Biological Forum – An International Journal 15(2): 414-419(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Residue Recycling on Leaf Area Index and Nutrient Uptake Pattern of Wheat Crop under different Potassium Management Practices

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(Received: 17 December 2022; Revised: 06 February 2023; Accepted: 09 February 2023; Published: 14 February 2023)
(Published by Research Trend)

ABSTARCT: Crop residues management and balanced nutrition of crops are important techniques for sustaining the diverse agricultural production systems. In this context, the present work is planned to find out the approaches to increase the resource use efficiency by crop residue reuse *i.e*, by alternating the potassium application with efficient crop residue management. Therefore, a field experiment was conducted at the Research Farm of the ICAR-Indian Agricultural Research Institute (IARI), New Delhi during *Rabi* seasons of 2020-21. The experiment was laid out in split-plot design with three replications having single wheat cultivar HD 3086 with three residue management treatments in (no residue, Maize residue incorporation @ 3t/ha and Maize residue retention @ 3t/ha) main plot and five potassium management practices in [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)] sub plots. Results indicated that the crop residue retention @ 3t/ha recorded the higher LAI along with the split application of 100 % recommended dose of potassium (½ at basal + ½ top dress at 25 DAS). Similarly, maximum NPK uptake both in grain and straw of wheat was observed with crop residue incorporation @ 3t/ha with the split application of 100 % RDK.

Keywords: Crop residue, Nutrient uptake, Potassium management, Soil fertility.

INTRODUCTION

wheat (*Triticum aestivum* L.) is the major cereal crop, In India, It occupies 31.61 Million Hectares acreage and production of 109.52 million tonnes with an productivity of 3464 kg/ha (Anonymous, 2021). Globally, wheat contributes nearly 55 percent of the carbohydrates and 20 percent of the food calories consumed (Breiman and Graur 1995). In India, it is the staple food and provides 61% of the country's protein requirements (Majumdar *et al.*, 2013). 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). In addition, growing labour and water scarcity, increasing fuel prices, changing climatic are likely to further affect the productivity of wheat adversely (Sapkota *et al.*, 2014).

The plant parts which remain after harvesting and threshing of the crop are generally considered as crop residues. In the past crop residues have been treated as a waste which need to be disposed off, but since last few years these gain importance as a valuable natural resource. Crop nutrient requirements can be fulfilled by using the recycling the crop residues and using them as a manure. Furthermore, these also enhances the soil physical and chemical properties (Powel and Unger 1997). The addition of crop residues 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). Crop residues lying over the soil surface protects the soil from crust formation, sealing of the pores, and detachment of soil particles by obstructing and buffering the kinetic energy of raindrops and runoff water, and improving the infiltration rate (Lentz and Bjorneberg 2003). If the crop residues are not returned to soil then it results into a net negative soil-nutrient balance and multi nutrient deficiency as the nutrients are continuously removed by the crops. This is one of the probable reasons for the declining yield in the IGP regions (Gadde *et al.*, 2009). 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 imbalance use of fertilizers in India has led to low nutrient use efficiencies, lowered profits and increased environmental problems (Pampolino *et al.*, 2012). More attention has been paid to fertilization of N and P, but not to K, by either inorganic fertilizer or organic manure. Optimum K application may contribute to a sustainable yield and high nutrient efficiency. The crop responses to potassium have increasingly been reported (Prasad and Prasad 1993). Antonio *et al.* (2011) found that potassium is primarily located in the cytoplasm and vacuoles of the cell where it act as an enzyme activator, regulates functioning of stomata, and also helps in transfer of compounds across membranes. The soil fertility in respect of potassium is fast declining (Yadav *et al.,* 1998). Since additions of potassium from the atmosphere and leaching losses are negligible, the maintenance of potassium status of soil depends on the return of a large proportion of crop residues and application of fertilizer potassium in accordance with the needs of the system. The vegetative part (stem or straw) contributed fifty three to ninety percentage of the potassium uptake through plants. It is generally supplied as K- fertilizers in both intensive and extensive agricultural systems (Zhang *et al.*, 2011). 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). The reason to conduct the study or research gap are the lack of knowledge on the combined effect of residue and potassium management on growth and nutrient use efficiency of wheat and Most of the past research works on increase of wheat productivity due to nitrogen and phosphorus fertilizer giving less importance to potassic fertilizer. Therefore, Keeping this in view, the present research was worked to find out the ways to increase the growth, optimum use of nutrients by the crop and sustaining the soil fertility after the harvest of Wheat crop.

MATERIAL AND METHOD

The experiment was performed at ICAR-IARI Research Farm, New Delhi .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 soil of the Research Farm represents Indo-Gangetic plain and belongs to Mehrauli series of order Inceptisol. The soil is alluvial, sandy loam in texture has nearly level to gently sloping topography. The soil was sandy loam in texture with pH 8.18, low in organic carbon, available N, medium in available P, and available K. The experiment was carried out in split plot design having three replications. The plot size was 5 m × 3.30 m (16.5m^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 and Maize residue retention @ 3t/ha 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. 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 respectively. Potassium was applied in the form of muriate of potash (MOP) as per treatment at the recommended rate of 60 kg/ha. 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.

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. It is expressed as the ratio of leaf area (cm^2) to the ground area (cm^2) occupied by the plant.

At harvesting stage, plant samples were collected and dried in hot air oven at 60-65±2ºC for 6 hours. The oven dried samples of grains and straw were ground and analyzed to determine N, P, K concentrations. Nutrient (N, P and K) uptake was calculated by multiplying nutrient content with grain or straw yield and expressed kg/ha.

RESULTS AND DISCUSSION

Leaf area index. The leaf area index of wheat was significantly influenced with the application of different residue and potassium management treatments at different growth stages during the experimentation. The significantly higher LAI was reported under crop residue retention treatment at all the growth stages followed by residue incorporation treatment (Table 1). The maximum value of leaf area index (4.53) was recorded with the crop residue retention treatment and the lowest (4.31) with control treatment at 90 DAS. Prasad *et al.* (1999) found that growth, LAI and dry matter synthesis improved under residue management treatments. Meelu *et al.* (1994) observed that growth parameters of wheat plants was significantly increased by residue application. This is in conformity with results of Dwivedi and Thakur (2000); Das *et al.* (2001); Surekha *et al.* (2003); Tejada and Gonzalez (2003); Shafi *et al.* (2007); Bakht *et al.* (2009); Brar *et al.* (2010); Pooniya and Shivay (2011). Prasad *et al.* (1999) investigated the influence of crop residue management on crop growth, yield and soil fertility under rice-wheat cropping system.

The different potassium management practices also significantly influenced the leaf area index in wheat at different growth stages (Table 1). The significantly highest leaf area index was noticed with the split application of 100 % RDK (½ at basal + ½ top dress at 25 DAS). However the leaf area 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 maximum value (0.28, 3.72 and 4.60) was recorded under 100 % RDK in split application and lowest (0.21, 3.10 and 4.19) recorded under control at 30, 60 and 90 DAS respectively. The interaction between the residue and potassium management practices on LAI was found significant at respective growth stages (Table 1). 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 (Asif *et al.,* 2007).

Interaction effect of residue and potassium management on LAI of wheat crop at 90 DAS was found significant (Table 2). The treatment crop residue retention with split application of 100 % RDK (½ at basal + ½ top dress at 25 DAS) was superior with respect to LAI followed by crop residue retention with the split application of 50 % of RDK (½ at basal + ½ top dress at 25 DAS) as compared to no crop residue and control.

N, P and K uptake. A significant difference was observed in the uptake pattern of nitrogen, phosphorus and potassium in grain and straw of wheat with different residue and potassium management treatments (Table 3). The uptake of nitrogen in grain (88.7 kg/ha) and straw (37.8 kg/ha), was highest with crop residue incorporation followed by the residue retention treatment. The lowest value for N uptake in grain (73.2 kg/ha) and straw (30.7 kg/ha) was recorded under no residue treatment. The similar trend was also followed for Phosphorus and potassium uptake. Logah (2011) also observed that combined use of crop residues along with chemical fertilizer application resulted in the highest total N, P, K contents and have faster decomposition rate. Higher K content of soil was observed under green manuring as compared to no green manuring (Narayan and Lal 2005). Scafnozzi *et al.* (1997) observed an increase in total N uptake following crop residues incorporation. In addition to this, returning crop residues have a net positive effect on soil potassium status and thereby have capability to maintain the soil productivity in a sustainable manner (Nyborg *et al.,* 1995; Patra *et al.,* 1999; Campbell *et al.,* 2001).

Similarly, The nutrients uptake both in grain and straw were significantly affected by different potassium management practices (Table 3) maximum N, P and K uptake in grain (91.0, 16.8 and 22.5 kg/ha), straw (34.1, 12.8 and 100.9 kg/ha) respectively were recorded with the split application of 100 % RDK (½ at basal + ½ top dress at 25 DAS). 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. While the minimum values were recorded under control treatment. Various studies have concluded that practicing reduced tillage, balanced fertilizer application and diversification of cropping systems can help in increasing organic nitrogen as well as mine ralizable nitrogen. Baque *et al.* (2006) found an increase in uptake of N, P and K by increasing the dose of fertilizer potassium. Prasad *et al.* (2010) similarly revealed the positive effects of crop residue application on available nitrogen in soil.

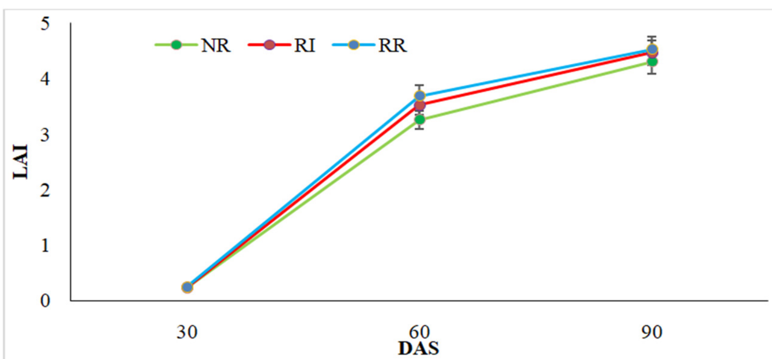

Fig. 1. Effect of crop residue management on LAI of wheat.

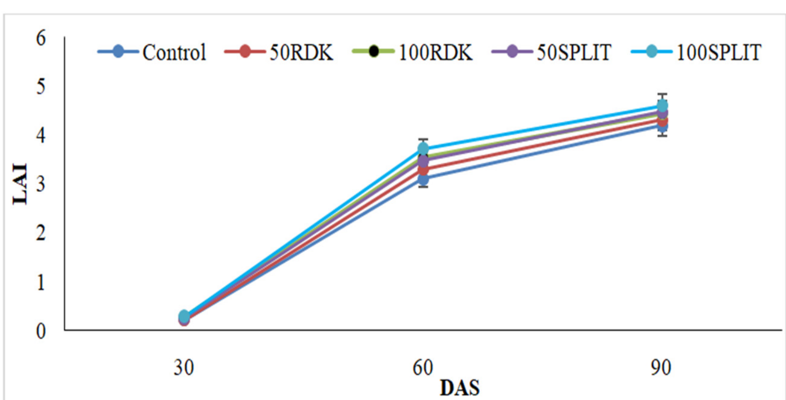

Fig. 2. Effect of potassium management on LAI of wheat.

Table 1: Effect of crop residue and potassium management on LAI of wheat.

Treatment	LAI		
	30 DAS	60 DAS	90 DAS
Residue management			
No residue	0.23	3.26	4.31
Maize residue incorporation @ 3t/ha	0.24	3.52	4.47
Maize residue retention @ 3t/ha	0.25	3.69	4.53
SEm±	0.001	0.007	0.004
CD(P=0.05)	0.005	0.027	0.018
Potassium management			
Control	0.21	3.10	4.19
50% RDK	0.22	3.30	4.31
100% RDK	0.26	3.54	4.45
50 % RDK (½ at basal + ½ top dress at 25 DAS)	0.25	3.47	4.47
100 % RDK (½ at basal + ½ top dress at 25 DAS)	0.28	3.72	4.60
SEm±	0.001	0.011	0.009
CD(P=0.05)	0.004	0.031	0.026
Interaction (residue × potassium management)	**S**	**S**	**S**

*RDK= Recommended dose of K

Table 2: Interactive effect of crop residue and potassium management on LAI of wheat at 90 DAS.

Potassium management	Residue management			
	No residue	Maize residue incorporation @ 3t/ha	Maize residue retention @ 3t/ha	Mean
Control	4.19	4.20	4.19	**4.19**
50% RDK	4.26	4.37	4.29	**4.31**
100% RDK	4.35	4.52	4.48	**4.45**
50 % RDK (½ at basal + ½ top dress at 25 DAS) at 25 DAS	4.29	4.60	4.54	**4.47**
100 % RDK (½ at basal + ½ top dress at 25 DAS)	4.48	4.64	4.68	**4.60**
Mean	**4.31**	**4.47**	**4.43**	
			SEm±	**CD(P=0.05)**
Between two sub-plot at same level of main plot			0.022	0.047
Between two main-plot at same/different level of sub-plot			0.021	0.044

*RDK= Recommended dose of K

Table 3: Effect of crop residue and potassium management on nutrient uptake in wheat cultivation.

Treatment	N uptake (kg N/ha)		P uptake (kg P/ha)		K uptake (kg K/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
Residue management						
No residue	73.2	30.7	15.0	9.9	19.7	90.3
Maize residue incorporation @ 3t/ha	88.7	37.8	17.3	12.0	22.5	97.6
Maize residue retention @ 3t.ha	83.6	33.1	15.9	11.7	21.9	95.8
SEm±	0.37	0.40	0.20	0.19	0.37	0.92
CD(P=0.05)	1.54	1.65	0.80	0.77	1.49	3.73
Potassium management						
Control	65.4	28.9	14.9	9.4	19.1	88.8
50% RDK	77.8	31.2	15.8	10.7	20.2	92.9
100% RDK	88.9	33.2	16.2	11.4	21.6	96.2
50% RDK (½ at basal + ½ top dress at 25 DAS)	84.3	33.0	16.2	11.7	21.3	95.6
100% RDK (½ at basal + ½ top dress at 25 DAS)	91.0	34.1	16.8	12.8	22.5	100.9
SEm±	1.5	0.47	0.15	0.11	0.23	1.46
CD(P=0.05)	4.53	1.37	0.44	0.32	0.69	4.29

*RDK= Recommended dose of K

CONCLUSIONS

On the basis of one year study it was concluded that the Leaf area Index was significantly affected with residue and potassium management treatments. Similarly, the maximum nutrient uptake was also improved after harvest of crop as a result of residue application and balanced nutrition of the crop. Therefore, based on the results it can be established that the crop residue retention with split application of 100% recommended dose of potassium can be a better approach to increase resource use efficiency by crop residue reuse and optimum fertilizer applications.

FUTURE SCOPE

The research work can be helpful to researchers for further investigation and also may be useful to crop growers for opting suitable combination of residue and nutrient sources to enhancing the soil fertility and improving the growth of wheat.

Acknowledgements. The first author is grateful to ICAR for providing a Junior Research Fellowship for M.Sc. Program. I am honoured and grateful to all the co-authors for their support in writing this article.

Conflict of Interest. None.

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How to cite this article: Kajal Arora, Ram Swaroop Bana, Seema Sepat, Bhagyashree Phogat, Preeti Devatwal and Sunder Anchra (2023). Effect of Residue Recycling on Leaf Area Index and Nutrient Uptake Pattern of Wheat Crop under Different Potassium Management Practices. *Biological Forum – An International Journal, 15*(2): 414-419.