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Potassium management and residue recycling effects on wheat (*Triticum aestivum*) under maize (*Zea mays*) – wheat rotation

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Cereal-based cropping systems are kingpin of India's food security and have played paramount role in making India self-reliant in food production during recent past (Ramachandran 2013). Amongst cereals, wheat (*Triticum aestivum* L.) is the principal cereal next to rice (*Oryza sativa* L.), which occupies 31.5 million-hectares acreage with 107.6 million tonnes (mt) production and 3421 kg/ha productivity (MoA & FW 2020). Though the country is producing sufficient wheat grains to meet its contemporary demand but has to increase annual wheat production with a significant pace to achieve the ever-increasing future demands for burgeoning population (Krishnappa *et al.* 2022). Crop residues are key natural and eco-friendly resource for the stability of diverse agricultural systems (Choudhary *et al.* 2017). The addition of residues into the soil environment and the study of the changes associated with their addition are important in planning cultural operations and developing appropriate soil management strategies. Recycling of crop stubbles has potential to improve soil available K (Lv *et al.* 2021), organic matter and other nutrients (Bamboriya *et al.* 2017) to a greater extent. On the other hand, the use of blanket nutrient management recommendations in India has led to low nutrient use efficiencies, reduced factor productivity, lowered profits and increased environmental problems (Pampolino *et al.* 2012). Globally, K is applied to replenish only 35% of the K removed by crops which is much lower rate than replenishment, hence widespread K deficiency is observed in major production regions across the globe (Singh *et al.* 2021). Long-term fertilizer experiments have shown a comparatively better yield of crops when balanced NPK fertilization was done in comparison to NP usage only (Dutta *et al.* 2015). The residue burning problem is severe in irrigated agriculture, particularly in the mechanized wheat systems and the balanced application of fertilizers is also needed for sustainable crop production and maintenance of soil health. Hence, keeping this in view the present experiment was conducted to evaluate the effect of crop residue and potassium management on productivity and monetary efficiency of wheat as a new approach towards increasing the resource use efficiency.

A field experiment was conducted at the research farm of the ICAR-Indian Agricultural Research Institute, New Delhi during winter (*rabi*) season of 2020–21 on crop residue and potassium management in wheat. The soil of the experimental site was alluvial Typic Haplustepts, sandy loam in texture having 1.50 mg/m^3 bulk density, poor in organic carbon (0.44%) and available nitrogen (159 kg/ha), and medium in available P (14.4 kg/ha) and K (252 kg/ha) at the beginning of experiment. The experiment was conducted in split plot design with 3 replicates. In the main-plots, 3 maize (*Zea mays* L.) crop residue (no residue, maize residue incorporation @3 t/ha, maize residue retention @3 t/ha) treatments were applied. Five K levels [no K, 50% recommended dose of potassium (RDK), 100 % RDK, 50% of RDK (½ basal + ½ top dress at 25 DAS) and 100% of RDK (½ basal + ½ top dress at 25 DAS)] were taken in sub-plots. The residues of previous season maize crop were sun-dried and chopped residues of the crop were quantified and applied as per treatment. The wheat crop was fertilized with 120:60:60 kg/ha of N, P and K respectively. Basal application of Full dose of P and half dose of N were applied at the time of sowing. Potassium was applied as per treatment at the recommended rate of 60 kg/ha.

Yield attributes, viz. number of spike/m^2, number of grain/spike, test weight, spike length and spike weight were significantly influenced by different crop residue and potassium management treatments (Table 1). In general, crop residue retention treatment recorded the maximum number of spike/m^2 (555.4/m^2), number of grain/spike (55), 1000-grain weight (39.5 g), spike length (10.8 cm) and spike weight (3.30g) followed by crop residue incorporation

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treatment. Among the potassium management treatments split application of 100% RDK (½ at basal + ½ top dress at 25 DAS) was superior over control for all these yield attributes, and recorded highest number of spike/m^2 (590.1), number of grain/spike (58), 1000-grain weight (40.9 g), spike length (11.2 cm) and spike weight (3.40 g). However, the split application of 50% of RDK (½ at basal + ½ top dress at 25 DAS) was superior over control and was at par with 100 % RDK followed by 50% RDK. The control treatment recorded the lowest values for all the yield attributing characters. The maximum value under crop residue retention treatment might be due to the favorable effect of residue on soil moisture, soil temperature and increased availability of nutrients (Raghavendra *et al.* 2017, Bana *et al*. 2020). Ai *et al*. (2016) also reported that potassium application at all levels produced significantly higher yield attributing parameters of wheat compared to no potassium.

The maximum grain (6.27 t/ha) and straw (7.64 t/ha) yield of wheat was recorded with crop residue retention treatment followed by crop residue incorporation compared to no crop residue. In similar manner, 12.68, 10.03, 7.67 and 5.34% grain yield enhancement was also recorded in split 100 % RDK (½ at basal + ½ top dress at 25 DAS), 100% RDK, 50% RDK (½ at basal + ½ top dress at 25 DAS) and 50% RDK treatments respectively over control (Fig 1). This increase in grain and straw yields of wheat with the addition of crop residue, might be due to positive impact of crop residue on the status of soil organic matter, which leads to higher uptake of available nutrients from the soil (Bana *et al.* 2018). Further, soil moisture conservation under residue retention enhanced the growth and biomass production of crops both directly and indirectly by increasing the bio-availability and utilization of applied and endemic nutrients (Faiz *et al*. 2022). Wang *et al*. (2020) also reported an increased trend in wheat yield with the application of potassium fertilizer. The interaction effect between the crop residue and potassium management practices showed no significant difference on yield parameter of wheat crop.

Production and monetary efficiency of wheat crop was significantly influenced with different crop residue

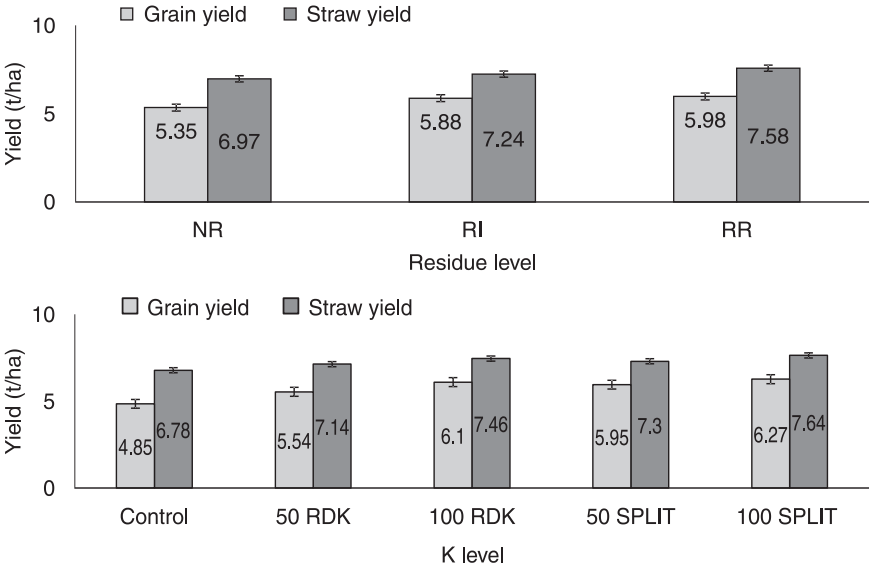

Fig 1 Effect of crop residue and potassium management on grain and straw yield of wheat. *NR, no-residue; RI, residue incorporation; RR, residue retention; RDK, Recommended dose of K.

Table 1 Effect of crop residue and potassium management on yield attributes of wheat

Treatment	Yield attribute				
	No. of spike/ m^2	No. of grain/ spike	1000-grain weight (g)	Spike length (cm)	Spike weight (g)
Residue management					
No residue	501.1	47	38.6	10.2	2.76
Maize residue incorporation @3 t/ha	535.0	50	39.0	10.6	2.97
Maize residue retention @3 t/ha	555.4	55	39.5	10.8	3.30
SEm±	10.03	1.25	0.06	0.08	0.07
CD(P=0.05)	40.47	5.04	0.24	0.35	0.31
Potassium management					
Control	464.2	41	37.1	9.6	2.57
50% RDK	494.4	46	38.0	10.1	2.92
100% RDK	558.5	54	39.9	10.9	3.14
50 % RDK (½ at basal + ½ top dress at 25 DAS)	545.3	52	39.3	10.8	3.03
100 % RDK (½ at basal + ½ top dress at 25 DAS)	590.1	58	40.9	11.2	3.40
SEm±	13.10	2.43	0.19	0.08	0.05
CD (P=0.05)	38.46	7.13	0.55	0.24	0.16

*RDK, Recommended dose of K.

and potassium management practices. Among the different residue management practices maximum monetary efficiency (₹769/ha/day) was reported under crop residue retention treatment while minimum was reported with no crop residue treatment (₹705/ha/day). Among the different potassium management treatments, the split application of 100% RDK recorded the maximum (₹819/ha/day) value followed by 100% RDK which was at par with the split application of 50% of RDK (½ at basal + ½ top dress at 25 DAS) followed by 50% RDK. A similar trend was also followed for production efficiency. Maximum production efficiency was reserved with residue retention (41 kg/ha/day) and 100% RDK in split doses (43 kg/ha/day). Both the production and monetary efficiency were based on grain yield and net returns of wheat crop which also showed improvement with crop residue and potassium management practices. The results were in closer conformity with Bana *et al.* (2018) and Sepat *et al.* (2019) in the similar agro-ecologies.

SUMMARY

The crop residue application and the balanced fertilization with 3 major macronutrients mainly emphasizing on different potassium management practices significantly improve the yield attributing components of wheat crop. Likewise, the highest grain, straw and biological yield in wheat crop was observed with crop residue retention and the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS). The maximum production efficiency and monetary efficiency was recorded under the crop residue retention. Among the potassium management practices the efficiencies were recorded maximum with the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS). Hence, it can be concluded that for enhanced productivity and greater monetary efficiency, the crop residue retention and the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS) could be a better management practice for better growth and development of wheat crop in a maize-wheat rotation. However, to have greater insights on the residue retention and potassium effects, the future research may focus on understanding water and nutrient release pattern in the soil profile, improvement in soil physical and mechanical properties, rhizospheric microbial dynamics and physiological effects on the wheat plants due to diverse residue management systems and potassium application protocols.

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