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Effect of Crop Residue and Potassium Management Practices on Growth and Yield of Wheat (*Triticum aestivum* L.)

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Abstract: An investigation was carried out at ICAR-Indian Agricultural Research Institute (IARI), New Delhi during rabi seasons of 2020-21, with the objective to determine better crop residue and potassium management practices for growth parameters and their impact on yield of wheat. The experiment was laid out in split-plot design with three replications having three residue management treatments in main plot and five potassium management practices [Control (no application of fertilizer, (K1), 50% of RDK (K2), 100% of RDK (K3), 50% of RDK (½ basal + ½ top dress at 25 DAS, (K4) and 100% RDK (½ basal + ½ top dress at 25 DAS), (K5)] in sub-plot. Results indicated that the higher values of all the growth parameters, grain, straw yield and harvest index of wheat was recorded with the crop residue retention @ 3t ha^{-1} with the split application of 100% recommended dose of potassium (½ at basal + ½ top dress at 25 DAS).

Key words: Crop residue, potassium management, wheat.

Wheat (*Triticum aestivum* L.) is the principal cereal crop of the world and stands next to rice in India. Globally, wheat contributes nearly 55 percent of the carbohydrates and 20 percent of the food calories consumed (Breiman and Graur, 1995). In India, it occupies 31.61 Million Hectares acreage and production of 109.52 million tonnes with a productivity of 3464 kg ha^{-1} (Anonymous, 2021) and provides 61% of the country's protein requirements (Majumdar *et al*., 2013). To sustainably meet the wheat demands for the food, feed, industrial sectors and international markets, the wheat production in India needs to be enhanced significantly (Bana *et al*., 2015). But, various factors are adversely affecting the wheat output in India such as delayed planting, faulty crop establishment systems, inadequate and imbalance nutrient crop nutrition, moisture stress during critical stages of life cycle and degrading soil health (Pooniya *et al*., 2015; Bana *et al*., 2018).

Crop residues are key natural and eco-friendly resource for the stability of diverse agricultural systems (Singh, 2013). In cereal-based cropping systems, huge volume of crop residues are produced and large portion of unused crop residues are spread on wheat field by combine-harvester, which are not suitable to feed the cattle because soil particles remain adhered to them (Prasad *et al*., 1999). About 30-40% of N, 25-30% of P, 30-40% of S and 75-80% of K taken up by the cereals are accumulated in residue component, making them valuable sources of nutrients (Singh and Sidhu, 2014). The addition of crop residues enhances soil quality and increase soil nutrients, especially N and K. Furthermore, crop residues are the primary energy resource for soil microorganisms and an important source of plant nutrients (Choudhary *et al*., 2017). In addition, crop residue also moderate soil temperature and increase the water retention capacity (Sarkar *et al*., 2020). Retention of crop residues on soil surface had substantially higher organic carbon than compare to residue incorporation (Saurabh *et al*., 2021).

On the other hand, the use of blanket nutrient management recommendations in India has led to low nutrient use efficiencies, lowered profits and increased environmental problems (Pampolino *et al*., 2012). However, to meet the production targets, more attention has been paid to fertilization of N and P, but not to K, by either inorganic fertilizer or organic manure. Globally, K is applied to replenish only 35% of the K removed by crops that is much lower rate than replenishment, hence in major production regions of the world widespread K deficiency is observed (Singh *et al*., 2021). According to Hasan (2002), about

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72% of India's agricultural area need immediate K fertilization for healthy crop production because such imbalances of K are widespread in agricultural soils and particularly in sandy and lateritic soils due to leaching (Rengel and Damon, 2008). Long term fertilizer experiments have shown a comparatively better yield of crops when balanced NPK fertilizers are used in comparisons to NP use only (Dutta *et al*., 2015). So, balanced application of fertilizers is needed for sustainable crop production and maintenance of soil health. Therefore, considering these fact in view present investigation was carried out to study the effect of crop residue and potassium management practices on growth and yield of wheat.

Materials and Methods

Experimental site and soil

The experiment was performed at ICAR-IARI Research Farm, New Delhi in the field no. Mid-Block 3A of ICAR-IARI Research Farm, which is situated at 28°35′N latitude, 77°12′E longitude and at an altitude of about 228.6 m above mean sea level (MSL). The climate of New Delhi is a semi-arid and sub-tropical with hot dry summer and cold winter. The average maximum temperature is observed in the month of June and the mean minimum temperature is observed in January, the minimum and maximum temperature during the cropping season was -0.8°C and 40°C, respectively. A total rainfall of 76.8 mm was received during the cropping season (Nov. - March). On an average, evaporation was 2-2.9 mm day^{-1} and mean pan evaporation during the cropping season was 441.3 mm. The soils of research farm was alluvial, sandy loam in texture nearly level to gently sloping topography with pH 8.18, low in organic carbon, available N, medium in available P and available K.

Experimental design and treatments

The field experiment was carried out in split plot design having three replications. The plot size was 5 m x 3.30 m (16.5 m^2) with 15 treatment combinations. The treatments comprised of three levels of crop residue in main plot viz., no residue, Maize residue incorporation @ 3t ha^{-1} and Maize residue retention @ 3t ha^{-1} and four levels of potassium management viz., control ((no application of potassium), 50% of RDK (recommended dose of potassium), 100% of RDK, 50% of RDK (½ basal + ½ top dress at 25 DAS) and 100% of RDK (½ basal + ½ top dress at 25 DAS). The Wheat variety HD 3086 was sown in lines with row to row spacing of 22.5 cm. The residues of previous season maize crop were sun dried and applied in the field as per treatment. The total N (0.65%), P (0.09%) and K (1.68%) concentration of maize residue were determined by modified Kjeldahl method, Vanado-molybdophosphoric acid yellow colour method and flame photometer method, respectively (Jackson, 1973). Nitrogen and phosphorus demand of crop was fulfilled with the application of recommended dose of N and P_2O_5 fertilizers in the form of urea, SSP at the rate of 120-60 N and P_2O_5 kg ha^{-1}, respectively. Potassium was applied in the form of muriate of potash (MOP) as per treatment at the recommended rate of 60 kg ha^{-1}. Basal application of Full dose of P and half dose of N were applied at the time of sowing. Remaining dose of nitrogen was top dressed in two equal splits after the first and second irrigation.

Biometric observations

The biometric observations were recorded as per the standard procedures at defined intervals. For measuring the plant height, five plants were randomly chosen and tagged permanently for each plot. Height of tagged plants were measured at 30 and 60 DAS from ground surface to the tip of the top most leaf. Number of tillers according to m^2 were counted from permanently marked five plants in each plot at harvest and lastly averaged into tiller m^{-2}. For measuring the leaf area (cm^2) of selected plants leaf area meter (LI-COR Model LI-3100, Lambda Instrument Corporation, Nebraska USA) was used. The leaves were separated from the stem and cleaned with distilled water and then dried with tissue paper. The leaf area expressed in cm^2 per plant. LAI of selected plants was calculated by means of the formula as given below. It is expressed as the ratio of leaf area (cm^2) to the ground area (cm^2) occupied by the plant.

$$LAI = \frac{Total\ leaf\ area\ (cm^2)}{Total\ ground\ area\ (cm^2)}$$

For measuring the grain yield crop of every plot was harvested separately manually leaving two border rows on either side of treatment plots. The produce so obtained was sun dried for three days. Weighing of the produce was done when the moisture content of the grain reduced to 12.5%. The seeds obtained from the produce of individual plot were recorded as seed yield kg plot^{-1} and later it was converted into tonnes ha^{-1}. From the net plot harvested produce, straw yield was calculated by subtracting grain yield from the total biological yield and was expressed in t ha^{-1}. The grain and straw yield were recorded from net plot area of each treatment. Harvest index (HI) was calculated by using the following expression which is given by the proportion of economic yield (grain yield) to the total biological yield.

$$HI = \frac{\textit{Economic yield (t ha}^{-1}\textit{)}}{\textit{Biological yield (t ha}^{-1}\textit{)}}$$

Statistical analysis: The experimental data was subjected to statistical analysis by using the standard technique of analysis of variance (ANOVA). The significance of treatment means was tested using F-test. The critical difference (P=0.05) were worked out to evaluate differences between treatment means. The interactions between the treatments were given wherever interaction effect was significant (Gomez and Gomez, 1984).

Results and Discussion

Growth parameters

The crop residue and different potassium management practices significantly improved the growth of wheat. A significant difference was recorded in the plant height of wheat at 60 DAS (Table 1). The plant height was significantly higher under the crop residue retention treatment at 60 DAS followed by the plant height under crop residue incorporation compared to control treatment. However there was no significant difference was observed in the plant height at 30 DAS. The leaf area index at 30 and 60 DAS and the number of tillers m^{-2} at the harvest of wheat were also reported significantly higher under crop residue retention treatment at all the growth stages followed by residue incorporation treatment (Table 1). In wheat plant height, LAI and number of tillers m^{-2} were not significantly affected at early growth stages by residue management treatments. It might be due to the effect of residue application was not realized at early growth stages. At later growth stages a significant increase in all the growth parameters were observed under crop residue retention treatment, the reason for this increase is that keeping the crop residue on soil surface may provide the protection to soil by the impact of beating action of falling raindrop against crusting and surface sealing, also have a positive effect on soil moisture conservation, macro-porosity along with reduction in soil compaction (Blanco-Canqui *et al*., 2006; Lal, 2005; Singh *et al*., 2011; Meena *et al*., 2015). The beneficial response of crop residue to the growth of wheat might be due to improved levels of nitrogen in the soil because of nitrogen

Table 1. Effect of crop residue and potassium management on growth parameters of wheat

Treatment	Plant height (cm)		LAI		Tiller (m^{-2}) at harvest
	30 DAS	60 DAS	30 DAS	60 DAS	
Residue management					
No residue	29.4	62.5	0.23	3.26	552.4
Maize residue incorporation @ 3t ha^{-1}	31.2	67.5	0.24	3.52	573.3
Maize residue retention @ 3t ha^{-1}	31.3	72.6	0.25	3.69	591.7
SEm±	0.56	0.66	0.001	0.007	5.36
CD (P=0.05)	NS	0.93	0.005	0.027	21.62
Potassium management					
Control	28.4	59.8	0.21	3.10	509.2
50% RDK	30.1	64.3	0.22	3.30	545.2
100% RDK	31.2	70.0	0.26	3.54	597.0
50% RDK (½ at basal + ½ top dress at 25 DAS	30.7	67.9	0.25	3.47	586.6
100% RDK (½ at basal + ½ top dress at 25 DAS	32.8	75.6	0.28	3.72	624.6
SEm±	0.72	1.53	0.001	0.011	8.72
CD (P=0.05)	2.11	4.49	0.004	0.031	25.60

*RDK= Recommended dose of K.

released by the decomposing crop residues and also might be attributed as a result of reduced tiller mortality, increased photosynthetic rate, improved cell expansion, balanced nutrition under improved nutrient contents (Dhar *et al*., 2014). Similar findings were also reported by Amgain (2018) and Ravi *et al*. (2019).

The different potassium management practices significantly influenced the plant height, LAI and tillers m^{-2} at all the observed growth stages of wheat (Table 1). The significantly highest values for all the parameters were observed with the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS) at all the growth stages. However the recorded values with split application of 50% of RDK (½ at basal + ½ top dress at 25 DAS) was at par with 100% RDK followed by 50% RDK. A significant difference was recorded with the application of 50% RDK compared to control. The reason behind this increase in all plant growth parameter with potassium application might be due to the role of potassium in the synthesis of cell, enzyme activation, nutrient transport and uptake which consequently increased growth performance of wheat (Epstein and Bloom, 2005; Pettigrew, 2008). Kubar *et al*. (2019) also observed a significant effect on growth of wheat under varying level of potassium application. The probable reason for increase in leaf area at higher K doses is activation of various enzymes, increased synthesis of proteins, improved N uptake and its efficient utilization (Akhtar *et al*. 2003; Asif *et al*. 2007). These results are in agreement with those of Mehdi *et al*. (2007) and Ullasa *et al*. (2017).

Yield and Harvest Index

The data in Table 2 revealed that residue management treatments had a positive effect on grain and straw yield of wheat. Compare to the different residue treatment, significantly highest grain yield was recorded under crop residue retention treatment followed by crop residue incorporation and the lowest value is observed under control. Respective grain yield increase under crop residue retention and incorporation treatments was 11.77% and 9.91% as compared to no residue. Similarly, Straw yield of wheat crop was significantly increased with different residue management treatments than compare to no residue application. The increase in straw yield was the extent of 8.75% and 3.87% with the crop residue retention and incorporation treatments respectively as compared to control. 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. The release of nutrient from the decomposition of crop residue is a slow process and occurs throughout the growth period, which provides

Table 2. Effect of crop residue and potassium management on grain, straw yield and harvest Index of wheat

Treatment	Yield (t ha^{-1})		Harvest index (%)
	Grain	Straw	
Residue management			
No residue	5.35	6.97	39.67
Maize residue incorporation @ 3 t ha^{-1}	5.88	7.24	40.86
Maize residue retention @ 3 t ha^{-1}	5.98	7.58	41.95
SEm±	0.05	0.09	0.23
CD (P=0.05)	0.07	0.39	0.93
Potassium management			
Control	4.85	6.78	39.61
50% RDK	5.54	7.14	40.32
100% RDK	6.10	7.46	41.21
50% RDK (½ at basal + ½ top dress at 25 DAS	5.95	7.30	40.87
100% RDK (½ at basal + ½ top dress at 25 DAS	6.27	7.64	42.14
SEm±	0.08	0.12	0.18
CD (P=0.05)	0.26	0.35	0.54

*RDK= Recommended dose of K.

the nutrient to crop for longer period and decrease the loss of nutrients, results in better plant growth including higher grain and straw yields (Sayre *et al*., 2005). Singh *et al*. (2004) also observed that incorporating crop residues have resulted into significant improvement in soil organic matter content and availability of K in soil, leading to improved nutrient balance and yield as well. Wheat grain was increased with crop residue application as compared to the control treatment (no residue) (Wei *et al*.2015). A close positive response has also been reported by Jat *et al*. (2010); Ram *et al*. (2010); Meena *et al*. (2015) and Saad *et al*. (2015). Similarly, different potassium management practices significantly influenced the grain yield (Table 2). In different potassium management practices, the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS) recorded the significantly highest grain yield followed by 100% RDK and the grain yield with the split application of 50% of RDK (½ at basal + ½ top dress at 25 DAS) was at par with 100% RDK followed by 50% RDK. The control treatment recorded lowest grain yield. In a like manner, 12.68, 10.03, 7.67 and 5.31% straw 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. This increase in yield of wheat with the increasing and split dose of potassium application can be understood by the functions of the potassium in the plant are mainly related to physiological processes. These functions are varied and provide the drought tolerance, frost resistance and resistance to pests and diseases. Thus adequate potassium provides some insurance against adverse conditions in difficult growing seasons and its deficiency causes stunting growth with shortening of internodes and also leads to a reduction in photosynthesis, (Ashley *et al*., 2005). Singh *et al*. (2013) reported an increase in wheat yield across different locations having different soil texture, soil K status, climatic conditions and irrigation facilities with the application of potassium fertilizer. Zhang *et al*. (2011) also found that application of synthetic NPK fertilizer improved the wheat and maize yield as compared to treatments that received nitrogen and phosphorous only. Similar findings were also reported by Jat *et al*. (2014).

The crop residue and potassium management practices also had a significant effect on harvest index of wheat compare to the different residue management treatments, highest value for the harvest index (41.95%) was observed under crop residue retention treatment followed by crop residue incorporation (40.86%) and the lowest value (39.67%) is observed under no residue treatment. In different potassium management practices, the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS) recorded the highest value (42.14%) followed by 100% RDK and the value of harvest index with the split application of 50% of RDK (½ at basal + ½ top dress at 25 DAS) was at par with 100% RDK followed by 50% RDK. The control treatment recorded lowest harvest index (39.61%).

Conclusion

Based on the research findings of experiment, it can be concluded that residue retention treatment with the split application of 100% RDK (½ at basal + ½ top dress at 25 DAS) was found optimum in terms of crop growth performance, yield of wheat under Typic Haplustepts soil of semi-arid region of New Delhi.

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