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Efficacy of phosphate solubilizing bacteria biofertilizer with phosphorus on growth and yield of gram (*Cicer arietinum*)

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ABSTRACT

A field experiment was conducted during the winter season of 1992–93 and 1993–94 to judge the efficacy of the PSB with various sources and levels of phosphorus on production of gram. The PSB inoculant enhanced grain yield by 2.37 q/ha (10.7%) and net return by Rs 1,881/ha. Among the P sources, rock phosphate + pyrite proved the best followed by single superphosphate, diammonium phosphate, rock phosphate, extra grain yield ranged from 3.30 to 5.66 q/ha (10.6 to 19.7%) and net profit from Rs 3,175 to 5422/ha. Crop responded up to 60 kg P_2O_5/ha significantly; the additional grain yield being 9.80 q/ha (40.8%) and net profit Rs 8,984/ha over no P. The best combination was PSB + rock phosphate + pyrite + 60 kg P_2O_5, giving 38.87 q/ha grain yield and Rs 32, 478/ha net return, but it was comparable with uninoculated + rock phosphate + pyrite + 60 kg P_2O_5/ha.

Phosphorus plays a key role in the balanced nutrition of plants. Indian soils are rich in P but more than two-thirds of the native phosphates are unavailable and applied P fertilizers are rendered unavailable within a short period due to its chemical fixation in soil. Phosphorus-solubilizing micro-organisms (PSM) not only solubilize inorganic phosphates occurring in soil or added as rock phosphate but also mineralize organic phosphates present in the soil and added through crop residues and organic manures. Phosphate sulubilizing bacteria (PSB) inoculants play an important role in making P available to crop plants as they increase the yield (Marwaha, 1981; Gaur, 1985; Gaur, 1990; Gaur and Gaind, 1992). Keeping this in view, the efficacy of Phosphate-solubilizing bacteria (PSB) (NAFED Culture) was ascertained under different sources and levels of phosphorus on the production of gram (*Cicer arietinum* L.).

MATERIALS AND METHODS

A field experiment was conducted at the ZARS, Tikamgarh, during the winter (*rabi*) season of 1992–93 and 1993–94. The soil of the experiment field was clay loam having pH 7.6, available N, P_2O_5, K_2O and S, 290, 23, 403 and 13 kg/ha respectively. The total rainfall received during 1992–93 and 1993–94 was 852 and 1,010 mm respectively. There were 2 PSB treatments (uninoculated and inoculated) with 4 sources of phosphorus [diammonium phosphates (DAP)], single superphosphate (SSP), rock phosphate (RP) and RP + pyrite in the main plots, and 4 levels of phosphorus (0, 20, 40 and 60 kg P_2O_5/ha in the subplots) and were laid out in split-plot design

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Table 1. Growth, yield-attributes and yield of gram under different treatments (pooled data of 2 years)

Treatment	Height (cm)	Branches/ plant	Dry matter/ plant (g)	Pods/ plant	Seeds/ plant	Seed weight/ plant (g)	1,000-seed weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Net return (Rs/ha)	Benefit : cost ratio
PSB culture											
Uninoculated	39.26	9.48	20.40	41.20	59.81	9.38	148	22.25	35.73	17,649	5.68
Inoculated	41.65	11.92	23.17	46.70	67.71	10.83	154	24.62	39.32	19,530	5.82
CD (P = 0.05)	1.36	1.23	1.65	3.78	4.35	0.65	1.23	1.51	1.19	881	
P source											
DAP	38.72	9.17	20.22	39.12	54.37	8.26	146	28.78	34.61	23,317	5.53
SSP	42.55	11.25	19.72	47.16	70.74	10.82	152	31.14	37.95	25,464	5.97
RP	37.89	8.75	24.25	36.68	51.35	7.80	143	28.78	35.07	23,564	6.66
RP + pyrite	43.49	13.01	27.77	52.02	76.98	11.85	154	34.44	40.89	28,739	7.55
CD (P = 0.05)	1.76	0.97	03.23	2.55	3.69	0.71	1.70	2.58	0.02	2,071	
P (kg/ha)											
0	32.70	6.76	18.42	37.50	51.48	7.72	145	23.99	29.57	18,589	5.67
20	38.06	9.10	20.30	44.37	64.29	9.64	153	29.27	37.02	23,143	6.42
40	42.70	10.08	25.56	51.84	77.76	11.81	159	31.19	40.17	25,093	6.59
60	45.17	12.02	27.67	59.47	89.79	13.73	165	33.79	43.54	27,573	6.90
CD (P = 0.05)	1.82	1.88	1.46	6.01	7.21	1.08	1.62	1.75	1.70	1,887	

DAP. Diammonium phosphate; SSP. single superphosphate; RP. rock phosphate.

with 3 replications.

A uniform dose of 23 kg N/ha and 20 kg K_2O/ha along with pertinent levels of P was applied basal. Pyrite @ 100 kg/ha. was also applied as basal. Gram cv. 'ICCV 10' was sown during 10–25 October with 100 kg seed rate/ha and 30 cm row spacing. Seed were inoculated with PSB culture @ 10 g/kg seed. The crop was irrigated twice at pre-flowering and seed-development stages. The crop was harvested between 10 and 20 March in both the seasons.

RESULTS AND DISCUSSION

Inoculation with PSB inoculant significantly increased the growth, yield and yield components of gram over no inoculant (Table 1). The increase in grain and straw yield was 2.37 and 3.59 q/ha respectively owing to PSB inoculation. Benefit : Cost ratio was higher and the extra net return being Rs 1, 881/ha. These findings are in agreement with those of Gaur (1990) and Gopalakrishnan and Palaniappan (1991). Gaur and Gaind (1992) reported that PSB also synthesize growth-promoting substances and produce vitamins which augment plant growth.

Among the P sources, rock phosphate + pyrite proved significantly superior to diammonium phosphate, single superphosphate and rock phosphate with respect to growth, yield components, grain, straw yield and net return. The benefit : cost ratio was highest (7.55). The second the best P source was single superphosphate. The extra grain and straw yields were 3.30 5.66 q (10.6–19.7%) and 2.94 6.28 q/ha (7.7–18.1%) respectively, and net return Rs 3,175–5422/ha due to rock phosphate + pyrite. Almost similar results were reported by Gopalakrishnan and Palaniappan (1991) in soybean–sunflower cropping system. The higher yield from rock phosphate + pyrite and single superphosphate was due to supply of sulphur from these P sources. The

Table 2. Interaction effect of PSB x P sources x P levels on yield and net return from gram (pooled of 2 years)

P (kg/ha)	DAP		SSP		RP		RP + P	
	I_0	I_1	I_0	I_1	I_0	I_1	I_0	I_1
				Grain yield (q/ha)				
0	21.50	25.10	23.00	24.14	23.10	23.95	21.40	25.29
20	25.16	28.24	27.72	29.44	24.74	28.84	30.11	32.60
40	28.34	29.43	30.22	31.54	27.66	29.99	33.00	35.25
60	30.07	31.45	33.68	34.12	29.61	31.76	37.51	38.87
				Net return (Rs/ha)				
0	17,054	19,310	18,243	19,149	18,323	18,998	16,974	20,061
20	20,172	22,892	22,630	23,978	20,618	23,220	24,689	26,933
40	23,032	23,831	24,924	25,374	22,500	24,380	27,397	29,378
60	24,457	25,588	27,884	27,971	24,485	26,172	31,559	32,478
CD (P = 0.05) grain yield	1.52							
Net return	2,115							

I_0: Uninoculated; I_1, inoculated; DAP, diammonium phosphate; SSP, single superphosphate; RP, rockphosphate; P, pyrite

higher yield from rock phosphate + pyrite over single superphosphate and diammonium phosphate in normal soil pH may be only due to pyrite which supplied 22–24% S as well as 20–22% Fe as compared with only 12% S from single superphosphate and no S from diammonium phosphate.

Increasing levels of P up to 60 kg/ha increased the growth, yield attributes, grain and straw yields and net return significantly over no phosphorus. The benefit : cost ratio was highest (6.90). The extra grain and straw yield was 9.8 and 14.0 q/ha respectively and net return Rs 8,984/ha due to 60 kg P_2O_5/ha.

The interaction PSB x P sources x P levels was found significant (Table 2). The highest grain yield (38.87 q/ha) and net return (Rs 32,478/ha) was obtained when gram was grown using PSB with rock phosphate + pyrite and 60 kg P_2O_5/ha. This interaction was found significantly superior to rest of the interactions except the one having no PSB but rock phosphate + pyrite and 60 kg P_2O_5/ha, which stood the second best; grain yield being 37.51 q/ha and net return Rs 31,559/ha.

REFERENCES

Gopalakrishnan, B. and Palaniappan, S. P. 1991. Agronomic effectiveness of Mussoorie rock-phosphate in soybean-sunflower cropping system. *Indian Journal of Agronomy* **36** (3) : 450–452.

Marwaha, B. C., Kanwar, B. S. and Tripathi, B. R. 1981. Note on chemical evaluation of some Indian rock phosphate. *Indian Journal of Agricultural Sciences* **51** : 357–362.

Gaur, A. C., and Gaind, Sunita. 1992. Role of phosphorous-solubilizing micro-organisms in crop productivity and enriched organic manure. 134 pp. Rai, M. M., and Verma, L. N. (Eds). (In) *National Seminar on Organic Farming* held during 28–29 September, 1992 at College of Agriculture, Indore (M.P.)

Gaur, A. C. 1985. (In) *Proceedings of the National Seminar on Development and Use of Biofertilizer*. Ministry of Agriculture, New Delhi.

Gaur, A. C. 1990. *Phosphate-Solubilizing Micro-organisms as Biofertilizer*. 176 pp. Omega Scientific Publishers, New Delhi.