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RESEARCH PAPER

Grain yield and nutrient uptake of rice (*Oryza sativa* L.) under crop residue incorporation and different nitrogen management practices

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Abstract : Field experiments were conducted in the wetland farm of S.V. Agricultural College (Acharya N.G. Ranga Agricultural University), Andhra Pradesh for two consecutive years 2002 – 2003 and 2003 – 2004 and results revealed that by raising a reasonably short duration leguminous crop (either a pulse crop or vegetable crop depending up on the farming situation) preceding to rice and incorporation of the crop residues after picking the economic yield and supply of 100 per cent recommended dose of nitrogen through fertilizer to rice was found the best nitrogen management package for rice in terms of higher grain yield, nutrient uptake and economic returns. Incorporation of fieldbean crop residues (C_3) was found superior to any other crop residue incorporation with regard to dry matter production, yield and nutrient uptake. The highest gross returns and net returns as well as benefit-cost ratio recorded with the incorporation of crop residues of fieldbean (C_3). Supply of 100 per cent N through fertilizer to rice (N_2) was found to be superior to any other nitrogen management practices, with regard to dry matter production and yield.

Key Words : Rice, Crop residue incorporation, Different nitrogen management practices

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INTRODUCTION

Currently used management practices are over dependent on mineral fertilizers. They do not provide a good balance between soil nutrient supply and crop requirements there by deteriorating the sustainable soil fertility and health on long term basis. Instead of using recommended dose of nitrogen exclusively through fertilizer, a strategy of integrated use of recommended dose of nitrogen through fertilizer in combination with any organic manures, which is abundantly available locally should be tried to satisfy the nitrogen requirement of rice crop to produce higher yield, without impairing soil health.

The version of crop residue incorporation is beneficial depending upon the farming situation. Grain legumes, in contrast with green manures, provide grain to augment income and protein as well as reduce the use of mineral nitrogen in rice-based cropping systems. In areas, where clear cut fallow of a short duration is available preceding the transplanted low land rice crop, legumes like greengram, cluster bean, fieldbean and cowpea can be raised as preceding crops to rice. After the harvest of the saleable yield, the left over crop residues can be incorporated prior to transplanting of succeeding rice. The practice of crop residue incorporation after pod harvest is feasible and economical, where a period of 45 to 60 days is available before planting of rice and this can contribute about 50 to 60 kg N ha^{-1} to the succeeding rice crop (Meelu *et al.*, 1985 and Kulkarni and Pandey, 1988). Research efforts to maximize the productivity and economic returns of the rice by developing appropriate and viable nitrogen management practices, without any discount

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Table A : Quantity of crop residues and nutrient content (%) of crop residues and FYM, incorporated before planting of rice

Source	2002-03				2003-04			
	Crop residues incorporated* (kg ha^{-1})	N	P_2O_5	K_2O	Crop residues incorporated* (kg ha^{-1})	N	P_2O_5	K_2O
FYM	--	0.50	0.20	0.51	--	0.50	0.20	0.51
Greengram residue*	7230	0.81	0.20	0.62	6970	0.83	0.21	0.64
Clusterbean residue*	13820	0.52	0.12	0.49	13100	0.54	0.14	0.51
Fieldbean residue*	16900	0.66	0.15	0.45	17200	0.65	0.16	0.44
Cowpea residue*	15440	0.61	0.14	0.50	15200	0.60	0.15	0.49

*On fresh weight basis

of soil health are long due in the southern agro-climatic zone of Andhra Pradesh. Hence, the present study was conducted to assess the effectiveness of incorporation of crop residues, farm yard manure and fertilizer on grain yield and nutrient uptake of rice.

MATERIAL AND METHODS

Field investigations were conducted during 2002-03 and 2003-04 at wetland farm of S.V. Agricultural College, Tirupati. The soil was was sandy clay loam in texture, slightly alkaline in reaction (pH 7.6), low in organic carbon (0.27 %) and available nitrogen (160.8 kg N ha^{-1}), medium in available phosphorus (25.6 kg P_2O_5 ha^{-1}) and available potassium (175.4 kg K_2O ha^{-1}). The experiment was laid out in a randomized block design with five replications. There were four treatments comprising of preceding crops to rice raised during *Kharif* season *viz*., Greengram, Clusterbean, Fieldbean and Cowpea. After the last picking of the economic yield of respective crops at 75 DAS the plants were uprooted from and crop residues were recorded on fresh weight basis. The crop residues were chopped and incorporated in the respective plots. The N, P and K content of crop residues were analysed by standard procedures outlined by Jackson (1973). The varieties of greengram, clusterbean, fieldbean, cowpea were LGG-407, Pusa Navabahar, HA-3 and CO-4, respectively.

Rice crop was taken up in split plot design during *Rabi* season after the harvest of *Kharif* preceding crops to rice in the same undisturbed layout, by sub-dividing each of the *Kharif* treatments into four subplots and four nitrogen management practices *viz.*, no nitrogen, 100 per cent nitrogen through fertilizer, 50 per cent nitrogen each through fertilizer and FYM and 100 per cent nitrogen through FYM were assigned. Results of the trial were analyzed in a split plot design treating effects of incorporation of crop residues of four preceding crops to rice treatments as main plots and four nitrogen management practices imposed on *Rabi* rice as sub-plots. The recommended dose of nutrients was 120 kg N, 80 kg P_2O_5 and 40 kg K_2O ha^{-1}. The N content in FYM (Table A) was taken into consideration and the quantity of FYM required for N_3 and N_4 treatments was calculated and incorporated in to the plots 10 days before transplanting of rice. For the treatments N_2 and N_3, fertilizer nitrogen in the form of urea was applied in three split doses of 50 per cent as basal, 25 per cent at active tillering and 25 per cent at panicle initiation stages. A uniform dose of 80 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied basally to all the treatments except to N_1, in the form of single super phosphate and murate of potash, respectively, after duly taking into consideration of phosphorus and potassium content of FYM in the FYM involved treatments. Test variety of rice was NLR 33359. Plant samples collected for drymatter estimation at different growth stages of rice were oven dried, grounded into fine powder and used for nutrient analysis. N, P and K contents of plant samples were analysed by the standard procedure out lined by Jackson (1973). The uptake of N, P and K in Kg ha^{-1} at different stages of crop growth was calculated by multiplying the nutrient content with the respective drymatter weights.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Incorporation crop residues :

Incorporation of different crop residues had exerted variable influence on the dry matter production and yield of rice crop. Preceding crops to rice *viz.*, greengram, clusterbean, fieldbean and cowpea produced differential quantity of crop residues and added different quantities of nutrients. All the crops were terminated at 75 DAS (after taking economic yield) and by that time whatever quantity of crop residues accumulated were incorporated sufficiently in advance of planting rice, to ensure proper decomposition and supply of nutrients in to soil solution. Similar findings of varied quantities of crop residue production and nutrient addition up on incorporation to the succeeding crop, as noticed in the present study have been amply recorded earlier by John *et al.* (1989). The preceding crops to rice were not only a source of income but also enrich the exhausted soil by way nutrient enrichment, besides improving soil physical properties (Kalyan Singh *et al.*, 1989).

Incorporation of fieldbean crop residues (C_3) was found superior to any other crop residue incorporation with regard to dry matter production, grain yield (Table 1) and nutrient uptake (Table 2). The beneficial effect of incorporation of fieldbean crop residues after pod harvest might be due to higher quantity of nutrient addition and adequate decomposition of green parts of fieldbean, which might have enabled the rice plant to get almost an ensured and continuous nitrogen supply distributed over the entire period of crop growth. Crop residues undergo decomposition at a slower rate under submerged conditions, releasing ammonical nitrogen in reasonable quantities over a long period of time. Thus, the rhizo-ecosystem of low land gets enriched with less leechable form of available nitrogen. Superior performance of rice crop with incorporation of fieldbean (C_3) crop residues as observed in the present study corroborates the findings of John *et al.* (1992). The performance of rice crop was suboptimal with the incorporation of greengram (C_1) crop residues. This might be due to lesser quantity of readily available nitrogen in soil solution due to the lower quantity of residues incorporated. Increased uptake of N with the incorporation of fieldbean crop residues was the result of higher dry matter production

Table 1 : Dry matter production, grain yield and economics of rice as influenced by crop residue incorporation and nitrogen management practices

Treatments	DMP (kg ha^{-1}) AT	PI	F	H	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost ratio
Cropping system, 2002-2003									
Incorporation of crop residues									
C_1: incorporation of greengram crop residues	1879	4703	7736	9207	3936	5641	31783	16560	2.07
C_2: incorporation of clusterbean crop residues	2260	5160	8313	9897	4357	6342	35254	20030	2.31
C_3: incorporation of fieldbean crop residues	2997	6066	9481	11283	5342	7547	43054	27830	2.83
C_4: incorporation of cowpea crop residues	2629	5602	8901	10583	5020	6946	40348	27830	2.65
S.E. $\pm$	99	166	252	297	141	261	894	659	0.08
C.D. (P=0.05)	174	292	442	521	248	458	1564	1154	0.14
Nitrogen management practices									
N_1: No nitrogen	1901	3972	6986	8444	3400	5504	27927	15627	2.27
N_2:100% recommended nitrogen through fertilizer	2999	6312	9722	11546	5454	7649	43919	28434	2.84
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	2609	5857	9164	10839	5090	6977	40861	24763	2.54
N_4: 100% recommended nitrogen through farm yard manure	2257	5391	8559	10142	4710	6345	37732	20721	2.22
S.E. $\pm$	140	235	355	421	200	369	1264	933	0.11
C.D. (P=0.05)	208	348	527	624	296	546	1866	1378	0.17
Cropping system, 2003-2004									
Incorporation of crop residues									
C_1: incorporation of greengram crop residues	1758	4282	7832	9061	3574	5537	29170	13947	1.91
C_2: incorporation of clusterbean crop residues	2147	4706	8414	9757	4142	6242	33674	18450	2.21
C_3: incorporation of fieldbean crop residues	3106	5765	9577	11192	5326	7506	42911	27688	2.82
C_4: incorporation of cowpea crop residues	2625	5231	8995	10473	4698	6850	38022	22798	2.49
S.E. $\pm$	89	150	243	284	151	242	856	641	0.06
C.D. (P=0.05)	158	264	428	498	265	425	1498	1123	0.11
Nitrogen management practices									
N_1: No nitrogen	1763	3537	7078	8302	3184	5471	26391	14091	2.15
N_2:100% recommended nitrogen through fertilizer	3100	5989	9822	11421	5249	7499	42368	26883	2.74
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	2624	5496	9247	10725	4853	6875	39129	23032	2.43
N_4: 100% recommended nitrogen through farm yard manure	2148	4962	8672	10035	4453	6288	35889	18878	2.11
S.E. $\pm$	127	212	346	401	214	343	1211	908	0.08
C.D. (P=0.05)	186	315	510	594	316	507	1787	1340	0.13

AT: Active Tillering PI: Panicle Initiation F: Flowering H: Harvest

and enhanced absorption of N, while that of P and K might be due to better foraging of soil, due to vigorous root growth, thus accumulating more phosphorus and potassium in plant in addition to enhanced dry matter production. Favourable effect of crop residues incorporation and positive response of rice to incorporated crop residues as exhibited in the present study corroborates the findings of Buresh and De Datta (1991) and Singh *et al.* (1991). The highest gross returns and net returns as well as benefit-cost ratio recorded with the incorporation of crop residues of fieldbean (C_3) were due to higher grain and straw yield realized by this treatment than with any other crop residue incorporation.

Nitrogen management practices:

Different nitrogen management practices had exerted variable influence on drymatter production, yield (Table 1) and nutrient uptake (Table 2) of rice. Supply of 100 per cent N through fertilizer to rice (N_2) was found to be superior to any other nitrogen management practices, with regard to dry matter production and yield. This superiority with the supply of 100 per cent N through fertilizer, might be attributed to due to ready availability of comfortable level of instantly usable nitrogen by rice crop, which would have created favourable environment of nitrogen nutrition in the rhizo-ecosystem of low land rice. Fertilizer N was applied with 50 per cent as basal and the remaining 50 per cent in two equal splits at active tillering and panicle initiation stages of rice crop. Such situation of comfortable level of instantly usable nitrogen favours optimum nitrogen uptake by rice crop at different growth stages. Similar situation existed during the present study as reflected by dry matter production and grain yield. Comfortable level of plant nitrogen has manifested elevated level of growth and yield structure, resulting in superior performance of rice crop. Ready availability of nitrogen in soil solution may be delayed with higher proportion of organic sources due to the process of slow mineralization under anaerobic low land conditions.

Superior performance of rice crop with supply of 100 per cent nitrogen through fertilizer (N_2) compared to substitution of 50 and 100 per cent recommended dose of nitrogen through farm yard manure as exhibited in the present study corroborates the findings of Jana and Ghosh (1996). Poor effect of organic source at 100 per cent level could be due to addition of high amount of carbonaceous residues which might lead to spurt of biochemical activities in the flooded soil causing ephemeral toxicity (Yoshida, 1978). Organic manures under go decomposition at a slower rate under submerged conditions, releasing nitrogen in regulated quantities over a long period of time. But many a time, it may be insufficient to meet the nitrogen requirement of rice crop at appropriate time during crop growing period. The performance of rice crop was sub-optimal with the supply of 100 per cent nitrogen through FYM (N_4) and it was only superior to no N (N_1). This might be due to disproportionate availability nitrogen in soil solution due to the process of slow mineralization of farm yard manure under low and conditions. Increased uptake of N with the supply of 100 per cent N through fertilizer was the result of higher dry matter production and enhanced absorption of N, while that of P and K might be due to better foraging of soil, due to vigorous root growth, thus accumulating more P and K in plant in addition to enhanced dry matter production (Table 2). Favourable effects of N on rice and positive response to applied N has been undisputed and universally established by voluminous research, as was reviewed comprehensively by Mamaril *et al.* (1987).

The highest gross returns, net returns and benefit-cost ratio were recorded with application of 100 per cent nitrogen through fertilizer (N_2) followed by supply of 50 per cent nitrogen each through fertilizer and FYM ($N_{3)}$. Since the cost of nitrogen through fertilizer was relatively cheaper than organic source of nitrogen, the net returns and the benefit-cost ratio realized with supply of 100 per cent nitrogen through fertilizer (N_2) were higher than with other nitrogen management practices. Supply of 100 per cent nitrogen through fertilizer was more profitable than either application of organic manures alone or their combination with fertilizer to the rice crop.

Based on the out come of the investigation, it could be inferred that by raising a reasonably short duration leguminous crop (either a pulse crop or vegetable crop depending up on the farming situation) preceding to rice and incorporation of the crop residues after picking the economic yield and supply of 100 per cent recommended dose of nitrogen through fertilizer to rice was found the best nitrogen management package for rice in terms of higher productivity and economic returns.

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