Indian Journal of Agronomy **46** (4) : 648–653 (December 2001)

Recycling effect of crop residues with chemical fertilizers on physico-chemical properties of soil and rice (*Oryza sativa*) yield

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Received : January 2001

ABSTRACT

A field experiment was conducted at the Assam Agricultural University, Jorhat, during the rainy season of 1997 and 1998, to study the recycling effect of crop residues along with chemical fertilizers on physico-chemical properties of soil at harvest and on yield of rice (*Oryza sativa* L.). Incorporation of crop residues like wheat (*Triticum aestivum* L. emend. Fiori & Paol.) straw (5 tonnes/ha) or rice straw (5 tonnes/ha) decreased the bulk density and increased the organic matter, cation-exchange capacity, hydraulic conductivity, water-holding capacity of soil than the initial values after 2 years of study and also increased the grain and straw yields of rice. Rice straw-incorporated treatment did not show significant difference with wheat straw-incorporated treatment. Increasing levels of NPK applied in rice increased grain and straw yields and did not show any significant effect on soil physico-chemical properties.

Key words : Crop residues, Chemical fertilizers, Physico-chemical properties, Rice yield

Application of organic materials along with inorganic fertilizers into soil leads to increase the crop productivity and also sustained the soil health permanently in the areas of high rainfall as well as in wet cultivation of rice where fertilizers efficiency is very low. Application of organic manures can counteract the deleterious effect of continuous use of fertilizers on physico-chemical properties of soil (Singh *et al.*, 2000). Considering the advantage of recycling of plant biomass and the concept of sustainable agriculture the present experiment was carried out to study the recycling effect of crop residues with chemical fertilizers on physico-chemical properties of soil at harvest and on yield of rice.

MATERIALS AND METHODS

An experiment was conducted during the rainy season of 1997 and 1998 at the

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Assam Agricultural University, Jorhat. The treatments comprising 3 sources of crop residues, viz. no crop residue, wheat straw (5 tonnes/ha) and rice straw (5 tonnes/ha), and 4 levels of NPK, viz. 0, 50, 75 and 100% recommended doses of NPK for rice, were replicated thrice in randomized block design. Crop residues were chopped and applied 1 week before rice transplanting. Rice variety 'Basundhara' was transplanted during the third week of July in both the years. The soil was sandy loam, with pH 5.3, bulk density 1.48 g/cc, hydraulic conductivity 7.5 cm/hr, organic matter 1.16%, cation-exchange capacity 6.1 Cmol (P^+)/kg, maximum water-holding capacity 37.67% and available N, P_2O_5 and K_2O were 265.8, 14.7 and 71.9 kg/ha respectively. The total rainfall during the whole crop season was 1,322.9 and 1,015.7 mm in 1997 and 1998, respectively, which was well distributed throughout the growth period. The weekly average maximum and minimum temperatures during crop season were 31.04°C and 23.28°C in 1997 and 31.68° and 24.86°C in 1998 respectively.

RESULTS AND DISCUSSION

Effect on physico-chemical properties of soil

pH : Soil pH at harvest of rice was not significantly affected by incorporation of different crop residues and application of different levels of NPK fertilizers (Table 1).

Bulk density: Soil bulk density in 0–20 cm and 20–40 cm depth of soil at rice harvest significantly decreased with the incorporation of different crop residues over the control. Addition of crop residues (rice straw or wheat straw) and subsequent decomposition added organic matter to soil and thus mass per unit volume of soil reduced. Lower bulk density in rice-straw and wheat straw-incorporated plots was due to higher carbon content of straw. Decrease in bulk density with the increase in organic carbon was also reported by Lanjewar *et al.* (1992).

Hydraulic conductivity: Hydraulic conductivity of soil increased significantly due to incorporation of crop residues in rice field over the control. Addition of crop residues in soil-added organic matter which created favourable environment for increasing hydraulic conductivity. Mishra and Sharma (1997) also reported similar results.

Organic matter: Organic matter in soil at harvest of rice was favourably influenced by addition of different crop residues, resulting significantly higher organic matter in soil. Addition of carbonaceous substances in soil which on decomposition added organic matter. Lanjewar *et al.* (1992) reported that addition of plant biomass increased the organic matter in soil.

Cation-exchange capacity: Both the crop residues improved the cation-exchange capacity of soil over the control. Incorporation of crop residues increased the humus content of soil on their decomposition and thus increased the cation-exchange capacity. Yadav and Kumar (1993) also reported increase in cation-exchange capacity due to addition of organic matter.

Maximum water-holding capacity: Incorporation of crop residues decreased the bulk density and increased the soil porosity, thus significantly enhanced the water-holding capacity of soil. Organic

Table 1. Soil physico-chemical properties at harvest of rice as affected by recycling of crop residues and different levels of NPK

Treatment	pH		Bulk density (g/cc)				Hydraulic conductivity (cm/hr)		Organic matter (%)		Cation exchange capacity (cmol (P^+)/kg)		Maximum water-holding capacity (%)	
	1997	1998	0–20 cm		20–40 cm									
			1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Crop residue														
No crop residue	5.6	5.5	1.42	1.43	1.54	1.53	9.38	9.58	1.25	1.21	8.61	9.52	35.38	36.76
Wheat straw (5 tonnes/ha)	5.5	5.4	1.36	1.34	1.50	1.44	11.19	11.66	1.44	1.45	11.62	11.83	46.65	50.60
Rice straw (5 tonnes/ha)	5.5	5.5	1.36	1.33	1.49	1.43	11.48	11.99	1.44	1.47	12.14	12.35	47.63	51.06
CD (P=0.05)	NS	NS	0.02	0.03	0.02	0.02	0.71	0.59	0.04	0.04	0.14	0.24	7.33	3.07
Chemical fertilizer														
No NPK	5.4	5.3	1.38	1.37	1.51	1.48	10.55	11.00	1.36	1.36	10.77	11.22	40.85	45.94
50 % NPK	5.5	5.5	1.39	1.37	1.51	1.47	10.73	11.08	1.37	1.38	10.76	11.22	43.51	45.37
75% NPK	5.6	5.5	1.38	1.36	1.50	1.46	10.67	11.11	1.38	1.38	10.81	11.25	44.44	46.38
100% NPK	5.6	5.5	1.38	1.36	1.51	1.46	10.75	11.12	1.38	1.39	10.82	11.24	44.08	46.55
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.03	5.19	11.31	12.21	11.54	11.92	7.89	6.25	12.95	12.88	7.51	8.54	19.41	7.86

materials with high C : N ratio like rice straw or wheat straw improves the soil physical properties like water holding capacity. Favourable effect of crop residues on soil water-holding capacity was also reported by Yadav and Kumar (1993).

Thus, addition of crop residues like rice straw or wheat straw improved the physico-chemical properties of soil after rice harvest compared to initial values. However, the values recorded under rice straw-incorporated plot did not differ with wheat-straw-incorporated plot. Different levels of NPK fertilizers did not show any significant effect on soil physico-chemical properties.

Effect on yield

Incorporation of rice straw increased the grain yield significantly over the control; however, it was on a par with wheat straw incorporation (Table 2). Addition of crop residues improved the soil health, thus increased effective tillers, length of panicle and grains/panicle (Table 3) which ultimately attributed to increase in grain yield. Straw yield obtained under wheat straw-incorporated treatment was statistically at par with rice straw-incorporated treatment and both the treatments produced significantly higher values over no-crop residue treatment. Crop residues on decomposition released nutrients to soil slowly throughout the growth period of rice plant which resulted better plant growth (Table 3) and higher straw yield. Naphade *et al.* (1993) reported similar effect of organic matter management.

Both grain and straw yields of rice

Table 2. Grain and straw yields of rice as affected by recycling of crop residues and different levels of NPK

Treatment	Grain yield (q/ha)			Straw yield (q/ha)		
	1997	1998	Pooled	1997	1998	Pooled
Crop residue						
No crop residue	22.69	24.94	23.82	65.05	71.61	68.33
Wheat straw (5 tonnes/ha)	26.76	29.98	28.37	71.03	75.74	73.39
Rice straw (5 tonnes/ha)	28.13	30.74	29.43	70.90	75.40	73.15
CD (P=0.05)	1.52	1.60	1.46	3.60	1.60	2.88
Chemical fertilizer						
No NPK	17.04	18.21	17.63	50.77	52.81	51.79
50 % NPK	25.94	26.88	26.41	66.53	70.85	68.69
75% NPK	29.54	33.89	31.72	76.11	82.68	79.40
100% NPK	30.89	35.57	33.23	82.56	90.66	86.61
CD (P=0.05)	1.78	1.91	1.82	4.15	1.85	3.25
CV (%)	7.03	13.88	10.46	12.55	6.16	9.61

Table 3. Growth and yield components of rice as affected by recycling of crop residues and different levels of NPK

Treatment	Plant height (cm)		Effective tillers/ m^2		Panicle length (cm)		Grains/ panicle		Test weight (g)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Crop residue										
No crop residue	85.18	84.00	282.98	290.11	18.14	18.79	115.23	119.91	25.13	25.56
Wheat straw (5 tonnes/ha)	90.48	91.44	306.83	311.85	21.88	22.59	123.93	128.55	25.31	25.64
Rice straw (5 tonnes/ha)	90.37	91.64	310.53	313.98	22.09	22.79	125.44	129.02	25.22	25.62
CD (P=0.05)	2.82	2.01	4.08	5.17	0.76	0.75	4.14	2.67	NS	NS
Chemical fertilizer										
No NPK	81.78	82.37	245.23	249.40	17.52	17.94	112.33	117.43	23.93	24.19
50 % NPK	90.11	91.53	286.94	292.87	21.27	21.98	122.67	127.19	24.52	25.46
75% NPK	93.89	94.70	332.69	338.81	23.57	24.43	129.24	133.49	26.16	26.34
100% NPK	94.26	95.51	347.59	352.17	24.47	25.18	131.22	134.52	26.26	26.43
CD (P=0.05)	3.20	2.26	4.71	5.98	0.87	0.87	4.69	3.00	0.77	0.93
CV (%)	13.63	12.54	11.59	11.98	4.11	3.96	13.88	12.39	3.13	9.13

increased with increasing levels of the recommended NPK fertilizers. Application of higher levels of NPK fertilizers significantly increased the vegetative growth and yield-attributing components which resulted in increased photosynthetic area as well as sink area which ultimately resulted in higher grain and straw yields. The highest grain and straw yields were recorded under 100% NPK level, followed by 75, 50 and 0% NPK level.

It could be inferred from the present study that addition of crop residues improved the soil health, and thus increased the growth and yield components which gave higher yield. Increasing levels of NPK application increased the yield and 100% recommended NPK dose gave the highest yield of rice.

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