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Neeraj Kumar Verma [α] & Binod Kumar Pandey [σ]

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I. Introduction

Rice and wheat are currently grown in rotation on almost 26 million hectares of South and East Asia under diverse climatic and soil condition (Timsina and Connor, 2001), contributing 72, 85, 92, 100 and 71% of the total cereal pool of China, India, Pakistan, Bangladesh and Nepal, respectively (Singh and Paroda, 1994). Rice-wheat is the dominant cropping system of Indo-Gangetic plains of India. With the development of high yielding, photo-insensitive cultivars of rice and increased irrigation facilities, the rice cultivation has extended to non-traditional areas of North India where wheat was dominant crop in winter. Similarly, cultivation of wheat extended to some of the traditional rice areas due to development of high yielding, semi-dwarf wheat varieties responsive to nutrient and water. Recently it has been observed that the system is showing sign of fatigue and the crop yield is either stagnating or the factor productivity has fallen down thereby suggesting the requirement of more input to produce the same grain yield. Declining soil fertility resulting from depletion of nutrients, their imbalance application and reduced recycling of organic matter, water-induced degradation of soil and water resources leading to spread of salinity and water balance aberrations, increase in the incidence of pest and disease and loss in biodiversity are some of the factors that adversely affect the sustainability of the production system. There are substantial areas under rice which are combined harvested and also increasing tendency among the farmers to harvest the crop just near the ear-head, leaves behind enormous quantity of nearly 3/4th of the crop residue amounting a million of tonnes is disposed off by burning. The primary reason for burning rather than incorporation for enriching the soil is absence of any suitable residue management practice. The total nutrient value of residues are half of the total contents because it is known that only about 50% of the nutrients are mineralized in the soil on decomposition of crop residues. Their conservative estimates reveal that about 1.6 million tonnes of nutrients from crop residues in rice-wheat system are available for recycling. Besides NPK, cestimated to be about 4.8 mt, which can replace about 30% of the total fertilizer consumption in the country with the intensification of agriculture especially in rice-wheat growing regions of the country. The significance of recycling the organic resources for replacement of plant nutrients and the residues also contain appreciable amount of secondary and micronutrients. Based on the above assumptions, it is estimated that about 43 and 37 million tonnes of straw is in utilization from rice and wheat crop, respectively. The total nutrient value (in terms of NPK) of these crop residues is maintenance of soil health has already been established. However, the limited availability of organic manures and almost nil possibility of in-situ green manuring for wheat after the harvest of rice, the only alternative left is the direct incorporation as rice crop residue to maintain soil organic carbon.

II. Materials and Methods

The experiment was conducted at the Brahmanand Mahavidyalaya Agricultural Research Farm, Post-Rath, District Hamirpur, State-Uttar Prad-

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esh (India) during the winter (*rabi*) season of 2007-08 and 2008-09. The soil of experimental field was 'parwa' (A category of red soil) with slightly alkaline in reaction (pH 7.6) which was low in available nitrogen (200.83 N_2O kg ha^{-1}), medium in available phosphorus (29.28 P_2O_5 kg ha^{-1}) and high in available potassium (474.16 K_2O kg ha^{-1}) and ranging 0.56% organic carbon content. The trial was laid out in randomized block design with three replications having 14 treatment combinations of within recommended dose (T1- Sowing wheat without incorporation of rice residue and recommended NPK (Control), T2- Rice residue incorporation + recommended NPK in wheat sowing, T3- 15% of N at rice residue incorporation + rest in wheat sowing, T4- 30% of N at rice residue incorporation + rest in wheat sowing, T5- 15% of NP at rice residue incorporation + rest in wheat sowing, T6- 30% of NP at rice residue incorporation + rest in wheat sowing, T7- 15% of NPK at rice residue incorporation + rest in wheat sowing, T8- 30% of NPK at rice residue incorporation + rest in wheat sowing) and over dose and above recommended dose (T9- 15% N + recommended NPK, T10- Addition of 30% N + recommended NPK, T11- Addition of 15% NP + recommended NPK, T12- Addition of 30% NP + recommended NPK, T13- Addition of 15% NPK + recommended NPK, T14- Addition of 30% N PK + recommended NPK). NPK dose in wheat crop were applied half as basal dressing and half as top dressing after 35 days stage of crop. Field was prepared and transplanted the rice seedling in plot for commercial rice cultivation along with recommended package of practices. In rice crop, a pre-harvest irrigation was applied. Rice residue were incorporated as per the treatment (residue removed from T_1 plots) wheat was sown in lines at 22.5 cm apart using a seed rate of 100 kg ha^{-1} on 10 Oct and harvested on 30 March. In rice residue removed and incorporated field conventional tillage practices were used, for the rice residue removed plot (T_1), the field was ploughed with desi plough and left of 7 days, thereafter, one pre-sowing irrigation was applied to the field. At the right tilth, 4 cross ploughing were done with desi plough. The planking was done invariably after each cross ploughing in order to get fine seed bed. Field preparation worked out for residue incorporated plot, the residue incorporated with the help of disc harrow and then all practices were same as residue removed treatment. On the basis of plot size and treatment, doses of nitrogen, phosphorus and potassium through Urea, Single Super Phosphate and Murate of Potash were applied at all the treatment as basal dressing. Others practices viz. interculture, weeding and plant protection measures were applied as need based. The grain and straw samples collected at the time of harvest were dried in the oven and ground by sample grinder. After grinding, the samples were analysed chemically for nitrogen content by micro Kjeldahl's method, as given by (Jackson, 1973).

$$\text{Uptake of nutrient (kg ha}^{-1}) = \frac{\text{content (\%)}}{100} \times \text{yield (q ha}^{-1})$$

III. Results and Discussion

Various rice residue and nutrient management systems significantly affect the plant height with the age of wheat crop. Rice residue incorporation with 30% additional NPK + recommended NPK produced significantly taller plants over sowing of wheat without incorporation of rice residue+recommended NPK and rice residue incorporation + recommended NPK at wheat sowing during both the years. The increased plant height might be due to cumulative effect of narrow C:N ration, nutrients availability, soil health and good plant establishment, residue management treatment had the little effect on plant height as reported by Griffin *et al.* (1982). Meelu *et al.* (1994) also reported that incorporation of residue had beneficial effects on plant height. Significant variation in plant height might be also due higher levels of nitrogen resulted in more nitrogen uptake, which caused better metabolization of synthesized carbohydrates into amino acids and protein which in turn stimulated the cell division and cell elongation and thus allowed the plant to grow faster, which expressed morphologically an increase in plant height.

Number of tillers per running metre was affected significantly due to various rice residue and nutrient management systems at all the stages of the crop growth during both the years. It increased progressively upto 90^{th} day stage and thereafter decreased. Significantly higher number of tillers per running metre was obtained with rice residue incorporated as compared to rice residue removed during both the years. This might be due to good LAI and root growth and development in the upper layer of soil surface where these got the good opportunity for nutrient uptake. This made possible with rice residue incorporation due to higher organic matter content in soil. Good pulverization of soil may be achieved as field was ploughed for residue incorporation. It increased the availability of nutrients, which resulted into increased tillering and thus, number of tillers per running metre. In relation to these findings, Meelu *et al.* (1994) also reported the higher number of tillers with incorporation of residue treatment in the soil. The higher number of tillers associated with increasing levels of nutrient might be due to less tiller mortality, enhanced photosynthetic area, proper nourishment, enhanced cell expansion and various metabolic processes in presence of abundant supply of nutrients which resulted into increased tillering and, thus, more number of shoots per running metre. These findings are in support to those of Malik (1981) who noted positive effect of nitrogen upto 240 kg ha^{-1} on the number of tillers in wheat.

Yield attributes viz. number of effective tillers running m^{-1}, length of ear head, number of spikelets $spike^{-1}$ and 1000-grain weight is the resultant of good crop growth, photosynthesis and nutrient uptake, the highest values of these parameters were recorded with rice residue incorporation including 30% additional NPK application+recommended NPK, whereas the lowest values were found in application only recommended NPK having without any incorporation of rice residue. Additional fertilization pushed up the removal of nutrient and water from soil by the crop, which might have enhanced the photosynthesis and translocation of assimilate from source (leaves and stem) to sink vis-à-vis grain yield. Grain and straw yields affected significantly due to rice residue and nutrient management practices during both the years. The higher grain and straw yields were recorded when rice residue incorporation was coupled with application of 30% additional NPK + recommended NPK which was recorded more than other treatments during both the years. It might be due to the addition of crop residue and additional fertilization which might have improved the soil health and consequently higher uptake of available nutrients from the soil and increased the number of effective tillers running m^{-1}, length of ear head, number of spikelets $spike^{-1}$ and 1000-grain weight, which ultimately attributed to increase in grain yield. Crop residue on decomposition released nutrients slowly throughout the growth period, which resulted better plant growth and higher straw yield. Incorporation of wheat straw and burning both had higher grain and straw yield of rice over the straw removed (Maskina *et al.*, 1987). Under the clay loam soil incorporation of rice straw increased the wheat yield over sandy loam soil as reported by Singh *et al.* (1992) and Bakht *et al.* (2009).

Nitrogen uptake by grain and straw influenced significantly by rice residue and nutrient management practices during both the years. Highest nitrogen uptake by grain and straw was recorded under the treatment when rice residue incorporated with 30% additional NPK + recommended NPK against sowing of wheat without incorporation of rice residue application + recommended NPK and rice residue incorporation + recommended NPK. Increase in nitrogen uptake by grain and straw may be due to better root establishment which resulted in better translocation of absorb nutrients from soil and its translocation to plant and seed which may cause higher plant growth, grain and straw yields and ultimately increased the uptake of nitrogen. Adequate supply of nutrient in the root zone increased the movement of nutrient in soil solution and ultimately their greater absorption and utilization by the growing plants. Kumar *et al.* (1995) reported that each increment of nitrogen level from 60 to 180 kg ha^{-1} increased the grain and straw yields as well as N uptake under loamy soil condition at Karnal. Kumar *et al.* (2000) also reported that nitrogen uptake increased with increasing level of nitrogen upto 120 kg ha^{-1} under sandy loam soils of Bihar. Increased nitrogen uptake in residue incorporated treatment was mainly due to cumulative effect of better soil health, increased the availability of nutrients and better root and plant growth and development, which enhanced the crop yield. These results are in conformity to those reported by Dwivedi and Thakur (2000) under silt-clay loam soil that incorporation of rice straw increased the nitrogen uptake. Similar, findings were also reported by Das *et al.* (2001) in rice.

Rice residue and nutrient management significantly influenced the organic carbon content during both the years. Significantly higher organic carbon content was recorded with rice residue incorporation with application of 30% additional N+P+K + recommended NPK and rice residue incorporation with application of 15% additional N+P+K + recommended NPK against sowing of wheat without incorporation of rice residue + recommended NPK. It is probably due to the fact that addition of carbonaceous substances in soil which on decomposition added organic matter. Verma and Bhagat (1992) have also recorded the maximum soil build-up of organic carbon under the rice straw chopped and incorporated with animal manure, followed by animal manure and straw mulch, while minimum organic carbon under rice straw burnt and rice straw removed.

IV. Conclusion

Farmers of being practiced in rice-wheat system region may, therefore, be advised to adopt rice residue incorporation practice with 30% additional fertilizer under rice-wheat cropping system to get higher yield and benefits from wheat.

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Table 1 : Effect of varying rice residue management practices on plant height (cm) at various growth stages of wheat

Treatment	Plant height (cm)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	13.83	13.69	35.00	34.65	46.42	45.95	55.52	54.97
T_2	14.36	14.50	36.34	36.71	48.20	48.69	57.66	58.23
T_3	15.07	15.37	38.14	38.90	50.58	51.60	60.50	61.71
T_4	15.25	15.32	38.59	38.78	51.18	51.43	61.21	61.52
T_5	15.43	15.47	39.04	39.15	51.77	51.93	61.93	62.11
T_6	15.78	15.87	39.93	40.17	52.96	53.28	63.35	63.73
T_7	16.13	16.20	40.83	41.00	54.15	54.37	64.77	65.03
T_8	16.31	16.43	41.28	41.57	54.75	55.13	65.49	65.94
T_9	17.38	17.43	43.97	44.10	58.32	58.49	69.76	69.97
T_{10}	17.73	17.75	44.87	44.91	59.51	59.57	71.18	71.25
T_{11}	17.91	17.98	45.32	45.50	60.11	60.35	71.89	72.18
T_{12}	18.08	18.14	45.77	45.90	60.70	60.88	72.60	72.82
T_{13}	18.26	18.30	46.22	46.31	61.30	61.42	73.32	73.46
T_{14}	18.44	18.61	46.66	47.08	61.89	62.45	74.03	74.69
SEm±	0.52	0.57	1.32	1.45	1.75	1.92	2.09	2.30
CD at 5%	1.51	1.66	3.83	4.21	5.07	5.58	6.07	6.68

Table 2 : Effect of varying rice residue management practices on number of tillers per running metre at various growth stages of wheat

Treatment	Number of tillers running metre^{-1}							
	30 DAS		60 DAS		90 DAS		At harvest	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	21.22	21.01	44.96	44.51	49.22	48.73	42.93	42.50
T_2	22.44	22.66	47.53	48.01	52.04	52.56	45.38	45.84
T_3	25.77	26.29	54.60	55.69	59.77	60.97	52.13	53.17
T_4	26.08	26.21	55.24	55.51	60.48	60.78	52.74	53.01
T_5	26.38	26.46	55.88	56.05	61.18	61.36	53.36	53.52
T_6	26.98	27.15	57.16	57.51	62.58	62.96	54.58	54.91
T_7	27.59	27.70	58.45	58.68	63.99	64.25	55.81	56.03
T_8	27.89	28.09	59.09	59.51	64.69	65.15	56.42	56.82
T_9	29.71	29.80	62.95	63.13	68.91	69.12	60.10	60.28
T_{10}	30.32	30.35	64.23	64.29	70.32	70.39	61.33	61.39
T_{11}	30.62	30.75	64.87	65.13	71.02	71.31	61.94	62.19
T_{12}	30.93	31.02	65.51	65.71	71.73	71.94	62.56	62.74
T_{13}	31.23	31.29	66.16	66.29	72.43	72.57	63.17	63.30
T_{14}	31.53	31.82	66.80	67.40	73.13	73.79	63.78	64.36
SEm±	0.88	0.97	1.87	2.06	2.05	2.26	1.79	1.97
CD at 5%	2.57	2.83	5.44	6.00	5.96	6.56	5.20	5.73

Table 3 : Effect of varying rice residue management practices on number of effective tillers metre^{-2}, length of ear head and number of spikelets spike^{-1} in wheat

Treatment	Number of effective tillers metre^{-2}		Length of ear head (cm)		Number of spikelets spike^{-1}	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	218.05	215.87	7.01	6.94	11.48	11.37
T_2	230.51	232.82	7.41	7.49	11.94	12.06
T_3	264.78	270.07	8.52	8.69	13.01	13.27
T_4	267.89	269.23	8.62	8.66	13.17	13.23
T_5	271.01	271.82	8.72	8.74	13.32	13.36
T_6	277.24	278.90	8.92	8.97	13.63	13.71
T_7	283.47	284.60	9.12	9.15	13.93	13.99
T_8	286.58	288.59	9.22	9.28	14.09	14.18

T_9	305.27	306.19	9.82	9.85	15.00	15.05
T_{10}	311.50	311.81	10.02	10.03	15.31	15.33
T_{11}	314.62	315.87	10.12	10.16	15.46	15.52
T_{12}	317.73	318.68	10.22	10.25	15.62	15.66
T_{13}	320.85	321.49	10.32	10.34	15.77	15.80
T_{14}	323.96	326.88	10.42	10.51	15.92	16.07
SEm$\pm$	9.08	10.00	0.29	0.32	0.45	0.49
CD at 5%	26.39	29.08	0.85	0.94	11.48	1.43

Table 4 : Effect of varying rice residue management practices on test weight (g), Grain yield (q ha^{-1})and Straw yield (q ha^{-1}) of wheat

Treatment	Test weight (g)		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	30.27	29.97	35.99	35.63	43.19	43.32
T_2	31.48	31.80	38.05	38.43	46.04	45.84
T_3	34.31	34.99	43.71	44.58	53.76	54.32
T_4	34.71	34.88	44.22	44.44	53.51	54.62
T_5	35.11	35.22	44.74	44.87	54.58	55.43
T_6	35.92	36.14	45.76	46.04	56.29	57.62
T_7	36.73	36.87	46.79	46.98	58.49	58.78
T_8	37.13	37.39	47.31	47.64	58.66	59.84
T_9	39.55	39.67	50.39	50.54	61.48	62.00
T_{10}	40.36	40.40	51.42	51.47	62.22	62.71
T_{11}	40.76	40.93	51.93	52.14	63.88	64.15
T_{12}	41.17	41.29	52.45	52.61	63.46	63.65
T_{13}	41.57	41.65	52.96	53.07	66.20	66.73
T_{14}	41.97	42.35	53.48	53.96	66.31	67.31
SEm$\pm$	1.18	1.30	1.50	1.65	1.84	2.05
CD at 5%	3.43	3.78	4.36	4.80	5.36	5.95

Table 5 : Effect of varying rice residue management practices on nitrogen uptake in grain and straw of wheat

Treatment	Nitrogen uptake (kg ha^{-1})				O.C. (%)	
	Grain		Straw			
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	59.18	58.00	20.73	20.59	0.27	0.27
T_2	63.31	64.58	23.20	23.33	0.32	0.32
T_3	73.59	76.56	27.42	28.26	0.32	0.33
T_4	75.33	76.09	27.61	28.32	0.32	0.33
T_5	77.09	77.56	28.49	29.02	0.33	0.33
T_6	80.68	81.65	30.06	30.95	0.33	0.33
T_7	84.34	85.02	31.94	32.22	0.33	0.33
T_8	86.21	87.42	32.38	33.26	0.33	0.33
T_9	97.82	98.41	36.15	36.57	0.34	0.34
T_{10}	101.85	102.06	37.33	37.66	0.35	0.35
T_{11}	103.90	104.73	38.71	39.03	0.35	0.35
T_{12}	105.97	106.60	38.84	39.07	0.35	0.35
T_{13}	108.06	108.49	42.50	42.93	0.36	0.36
T_{14}	110.16	112.16	42.97	44.01	0.36	0.36
SEm$\pm$	2.82	3.17	1.06	1.21	0.01	0.01
CD at 5%	8.20	9.23	3.07	3.52	0.03	0.03