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Effect of organic manure on yield and nutrient uptake under rice - rice cropping system

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Abstract: A field experiment was conducted during winter *(rabi)* 1996 and rainy *(khaif)* 1997 seasons to study the effect of organic manure on the yield and nutrient uptake under rice *(Oryza saliva L.)* - rice cropping system. Among the eight manures tested, application of farmyard manure (10 t ha^{-1}) in combination with neemcake (3 t ha^{-1}) has been found to be equally effective for getting higher grain yield and improved nutrient uptake, when compared to chemical N fertilizer application. Total nutrient uptake by rice crop differed significantly due to organic-manure applied treatments and application of farmyard manure + neemcake resulted in higher uptake (102.06 kg ha^{-1}), which was 20.7% more compared to chemical N fertilizer applied plot. The maximum N use efficiency (27.51 kg grain kg^{-1} N) was recorded in the same treatment, which was followed by farmyard manure combined with poultry manure; and press mud combined with poultry manure. Similar higher Apparent N recovery patterns also were recorded by organic manure treatments. Organic manures exhibited 22.7% and 21.5% higher total P and K uptake respectively in both the seasons of study when compared to chemical N fertilizer applied treatments. The significant increase in grain yield was supported by higher number of panicle bearing tillers, straight ear heads and 1000-grain weight, which was observed more in organic manure applied plot as compared to inorganic fertilizer.

Key Words: Rice, Organic manures, Nutrient uptake, N-use efficiency.

Introduction

In recent years, rice has emerged as the principal stable food crop in the western part of TamilNadu (Coimbatore). In Coimbatore plains, rice *(Oryza sativa L.)* - rice cropping system occupies nearly 10 lakh ha area. Growing two or more crops per year involves heavy removal of plant nutrients, nitrogen being the key input limiting rice production. To produce a ton of grain, the rice crop takes up an average of 20 kg N ha^{-1} from the soil over a period 3-5 months. To sustain the rice productivity at present levels, the N removed in harvested produce or lost from the system must be replaced by N fertilizers or must be obtained from organic manures. Addition of N through organic manures exhibited better replenishment of losses of N through crop harvest and other mechanisms, creating a dynamic equilibrium (Ladha 1997), this equilibrium needed to be sustained for increasing the rice production and high-yielding rice varieties ability to use additional nutrient inputs which were thus developed. Compared with traditional varieties, the recently introduced rice Hybrids remove larger amounts of N from the system. Moreover, use of organic manure not only acts as a source of N and other nutrients but also increase the efficiency of applied nitrogen (Zhu *et al.* 1987). The information on the effectiveness of organic manure with different combination on high yielding rice varieties is mearge. Thus, the present study was undertaken to find out the usefulness of organic manures on grain yield, N uptake and nutrient use efficiency.

Materials and Methods

Field experiments were conducted during winter *(rabi)* 1996 and rainy *(kharif)* 1997 at Research Farm of Tamil Nadu Agricultural University, Coimbatore. The soil was clay loam with pH of 8.2 and the organic matter content of 0.78%. The available N, P and K content of the experimental soil were 285, 15.4 and 616 kg ha^{-1} respectively. The experiment was laid out in Randomized Block Design (RBD) with 15 treatments and 3 replications. The treatments included were:

Table 1. Nutrient contents of organic manure - *Rabi* 1996

S.No.	Organic manures	Nutrient contents (%)			Quantity applied on dry basis to substitute 75 kg ha^{-1}
		N	P	K	
1.	*Sesbania rostrata*	2.50	0.85	1.60	3.00
2.	FYM	0.80	0.45	0.74	9.37
3.	Pressmud	0.70	1.10	0.70	10.71
4.	Biogas slurry	0.75	1.00	0.80	10.00
5.	Azolla	4.60	1.45	1.65	0.815*
6.	Neemcake	3.80	0.85	1.00	1.97
7.	Poultry manure	2.50	1.30	1.40	3.00

Table 1a. Nutrient contents of organic manures - *Kharif* 1997.

S.No.	Organic manures	Nutrient contents (%)			Quantity applied on dry basis to substitute 75 kg ha^{-1}
		N	P	K	
1.	*Sesbania rostrata*	3.00	0.85	1.60	2.00
2.	FYM	0.50	0.40	0.74	12.37
3.	Pressmud	1.09	1.40	0.75	5.50
4.	Biogas slurry	1.40	1.10	0.80	4.28
5.	Azolla	4.30	1.40	1.60	0.70*
6.	Neemcake	3.80	0.70	0.75	1.58
7.	Poultry manure	3.00	2.24	1.87	2.00

* To substitute 37.5 kg N ha^{-1}

T_1 : 50% N as *Sesbania rostrata* + 25% N as *Azolla* + 25% N as *Azospirillum;*

T_2 : 50% N as *Sesbania rostrata* + 50% N as neemcake;

T_3 : 50% N as *Sesbania rostrata* + 50% N as poultry manure;

T_4 : 50% N as FYM + 25% N as *Azolla* +25% N as *Azospirillum;*

T_5 : 50% N as FYM + 50% N as neemcake;

T_6 : 50% N as FYM +50% N as poultry manure;

T_7 : 50% N as press mud + 25% N as *Azolla* + 25% N as *Azospirillum,*

T_8 : 50% N as press mud + 50% N as neemcake;

T_9 : 50% N as press mud + 50% N as poultry manure;

T_{10} : 50% N as biogas slurry + 25% N as *Azolla* +25% N as *Azospirillum;*

T_{11} : 50% N as biogas slurry + 50% N as neemcake;

T_{12} : 50% N as biogas slurry + 50% N as poultry manure;

T_{13} : Recommended NPK 120:38:38 in *kharif* 150:50:50 in *rabi,*

T_{14} : Absolute control (No NPK);

T_{15} : RFD+Herbicide (butachlor 2.5 kg a.i ha^{-1})+ Pesticide (pendimethalin 1.5 kg a.i ha^{-1}) by chemical.

Organic manures, green manures and biofertilizers were analyzed for their N contents and based on values (Table 1 & 1a), required quantities (120 kg N ha^{-1} for *kharif* and 150 kg N ha^{-1} for *rabi*) were incorporated into the soil 10 days before transplanting of rice. *Azospirillum* was given as seed inoculation in nursery and applied to soil and for plant protection biocontrol agents *(Trichogramma japonica* and

Table 2. Effect of organic and chemical fertilizer on grain yield and nutrient use efficiency on rice hybrid

Treatments	Grain yield (kg ha^{-1})			Apperant N recovery			Agronomic efficiency		
	1996	1997	Mean	1996	1997	Mean	1996	1997	Mean
T_1 - Sr + Az + As	3470	4095	3782	0.24	0.26	0.25	11.47	15.08	28.55
T_2 - Sr + Nc	3990	4301	4145	0.27	0.39	0.33	14.94	16.85	23.36
T_3 - Sr + Pom	4280	5024	4642	0.35	0.73	0.54	16.88	22.83	28.28
T_4 - Fym + Az + As	3160	4483	3821	0.23	0.46	0.34	9.38	18.28	13.83
T_5 - Fym + Nc	5240	6095	5667	0.46	0.96	0.71	23.27	31.75	27.51
T_6 - Fym + Pom	4490	5521	5005	0.27	0.33	0.34	18.19	26.95	22.57
T_7 - Pm + Az + As	3620	4590	105	0.28	0.42	0.34	12.51	19.21	18.28
T_8 - Pm + Nc	4300	4631	4465	0.34	0.58	0.43	17.02	19.54	20.22
T_9 - Pm + Pom	4410	5010	4710	0.28	0.79	0.56	17.72	22.74	11.08
T_{10} - Bs + Az + As	2950	3980	3465	0.28	0.18	0.23	8.01	14.16	17.09
T_{11} - Bs + Nc	4040	4090	4065	0.28	0.32	0.30	19.11	15.08	16.97
T_{12} - Bs + Pom	4090	4015	4856	0.28	0.29	0.28	19.54	14.41	16.97
T_{13} - Rec. NPK	4650	5623	5136	0.30	0.81	0.55	19.32	27.78	16.97
T_{14} - Control	1750	2282	2016						
T_{15} - Con. Farm.	4740	5042	4891	0.30	0.83	0.56	19.32	27.96	23.95
SEd	56	63.1							
CD (0.05)	105	140							

Sr - *Sesbania rostrata*, Az - Azolla, As - Azospirillum, Nc - Neemcake, Pom - Poultry manure, Fym - Farmyard manure, Bs - Biogas slurry, Pm - Pressmud.

Trichogramma chilonis) were used. For controlling weeds expect for the T_{15} treatment hand weeding twice (25 DAT and 35 DAT) was adopted for all the treatments.

For conventional farming, nitrogen was given in 3 equal splits as basal, at maximum tillering and panicle initiation stages of the crop. Thirty-day old seedlings of both the varieties (CORH-1 in *rabi* 1996 and ASD-18 in *kharif* 1997) were transplanted at 20x15 cm spacing. Saturation to continuous submergence of 5+2 cm water was maintained throughout the crop growth period and plots were kept weed free.

The nitrogen, both in grain and straw, was estimated by Micro- Kjeldahl digestion and distillation method (Jackson, 1967) and uptake was calculated by multiplying N content with the yield. Similarly, phosphorous by Colorimetric method and potassium by Flame Photometric method were estimated. Grain yield were reported on the basis of 14% moisture content. To calculate the N- use efficiency and Apparent N Recovery, framework of Pillai and Vamadevan (1978) was adopted.

Results and Discussion

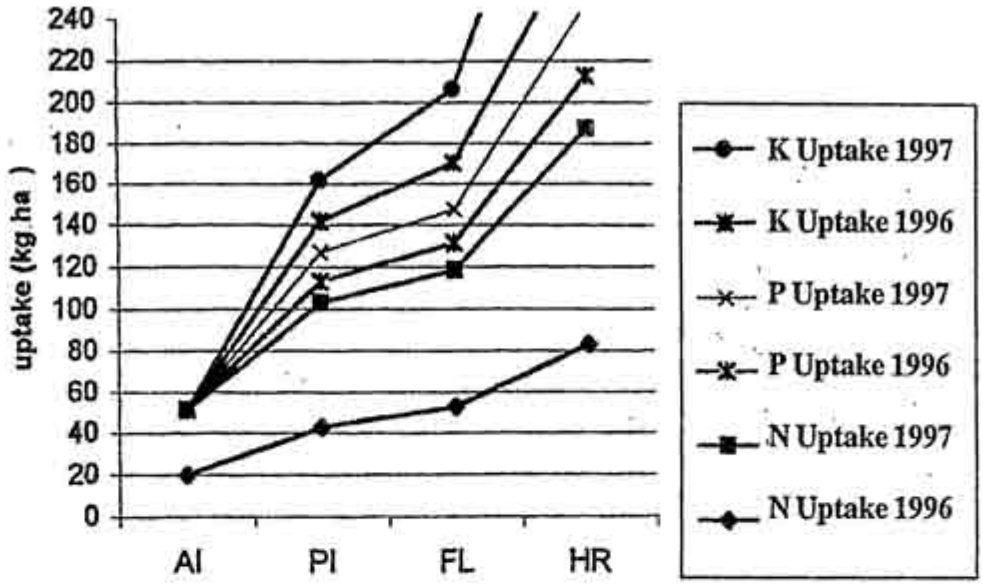
Yield

The yield trend of rice for the two seasons is presented in Table 2. The grain yield of rice increased significantly with the application of organic ma-

Table 3. Effect of organic manure and chemical N fertilizers on nutrient uptake of rice (kg ha^{-1})

Treatments	N uptake						P uptake						K uptake					
	1996			1997			1996			1997			1996			1997		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T1	47.50	23.75	71.38	47.93	23.96	71.89	13.31	6.65	19.97	15.86	7.92	23.78	17.13	8.56	25.70	37.10	18.56	55.70
T2	55.50	27.65	82.97	58.01	29.00	87.01	20.79	6.93	20.79	16.33	8.16	24.49	20.44	10.22	30.67	41.01	20.50	61.52
T3	58.70	29.35	88.06	85.56	42.78	128.34	19.90	9.95	29.86	28.60	14.29	42.89	30.27	15.13	45.41	61.10	30.55	91.67
T4	44.40	22.20	66.62	63.35	31.67	95.02	18.40	69.20	27.91	25.08	12.54	37.63	27.54	13.77	41.32	56.65	28.27	84.83
T5	67.94	34.12	102.10	109.24	54.61	163.85	23.58	11.79	35.37	35.10	17.55	52.37	35.08	17.54	52.62	88.94	44.47	133.40
T6	62.40	31.20	93.61	94.46	47.22	141.68	21.08	10.54	31.64	28.40	14.20	42.67	33.23	16.61	49.85	83.22	41.61	124.80
T7	50.06	25.03	75.09	60.62	30.30	90.92	14.64	7.32	21.98	21.84	109.20	32.78	22.38	11.19	33.57	72.44	36.72	72.44
T8	58.64	29.32	87.96	73.28	36.64	109.92	18.42	9.21	27.63	25.44	12.72	38.18	27.02	13.51	40.54	62.98	31.49	94.41
T9	58.02	29.01	87.04	89.94	144.96	134.90	20.26	10.13	30.40	28.68	14.54	43.03	34.56	17.18	51.54	85.88	42.94	128.80
T10	56.14	28.07	84.21	41.40	20.70	62.10	11.40	5.70	17.11	16.14	8.08	24.23	16.37	8.18	24.56	32.64	16.32	48.96
T11	56.90	28.48	85.45	52.60	26.30	78.90	12.36	6.18	18.56	16.08	8.49	25.49	16.01	8.00	24.02	39.27	19.63	48.96
T12	58.32	29.16	87.49	50.70	24.90	74.71	14.16	7.08	21.26	21.12	10.56	31.69	17.14	8.57	25.72	42.92	21.46	64.39
T13	63.92	31.96	95.88	91.60	45.82	137.48	21.98	10.99	32.97	31.96	15.98	47.04	35.79	17.59	53.69	75.38	37.69	113.10
T14	18.23	9.23	28.50	29.58	14.78	44.35	8.86	4.43	13.31	10.94	5.47	16.42	11.39	5.69	17.09	15.94	7.97	23.92
T15	65.82	32.91	98.73	93.63	46.81	140.45	22.18	11.09	33.27	31.50	15.75	47.27	34.86	17.43	52.29	75.90	37.65	113.90
SEd	2.42	2.32	2.86	3.12	3.12	3.33	1.29	1.43	1.25	1.04	1.05	1.16	1.32	1.07	1.16	3.12	3.07	3.23
CD(P=0.05)	5.64	5.25	5.96	6.42	6.51	6.66	2.59	2.86	2.78	2.08	2.08	2.58	2.13	2.13	2.5	6.23	6.13	6.42

Fig.1 Mean nutrient uptake pattern at different growth stages



AT - Active Tillering; PI - Panicle Initiation, FL - Flowering, HR - Harvesting

nures over the recommended NPK (through chemical fertilizer) during 2 years of experimentation. Combined application of farmyard manure (10 t ha^{-1}) with neemcake (3 t ha^{-1}) registered the higher grain yield in 1996 and 1997 respectively, which was 8 and 11.2% higher than that of conventional farming with chemical N fertilizer. The values were closely followed by the yield obtained with treatments T_{15} (conventional farming), T_{13}, T_6, (FYM+ poultry manure), T_9 (pressmud+ poultry manure) in *rabi* 1996 and T_{13}, T_6, T_5 in *kharif* 1997. Among the different organic sources tried farmyard manure, poultry manure and powdered neemcake proved better than the application of chemical fertilizers. Higher yield obtained from the above treatments might be attributed to rapid mineralization of N and sustained supply of N from farmyard manure, which might have met the N requirement of crop over a long period at the critical stages. Application of farmyard manure resulted in higher yields than that of other treatments; this could be owing to higher quantity of nutrients supplied through farmyard manure at 10 t ha^{-1} than in other treatments. Inclusion of neemcake in the combination might have controlled the soil borne pest and diseases. Naphade *et al.* (1993) reported similar beneficial effect of organic manure on rice yield.

Nitrogen uptake

Nitrogen uptake in grain, straw and total was influenced significantly by all the treatments. The higher value of N uptake was observed with farmyard manure + neemcake treatment which was on par with conventional farming (Table 3). The data on N uptake revealed that N accumulation was comparatively faster between active tillering and panicle initiation stages, while slower between panicle initiation and flowering stages and it increased considerably from flowering to harvesting stage (Figure 1). The application of N either through chemical fertilizer or farmyard manure was sufficient to meet the intensity of depletion and capacity of the soil to supply nitrogen to the crop. The application of FYM @ 10 t ha^{-1} recorded N uptake similar to that of 120 or 150 kg N ha^{-1} and this improvement in uptake of N in rice probably due to improvement in soil conditions, which encouraged the proliferation of roots, improved synchrony between supply and plant demand, might have enhanced the rice plants ability to draw more nutrients from larger area and greater depth as reported by Brar *et al.* (1995).

Phosphorus uptake

Phosphorus uptake by grain and straw was influenced significantly by various nutrient

management treatments in both the years. The significantly higher P uptake in grain and straw was recorded with farmyard manure+ neem cake (15 kg ha^{-1}) followed by conventional farming (13.14 kg ha^{-1}) and recommended NPK (13.0 kg ha^{-1}) during *rabi* 1996-97, while farmyard manure+ neemcake (19.77 kg ha^{-1}) was found to be at par with recommended NPK (14.37 kg ha^{-1}) during *kharif* 1997. Increased availability of P in soil could have been brought about not only by the decomposition of farmyard manure (Yadvinder singh *et al*, 1994) but also by synergistic effect existing between N + P due to application of organic manures.

Potassium uptake

Potassium uptake by grain and straw during both the years was significantly influenced by all the treatments. The highest total K uptake was recorded by recommended NPK (53.69 kg ha^{-1}) and remained on par with that recorded by conventional farming (52.29 kg ha^{-1}) and farmyard manure + neemcake (52.62 kg ha^{-1}) during *rabi* 1996-97. During *kharif* 1997, the K uptake registered similar trend as that of nitrogen. Higher dry-matter production and significant differences in rice grain yield due to the higher application of N might have contributed to the higher uptake of K. Another possible reason could be the higher proliferation of roots in N- applied treatment, which could have resulted in higher uptake of nutrients (Budhar, 1994).

Nitrogen- use efficiency (NUE)

The NUE as estimated by Agronomic Efficiency (AE) and Apparent N Recovery (ANR) was favorably influenced by organic manure application. Farmyard manure +neemcake resulted in higher AE of 27.51 kg grain kg-1 N (Table 2). The rate of N release in these treatments also probably matched well with the N requirement of rice crop, enabling the realization of higher grain yield as well as greater efficiency.

Apparent N recovery was higher with farmyard manure+ neemcake treatment. Better availability of N and reduced N losses might have increased the ANR with organic manures while, conventional method of fertilizer application would have increased the losses and resulted in reduced recovery of N, because of higher rates of ammonia volatilization and denitrification (Crasswell and Godwin, 1984) and from this experiment taking the seasonal variation in crop pattern into consideration it can be concluded, that the combined application of FYM@ 10 t ha^{-1} and 3 t ha^{-1} neemcake to substitute 150 kg N ha^{-1} in *rabi* and 8 t FYM ha^{-1} and 5.7 t ha^{-1} in *kharif*, are beneficial in achieving the higher nutrient uptake and higher production of grain yield.

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