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Integrated Nutrient Management for Higher Productivity and Better Soil Health under Rice (*Oryza sativa*) - based Cropping Systems

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ABSTRACT

An experiment was conducted during *kharif* and *rabi* 1999-2000 and 2000-01 on sandy clay loam soil at College Farm, College of Agriculture, Rajendranagar, Hyderabad to study the effect of conjunctive use of inorganic and organic sources of nitrogen and inorganic nitrogen alone on soil fertility in rice-based cropping systems. Significantly lower soil available N, P_2O_5 , K_2O and higher bulk density were observed with application of 100% N through urea to rice compared to 25 % N through FYM+75% N through urea applied to rice. However, application of 25% N through GM along with 100% N through urea proved to be the best with respect to available N, P_2O_5, K_2O and physico-chemical properties after *kharif* and *rabi* crops. Groundnut grown during *rabi* after rice resulted in significantly higher soil available N, P_2O_5, K_2O, lower BD and EC compared to maize, wheat and soybean. Among cropping systems, rice-maize sequence has produced significantly higher RGEY compared to other cropping systems.

Key words : Bulk Density, EC and Urea,Green Manuring,Rice grain equivalent yield, Soil available N, P_2O_5, K_2O.

Rice-rice cropping sequence is the most predominant system in India and this sequence leads to decline in yield due to diminishing supply of soil nitrogen (Krishna and Reddy, 1997). Under limited water supply, the upland crops like maize, wheat, soybean and groundnut that require less water are to be preferred. Excessive and indiscriminate use of chemical fertilizers in intensive cropping systems cause yield decline, nutrient imbalance and result in adverse effects on soil physico - chemical properties. Integrated nutrient management in rice and rice-based cropping systems is essential for improving the soil fertility and stability in production. Information on the residual effect of integrated nitrogen management practices to rice on succeeding crops is limited. In view of the above, an investigation was taken up to know the effect of conjunctive use of inorganic and organic sources of nitrogen and inorganic nitrogen alone on productivity and physico-chemical properties of soil in rice-based cropping systems.

MATERIAL AND METHODS

An experiment was conducted at College Farm, Rajendranagar, Hyderabad, on sandy clay loam soil during *kharif and rabi* , 1999-2000 and 2000-01. The *kharif rice* was studied in a randomized block design with four replications having five nitrogen management practices (25% N through farm yard manure (FYM) + 75% N through Urea, 25% N through FYM+100% N through urea, 25% N through green manure (GM) – Sunnhemp +75% N through urea, 25% N through GM + 100% N through urea and 100% N through urea). In *rabi ,* each of the *kharif* treatment was sub-divided into four plots to accommodate wheat, maize, soybean and groundnut. Results of the trial were analysed in a split-plot design treating N management practices to *kharif rice* as main plot and *rabi* crops as sub-plot treatments. The experimental soil was low in available N (235 kg/ha), medium in available P_2O_5 (20 kg/ha) and K_2O (271 kg/ha), 0.6% organic carbon, pH 8.0 and EC 0.48 d S m^{-1} A fertilizer dose of 120:60:40 kg ha^{-1} NPK was applied to *kharif* rice (Var. IR-64). In the *rabi* season wheat variety Sonalika was fertilized with 100:40:40 kg ha^{-1} NPK and maize variety Thishulatha with 120: 60: 40; soybean variety PK-472 with 20: 80: 50 and groundnut variety K-134 with 30: 60: 45 kg ha^{-1} NPK. The spacing adopted to rice, wheat, maize, soybean, and groundnut was 20 x 10 cm, 22.5 x 5 cm, 60 x 20 cm, 30 x 10 cm and 30 x 10 cm, respectively. Sunnhemp was raised in a separate field, harvested at 45 days after sowing, transported and incorporated in the experimental field. It was cut into small pieces before incorporation for early decomposition. The integrated nutrient management treatments were imposed to *kharif* rice based on the N content in the green manure and FYM to substitute 25% of the recommended 120 kg N ha^{-1}

Table 1. Soil available nitrogen, phosphorus and potassium (kg ha^{-1}) after harvest of *kharif* rice as influenced by various N management practices

Treatments to rice	Available nitrogen		Available phosphorus		Available potassium	
	1999	2000	1999	2000	1999	2000
25% of N through FYM + 75% of N through urea	241	249	21.2	21.4	273	274
25% of N through FYM + 100% of N through urea	251	258	21.9	22.0	276	276
25% of N through GM + 75% of N through urea	245	250	21.5	21.7	274	274
25% of N through GM + 100% of N through urea	257	264	22.7	22.8	277	277
100% of N through urea	238	243	20.7	20.4	272	274
SEm ±	0.7	0.5	0.2	0.2	0.4	0.3
CD (P=0.05)	2.0	1.5	0.6	0.6	1.2	1.0

Table 2. Bulk density (g cm^{-3}) of soil after harvest of *kharif* rice as influenced by various N management practices to rice

Treatments to rice	Bulk density	
	1999	2000
25% of N through FYM + 75% of N through urea	1.48	1.47
25% of N through FYM + 100% of N through urea	1.48	1.47
25% of N through GM + 75% of N through urea	1.48	1.47
25% of N through GM + 100% of N through urea	1.48	1.47
100% of N through urea	1.49	1.50
Mean	1.48	1.47
SEm ±	0.008	0.002
CD (P=0.05)	NS	0.006
Initial value	1.49	

to rice. The green manure of sunnhemp and farm yard manure were incorporated in the soil, ten days before transplanting of rice. Sunnhemp had 2.52, 0.16 and 0.51% N, P and K during 1999 while it had 2.47, 0.19 and 0.53% N, P and K during 2000. FYM had 0.64, 0.28 and 0.58% during 1999 while it had 0.61, 0.27 and 0.53% of these nutrients in 2000. A quantity of 1214 and 1190 kg ha^{-1} of sunnhemp was incorporated during 1999 and 2000, respectively. Similarly, 4697 and 4918 kg ha^{-1} of FYM was added, respectively. The experiment was continued for four seasons in the same field. Soil bulk density (BD) and EC (Electrical conductivity) were determined before sowing and after harvest in all the four seasons. Soil samples were drawn (30 cm depth) from all the treatments after harvest of each crop in the cropping system (*kharif* and *rabi*) and analysed for the soil available N, P_2O_5 and K_2O. Grain yield of all the test crops in the cropping system was converted into rice grain equivalent yield (RGEY) on the basis of prevailing market prices. The RGEY of rice-based cropping system was obtained by following the formula.

Rice grain equivalent yield (kg ha^{-1}) =
Grain yield of *kharif* rice (kg ha^{-1}) +
[Yield of *rabi* crops (kg ha^{-1}) x
Price of *rabi* crops (Rs kg^{-1}) /
Price of rice grain (Rs kg^{-1})]

RESULTS AND DISCUSSION

Soil fertility status after *kharif* rice

Available nitrogen

Application of 25 % N through GM + 100 % N through urea to rice recorded significantly higher available nitrogen over all the remaining treatments

Table 3. Soil available nitrogen, phosphorus and potassium (kg ha^{-1}) after harvest of *rabi* crops as influenced by various N management practices to *kharif* rice

Treatments to rice	Soil available N		Soil available P_2O_5		Soil available K_2O	
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
N Management in Rice						
25% of N through FYM + 75% of N through urea	244	258	21.4	21.6	272	274
25% of N through FYM + 100% of N through urea	254	265	21.8	22.2	274	276
25% of N through GM + 75% of N through urea	248	258	21.4	22.0	273	275
25% of N through GM + 100% of N through urea	262	272	22.6	23.0	275	278
100% of N through urea	241	253	20.4	20.6	271	274
SEm ±	0.19	0.47	0.06	0.03	0.14	0.09
CD (P=0.05)	0.57	1.4	0.19	0.10	0.42	0.26
Cropping Systems						
Rice-Wheat	247	256	21.3	21.8	273	275
Rice-Maize	246	257	21.4	21.8	273	275
Rice-Soybean	251	264	21.6	21.9	273	275
Rice-Groundnut	255	267	21.8	22.0	274	276
SEm±	0.07	0.27	0.03	0.01	0.03	0.02
CD (P=0.05)	0.20	0.80	0.10	0.03	NS	NS
Interaction						
SEm±	0.35	0.85	0.11	0.06	0.23	0.14
CD (P=0.05)	NS	NS	NS	NS	NS	NS

(Table 1). Application of 25 % N through FYM + 100% N through urea to rice resulted in significantly higher available nitrogen than that of 25 % N through GM or FYM + 75 % N through urea and 100 % N through urea to rice. Incorporation of organic manures in rice-based cropping systems increased the nutrient pool and reduced the losses of nutrients. Green manures which are comparatively more succulent with narrow C: N ratio than FYM release nitrogen on decomposition rapidly in to soil pool. Green manure , applied as a source of nitrogen to rice, undergoes decomposition, releasing N steadily to meet the crop requirement.Significantly lower available nitrogen in soil was observed with application of 100 % N through urea to rice . Urea, which is the most available form for N when applied to rice is subjected to leaching and volatilization losses in addition to crop uptake resulted in lower availability after *kharif* rice (Vasanth Kumar, 1996).

Available phosphorus

Significantly higher available phosphorus in soil was found with 25 % N through GM + 100 % N through urea over the other remaining treatments (Table 1). The buildup of available phosphorous in soil is due to release of organic acids during microbial decomposition of green manure which might have helped in the solubility of native phosphorus.The available phosphorus in soil with application of 25 % N through FYM + 100 % N through urea was comparable with 25 % N through GM + 75 % N through urea to rice. Application of 25 % N either through GM or FYM + 75 % N through urea to rice resulted in comparable available phosphorus in soil. Application of 100 % N through urea to rice resulted in significantly lower available phosphorus in soil.

Available potassium

Significantly higher available potassium in soil was recorded with 25 % N through GM + 100 % N through urea over the other treatments (Table 1). Application of 25 % N through FYM + 100 % N through urea resulted in significantly higher available potassium in soil than that of 25 % N through GM + 75 % N through urea, 25 % N through FYM + 75 % N through urea and 100 % N through area.

Table 4. Soil physico-chemical properties after harvest of *rabi* crops and rice grain equivalent yield (kg ha^{-1}) of rice-based cropping systems as influenced by N management practices to *kharif* rice and cropping systems

Treatments to rice	Bulk density (g cm^{-3})		EC (d S m^{-1})	Rice grain equivalent yield	
	1999-2000	2000-2001	2000-2001	1999-2000	2000-2001
N Management in Rice					
25% of N through FYM + 75% of N through urea	1.47	1.46	0.48	7054	7062
25% of N through FYM + 100% of N through urea	1.48	1.47	0.48	8860	8927
25% of N through GM + 75% of N through urea	1.48	1.47	0.49	7683	7697
25% of N through GM + 100% of N through urea	1.48	1.47	0.48	9107	9105
100% of N through urea	1.48	1.49	0.50	8308	8317
SEm ±	0.002	0.003	0.002	49	94
CD (P=0.05)	0.006	0.009	0.006	147	282
Cropping Systems					
Rice-Wheat	1.48	1.48	0.49	8132	8085
Rice-Maize	1.48	1.48	0.49	9328	9353
Rice-Soybean	1.48	1.47	0.48	6697	6745
Rice-Groundnut	1.48	1.47	0.48	8652	8704
SEm±	0.001	0.001	0.001	17	27
CD (P=0.05)	NS	0.003	0.003	51	80
Interaction					
SEm±	0.009	0.008	0.006	94	159
CD (P=0.05)	NS	NS	NS	NS	NS

Physico-chemical properties

Soil bulk density after harvest of rice (2000) was significantly influenced by different N management practices to rice. On the other hand, it did not differ significantly in 1999 (Table 2). Significantly higher bulk density (1.50 g/cc) was observed with application of 100 % N through urea to rice. Application of 25 % N through organic source + 75 or 100 % N through urea to rice reduced the bulk density (1.47 g cm^{-3}) from the initial value (1.49 g cm^{-3}). Under decomposition, organic manures produces polysaccharides, polyuronoides, cellulose and humus, which are responsible for firm binding between soil particles, resulting in more stable aggregates and porosity causing decline in bulk density (Bellanki and Badanur, 1997).

Soil fertility status after *rabi* crops

Treatments applied to *kharif* rice and cropping systems significantly influenced the available nitrogen, phosphorus and potassium status of the soil. Interaction effect of treatments to *Kharif* rice and cropping systems on available nitrogen, phosphorus and potassium in soil was found to be non significant (Table 3).

Application of 25 % N through GM + 100 % N through urea to preceding rice recorded significantly higher available nitrogen, phosphorus and potassium in soil over rest of the treatments. After rice, certain quantity of green manure continues to mineralize releasing nitrogen, which would add to the soil pool. Hence, there might be more soil available nitrogen in green manure applied treatments even after *rabi* crops compared to other treatments. Application of 25 % N through FYM + 100 % N through urea to rice observed significantly higher available nitrogen, phosphorus and potassium compared to application of 25 % N either through GM or FYM + 75 % N through urea and 100 % N through urea to rice. Significantly lower available nitrogen and phosphorus in soil were observed with application of 100 % N through urea to rice. Nitrogen supplying pattern became steady and long lasting when green manure and fertilizer nitrogen were combinedly applied to the system.

Significantly higher available nitrogen and phosphorus in soil was observed in groundnut over rest of the crops. Significantly lower available nitrogen in soil was recorded in maize during 1999-2000 and in wheat during 2000-2001. On the other hand,

Table 5. Rice grain equivalent yield (kg ha^{-1}) of rice-based cropping systems as influenced by N management practices imposed to *kharif* rice

Treatments to rice	1999-2000	2000-2001
N Management in Rice		
25% of N through FYM + 75% of N through urea	7054	7062
25% of N through FYM + 100% of N through urea	8860	8927
25% of N through GM + 75% of N through urea	7683	7697
25% of N through GM + 100% of N through urea	9107	9105
100% of N through urea	8308	8317
SEm ±	49	94
CD (P=0.05)	147	282
Cropping Systems		
Rice-Wheat	8132	8085
Rice-Maize	9328	9353
Rice-Soybean	6697	6745
Rice-Groundnut	8652	8704
SEm±	17	27
CD (P=0.05)	51	80
Interaction		
SEm±	94	159
CD (P=0.05)	NS	NS

Price of produce (Rs kg^{-1}): Rice: 5.3, Wheat: 6.1, Maize:4.5, Soybean:10.0 and Groundnut:12.2

significantly lower available phosphorus was observed in wheat than that of maize and soybean. This might be due to fixation of atmospheric nitrogen by legumes in their nodules by rhizobium through symbiotic N-fixation process (Santhy *et al.,* 1998).

Significantly lower available potassium in soil was registered with application of 100 % N through urea to rice, however, it was comparable with application of 25 % N through FYM + 75 % N through urea to rice. The build up of available K in soil was due to beneficial effect of green manure on the reduction of potassium fixation, releasing K due to the interaction of organic matter with clay and direct addition of K to the available pool of soil.

During 2000-2001, the bulk density after harvest of *rabi* crops was significantly influenced by *kharif* treatments to rice and different crops during *rabi* . Significantly higher bulk density was observed with application of 100 % N through urea to rice (Table 4). The bulk density did not vary significantly with application of 25 % N either through GM or FYM + 75 or 100 % N through urea to rice. Significantly lower bulk density (1.47 g/cc in 1999-2000 and 1.46 g/cc in 2000-2001) was recorded with application of 25 % N through FYM + 75 % N through urea to rice. The bulk density observed after harvest of groundnut and soybean was comparable and significantly lower than that was observed after harvest of wheat and maize during 2000-2001 but same in all crops during 1999-2000. Legumes in rotation produced better aggregation of soil particles compared to cereals and resulted in lower bulk density.

During 1999-2000, *kharif* rice and *rabi crops* did not influence the EC significantly, but significantly influenced during 2000-2001 (Table 4). Significantly higher EC was observed with application of 100 % N through urea to rice. The EC observed after harvest of groundnut and soybean was comparable and significantly lower than that was observed after harvest of wheat and maize. Increase in water holding capacity and buffering capacity of soil were associated with incorporation of legume residues (Santhy *et al* ., 1998). Inclusion of legume in cropping systems resulted in better physico-chemical status of soil.

Rice grain equivalent yield

Application of 25 % N through GM + 100 % N through urea to rice resulted in significantly higher RGEY (Table 5). Significantly lower RGEY was noticed with application of 25 % N through FYM + 75 % N through urea to rice. Lower dry matter production of *rabi* crops due to lower availability of N, P, K after *kharif* rice resulted in decreased yield, in addition to lower yield of *kharif* rice might have support the above trend of results. Among cropping systems, significantly higher RGEY was recorded with rice-maize. Significantly lower RGEY was noticed with rice-soybean. These trends were observed due to higher yield of maize followed by soybean. These findings corroborate with those observed by Mishra and Sharma (1997).

The results revealed that application of 25% N through GM (1.2 t ha^{-1}) along with 120 kg N/ha through urea to rice and recommended doses of fertilizers to *rabi* crops in rice-based cropping system is found to be ideal nutrient management practice for sustaining the soil fertility. Rice-maize cropping system with above N management practice to *kharif* rice and recommended dose of fertilizer application to *rabi* maize was promising sequence for higher productivity and better soil physico-chemical condition.

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