Indian Journal of Agronomy **52** (1) : 43–45 (March 2007)

Comparative study on combined and individual effects of farmyard manure and green-manuring with fertilizer N on growth and yield of rice (*Oryza sativa*) under submergence-prone situation

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Received : April 2006

ABSTRACT

A field experiment was conducted during 2003 and 2004 to study the combined and invidual effects of using farmyard manure (FYM), green-manure (*dhaincha : Sesbania aculeata* L.) along with fertilizer N on rice (*Oryza sativa* L.) variety 'Gayatri' experiencing 10 days' complete submergence at maximum tillering stage. The crops under both the organics (FYM and green-manuring) thrived better under submergence, due to greater root development, higher critical N level in plant, higher biomass production and less tiller mortality compared with their individual application. Consequently these crops gave significantly higher grain yield (3.03 tonnes/ha). The crops under both the organics ensured higher N uptake (55.50 kg/ha), apparent N recovery (38.32%) and N-use efficiency (29.50 kg grain/kg N applied).

Key words: Farmyard manure, Green-manuring, Nitrogen, Submergence, Flood-prone rice, Growth, Yield

The advent of high-yielding rice (*Oryza sativa* L.) varieties under flood-prone lowland situations require improved N management to invoke their in-built tolerance. This helps them tide over the submergence stress caused by flash-flooding (Reddy *et al.*, 1991). This tolerance mechanism is governed mostly by sustainability and subsequent deployment of biomass during submergence. Traditional N management involving the applications of basal N alone causes its low recovery (30-40%), and fails to ensure sustained N availability for higher biomass production during the period of flooding. Instead, integrated N management constituting both organic and fertilizer N may help the plant maintain sufficient biomass production (Ghosh and Sharma, 1999). However, the primary concern is to determine whether their individual or combined use becomes beneficial for rice. Therefore the present field experiment was conducted.

MATERIALS AND METHODS

A field experiment was conducted on rice 'Gayatri' during wet season (June to December) in 2003 and 2004 at Central Rice Research Insitute, Cuttack. The experimental site experienced naturally occurring hydrology, encountering water column maximum up to 75 cm. Organic N sources (FYM and *Sesbania aculeata*) were applied either individually or combined with fertilizer N, constituting 40 kg N/ha. Thus the treatments on N management (5) comprised no N, 20 kg N/ha each from urea and FYM or from urea and *Sesbania*, 10 kg N/ha each from FYM and *Sesbania*, and the rest 20 kg N/ha from urea, and 40 kg N/ha from urea alone. A uniform dose of 20 kg each of P_2O_5 and K_2O /ha was also applied through single superphosphate and muriate of potash respectively in all the treatments. The treatments were arranged in randomized complete block design with three replications. Drill seeding @ 80 kg seed/ha was done within 3-5 cm deep furrow at 15 cm × 20 cm spacing during mid-May and crop was harvested by end of December in both the years. The entire doses of P, K and FYM (0.50% N, on dry-weight basis) were applied basal at sowing. *Sesbania* seeds were intercropped @ 20 kg/ha with rice at 2:1 stand ratio (rice : *Sesbania*) and at 42 days *Sesbania* plants (0.54% N, on fresh-weight basis) were incorporated within soil as per estimated N dose (20 kg N/ha). Urea was applied as per treatment at 12 days after germination. The crop at maximum tillering stage remained under complete submergence of 75 cm deep water continuously for 10 days by the end of August. Agronomic parameters like tiller mortality, degeneration of root volume, degree of biomass production and the level of critical N in plant {SPAD value (Soil-Plant Analysis Development) (Suzuki, 1997)} were determined. Root volume was measured by water-dis-

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placement method. Plant samples were uprooted from the soil, and the mass was determined by water-displacement method.

RESULTS AND DISCUSSION

Flooding pattern and initial stand establishment

Water started accumulating in the field soon after the onset of monsoon rain during the third week of June in both 2003 and 2004. The flooding pattern remained almost similar during both the years. Initial stand under all the treatments did not suffer much; however, subsequent growth varied significantly. Water depth gradually rose with the advancement of crop growth. It registered a maximum depth of 75 cm at maximum tillering stage and caused complete crop submergence for 10 days consecutively. Tillering was better in the crops under Integrated nutrient management (INM) than in those under fertilizer N treatment. Thereafter the water level receded and fluctuated within 50-60 cm during panicle emergence to flowering stages. Then it started declining constantly towards crop maturity during the first week of December.

Crop submergence and growth attributes

Root development

Root development was impaired less in the crops treated with either of the organic N sources, combined with urea N. However, it was pronounced more in the crops treated with both the organics, accounting for 31.57 per cent increase in root volume after submergence (Table 1). Root development was impaired severely in the crops under fertilizer N alone (19.74%); whereas the crops under *Sesbania* (28.47%) and FYM (28.30%) recorded better root growth. Thus better root development in the crops under INM ensured greater plant survivability under stress situation (Reddy *et al.*, 1991).

Critical N level in plants

SPAD value in the crops under both the organics was 37.20 and 40.25 at these two flooding situations. These were above the normal value (35), which implies to be on a par with normal range of 1.40 to 1.60 g N/m^2 of leaf area (Sujuki, 1997). Comparable SPAD values were observed in the crops under FYM (35.50 and 37.70) and *Sesbania* (34.25 and 36.50) also. Higher N level in the plant implies sustainable biomass production over the submergence to ensure better crop survivability.

Biomass production and Tiller production

Although the biomass production was suppressed due to submergence stress, the crops under both the organics produced the highest biomass, both at the initiation as well as at end of submergence. Even the crops under FYM

Table 1. Growth and yield attributes and grain yield of rice under flood-prone situation as influenced by combined use of organic and fertilizer N (pooled data of 2003 and 2004)

*N management***	Plant biomass (g/m^2) Before submergence	After submergence	Tiller mortality (%)	Root Volume development after submergence (%)	Increase in SPAD value (%)	Plant height at maturity (cm)	Panicles (No./m^2)	Panicle weight (g)	Grain yield (t/ha)
Control (N_0)	162.45	130.20	48.00	14.46	2.0	132.77	150	3.34	1.85
Sesbania + urea	242.78	205.14	31.00	28.47	5.0	141.63	190	3.99	2.30
FYM + urea	240.30	210.73	27.50	28.30	4.5	143.37	219	4.02	2.55
Sesbania + FYM + urea	252.06	225.98	22.11	31.57	7.0	144.65	305	4.06	3.03
Urea	179.68	152.40	30.50	19.74	4.5	143.52	212	3.93	2.03
CD (P=0.05)	8.75	10.20	3.15	2.00	1.5	2.34	3	0.09	0.12

*Variation (%) between submergence initiation and at 10 days after submergence; **N @ 40 kg/ha through different sources and their combinations and *Sesbania* produced more biomass at these stages compared with that under fertilizer N alone. High biomass before flooding ensured better tolerance to stress, whereas its higher availability after submergence helped the crops recover fast from the stress, leading to better survivability (Sharma and Ghosh, 1999). Moreover, lower rate of its depletion (11.88%) was noticed in the crops under both the organics during submergence compared with that under *Sesbania* (16.84%) or FYM (14.65%).

Application of organics encouraged tiller production both before and after submergence. The crops under both the organics incurred less tiller mortality (22.11%), having 260/m^2 and 240/m^2 tillers at these two stages respectively. However, tiller mortality was more in the crops under *Sesbania* (31%) and FYM (27.5%), having 200/m^2 and 150/m^2, and 225/m^2 and 175/m^2 tillers respectively. In contrast, the crops under no N showed substantial tiller mortality (Reddy *et al.*, 1991).

Yield attributes and grain yield

Application of organics encouraged better panicle emergence, whereas panicle weight and plant height remained comparable in all other treatments except that under no N. The crops under combined application of FYM and *Sesbania* along with urea produced significantly highest grain yield (3.03 t/ha) than other crops. This was attributed to the supplementary effects owing to faster N availability from *Sesbania* followed by FYM (Ghosh, 2000). Initial N availability from fertilizer N encouraged better primary growth; whereas organic sources supplemented N availability for sustaining the growth. Their integral effects helped the crop thrive better during submergence as well as restoration after flood. Grain yield in the crops under FYM (2.55 t/ha) or *Sesbania* (2.30 t/ha) was also significantly higher than under fertilizer N (2.03 t/ha). Relatively higher yield in the crops under FYM was attributed to its prolonged and consistent N availability due to its well-decomposed nature (Sujuki, 1997).

N uptake, apparent N recovery and N-use efficiency

Combined application of organic and fertilizer N sources promoted greater N uptake, apparent N recovery and N-use efficiency. In both the years the application of organic N, particularly FYM either individually with urea or in combination with *Sesbania* and urea, resulted in greater N utilization compared with urea alone. The crops under individual application of FYM with urea encouraged better N uptake, apparent N recovery and N-use efficiency compared with the application of *Sesbania* with urea. On the contrary, significantly greater N uptake, apparent N recovery and N-use efficiency were found in the crops under the combined application of FYM and *Sesbania* along with urea N compared with other treatments (Table 2).

Table 2. N uptake in grain, nitrogen-use efficiency and apparent N recovery of rice as influenced by N management under flood-prone situation (pooled data of 2003 and 2004)

N management	N uptake (kg/ha)	N-use efficiency (kg grain/kg N applied)	Apparent N recovery (%)
Control (N_0)	40.17		
Sesbania + urea	50.30	11.25	25.32
FYM + urea	53.50	17.50	33.32
Sesbania + FYM + urea	55.50	29.50	38.32
Urea	52.20	4.50	30.07
CD (P=0.05)	1.12	5.35	2.50

Under this lowland condition, there was no N loss in the form of NO_3^--N, NO_2^--N or urea N as such. But N loss also occurs due to run-off of water, which was estimated 78 per cent of applied N in case of broadcasted prilled urea.

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