ADVNACE RESEARCH JOURNAL OF CROP IMPROVEMENT
Volume 1 Issue 2 (December, 2010) Page : 51-61

***Received :** May, 2010; **Accepted :** July, 2010*

Research Paper

Adding nitrogen through crop residues, organics and inorganics in rice based cropping system

C. RADHA KUMARI AND D. SRINIVASULU REDDY

See end of the article for authors' affiliations

Correspondence to :
C. RADHA KUMARI,
Department of Agronomy,
S.V. Agricultural College,
TIRUPATI (A.P.) INDIA

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 to investigate the performance of greengram, clusterbean, fieldbean and cowpea as preceding crops to rice and effectiveness of their crop residues incorporation, farm yard manure and fertilizer on performance of rice and on succeeding groundnut crop. Among the four short duration leguminous crops tried preceding to rice, fieldbean produced the highest the quantity of biomass and crop residues. Incorporation of fieldbean crop residues was found to be superior to any other crop residue incorporation with regard to growth and yield as well as nutrient uptake of rice. Dynamics of soil fertility status with regard to organic carbon, available nitrogen and potassium was superior with incorporation of fieldbean crop residues. Supply of 100 per cent N through fertilizer to rice was found to be superior with regard to growth and yield as well as nitrogen uptake of rice. Incorporation of fieldbean crop residues to preceding rice has recorded the highest yield attributes and pod yield of groundnut. Growth, yield attributes and pod yield of groundnut were the highest with the supply of 100 per cent of nitrogen thorough FYM to preceding rice.

Radha Kumari, C. and Srinivasulu Reddy, D. (2010). Adding nitrogen through crop residues, organics and inorganics in rice based cropping system, *Adv. Res. J. Crop Improv.,* **1** (2) : 51-61.

Key words : Rice, Groundnut, Crop residue incorporation, Nitrogen management practices

INTRODUCTION

Rice –groundnut is one of the important cropping system in the southern agroclimatic region and maintenance of optimum soil fertility is an important consideration for obtaining higher and sustainable yield due to large turn over of nutrients in soil plant system. In recent years the emphasis has been shifted from individual crop to cropping sysetm as a whole since the response in component crop of the cropping system are influenced by the preceding crops and the inputs applied to them. Legume crop residues incorporated into the field after harvesting seed can contribute considerable quantity of nitrogen to succeeding crops (Rekhi and Meelu, 1983). Conjuctive use of nutrients partly through organics and inorganics to preceding rice exhibited significant residual effect on succeeding groundnut (Thimmegowda and Devakumar, 1994). 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). Organic manures and crop residues have been proved to be viable components of nitrogen management, which can supplement and successfully replace costly fertilizer nitrogen. Research efforts to maximize the productivity and economic returns of the rice-groundnut cropping system, 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 performance of greengram, clusterbean, fieldbean and cowpea as preceding crops to rice and effectiveness of their crop residues incorporation, farm yard manure and fertilizer on performance of rice, groundnut succeeded to rice and dynamics of soil fertility.

MATERIALS AND METHODS

Field investigations were conducted during 2002-03 and 2003-04 at wetland farm of S.V. Agricultural College, Tirupati (Andhra Pradesh). Soil analysis for physico-chemical properties was carried out initially, prior to the start of the experiment and results of physico-chemical analysis revealed that experimental field was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon 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 of 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 up to 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 in to 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 incorporation of preceding crop residues 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. Then each of the main plots was subdivided into four sub plots of equal size and 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 in them 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 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 in to the plots 10 days before transplanting

Table 1 : 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 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 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.

Groundnut crop was raised during summer season after the harvest of *Rabi* rice in the same undisturbed layout of split plot design, to study the cumulative residual effect of incorporation of crop residues of preceding crops to rice and N management practices imposed on *Rabi* rice crop on the performance of succeeding groundnut.. Each plot of *Rabi* rice was ploughed using power tiller without disturbing the layout and plots were levelled individually using spades. No treatments were imposed to groundnut crop and the treatments consisted of the same those of *Rabi* rice. Treatments consisted of cumulative residual effect of incorporation of crop residues of four preceding crops to rice as main plot treatments and residual effect of four nitrogen management practices imposed on *Rabi* rice as sub-plot treatments . Incorporation. Test variety of groundnut was K-134 a spanish bunch type with a duration of 100-110 days, suitable for cultivation in summer season. Plant samples collected for drymatter estimation at different growth stages of groundnut were oven dried, ground 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. Soil samples were collected from the individual plots of the treatments immediately after harvesting of preceding crops to rice, rice and groundnut. The soil samples were analysed for organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al.,* 1954) and available potassium (Jackson, 1973).

RESULTS AND DISCUSSION

The results obtained from the present investigation have been discussed in the following sub heads :

Performance of preceding leguminous crops:

Among the four short duration leguminous crops incorporated preceding to rice, fieldbean produced the highest 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. 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 higher economic yield and net returns, while fieldbean produced higher 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, one should keep in mind that crops like clusterbean, though appear more remunerative, should not be recommended for larger areas, since the cost and marketing of green pods for vegetable purpose

Table 2 : Biomass, crop residues, greengram seed equivalent yield and economics of preceding crops 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.E. ±	225.7	486.5	---	58.6	494.2	394.1
C.D. (P=0.05)	720	1552	---	187	1576	1257

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

is a possible constraint, besides huge labour cost involved for multiple picking of pods.

Effect of incorporation of crop residues on rice:

Incorporation of different crop residues have exerted variable influence on the growth parameters, yield attributes and yield as well as nutrient uptake of rice. 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 picking all the matured greengram pods) 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 into soil solution. Similar findings of varied quantities of crop residues 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 (Singh *et al.*, 1989)

Incorporation of fieldbean crop residues was found to be superior to other crop residue incorporation with regard to taller plants, higher leaf area index, higher dry matter production, higher number of total and productive tillers per unit area, higher number of total and filled grains per panicle, grain yield and N, P and K uptake (Table 3). This beneficial effect of incorporation of fieldbean crop residues in rice may be ascribed to higher quantity of nutrient addition (111.6 kg ha^{-1}). Availability of adequate quantity of nutrients in the soil, obviously promotes the performance of rice crop. 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. Incorporation of fieldbean crop residues after the pod harvest increased panicles m^{-2} and filled grain $panicle^{-1}$ over the other treatments might be due to enhanced absorption of higher quantity of N by rice from panicle initiation to flowering, which can increase number of filled grains $panicle^{-1}$.

Increased uptake of N with the incorporation of fieldbean crop residues 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 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 has been reported by John *et al.* (1989) and Singh *et al.* (1989). The beneficial effect of incorporation

Table 3 : Growth, yield attributes, yield, nutrient uptake and economics of rice as influenced by crop residue incorporation and nitrogen management practices(mean of years data)

Treatments	LAI	No. of tillers m^{-2}	DMP (kg ha^{-1})	No. of panicles m^{-2}	Total no. of grains $panicle^{-1}$	No. of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	Nutrient uptake(kg ha^{-1})			Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
											N	P	K			
Incorporation of crop residues																
C_1	4.78	340	9207	291	67.7	57.7	22.4	3936	5641	40.7	71.9	28.3	168.3	31783	16560	2.07
C_2	4.87	383	9897	330	78.6	68.7	22.8	4357	6342	41.1	86.3	32.8	194.1	35254	20030	2.31
C_3	5.66	464	11283	417	100.8	91.9	23.5	5342	7547	41.9	118.0	41.8	238.0	43054	27830	2.83
C_4	5.27	420	10583	375	89.2	80.4	23.2	5020	6946	41.4	102.0	37.3	217.4	40348	27830	2.65
S.E.	0.13	10.2	212	10.6	2.3	1.9	0.08	101	187		1.6	1.31	5.4	639	471	0.06
C.D.(P=0.05)	0.32	25	521	26	5.6	4.8	0.2	248	458		3.9	3.2	13.2	1564	1154	0.14
Nitrogen management practices																
N_1	4.43	335	8444	282	68.4	57.8	22.1	3400	5504	38.2	69.3	25.2	149.7	27927	15627	2.27
N_2	5.72	466	11546	420	100.2	92.2	23.6	5454	7649	42.6	119.0	43.0	245.8	43919	28434	2.84
N_3	5.31	427	10839	378	89.9	80.3	23.3	5090	6977	42.2	102.3	38.5	223.2	40861	24763	2.54
N_4	4.82	378	10142	333	77.9	68.4	22.9	4710	6345	41.6	87.2	33.5	199.1	37732	20721	2.22
S.E.	0.18	14.4	301	15.0	3.2	2.8	0.11	143	264		2.2	1.84	7.6	903	667	0.08
C.D.(P=0.05)	0.38	31	624	31	6.7	5.7	0.3	296	546		4.6	3.8	15.7	1866	1378	0.17

of fieldbean crop residues after pod harvest might be due to adequatee 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 crop residues as observed in the present study corroborates the findings of John *et al.* (1989). The performance of rice crop was suboptimal with the incorporation of greengram 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 residues of fieldbean were due to higher grain and straw yield realized by this treatment than other crop residue incorporation.

Effect of nitrogen management practices on rice:

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 as well as nitrogen uptake (Table 3). 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 taller plants, higher leaf area index, higher dry matter production, higher number of total and productive tillers per unit area, higher number of total and filled grains per panicle, grain yield and nutrient uptake.

Superior performance of rice crop with supply of 100 per cent nitrogen through fertilizer 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 and it was only superior to no N. This might be due to disproportionate availability of nitrogen in soil solution due to the process of slow mineralization of farm yard manure under low and conditions. The highest gross returns, net returns and benefit-cost ratio were recorded with application of 100 per cent nitrogen through fertilizer followed by supply of 50 per cent nitrogen each through fertilizer and FYM. 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 were higher than with other nitrogen management practices.

Residual and cumulative effect of crop residue incorporation and nitrogen management practices to rice on succeeding groundnut:

Incorporation of fieldbean crop residues to preceding rice has recorded the highest plant height, LAI and dry matter production of groundnut, which were significantly superior to other crop residues incorporation. Plant height, leaf area index and dry matter production were the highest with the supply of 100 per cent of nitrogen thorough FYM to preceding rice, which was however, comparable with supply of 50 per cent nitrogen each through fertilizer and FYM but significantly superior to supply of 100 per cent nitrogen through fertilizer and non-supply of nitrogen, which were comparable with each other (Table 4). This might be due to substantial amount of residual nutrients left by fieldbean crop residues to extend the favourable carry over effect on succeeding groundnut crop.

Incorporation of fieldbean crop residues to preceding rice has recorded significantly higher yield attributes of groundnut *viz.,* number of pods plant^{-1} and hundred-kernel weight as well as pod yield and haulm yield other crop residues incorporation. This might be due to residual and cumulative effect with the incorporation of fieldbean crop residues, which was comparatively higher than that of the other crop residue incorporation.

The yield attributes of groundnut *viz.,* number of pods plant^{-1}, hundred-pod weight and hundred-kernel weight as well as pod and haulm yield and nutrient uptake were the highest with application of 100 per cent nitrogen through FYM to preceding rice, which was however, comparable with supply of 50 per cent nitrogen each through FYM and fertilizer, but significantly superior to supply of 100 per cent nitrogen through fertilizer and non-supply of

Table 4 : Growth, yield attributes, pod yield, nutrient uptake and economics of groundnut as influenced by cumulative residual effect of crop residue incorporation and nitrogen management practices to preceding rice (mean of 2 years data)

Treatments	LAI	DMP (kg/ha)	No. of pods plant	100 kernel weight (g)	Pod yield (kg ha⁻¹)	Haulm yield (kg ha⁻¹)	Shelling (%)	Harvest index* (%)	Nutrient uptake (kg ha⁻¹) N	P	K	Gross returns (Rs ha⁻¹)	Net returns (Rs ha⁻¹)	Benefit cost ratio
Incorporation of crop residues														
C_1	2.72	5195	10.0	30.0	1898	3604	72.8	34.23	77.0	10.5	69.8	25034	14384	2.35
C_2	2.96	5608	10.7	31.8	2063	3956	72.9	34.08	84.0	10.9	73.7	27215	16565	2.56
C_3	3.43	6517	12.2	35.5	2393	4737	73.5	33.39	96.8	11.8	81.3	31583	20933	2.97
C_4	3.20	6067	11.5	33.7	2228	4388	73.2	33.47	90.1	11.3	77.6	29403	18753	2.76
S.E.	0.06	123.4	0.24	75.6	75.6	97.2	0.94		1.18	0.09	1.47	887	0842	0.08
C.D.(P=0.05)	0.14	302	0.6	185	185	238	NS		2.9	0.2	3.6	2172	1864	0.19
Nitrogen management practices														
N_1	2.74	5200	9.7	29.5	1696	3745	72.2	31.19	79.3	10.7	67.4	22429	11779	2.11
N_2	2.87	5582	10.1	30.8	1911	3920	72.6	32.84	82.4	10.9	71.6	25242	14592	2.37
N_3	3.29	6119	12.0	34.7	2379	4384	73.4	35.23	91.5	11.3	80.1	31372	20722	2.95
N_4	3.42	6488	12.6	35.9	2594	4634	74.3	35.92	94.6	11.6	83.3	34192	23542	3.21
S.E.	0.08	174.5	0.35	106.9	106.9	137.5	1.17		1.67	0.24	2.08	1688	1642	0.15
C.D.(P=0.05)	0.17	360	0.7	220	220	284	NS		3.5	0.4	4.3	2854	2672	0.27

NS=Non significant

nitrogen to preceding rice, which were comparable with each other. This might be due to the residual effect of FYM either alone or in combination with fertilizer nitrogen, which was comparatively higher than that of the exclusive inorganic source of nitrogen applied to preceding rice crop. Significant carry over effect due to substitution of nitrogen with higher proportions of organic sources to rice crop on the succeeding crops was also reported by Thimmegowda and Devakumar (1994). Residual effect of fertilizer nitrogen applied to rice was not traceable on the succeeding groundnut crop (Ramaseshaiah *et al.,* 1985). Higher uptake of nitrogen, phosphorus and potassium by groundnut crop with the incorporation of fieldbean crop residues and with application of 100 per cent nitrogen through FYM (N_4) to preceding rice crop might be due to higher availability of nitrogen in the soil and enhanced dry matter production. The highest gross returns and net returns as well as benefit-cost ratio recorded with the incorporation of crop residues of fieldbean to preceding to rice and supply 100 per cent nitrogen through FYM were due to higher pod and haulm yield realized by this treatment than other crop residues incorporation and nitrogen management practices.

Total biomass production of the rice -groundnut cropping system:

Biological productivity of the cropping system expressed in terms of total biomass production was highest with the incorporation of fieldbean crop residues and application of 100 per cent nitrogen through fertilizer (N_2) to rice. (Table 5). The superiority with these treatments can be attributed to sum total of the treatmental effect of respective crops in the cropping system The deflated performance of rice crop with application of nitrogen through exclusive organic source has been compensated with superior performance of succeeding groundnut resulted from higher residual effect of the above treatments.

Rice grain equivalent yield of the rice -groundnut cropping system:

Economic yield of the cropping system was altered to a noticeable extent by incorporation of crop residues and nitrogen management practices imposed to rice. Economic yield of the cropping system was expressed in terms of rice grain equivalent yield (Table 5).The highest economic yield of the cropping system was recorded with the incorporation of fieldbean crop residues and supply of 100 per cent nitrogen through FYM. This indicates that for the entire cropping system the economic yield realized with recommended nitrogen application through any source

Table 5 : Total biomass production, rice grain equivalent yield and economics of rice-groundnut cropping system as influenced by residual effect of crop residue incorporation and nitrogen management practices (mean of 2 years data)

Treatments	Total biomass production (kg ha^{-1})	Rice grain equivalent yield (kg ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost ratio
Incorporation of crop residues					
C_1: incorporation of greengram crop residues	14268	7135	54497	28623	2.09
C_2: incorporation of clusterbean crop residues	15381	7965	60860	34986	2.34
C_3: incorporation of fieldbean crop residues	17608	9718	74136	48262	2.86
C_4: incorporation of cowpea crop residues	16527	8909	67963	42089	2.61
S.E.±	319	148	688	515	0.06
C.D. (P=0.05)	782	364	1685	1262	0.14
Nitrogen management practices					
N_1: No nitrogen	13483	6383	49168	26219	2.14
N_2:100% recommended nitrogen through fertilizer	16947	8796	67641	41505	2.59
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	16851	9232	70473	43725	2.64
N_4: 100% recommended nitrogen through farm yard manure	16503	9232	70173	42512	2.53
S.E.±	452	210	973	729	0.08
C.D. (P=0.05)	934	434	2010	1508	0.17

could meet the nutritional demand of the entire system equally. The lower yields of rice with treatments of higher proportion of organic nitrogen has been compensated with higher yields of the succeeding groundnut by enhanced residual N by these treatments and vice versa, thus resulting in comparable realization of economic yield of the cropping system with different nitrogen management practices to rice.

Economics of the rice -groundnut cropping system:

The economics of the production practices play pivotal role in making recommendations for adoption of given technology on the farms. In the present investigation, the highest gross returns were recorded with the incorporation of fieldbean crop residues whereas, with regard to nitrogen management practices, supply of 50 per cent nitrogen each through fertilizer and FYM resulted in highest gross returns (Table 5). This was similar to the trend of economic yield of the individual crops of the cropping system.

The highest net returns of the cropping system were recorded with incorporation of fieldbean crop residues whereas, among nitrogen management practices, supply of 50 per cent nitrogen each through fertilizer and FYM recorded highest net returns. This was similar to the trend of economic yield of the individual crops of the cropping system. Incorporation of fieldbean crop to preceding rice has recorded highest benefit-cost ratio followed by incorporation of cowpea crop residues. Application of 50 per cent nitrogen each through fertilizer and FYM to preceding rice has recorded the highest benefit-cost ratio. Higher economic yield of the cropping system with reasonable cost of the said nitrogen management practices resulted in increased returns per each rupee invested.

Economics of the cropping system as a whole (Including preceding crops to rice):

The highest gross and net returns as well as benefit-cost ratio from the cropping system as a whole (preceding crops to rice-rice-groundnut) were realized with incorporation of clusterbean crop residues followed by incorporation of field bean crop residues. Whereas, among nitrogen management practices, supply of 50 per cent nitrogen each through fertilizer and FYM recorded highest gross and net returns followed by supply of 100 per cent nitrogen through FYM. The highest benefit-cost ratio was realized with supply of 50 per cent nitrogen each through fertilizer and FYM, followed by supply of 100 per cent nitrogen through fertilizer and 100 per cent nitrogen through FYM (Table 6).

Dynamics of Soil Fertility in rice-groundnut cropping system:

The pre-experimental and post harvest soil fertility status of the soil (organic carbon, available nitrogen, available phosphorus and available potassium) after preceding crops to rice, rice and groundnut was estimated

Table 6 : Economics (Rs ha^{-1}) from the cropping system of preceding crops to rice– rice - groundnut as a whole (mean of 2 years data)

Treatments	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost ratio
Incorporation of crop residues			
C_1: incorporation of greengram crop residues	70585	40507	2.34
C_2: incorporation of clusterbean crop residues	96643	63680	2.93
C_3: incorporation of fieldbean crop residues	79635	50597	2.73
C_4: incorporation of cowpea crop residues	76264	47101	2.60
S.E.±	688	674	0.0024
C.D. (P=0.05)	1685	1568	0.06
Nitrogen management practices			
N_1: No nitrogen	65586	38200	2.39
N_2:100% recommended nitrogen through fertilizer	84058	53486	2.74
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	86891	55707	2.78
N_4: 100% recommended nitrogen through farm yard manure	86591	54493	2.69
S.E.±	973	906	0.034
C.D. (P=0.05)	2012	1870	0.07

during both years of study to assess the dynamics of the soil fertility status in the cropping system as influenced by different treatments imposed on rice. The trend of treatmental influence on the four soil fertility status parameters mentioned above on the cropping system was similar during both the years of study, differing only in the magnitude.

Soil Organic Carbon:

Post harvest soil organic carbon status of the cropping system (preceding crops to rice, rice and groundnut) with incorporation of different crop residues and varied nitrogen management practices to rice and raising residual crop of groundnut without imposing any treatments was found improved over the pre-experimental status (Table 7). Irrespective of the treatments, soil organic

Table 7 : Dynamics of soil organic carbon and available nitrogen in rice – groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to preceding rice (mean of 2 years data)

Treatments	Dynamics of soil organic carbon (%)				Dynamics of soil available nitrogen (kg ha^{-1})			
	Initial	Post harvest of preceding crops to rice	Post harvest of rice	Post harvest of groundnut	Initial	Post harvest of preceding crops to rice	Post harvest of rice	Post harvest of groundnut
$C_1 N_1$	0.24	0.27	0.26	0.27	160.8	171.9	142.7	153.3
$C_1 N_2$	0.24	0.27	0.26	0.29	160.8	171.9	169.0	178.2
$C_1 N_3$	0.24	0.27	0.35	0.37	160.8	171.9	187.1	195.32
$C_1 N_4$	0.24	0.27	0.37	0.38	160.8	171.9	196.9	206.6
$C_2 N_1$	0.24	0.28	0.28	0.29	160.8	175.6	151.0	162.1
$C_2 N_2$	0.24	0.28	0.28	0.31	160.8	175.6	178.1	187.0
$C_2 N_3$	0.24	0.28	0.37	0.39	160.8	175.6	195.0	204.0
$C_2 N_4$	0.24	0.28	0.39	0.40	160.8	175.6	205.7	215.4
$C_3 N_1$	0.24	0.29	0.33	0.34	160.8	180.7	168.6	179.7
$C_3 N_2$	0.24	0.29	0.33	0.36	160.8	180.7	195.6	204.6
$C_3 N_3$	0.24	0.29	0.42	0.44	160.8	180.7	212.6	221.6
$C_3 N_4$	0.24	0.29	0.44	0.45	160.8	180.7	223.2	233.0
$C_4 N_1$	0.24	0.28	0.31	0.32	160.8	177.2	159.8	171.2
$C_4 N_2$	0.24	0.28	0.31	0.34	160.8	177.2	186.8	195.8
$C_4 N_3$	0.24	0.28	0.4	0.42	160.8	177.2	204.3	212.8
$C_4 N_4$	0.24	0.28	0.42	0.43	160.8	177.2	214.5	224.2

carbon status of the cropping system was found improved with the raising of preceding crops to rice and declined slightly with the raising of rice, rice and groundnut, during both the years of experimentation. The highest soil organic carbon status after the completion of each of the annual cycle of the cropping system was recorded with the combination of incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through FYM to rice, while it was found the lowest with the combination of incorporation of greengram crop residues with out supplying nitrogen through any source to rice.

Soil available nitrogen:

Post harvest soil available nitrogen status of the cropping system (preceding crops to rice, rice and groundnut) with incorporation of different crop residues and varied nitrogen management practices to rice and raising residual crop of groundnut without imposing any treatments was found improved over the pre-experimental status, except in case of incorporation of greengram crop residues with out supplying nitrogen through any source to rice where it was slightly lesser than the initial status (Table 7). Irrespective of the treatments, soil available nitrogen status of the cropping system was found improved with the raising of preceding crops to rice, rice crop and groundnut. The highest soil available nitrogen status after the completion of each of the annual cycle of the cropping system was recorded with the combination of incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through FYM to rice, while it was found the lowest with the combination of incorporation of greengram crop residues with out supplying nitrogen through any source to rice.

Soil available phosphorus:

Post harvest soil available phosphorus status of the cropping system (preceding crops to rice, rice and groundnut) with incorporation of different crop residues and varied nitrogen management practices to rice and raising residual crop of groundnut without imposing any treatments was found improved over the pre-experimental status, except with incorporation of greengram residues coupled with different nitrogen management practices to rice, where it was marginally lesser than the initial status (Table 8). Irrespective of the treatments, soil available phosphorus status of the cropping system was found improved with the raising of preceding crops to rice and rice crop and declined with the raising of groundnut, during both the years of experimentation. The highest soil available phosphorus status after the completion of each of the annual cycle of the cropping system was recorded with the combination of incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through FYM to rice, while it was found the lowest with the combination incorporation of greengram crop residues with out supplying nitrogen through any source to rice.

Table 8 : Dynamics of soil available phosphorus and available potassium in rice – groundnut cropping system as influenced by crop residue incorporation and nitrogen management practices to preceding rice (mean of 2 years data)

Treatments	Dynamics of soil available phosphorus (kg ha^{-1})				Dynamics of soil available potassium (kg ha^{-1})			
	Initial	Post harvest of preceding crops to rice	Post harvest of rice	Post harvest of groundnut	Initial	Post harvest of preceding crops to rice	Post harvest of rice	Post harvest of groundnut
$C_1 N_1$	25.6	27.0	25.8	23.4	175.4	186.9	181.3	196.7
$C_1 N_2$	25.6	27.0	26.9	24.2	175.4	186.9	192.3	208.1
$C_1 N_3$	25.6	27.0	31.3	24.8	175.4	186.9	222.9	225.6
$C_1 N_4$	25.6	27.0	32.4	25.5	175.4	186.9	240.6	242.3
$C_2 N_1$	25.6	28.2	28.8	25.8	175.4	194.0	189.2	204.6
$C_2 N_2$	25.6	28.2	29.6	26.9	175.4	194.0	200.2	216.0
$C_2 N_3$	25.6	28.2	33.8	27.0	175.4	194.0	230.7	233.5
$C_2 N_4$	25.6	28.2	34.3	27.8	175.4	194.0	248.5	250.3
$C_3 N_1$	25.6	30.4	30.6	27.9	175.4	205.4	205.1	220.4
$C_3 N_2$	25.6	30.4	32.3	28.3	175.4	205.4	216.0	231.8
$C_3 N_3$	25.6	30.4	35.9	28.9	175.4	205.4	246.6	249.3
$C_3 N_4$	25.6	30.4	36.8	29.6	175.4	205.4	264.3	266.1
$C_4 N_1$	25.6	28.9	29.7	26.8	175.4	198.6	197.3	212.5
$C_4 N_2$	25.6	28.9	31.3	27.8	175.4	198.6	208.1	223.9
$C_4 N_3$	25.6	28.9	35.1	27.8	175.4	198.6	238.7	241.4
$C_4 N_4$	25.6	28.9	35.8	28.9	175.4	198.6	256.4	248.3

Soil available potassium:

Post harvest soil available potassium status of the cropping system (preceding crops to rice, rice and groundnut) with incorporation of different crop residues and varied nitrogen management practices to rice and raising residual crop of groundnut without imposing any treatments was found improved over the pre-experimental status. Irrespective of the treatments, soil available potassium status of the cropping system was found improved progressively with the raising of preceding crops to rice, rice and groundnut (Table 8). The highest soil available potassium status after the completion of each of the annual cycle of the cropping system was recorded with the combination of incorporation of fieldbean crop residues along with the supply of 100 per cent nitrogen through FYM to rice, while it was found the lowest with the combination incorporation of greengram crop residues with out supplying nitrogen through any source to rice.

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. Incorporation of fieldbean crop residues left over substantial quantity of soil nutrients after the harvest of rice and increased the soil organic carbon content. The results are in accordance with the findings of John *et al.* (1989), that crop residues often leave substantial residual effect on succeeding crops in the cropping system. The sustainable advantage noticed in the present study with the incorporation of crop residues has been amply indicated by John *et al.* (1992). Slowly mineralizing organic fractions under anaerobic lowland conditions would leave behind enriched status of soil fertility, even after sufficient uptake of nutrients by rice crop. Slow decomposition and mineralisation of crop residues and farmyard manure added in large quantities to preceding rice crop would have enriched the organic carbon, available nitrogen, phosphorus and potassium status of soil after the harvest of groundnut. These results are in agreement with those Buresh and De Datta (1991).

Post harvest fertility status of soil was at relatively lesser level with supply as 100 per cent nitrogen through fertilizer, which might be due to higher level of nutrient uptake. Higher growth and yield associated with this treatment obviously removes larger quantity of nutrients from soil than the other nitrogen management practices. Application of recommended nitrogen either through exclusive organic source or the combination of organics and fertilizer to supply 50 per cent nitrogen through each, would leave substantial quantity of soil nutrients after the harvest of rice or increase the soil organic carbon content. The substantial advantage noticed in the present study with the integration of organic manures and fertilizer has been amply indicated by Vasanthakumar (1996). Slowly mineralizing organic fractions under anaerobic lowland conditions would have left behind enriched status of soil fertility, even after sufficient uptake of nutrients by 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 50 per cent recommended dose of nitrogen each through fertilizer and FYM to rice followed by raising groundnut as residual crop, to utilize the residual fertility was found the best integrated nitrogen management package for rice-groundnut cropping system, not only in terms of higher productivity and economic returns, but also for sustaining the soil fertility status at a fairly high level.

Authors' affiliations:
D. SRINIVASULU REDDY, Department of Agronomy, S.V. Agricultural College, TIRUPATI (A.P.) INDIA

LITERATURE CITED

Buersh, R. J. and De Datta, S. K. (1991). Nitrogen dynamics and management in rice legume cropping systems. *Adv. Agron.*, **45** (1) : **59**.

Jana, M.K. and Ghosh, B.C. (1996). Integrated nutrient management in rice (*Oryza sativa*) - rice crop sequence. *Indian J. Agron.*, **41**(2): 183-187.

Jackson, M.L. (1973). *Soil chemical analysis*. Prentice Hall of India Pvt. Ltd., new Delhi, pp.134-204.

John, P. S., Pandey, R.K., Buresh, R. J. and Prasad, R. (1989). Low land rice response to urea following three cowpea cropping systems. *Agro. J.*, **181**: 853-857.

John, P.S., Pandey, R.K., Buresh, R.J. and Prasad, R. (1992). Nitrogen contribution of cowpea green manure and residue to upland rice. *Plant & Soil,* **142**: 53-61.

Kulkarni, K.R. and Pandey, R.K. (1988). Annual legumes for food and as green manure in a rice based cropping system. In: *Sustainable agriculture - green manure in rice farming*. International Rice Research Institute, Los Banos, Laguna, Philippines.

Olsen, S.R., Cole, C.L. Watanabe, F.S. and Dean, D. A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate, USDA Cir. No.939.

Ramaseshaiah, K., Yogeswara Rao, Y. and Bheemaiah, G. (1985). Fertilizer requirements of groundnut grown in sequence with rice. *Indian J. agric. Sci.,* **55**(1): 25-27.

Rekhi, R.S. and Meelu, O.P. (1983). Effect of complimentary use of mung straw and inorganic fertilizer nitrogen on the nitrogen availability and yield of rice. *Oryza,* **20**: 125- 129.

Singh, Kalyan, Srivastava, Vinod Kumar and Singh, K.P. (1989). Studies on nitrogen economy in rice through summer mung as affected by nitrogen and *Rhizobium*. *Andhra agric. J.,* **36**(2&3): 189-194.

Subbaiah, B.V. and Asija, G.L. (1956). A rapid procedure for determination of available nitrogen in soils. *Curr. Sci.,* **25**:259-260.

Thimmegowda, S. and Devakumar, (1994). Effect of residual fertility on yield of groundnut grown in rice fallows. *Indian Agriculturist,* **38**: 287-290.

Vasantha Kumar, T.T. (1996). Nitrogen management through green manuring and fertilizer in lowland rice. M.Sc.(Ag.) Thesis, Acharya N.G.Ranga Agricultural University, Hyderabad (A.P.).

Walkey, A. and Black, C. A. (1934). An examination of Degtiaroff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Sci.,* **37**:29-34.

Yoshida, T. (1978) Microbial metabolism in rice soils. In : *Soil and rice*. International Rice Research Institute, Los Banos, Philippines, pp.443-463.

****
******