Annals of Arid Zone 40(1): 43-48, 2001

Effect of Sources and Levels of Phosphorus and P Solubilizers on Yield and Nutrient Uptake in Rainfed Greengram

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Abstract: Grain and haulms yield, nutrient uptake, nutrient use efficiency (NUE) and recovery were improved by the sources of P in greengram. The single super phosphate (SSP) @ 18.75 kg P_2O_5 ha^{-1} coupled with seed soaking registered higher yield, P uptake and B/C ratio. The rock phosphate (RP) @ 25 kg P_2O_5 ha^{-1} with phosphobacterium and VA-Mycorrhiza was at par with SSP. The net gain in P balance was higher under integration of RP with P solubilizing microorganisms as compared to SSP treatments.

Key words: Greengram, phosphorus, net return, efficiency, B/C ratio.

Phosphorus is the most critical element in highly weathered tropical and subtropical soils. The per cent utilization of added P by the crops is very low and the recovery rate rarely exceeds 20% and rest is rendered unavailable in the soil due to fixation. Among various sources of P, the superiority of DAP and SSP has been studied (Singaram and Kothandaraman, 1993). The phosphate nutrition in many crops grown in soil low in fertility soils has been improved through the use of 'P' solubilizing microorganisms (Gaur, 1990; Tarafdar *et al.*, 1991). The possibilities of utilizing low grade rock phosphate (RP) as a source of P has been explored to develop alternate cheaper sources of P fertilization (Roy *et al.*, 1999a; 1999b). The usefulness of seed pelleting and fortification with nutrients in improving the yield of pulses were studied (Ponnuswamy and Vijaya, 1997). In the north-western zone of Tamil Nadu, greengram is grown on an area of 20,000 ha in red loamy sand soils with high P fixation. The present investigation was taken up to study the efficacy of sources with and without P solubilizing bio-inoculants and seed soaking on greengram under rainfed condition.

Materials and Methods

Field experiments were carried out for three years during 1995-97 at Regional Research Station, Tamil Nadu Agricultural University, Paiyur. The soil was red loamy sand and belonged to the great group Typic Ustorthent. The $KMnO_4$-N status was 176, 194 and 218 kg ha^{-1}, Olsen-P 9.8, 12.1 and 10.8 kg ha^{-1} and NH_4OAc-K 150, 266 and 240 kg ha^{-1} in the three years of experimentation, respectively. The experiments consisted of twelve treatments (Table 1) in a randomized block design with three replications. Greengram variety Paiyur-1 was grown as test crop adopting a spacing of 30x10 cm at a seed rate of 20 kg ha^{-1}. The seed soaking was done @ 20 g fertilizer per kg seed for one hour. Phosphobacterium (*Bacillus megatherium* var. phosphaticum) @ 2 kg ha^{-1} with population of 10^8 cells g^{-1} of lignite-based carrier was applied to soil by mixing with 50 kg FYM. The

mycorrhizal fungus (*Glomus mosseae*) was propagated on guinea grass (*Panicum maximum*) grown in soil: vermiculite mixture (1:1) for eight weeks. The roots of the host crop were cut into small pieces (1-2 cm) and mixed with the rhizosphere soil, removed separately. The mixture was applied as the source of mycorrhizal inoculum for greengram with the viable spore load of 550±10 cells per 100 g (2.75 million spores ha^{-1}). The P fertilizers, as per treatment schedule, were given through soil application basally. A uniform dose of N @ 12.5 kg ha^{-1} as urea was applied to all the plots. Data on growth characters and yield of grain and haulms were recorded. The soil samples were analyzed for the available P status (Watanabe and Olsen, 1965) and balance sheet for P was calculated (More and Agale, 1993). The grain and haulms were analyzed for total N (Humphries, 1956), P and K (Jackson, 1973) and uptake was computed. The P use efficiency (Singh *et al.*, 1999), P recovery (Bartholomew and Clark, 1965), net returns and B/C ratio (Jain and Rao, 1980) were worked out. The data were subjected to analysis of variance and least significant difference tests (Snedcor and Cochran, 1968).

Results and Discussion

Plant Growth and Yield Attributes

The plant height, number of pods, number of seeds per pod and grain weight were significantly improved by the sources and levels of P. Maximum height of 73.5 cm, 67.2 pods, 12.7 seeds and 31.4 g weight per 1000 grain were recorded (Table 1) at 18.75 kg P_2O_5 ha^{-1} as SSP with seed soaking, while the lowest values were obtained in control. The number of branches and pod length, though varied among the treatments, did not attain the level of significance.

Table 1. Effect of treatments on growth and yield attributes of greengram (mean of three years)

Treatment		Plant height (cm)	Pods $plant^{-1}$	Pod length (cm)	Seeds pod^{-1}	1000 grain wt. (g)
T1	Control	65.3	50.1	7.17	10.4	28.4
T2	Seed soaking with SSP @ 20 g SSP kg^{-1} seed for 1 h	72.4	56.9	7.36	11.4	29.9
T3	Seed soaking with RP @ 20 g RP kg^{-1} seed for 1 h	65.2	62.1	7.48	11.1	30.5
T4	25 kg P_2O_5 ha^{-1} as SSP	72.4	56.3	7.58	12.2	30.5
T5	25 kg P_2O_5 ha^{-1} as RP	72.0	47.1	7.45	12.0	31.3
T6	12.5 kg P_2O_5 ha^{-1} as SSP+T2	68.1	60.6	7.44	12.2	30.5
T7	12.5 kg P_2O_5 ha^{-1} as RP+T3	72.5	58.5	7.50	11.9	30.5
T8	18.75 kg P_2O_5 ha^{-1} as SSP+T2	73.5	67.2	7.61	12.7	31.4
T9	18.75 kg P_2O_5 ha^{-1} as RP+T3	71.2	64.8	7.62	12.2	31.0
T10	25 kg P_2O_5 ha^{-1} as RP+Pbm	71.0	62.7	7.45	11.6	30.7
T11	25 kg P_2O_5 ha^{-1} as RP+VAM	68.5	49.8	7.49	11.8	29.5
T12	25 kg P_2O_5 ha^{-1} as RP+Pbm+VAM	70.3	65.7	7.67	12.4	31.0
LSD (P = -.05)		4.08	8.94	NS	0.80	1.34

Table 2. Effect of sources and levels of P on yield and P uptake of greengram (mean of three years)

Treatment	Yield (kg ha^{-1})		P use efficiency (kg grain kg^{-1} P)	P recovery (%)	Net return (Rs.)	R/C ratio
	Grain	Haulms				
T1	844	1577	–	–	10060	1:4.87
T2	1064	1878	–	–	13355	1:6.13
T3	1118	2087	–	–	14167	1:6.34
T4	1214	2223	14.80	15.04	15110	1:5.87
T5	1141	2040	11.88	12.28	14215	1:5.90
T6	1200	2287	28.48	35.52	15145	1:6.30
T7	1154	2064	24.80	31.52	14507	1:6.18
T8	1374	2491	28.27	36.27	17630	1:6.92
T9	1197	2186	18.83	25.81	15127	1:6.35
T10	1221	2252	15.08	21.00	15405	1:6.29
T11	1219	2162	15.00	20.36	15135	1:5.80
T12	1276	2346	17.28	24.32	15980	1:6.06
LSD (P=0.05)	113.4	428.0	–	–	–	–

*Treatments explained in Table 1.

Yield, uptake and recovery

The yield of greengram increased significantly due to fertilization and the highest grain and haulms yield of 1374 and 2491 kg ha^{-1} were recorded at 18.75 P_2O_5 ha^{-1} as SSP + seed soaking (T8). However, this was at par with 25 kg P_2O_5 ha^{-1} as RP coupled with phosphobacterium (Pbm) and VAM (T12) with grain yield of 1276 kg ha^{-1} (Table 2). The yield increase in the treatments T8 and T12 was 62.8 and 51.2%, respectively, over control. The increase in grain yield might be due to better yield attributing parameters and availability of P for higher production (Ramamoorthy and Arokiaraj, 1997). Though the N and K uptake in grain and haulms were higher in the said treatments, the variations failed to attain any level of significance over other treatments. However, the P uptake was significantly affected and the treatment T8 showed its superiority with higher uptake in grain (7.95 kg ha^{-1}), and haulms (6.79 kg ha^{-1}) followed by T12. Increase in yield and uptake in greengram due to SSP and RP with phosphate solubilizers was reported by Roy *et al.* (1999a, b) and Das *et al.* (1999).

The P-use efficiency decreased with increase in levels of P irrespective of the sources with values of 28.48 and 28.27 kg grain per kg P_2O_5 at 50% (12.50 kg P_2O_5 ha^{-1}) and 75% level (18.75 kg P_2O_5 ha^{-1}), respectively, for SSP (Table 2). The PUE was the lowest (11.88 kg grain) at 25 kg P_2O_5 ha^{-1} as RP (T5) and it improved by 45.5% (17.28 kg grain per kg P_2O_5) through the inoculation of Pbm and VAM (T12). The recovery of P was again higher in T8 (36.27%). The effectiveness of RP also improved through the addition of P solubilizers from 12.28% (T5) to 24.32% (T12). The improvement in P recovery might be due to more solubilization of water soluble P in SSP and solubilization and mobilization of P by solubilizers in RP in turn resulted

in higher P uptake. This corroborates with the findings of Das *et al.* (1999).

Monetary returns

Application of 18.75 kg P_2O_5 ha^{-1} as SSP with seed soaking (T8) accounted for the highest net return of Rs. 17,630 ha^{-1} with B/C ratio of 1:6.92, followed by 25 kg P_2O_5 ha^{-1} as RP coupled with P solubilizers with a net income of Rs. 15,980 ha^{-1}. The lowest net return of Rs. 10,060 ha^{-1} and B/C ratio of 1:4.87 were observed in no-P control.

Phosphorus balance

The balance sheet of available P in greengram for the three years of experimentation (Table 3) showed a negative balance in control and seed soaking alone. Application of P_2O_5 (25 kg ha^{-1}) through RP with Pbm (T10) during the first year (15.94 kg ha^{-1}) and RP coupled with Pbm and VAM during second (14.19 kg ha^{-1}) and third (13.66 kg ha^{-1}) years resulted in higher residual available P with a net gain of +6.14, +2.09 and +2.86 kg ha^{-1}, respectively. The mean gain/loss over the three years also showed a higher positive balance of +3.31 and +2.94 kg ha^{-1} under RP with Pbm+VAM, respectively. Dissolution of low grade indigenous rock phosphate in neutral to slightly alkaline soils and release of P through P solubilizers has been reported (Mishra and Nanda, 1993; Roy *et al.*, 1999a; 1999b).

The present investigation suggests that the application of 18.75 kg P_2O_5 ha^{-1} (75% level) as SSP with seed soaking registered high yields. However, the application of RP @ 25 kg P_2O_5 ha^{-1} coupled with P solubilizers is at par with SSP with improvement in the soil residual available P status and net positive P balance. Hence, the rock phosphate with phosphobacterium and VAM (*Glomus mosseae*) could be used as a cheaper source of P in place of super

Table 3. Effect of P sources and levels on nutrients uptake of greengram (mean of three years)

Treatment*	N uptake		P uptake		K uptake	
	Grain	Haulms	Grain	Haulms	Grain	Haulms
T1	28.3	25.0	4.31	3.63	12.8	51.1
T2	34.0	28.9	4.61	4.27	14.4	50.7
T3	33.6	29.7	5.13	5.45	15.4	51.8
T4	36.6	33.3	5.69	6.01	17.5	64.6
T5	34.1	32.6	5.92	5.09	15.8	57.5
T6	40.6	37.6	6.66	5.72	16.9	54.1
T7	37.0	32.5	6.42	5.46	15.6	54.7
T8	44.4	36.9	7.95	6.79	19.2	67.8
T9	39.6	35.6	7.00	5.78	16.8	64.2
T10	38.0	35.6	7.14	6.05	18.4	58.6
T11	36.9	35.6	7.02	6.01	16.9	58.2
T12	41.7	37.7	7.49	6.53	18.5	61.4
LSD (P=0.05)	NS	NS	1.57	1.29	NS	NS

*Treatments explained in Table 1.

Table 4. Balance sheet of available P (kg ha^{-1}) in greengram

Treatment*	1995		1996		1997		Mean gain (+) or loss (-) over three years
	P status at the end	Net gain (+) or loss (-)	P status at the end	Net gain (+) or loss (-)	P status at the end	Net gain (+) or loss (-)	
T1	8.72	-1.08	10.79	-1.31	8.48	-2.32	-1.57
T2	7.05	-2.75	9.76	-2.34	9.42	-1.38	-2.16
T3	11.20	+1.40	10.34	-1.76	8.48	-2.32	-0.89
T4	15.35	+5.55	11.50	-0.60	11.20	+0.40	+1.78
T5	8.72	-1.08	11.20	-0.90	10.84	+0.04	-0.65
T6	10.34	+0.54	12.14	+0.04	12.14	+1.34	+0.64
T7	12.98	+3.18	10.79	+1.31	12.64	+1.84	+1.23
T8	10.38	+0.58	12.50	+0.40	12.64	+1.84	+0.94
T9	15.53	+5.73	13.04	+0.96	11.50	+0.70	+2.46
T10	15.94	+6.14	13.66	+1.56	13.04	+2.24	+3.31
T11	14.45	+4.65	12.98	+0.88	12.98	+2.18	+2.57
T12	13.66	+3.86	14.19	+2.09	13.66	+2.86	+2.94

*Treatments explained in Table 1; initial available P status (kg ha^{-1}) are: 9.8 (1995), 12.1 (1996) and 10.8 (1997).

phosphate to improve the growth and yield of greengram with sustained soil fertility in the slightly alkaline loamy sand soils.

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