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Effect of Residue Management Practices and Fertilizer Levels on Growth, Yield Attributes and Yield of Wheat in Rice-Wheat Cropping System

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Abstract: A field investigation was carried out at *Krishi Vigyan Kendra,* Damla, Yamunanagar of CCSHAU, Hisar (Haryana) during *Rabi,* 2019-20. The experiment was conducted in split-plot design having six residue management practices in main plots ($C_0R_1T_3$: Combine harvesting of paddy without SMS + burning of crop residues + wheat sowing by conventional tillage method; $C_0R_2T_1$: Combine harvesting without SMS + residue shredding with mulcher + happy seeder sowing; $C_0R_2T_0$: Combine harvesting without SMS + happy seeder sowing; $C_1R_2T_0$: Combine harvesting with SMS + happy seeder sowing; $C_0R_2T_2$: Combine harvesting without SMS + residue shredding with straw chopper + happy seeder sowing and; $C_2R_0T_3$: Manual harvesting + residue removal + wheat sowing by conventional tillage method) and three fertilizer levels (75, 100 and 125% of recommended dose of fertilizer- RDF) in sub-plots. Among the residue management practices, the plant growth parameters, yield attributes and grain yield were the highest in $C_0R_2T_1$ which was statistically similar to other treatments with retention of paddy residue on soil surface ($C_0R_2T_0$, $C_1R_2T_0$ and $C_0R_2T_2$) but significantly higher than either burning ($C_0R_1T_3$) or removal of paddy residue ($C_2R_0T_3$). Fertilizer level with 125% RDF significantly improved the plant growth parameters, yield attributes and yield over other fertilizer levels. The interactive effects revealed that grain yield of wheat under treatments of residue retention on soil surface resulted in significantly higher grain yield at 125% RDF but in other treatments increase in fertilizer level from 100 to 125% RDF did not cause significant improvement in grain yield of wheat.

Keywords: Burning, Happy seeder, Fertilizer levels, Residue retention

Rice-wheat is the most prominent as well as exhaustive cropping system occupying around 18 mha area in Asia (Kumar et al 2019). Even in India, it is one of the most widely adopted cropping system due to favourable government policies like subsidized electricity and fertilizers, assured procurement and technological advancement like development of input responsive high yielding varieties and mechanization of both the crops (Shiferaw et al 2013). Increased mechanisation, particularly use of combine harvesters has led to generation of huge amount of crop residues. Combine harvesters finish the harvesting of paddy quickly and are easy to use as well as reduce the supervision of labour which made them popular in very short span of time. The loose residue generated during combine harvesting of paddy hampers tillage operations and sowing of subsequent wheat crop (Dutta et al 2022). For timely sowing of wheat, farmers find burning of crop residue as most economical and time saving option available to the farmers. Burning of crop residue results in loss of large volume of nutrients from the nutrient pool of soil, loss of organic matter (Sidhu et al 2015), loss of soil moisture (Moitinho et al 2021) and also enhances the degradation of soil quality and ecosystem. Scanty management of this surplus crop residue in rice-wheat cropping system is a deliberate threat to its sustainability leading to a number of problems. Instead of burning, alternate residue management practices can contribute to improved soil health, long-term sustainability and mitigation of climate change related greenhouse gases concentration in the atmosphere by reducing carbon dioxide emissions (Desrochers et al 2019).

Collection and transportation of voluminous mass of paddy residue is cumbersome, therefore, ex-situ residue management is still not an economically viable option (Lohan et al 2018). Conservation agricultural practices with reduced tillage, residue as mulch, improved crop establishment etc. are need of an hour to manage degrading soil health and to overcome yield stagnation. Soil physical (Indoria et al 2017), chemical (Jat et al 2018) and biological (Choudhary et al 2018) properties particularly those related to soil carbon sequestration (Xue et al 2018) are influenced by tillage practices. Several mechanization options in the form of combine fitted with SMS (super straw management), happy seeder, zero till drill machine, mulcher, paddy straw chopper, shrub master, reversible MB plough, baler etc. has been proposed to solve this problem of stubble burning (Gill 2018). Conservation agriculture practices like zero tillage sowing of wheat using zero till drill or happy seeder directly into the combine harvested paddy field enables the farmer to reduce input cost, increase profitability, and conserve water, labour, energy, soil nutrients and farm chemicals along with enhanced crop growth and yield. So selection of suitable residue management practices that are eco-accommodating and also increment the farmer income is of utmost importance. Retention of crop residue returns organic matter to the soil and also affects the soil nutrient recycling (Turmel et al 2015). Nutrient supply from crop residue can affect the amount of fertilizer required for optimisation of crop yield. Crop residue left on soil surface are devoid of favourable environment for residue decomposition, thus may not contribute nutrient to the next crop and might even reduce available form of nutrients such as N by the process of immobilisation. Rejuvenation of soil health through better residue management practices along with right amount of fertilizer is a necessary imperative to maintain or increase productivity level of this most farmer adopted cropping system. Hence the present investigation was conducted to evaluate the effect of different rice residue management practices and fertilizer levels on growth and yield of wheat crop.

MATERIAL AND METHODS

A field experiment was conducted during *rabi* 2019-20 to study the effect of residue management practices and fertilizer levels on growth, yield attributes and yield of wheat in rice-wheat cropping system at Farm of KVK Damla (Yamunanagar) of CCS Haryana Agricultural University, Hisar. The soil of experimental site was sandy loam having pH (7.84), EC (0.55 dS m^{-1}), O.C. (0.34%), low in available nitrogen (132 kg ha^{-1}), medium in available phosphorus (16 kg ha^{-1}) and high in available potassium (366 kg ha^{-1}). The experiment was conducted in split-plot design keeping six treatments of residue management practices ($C_0R_1T_3$: Combine harvesting of paddy without SMS, burning of crop residues and sowing of wheat by conventional tillage method; $C_0R_2T_1$: Combine harvesting of paddy without SMS, residue shredding with mulcher followed by happy seeder sowing of wheat; $C_0R_2T_0$: Combine harvesting of paddy without SMS, direct sowing of wheat with happy seeder; $C_1R_2T_0$: Combine harvesting of paddy with SMS followed by sowing of wheat using happy seeder; $C_0R_2T_2$: Combine harvesting of paddy without SMS, residue shredding with straw chopper followed by happy seeder sowing of wheat and $C_2R_0T_3$: Manual harvesting of paddy, residue removal and sowing of wheat with conventional tillage practice) as main plots and three fertilizer levels (75% RDF: 75 per cent of recommended dose of fertilizer; 100% RDF: 100 per cent of recommended dose of fertilizer and 125% RDF: 125 per cent of recommended dose of fertilizer) as sub-plots replicated thrice. Experimental site was under rice-wheat cropping system before the establishment of the experiment for past 5 years. Previous direct seeded rice crop was harvested according to treatments in the plots followed by pre-sowing irrigation and sowing of wheat according to the treatments. Conventional tillage practice involved two harrowing followed by cultivator and planking to prepare a fine seedbed. The wheat variety HD-3086 at recommended seed rate of 100 kg ha^{-1} was sown in the first week of December, 2019 and harvested in April, 2020. Recommended dose of N-P-K was 150-60-60 kg/ha, respectively and fertilizer dose was applied as per the treatments. Entire amount of P (diammonium phosphate) and K (Muriate of potash) was applied as basal dose at the time of sowing. N dose was applied in two splits at sowing and at first irrigation. Plant population was taken 15 days after sowing by counting the number of plants from four 50 cm row length in each plot. Plant height of five plant samples from each plot was measured from ground levels to the tip of the leaf up to heading but after that it was measured from ground level to the tip of the ear. Number of tillers were counted in 50 cm row length from four randomly selected spots per plot. Five plants from each plot were sun dried followed by oven drying and averaged to dry weight per meter row length with help of number of plants per meter row length. Leaf area of plants in 0.25 m row length was measured with the help of leaf area meter and then leaf area index was calculated as

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}} \times 100$$

Number of effective tillers were counted from 1 m^2 area from two spots in each plot. Ten randomly selected spikes from each plot were used to measure spike length and number of grain per spike. Weight of 1000-grains was taken to calculate the test weight in grams. At maturity each plot was harvested manually, sun dried and threshed to calculate grain yield of wheat. Statistical analysis was performed using OPSTAT analysis tool at 5% level of significance.

RESULTS AND DISCUSSION

Growth parameters: Various residue management practices posed no significant impact on plant height, dry matter accumulation and number of tillers recorded at 30 DAS (Table 1). No significant impact of various residue management practices was observed on number of tillers at 60 DAS. Highest plant height, dry matter accumulation mrl^{-1} and number of tillers were with $C_0R_2T_1$ treatment at subsequent stages which were recorded statistically similar to other residue retained treatments ($C_0R_2T_0$, $C_1R_2T_0$, $C_0R_2T_2$)

but significantly higher than either burning ($C_0R_1T_3$) or removal ($C_2R_0T_3$) of crop residue. Better soil moisture regime, less fluctuation in soil temperature, improved soil fertility, soil porosity and activity of microorganisms might have contributed to better vegetative growth in residue retained conditions (Guo et al 2015 and Gairhe et al 2021). Highest leaf area index was in $C_0R_2T_1$ (4.38) followed by other residue retained treatments ($C_0R_2T_0$, $C_1R_2T_0$, $C_0R_2T_2$) and significantly higher than treatment with residue burning ($C_0R_1T_3$) or removal ($C_2R_0T_3$) (Table 2). Meena et al (2018) also reported higher leaf area index in wheat with retention of crop residue on soil surface by virtue of lowering the water stress with increased plant available water.

Among the fertilizer levels, no significant difference in growth parameters was observed at 30 DAS (Table 1). At successive observations, 125% RDF treatment recorded significantly higher plant height, dry matter accumulation and number of tillers compared to 75% and 100% RDF treatment. This might be due to higher nutrient availability to plants particularly of nitrogen, which favored better vegetative growth (Narolia et al 2016 and Irfan et al 2018). LAI at anthesis (Table 2) with 125% RDF was 9.6 and 3.6 per cent significantly higher than 75% RDF and 100% RDF due to enhanced vegetative growth. Similar findings of higher LAI with higher NPK levels were also reported by Babar et al (2019).

Yield attributes and yield: No significant impact of various residue management practices and fertilizer levels was observed on plant population of wheat (Table 2). However, higher population was observed under treatments involving conventional tillage after removal ($C_2R_0T_3$) or burning of crop residue ($C_0R_1T_3$). This was due to better contact of seed with soil particles because of fine seed bed preparation under conventional tillage practice compared to sowing with no-tillage after rice harvest (Xue et al 2018). Yield attributes and grain yield was significantly and positively affected by various residue management practices involving retention of crop residue (Table 2). $C_0R_2T_1$ recorded significantly higher tillers, grains spike^{-1}, thousand grains weight and grain yield (332.2, 44.1, 41.9 g and 5276 kg ha^{-1}) compared to treatments with residue burning- $C_0R_1T_3$ or residue removal- $C_2R_0T_3$. Better soil moisture regime, higher availability of nutrients at later crop growth stages because of decomposition of rice residue, late maturity etc. might have contributed to increased yield attributes which in turn resulted in higher grain yield under residue retention treatments with no-till conditions (Bartaula et al 2020). Similarly, Tripathi et al (2015) also reported higher yield of wheat with retention of crop residue on soil surface.

Among the fertilizer levels, 125% RDF treatment

Table 1. Effect of residue management practices and fertilizer levels on plant height, plant dry matter and number of tillers of wheat

Treatment	30 DAS			60DAS			90 DAS			120 DAS		
	Plant height (cm)	Plant dry matter (g mrl^{-1})	No. of tillers per mrl	Plant height (cm)	Plant dry matter (g mrl^{-1})	No. of tillers per mrl	Plant height (cm)	Plant dry matter (g mrl^{-1})	No. of tillers per mrl	Plant height (cm)	Plant dry matter (g mrl^{-1})	No. of tillers per mrl
Residue management practices												
$C_0R_1T_3$	16.46	8.52	43.11	36.86	39.09	64.82	70.59	96.38	68.36	90.03	178.47	66.29
$C_0R_2T_1$	16.08	8.37	43.11	40.74	42.61	68.04	75.34	105.36	72.58	96.09	189.66	71.31
$C_0R_2T_0$	16.36	8.49	42.22	39.72	41.35	65.38	73.42	101.92	69.91	93.57	185.32	68.71
$C_1R_2T_0$	16.22	8.40	42.33	40.33	41.81	67.03	74.6	102.42	71.61	95.19	186.94	70.32
$C_0R_2T_2$	16.16	8.41	42.89	40.58	42.48	67.82	75.2	104.5	72.36	95.79	188.39	71.11
$C_2R_0T_3$	16.39	8.49	42.78	36.61	38.91	64.36	70.07	95.47	67.89	89.49	177.2	65.76
CD (p=0.05)	NS	NS	NS	1.35	1.65	NS	2.13	3.96	3.46	3.45	4.81	3.65
Fertilizer levels												
75% RDF	16.11	8.41	42.67	38.06	38.85	64.33	70.99	95.83	67.56	90.59	170.76	66.02
100% RDF	16.29	8.45	42.72	39.39	41.28	66.46	73.79	101.84	70.66	93.99	187.22	69.12
125% RDF	16.43	8.48	42.83	39.97	42.99	67.94	74.82	105.35	73.14	95.49	195.01	71.61
CD (p=0.05)	NS	NS	NS	0.63	1.46	1.54	1.09	3.71	1.88	1.76	3.88	1.98

*mrl= Meter row length; DAS= Days after sowing

Table 2. Effect of residue management practices and fertilizer levels on yield attributes, yield and LAI at anthesis of wheat

Treatments	Plant population per mrl	Effective tillers m^{-2}	Grains $spike^{-1}$	1000- grains weight (g)	LAI at anthesis	Grain yield (kg ha^{-1})
Residue management practices						
$C_0R_1T_3$	16.46	318.67	42.67	39.79	66.29	4934
$C_0R_2T_1$	16.08	332.22	44.12	41.92	71.31	5276
$C_0R_2T_0$	16.36	327.33	43.53	41.18	68.71	5153
$C_1R_2T_0$	16.22	328.67	43.68	41.35	70.32	5177
$C_0R_2T_2$	16.16	330.78	44.02	41.78	71.11	5238
$C_2R_0T_3$	16.39	317.33	42.62	39.61	65.76	4817
CD (p=0.05)	NS	8.28	0.83	1.05	3.65	131
Fertilizer levels						
75% RDF	16.11	317.28	42.10	39.83	66.02	4722
100% RDF	16.29	326.33	43.55	41.08	69.12	5190
125% RDF	16.43	333.89	44.67	41.91	71.61	5385
CD (p=0.05)	NS	4.28	0.57	0.85	1.98	66

*mrl= Meter row length; DAS= Days after sowing

Table 3. Interaction effect of residue management practices and fertilizer levels on grain yield (kg ha^{-1})

Treatments	Residue management practices						
Fertilizer levels	$C_0R_1T_3$	$C_0R_2T_1$	$C_0R_2T_0$	$C_1R_2T_0$	$C_0R_2T_2$	$C_2R_0T_3$	Mean
75% RDF	4650	4800	4747	4767	4783	4583	4722
100% RDF	5023	5377	5252	5263	5340	4887	5190
125% RDF	5130	5650	5462	5500	5590	4980	5385
Mean	4934	5276	5153	5177	5238	4817	
Factors							CD (p=0.05)
Residue management practices at same fertilizer level							186
Fertilizer levels at same level of residue management practices							168

recorded significantly higher number of effective tillers, number of grains $spike^{-1}$ and thousand grains weight (333.9, 44.7 and 41.9g) as compared to 75% RDF and 100% RDF. Grain yield was also significantly improved by 14 per cent with 125% RDF over 75% RDF treatment (4722 kg ha^{-1}). Higher yield attributes and grain yield in wheat with higher fertilizer level might have contributed by increase in availability of nutrients with increase in fertilizer levels (Safar-Noori et al 2018). Significant interaction effect was observed between various residue management practices and fertilizer levels (Table 3). Increase in grain yield was significant with 125% RDF over 100% RDF treatment only in residue retained treatments. No significant increase in grain yield was observed with increase in fertilizer level from 100% RDF to 125% RDF in treatments with no residue retention. Application of higher fertilizer dose particularly nitrogen led to faster decomposition of crop residues due to better growth of microbial population which further enhanced the nutrient availability in residue retained conditions (Roozbeh and Rajaie 2021).

CONCLUSIONS

Adoption of mechanized agricultural practice with retention of crop residue on soil surface provides a better solution for in-situ management of crop residue. Results revealed that combine harvesting of paddy without SMS, residue shredding with mulcher followed by sowing of wheat with happy seeder resulted in better growth performance, yield attributes and yield of wheat. Application of 125 per cent recommended dose of fertilizer significantly improved the grain yield in no-till residue retained conditions. This increase over the 100 per cent recommended dose of fertilizer was non-significant in conventional tillage practice having no residue retention.

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