

Effect of crop-residue incorporation load on nitrogen requirement of succeeding crops and soil productivity in rice (*Oryza sativa*) –wheat (*Triticum aestivum*) system

R.S. NARANG, S.S. BRAR AND SANJEEV KUMAR

Department of Agronomy, Punjab Agricultural University, Ludhiana 141 004

Received: September 1999

ABSTRACT

A field experiment was conducted during 1992–93 to 1994–95 to investigate the effect of incorporation of variable crop residue loads of combine harvested rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) crops on the nitrogen requirement of succeeding crops of wheat and rice grown in sequence and soil productivity. The treatments consisted of 3 levels of residue loads in the main plots and 3 of nitrogen (80, 120, 160 kg N/ha) in the subplots. The crop sequence of wheat followed by rice was taken for 3 years on the same site. An increasing trend was noted in crop yield and productivity with the increase in the level of residue load incorporated. The incorporation of moderate level of crop residue load in conjunction with the application of recommended level of N (120 kg/ha) not only assisted in increasing the grain yield but also increased the organic matter content, available N and P.

Key words: Crop residue, N, Soil productivity, Rice–wheat system

In the Indo-Gangetic plains region of India nearly 12 million ha is accounted for rice–wheat rotation. Substantial area under this crop sequence is combine harvested, leaving enormous quantities of organic matter—the quantities depend on the crop status and soil fertility. The disposal of crop residue, in general, and rice, in particular, has received increasing attention. Crop residues can be managed by removing or by burning, or by *in-situ* incorporation. The burning of residues is not only a source of atmospheric pollution but also results in loss of precious plant nutrients and valuable renewable organic mat-

ter resources (Ponnamperuma, 1984). The physical removal of combine harvested crop residue is no longer feasible because of increased labour cost and scarce labour availability. Thus public concern over wastage of this valuable resource stimulated interest in the incorporation of above-ground biomass (stubble and straw). The incorporation of such large quantities of crop residue, however, results in temporary immobilization of plant nutrients, resulting in neutralizing the beneficial effects of incorporation in soil on grain yield of succeeding crops. Variable results have been reported by Bhatnagar *et al.* (1983)

and Beri *et al.* (1995).

A field experiment was therefore conducted for 3 years to study as to how the incorporation of variable loads of organic residue of rice and wheat crops from combine harvested fields would affect the N requirement and performance of succeeding crops of wheat and rice in the sequence, and effect of such incorporation, year after year on the physico-chemical properties of soil.

MATERIALS AND METHODS

The field experiment was carried out at Agronomy Research Farm, Ludhiana (30°54'N and 75°48'E) at an elevation of 247 m above mean sea-level, from crop season 1992-93 to 1994-95. The soil was loamy sand (Typic Ustochrept), having pH 7.8, electrical conductivity 0.21 dS/m and was low in organic carbon (0.30%) and available nitrogen (182 kg N/ha), high in available phosphorus (36 kg P/ha) and high in available potassium (182 kg K/ha). To initiate the experiment a crop of rice was transplanted during rainy season (*kharif*) (second fortnight of June) and it was applied 80, 120 and 160 kg N/ha to create 3 rice residue loads. The crop after simulated combine harvesting was incorporated as such in the respective main plots. During different year's crop residue loads L_1 , L_2 and L_3 were as given in the Table 1 and wheat was sown 4 weeks after incorporation of rice above-ground biomass and applied 3 levels of nitrogen, viz. 80, 120, and 160 kg N/ha. Likewise, the biomass obtained

as result of 3 levels of N, resulting in 3 variable crop residue loads was combine harvested (simulated) and incorporated into soil. The rice crop was raised with 3 levels of N (80, 120 and 160 kg/ha) transplanted 4 weeks after incorporation of wheat residue. In case of wheat, half of the treatmental N was applied at the time of sowing, and remaining half was applied through urea at the first irrigation 4 weeks after sowing. A basal dose of 60 kg P_2O_5 /ha and 30 kg K_2O /ha was given at the time of sowing. While in rice, N was applied in 3 splits, viz. one-third at time of last puddling, one-third 3 weeks after transplanting and the rest 6 weeks after transplanting. Besides, the crop received 25 kg $ZnSO_4$ /ha (5.75 kg Zn/ha). Recommended package of practices was followed to raise the crops. Thorough incorporation to a mean depth of 10-15 cm was achieved with the help of off-set disc harrow run after shredding of the standing crop residue left-over after combine harvesting with a rotary blade shredder into 25-30 cm fragments. The yield data on wheat and rice were recorded every year for 3 years. The soil samples were analyzed for organic carbon, available N, P and K by standard methods after completion of 3 cycles of rice-wheat sequence.

RESULTS AND DISCUSSION

Grain yield

Wheat: Different rice residue loads incorporated did not influence the grain yield of succeeding wheat during the first year (Table.2).

Table 1. Average quantity of crop residue loads of rice and wheat (tonnes/ha) incorporated during different years

Crop residue load	1992-93		1993-94		1994-95		Total load incorporated	
	Rice*	Wheat**	Rice	Wheat	Rice	Wheat	Rice	Wheat
L_1	4.4	6.9	7.8	6.0	5.6	5.9	17.8	18.8
L_2	5.6	7.7	8.6	6.3	6.2	6.2	20.4	20.2
L_3	6.0	8.5	9.4	6.5	6.5	6.3	21.9	21.3

*Rice residue incorporated before sowing wheat; **wheat residue incorporated before transplanting rice

But wheat grain yield showed a significantly higher production with incorporation of higher crop loads (L_2 and L_3) over that of lower load (L_1) during the next 2 years, L_2 and L_3 being at par. Incorporation of lower loads (L_1) recorded wheat yield of 50.4 q/ha which was lesser by a margin of 0.6 q/ha with incorporation of higher, i.e. 6.0 tonnes/ha (L_3) of rice residue in the first year. However, wheat yields at L_2 and L_3 were at par between themselves and were significantly higher than L_1 during 1993–94 and 1994–95, with differences getting increased with time at high levels of loads. It is possible that L_3 might yield significantly higher than L_2 with time. Sidhu and Beri (1989) also observed such effect.

Wheat grain yield was significantly higher with 160 kg N/ha over 120 and 80 kg N/ha during 1992–93 and 1993–94; however, during 1994–95 though the trend of high yield was maintained at 160 kg N/ha, the differences at 120 and 160 kg N/ha were not significant. The interaction of N and residue

loads was, however, not significant in any of the years, but maximum yield in all 3 years was obtained at $N_3 \times L_3$, followed by $N_3 \times L_2$ and $N_3 \times L_1$.

A general trend in yield improvement was thus observed with highest yields, being obtained in the initial year with application of higher level of 160 kg N/ha at least, and as the yield at 120 kg N/ha tends to equalize that of 160 kg N/ha in the third year, this might obviate the need for higher level, expiry year of 2–3 year gestation period, often observed in such studies.

Rice: The wheat residue loads affected the rice yield significantly during both the years. The highest yield of rice in both the years was obtained at L_3 . In 1993–94, rice grain yield at L_3 was significantly superior to L_1 , whereas L_2 was at par with both L_3 and L_1 . In 1994–95, the trend of the previous year was found to persist. The results thus indicate that differential effect of wheat residue loads incorporated in the initial years, becomes distinctly

Table 2. Effect of crop residue loads and nitrogen on yield of wheat and rice (q/ha)

Nitrogen (kg/ha)	Wheat											
	1992–93				1993–94				1994–95			
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
	<i>Wheat</i>											
N_{80}	46.2	44.8	43.3	44.8	42.2	43.4	43.0	42.9	43.2	45.7	46.6	45.1
N_{120}	51.8	51.5	49.4	50.9	47.1	47.5	48.1	47.6	49.6	49.9	50.8	50.1
N_{160}	53.1	55.3	56.7	55.0	49.1	50.7	51.1	50.3	50.1	50.9	52.1	51.0
Mean	50.4	50.5	49.8		46.1	47.2	47.4		47.6	48.8	49.8	
<i>CD (P = 0.05)</i>												
Load (L)	NS				1.03				1.12			
N level (N)	3.23				1.61				1.95			
Interaction (L x N)	NS				NS				NS			
	<i>Rice</i>											
N_{80}					51.0	54.5	55.0	53.5	32.5	36.5	40.5	36.5
N_{120}					58.6	58.2	59.6	58.8	37.4	40.8	42.1	40.1
N_{160}					60.4	61.6	64.1	62.0	40.3	41.4	42.8	41.5
Mean					56.7	58.1	59.6		36.7	39.6	41.8	
<i>CD (P = 0.05)</i>												
Loads (L)					1.81				1.74			
N levels (N)					1.84				1.01			
Interaction (L x N)					NS				1.75			

Table 3. Nutrient status (0–15 cm soil layer) in relation to loads of crop residue incorporated at the end of 3-year rice–wheat cycle after harvest of wheat

Treatment	Organic carbon (%)	Available nutrients (kg/ha)		
		N	P	K
<i>Crop residue load (tonnes/ha)</i>				
L ₁	0.33	183.5	39.4	187.5
L ₂	0.35	199.2	40.0	190.0
L ₃	0.38	198.1	40.8	193.6
Trend	+ve	+ve	+ve	+ve
<i>Nitrogen (kg/ha)</i>				
N ₈₀	0.35	176.5	38.7	189.4
N ₁₂₀	0.35	198.6	40.6	191.5
N ₁₆₀	0.36	205.8	41.0	190.3
Initial	0.30	182.0	36.0	180.0
Trend	Status quo	+ve	+ve	+ve

marked at higher level of residue inputs.

The interaction of wheat residue loads and N levels to rice was significant in 1994–95 only showing that the wheat loads effect tended to become less distinctive at the increased N levels. Rice grain yield at L₃N₁₂₀ was at par with L₃N₁₆₀. These results corroborate the findings of Srivastva *et al.* (1988). This showed that compensation in N use up to 40 kg/ha could be effected through resorting to higher level of wheat residue inputs or vice-versa. Sidhu and Beri (1989) also reported that the incorporation of wheat residue before sowing corn, to be equivalent to about 40 kg N/ha. But such trend needs further confirmation.

Soil fertility: In general, there was a positive trend in respect of all the soil-fertility parameters with incorporation of higher levels of organic residue in soil and all the components, viz. organic carbon, available N, P and K, over

the initial value. The effect was pronounced on the build-up of P, due probably in response to more solubilizing of added organic P material by the soil microflora.

Thus soil fertility can be improved by further continuation of incorporation of crop residue loads of combine harvested rice and wheat crops in conjunction with 160 kg N/ha to wheat, at least during the initial years. And it might possibly be sustained with recommended level of 120 kg N/ha input, after initial gestation phase of 2–3 years is over and whence the cumulative effect of added organic matter laid to come into play.

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