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Cumulative residual effect of crop residues, farm yard manure and fertilizer on succeeding groundnut (*Arachis hypogea* L.) in rice based cropping system

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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 to investigate the cumulative residual effect of incorporated crop residues and different nitrogen management practices applied to preceding lowland rice on the performance of succeeding groundnut and results revealed that cumulative residual effect of incorporation of fieldbean crop residues and supply of 100 per cent N through FYM to rice has resulted in superior performance of groundnut crop compared to any other crop residue incorporation and nitrogen management practices adopted to preceding rice crop. However, similar magnitude of performance of groundnut was noticed with the combination of fieldbean crop residue incorporation and supply of 50 per cent nitrogen each through fertilizer and FYM to preceding rice.

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

INTRODUCTION

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 in to the field after harvesting seed can contribute considerable quantity of nitrogen to succeeding crops (Rekhi and Meelu, 1983). About less than 30 per cent of nitrogen and small fractions of phosphorus and potash in organic manure may become available to immediate crop and rest to subsequent crop (Gaur and Singh, 1982). Conjuctive use of nutrients partly through organics and inorganics to preceding rice exhibited significant residual effect on succeeding groundnut (Thimmegowda and Devakumar, 1994). 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. Since, the information on cumulative residual effect of crop residue incorporation and nitrogen management practices on succeeding groundnut grown after rice is lacking for southern agroclimatic zone of Andhra Pradesh, the present study was conducted to assess the effectiveness of cumulative residual effect of incorporation of crop residues, farm yard manure and fertilizer on growth, pod yield, nutrient uptake of groundnut and post harvest soil fertility status.

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, by drawing soil samples at random from 0-30 cm depth of the experimental field. The 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

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(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. 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 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.

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. The layout of *Rabi* rice crop was undisturbed, in which groundnut crop was sown. 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 *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 residual effect of 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. Test variety of groundnut was K-134 a spanish bunch type with a duration of 100-110 days, suitable for cultivation in summer season. The seeds of groundnut were treated with mancozeb (3 g kg^{-1} seed) and used for sowing with a spacing of 22.5 x 10 cm. Sowing was done by hand dibbling. Intercultivation was done with star weeder at 20 and 40 days after sowing for controlling weeds in inter row spaces followed by hand hoeing for removal of intra row weeds. 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 rice and groundnut. The soil samples were analysed for organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), available

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

phosphorus (Olsen *et al.*, 1954) and available potassium (Jackson, 1973).

RESULTS AND DISCUSSION

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

DMP and grain yield of rice:

Incorporation of fieldbean crop residues after picking the economic yield resulted in higher dry matter production and grain yield of rice. 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. Comfortable level of absorbed and assimilated nitrogen in the plants has

Table 2 : Residual effect of crop residue incorporation and nitrogen management practices on grain yield of rice and soil fertility status after rice harvest

Treatments	Dry matter production (kg ha^{-1}) AT	PI	F	H	Grain yield (kg ha^{-1})	Available nutrient status in soil after rice harvest (kg ha^{-1}): soil organic carbon (%)	soil available nitrogen	soil available phosphorus	soil available potassium
Cropping system, 2002-2003									
Incorporation of crop residues									
C_1: incorporation of greengram crop residues	1879	4703	7736	9207	3936	0.30	171.7	28.8	193.3
C_2: incorporation of clusterbean crop residues	2260	5160	8313	9897	4357	0.32	179.8	31.0	201.1
C_3: incorporation of fieldbean crop residues	2997	6066	9481	11283	5342	0.37	197.3	33.5	217.0
C_4: incorporation of cowpea crop residues	2629	5602	8901	10583	5020	0.35	188.7	32.5	209.1
S.E. $\pm$	71	119	180	212	101	0.004	3.12	0.01	2.66
C.D.(P=0.05)	174	292	442	521	248	0.01	7.6	NS	6.5
Nitrogen management practices									
N_1: No nitrogen	1901	3972	6986	8444	3400	0.29	153.6	28.2	178.3
N_2:100% recommended nitrogen through fertilizer	2999	6312	9722	11546	5454	0.29	177.0	30.0	188.0
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	2609	5857	9164	10839	5090	0.38	198.5	33.5	217.1
N_4: 100% recommended nitrogen through farm yard manure	2257	5391	8559	10142	4710	0.39	208.5	34.4	237.2
S.E. $\pm$	100	168	254	301	143	0.005	4.4	0.02	3.78
C.D.(P=0.05)	208	348	527	624	296	0.01	9.1	NS	7.7
Cropping system, 2003-2004									
Incorporation of crop residues									
C_1: incorporation of greengram crop residues	1758	4282	7832	9061	3574	0.32	176.3	29.4	225.4
C_2: incorporation of clusterbean crop residues	2147	4706	8414	9757	4142	0.34	185.1	32.3	233.3
C_3: incorporation of fieldbean crop residues	3106	5765	9577	11192	5326	0.39	202.7	34.3	249.1
C_4: incorporation of cowpea crop residues	2625	5231	8995	10473	4698	0.37	194.1	33.5	241.2
S.E. $\pm$	64	107	174	203	108	0.008	3.8	0.02	2.94
C.D.(P=0.05)	158	264	428	498	265	0.02	7.8	NS	7.2
Nitrogen management practices									
N_1: No nitrogen	1763	3537	7078	8302	3184	0.30	157.6	29.2	208.3
N_2:100% recommended nitrogen through fertilizer	3100	5989	9822	11421	5249	0.30	187.8	30.3	220.5
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	2624	5496	9247	10725	4853	0.39	201.1	34.6	252.4
N_4: 100% recommended nitrogen through farm yard manure	2148	4962	8672	10035	4453	0.42	211.7	35.3	267.9
S.E. $\pm$	91	152	247	287	153	0.001	4.5	0.02	4.16
C.D.(P=0.05)	186	315	510	594	316	0.02	9.3	NS	8.6

AT : Active Tillering PI : Panicle Initiation F : Flowering H : Harvest manifested elevated level of growth and yield structure, resulting in superior performance of rice crop. 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 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.

Supply of 100 per cent N through fertilizer to rice (N_2) was found to be superior to any other nitrogen management practices (Table 2), with regard to dry matter production and grain yield of rice. 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. 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. 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). 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 of nitrogen in soil solution due to the process of slow mineralization of farm yard manure under low land conditions.

Post harvest soil fertility status (after rice) :

Post-harvest soil fertility status (available nutrient status in soil after rice harvest) with regard to organic carbon, available nitrogen and potassium was superior with incorporation of fieldbean crop residues (C_3) followed by incorporation of cowpea (C_4) clusterbean (C_2) and greengram (C_1) (Table 2). The lowest status of above mentioned soil fertility parameters were recorded the incorporation of greengram crop residues (C_1). The available phosphorus status did not vary to a statistically traceable extent due to crop residues incorporation. 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. 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.

Post harvest soil fertility status (available nutrient status in soil after rice harvest) with regard to organic carbon, was superior with application of 100 per cent nitrogen through FYM (N_4), which was significantly higher than with supply of 50 per cent nitrogen each through FYM and fertilizer (N_3) and both of them were significantly superior to supply of 100 per cent nitrogen through fertilizer (N_2) and no nitrogen (N_1). The highest status of residual soil available nitrogen and available potassium was recorded with the supply of 100 per cent nitrogen through FYM, followed by supply of 50 per cent nitrogen each through fertilizer and FYM, supply of 100 per cent nitrogen through fertilizer and no N application, with significant disparity between any two. The lowest status of the above mentioned soil fertility parameters were recorded with non-supply of nitrogen (N_1) followed by 100 per cent fertilizer nitrogen. The available phosphorus status did not vary to statistically traceable extent due to nitrogen management practices.

The above trend clearly indicates the role of organic manures in maintaining or building soil fertility. Post

Table 3 : Growth of groundnut as influenced by cumulative residual effect of crop residue incorporation and nitrogen management practices to preceding rice

Treatments	Plant height (cm)				Leaf area index				Dry matter production ($kg\ ha^{-1}$)			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Cropping system, 2003 -2004												
Incorporation of crop residues												
C_1: incorporation of greengram crop residues	6.5	13.7	23.4	30.6	0.49	1.60	2.72	2.35	489	2170	3888	5195
C_2: incorporation of clusterbean crop residues	6.7	15.8	25.6	32.7	0.49	1.64	2.96	2.59	556	2426	4212	5608
C_3: incorporation of fieldbean crop residues	7.2	20.3	30.0	36.4	0.60	1.73	3.43	3.06	689	2923	4779	6517
C_4: incorporation of cowpea crop residues	6.9	18.0	27.8	34.6	0.54	1.69	3.20	2.82	626	2677	4552	6067
S.E. ±	0.05	0.6	0.7	0.65	0.01	0.01	0.06	0.08	18.3	85.0	87.0	123.4
CD(P=0.05)	0.1	1.5	1.8	1.6	0.04	0.03	0.14	0.21	45	208	215	302
Nitrogen management practices												
N_1: No nitrogen	6.5	13.7	22.2	27.6	0.44	1.59	2.74	2.29	506	2119	3818	5200
N_2:100% recommended nitrogen through fertilizer	6.6	15.3	23.8	29.2	0.48	1.62	2.87	2.52	545	2371	4086	5582
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	7.0	18.6	29.6	37.9	0.56	1.70	3.29	2.94	634	2730	4635	6119
N_4: 100% recommended nitrogen through farm yard manure	7.2	20.3	31.2	39.7	0.59	1.73	3.42	3.07	675	2970	4892	6488
S.E. ±	0.07	0.9	1.04	0.92	0.02	0.02	0.08	0.12	26.0	120.2	124.2	174.5
CD(P=0.05)	0.2	1.8	2.1	1.9	0.05	0.04	0.17	0.25	54	248	275	360
Cropping system, 2004-2005												
Incorporation of crop residues												
C_1: incorporation of greengram crop residues	6.3	14.9	22.3	30.0	0.46	1.59	2.83	2.26	509	2231	4196	5073
C_2: incorporation of clusterbean crop residues	6.7	16.9	24.2	31.6	0.51	1.63	3.16	2.53	574	2447	4479	5501
C_3: incorporation of fieldbean crop residues	7.3	20.3	29.0	35.3	0.61	1.71	3.53	3.02	574	2895	4971	6223
C_4: incorporation of cowpea crop residues	7.0	18.4	26.4	33.5	0.56	1.68	3.35	2.78	641	2671	4738	5930
S.E. ±	0.06	0.6	0.7	0.61	0.02	0.008	0.06	0.09	23.7	80.1	100.5	113.6
CD(P=0.05)	0.1	1.4	1.7	1.5	0.04	0.02	0.17	0.24	58	196	236	278
Nitrogen management practices												
N_1: No nitrogen	6.5	14.7	21.7	27.1	0.46	1.59	2.83	2.18	523	2167	4095	5022
N_2:100% recommended nitrogen through fertilizer	6.6	16.2	22.7	28.5	0.49	1.61	3.00	2.45	572	2388	4346	5346
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	7.1	19.2	27.8	36.6	0.57	1.69	3.43	2.88	648	2748	4854	6019
N_4: 100% recommended nitrogen through farm yard manure	7.2	20.5	29.6	38.2	0.61	1.72	3.62	3.07	689	2941	5089	6342
S.E. ±	0.08	0.8	0.9	0.86	0.02	0.01	0.09	0.14	34.1	113.2	142.1	174.5
C.D. (P=0.05)	0.2	1.7	2.0	1.8	0.05	0.03	0.2	0.28	70	234	293	360

harvest fertility status of soil was at relatively lesser level with supply as 100 per cent nitrogen through fertilizer (N_2), which might be due to higher level of nutrient uptake. Higher growth and yield associated with this treatment (N_2) obviously removes larger quantity of nutrients from soil than the other nitrogen management practices. The above trend clearly indicated that 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 results are in accordance with the findings of Maskina and Meelu (1984). 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.

Growth of groundnut :

At all the crop growth stages of recording, plants of the tallest stature, highest LAI and drymatter production of groundnut were produced with the incorporation of crop residues of fieldbean (C_3) to preceding rice followed by cowpea (C_4), clusterbean (C_2) and greengram (C_1) residues, with significant disparity between any two of them and shortest plants were noticed with the incorporation of crop residues of greengram (C_1) to preceding rice, during both the years of study (Table 3). 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 .The tallest plants, highest LAI and drymatter production of groundnut were produced with the supply of 100 per cent nitrogen through FYM (N_4) to preceding rice, which were comparable with 50 per cent nitrogen each through fertilizer and FYM (N_3), but significantly superior to 100 per cent nitrogen through fertilizer (N_2) and no nitrogen (N_1), which in turn were comparable between them and the shortest plants were noticed with non-supply of nitrogen (N_1) to preceding rice, during both the years of study.

Yield attributes of groundnut :

The highest number of pods plant^{-1}, hundred pod weight, hundred kernel weight, pod yield and haulm yield were produced with the incorporation of crop residues of fieldbean to rice (C_3) followed by cowpea (C_4), clusterbean (C_2) and greengram (C_1), with significant disparity between any two of them and the lowest number of pods plant^{-1}, hundred pod weight, hundred kernel weight, pod yield and haulm yield was noticed with the incorporation of crop residues of greengram (C_1) to preceding rice, during both the years of study (Table 4). 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, with in the crop residues incorporation, differential residual response with different crop residues added can be attributed to their pattern of mineralization and decomposition. Supply of 100 per cent nitrogen through FYM (N_4) to preceding rice resulted in the production of highest number of pods plant^{-1}, hundred-pod weight, hundred-kernel weight as well as pod yield and haulm yield,which was comparable with 50 per cent nitrogen each through fertilizer and FYM (N_3), but significantly superior to 100 per cent nitrogen through fertilizer (N_2) and no nitrogen (N_1), which were comparable between them and the lowest number of pods plant^{-1}, hundred pod weight, hundred kernel weight, pod yield and haulm yield were noticed with non-supply of nitrogen (N_1) to preceding rice, during both the years of study. 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. During both the years of study, shelling percentage of groundnut did not show any significant variation due to residual and cumulative effect of either incorporation of different crop residues or varied nitrogen management practices tried on preceding rice. Harvest index of groundnut was not altered to a statistically noticeable extent either by incorporation of different crop residues or nitrogen management practices to preceding rice. However, the highest value of harvest index was recorded with incorporation of fieldbean crop residues (C_3) in combination with the supply of 100 per cent nitrogen through FYM (N_4) to preceding rice, while it was the lowest with incorporation of greengram crop residues (C_1) without any nitrogen supply (N_1).

In the present study, the residual effect of organic source at higher proportion was evident from higher dry matter accrual, number of pods plant^{-1}, 100 pod weight, 100 kernel weight, pod and haulm yield. This clearly indicates that organic source at higher proportion can sustain the nutrient status of soil to produce reasonable residual effect. Organic source of nitrogen, besides supplying nutrients to the current crop, quite often leave substantial residual effect on succeeding crops in the cropping system. These results are in accordance with the findings of Maskina and Meelu (1984). 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 Paulraj and Velayudham (1995). Residual effect of fertilizer nitrogen applied to rice was not traceable on the succeeding groundnut crop as exhibited in the present study corroborates the findings of Ramaseshaiah *et al.*(1985).

Nutrient uptake of groundnut :

Higher uptake of nitrogen by groundnut crop with the incorporation of fieldbean crop residues (C_3) and with application of 100 per cent nitrogen through FYM (N_4) to preceding rice crop might be due to higher availability of

Table 4 : Yield attributes, pod yield and economics of groundnut as influenced by cumulative residual effect of crop residue incorporation and nitrogen management practices to preceding rice

Treatments	Number of pods plant^{-1}	100 pod weight (g)	100 kernel weight (g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Shelling percentage	Harvest index*	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost ratio
Cropping system, 2003-2004										
Incorporation of crop residues										
C_1: incorporation of greengram crop residues	10.0	74.1	30.0	1898	3604	72.8	34.23	25034	14384	2.35
C_2: incorporation of clusterbean crop residues	10.7	76.6	31.8	2063	3956	72.9	34.08	27215	16565	2.56
C_3: incorporation of fieldbean crop residues	12.2	81.4	35.5	2393	4737	73.5	33.39	31583	20933	2.97
C_4: incorporation of cowpea crop residues	11.5	79.0	33.7	2228	4388	73.2	33.47	29403	18753	2.76
S.E. $\pm$	0.24	0.86	75.6	75.6	97.2	0.94	---	887	0842	0.08
C.D.(P=0.05)	0.6	2.1	185	185	238	N.S.	----	2172	1864	0.19
Nitrogen management practices										
N_1: No nitrogen	9.7	73.9	29.5	1696	3745	72.2	31.19	22429	11779	2.11
N_2:100% recommended nitrogen through fertilizer	10.1	75.6	30.8	1911	3920	72.6	32.84	25242	14592	2.37
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	12.0	80.0	34.7	2379	4384	73.4	35.23	31372	20722	2.95
N_4: 100% recommended nitrogen through farm yard manure	12.6	81.7	35.9	2594	4634	74.3	35.92	34192	23542	3.21
S.E. $\pm$	0.35	1.21	106.9	106.9	137.5	1.17	----	1688	1642	0.15
C.D.(P=0.05)	0.7	2.5	220	220	284	N.S.	---	2854	2672	0.27
Cropping system, 2004-2005										
Incorporation of crop residues										
C_1: incorporation of greengram crop residues	9.1	72.9	29.1	1743	3395	73.2	33.85	23005	12355	2.16
C_2: incorporation of clusterbean crop residues	9.9	75.7	30.9	1938	3762	73.3	33.79	25577	14927	2.40
C_3: incorporation of fieldbean crop residues	11.5	80.6	34.6	2328	4540	73.6	33.77	30725	20075	2.88
C_4: incorporation of cowpea crop residues	10.6	78.4	32.7	2133	4184	73.5	33.59	28154	17504	2.64
S.E. $\pm$	0.16	0.78	0.65	78.4	88.2	0.82	----	937	902	0.09
C.D.(P=0.05)	0.4	1.9	1.6	192	216	NS	----	2294	2014	0.23
Nitrogen management practices										
N_1: No nitrogen	8.9	72.9	28.5	1633	3546	72.6	31.52	21590	10940	2.03
N_2:100% recommended nitrogen through fertilizer	9.3	74.7	29.7	1798	3723	73.1	32.76	23753	13103	2.23
N_3: 50% recommended nitrogen through fertilizer + 50% recommended through farm yard manure	11.2	79.2	33.7	2243	4187	73.7	34.90	29584	18934	2.78
N_4: 100% recommended nitrogen through farm yard manure	11.6	81.0	35.3	2468	4426	74.3	35.82	32533	21883	3.05
S.E. $\pm$	0.23	1.10	0.92	110.9	124.8	1.02	----	1814	1794	0.18
C.D.(P=0.05)	0.5	2.3	1.9	229	258	NS	----	3140	2942	0.29

Table 5 : Nutrient uptake of groundnut and soil fertility after groundnut harvest as influenced by cumulative residual effect of crop residue incorporation and nitrogen management practices preceding rice

Treatments	Nitrogen uptake				Phosphorus uptake				Potassium uptake				Available nutrient status in soil after groundnut harvest (kg ha^{-1})			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	soil organic carbon (%)	soil available nitrogen	soil available phosphorus	soil available potassium
Cropping system, 2003-2004																
Incorporation of crop residues																
C_1					2.1	6.0	7.0	10.5	13.1	38.4	61.2	69.8	0.33	177.7	24.3	199.3
C_2	23.9	65.8	75.9	84.0	2.3	6.5	7.0	10.9	14.8	41.6	65.0	73.7	0.35	186.5	26.3	207.2
C_3	28.0	73.7	88.9	96.8	2.7	7.3	7.0	11.8	18.4	48.3	72.6	81.3	0.40	204.1	28.4	223.0
C_4	25.9	70.0	82.3	90.1	2.5	6.9	7.0	11.3	16.5	44.9	68.9	77.6	0.38	195.3	27.3	215.1
S.E. ±	0.57	1.14	1.31	1.18	0.04	0.07	0.08	0.09	0.61	1.10	1.47	1.47	0.05	3.4	0.02	2.78
C.D. (P=0.05)	1.4	2.8	3.2	2.9	0.1	0.2	0.2	0.2	1.5	2.7	3.6	3.6	0.01	8.3	NS6	6.8
Nitrogen management practices																
N_1	21.3	61.9	71.5	79.3	2.0	6.2	8.4	10.7	11.8	36.3	58.7	67.4	0.30	160.4	25.6	185.3
N_2	22.8	64.6	74.6	82.4	2.2	6.5	8.7	10.9	13.5	38.9	62.9	71.6	0.32	184.2	26.6	198.5
N_3	26.8	71.3	83.4	91.5	2.6	6.9	9.1	11.3	18.0	48.1	71.5	80.1	0.40	204.5	26.7	220.5
N_4	28.3	73.9	86.5	94.6	2.7	7.2	9.4	11.6	19.7	50.0	74.6	83.3	0.41	214.4	27.5	240.3
S.E. ±	0.81	1.62	1.85	1.67	0.05	0.22	0.24	0.24	0.87	1.56	2.08	2.08	0.08	4.8	0.02	3.93
C.D. (P=0.05)	1.7	3.3	3.8	3.5	0.2	0.4	0.4	0.4	1.8	3.2	4.3	4.3	0.03	9.9	NS	8.1
Cropping system, 2004-2005																
Incorporation of crop residues																
C_1	24.3	65.8	72.1	80.1	2.2	6.2	8.5	10.7	14.7	39.0	62.8	71.5	0.34	189.0	24.7	237.1
C_2	26.4	69.7	79.2	87.1	2.4	6.6	8.9	11.1	16.6	42.3	66.6	75.3	0.36	197.8	27.4	245.1
C_3	29.7	77.1	91.0	98.9	2.8	7.5	9.9	12.1	20.2	49.3	74.5	83.2	0.41	215.4	29.5	260.9
C_4	28.1	73.5	84.6	92.7	2.6	7.0	9.4	11.6	18.6	45.8	70.7	79.4	0.39	206.8	28.4	253.1
S.E. ±	0.61	1.31	1.39	1.22	0.04	0.08	0.09	0.09	0.54	1.31	1.51	1.51	0.06	3.5	0.02	3.11
C.D. (P=0.05)	1.5	3.2	3.2	3.0	0.1	0.2	0.2	0.2	1.4	3.2	3.7	3.7	0.01	8.5	NS	7.6
Nitrogen management practices																
N_1	23.5	62.8	73.3	81.3	2.1	6.4	8.7	10.9	13.3	37.4	60.3	69.0	0.31	172.8	26.4	231.9
N_2	24.6	66.1	76.0	83.8	2.2	6.6	8.9	11.1	15.2	40.6	64.5	73.2	0.33	198.6	27.4	241.5
N_3	29.2	75.3	87.1	95.1	2.7	7.1	9.3	11.6	19.9	47.3	73.3	82.0	0.41	212.4	27.6	254.6
N_4	30.6	78.0	90.4	98.6	2.8	7.3	9.6	11.8	21.7	51.0	76.5	85.1	0.42	225.2	28.5	268.3
S.E. ±	0.87	1.85	1.96	1.73	0.06	0.11	0.26	0.13	1.04	1.85	2.14	2.13	0.09	4.9	0.02	4.4
C.D. (P=0.05)	1.8	3.8	3.6	3.6	0.2	0.3	0.4	0.4	2.1	3.8	4.4	4.4	0.03	10.1	NS	9.0

N.S.-Non significant

nitrogen in the soil and enhanced dry matter production. The higher uptake of phosphorus and potassium with the same treatments of incorporation of fieldbean crop residues and supply of 100 per cent nitrogen through FYM to preceding rice 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 accumulation under the influence of higher amount of residual N (Table 5).

Economics of groundnut :

The highest gross returns and net returns as well as benefit-cost ratio of groundnut recorded with the incorporation of crop residues of fieldbean (C_3) to preceding to rice, were due to higher pod and haulm yield realized by this treatment than to any other crop residues incorporation. The highest gross returns, net returns and benefit-cost ratio realized with the supply 100 per cent nitrogen through FYM (N_4) to preceding rice, were due to higher pod yield realized by this treatment than to any other nitrogen management practices applied to preceding rice and also since groundnut crop was raised as residual crop, the cost of cultivation did not differ among the treatments(Table 4).

Post harvest soil fertility status (after groundnut) :

The highest post harvest (available nutrient status in soil after groundnut harvest) organic carbon, available nitrogen and potassium content of soil were noticed with the incorporation of fieldbean crop residues (C_3) to preceding rice, which were significantly superior to any other crop residues incorporation. The available phosphorus did not show any significant variation with different crop residues incorporation treatments, even though it was highest with incorporation of field been crop residues, while the lowest post harvest organic carbon, available nitrogen and potassium content of soil was associated with incorporation of greengram crop residues (C_1). The highest post harvest organic carbon content of soil was recorded with the supply of 100 per cent nitrogen through FYM (N_4) to preceding rice, which was however, comparable with supply of 50 per cent nitrogen each through fertilizer and FYM (N_3) but significantly superior to supply of 100 per cent nitrogen through fertilizer (N_2) and non-supply of nitrogen (N_1) to preceding rice, which were comparable with each other. Post harvest soil available nitrogen and potassium were the highest with supply of 100 per cent nitrogen through FYM to preceding rice, which were followed by supply of 50 per cent nitrogen each through fertilizer and FYM, 100 per cent nitrogen through fertilizer and no N application, with significant disparity with each other. The available phosphorus did not show any significant variation with different nitrogen management practices, even through it was highest with supply of 100 per cent nitrogen through FYM, while the lowest was recorded with supply of 100 per cent nitrogen through fertilizer. 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 (Table 5). These results are in agreement with those of Buresh and De Datta (1991).

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 upon 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 to achieve higher growth, productivity and economic returns of succeeding groundnut.

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