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Uptake and balance sheet of nitrogen and phosphorus in gram (*Cicer arietinum*) as influenced by phosphorus, biofertilizer and micronutrients under rainfed condition

S.K. SARAWGI[1], P.K. TIWARI[2] AND R.S. TRIPATHI

Department of Agronomy, College of Agriculture, Indira Gandhi Agricultural University, Raipur, Madhya Pradesh 492 012

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ABSTRACT

A field experiment was conducted during 1995–96 and 1996–97 to study the effect of phosphorus, *Rhizobium* culture, phosphate-solubilizing bacteria (PSB) and micronutrients on uptake of nitrogen and phosphorus and their balance sheet in soil of chickpea (*Cicer arietinum* L.) crop in a rice (*Oryza sativa* L.) based cropping system under rainfed conditions. Uptake of N and P increased with the increasing levels of P and it was further increased with application of phosphate-solubilizing bacteria alone or in combination with rhizobium culture with each level of P. Use of phosphate-solubilizing bacteria and rhizobium culture along with inorganic phosphorus fertilizers increased the grain yield and uptake of N and P. This also solubilized the native and applied phosphorus and reduced phosphorus fixation.

Key words : N, P uptake and balance sheet, Gram, Biofertilizer

Integrated nutrient management for prevailing cropping systems appears to be one of the effective ways to meet the economical nutritional requirement of crop (Kulkarni *et al.*, 1993; Pandey and Tripathi, 1993). Phosphate-solubilizing bacteria (PSB) are known to mobilize the unavailable P in soil and make it available to crop. Though a considerable information is available on nutritional aspects in irrigated condition for P fertilization alone, that on phosphatic fertilizer with PSB, RC, organic manuring and supply of micronutrients is lacking under rainfed condition.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 1995–96 and 1996–97 at Research Farm of Indira Gandhi Agricultural University, Raipur (Madhya Pradesh), under rainfed condition. The soil was silty clay (Vertisols) with pH 7.3, having 302 and 318 kg available N/ha; 13.4 and 12.7 kg P/ha and 450 and 441 kg K/ha during 1995–96 and 1996–97 respectively. There were 12 treatments, viz. no phospho-

rus, 30 kg phosphorus/ha, 60 kg phosphorus/ha, no phosphorus + PSB, 30 kg phosphorus/ha +PSB, 60 kg phosphorus/ha + PSB, no phosphorus +PSB + RC, 30 kg phosphorus /ha + PSB + RC, 60 kg phosphorus/ha + PSB + RC, 60 kg phosphorus (10% through FYM + 90% through SSP) + PSB + RC, 60 kg phosphorus/ha (20% through FYM + 80% through SSP) + PSB + RC, 60 kg phosphorus/ha + PSB + RC + seed treatment with Mo and Fe (Table 1). Chickpea (cv. 'JG 74') was sown at 30 cm spacing on 10 and 13 December 1995 and 1996 respectively with light irrigation through sprinkler. A common dose of N and potash each @ 30 kg/ha was drilled at sowing. In treatment T_{11}, where FYM (0.5% N), 0.2% P_2O_5 and 0.5% K_2O supply full dose of N and K, urea and nitrate of potash (MOP) were not applied, whereas in T_{10} the quantity of urea and MOP was reduced by half. The seeds were treated with *Rhizobium* and PSB each @ 10 g/kg seed and/or 5 g ammonium molybdate and 15 g ferrous sulphate/kg seed as per treatments. Total and available soil N and P were determined by standard methods described by Tandon (1993).

RESULTS AND DISCUSSION

Nitrogen and phosphorus uptake

Grain accumulated more N and P than straw (Table 1). Uptake of N and P by grain of gram increased significantly with

Table 1. Uptake of nitrogen and phosphorus by chickpea as influenced by phosphorus, bacterial culture and micronutrients

Treatment	Nitrogen (kg/ha)				Phosphorus (kg/ha)			
	Grain		Straw		Grain		Straw	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
0 kg P_2O_5/ha	25.0	25.3	9.8	9.1	2.79	2.45	2.48	2.21
30 kg P_2O_5/ha	29.3	27.6	12.4	11.1	4.35	3.26	1.79	2.53
60 kg P_2O_5/ha	32.8	35.2	13.3	12.3	5.46	5.29	3.04	2.85
0 kg P_2O_5 + PSB	27.7	30.9	11.3	10.4	3.26	3.62	2.61	2.32
30 kg P_2O_5 + PSB	34.0	41.1	13.7	14.0	5.76	5.33	3.30	3.35
60 kg P_2O_5 + PSB	40.5	44.6	14.6	17.0	6.87	6.70	3.37	4.33
0 kg P_2O_5 + PSB + RC	31.1	35.4	13.0	12.3	4.64	4.60	2.78	2.96
30 kg P_2O_5 + PSB + RC	38.5	42.8	16.8	16.6	6.36	5.83	3.66	3.69
60 kg P_2O_5 + PSB + RC	51.4	44.8	20.8	18.9	8.43	7.38	4.12	4.39
60 kg P_2O_5 (10% FYM + 90% SSP) + PSB + RC	46.2	38.2	19.2	15.3	7.42	5.96	3.91	3.52
60 kg P_2O_5 (20% FYM + 80% SSP) + PSB + RC	42.4	34.3	14.7	13.9	6.96	5.41	3.33	3.00
60 kg P_2O_5 + PSB + RC + seed treatment Mo, Fe	56.3	45.8	21.4	19.8	8.70	7.46	4.22	4.58
CD (P = 0.05)	7.8	5.6	3.8	3.2	1.47	1.33	0.86	0.80

Y_1, 1995–96; Y_2, 1996–97

Table 2. Balance sheets for nitrogen and phosphorus (kg/ha) as influenced by phosphorus, bacterial culture and micronutrients

Treatment	Grain yield (q/ha)	Nitrogen			Phosphorus		
		Total available N for crop I + A*	Uptake of N	Balance of N after harvesting	Total available P_2O_5 for crop I + A*	Uptake of N	Balance of P_2O_5 after harvesting
		1995—96					
T_1, 0 kg P_2O_5/ha	8.22	306 + 30	34.8	290	36.2 + 00	12.1	24.3
T_2, 30 kg P_2O_5/ha	9.26	296 + 30	41.6	290	28.3 + 30	16.3	28.3
T_3, 60 kg P_2O_5/ha	10.12	298 + 30	46.1	306	29.3 + 60	19.5	36.5
T_4, 0 kg P_2O_5 + PSB	8.82	308 + 30	38.9	296	32.2 + 00	13.4	29.7
T_5, 30 kg P_2O_5 + PSB	10.68	305 + 30	47.8	308	29.1 + 30	20.7	32.7
T_6, 60 kg P_2O_5 + PSB	12.50	304 + 30	55.1	321	30.0 + 60	23.4	40.4
T_7, 0 kg P_2O_5 + PSB + RC	9.47	295 + 30	44.0	306	31.3 + 00	16.9	30.3
T_8, 30 kg P_2O_5 + PSB + RC	10.97	294 + 30	55.3	316	25.3 + 30	22.9	37.4
T_9, 60 kg P_2O_5 + PSB + RC	13.82	303 + 30	72.2	330	32.4 + 60	28.7	44.4
T_{10}, 60 kg P_2O_5 (10% FYM + 90% SSP) + PSB + RC	13.25	308 + 30	65.5	320	26.0 + 60	25.9	41.3
T_{11}, 60 kg P_2O_5 (20% FYM + 80% SSP)+PSB+RC	12.90	307 + 30	57.1	328	33.3 + 60	23.6	38.5
T_{12}, 60 kg P_2O_5+PSB+RC + seed treatment with Mo and Fe	14.51	301.30	77.6	339	33.3 + 60	29.6	45.8
CD (P = 0.05)	1.62						
		1996—97					
T_1, 0 kg P_2O_5/ha	8.18	318 + 30	34.4	298	30.4 + 00	10.69	20.1
T_2, 30 kg P_2O_5/ha	8.59	318 + 30	38.7	306	28.0 + 30	13.26	31.6
T_3, 60 kg P_2O_5/ha	10.81	316 + 30	47.5	313	30.0 + 60	18.64	38.8
T_4, 0 kg P_2O_5 + PSB	9.78	320 + 30	41.3	303	29.6 + 00	13.60	28.4
T_5, 30 kg P_2O_5 + PSB	12.70	318 + 30	55.1	311	30.2 + 30	19.88	36.5
T_6, 60 kg P_2O_5 + PSB	13.41	318 + 30	61.6	320	30.0 + 60	25.25	38.0
T_7, 0 kg P_2O_5 + PSB + RC	10.96	316 + 30	47.7	306	30.4 + 00	17.31	29.0
T_8, 30 kg P_2O_5 + PSB + RC	12.96	320 + 30	59.4	322	29.0 + 30	21.80	36.0
T_9, 60 kg P_2O_5 + PSB + RC	13.18	316 + 30	63.7	328	29.6 + 60	26.95	38.0
T_{10}, 60 kg P_2O_5 (10%FYM + 90% SSP + PSB + RC	11.93	320 + 30	53.5	308	30.0 + 60	21.71	36.6
T_{11}, 60 kg P_2O_5 (20% FYM + 80% SSP) + PSB + RC	10.82	320 + 30	48.3	311	28.7 + 60	19.26	37.0
T_{12}, 60 kg P_2O_5 + PSB + RC + seed treatment with Mo and Fe	13.33	316 + 30	65.6	331	28.0 + 60	27.57	36.6
CD (P = 0.05)	1.87						

*I , Initial available N; A, applied nitrogen fertilizers

increasing level of P during the second year. Similarly, Raju *et al.*, (1991) reported that increasing level of P from 20 to 60 kg/ha significantly increased the uptake of N and P by rainfed gram. Uptake of N and P increased significantly due to inoculation of PSB in each combination of P and it further significantly increased when combined with rhizobium culture. Uptake of N and P showed similar trends in straw. Alagawadi and Gaur (1988) and Shrivastava and Ahlawat (1995) reported similar results. Significantly highest uptake of N and P was obtained due to combined application of 60 kg P_2O_5/ha, PSB, rhizobium and seed treatments with Mo and Fe. This may be due availability of nutrients for bacterial population, nitrogen fixation and crop growth. Mo and Fe were found to be the most suitable micronutrients for nodulation, N_2 fixation.

Grain yield increased significantly with increasing level of P and it further increased when combined with inoculation of PSB and RC (Table 2). The response of PSB was greater with lower level of P than higher level. These results are in conformity with those reported by Tiwari *et al.* (1989). There was a decrease in yield when FYM containing 6 kg and 12 kg P_2O_5 was applied along with PSB and RC. Patel and Patel (1991) observed no significant difference in yield due to FYM application.

Balance sheet for N and P

There was a depletion of soil N (Table 2) during both the years, when no P, 30 kg P_2O_5/ha and no P + PSB were applied except in 30 kg P_2O_5/ha during first year where a slight build up of available soil N (5.6 kg/ha) was recorded. Build up of soil N level was recorded due to addition of with or combined application of PSB and rhizobium. Highest build up of soil N was recorded with 60 kg P_2O_5/ha, PSB, rhizobium and micronutrients during both the years. Application of PSB alone reduced the depletion pattern of available soil N over no PSB. There was build up of available soil N with 30 and 60 kg P_2O_5/ha. Reduction in available soil N under FYM treatment may be attributed to imbalance of nutrient supply because N and K were not applied through fertilizer at the time of sowing which resulted in poor early crop growth and most of the available nutrients be used by the micro-organisms for building their tissues.

Application of PSB alone without P helped in solubilization of native P over no inoculation. It was further observed that fixation of P reduced with 30 and 60 kg P_2O_5/ha along with PSB. Combined application of PSB and rhizobium alone resulted in net solubilization of native P over no P. It was observed that either application of 60 kg P/ha as fertilizer alone or 20% P through the farmyard manure fixed more P. This may be due to presence of more organic matter in Vertisol. The impact of micro-nutrients was also recorded for reduction in phosphorus fixation.

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