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Effect of organic and inorganic sources of nitrogen on growth, yield, nitrogen uptake and economics of lowland rice

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Abstract: Combinations of organic sources of nitrogen have exerted variable influence on growth and yield of rice. Study on relative efficacy of organic sources of nitrogen in low land rice revealed that combination of 50% N through fertilizer and 50% N through different organic sources (Glyricidia leaf (GL), Poultry manure (PM), Farm yard manure (FYM) and Neem cake (NC) produced significantly higher growth and yield parameters than other combination treatments. The growth and yield parametrs were at the lowest with 100% N through organic sources (FYM N_{50} +GL N_{50}) alone. Combinations of 50% N each through fertilizers and different organic sources (GL, PL, FYM and NC) recorded higher N uptake compared to the rest of the treatments,. Nitrogen supplied entirely through fertilizer registered the lowest soil fertility status. Maximum gross and net returns as well as high benefit cost ratio was obtained with 50 per cent substitution of inorganic nitrogen source with glyricidia leaf manure.

Keywords: Nitrogen, Organic and Inorganic sources, Rice.

Introduction

Rice is the staple food crop for about 40 per cent of the worlds population grown over an area of 43 million hectares with a production of 84.7 million tons (Siddiq, 2000). The productivity of rice in India, is 2.1 t ha^{-1} which is far below the other rice growing countries (South Korea 6.60 t ha^{-1}, Japan 6.43 t ha^{-1}). Among several factors responsible for low productivity, improper fertilizer management particularly nitrogen is one of the reasons. The nitrogen use efficiency in low land rice is extremely low, seldom reaches 40% (De Datta *et al.* 1968). Continuous use of chemical fertilizers without organic sources would lead gradual decline of organic matter content and native nitrogen status in the soil, which results in lower rice production. From the sustainability points of view, alternatives have to be found out the productive capacity of rice soils. In the face of continuing global energy crisis and progressively prohibitive cost of fertilizer nitrogen, there is a renewed interest towards sustainable low cost alternatives like organic manures. So there is a need to explore an alternative system nutrient supply. Among various organic manures Glyricidia leaf is considered as the promising renewable, nutrient rich source and can be served as a substitute to cut down the costs of fertilizers input. (Anil Kumar and Mathew , 1994). Hence, it is necessary to find out the extent and possibility of substituting fertilizer nitrogen with less costly and more effective sources for sustainability and yield stability.

Materials and Methods

An experiment was conducted during rabi season of 1999 at S.V. Agricultural College, Farm, Tirupati. The experimental soil is sandy loam in texture has pH 7.8, organic carbon 0.27% and the available N,P and K were 181,20 and 105 kg ha^{-1}. The experiment was laid out in randomized block design replicated thrice with ten treatments comprising of four organic sources (Farmyard manure (FYM), Poultry manure (PM), Neem cake (NC) and Glyricidia leaf manure (GL)) and an inorganic source urea (FN). All these sources were used in the combinations of 50 and 75 per cent of fertilizers N with 50 and 25 per cent each of organic sources (FYM, PM, NC and GL) to supply 100 per cent recommended N, along with 100%

Table 1. Plant height (cm), leaf area index (LAI), number of tillers m^{-2} and dry matter production (kg ha^{-1}) of rice as influenced by different combinations of organic and inorganic sources of nitrogen.

Treatment	Plant height (cm)	LAI	Number of tillers m^{-2}	Dry matter production t ha^{-1}
FN_{100}	91.9	4.23	648	12.5
FYM N_{50}+GL N_{50}	86.3	3.98	613	13.9
FN_{50} + $FYMN_{50}$	97.5	4.53	686	13.2
FN_{75} + $FYMN_{25}$	92.4	4.27	664	12.5
FN_{50} + PMN_{50}	97.9	4.56	691	13.3
FN_{75} + PMN_{25}	92.9	4.29	656	12.6
FN_{50} + NCN_{50}	97.0	4.51	682	13.2
FN_{75} + GLN_{25}	92.1	4.25	650	12.5
FN_{50} + GLN_{50}	97.8	4.59	697	13.3
FN_{75} + GLN_{25}	93.3	4.31	660	12.6
SEm+	0.94	0.053	5.7	0.18
CD (P=0.05)	2.9	0.16	17	0.54

Table 2. Yield attributes and yield of rice as influenced by different combinations of organic and inorganic sources of nitrogen.

Treatment	Number of panicles m^{-2}	Total grains $panicle^{-1}$	Filled grains $panicle^{-1}$	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	*Harvest index
FN_{100}	384	88	76	20.5	5470	6957	44.0
FYM N_{50}+GL N_{50}	363	81	73	20.0	4928	6405	43.4
FN_{50} + $FYMN_{50}$	404	93	83	21.2	5850	7296	44.5
FN_{75} + $FYMN_{25}$	386	88	77	20.6	5497	6968	44.1
FN_{50} + PMN_{50}	406	93	83	21.3	5875	7327	44.5
FN_{75} + PMN_{25}	388	89	77	20.7	5522	6994	44.1
FN_{50} + NCN_{50}	401	93	83	21.2	5824	7293	44.4
FN_{75} + GLN_{25}	384	88	76	20.5	5474	6962	44.0
FN_{50} + GLN_{50}	408	94	84	21.4	5916	7348	44.6
FN_{75} + GLN_{25}	390	89	78	20.8	5548	7004	44.2
SEm+	2.69	1	0.97	1.10	78.7	86.5	
CD (P=0.05)	8	3.2	2.9	0.3	234	257	

* Data were not analysed statistically

N through fertilizer (FN_{100}) and 100% N through organic source (FYM N_{50} + GL N_{50}). All organic manures were incorporated ten days before transplantation of rice. The recommended dose of fertilizers were 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare. Entire quantity of phosphorus and potassium was applied basally through single super phosphate and muriate of potash respectively, after duly considering the P_2O_5 and K_2O content of organic manures.

Nitrogen was applied through urea in three split doses of 50 per cent as basal, 25 per cent at active tillering stage and the remaining 25 per cent at panicle initiation stage as per the quantities prescribed for different treatments. Nitrogen content in different organic manures was taken into consideration to adjust the quantities of different organic sources (FYM, PM, NC, GL) to supply nitrogen on equal nutrient basis as with urea. The test variety of rice was NLR-33359. The data obtained on various growth and yield parameters were statistically analysed by following the "Analysis of variance" for randomized block design as suggested by Panse and Sukhatme (1985).

Results and Discussion

Effect of organic sources of nitrogen on growth

Conjunctive use of fertilizer N of different sources to supply equal quantity N and variable influence on growth parameters *viz.* plant height, leaf area, number of tillers and dry matter production of rice were significantly higher in treatment receiving 50% N through fertilizers and 50% through different organic sources (GL, PM, FYM and NC). Dry matter production is as a result of development of different organics (GL, PM, FYM and NC) was due to optimum use of inorganic and organic sources of N, which would have created favorable environment of N nutrition in the rhizosphere of low land rice. Fertilizer N would be available to the crop instantly and immediately after application, while organic N would be slowly mineralized. Thus, initial requirements of N would have met from the former sources and subsequent requirement of N from the latter source and thus providing N supply throughout the growing period. Such situation favours N uptake by rice at different growth stages. Timely availability of N under this situation (50% N through fertilizer and 50% N through different organics) would have facilitate better photosynthesis activity and promote the dry matter production.

Increased growth parameters of rice crop with conjunctive of fertilizer N and organic sources has been established by Reddy (1997), Rao (1998), Dubey and Verma (1999), and Selvam (2000). Reduced stature of growth parameters with 100% N supplied through fertilizer (FN_{100}) might be due to leaching loss of N as the soil is sandy clay loam in texture.

Effect of organic and inorganic sources of nitrogen on yield attributes and yield

The beneficial effect with combined supply of 50% N each through fertilizer and different organic sources (GL, PM, FYM and NC) on growth parameters was subsequently reflected in improving yield attributes such as number of panicles per m^{-2}, total number of grains per panicle, number of filled grains per panicle and grain weight (Table 2).

Increased availability of nitrogen with 50% N through fertilizer and 50% N through different organics would be coinciding with peak nitrogen demand of crop growth stages (seedling establishment, active tillering and panicle initiation), due to which would have might in transformation of tillers to production of productive panicles and inflated the stature of other yield attributed. Poor performance of 100% N supplied through organic sources (FYM N_{50} + GL N_{50}) alone is presumably due to slow mineralization of organic N and immobilization of soil available N, resulting in less supply of N at critical stages of crop growth leading to reduced yield attributes. The rate of mineralization of N from organic sources probably could not synchronize with N requirement of rice, which would have resulted in lower yield attributes. Present findings were in agreement were with results of Reddy (1996).

The highest grain yield (5916 kg ha^{-1}) was recorded with the combination of 50% N each though fertilizer and Glyricidia leaf manure (FN_{50} + GL N_{50}), which was however comparable with the combination of 50% N through fertilizer and 50% N through other organic sources (PM, FM, and NC) but were significantly superior to the rest of the treatments (Table 2). The average increase in grain yield with supply of 50% N each through fertilizer

Table 3. Nitrogen uptake and Economics of lowland rice as influenced by different combinations of organic and inorganic sources of nitrogen.

Treatment	Nitrogen uptake (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
FN_{100}	99	35752	24958	3.31
FYM N_{50}+GL N_{50}	96	32278	19883	2.60
FN_{50} + $FYMN_{50}$	100	38163	25780	3.08
FN_{75} + $FYMN_{25}$	100	35917	24238	3.09
FN_{50} + PMN_{50}	111	38326	27600	3.57
FN_{75} + PMN_{25}	101	36077	25328	3.35
FN_{50} + NCN_{50}	109	38009	21382	2.29
FN_{75} + GLN_{25}	100	35778	22067	2.61
FN_{50} + GLN_{50}	112	38579	27773	3.57
FN_{75} + GLN_{25}	102	36236	25436	3.35
SEm+	1.2	562.9	50.0	
CD (P=0.05)	3.5	1672	1485	

and different organics (GL, PM, GYM and NC) over 100% N through organic sources and 100% N through fertilizer (F N_{100}) was 16.0% and 6.8%, respectively. The conjunctive use of 75% N through fertilizer and 25% N through different organics (GL, PM, FYM and NC) resulted in 10.6% increase in grain yield over 100% N supplied through organic sources alone. The increased yield was due to cumulative effect of improvement in growth as well as yield attributes. Further, better performance of rice crop with 50% N each thorough fertilizer and different organics (GL, PM, FYM and NC) was also due to higher filled grains per panicle. Superior performance of rice with the integrated N supply as exhibited in the present study corroborates the findings of Roy *et al.* (1997), Arvind Kumar *et al.* (1998), Dubey and Verma (1999) and Selvam (2000).

The yield reduction (4928 kg $^{-1}$) in organic source (FYM N_{50} + GL N_{50}) might be due to toxicity of accumulation of toxic chemicals released during anaerobic decomposition. Through anaerobic decomposition of excessive organic matter, soil redox potential drops, harmful substance such as organic acids are formed ans cause root injury. These finding were in consonance with the results of Reddy (1996) and Dubey and Verma (1999).

Significantly the highest straw yield was obtained with the combination of 50% N each through fertilizer and Glyricidia leaf manure (F N_{50} + GL N_{50}), however it was comparable with other organic sources (PM, FYM and NC) in similar combination but were significantly superior to rest of treatments. This might be due to increased plant height, leaf area, tiller production and dry matter accumulation with those treatments. This is in confirmation with the findings of Bal *et al.* (1993), Dubey and Verma (1999) and Selvam (2000).

Effect o organic and inorganic sources of nitroger on Nitrogen uptake and economics

Nitrogen uptake was progressively increased upto maturity irrespective of the treatments The combinations of 50% N each through fertilizer and different organic sources (GL PM, FYM, and NC) recorded the highest N uptake compared to the rest of the treatments availability of nitrogen in the rhizosphere coupled with enhanced dry matter production. Increased

N uptake of crop with conjuctive of fertilizer N and Organic sources has been established (Roy *et al.* 1997).

Higher net returns of Rs. 27,773/- and benefit cost ratio of 3.57 were obtained with the treatment FN_{50} + GL N_{50}, Which was on par with FN_{50} + PM N_{50} combination, but were significantly superior to the rest of the treatments. Higher level of grain and straw yields associated with the above mentioned treatments has resulted in enhanced returns. Higher output was made possible with relativity cheaper sources of N (organic manures) with appropriate level of substitution (Table 3), which in turn has escalated the returns from rice production. Lower net returns and benefit cost ratio with FN_{50} +NC N_{50} and FN_{75} + NC N_{25} combinations were due to high cost of neem cake. The lowest net returns and benefit cost ratio with 100% N supplied through organic sources alone (FYM N_{50} + GL N_{50}) might be due to distinctly lesser grain and straw yields which inturn has reflected the returns from rice cultivation.

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