Indian Journal of Agronomy **45** (3) : 458–462 (September 2000)

Effect of moisture regime and nitrogen on decomposition of combine harvested rice *(Oryza sativa)* residue and performance of succeeding wheat (*Triticum aestivum*) in rice–wheat system in Punjab

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Received: December 1999

ABSTRACT

A field experiment was carried out at Ludhiana (30° 54' N and 75° 48' E) on loamy sand soil from 1992–93 to 1994–95, to study the effect of nitrogen and irrigation on the decomposition of combine harvested rice (*Oryza sativa* L.) residue and consequently on stand establishment, growth and yield of suceeding wheat (*Triticum aestivum* L. emend. Fiori & Paol.). Application of extra nitrogen @ 40 kg/ha along with 1 irrigation at the time of incorporation of rice straw not only reduced the immobilization of available N but also resulted in quantum jump in wheat yield. All the growth and yield attributes of wheat, viz. emergence count, plant height, effective tillers and grains/ear significantly improved with additional nitrogen and irrigation as compared to farmers practice of residue burning or residue incorporation, followed by conventional tillage with recommended/normal nitrogen and irrigation.

Key words : Rice, Wheat, Moisture regime, N, Rice–wheat system

In Punjab (India) where 2 crops are grown in a year, rice–wheat cropping system is practised on nearly 2.3 million ha. To ensure an early sowing as well as to curtail the higher cost of harvesting and threshing by manual laboures, farmers operate combine harvesters in nearly 85% of the area under rice in the state. The *in-situ* burning being quick and an easy approach for disposal of the residues left in the field is popular with the farmers. The buring of residues, however, besides adding to atmosphere pollution, results in loss of valuable renewable organic matter resource. Thus, public concern over wastage of this precious resource stimulated interest in the incorporation of straw.

The primary factors hampering the recycling of rice residues are: its improper incorporation due to use of off-set disc harrow as primary tillage implement, wide C:N ratio, slow decomposition rate under the rapidly falling temperature regime (second fortnight of October) and inadequate availability of the moisture in the top 30 cm layer. This causes frequent choking of seed drill (Glen *et al.*, 1988), inadequate plant stands and immobilization of applied inorganic nitrogen (Beri *et al.*, 1995) and consequent low productivity in the residue-incorporated fields. Therefore this experiment was planned and carried out to develop a suitable technology to hasten the decomposition of rice straw through moistute regime and nitrogen supply in the rice–wheat system, to achieve stable, high yield of succeeding wheat crop.

MATERIALS AND METHODS

The field experiment was carried out at the Agronomy Research Farm, Ludhiana, from the winter (*rabi*) season (October–April) of 1992–93 to 1994–95 on loamy sand soil, generally classified as Typic Ustochrept, with normal EC (0.20 dS/m) and pH (7.8). It was low in organic carbon (0.26%) and available nitrogen (147 kg/ha), high in available phosphorus (36 kg/ha) and medium in available potassium (169 kg/ha).

Table 1. Details of the treatments used in the experiment

Treatment	Details
T_1	$C_I + R_N + R_I$
T_2	$C_I + R_N + E_I$
T_3	$C_I + E_N + R_I$
T_4	$C_I + E_N + E_I$
T_5	$C_B + R_B + R_I$ (farmers' practice)

C_I, Residue incorporated with off-set disc harrow; R_N, N at recommended rate, 120 kg N/ha; R_I, recommended post-sowing irrigation; E_N, extra N @ 40 kg N/ha applied at incorporation; E_I, extra irrigation applied immediately after incorporation; C_B, rice residue burnt

The experiment was laid out in quadruplicate randomized block design with 5 treatments as detailed in Table 1. The extra nitrogen at 40 kg/ha and extra irrigation (7.5–8.0 cm) were applied immediately after rice residue incorporation, so as to provide congenial moist environment for high microbial activity. Normal nitrogen comprised application of 120 kg N/ha in 2 splits, half basal at sowing time and remaining after the first irrigation at about 4 weeks after seeding. Besides, wheat crop was provided with a dose of 60 kg P_2O_5/ha (whole applied at the time of sowing), 3–4 irrigations and weed-management measure with isoproturon @ 0.94 kg/ha as recommended by the Punjab Agricultural University, Ludhiana. Wheat variety HD 2329' was sown in the second fortnight of November using 100 kg seed/ha in rows 20 cm apart and harvested in the third week of April during all the years.

RESULTS AND DISCUSSION

Grain yield

The grain and its components, viz. number of effective ear-bearing tillers, number of grains/ear and straw yield, were significantly higher under treatment T_4 (rice paddy residue-incorporated plots) applied with extra irrigation and extra nitrogen compared with T_1 (control) and T_5 (farmer's practice). The findings corroborated the results of Sarkar *et al.* (1991) and Singh *et al.* (1992). The lowest effective tiller number and plant height under T_1 might be probably due to temporary interlocking of available nitrogen under T_1 and simultaneous high demand of nitrogen existing at the time of tiller production/grand growth.

The mean data of 3 years (Table 2) revealed that statistically better grain yield was obtained with farmers' practice (T_5) over the control T_1, thereby, indicating slightly depressed yield under residue-incorporated conditions applied with normal inputs. Sidhu and Beri (1989) also obtained low wheat yields under residue-incorporated situations applied with normal inputs compared to residue-burning practice.

Nitrogen uptake

The total N uptake showed that there was 24 kg/ha more N uptake under T_4 than under T_1, treatment, the standard control (Table 2). Likewise, total uptake of nitrogen was higher by 5.6 kg/ha under T_2 (extra irrigation) and 16.1 kg/ha under T_3 (extra nitrogen). This shows that extra irrigation alone improved the nitrogen availability by only a nominal margin. Additional application of 40 kg N/ha alone resulted in almost 3 times more uptake than the extra irrigation alone; but combined application of an extra irrigation and 40 kg N/ha at the time of incorporation under T_4 increased the uptake by margin which was more than combined individual figure obtained under T_2 and T_3; thus boosted the yield by a substantial margin. Jana and Ghosh (1996) also reported similar increase in N uptake. They further reported that higher uptake of nutrients by the crop contributes towards the increased grain yield.

Soil-fertility status

The soil-fertility status was monitored after completion of 3-year cycle of rice–wheat system (Table 3). The available N and P respectively improved to 225 and 217 and 40.0 and 43.5 kg/ha under T_3 ($C_1 + E_N + R_1$) and T_4 (C_1+E_N + E_1) over the initial values of 182 kg N/ha and 36 kg P/ha. The respective values for T_5 (C_1+ R_N + R_1) treatment were 192.8 kg N/ha and 39.2 kg

Table 2. Effect of crop-residue management on growth, yield and total N uptake in wheat (mean data of 3 years)

Treatment		Seedling emergence/m row length	Effective tillers (No./m²)	Final plant height (cm)	Grains/ ear	1,000-grain weight (g)	Grain yield (q/ha)	Straw (q/ha)	Total uptake (kg/ha)
T_1	$C_1+R_N+R_1$	49.8	426	78.1	46.1	42.6	49.4	74.2	100.7
T_2	$C_1+R_N+E_1$	50.6	433	79.4	46.5	42.6	50.7	76.4	106.3
T_3	$C_1+E_N+R_1$	51.3	442	79.1	48.3	42.3	53.1	79.4	116.8
T_4	$C_1+E_N+E_1$	52.0	452	80.2	48.8	42.5	55.1	81.5	124.7
T_5	$C_1+R_N+R_1$ (farmers' practice)	51.0	437	78.9	47.3	42.9	51.6	77.1	109.2
CD (P=0.05)		NS	8.0	1.26	0.81	NS	1.66	2.44	2.00

T_1, Rice residue incorporated, recommended nitrogen and irrigation applied; T_2, rice residue incorporated, recommended nitrogen and extra irrigation applied; T_3, rice residue incorporated; extra nitrogen @ 40 kg/ha and recommended irrigation applied; T_4, rice residue incorporated, extra nitrogen and extra irrigation applied; T_5, rice residue burnt, recommended nitrogen and recommended irrigation applied

Table 3. Tillage dynamics and economics

Treatment	No. of operations			Time (hr/ha)	Fuel (litres /ha)	Expenses incurred on extra N/irrigation + fuel (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)
	Discing	Cultivator	Planking					
T_1	6	2	1	8	35.2	241	19,887	10,271
T_2	4	2	1	6	26.4	263	20,419	10,781
T_3	4	2	1	6	26.4	472	21,364	11,517
T_4	4	2	1	6	26.4	575	22,137	12,187
T_5	2	2	1	4	17.6	120	10,758	11,263

T_1 Rice residue incorporated, recommended nitrogen and irrigation applied; T_2, rice residue incorporated, recommended nitrogen and extra irrigation applied; T_3, rice residue incorporated, extra nitrogen @ 40 kg/ha and recommended irrigation applied; T_4; rice residue incorporated, extra nitrogen and extra irrigation applied; T_5; rice residue burnt, recommended nitrogen and recommended irrigation applied

Tractor Model : (1985); Time taken for a single operation/ha–discing, 1 hr; cultivator, 45 min; planking ; 30 min; fuel consumption, 4.4 litres/ha; price of diesel/litre, Rs 6.85; price of 40 kg N as urea, Rs 292; price of 1 irrigation + labour charges, Rs 83; cost of wheat cultivation, Rs 9,375/ha

P/ha, showing appreciable improvement over the initial values. Bhandari *et al.* (1997) also reported positive flux of nitrogen, phosphorus and organic carbon due to incorporation of combine harvested paddy residue.

Tillage dynamics and Economics

Residue incorporation without additional nitrogen or irrigation T_1, involved maximum number of field operations (9), time (8 hr/ha) and fuel (35.2 litres/ha), however, field operation, time and fuel consumption were considerably reduced in farmers' practice of residue burning. Of the various treatments, application of extra 40 kg N/ha and an additional irrigation immediately after incorporation recorded the highest net monetary returns in pooled data (Table 4). The farmers' practice (T_5) showed an edge over residue incorporation applied with normal nitrogen and irrigation (T_1).

Thus to derive maximum benefit of incorporated rice residue, an additional 40 kg N/ha and an extra irrigation be applied at the time of incorporation of crop residue.

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