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Application of crop residues in combination with chemical fertilizers for sustainable productivity in rice (*Oryza sativa*)– wheat (*Triticum aestivum*) system

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ABSTRACT

In an experiment conducted during 1997–98 and 1998–99, incorporation of crop residues of either rice (*Oryza sativa* L.) straw or wheat (*Triticum aestivum* L. emend. Firori & Paol.) straw increased the yield and yield components of rice and nutrient uptake and also improved the physico-chemical properties of the soil which provided better soil environment for crop growth. Increasing levels of NPK application increased the yield-attributing characters and nutrient uptake by both the crops which ultimately increased the grain and straw yields thus, 100% NPK levels gave the highest yield. There was no significant effect on physico-chemical properties of soil due to increasing levels of NPK application.

Key words : Crop residues, Chemical fertilizers, Rice–wheat sequence

Rice–wheat sequential cropping being an important cropping system plays a significant important role in food security of India. This system has gained popularity in Assam in recent years which at present occupies nearly 0.02 million ha area. Growing of 2 cereal crops in a year involves heavy removal of plant nutrients which leads to poor soil fertility. Continuous use of only chemical fertilizers in rice–wheat system resulted in the decline in the yield potential of the crops of this cropping system and also deteriorated physico- chemical properties of soil. Therefore, it is desirable to improve or maintain the physico-chemical properties of the soil, increase the efficiency of applied nutrients, and maintain a balance between supply and demand of nutrients by crops through integration of organic and inorganic sources of nutrients for sustainable production. Keeping this in view, the present study was undertaken to evaluate the integrated nutrient supply on the production of rice and wheat in rice–wheat system.

MATERIALS AND METHODS

The field experiment was conducted during 1997–98 and 1998–99 under rainfed conditions at the Assam Agricultural University, Jorhat, Assam. The treatments were 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 fertilizers (0, 50, 75 and 100% of recommended doses) applied to rice and wheat. The trial was conducted in randomized block design having 3 replications. The soil was sandy loam in texture with pH 5.3, having bulk density 1.48 kg Mg/m^3, organic matter 1.16% and available N, P_2O_5 and K_2O 265.8 kg, 14.7 and 71.9 kg respectively. Crop residues were chopped into small pieces and applied 1 week ahead of rice transplanting. A medium-duration rice variety 'Basundhara' was transplanted in the third week of July in both the years. After harvest of rice 'Sonalika' wheat was sown in the last week of November with the addition of same treatments in the same plots. The total rainfall during whole crop seasons was 1,477.3 mm and 1,015.7 mm in 1997–98 and 1998–99, respectively, and distributed uniformly throughout the crop- growth period. However, during the whole wheat season of 1998–99 there was no rainfall.

RESULTS AND DISCUSSION

Yield of rice and wheat

Direct application of crop residues in both rice and wheat signficantly increased the grain and straw yields of both rice and wheat (Table 1). Addition of crop residues and subsequent decomposition released nutrients that helped increase the values of all yield-attributing characters of both rice and wheat which ultimately resulted higher grian and straw yields of both the crops as compared to no-crop residue treatment. The grain and straw yields of both rice and wheat under rice straw and

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wheat straw plots were statistically at par.

Increasing levels of NPK applied both in rice and wheat crops increased grain and straw yields significantly of both the crops. Application of higher levels of NPK, significantly increased the yield-attributing characters of both rice and wheat which resulted in higher grain and straw yields of rice and wheat, showing the highest values under 100% NPK level.

Yield components of rice and wheat

Yield components of rice, viz. effective tillers and grains/panicle, increased significantly with addition of crop residues (Table 1). Rice straw-incorporated plot showed the highest values of yield components of rice, being significantly higher than no-crop residue treatment and was at par with wheat straw-incorporated plot in both the years. Similarly, yield components of wheat like effective tillers and grains/spike also increased significantly owing to application of crop residues. Rice-straw incorporated plot showed the highest values of yield commonents of wheat and were at par with wheat-straw incorporated plot, and both the treatments produced significantly higher values over no-crop residue treatment. Application of crop residues and its subsequent decomposition in soil released plant nutrients in slow manner throughout the crop-growth period causing better uptake of nutrients by both rice and wheat crop. Thus, it increased the values of yield- attributing characters of both rice and wheat. Similar results were also reported by Rajput and Warsi (1991).

Increasing levels of NPK applied both in rice and wheat crops increased the values of yield-attributing characters significantly, giving the highest values at 100% NPK. Higher amount of nutrients application increased the availability of nutrients in root zone, thus more uptake of nutrients by plants resulted in higher values of yield-attributing characters. Dixit (1994) also reported similar type of results.

Nutrient uptake by rice and wheat

Total NPK uptake by rice and wheat was significantly influenced by crop residue treatments. The highest uptake of nutrients was recorded in rice-straw incorporated plot which was at par with wheat-straw incorporation (Table 2). Incorporation of crop residues either rice straw or wheat straw released nutrients slowly throughout the crop-growth period on their decomposition which resulted in better crop growth and higher dry-matter production. Higher total NPK uptake at harvest due to crop residues incorporated treatments, might be attributed higher NPK content in grain and straw over the control treatment

Table 1. Mean yield and yield components of rice and wheat and economics as affected by recycling of crop residues in combination with chemical fertilizers in rice–wheat cropping system

Treatment	Rice					Wheat					Net return (Rs/ha)	Benefit : cost
	Grain yield (kg/ha)	Straw yield (kg/ha)	Effective tillers/ m^2	Grains/ panicle	1,000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Effective tillers/ m^2	Grains/ spike	1,000-grain weight (g)		
Crop residue												
No crop residue	2,382.5	4,833.0	296	119	25.3	1,218.0	2,335.5	163	21	44.6	16,260	1.59
Wheat straw (5 tonnes/ha)	2,837.0	5,338.5	310	127	25.5	1,411.5	2,618.5	284	24	45.2	19,517	1.70
Rice straw (5 tonnes/ha)	2,943.0	5,315.0	313	127	25.4	1,490.0	2,714.5	289	25	45.1	20,566	1.73
CD (P=0.05)	154.06	260.0	4.3	3.2	NS	84.0	220.0	8.5	1.1	NS		
Chemical fertilizer												
No NPK	1,762.5	3,179.0	247	115	24.1	823.5	1,558.0	208	19	40.9	9,520	1.01
50% NPK	2,640.0	4,869.0	290	125	24.9	1,119.0	2,302.5	271	23	44.6	16,875	1.53
75% NPK	3,171.5	5,939.5	336	131	26.3	1,692.0	3,058.0	309	26	47.2	23,653	1.97
100% NPK	3,323.0	6,661.0	350	133	26.3	1,827.0	3,306.0	327	27	47.2	25,330	2.02
CD (P=0.05)	180.2	279.0	5.2	3.7	0.7	98.5	243	10.2	1.1	1.0		

together with higher dry-matter yields. Similar observations were reported by Mittra and Sharma (1991) regarding higher nutrient concentration in plant parts with application of crop residues.

Increasing levels of NPK application influenced the total NPK uptake at harvest of both rice and wheat, giving the highest values under 100% NPK level. Application of higher doses of NPK might have increased the NPK concentration in grain and straw of rice and wheat crop. Higher NPK content at higher level of NPK application together with higher dry-matter production resulted higher NPK uptake. This results support the findings of Ghosh and Chatterjee (1981), Dhillon and Dhillon (1991) and Pandey *et al.* (1993).

Physico-chemical changes in soil

Incorporation of crop resiudes like rice straw or wheat straw before transplanting of rice and before wheat sowing in rice–wheat system showed that at the end of whole study, i.e. after harvest of second year wheat crop, the bulk density of the soil decreased and organic matter content increased than the initial values than no-crop residue treatment (Table 3). Rice straw and wheat straw application did not show any significant variation.

Table 2. Recycling effect of crop residues and levels of chemical fertilizers on total uptake of NPK (kg/ha) by rice and succeeding wheat crop

Treatment	Rice						Wheat					
	Total N uptake		Total P uptake		Total K uptake		Total N uptake		Total P uptake		Total K uptake	
	1997	1998	1997	1998	1997	1998	1997–98	1998–99	1997–98	1998–99	1997–98	1998–99
Crop residue												
No crop residue	62.7	70.2	21.1	23.0	104.3	113.9	32.4	21.4	8.9	5.7	42.3	28.6
Wheat straw 5 tonnes/ha	76.1	81.9	25.6	29.1	118.2	128.2	38.8	26.3	11.3	7.4	51.8	33.8
Rice straw 5 tonnes/ha	78.5	83.8	26.2	29.3	119.6	132.3	41.4	27.3	12.2	7.9	54.3	35.1
CD (P=0.05)	4.0	2.7	2.1	NS	5.0	4.0	3.1	1.6	0.8	0.6	2.8	2.5
Chemical fertilizer												
No NPK	72.3	48.8	14.6	15.0	80.0	81.6	18.9	14.7	4.8	3.6	25.2	20.7
50% NPK	69.7	72.3	22.6	24.0	109.9	116.4	32.9	21.4	8.9	5.6	44.1	27.6
75% NPK	82.8	92.1	28.4	33.0	127.8	145.4	47.2	30.4	14.0	8.9	61.9	39.0
100% NPK	89.9	101.4	31.8	37.1	139.7	155.8	51.2	33.7	15.5	9.8	67.3	42.7
CD (P= 0.05)	4.6	3.1	2.4	10.3	5.8	4.6	3.6	1.9	0.9	0.7	3.2	2.9

Table 3. Soil physico-chemical changes after 2 years as affected by recycling of crop residues in combination with chemical fertilizers in rice–wheat cropping system

Treatment	Organic matter (%)	Bulk density (g/cc)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Crop residue					
No crop residue	1.22	1.41	230.17	9.31	49.04
Wheat straw (5 tonnes/ha)	1.51	1.30	240.32	14.02	61.04
Rice straw (5 tonnes/ha)	1.52	1.30	238.38	13.75	59.84
CD (P=0.05)	0.03	0.02	3.52	0.38	3.05
Chemical fertilizers					
No NPK	1.41	1.34	214.73	7.78	47.22
50% NPK	1.42	1.35	245.26	12.16	55.93
75% NPK	1.42	1.33	246.81	14.59	60.38
100% NPK	1.43	1.34	249.20	14.80	63.02
CD (P=0.05)	NS	NS	4.08	0.44	3.52
Initial values	1.20	148	265.80	14.70	71.90

Addition of crop residues, which on decomposition, added humus to the soil and thus mass per unit volume of soil decreased resulting in decrease in bulk density and increase in organic matter content. Our results support those of Panda *et al.* (1999). However, application of different levels of NPK did not affect the physical properties of soil.

Available N, P_2O_5 and K_2O in soil after 2 years increased significantly due to application of crop residues over no-crop residue treatment. However, rice straw incorporation did not show any significance with wheat-straw incorporated treatment. Application of higher levels of NPK both in rice and wheat also increased the available N, P_2O_5 and K_2O in soil after crop harvest. But residual available N, P_2O_5 and K_2O due to application of crop residues were less than initial values, which might be due to heavy removal of these nutrients by rice and wheat crop. Similarly, increasing levels of NPK application though increased the residual available nutrients in soil, the values were also less than initial values due to heavy removal of nutrients by the crops. Only 100% NPK level produced the highest available P_2O_5 than initial values.

Economics

Addition of crop residues like rice straw or wheat straw both in rice and wheat crops increased net return and benefit : cost ratio (Table 1). Application of crop residues increased grain and straw yields of rice and wheat thus, increased economic benefits. Among different crop residues, rice straw application showed the highest economic return followed by wheat straw application.

Increasing levels of NPK applied both in rice and wheat increased the net return and benefit : cost ratio, giving the highest return under 100% NPK level. Increasing levels of NPK increased both grain and straw yields of rice and wheat, thus increased the economic return.

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