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Contribution of *Sesbania* species to yield and nitrogen nutrition in lowland rice (*Oryza sativa*)

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ABSTRACT

A 2-year field experiment on a Mollisol at Pantnagar showed that rice (*Oryza sativa* L.) yield obtained in treatments, viz. green-manuring of *Sesbania cannabina* (Retz.) Pers.; syn. *S. aculeata* Pers. (6,399 kg/ha in 1991 and 5,284 kg/ha in 1992) or *Sesbania rostrata* Brem. (6,518 kg/ha in 1991 and 5,371 kg/ha in 1992), was equivalent to 90 kg N/ha (6,309 kg/ha in 1991 and 5,204 kg/ha in 1992) as prilled urea (PU) applied in splits. The yield levels obtained in the above treatments were at par with higher dose of N (120 kg N/ha) as PU in splits or green-manuring + additional dose of N (45 kg/ha). Yield increase was attributed to significant variations in number of panicles/ m^2, 100-grain weight and N uptake by the crop. These yield attributes and rice yield had a significant correlation with wet soil NH_4^+-N which increased by green-manuring with *Sesbania*.

Low soil fertility, particularly nitrogen deficiency, is an important constraint in rice (*Oryza sativa* L.)-growing countries in South and South-east Asia. An increasing world-wide effort has been made to enhance biological production of nitrogen fertilizer, a process which uses solar energy, a renewable energy form rather than ever-shrinking fossil-fuel supply. In the present study, an attempt was made to evaluate the extent of contribution of N by *Sesbania cannabina* (Retz.) Pers.; syn. *S. aculeata* Pers. and *Sesbania rostrata* Brem. towards nitrogen requirement of lowland rice, alone or in combination with prilled urea (PU) and their effects on wet soil NH_4^+-N.

MATERIALS AND METHODS

The experiment was conducted during 1991 and 1992 on a clay loam-soil (*tarai* Mollisol of northern India) at the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (29°N, 79.3°E, 243.8 m). The soil was high in organic carbon (1.26%) and available (Olsen's) P (65 kg/ha), medium in available K (260 kg/ha). The total nitrogen content was 0.119%, with pH 7.3 and cation-exchange capacity 28.5 (mol/kg) soil. The experiments was laid out in randomized block design, replicated 3 times with 10 treatments: T_1, control, i.e. no nitrogen from any source; T_2, 45 kg N/ha as PU in splits (50% before transplanting, 25% at tillering 25% at panicle initiation); T_3, 90 kg N/ha as PU in splits; T_4, 120 kg N/ha as PU in splits; T_5, *Sesbania rostrata* Brem. 50-day-old incorporated before transplanting; T_6, *S. cannabina* 50 days old incorporated before transplanting; T_7, *S. rostrata* 50 days old incorporated + N @ 45 kg/ha as PU in splits; T_8, *S. rostrata* 50 days old incorporated + N

@ 45 kg/ha as PU at panicle initiation; T_9, *S. cannabina* 50 days old incorporated + N @ 45 kg/ha as PU in splits; T_{10}, *S. cannabina* 50 days old incorporated + N @ 45 kg/ha as PU at panicle initiation.

Wet soil NH_4^+-N was determined by means of the Nessler's reagent as per the procedure of Nessler (Jackson, 1973). For N uptake, grain and straw samples were analyzed for N (Black, 1973) and pooled together to give total N uptake. Grain yield was reported as 14% moisture. Number of panicles was recorded from 5 hills randomly tagged from the third row of each side and converted to number/m^2. The gross and net areas of plots were 20.0 m^2 and 11.2 m^2 respectively Simple linear regression was performed to study the inter-relationship between various parameters (Snedecor and Cochran, 1967). The rice variety 'Pant Dhan 4' was grown.

RESULTS AND DISCUSSION

Rice yield

Different levels of N and green-manure of *Sesbania* significantly increased grain yield of rice compared with the control (Table 1). Application of N 90 kg/ha (yielding 6,309 kg/ha in 1991 and 5,204 kg/ha in 1992) was as good as green-manuring alone by *S. rostrata* (giving yield 6,518 kg/ha in 1991 and 5,371 kg/ha in 1992), *S. cannabina* (6,399 kg/ha in 1991 and 5,284 kg/ha in 1992). Rice yields obtained under 45 and 90 kg N/ha were at par. *Sesbania* green-manuring in combination with 45 kg N/ha as PU either in splits gave yield 7,045 kg/ha in 1991 and 5,897 kg/ha in 1992 under *S. rostrata* + PU and 7,053 kg/ha in 1991 and 5,909 kg/ha in 1992 in *S. cannabina* + PU or at panicle-initiation stage (7,232 kg/ha in 1991 and 6,079 kg/ha in 1992 under *S. rostrata* and 7,202 kg/ha in 1991 and 6,068

Table 1. Grain yield, panicles/m^2, 100-grain weigt and N uptake in rice as influenced by various treatments

Treatment	Grain yield (kg/ha)		Panicles/ m^2		100-grain weight (g)		Total N uptake (kg/ha)	
	1991	1992	1991	1992	1991	1992	1991	1992
T_1	4,702	3,738	145	138	27.1	23.4	74.5	58.3
T_2	5,774	4,420	195	175	27.3	23.9	99.9	79.1
T_3	6,309	5,204	227	193	28.9	24.6	117.7	101.8
T_4	7,024	5,946	293	255	29.4	25.0	141.9	119.4
T_5	6,518	5,371	245	230	28.4	23.9	126.7	105.1
T_6	6,399	5,284	227	218	27.4	23.8	121.7	100.5
T_7	7,054	5,897	257	233	29.1	24.7	143.4	119.3
T_8	7,232	6,079	293	255	29.0	24.4	150.6	123.7
T_9	7,053	5,909	248	248	29.9	24.7	140.9	118.6
T_{10}	7,202	6,068	287	250	29.4	25.7	155.2	147.8
Mean	6,257	5,391	242	219	28.6	24.4	127.2	106.8
F-test	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.
CD (P = 0.05)	1,107	1,085	47	43	1.3		18.9	22.4

Details of treatments are given in text

Table 2. NH_4^+-N concentration (ppm) in wet soil as influenced by various treatments

Treatment	Panicle-initiation stage		50% flowering stage	
	1991	1992	1991	1992
T_1	13.0	10.3	8.7	8.6
T_2	19.0	13.9	14.0	11.0
T_3	22.0	15.0	16.0	10.9
T_4	27.3	26.6	19.7	17.8
T_5	27.3	30.2	19.3	18.9
T_6	27.3	24.7	19.0	19.3
T_7	30.0	32.0	23.0	24.1
T_8	34.0	31.0	28.0	27.7
T_9	30.0	31.2	22.0	22.7
T_{10}	34.3	31.5	28.7	27.6
Mean	26.4	24.6	19.8	18.8
F-test	Sig.	Sig.	Sig.	Sig.
CD (P = 0.05)	3.1	5.4	2.7	2.5

Details of treatments are given in text

kg/ha in 1992 under *S. cannabina* produced grain yield equivalent to recommended dose, i.e. 120 kg N/ha in splits (7,024 kg/ha in 1991 and 5,946 kg/ha in 1992). The rice-yield differences between 90 and 120 kg N/ha through PU, green-manuring alone or in combination with PU were found non-significant; yet integrated management of *Sesbania* and PU saved more than 60% of chemical N.

Increase in grian yield are explained by the increased number of panicles 100-grain weight and also by significant variation in wet soil NH_4^+-N at different growth stages of rice crop (Table 2). The latter showed significant positive correlations (Table 3), with grain yield, number of panicles and total N uptake. Hence, *Sesbania* green-manuring or with PU supplies NH_4^+-N to the

Table 3. Linear regression equations for grain yield against N-uptake, number of panicles, wet soil NH_4^+-N and for N-uptake, number of panicles against wet soil NH_4^+-N

1991		1992	
Y = a + bx	r value	y = a + bx	r value
Grain yield (kg/ha) against N uptake (kg/ha)			
Y = 2,202 + 3.4 x	0.94**	Y = 1,731 + 3.5 x	0.91**
Grain yield (kg/ha) against panicles/m^2			
Y = 3,346 + 13 x	0.70**	Y = 2,414 + 13.5 x	0.64**
Grain yield (kg/ha) against wet soil NH_4^+-N (ppm) with X_1 at panicle initiation, X_2 at 50% flowering			
$Y = 3,816 + 102\ x_1$	0.73**	$Y = 3,654 + 69\ x_1$	0.65**
$Y + 4,286 + 113\ x_2$	0.72**	$Y = 3,096 + 88\ x_2$	0.64**
Total N uptake (kg/ha) against wet soil NH_4^+-N (ppm)			
$Y = 36 + 3.4\ x_1$	0.88**	$Y = 48 + 2.3\ x_1$	0.82**
$Y = 53 + 3.7\ x_2$	0.86**	$Y = 50 + 2.8\ x_2$	0.79**
Panicles/m^2 against wet soil NH_4^+-N (ppm)			
$Y = 53 + 5.9\ x_1$	0.78**	$Y = 124 + 8.8\ x_1$	0.74**
$Y = 116 + 6.3\ x_2$	0.76**	$Y = 133 + 4.4\ x_2$	0.68**

** Correlation coefficient is significant at 1% level

rice crop through continuous mineralization of organic N, thus increases N-use efficiency, ultimately giving higer rice yields. Response of rice to *Sesbania* was reported by Maskina *et al.* (1984), Meelu and Morris (1987), Mahapatra *et al.* (1987) and Mahapatra and Sharma (1989).

Wet soil NH_4^+-N

Sesbania alone or in combination with PU maintained higher level of wet soil NH_4^+-N (Table 2) due to continuous mineralization of organic nitrogen (Singh, 1984). Regression study reveal that wet soil NH_4^+-N had significant positive correlations with grain yield and total N uptake. De Datta (1987), Meelu and Morris (1987), Mahapatra *et al.* (1987), Mahapatra and Sharma (1989) reported beneficial effects of integrated management of *S. cannabina* and chemical N with respect to wet soil NH_4^+-N and N uptake. All the correlation coefficients of wet soil NH_4^+-N with other parameters were highly significant. However, the degree of closeness of the linear relationship between number of panicles and NH_4^+-N at panicle-initiation stage was higher than in case of NH_4^+-N at 50% flowering stage.

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