

Effect of integrated nutrient supply and management on yield of rice (*Oryza sativa*) and nitrogen and phosphorus recovery by it in acid lateritic soils

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 1996 and 1997 on rice (*Oryza sativa* L.) in acid lateritic soil of Sekhampore, Birbhum district, West Bengal. Highest green and dry matter of *Sesbania aculeata* (SA) was obtained with the application of single superphosphate (SSP) @ 30 kg P/ha as also the N and P content in dry matter. Grain and straw yields, N uptake and P recovery of rice were highest when *S. aculeata* was grown and incorporated followed by fertilizer application @ 30, 15 and 15 kg N,P, and K/ha as basal dose to rice. Uptake of P in rice and agronomic efficiency of N were maximum when *S. aculeata* was fertilized with single superphosphate @ 30 kg P/ha and was incorporated prior to rice transplantation. The agronomic efficiency of P was higher with fertilizers applied @ 30, 15 and 15 kg N,P and K/ha to rice after *S. aculeata* incorporation.

Key words : *Sesbania*, Rice, Apparent recovery, Agronomic efficiency

Agriculture production systems following high demographic pressure are facing a period of uncertainty and change. Intensive farming has led to over-production associated with environmental consequences largely affecting the soil health arising from long-term use of inorganic fertilizers in large quantities. Green-manuring, which is of organic origin, offers the twin benefits of

soil quality and fertility enhancement while meeting a part of nutrients need of crops (Vinod Kumar *et al.*, 1999). But, green-manuring alone cannot sustain the high yields required these days. Therefore, fertilizers are to be integrated with organic sources to replenish the continuous removal of plant nutrients. Red and lateritic soils are low in organic matter and acidic in nature

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(Barthakur, 1990). Availability of P is highly pH dependent and fixation occurs due to precipitation of soluble calcium phosphate as relatively insoluble iron and aluminium phosphates. Increasing the availability of P can be accomplished through integration of P fertilizers and green-manure crop (Halepyati and Sheelavantar, 1992). The investigation was an effort to determine the agronomic effectiveness of most efficient proportion of fertilizer integration to *Sesbania aculeata* in view of the scarce information in the dry and lateritic tracts of West Bengal.

MATERIALS AND METHODS

The field trials were conducted during rainy (*kharif*) seasons of 1996 and 1997 on rice at the Regional Research Substation, Sekhampore, Birbhum, West Bengal. The soil was lateritic (Entisol) and contained 0.548% total organic C, very low N (0.048%) and available P (12.08) kg/ha). The experiment was carried out in randomized block design with each treatment replicated thrice. Treatment consisted of T₁; no *Sesbania aculeata* and no input to rice; T₂; NPK was applied to rice @ 60,30 and 30 kg/ha in the form of urea, single superphosphate and muriate of potash respectively. Half of the N was basally applied and the rest top-dressed 25 days after transplanting; T₃, *S. aculeata* was sown @ 12.5 kg seed/ha and was incorporated into soil after 45 days, prior to 7 days of rice transplantation; T₄, *S. aculeata* was fertilized with single super-phosphate @ 30 kg P/ha and was incorporated as in T₃; T₅, *S. aculeata* was grown and incorporated as in T₃ followed by fertilizer (as in T₂) substitu-

tion to rice as basal dose @ 30,15 and 15 kg N,P, and K/ha; T₆, *S. aculeata* was grown as in T₂ and was fertilized with single superphosphate @ 15 kg P/ha. No fertilizers were supplemented to rice after *S. aculeata* incorporation; T₇, *S. aculeata* was grown and incorporated prior to rice transplantation as in T₃, followed by application of single superphosphate @ 30 kg P/ha to rice at the time of trans-plantation. Rice ('IR 36') was transplanted on 25 and 29 July during 1996 and 1997, respectively, in rows 15 cm apart and 10 cm between hills. The N and P contents of the plant materials were estimated by modified kjeldahl and molybdenum blue methods respectively (Chapman and Pratt, 1961). Apparent recovery and agronomic efficiency were computed as proposed by Prasad (1990). The data were analysed with computer statistical package (IRRISTAT) developed by Biometrics Unit, International Rice Research Institute, Philippines.

RESULTS AND DISCUSSION

Green and dry matter of Sesbania

Application of single superphosphate @ 30 kg P/ha to *S. aculeata* (T₄) produced the highest green and dry matter (Table 1). There was also a corresponding increase in N and P contents in dry matter of *S. aculeata* with T₄. As a result, higher amount of both N and P fertilization to *S. aculeata* was beneficial in better nodulation with increase in the efficiency of nodule bacteria and therefore higher biomass production.

Grain and straw yield

Higher grain yield was obtained under

Table 1. Biomass production of *Sesbania* and N and P content in dry matter as affected by different treatments (mean data of 2 years)

Treatment	<i>Sesbania</i>		Content in <i>Sesbania</i> dry matter (%)		Nutrients added to soil (kg/ha)						
	Green matter (tonnes/ha)	dry matter (q/ha)	N	P	N			P			
					F	S	Total	F	S	Total	
T ₁											
T ₂					60		60	30			30
T ₃	14.8	20.7	1.06	0.48	0	22	22	0	10	10	
T ₄	19.5	25.6	1.12	0.53	0	28	28	30	11	43	
T ₅	15.1	21.3	1.04	0.52	30	22	52	15	11	26	
T ₆	16.6	21.8	1.04	0.53	0	23	23	15	11	26	
T ₄	14.0	19.6	1.06	0.51	0	21	21	30	15	45	

Details of treatments are given in Materials and Methods
F, Fertilizer; S, *Sesbania*

T₅ treatment, although it was statistically at par with T₂ and T₆ (Table 2). About 109% increase in grain yield would be obtained with T₅ over T₁. In contrast to T₂, the increase in grain yield with T₅ was 14%. Incorporation of SA only (T₃), however, registered a reduction in grain yield of 32% as against the recommended application of chemical fertilizers to rice exclusively (T₂). When single superphosphate was supplemented to *S. aculeata* both @ 30 (T₄) and 15 kg P/ha (T₆) the grain yield increases over T₁ were 24 and 12% respectively. Notably the grain yield with treatments T₂, T₄, T₆ and T₇ were all statistically at par. When *S. aculeata* was supplemented with P @ 30 kg P/ha (T₄), 13% increase in grain yield was obtained as against T₇ treatment in which rice was supplemented with the same dose of P through single superphosphate after *S. aculeata* incorporation. But the dose of P when reduced to half as in T₆, i.e. @ 15 kg/

ha, and supplemented to *S. aculeata*, the increase in grain yield over T₇ was only 2%. The straw yield also followed similar pattern of production with the respective treatments.

N and P uptake

The mean total uptake of N was significantly highest with T₅ but at par with T₂, although the N added through T₂ treatment was more (Table 2). Higher N uptake in T₅ might be due to the increase in available N pool in soil resulting from greater multiplication of soil microbes which could convert organically bound N to inorganic form (Bellaki and Badanur, 1997). *Sesbania* when added with inorganic N, higher release of hydrolyzable as well non-hydrolyzable forms of N occur (Chakraborty *et al.*, 1988) which phenomenon partly was responsible for increases in availability of N to rice and therefore higher uptake. Surender Rao and

Table 2. Grain and straw yields, total uptake, apparent recovery and agronomic efficiency of different treatments in rice

Treatment	Grain yield (q/ha)		Mean	Straw yield (q/ha)		Mean	Mean total uptake (kg/ha)		Mean apparent recovery (%)		Mean agronomic efficiency (%)	
	1996	1997		1996	1997		N	P	N	P	N	P
T ₁	16.7	19.9	18.3	24.34	22.87	19.27	12.42	58.41	23.4	58.6	117.36	
T ₂	32.3	34.7	33.5	45.11	42.88	84.32	19.46	38.36	24.10	72.7	160.00	
T ₃	23.7	26.9	25.3	34.30	31.87	57.71	14.83	63.96	33.67	108.4	70.00	
T ₄	29.9	32.86	31.38	41.22	40.16	67.18	26.90	74.30	32.00	85.00	170.00	
T ₅	36.9	39.7	38.30	48.95	47.10	87.91	20.74	52.91	34.53	103.21	91.30	
T ₆	25.6	31.34	28.47	37.12	36.44	61.44	21.40	51.09	23.02	105.2	49.10	
T ₇	26.5	29.00	37.75	37.24	35.52	60.00	22.78					
CD (P=0.05)	3.6	14.23	9.5	9.2	7.7	11.4	5.9					

Details of treatments are given in Materials and Methods

Sitaramaya (1997) stated that green-manure application increased the available soil N and N uptake of rice both by grain and straw. Next in order of N uptake was T₄ and T₆ than rest of the treatments under study. This was due to higher amount of N added to soil through higher green and dry-matter production of *S. aculeata*. Highest uptake of P in T₄ treatment was the resultant effect of higher amount of total P added both through chemical fertilizers and *S. aculeata* incorporation, and reduction in P-fixing capacity of soil by forming barrier on sesquioxide by the organic materials (Bellaki and Badanur, 1997). Besides, legumes have the ability to utilize insoluble phosphates and when incorporated as green-manures liberate P into soil on mineralization, thus enrichment of the pool of available P occurs (Vig *et al.*, 1997).

Apparent recovery of N and P

Apparent N recovery in T₅ treatment was highest, indicating the benefits of integration of organic and chemical supplements (Table 2). Neither chemical fertilizers only (T₂) or *S. aculeata* incorporation only (T₃) could increase the N and P recovery. The treatments which received single superphosphate @ 30 kg P/ha (T₄) and 15 kg P/ha (T₄) to *S. aculeata* crop the N and P recovery was more than T₇ treatment when rice was supplemented with single superphosphate @ 30 kg/ha. This suggested the increase in nutrient supply efficiency when *S. aculeata* was fertilized thus rendering available large percentage of fertilizer nutrient to legume and reducing or arresting fixation in soil. However, unlike N recovery, the highest P

recovery was obtained with T₆ treatment.

Agronomic efficiency

Agronomic efficiency reflects the production per kg of nutrient applied. Highest agronomic efficiency of N was recorded in T₄, followed by T₇ and lowest in chemical fertilizer treatment (T₂) (Table 2). This is suggestive that green-manure incorporation either alone or in combination with fertilizers increases the production capacity per kg of N applied. In case of agronomic efficiency of P, however, the highest was observed with T₅ when fertilizers were applied to rice after *Sesbania* incorporation, although the apparent recovery of P was lower than T₄. Response of rice to green-manure depends on the time of its application. Singh and Rai (1973) observed maximum increase of organic P in soil on the day 30 of the decomposition of a 60-day crop. When *S. aculeata* was grown fertilized with single superphosphate and was incorporated (T₄), recovery of P was higher than T₅, but this available P might have been utilized for grain-formation processes. The *S. aculeata* when incorporated after fertilizer application, the decomposition rate is accelerated with concomitant release of exchangeable Na which is helpful for acid lateritic soil (Singh, 1969). However, Mitsui (1954) reported that P application during the initial growth stages was most effective for good yield. But the higher agronomic efficiency of P in T₄ than T₇ indicated the beneficial effect of chemical P substitution to *S. aculeata*.

Substitution of P to *Sesbania aculeata* @ 30 kg/ha and subsequent incorporation

prior to rice without any further chemical supplements to rice may be a viable option for sustainable production of rice-based systems in acid lateritic soils.

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