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BALANCE SHEET OF NITROGEN AND PHOSPHORUS AS INFLUENCED BY ROCK PHOSPHATE AND SUPER PHOSPHATE APPLIED WITH PHOSPHATE SOLUBILIZING MICROORGANISM AND RHIZOBIUM SP. ON COWPEA

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ABSTRACT

A field experiment was conducted Gandhigram Rural Institute in garden soil under irrigated conditions. The pH and EC of soil were 7.5and 0.3 dsm^{-1} respectively. The available N and P in the soil were 196.5 and 5.4 (Kg/ha) respectively. After cowpea harvest the available nitrogen and phosphorus in the soil and plant samples were estimated. The available nitrogen and phosphorus in the soil were increased in all the treatments when compared to the control. T_{15} treatment which received 100% rock phosphate and all the three inoculants was significantly better than control.

Key words: Nitrogen, Phosphorus, Rock phosphate, Phosphate solubilization, Balance Sheet, *Rhizobium* sp.

INTRODUCTION

Improving soil fertility is one of the most common practices in agricultural production. Nitrogen (N) and phosphorus (P) are the two most essential plant nutrients for maximizing crop productivity. The average P-content in soils is approximately 0.05% (w/w), only 0.1% of the total P is available to plants, and a shortage of available P in soils is one of the key chemical factors restricting plant growth and development. Rock phosphate (RP), contains some form of the mineral apatite, are applied directly to the soil with varying agronomic efficiencies depending on the type of soil and crop. The use of microorganisms to solubilize elemental phosphorus from insoluble rock phosphate is a promising method to greatly reduce not only environmental pollution but also production costs. The mechanisms that microorganisms use to solubilize phosphate include acidification, chelation and exchange reactions. These nutrients are limited in soils, which remain as a major challenge to agriculturists and land managers.

Legumes are not only vital to the health of people and animals in a predominantly vegetarian population but also play an important role in agriculture by maintaining and improving soil fertility. In general legumes are nodular and mycorrhizal in nature, however, inoculations with selected efficient strains of *Rhizobium* and VAM further have improved nodulation, N fixation, growth and P nutrition in some forage and grain legumes (Smith, 1988). The relationship between legumes and rhizobia is mutually beneficial, because the bacterial cells obtain energy for growth from the host and the plants use nitrogen fixed by these microorganisms (Schultze and Kondorosi, 1998). The N fixing legume plants usually require more P than the plants depending upon mineral N fertilizers. Nodule establishment and functioning are important links for P and nodules have usually the highest P content in the plant. Therefore P deficiency condition results in reduced biological nitrogen fixation (BNF) potential and P fertilization will usually result in enhanced nodule number and mass as well as greater BNF potential.

The present project was undertaken in Gandhigram Rural Institute, Gandhigram, Dindigul to study the balance sheet of N and P after cowpea cultivation as influenced by phosphate solubilizing microorganisms and *Rhizobium* sp. fertilized with rock and super phosphate on cowpea (*Vigna unguiculata* L. (Walp.)).

METHODOLOGY

A field study was conducted in garden soil under irrigated conditions. The soil had pH 7.5, EC 0.3 dsm^{-1}. The available N, P and K in the soil were 196.5, 5.4 and 128.5 (Kg/ha) respectively. The study was laid out in randomized block design with 3 replications. The treatment details were given in Table 1.

Treatments	Treatment details
T_0	Control
T_1	100 % (50 kg) Super phosphate (SP)
T_2	75 % (37.5 kg) Rock phosphate (RP) + 25 % (12.5 kg) Super phosphate
T_3	100 % (50 kg) Rock phosphate
T_4	T_2 + Phosphate Solubilizing Bacteria (PSB)
T_5	T_3 + Phosphate Solubilizing Bacteria
T_6	T_2 + Phosphate Solubilizing Fungi (PSF)
T_7	T_3 + Phosphate Solubilizing Fungi
T_8	T_2 + *Rhizobium* sp. (Rhz)
T_9	T_3 + *Rhizobium* sp.
T_{10}	T_4 + *Rhizobium* sp.
T_{11}	T_5 + *Rhizobium* sp.
T_{12}	T_6+ *Rhizobium* sp.
T_{13}	T_7 + *Rhizobium* sp.
T_{14}	T_8 + + Phosphate Solubilizing Bacteria + Phosphate Solubilizing Fungi
T_{15}	T_9 + Phosphate Solubilizing Bacteria + Phosphate Solubilizing Fungi

For dual inoculation phosphate solubilizing bacteria (PSB), phosphate solubilizing fungi (PSF) and nitrogen fixing bacteria (NFB) inoculants were mixed in equal amount (each of 5 g/kg seed) for seed treatment. A basal dose of 25 kg N /ha and 50 kg P/ha were applied in the form of urea, super phosphate and rock phosphate as per treatments (28.5% total P_2O_5), cowpea (Co 2) was sown in having 30cm row spacing. After harvest soil samples (0-15cm) were collected from each plot and analysed for available N and P content. Plant samples were also analysed for N and P uptake. Standard methods of soil and plant analysis were followed.The total N in plant was estimated by MicroKjeldhal method (Piper, 1966). The total P content of the plant sample was estimated by the vanadomolybdophosphate yellow colour method (Piper, 1966) and expressed in kg/ha. Available nitrogen content in the soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956) P content of the soil was estimated by calorimetric method (Olsen *et al.*1954) and expressed in kg/ha.

RESULTS AND DISCUSSION

Nitrogen balance: The residual N in the soil was increased in all the treatments as compared to initial available N but its concentration differed among treatments (Table 2). The increase in residual N in the available form left in the soil was to the in tune of – 18.27 to 74.36 kg/ha, which was maximum in T_{15}, followed by the treatment T_9 recorded 64.94 kg/ha. Application of inorganic fertilizers, biofertilizers and their interaction on the availability of nitrogen was significant.

Phosphorus Balance: Average available soil phosphorus indicated a significant increase due to application of hundred per centage RP along with PSB, PSF and *Rhizobium* sp. inoculation compared with the control. When compared to initial status of available P it was observed that all the treatments showed gain of P, which was highest in treatment T_{15} and lowest was observed in the control treatment T_0 (Table 3). The residual P in the soil showed negative trend under all the treatments. The depletion in net amount P was – 36.2 to 6.9 kg/ha, which was high under T_1 treatment that was 100 % SP and minimum in control treatment.

The increase in residual N with phosphate application was due to increase in BNF process, root mass and leaf biomass retained in the soil. Similar observations have been reported (Gaur, 1990 and Dubey, 1997). The depletion in net amount of P due to removal of P from the furrow layers, poor availability and rapid chemical fixation of P from RP has been observed. Similar observations on P depletion in net amount have been reported (Chatterjee *et al.* 1972). The P fertilization caused higher loss of net amount of residual P possibly due to more utilization and demand by cowpea for root proliferation, nitrogen fixation, higher yield and protein synthesis (Rao and Singh, 1983). Phosphate solubilizing bacteria had the ability to increase the P availability through dissolution and solubilization of fixed, native P (Gaur, 1990).

The available nitrogen and phosphorus in soil were increased after harvest of Cowpea. Phosphate solubilizing microorganism inoculation with P fertilizers resulted in increased P availability and low depletion of P as compared to P applied alone. The highest available soil nutrients nitrogen and phosphorus was significantly higher by the application of 100 % RP along with PSB, PSF and *Rhizobium* sp. in T_{15} treatment. The investigation suggested that inoculation of 100 % RP along with PSB, PSF and *Rhizobium* sp. can improve the growth and yield of cowpea.

The inoculation of crops with nitrogen fixing and phosphate solubilizing microorganisms enhanced various physiological activities culminating to higher dry matter production and grain yield. It can be summarized that the practice of triple inoculation was found more effective as compared to traditional practice of single inoculation of the inoculum.

Table 2. Balance sheet of available Nitrogen (kg/ha)

Treatments	**Initial soil N**	**N added through fertilizer**	**N removed by crop**	**Difference (3-4)**	**Available soil N at initiation + (N added – removed (2+5)**	**Available soil N after harvesting the crop**	**Net N left in the soil 7 – (3+2)**	**Loss (-) or gain (+) of N (7-6)**
1	2	3	4	5	6	7	8	9
T_0	196.5	0	17.07	-17.07	179.43	198.68	2.18	19.25
T_1	196.5	25	17.39	7.61	204.11	205.45	-16.05	1.34
T_2	196.5	25	17.34	7.66	204.16	203.23	-18.27	-0.93
T_3	196.5	25	18.74	6.26	202.76	210.75	-10.75	7.99
T_4	196.5	25	17.84	7.16	203.66	243.25	21.75	39.59
T_5	196.5	25	18.87	6.13	202.63	270.15	48.65	67.52
T_6	196.5	25	17.98	7.02	203.52	222.48	0.98	18.96
T_7	196.5	25	20.31	4.69	201.19	264.85	43.35	63.66
T_8	196.5	25	20.64	4.36	200.86	246.71	25.21	45.85
T_9	196.5	25	21.78	3.22	199.72	286.44	64.94	86.72
T_{10}	196.5	25	21.2	3.80	200.30	242.34	20.84	42.04
T_{11}	196.5	25	22.89	2.11	198.61	256.76	35.26	58.15
T_{12}	196.5	25	22.04	2.96	199.46	238.56	17.06	39.10
T_{13}	196.5	25	24.62	0.38	196.88	278.92	57.42	82.04
T_{14}	196.5	25	26.78	-1.78	194.72	260.84	39.34	66.12
T_{15}	196.5	25	29.27	-4.27	192.23	295.86	74.36	103.63
SEd			3.4610			3.6408		
CD (0.05)			7.0684			7.4356		
CD (0.01)			9.5178			10.012		
CV %			3.74			1.84		

Table 3. Balance sheet of available Phosphorus (kg/ha)

Treatments	Initial soil P	P added through fertilizer	P removed by crop	Difference (3-4)	Available soil P at initiation + (P added – removed (2+5)	Available soil P after harvesting the crop	Net P left in the soil 7 – (3+2)	Loss (-)or gain (+) of P (7-6)
1	2	3	4	5	6	7	8	9
T_0	5.4	0	12.48	-12.5	-7.1	12.3	6.9	19.4
T_1	5.4	50	12.66	37.3	42.7	14.8	-40.6	-27.9
T_2	5.4	50	12.63	37.4	42.8	15.6	-39.8	-27.2
T_3	5.4	50	13.5	36.5	41.9	17.9	-37.5	-24.0
T_4	5.4	50	12.96	37.0	42.4	18.4	-37.0	-24.0
T_5	5.4	50	13.53	36.5	41.9	18.9	-36.5	-23.0
T_6	5.4	50	13.07	36.9	42.3	17.6	-37.8	-24.7
T_7	5.4	50	14.68	35.3	40.7	18.2	-37.2	-22.5
T_8	5.4	50	15.2	34.8	40.2	15.9	-39.5	-24.3
T_9	5.4	50	15.89	34.1	39.5	16.5	-38.9	-23.0
T_{10}	5.4	50	15.13	34.9	40.3	18.7	-36.7	-21.6
T_{11}	5.4	50	16.43	33.6	39.0	19.2	-36.2	-19.8
T_{12}	5.4	50	15.98	34.0	39.4	18.4	-37.0	-21.0
T_{13}	5.4	50	17.3	32.7	38.1	18.6	-36.8	-19.5
T_{14}	5.4	50	18.75	31.3	36.7	19.2	-36.2	-17.5
T_{15}	5.4	50	20.44	29.6	35.0	19.5	-35.9	-15.5
SEd			0.4362			3.6408		
CD (0.05)			0.8909			7.4356		
CD (0.01)			1.1996			10.012		
			13.50			1.84		

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