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Effect of Crop Residue Incorporation and Nitrogen Management Practices on Growth and Yield of Rice (*Oryza sativa L.)*

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ABSTRACT

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

Key words : Crop Residue Incorporation, Nitrogen Management Practices, Rice

Currently used management practices which are over-dependent on mineral fertilizers do not provide a good balance between soil nutrient supply, crop requirements, deteriorating the sustainable soil fertility and health on long term basis. Organic manures, which can supply a portion of the P and K along with the secondary and micronutrients required by crops, can help to offset the negative nutrient balances and slow down nutrient depletion processes. Farmyard manure was considered as nutrient rich renewable source to substitute partially the fertilizer nitrogen. Instead of using higher than recommended dose of nitrogen exclusively through fertilizer, a strategy of integrated use of recommended dose of nitrogen through fertilizer in combination with any amount of cheaper organic source, which is abundantly available locally should be tried to satisfy the higher 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, crops like greengram, cluster bean, fieldbean and cowpea can be raised as preceding crops to rice and after the harvest of the saleable yield, the left over crop residues of these crops 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 (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 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 growth and yield of rice.

MATERIAL AND METHODS

Field investigations were conducted during 2002-03 and 2003-04 at wetland farm of S.V. Agricultural College, Tirupati, Andhra Pradesh. The experimental field was sandy clay loam in texture, slightly alkaline in reaction (P^H 7.6), low in organic carbon (0.27 %) and available nitrogen (160.8 kg ha^{-1}), medium in available phosphorus (25.6 kg ha^{-1}) and available potassium (175.4 kg ha^{-1}). The experiment was laid out in a randomized block design with five replications. There were four treatments comprising preceding crops to rice raised during kharif season *viz.,* C_1: Greengram C_2: Clusterbean C_3: Fieldbean C_4: Cowpea whose crop residues (after picking the economic yield up to a common period of time of 75 days) are to be incorporated prior to transplanting of succeeding rice crop. Immediately after the last picking of the economic yield of respective crops upto 75 DAS, plants were uprooted from the entire plot area and weights of the four crop residues were recorded on fresh weight basis. At the time of termination of crops, they were at different post- flowering stages, possessing immature pods, flowers and even flower buds. Since, the crop residues have to be incorporated at a common point of time, all of them were removed without waiting for their full maturity. The crop residues thus obtained were chopped and incorporated into their respective plots. Samples of all the crop residues were taken plot and replication-wise, to estimate the nutrient content (Table 1) before incorporation. N, P and K contents 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 raised during *rabi* season after harvest of preceding crops to rice (raised during *kharif*) in the same layout, by sub-dividing each of the *kharif* treatments into four sub-plots, to which four nitrogen management practices were assigned. Each plot of preceding crops (*kharif*) to rice, which was considered as main plot for rice (*rabi*) was puddled under water with power tiller after the crop residues of preceding crops were incorporated *in situ*, without disturbing the field layout. A calculated quantity of farm yard manure was incorporated as per the subplot treatments. Five days after the incorporation of FYM, the sub-plots were puddled finally with power tiller, without disturbing the lay out. Then the individual plots were microlevelled with spade. Adequate care was taken to avoid difference of water levels in the individual sub plots, to maintain uniformity for the decomposition of added crop residues and FYM. Rice crop was taken up in a split plot design with incorporation of crop residues of four preceding crops to rice as main plot treatments *viz.,* C_1: incorporation of greengram crop residues C_2: incorporation of clusterbean crop residues C_3: incorporation of fieldbean crop residues and C_4: incorporation of cowpea crop residues and four nitrogen management practices imposed on *rabi* rice as sub-plot treatments *viz.,* N_1: No nitrogen N_2:100% recommended nitrogen through fertilizer, N_3: 50% recommended nitrogen through fertilizer + 50% recommended nitrogen through farm yard manure N_4: 100% recommended nitrogen through farm yard manure. 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 1) was taken into consideration and the quantity of FYM required for N_3 and N_4 treatments was calculated and incorporated into 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

Table 1. Quantity of crop residues and nutrient content (%) of crop residues and FYM, incorporated before plantingof 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

Table 2. Biomass, crop residues, greengram seed equivalent yield and economics of preceding crop to rice (mean of 2 years data)

Preceding crops to rice	Total biomass production* (kg ha^{-1})	Crop residues** (on fresh weight basis) (kg ha^{-1})	Absolute economic yield*** (kg ha^{-1})	Greengram seed equivalent yield (kg ha^{-1})	Gross returns* *** (Rs ha^{-1})	Net returns**** (Rs ha^{-1})
C_1 – Greengram@	2528	7100	1031	1031	16496	12292
C_2 – Clusterbean#	4406	13460	13687	3169	34217	27128
C_3 – Field bean#	6461	17050	862	1354	5172	2008
C_4 – Cowpea#	5392	15320	1388	1551	8328	5039
S.Em ±	225.7	486.5	—	58.6	494.2	394.1
CD (P=0.05)	720	1552	—	187.0	1576	1257

* On dry weight basis ** Incorporated in to the field immediately after picking the economic yield.
#Green pods for vegeta *** Data were not statistically analysed due to difference in nature of economic yield
@Seed **** Based on the monetary value of only economic yield of crops.

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 used was NLR 33359. Twenty four days old seedlings were transplanted with a inter- and intra-row spacing of 15 x 10 cm @ two seedlings hill^{-1}. A thin film of 2-3 cm water was maintained at the time of planting and there after water level of 5 ± 2 cm was maintained during the entire crop growing period up to completion of grain filling stage, except at the time of top dressing. The water from the field was withdrawn one week before harvesting. Hand weeding was done twice at 25 and 40 days after transplanting to keep the weeds under check. No plant protection measures were taken, since there was no pest or disease incidence during crop growth period.

RESULTS AND DISCUSSION

Performance of preceding crops to rice

Among the four short duration leguminous crops tried preceding to rice, fieldbean produced the highest the quantity of biomass and crop residues, while greengram produced the lowest quantity of biomass and crop residues (Table 2). The highest economic yield (in terms of greengram equivalent yield) was produced by clusterbean and it was the lowest with greengram. Gross and net returns were the highest with clusterbean and the lowest with greengram. Different crops performed differently, with respect to different aspects, with significant disparity between any two of the four crops. The crop produced the highest quantity of crop residues could not give the highest saleable yield and monetary returns and vice versa. In the present case, clusterbean produced the highest quantity of economic yield and net returns, while fieldbean produced the highest quantity of crop residues and consequently larger quantity of nutrients supplied to succeeding rice crop. Therefore, the choice of crop for the purpose of crop residues should be of short duration in nature, with capability to produce as large quantity of crop residues as possible along with the production of sizeable economic yield, to ensure reasonable monetary returns. However, clusterbean, though appear more remunerative, should not be recommended for larger areas, since the cost and marketing of green pods for vegetable purpose is a possible constraint, besides huge labour cost involved for multiple picking of pods.

Incorporation crop residues

Incorporation of different crop residues have exerted variable influence on the growth parameters 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. Similar findings of varied quantities of crop residue production and nutrient addition upon incorporation to the succeeding crop, were also recorded by John *et al.* (1989). The preceding crops to rice were not only a source of income but also enrich the

Table 3. Growth of rice as influenced by crop residue incorporation and nitrogen management practices

Treatments	Plant height (cm)			LAI			Number of tillers m^{-2}				DMP (kg/ha)			
	AT	PI	F	AT	PI	F	AT	PI	F	H	AT	PI	F	H
Cropiping system, 2002-2003														
Incorporation of crop residues														
C_1: incorporation of greengram crop residues	41.3	60.5	70.8	1.53	2.98	4.48	459	495	431	340	1879	4703	7736	9207
C_2: incorporation of clusterbean crop residues	45.4	67.6	77.9	1.89	3.32	4.87	497	541	475	383	2260	5160	8313	9897
C_3: incorporation of fieldbean crop residues	53.6	84.6	100.5	2.63	4.12	5.66	578	619	554	464	2997	6066	9481	11283
C_4: incorporation of cowpea crop residues	50.0	76.1	89.1	2.24	3.74	5.27	538	576	510	420	2629	5602	8901	10583
S.Em	0.86	1.72	1.96	0.04	0.09	0.13	7.36	12.2	10.6	10.2	71	119	180	212
CD(0.05)	2.1	4.2	4.8	0.11	0.23	0.32	18	30	26	25	174	292	442	521
Nitrogen management practices														
N_1: No nitrogen	38.9	61.0	70.6	1.53	2.99	4.43	456	496	427	335	1901	3972	6986	8444
N_2:100% recommended nitrogen through fertilizer	54.4	84.1	97.8	2.64	4.14	5.72	577	623	557	466	2999	6312	9722	11546
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	50.3	75.9	89.8	2.24	3.74	5.31	541	581	517	427	2609	5857	9164	10839
N_4: 100% recommended nitrogen through farm yard manure	46.0	67.8	79.5	1.87	3.32	4.82	497	533	469	378	2257	5391	8559	10142
S.Em	1.21	2.43	2.78	0.06	0.13	0.18	10.4	17.3	15.0	14.4	100	168	254	301
CD(0.05)	2.5	5.0	5.7	0.13	0.27	0.38	21	36	31	31	208	348	527	624
Cropiping system, 2003-2004														
Incorporation of crop residues														
C_1: incorporation of greengram crop residues	41.9	64.1	76.3	1.52	2.74	4.30	438	480	424	336	1758	4282	7832	9061
C_2: incorporation of clusterbean crop residues	46.1	71.7	85.2	1.96	3.11	4.71	476	605	468	379	2147	4706	8414	9757
C_3: incorporation of fieldbean crop residues	51.7	83.4	100.4	2.80	3.90	5.53	559	605	548	458	3106	5765	9577	11192
C_4: incorporation of cowpea crop residues	48.8	78.6	93.3	2.35	3.51	5.12	513	564	508	421	2625	5231	8995	10473
S.Em	0.90	1.84	2.08	0.05	0.08	0.13	6.54	11.4	8.9	8.2	64	107	174	203
CD(0.05)	2.2	4.5	5.1	0.13	0.21	0.31	16	28	22	20	158	264	428	498
Nitrogen management practices														
N_1: No nitrogen	37.0	63.2	74.8	1.48	2.65	4.29	441	484	419	333	1763	3537	7078	8302
N_2:100% recommended nitrogen through fertilizer	54.8	85.9	100.9	2.82	3.96	5.54	556	601	562	460	3100	5989	9822	11421
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	50.7	78.3	92.9	2.40	3.54	5.12	512	565	504	420	2624	5496	9247	10725
N_4:100% recommended nitrogen through farm yard manure	46.0	70.6	86.7	1.93	3.12	4.70	476	522	462	381	2148	4962	8672	10035
S.Em	1.27	2.61	2.95	0.07	0.12	0.18	9.25	16.1	12.7	11.6	91	152	247	287
CD(0.05)	2.6	5.4	6.1	0.15	0.25	0.37	19	33	26	24	186	315	510	594

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

Table 4. Grain yield and economics of rice as influenced by crop residue incorporation and nitrogen management practices

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross yield (kg ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost
Cropiping system, 2002-2003					
Incorporation of crop residues					
C_1: incorporation of greengram crop residues	3936	5641	31783	16560	2.07
C_2: incorporation of clusterbean crop residues	4357	6342	35254	20030	2.31
C_3: incorporation of fieldbean crop residues	5342	7547	43054	27830	2.83
C_4: incorporation of cowpea crop residues	5020	6946	40348	27830	2.65
S.Em	101	187	639	471	0.06
CD(0.05)	248	458	1564	1154	0.14
Nitrogen management practices					
	3400	5504	27927	15627	2.27
N_2:100% recommended nitrogen through fertilizer	5454	7649	43919	28434	2.84
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	5090	6977	40861	24763	2.54
N_4: 100% recommended nitrogen through farm yard manure	4710	6345	37732	20721	2.22
N_1: No nitrogen	143	264	903	667	0.08
CD(0.05)	296	546	1866	1378	0.17
Cropiping system, 2003-2004					
Incorporation of crop residues					
C_1: incorporation of greengram crop residues	3574	5537	29170	13947	1.91
C_2: incorporation of clusterbean crop residues	4142	6242	33674	18450	2.21
C_3: incorporation of fieldbean crop residues	5326	7506	42911	27688	2.82
C_4: incorporation of cowpea crop residues	4698	6850	38022	22798	2.49
S.Em	108	173	612	458	0.04
CD(0.05)	265	425	1498	1123	0.11
Nitrogen management practices					
N_2:100% recommended nitrogen through fertilizer	3184	5471	26391	14091	2.15
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	5249	7499	42368	26883	2.74
N_4: 100% recommended nitrogen through farm yard manure	4853	6875	39129	23032	2.43
N_1: No nitrogen	4453	6288	35889	18878	2.11
S.Em	153	245	865	649	0.06
CD(0.05)	316	507	1787	1340	0.13

exhausted soil by way nutrient enrichment, besides improving soil physical properties (Kalyan Singh *et al.*, 1989).

Incorporation of fieldbean crop residue (C_3) was found to be superior to any other crop residue incorporation with regard to growth (Table 3) and yield (Table 4). This beneficial effect of incorporation of fieldbean crop residues in rice may be ascribed to higher quantity of nutrient addition. Availability of adequate quantity of nutrients in the soil, obviously promotes the performance of rice crop. Similar situation existed during the present study as reflected by taller plants, higher leaf area index, higher dry matter production and grain yield. Comfortable level of absorbed and assimilated nitrogen in the plants has manifested elevated level of growth and yield structure, resulting in superior performance of rice crop. The beneficial effect of incorporation of fieldbean crop residues after pod harvest might be due to 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 leachable form of available nitrogen. Superior performance of rice crop with incorporation of fieldbean (C_3) crop residues, 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. The highest gross returns and net returns as well as benefit-cost ratio recorded with the incorporation of crop residue 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 have exerted variable influence on the growth parameters and yield. 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 growth(Table 3) and yield (Table 4).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. Since N was applied in splits there was a situation of comfortable level of instantly usable nitrogen might have favoured optimum nitrogen uptake by rice crop at different growth stages as reflected by taller plants, higher leaf area index, higher 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, 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 , 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.

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.

It could be inferred that by raising a reasonably short duration leguminous crop (either a pulse crop or vegetable crop depending upon 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 growth, higher productivity and economic returns.

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