 60 and 90 DAS was recorded by carefully uprooting five randomly selected plants in adjacent rows of border lines in each plot and the average of five plants was expressed as a number of nodules per plant. The selected plants were saturated with water on the previous evening of observation. Next morning, selected five plants were carefully lifted along with the adhering soil mass. Enough care was taken to keep the root system intact so that none of the nodules were lost. All the nodules were collected and counted after carefully washing-off the soil. The nodules separated from five plants were oven dried at 65 to 70ºC to a constant weight and expressed in mg per plant.

The seeds of groundnut were treated with *Rhizobium* in all the treatments. The preceding bajra (var. ICTP-8203) and sunhemp crops sown during first fort night of July and second crop groundnut (var. K-9) was sown in the second fort night of December in 30 cm x 10 cm spacing. The

plant protection measures were taken with spraying of nimbicidine in organic treatments and in case of RDF treated plots carbendazim and profenophos were used.

Results and Discussion

Kernel yield, number of root nodules and dry weight of root nodules

Phosphorus nutrition plays very important role in growth and productivity of groundnut. It also helps in proper root development and nodulation, apart from improving oil and protein contents of seed. For organic groundnut production, the permitted rich source of P and cost effective one is the rock phosphate

The data on kernel yield of groundnut was influenced significantly by application of different levels of rock phosphate to the preceding sunhemp and bajra crops. Among various treatments, RDF + FYM to both bajra and groundnut crops in the system recorded significantly higher kernel yield (1253 kg ha^{-1}) over rest of the treatments except the treatments supplied with rock phosphate @ 150 kg ha^{-1} (1200 kg ha^{-1}) and 200 kg ha^{-1} (1226 kg ha^{-1}) to preceding sunhemp and rock phosphate @ 200 kg ha^{-1} to preceding bajra which inturn recorded on par kernel yield with each other. Significantly lower kernel yield of 953 kg ha^{-1} was registered in the treatment of preceding bajra crop with rock phosphate @ 50 kg ha^{-1}.

The data on number of effective root nodules per plant of groundnut at different growth stages as influenced by different levels of rock phosphate to preceding sunhemp and bajra crops differed significantly. Number of root nodules recorded with the application of RDF + FYM to both bajra and groundnut crops in the system at 60 and 90 DAS (60.71 and 97.68 respectively) was significantly higher over all other treatments but it was on par with rock phosphate application @ 150 kg ha^{-1} (54.40 and 91.19 respectively) and 200 kg ha^{-1} (57.90 and 57.90) to preceding sunhemp and rock phosphate @ 200 kg ha^{-1} to preceding bajra (53.30). Similarly, at 60 DAS, application RDF + FYM to both bajra and groundnut crops in the system recorded significantly higher dry weight of root nodules (0.10 g plant crops) over all other treatments except rock phosphate application @ 150 and 200 kg ha^{-1} to the preceding sunhemp (0.082 g and 0.086 g $plant^{-1}$) and rock phosphate @ 200 kg ha^{-1} to the preceding bajra (0.075 g $plant^{-1}$). At 90 DAS, application of RDF + FYM to both the crops in bajra-groundnut cropping system recorded significantly higher dry weight of nodules per plant (0.160 g $plant^{-1}$). Significantly lower dry weight of root nodules was recorded with treatment of rock phosphate @ 50 kg ha^{-1} to the preceding bajra crop (0.058 g $plant^{-1}$).

Soil microbial population

Bacterial population of soil at different growth stages of groundnut as influenced by preceding crops cultivation along with application of different levels of rock phosphate differed significantly. At 30 DAS, bacterial population was found to be non-significant among the treatments which received different levels of rock phosphate to the preceding sunhemp and bajra crops. At 60 DAS, significantly higher bacterial population was recorded with the rock phosphate @ 200 kg ha^{-1} to the preceding sunhemp (69.1×10^7 CFU g^{-1} of soil) over rest of the other treatments and it was on par with rock phosphate @ 150 kg ha^{-1} to the preceding sunhemp (66.4×10^7 CFU g^{-1} of soil) and RDF + FYM to both crops of the system (64.7×10^7 CFU g^{-1} of soil). Treatment with rock phosphate @ 50 kg ha^{-1} to the preceding bajra crop noticed significantly lower number of bacterial colonies (47.3×10^7 CFU g^{-1} of soil). Similar trend was also noticed at 90 DAS.

Table.1 Kernel yield, number of root nodules and dry weight root nodules of groundnut as influenced by phosphorus management through levels of rock phosphate to preceding crops (Pooled data of 2014-15 and 2015-16)

Treatments	Kernel yield (kg ha^{-1})	Number of root nodules plant^{-1}		Dry weight of root nodules (g plant^{-1})	
		60 DAS	90 DAS	60 DAS	90 DAS
T_1: RP @ 50 kg ha^{-1} to preceding sunhemp	1012	47.17	83.62	0.060	0.103
T_2: RP @ 100 kg ha^{-1} to preceding sunhemp	1039	49.66	85.12	0.064	0.105
T_3: RP @ 150 kg ha^{-1} to preceding sunhemp	1200	55.40	91.19	0.082	0.135
T_4: RP @ 200 kg ha^{-1} to preceding sunhemp	1226	57.90	95.21	0.086	0.143
T_5: RP @ 50 kg ha^{-1} to preceding bajra	953	38.33	76.75	0.044	0.058
T_6: RP @ 100 kg ha^{-1} to preceding bajra	980	40.91	80.99	0.058	0.084
T_7: RP @ 150 kg ha^{-1} to preceding bajra	1113	51.67	85.06	0.066	0.113
T_8: RP @ 200 kg ha^{-1} to preceding bajra	1159	53.30	89.78	0.075	0.132
T_9: RDF + FYM	1253	60.71	97.68	0.101	0.160
S. Em. ±	**33.5**	**2.93**	**3.01**	**0.02**	**0.02**
CD (P=0.05)	**100.4**	**8.78**	**9.03**	**0.03**	**0.03**

RP: Rock phosphate

DAS: Days after sowing

RDF + FYM applied to both bajra and groundnut crops in the system

RDF: Recommended dose of fertilizers

Table.2 Bacteria, fungi and actinomycetes population at different growth stages of groundnut as influenced by phosphorus management through levels of rock phosphate to preceding crops (Pooled data of 2014-15 and 2015-16)

Treatments	Bacteria (No. × 10^7 CFU g^{-1} of soil)			Actinomycetes (No. × 10^3 CFU g^{-1} of soil)			Phosphorus solubilizers (No. × 10^3 CFU g^{-1} of soil)		
	30 DAS	60 DAS	30 DAS	30 DAS	30 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1: RP @ 50 kg ha^{-1} to preceding sunhemp	24.18	60.16	17.90	17.90	17.90	30.21	17.90	64.02	24.64
T_2: RP @ 100 kg ha^{-1} to preceding sunhemp	24.33	61.90	17.80	17.80	17.80	32.90	17.80	62.37	23.55
T_3: RP @ 150 kg ha^{-1} to preceding sunhemp	25.07	66.42	13.21	13.21	13.21	35.05	13.21	58.24	20.46
T_4: RP @ 200 kg ha^{-1} to preceding sunhemp	25.62	69.10	12.14	12.14	12.14	36.51	12.14	52.67	20.87
T_5: RP @ 50 kg ha^{-1} to preceding bajra	21.96	47.33	14.52	14.52	14.52	26.58	14.52	59.44	21.89
T_6: RP @ 100 kg ha^{-1} to preceding bajra	23.26	52.46	14.07	14.07	14.07	29.53	14.07	58.67	20.57
T_7: RP @ 150 kg ha^{-1} to preceding bajra	23.45	56.74	11.56	11.56	11.56	30.59	11.56	47.98	19.01
T_8: RP @ 200 kg ha^{-1} to preceding bajra	23.68	56.98	9.75	9.75	9.75	31.20	9.75	47.77	17.54
T_9: RDF + FYM	24.87	64.65	19.00	19.00	19.00	34.85	19.00	66.93	26.92
S. Em. ±	**1.02**	**1.70**	**1.30**	**1.30**	**1.30**	**1.13**	**1.30**	**1.58**	**0.86**
CD (P=0.05)	**NS**	**5.11**	**3.89**	**3.89**	**3.89**	**3.37**	**3.89**	**4.72**	**2.58**

RP: Rock phosphate
DAS: Days after sowing
NS: Non significant
RDF: Recommended dose of fertilizers
RDF + FYM applied to both bajra and groundnut crops in the system

Actinomycetes population was significantly influenced by different levels of rock phosphate applied to preceding sunhemp and bajra crops. At 30 DAS, application of rock phosphate @ 50, 100, 150 and 200 kg ha^{-1} to the preceding sunhemp (28.7, 28.9, 29.3 and 31.0 × 10^3 CFU g^{-1} soil) and rock phosphate @ 150 and 200 kg ha^{-1} to the preceding bajra (25.8 and 28.1 × 10^3 CFU g^{-1} soil) and RDF + FYM to both bajra and groundnut crops in the system (29.0 × 10^3 CFU g^{-1} soil) recorded significantly higher number of actinomycetes population and these were on par with each other. Significantly lower actinomycetes population was recorded with rock phosphate application @ 50 kg ha^{-1} to the preceding bajra crop (23.6 × 10^3 CFU g^{-1} soil). At 60 DAS, significantly higher actinomycetes population was recorded in the treatment rock phosphate @ 150 and 200 kg ha^{-1} to the preceding sunhemp (45.2 and 46.4 × 10^3 CFU g^{-1} soil) and RDF + FYM to both the crops (43.3 × 10^3 CFU g^{-1} soil) resulted in significantly lower actinomycetes population than rest of the treatments. Similar trend was also observed at 90 DAS. Phosphorus solubilizer's population at 30 DAS was found significant due to different levels of rock phosphate application to sunhemp and bajra crops at all the growth stages studied. At 30 DAS, application of RDF + FYM to bajra and groundnut crops in the system recorded significantly higher number of colonies and it was on par with treatments receiving rock phosphate @ 50 and 100 kg ha^{-1} to the preceding sunhemp. Similar trend was also observed at 60 and 90 DAS.

In the present investigation, significant improvement in the soil microbial population *viz*., bacteria, fungi, actinomycetes, N_2 fixers and P solubilizers at different crop growth stages was recorded with the treatments receiving higher levels of rock phosphate to preceding crops at different stages of groundnut (Tables 1 and 2). This could be attributed to release higher amounts of root exudates, supporting numerous and diverse micro flora.

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