

Prospects of recycling crop wastes in rice-based cropping system

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SINCE time immemorial only farmyard manure (FYM) and green manure were the recognized organic sources of plant nutrients. In rice-based cropping system crop waste of rice is mainly used as a source of fodder and fuel and thereby it is not available for recycling. However, wastes from other crops like maize, groundnut, mustard, jute and other crops can be suitably used as a source of organic manure when incorporated in appropriate dosage and time to benefit the subsequent rice crop.

Organic sources are generally low analysis materials and are required in bulk to meet the nutritional requirement of crop. The crop waste generated in a cropping system may not be sufficient to supply the nutrient required by subsequent crop. The remaining nutrients can be supplied through chemical fertilizer. Moreover, addition of inorganic nitrogen with organic materials accelerates the mineralization process by reducing C : N ratio. Thus there is a complementary effect of combined application of organic and inorganic sources of fertilizers. The nutrient released by organic matter is slow and steady and is available for longer time in soil, whereas the release of nutrients by inorganic fertilizer is rapid and prone to loss, particularly in sub-merged rice soil.

Therefore, it is important to understand benefit of use of crop wastes and green manure alone as well as in combination with inorganic fertilizer in sustaining productivity in rice-based cropping system.

In high rainfall region of eastern India, rice-based cropping system is commonly practised. Rice is the only crop which is grown during rainy (*kharif*) under sub merged condition while during dry season a sequential cropping with mustard, winter maize, summer groundnut and jute etc. can be suitably adopted in an economically viable system for higher land productivity and net returns. In cereal dominated crop rotation nutritional imbalance is becoming a major limiting factor for sustained land productivity. This is mainly due to the continuous use of high analysis selective chemical fertilizers in the same field and thereby depletion of secondary and micronutrients from the soil. To overcome such difficulties, organic enrichment by utilizing crop residue is one of the viable alternatives in the rice-based cropping system. Any organic material contains multinutrients, besides it improves soil physical condition and improves biological system of the soil. Thus it can play an important role in maintaining the land productivity of tropical soils, particularly the acid lateritic soil which is generally low in organic matter and nutrient status.

Availability of crop wastes and nutrient supply

Experiments conducted on some promising rice-based cropping system such as groundnut-rice, jute-rice,

mustard-rice and maize-rice reveals that maximum crop residue was obtained in maize which was to the extent of 5.0 tonnes/ha, followed by 3 tonnes/ha each from groundnut

Table 1. Composition of different organic materials and quantity of nutrients added

Organic materials	C : N ratio	Nutrient content (%)			Quantity applied (tonnes/ha)	Nutrient added (kg/ha)		
		N	P	K		N	P ₂ O ₅	K ₂ O
Sesbania	17	2.43	0.2	0.65	1.5	36.4	5.5	11.7
Mustard stover	68	0.73	0.1	0.77	3.0	21.9	7.9	27.6
Maize stover	57	0.89	0.1	0.62	5.0	44.8	15.4	37.0
Jute (leaf fall and root stubble)		1.04	0.5	0.80	2.5	26.0	12.0	20.0
Groundnut haulm	28	1.65	0.2	0.68	3.0	49.7	10.7	24.4

and mustard and 2.5 tonnes/ha in jute (leaf fall and root stubble). This biomass was incorporated in submerged rice field 30 days before transplanting. In case of jute, leaf biomass added as and when leaf drops on the ground as well as after shattering the rest of the leaves before retting. The major nutrients N, P and K supplied through these crop residues are presented in Table 1, which shows in groundnut crop, waste supplied maximum nutrients followed by maize, mustard and jute. The Table also reveals that the crop wastes cannot meet the recommended dose to rice (100 : 60 : 40 kg N, P₂O₅ and K₂O/ha). The balance nutrient was supplied through chemical fertilizer. The C : N ratio of different crop wastes varied which was maximum in mustard stover and minimum in sesbania (Table 1). Sesbania, a traditional green manure was included for comparison. This was grown *in situ* for 52 days and incorporated 7 days before transplanting of rice @ 1.5 tonnes/ha.

Effect of organic and inorganic fertilizer sources on rice

It was observed that application of organic materials alone, namely sesbania @ 1.5 tonnes/ha, crop residues of mustard and groundnut @ 3.0 tonnes/ha each and maize crop residue @ 5 tonnes/ha was favourable in increasing the yield of rice to the extent of 16% (Table 2). Increase in yield went as high as 84% when combined application of crop residue and inorganic fertilizer was made at the recommended level. The groundnut crop residue with narrow C : N ratio was found to be better organic source because it could release the nutrients faster than other crop wastes tested. The inorganic fertilizer applied alone has shown similar efficiency as that of combined application of organic and inorganic sources. This indicates that a part of the chemical fertilizer can be substituted by using organic sources. The

Table 2. Yield of rice as influenced by different combinations of organic and inorganic fertilizers

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	
	1993	1994	1993	1994
Control	2 556	2 567	3 822	3 827
IF	4 672	4 685	5 556	5 533
GM	2 918	2 979	4 082	4 306
GM + IF	4 562	4 563	5 320	5 588
GN	2 862	2 993	4 168	4 268
GN + IF	4 741	4 890	5 519	5 581
Ms	2 686	2 884	4 037	4 191
Ms + IF	4 302	4 476	5 172	5 388
Mz	2 831	2 904	4 171	4 258
Mz + IF	4 690	4 737	5 428	5 676
SEm ±	97	76	106	104
CD (5%)	292	228	319	313

IF, Inorganic fertilizer; GM, green manure; GN, groundnut; Ms, mustard; Mz, maize

Table 3. Residual fertility status of soil after 2 years of crop cycle as influenced by application of different sources of organic wastes and inorganic fertilizer

Treatment	Organic carbon (%)	Available nutrients (kg/ha)		
		N	P	K
Control	0.39	186.7	14.3	236.3
IF	0.42	253.4	19.2	257.1
GM	0.56	224.2	17.8	245.0
GM + IF	0.59	276.1	20.7	263.3
GN	0.66	233.2	19.6	255.1
GN + IF	0.68	277.1	21.6	272.0
Ms	0.58	208.7	17.1	254.7
Ms + IF	0.61	268.1	20.5	273.8
Mz	0.60	202.9	16.2	251.3
Mz + IF	0.62	262.8	19.3	271.1
Initial	0.38	180.2	12.7	224.6

IF, Inorganic fertilizer; GM, green manure; GN, groundnut; Ms, mustard; Mz, maize

Table 4. Total productivity in terms of rice grain equivalent yield, net returns and B : C ratio under mustard-rice, maize-rice, groundnut-rice and jute-rice cropping sequence

Cropping sequence	Rice equivalents grain yield (tonnes/ha)	Net returns (Rs/ha)	Benefit : cost ratio
Mustard-rice	6.41	11 690	1.33
Maize-rice	7.09	12 635	1.28
Groundnut-rice	8.64	17 039	1.71
Jute-rice	5.33		

replacement of nutrients through crop wastes and green manure varied from 21.9 to 49.6 kg N, 5.5 to 15.5 kg P₂O₅ and 11.7 to 36.9 kg K₂O/ha.

Residual fertilizer, land productivity and net profit

Application of green manure and crop residues improved the organic carbon (OC) content as well as N, P and K status of soil. There was build up in OC content in soil from the initial value of 0.36% to 0.68% after 2 years of cropping sequence. On the other hand the increase was only

0.41% in case of organic fertilizer. This shows that addition of organic matter has a bearing in improvement of soil fertility (Table 3).

Among the cropping sequences, highest land productivity (8.6 tonnes/ha) and net returns (Rs 17 039) were obtained in groundnut-rice, followed by maize-rice, mustard-rice and jute-rice cropping system. Further, application of inorganic fertilizers in combination with organic sources showed higher land productivity and net returns as compared to only inorganic fertilizer. Benefit : cost ratio was maximum

(1.75) in groundnut-rice (Table 4). By use of crop residue of mustard, jute, groundnut and maize a saving of Rs 415, 432, 669 and 811 could be made respectively from the total fertilizer cost of Rs 1 966, if supplied through only inorganic source. A saving of Rs 405 was obtained in case of green manuring.

Thus, recycling of crop wastes or use of green manure can substitute a part of chemical fertilizer for sustainability of soil fertility, higher land productivity, minimizing cost of fertilizer use and increased net income.

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