Indian Journal of Agronomy **45** (1) : 1–5 (March 2000)

Productivity of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system as affected by its residue management and fertility levels

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Received : December 1998

ABSTRACT

A field study on crop-residue management conducted from 1993 to 1997 on rice (*Oryza sativa* L.) –wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system at CCS HAU Rice Research Station, Kaul revealed that rice /grain yield was significantly superior with the incorporation of residues of both rice and wheat crops to their burning and removal. But in wheat the trend was reverse during the early years. During winter season (*rabi*) 1993-94, grain yield of wheat was found to be the lowest (35.8 q/ha) on incorporation of residues of both the crops. Burning of residues gave highest grain yield (43.7 q/ha), closely followed by their removal (42.8 q/ha). However, this deleterious effect on grain yield was recuperated in the subsequent years, thereby registering the highest grain yield of 49.2 q/ha, with the incorporation of residues in fourth wheat crop (1996-97). The influence of burning (44.7 q/ha) and removal (43.0 q/ha) of residues on grain yield of wheat remained at the lowest level amongst the 7 treatments on residue management in *rabi* 1996-97. The average productivity of the system was the highest (114.6 q/ha/year) where the residues of both the crops were incorporated, which was 6.0 and 6.2 q/ha/year higher than from their burning and removal respectively. Higher fertility (150 + 60 + 25 kg N, P_2O_5 and $ZnSO_4$/ ha) registered significantly higher grain yield than lower (100 + 40+25 kg N, P_2O_5 and $ZnSo_4$/ha). Organic carbon and total nitrogen in the soil increased with the incorporation of crop residues but decreased with their burning.

Key words: Residue management, Burning, Incorporation, Carbon, Nitrogen

Rice-wheat cropping system is being followed in about 10 million ha in India (Chaudhary and Pal, 1994). Owing to the exhaustive cropping system, this area during the recent past has shown the symptoms of resource degradation (Hobbs, 1994). Organic matter recycling may be one of the alternative practices for replenishing the depleted fertility from the soil. The predominant methods of harvesting paddy and

wheat crops leave significant amount of residues or stubbles in the field. The effect of residue management in such fields has been found inevitable (Sidhu and Beri, 1989). Hence the present investigation was undertaken to investigate and find out the effect of removal, burning and incorporation of crop residues in rice-wheat system in north-western conditions of India.

MATERIALS AND METHODS

A field experiment on rice-wheat system was carried out from 1993 to 1997 at CCS HAU Rice Research Station, Kaul. The experiment in main plots consisted of seven treatment combinations on removal, burning and incorporation of straw residues of rice and wheat crops, viz. PrWr—residues of paddy and wheat removed; PrWb—paddy residues removed and wheat residues burnt; PbWr—paddy residues burnt and wheat residues removed; PrWi—paddy residues removed and wheat residues incorporated; PiWr—paddy residues incorporated and wheat residues removed; PiWr—paddy residues incorporated and wheat residues removed; PiWi—residues of both the crops incorporated. In subplots, however, two fertility levels, i.e. F_1 (100 + 40 + 25 kg N, P_2O_5 and $ZnSO_4$/ha) and F_2 (150 + 60 + 25 kg N, P_2O_5 and $ZnSo_4$/ha) were kept.

F_2 is the recommended dose of fertilizer for both the crops in this sequence. To facilitate the decomposition of residues at the time of straw incorporation in the field, 25% nitrogen was applied. The remaining N was applied in 3 splits at 0, 21 and 42 days after transplanting in rice, and in 2 splits in wheat at sowing and first irrigation. The entire amount of P_2O_5 and $ZnSO_4$ was applied as basal.

The experiment was started from winter season (*rabi*) 1993-1994 with the sowing of wheat crop and concluded with the harvesting of wheat crop taken in *rabi* 1996-97. The yield results of 4 wheat crops and 3 rice crops have been reported, as the results of incorporation could be clearly visible up to the fourth crop of wheat. Wheat variety 'WH 542' was sown within normal time of sowing (up to third week of November), whereas rice cultivar 'IR 64' was planted between 25 June to 10 July during all the years of study. Rice seedlings when 30 days old were transplanted in split-plot design with four replications. The residues along with entire straw/stubbles left after threshing grains were either removed, burnt or incorporated. One uniform harrowing was used to incorporate crop left-over in other treatments. Two irrigations were given after incorporation of wheat residues for better decomposition before planting the rice crop. A pre-sowing irrigation for wheat crop was applied to whole field after incorporation of paddy residues. Soil samples were collected before the start of the experiment and after the completion of the first and second cycles, i.e. after harvesting of paddy crop and the analysis for organic carbon and total N.

RESULTS AND DISCUSSION

Effect on grain yield

The data in Table 1 reveal that there was pronounced effect of incorporation of residues on the grain yield of paddy during the first year itself. The grain yield of

paddy obtained by the incorporation of residues of both the crops (PiWi) was significantly superior to their removal (PrWr) or burning (PbWb). The lowest grain yield was obtained with the burning of residues of both the crops, which was at par with their removal during all the years. Incorporation of paddy residues alone gave better grain yield of paddy over most of the other treatments. Meelu *et al.* (1994) also reported the beneficial effect of incorporation of crop residues in rice-wheat system.

The grain yield of wheat was adversely affected by the incorporation of crop residues during the initial years of study. However, the deleterious effect was counterbalanced during the subsequent years (Table 1). The results indicate that in *rabi* 1993-94 the lowest grain yield of wheat was obtained where paddy residues alone (PiWr) or of both the crops (PiWi) were incorporated. This might be due to wide C : N ratio, indicating that decomposition was not up to the level of providing nutrients to the crop. The highest grain yield was obtained where the residues of both the crops were burnt (PbWb), which remained at par with their removal (PrWr). During the subsequent years the effect of residue incorporation on grain yield of wheat became conspicuous, thereby producing highest grain yield of 49.2 q/ha in PiWi treatment in *rabi* 1996-97, which was significantly superior to the residue burning (44.7 q/ha) or re-

Table 1. Grain yield and productivity of paddy (unhusked rice) and wheat affected by residue management and fertility level

Treatment	Grain yield (q/ha/year)							
	W93-94	P94	W94-95	P95	W95-96	P96	W96-97	Mean (P + W)*
Residue management								
PrWr	42.8	70.2	38.0	62.0	39.4	72.8	43.0	108.4
PrWb	42.6	72.1	40.7	61.4	40.7	72.7	44.8	100.8
PbWr	42.7	72.3	40.3	61.4	36.4	72.8	45.5	109.6
PbWb	43.7	70.5	42.8	61.0	34.4	72.3	44.7	108.6
PrWi	43.2	71.3	39.5	61.3	38.4	72.9	48.3	110.6
PiWr	36.4	74.6	37.2	63.8	38.0	74.8	46.1	111.5
PiWi	35.8	76.6	36.5	67.4	37.5	76.7	49.2	114.6
CD (P=0.05)	5.6	3.0	NS	2.6	2.9	3.1	2.8	-
Fertility level								
F_1	37.9	70.5	36.8	56.8	34.8	70.3	43.9	104.4
F_2	42.1	75.3	41.8	68.4	40.8	76.8	48.1	117.1
CD (P=0.05)	3.0	1.8	2.6	1.4	1.4	1.4	2.0	-

*Mean of last 3 cycles (1994 onwards); F_1=N, P_2O_5 and $ZnSO_4$ 100, 40 and 25 kg/ha; F_2=N, P_2O_5 and ZnSO4 150, 60 and 25 kg/ha

Table 2. Effect of residue management on organic carbon (%) and soil nitrogen (%) in clay-loam soil

Treatment	1993			1994			1995		
	C	N	C : N	C	N	C : N	C	N	C : N
PrWr	0.53	0.062	8.55	0.53	0.064	8.28	0.51	0.062	8.22
PrWb	0.53	0.066	8.03	0.52	0.063	8.25	0.51	0.063	8.10
PbWr	0.51	0.065	7.85	0.53	0.066	8.03	0.51	0.063	8.10
PbWb	0.52	0.064	8.12	0.51	0.064	7.97	0.51	0.063	8.10
PrWi	0.51	0.063	8.10	0.55	0.071	7.75	0.55	0.068	8.09
PiWr	0.52	0.064	8.13	0.56	0.074	7.57	0.57	0.076	7.50
PiWr	0.52	0.064	8.13	0.59	0.078	7.56	0.66	0.084	7.86

P = Paddy, W = wheat, r = removed, b = burnt, i = incorporated

moval (43.0 q/ha). Of both the crops. This might be due to the effect of increase in organic matter in the soil during the subsequent years where crop residues were incorporated (Table 1). By considering the average of productivity of 3 cycles, it was found that the highest productivity of the system was 114.6 q/ha/year with the incorporation of residues of both the crops, which was 6.0 and 6.2 q/ha/year higher than burning (PbWb) and removal (PrWr) respectively.

Higher fertility level (150 + 60 + 25 kg N, P_2O_5 and $ZnSO_4$/ha) produced significantly higher grain yield over the lower dose (100 + 40 + 25 kg N, P_2O and $ZnSO_4$/ha) in both the crops. Total productivity of the system was 12.7 q/ha/year more under higher fertility level (117.1 q/ha/year) than under lower level.

Effect on soil properties

The effect of incorporation and burning of residues was evident on organic carbon content of the soil (Table 2).

Incorporation of crop residues of both the crops (PiWi) increased the organic carbon content of the soil up to the highest level of 0.66 % from the initial status of 0.52%. Organic carbon was found lowest in the treatments where the crop residues of both or either of the crops were burnt. Total nitrogen was not affected due to burning of crop residues, whereas it increased with the incorporation of crop residues. The highest increase was recorded where the residues of both the crops were incorporated, thereby decreasing the carbon: nitrogen ratio. Singh and Paroda (1993) also reported increase in organic carbon and nitrogen content of the soil with the addition of wheat and rice straw.

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