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Original Article

Effect of Crop Residue and Nitrogen Level in Yield and Yield Attributing Traits of Rice under Rice-Wheat Cropping System

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ABSTRACT

A 3 years (2015, 2016 and 2017) field study was carried out at National Wheat Research Program, Bhirahawa, Rupandehi, Nepal to evaluate the influence of crop residues and nitrogen levels on rice. The experiment was conducted in split plot design with three replications. Main plots were two crop residue levels (with crop residue and without crop residue) and sub plots consisted of seven nitrogen levels (0, 25, 50, 75, 100, 125 and 150 kg N ha^{-1}). Combined analysis of three years data revealed that crop residue levels did not differ significantly in terms of grain yield; however, crop residues incorporation increased the rice grain yield slightly. Significant difference was observed with application of different nitrogen levels in grain yield and yield attributing characters viz; tillers m^{-2}, panicle length, number of filled grains per panicle and thousands grain weight. Rice grain yield was found at increasing rate with the increased level of nitrogen @ 150 kg ha^{-1}. Application of nitrogen @ 150 kg ha^{-1} gave highest grain yield of 4831 kg ha^{-1} which was found at par with nitrogen @ 125 kg ha^{-1} with grain yield of 4722 kg ha^{-1}. Crop residues with nitrogen @ 125 kg ha^{-1} resulted in 216 kg ha^{-1} higher rice grain yield than residues removed treatment. The overall conclusion drawn from the three years field experiment was an improved crop residue management with 125 kg N ha^{-1} increased the grain yield of rice.

Key words: Crop residue, Nitrogen levels, Rice, Yield

Introduction

In recent years, use of combined harvester for harvesting and threshing of rice and wheat crop has been increasing in Western Terai region of Nepal. The crop residue left over after harvesting of previous corp by using combined harvester is major concern to manage for planting succeeding crops under rice-wheat cropping system. So, farmers are compelled to burn such huge amount of crop residues. Burning of wheat residues is cost effective and the predominant method of disposal in areas under combined harvesting in the Indo Gangetic Plains (Samra *et al.,* 2003). However, disposal of crop residues by burning is no longer environmentally acceptable and often criticized for accelerating losses of soil organic matter and nutrients, increasing C emissions and reducing soil microbial activity (Kumar and Goh, 2000).

Crop residues incorporation can improve soil quality and reduce air pollution on a long-term basis. However, where residues have been soil incorporated, farmers often have concerns for reduced soil fertility from nutrient immobilization and problems for cultivation associated with slow rates of residues decomposition (Cookson *et al.,* 1998). Effective mitigation of these effects depends on developing crop residue management strategies that enhance residues decomposition. Realizing the potential benefits of cereal residues incorporation depends on synchronizing the release of N with the crop demands, while minimizing the risks to nutrient losses (Powlson *et al.,* 1985; Hooker *et al.,* 1982). Where residue has been incorporated before planting the next crop, grain yield was lower than where residues were removed or burned, resulting in N immobilization (Bahrani *et al.,* 2002; Singh *et al.,* 2004). The most influential factor on wheat yield is N fertilization, although the degree of influence is governed principally by weather conditions and residual soil N (Garrido-lestache *et al.,* 2005). Hence, this study was conducted to determine the effect of crop residue and nitrogen level on growth and yield of rice under rice-wheat cropping system.

Materials and methods

The field experiment was conducted in three cropping seasons of 2015, 2016 and 2017 at National Wheat Research Program (NWRP), Bhairahawa, Nepal and the field was laid out in split plot design: two crop residue levels (with and without residue) as whole plot and seven nitrogen levels (0, 25, 50, 75, 100, 125 and 150 kg ha^{-1}) as sub-plot which were replicated three times. The rice variety was sabitri and transplanted at the spacing of 20 cm × 20 cm. The plot size was 5 m × 3 m. Urea, single super phosphate and muriate of potash were the source of fertilizers used for supplying nitrogen, phosphorus and potash respectively. Full dose of phosphorus (30 kg P_2O_5 ha^{-1}), potassium fertilizers (30 kg K_2O ha^{-1}), and half dose of nitrogen was applied at the time of land preparation. Whole Crop residues were retained in the field as natural residues after wheat harvesting. The remaining half dose of Nitrogen was top-dressed in two equal splits viz; first at active tillering and second at panicle initiation stage.

Before harvest, plant height, panicle length and tillers m^{-2} of rice were recorded. After harvest, filled grains per panicle, 1000 grain weight and grain yield were recorded. Average plant height and panicle length were recorded from five sample plants. Average number of filed grains per panicle was counted from five panicles for each treatment. Grain yield was measured from 8 m^2 area. Grain yield was adjusted to 14% moisture content determined according to Yoshida (1981). Ten panicles were randomly collected from each plot to determine 1000 grain weight and number of filled grains per panicle.

Statistical analysis

Data were analyzed through GENSTAT statistical package and treatment means were compared using least significant difference (LSD) test at $P \leq 0.05$.

Results and discussion

Effect of crop residue

Results revealed that yield and yield components were significantly affected by nitrogen levels but crop residue had no significant effects on yield and yield components of rice during three cropping seasons (Table 1). Three years combined data analysis showed that incorporation of crop residue slightly increased plant height, panicle length, tillers m^{-2}, filled grains $panicle^{-1}$, 1000 grain weight and grain yield. This suggests that there was positive role of wheat residue in increasing rice yield as compared to without residue condition. The higher yield under residue incorporation might be due to the faster rate of decomposition of wheat straw due to high temperature and longer window between wheat residue incorporation and rice transplanting. Results obtained showed that both rice and wheat residues can be safely incorporated without any detrimental effects on the crops of rice or wheat grown immediately after incorporation.

Table 1. Effect of crop residue and nitrogen level on yield and yield components of rice under rice-wheat cropping system (3 years pooled analysis)

Treatments	Plant height (cm)	Panicle length (cm)	Tillers m^{-2}	Filled grains $panicle^{-1}$	1000 grain wt (gm)	Grain yield (kg ha^{-1})
Crop Residue						
Without crop residue	98	16	226	109	21	4182
With crop residue	99	17	242	111	22	4183
F-Test	ns	ns	ns	ns	ns	ns
LSD (0.05%)						
Nitrogen Level (N kg ha^{-1})						
0	90	13	187	98	19	3258
25	94	15	210	97	20	3676
50	96	15	227	108	21	3952
75	98	17	244	114	22	4393
100	102	18	252	117	22	4445
125	103	18	262	118	23	4722
150	106	19	259	117	23	4831
F-test	**	**	**	**	**	**
LSD (0.05%)	2.3	1.4	39.9	6.7	1.1	231.3
Year						
2014	91	13	215	108	21	3600
2015	97	16	247	104	22	4324
2016	107	20	242	118	22	4623
F-test	**	**	**	**	ns	**
LSD (0.05%)	1.8	1.1	15.2	4.9		126.7
CV %	4.1	14.9	14.9	10.2	10.9	6.9

*, ** and ns indicates significant levels at 0.05, 0.01 and non significant

Application of rice residue to wheat typically has a small effect on wheat yields during the short term of 1-3 years (Singh *et al.,* 2008; Singh *et al.,* 2005) but the effect appears in the fourth year with the incorporation of straw (Gupta *et al.,* 2007). Similarly, Khatri *et al.,* (2017) reported that after two year completion of experiment, biological yield of wheat increased significantly in rice crop residue incorporation treatment.

Effect of nitrogen

Plant height, panicle length, tillers m^{-2}, filled grains $panicle^{-1}$, 1000 grain weight and grain yield of rice significantly increased with increased N rates. Grain yield is a function of interplay of various yield components such as number of productive tillers, panicle length, percentage of grain filling and 1000 grain weight (Hassan *et al.,* 2003). Application of nitrogen @ 150 kg ha^{-1} resulted in significantly highest grain yield and yield components (Table 1), which was found statistically at par with the application of nitrogen @ 125 kg ha^{-1}. The increased grain yield with 125 kg N ha^{-1} might be due to the cumulative effect of the highest number of effective tillers m^{-2}, 1000 grain weight and filled grains $panicle^{-1}$ obtained from the supply of nitrogen for the plants. Similar results were found previously (Singh *et al.,* 2000; Salahuddin *et al.,* 2009). Whereas lowest yield and yield components were obtained from 0 kg N ha^{-1} treatments.

Year wise comparison of grain yield

In the first year, rice yield was found lowest under no crop residues incorporation and grain yield and yield components were found at increasing rate with cropping season increment (Figure 1), which is similar to (Rieger *et al.,* 2008) for no crop residue treatment. During third cropping season, yield was recorded highest of 4633 kg ha^{-1} under crop residue incorporation. Short-term effects of cereal residues (wheat straw) incorporation into paddy field include stimulation of CH_4 emissions, immobilization of available N, suppression of rice growth, and accumulation of toxic materials (Singh *et al.,* 2005; Singh *et al.,* 2008).

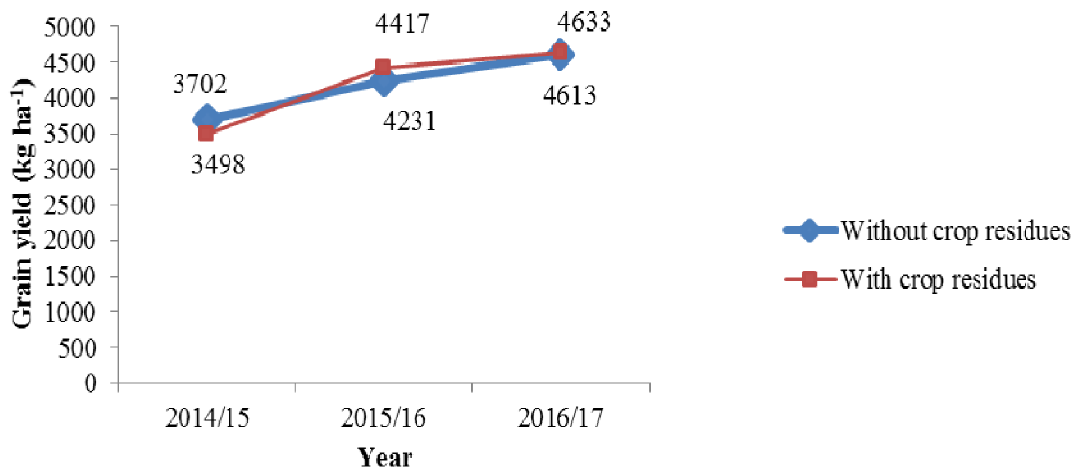

Figure 1. Year wise comparison of grain yield of rice as influenced by crop residues

Interaction effect of crop residue and nitrogen level

The interaction between crop residue and nitrogen level treatment were investigated in Figure 2. The grain yield of rice increased by increasing N levels in both without crop residue and with crop residue treatments. However, higher grain yield was obtained in crop residue incorporation treatment. Incorporation of crop residue into the soil with 150 kg N ha^{-1} gave the highest grain yield in rice of 4884 kg ha^{-1} which was found at par with nitrogen rate of 125 kg ha^{-1} (4830 kg ha^{-1}). Crop residues with nitrogen @ 125 kg ha^{-1} resulted in 216 kg ha^{-1} higher rice grain yield than residues removed treatment. Incorporation of crop residue into soil without N application gave the lowest grain yield of rice. This may be attributed to the soil N imbalance due to the slower decomposition (Figure 2).

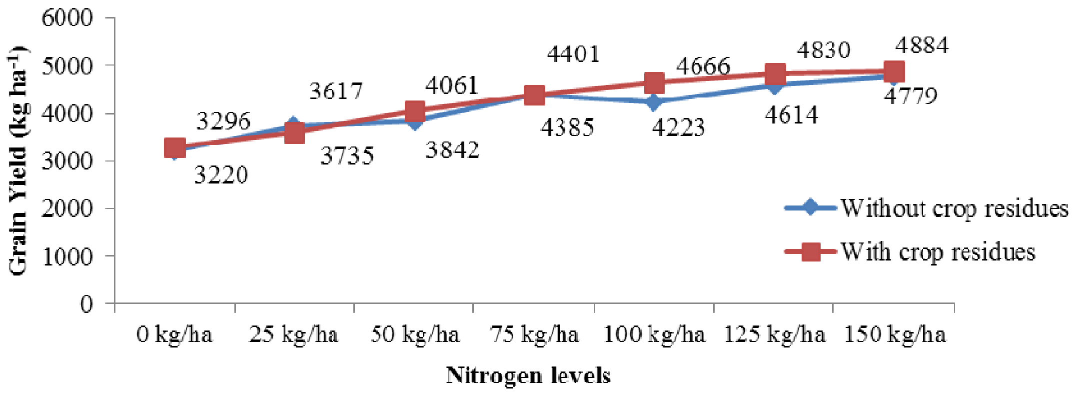

Figure 2. Interaction effect of Crop residues and Nitrogen levels on grain yield of rice (3 years Pooled analysis)

Conclusion

From the results of the present study, it can be concluded that 125 kg N ha^{-1} along with crop residue incorporation may be used to obtain the highest grain yields of rice under rice-wheat cropping system. Thus, farmers are suggested to incorporate crop residues with nitrogen dose of 125 kg ha^{-1} into the soil instead of burning; which is environmentally hazardous to human and soil health.

Conflict of interest

Authors declare no conflict of interest.

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