

Original Research Article

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Productivity of Wheat as Influenced by Crop Residue and Potassium Management in Maize (*Zea mays* L.) - Wheat (*Triticum aestivum* L.) - Mungbean Cropping System

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ABSTRACT

The field experiment was conducted at the 'Research farm' of Division of Agronomy, Indian Agricultural Research Institute, New Delhi, during 2014-15 and 2015-16 to study the growth parameter, yield and economies in maize-wheat-mungbean cropping system as influenced by crop residue and potassium management. The experiment consisted of 15 treatment combinations with three treatments in crop residue [no crop residue, Crop residue incorporation and fungal consortium incorporation and five treatments in recommended dose of potassium (RDK) (K kg/ha), potassium management [control, KSB, recommended dose of potassium 60 kg K/ha, 50% RDK+ KSB and 75% RDK+ KSB]. The wheat was positively influenced by variable crop residue and potassium management at growth stages during both the years. Results revealed that significantly highest plant height, DMA, LAI, mean crop growth rate, net assimilation rate, of wheat were noticed with treatment receiving fungal consortium incorporation which was statistically at par with crop residue incorporation. Similar results were also recorded for grain yield, straw yield and significant interaction grain yield in during 2014-15 and 2015-16 years. Further evaluation of revealed significantly improved due to K management practices during both years of experimentation. Potassium management in wheat of results revealed that significantly highest plant height, DMA, LAI, Mean crop growth rate, net assimilation rate, yield attributes, grain yield, straw yield of wheat were noticed with treatment receiving 100% RDK+ KSB which were statistically at par with 75% RDK+ KSB.

Keywords

Crop residue,
Fungal consortium,
KSB, DMA, LAI,
CGR, NAR and
yield

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Introduction

Maize (*Zea mays* L.) is 'belongs to *Poaceae* family' one of the most important cereal crops in the world that maintain the world agricultural economy. It is also considered as a "Queen of Cereals". In India, maize is considered a promising option for diversifying agriculture in upland areas. Maize occupies an

area of 8.85 million hectares with production and productivity of 22.84 million tonnes and 25.80 mt/ha, respectively (Agricultural Statistic at Glance, 2015). It has diversified uses as human food, animal feed and fodder, industrial raw materials *etc.* and fit well in all cropping systems due to fluctuating crop duration. India has the largest area under wheat (30.27 million ha), with a productivity

of 3093 kg ha⁻¹ and is the second largest producer of wheat (93.5 million tonnes) after China in the world (Agricultural Statistic at Glance 2015). Current production is sufficient to meet the wheat demand of India, but the country has to increase annual wheat production from 93 Mt at present to 105 Mt by 2025 to meet the increasing demand (Prasad, 2011). Legumes are widely recognized as builders of soil fertility and contribute substantial amounts of N for sustainability of cereal-based cropping systems. The inclusion of legumes increases soil fertility and consequently the productivity of succeeding cereal crops (Ghosh *et al.*, 2007). The inclusion of grain legumes was also beneficial for improving productivity, profitability, N economy and soil fertility in maize-wheat cropping system (Sharma *et al.*, 2009).

It is estimated that about 686.2 mt of crop residues are generated every year (Singh and Sidhu 2014). Out of this, about 234.4 mt crop residue is available as surplus (Hiloidhari *et al.*, 2014). Crop residues were natural resources with tremendous value to farmers and their use can be diversified as animal feed, composting, thatching for rural homes and fuel for domestic and industrial use. About 30-40 percent of nitrogen, 25-30 of percent phosphorus, 30-40 percent of sulphur and 75-80 percent of potassium uptake by cereal crops are retained in residues, making them valuable sources of nutrients (Singh and Sidhu 2014). The residue burning problem is severe in irrigated agriculture, particularly in the mechanized rice-wheat system. Crop residue incorporation in maize-based cropping system resulted in maximum growth and yield (Saha *et al.*, 2010) and also improved soil properties by increasing productivity, protein yield, energy output, soil organic carbon (C), soil N, P and K, population of bacteria, fungi, actinomycetes, microbial biomass, and CO₂ evolution in soil (Sharma *et al.*, 2010). Residue incorporation of the leguminous crop

had a more beneficial effect on subsequent crop and also improves soil physical conditions (Manoj *et al.*, 2009). The consortium of different hypercellulytic fungal culture can be used to lower C N ratio of crop residue to quickly decomposable to avail nutrient at early stages of plant growth. The microbial consortium lignocellulolytic fungi can be used for rapid bio-conversion of agro-waste using organic inputs (ICAR NEWS., 2008).

Materials and Methods

The field experiment was conducted during 2014-15 and 2015-16 at 'Research Farm' of Division of Agronomy, Indian Agricultural Research Institute, New Delhi (28.40° N latitude, 77.12° E longitude and 228.6 MSL). The climate of Delhi is the subtropical and semi-arid type with hot and dry summer, cold winter and mild to heavy rainfall. It falls under the agro-climate zone 'Trans-Gangetic plains'. The mean annual rainfall of Delhi is 652 mm and more than 80% of that generally occurs during the monsoon season (July-September) with the mean annual evaporation of 850 mm. Weather conditions are attributed to have an impact on the performance of crops. Consequently, it becomes utmost important to take into consideration the conclusion from the experimental results. The minimum and maximum temperature ranged between -0.9° and 20.2°C and 0.5° and 23.0°C, with the rainfall of 315.8 and 19.8 mm during the growth period of wheat 2014-15 and 2015-16, respectively. The data showed that as compared to 2015-16, abnormally very high rainfall (135.40 mm) was received in January, February and March of 2014-15. The soil of experimental site was sandy loam with a bulk density of 1.48 and 1.46 mg/m³. In soil organic carbon was 0.46 and 0.52% with 158.4 and 164.2 kg/ha available N, 14.45 and 16.2 kg/ha available P, 257.8 and 268.5 kg/ha available K in the first and second year,

respectively. The pH was 8.14 and 7.9 with EC of 0.28 and 0.26 dS/m during 2014-15 and 2015-16 years, respectively. The experiment consisted of 15 treatment combinations with three treatments in crop residue [no crop residue, Crop residue incorporation and fungal consortium incorporation] and five treatments in recommended dose of potassium (RDK) (K kg/ha), potassium management [control, KSB, recommended dose of potassium 60 kg K/ha, 50% RDK+ KSB and 75% RDK+ KSB] was carried out in split plot design and replicated thrice. The required quantity of different requirements viz., Crop residue, fungal consortium incorporation and as per the treatments was applied in field ten days before sowing of both the crops. For studying the growth and yield attributes parameters of wheat five plants were tagged randomly in the second row of either side in the field. Dry matter accumulation (DMA) and leaf area studies were done from the randomly selected one meter from second-row wheat and the yield and yield attributes were record at harvest.

Results and Discussion

Application of residue and K management in different treatment combinations resulted in significant increase in growth parameters viz., plant height, dry matter accumulation (DMA) and leaf area index (LAI) over the control during both the years of experimentations (Table 1 and 3). The plant height under crop residue incorporation + fungal consortium was higher at all the stages compared to crop residue incorporation and no crop residue. The tallest plant height was observed with the application of 100% recommended a dose of potassium (RDK) all the growth stages during both the years of studies. However, 75% RDK +KSB was at par with 100% RDK during both the years. Among the residue application treatment, crop residue + fungal consortium recorded highest dry matter accumulation

(1064.0 and 1080.2 g/m²) at harvest stages as compared to rest of the treatment during first and second year respectively. The dry matter accumulation under crop residue incorporation was significantly higher harvest stages compared to no crop residue. At harvest, the maximum dry matter accumulation (1097.7 and 1112.2 g/m²) was observed with 100% RDK harvest growth stages and significant over to rest of the treatment during both the years. However, it was statistically at par with 75% RDK+ KSB. Dry matter accumulation with 50% RDK + KSB and KSB significantly higher at all the stages compared to control during both years of study. As per the Borie *et al.*, (2002) reported from Southern Chile in Andisol these organic amendments with *Trichoderma viridaeae* increased plant performance (growth attributes) and mineral acquisition (wheat more than lupine. The significantly higher leaf area index was noticed with crop residue + fungal consortium at 75 and 100 DAS but statistically at par with crop residue incorporation during both years. However, at early stage growth, leaf area index not affected significantly with crop residue management. Maximum leaf area index was recorded with crop residue + fungal consortium (4.47 and 4.56) while minimum leaf area index (4.27 and 4.35) was noted with no crop residue. K management practices considerably enhanced the leaf area index at different growth stages over control during both years of experimentation. Significantly highest leaf area index of 4.52 and 4.61 was noted during the first and second year of investigation respectively due to the application of 100 % RDK as compared to rest of treatment but statistically at par with 75% RDK. As compared to the first year, maximum leaf area index was recorded in the second year of investigation. It might be due to residue application improved the physical condition of soil for better germination and seedling establishment (ICAR NEWS., 2008). Fungal consortium might have enhanced the

availability and uptake of nutrients due to faster mineralization and release of nutrient at various crop growth stages, which in turn may increase the cell division and synthesis of photosynthates at the respective point of growth and development and due to a increased the activities of beneficial microorganisms due to increased organic pool in soil, which resulted in production of growth-promoting substances and improved nutrient availability for longer period throughout the crop growth (Gurdeep and Reddy, 2017)

Crop growth indices

The data in the table indicated that crop growth rate of wheat was positively influenced by variable crop residue and K application rates at all growth stages during both the years (Table 2 and 3) Maximum mean CGR was increased continuously due to crop residue management up to 75-100 DAS during both years of study and subsequently decreased it. Maximum CGR of 20.62 and 20.83 g/g/day was observed with application of crop residue incorporation + fungal consortium significantly higher over no crop residue at all stages of wheat in both the year. Further evaluation of data in the same table revealed that CGR significantly improved due to K management practices during both years of experimentation. Among K management practices, significantly maximum CGR (21.46 and 21.67 g/m²/day) was recorded with 100% RDK at all growth stages over rest of the treatment but statically at par with 75% RDK + KSB.). A better soil physical condition provides more plant nutrients and source of energy for soil microbes. In crop residues on soil surface protect the soil against crusting and surface sealing, reduce soil compaction and temperature, conserve soil moisture, aggregation and macro-porosity and enhance root growth (Blanco- Canqui and Lal, 2006; Singh, 2011; Meena, 2015). It might be due to

synergistic interaction of potassium with other nutrients which resulted in increased nutrient availability for photosynthetic activity in the plant. Baque *et al.*, (2006) reported that uptake of N, P and K were enhanced with increasing levels of K. Higher rates of K allowed for the efficient use of more nitrogen, which resulted in better early vegetative growth (Anonymous, 1998). These results are also in close conformity with Juan *et al.*, (2009) and Grzebisz *et al.*, (2010) Xue *et al.*, (2000) and Sheng *et al.*, (2003).

A perusal of data presented in table showed that the Net Assimilation Rate (NAR) of wheat was positively influenced by variable residue and K application rates over control at all growth stages during both the years (Table 4). Significantly higher mean NGR was observed with application crop residue incorporation + fungal consortium over no crop residue at all stages of wheat in both the years. The maximum NAR (5.22 and 5.28 g/m²/day at 50-75 DAS) was recorded with crop residue incorporation + fungal consortium treatment followed by crop residue incorporation at all the stage of crop growth during 2014-15 and 2015-16. Among the different dose of potassium application, The maximum mean NAR (5.24 and 5.29 g/m²/day at 50-75 DAS) was recorded with 100% RDK treatment followed by 75% RDK + KSB, 50% RDK + KSB and KSB at all the stage of crop growth during 2014-15 and 2015-16. However, 100% RDK application significant as compared to rest of the treatment and it was statistically *at par* with 75% RDK+KSB. It might be due to synergistic interaction of potassium with other nutrients which resulted in increased nutrient availability for photosynthetic activity in the plant. Baque *et al.*, (2006) reported that uptake of N, P and K were enhanced with increasing levels of K. Higher rates of K allowed for the efficient use of more nitrogen, which resulted in better early vegetative growth (Anonymous, 1998).

Table.1 Effect of crop residue and potassium management on plant height at harvest and LAI of wheat

Treatments	Plant height		LAI							
			0-25 DAS		25-50 DAS		50-75 DAS		75-100 DAS	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Residue management										
No-crop residue	96.45	98.66	0.211	0.216	2.30	2.34	3.49	3.56	4.27	4.35
Crop residue incorporation	98.86	101.04	0.224	0.228	2.32	2.37	3.61	3.68	4.41	4.50
Crop residue incorporation + fungal consortium	99.74	101.94	0.228	0.232	2.33	2.38	3.63	3.71	4.47	4.56
SEm±	0.78	0.80	0.005	0.005	0.006	0.006	0.006	0.004	0.008	0.008
CD (P =0.05)	NS	NS	NS	NS	0.023	0.023	0.025	0.016	0.031	0.030
Potassium management										
Control	92.55	94.62	0.210	0.214	2.21	2.26	3.42	3.49	4.19	4.28
KSB	96.09	98.24	0.215	0.220	2.25	2.30	3.49	3.55	4.28	4.37
100% RDK (60 kg/ha)	102.02	104.30	0.229	0.234	2.40	2.45	3.69	3.77	4.52	4.61
50% RDK + KSB	99.83	102.06	0.223	0.228	2.34	2.39	3.61	3.69	4.43	4.52
75% RDK + KSB	101.26	103.52	0.227	0.232	2.37	2.42	3.67	3.74	4.49	4.58
SEm±	0.54	0.55	0.006	0.006	0.007	0.007	0.009	0.011	0.012	0.012
CD (P =0.05)	1.57	1.60	NS	NS	0.021	0.021	0.028	0.031	0.034	0.035

Table.2 Effect of crop residue and potassium management on mean crop growth rate of wheat

Treatments	Mean crop growth rate (g/day)									
	0-25 DAS		25-50 DAS		50-75 DAS		75-100 DAS		100-harvest	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Residue management										
No-crop residue	1.275	1.288	4.27	4.31	14.52	14.67	19.15	19.34	0.760	0.768
Crop residue incorporation	1.305	1.318	4.40	4.44	15.23	15.39	20.27	20.48	0.891	1.066
Crop residue incorporation + fungal consortium	1.313	1.327	4.43	4.48	15.43	15.59	20.62	20.83	0.951	1.174
SEm±	0.04	0.04	0.13	0.13	0.10	0.10	0.13	0.13	0.021	0.029
CD (P =0.05)	0.16	0.17	0.52	0.52	0.40	0.41	0.52	0.52	0.083	0.115
Potassium management										
Control	1.247	1.260	4.12	4.16	14.05	14.19	18.08	18.27	0.785	0.914
KSB	1.275	1.288	4.26	4.30	14.62	14.77	19.24	19.43	0.837	0.973
100% RDK (60 kg/ha)	1.336	1.349	4.54	4.59	15.83	15.99	21.46	21.67	0.923	1.061
50% RDK + KSB	1.309	1.322	4.42	4.47	15.26	15.41	20.37	20.58	0.900	1.029
75% RDK + KSB	1.323	1.336	4.50	4.55	15.56	15.71	20.92	21.13	0.892	1.035
SEm±	0.05	0.05	0.13	0.13	0.06	0.06	0.11	0.11	0.033	0.022
CD (P =0.05)	0.22	0.24	0.15	0.14	0.29	0.31	1.13	1.12	7.13	8.21

Table.3 Effect of crop residue and potassium management on effective tiller, dry matter accumulation and yield net accumulation rate of wheat

Treatments	Effective tillers/m ²		DMA		NAR					
	2014-15	2015-16	2014-15	2015-16	25-50 DAS		50-75 DAS		75-100 DAS	
					2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Residue management										
No-crop residue	357.67	364.27	995.8	1005.8	4.83	4.87	5.03	5.07	4.90	4.94
Crop residue incorporation	363.87	370.60	1047.9	1062.8	4.86	4.91	5.17	5.22	5.02	5.07
Crop residue incorporation + fungal consortium	367.07	373.27	1064.0	1080.2	4.87	4.95	5.22	5.28	5.06	5.12
SEm±	1.26	0.48	4.3	4.3	0.02	0.02	0.05	0.04	0.03	0.03
CD (P =0.05)	4.95	1.88	16.8	17.0	NS	NS	NS	NS	0.12	0.12
Potassium management										
Control	351.44	357.44	953.2	965.8	4.80	4.84	5.02	5.07	4.72	4.77
KSB	357.11	363.00	1001.5	1014.7	4.85	4.89	5.11	5.16	4.92	4.97
100% RDK (60 kg/ha)	371.67	379.33	1097.7	1112.2	4.89	4.95	5.24	5.29	5.19	5.24
50% RDK + KSB	363.33	369.56	1052.0	1066.0	4.86	4.91	5.15	5.21	5.03	5.09
75% RDK + KSB	370.78	377.56	1075.1	1089.3	4.87	4.92	5.18	5.23	5.10	5.15
SEm±	1.17	1.30	3.2	3.2	0.02	0.02	0.03	0.02	0.03	0.03
CD (P =0.05)	3.42	3.80	9.3	9.4	NS	NS	0.07	0.07	0.09	0.10

Table.4 Effect of crop residue and potassium management on yield attributes and yields of wheat

Treatments	Spike weight (g)		No. of grains spike ⁻¹		Test weight (g)		Grain yield (t/ha)		Straw yield (t/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Residue management										
No-crop residue	2.34	2.41	43.07	43.87	40.08	40.52	4.44	4.56	6.52	6.62
Crop residue incorporation	2.62	2.79	44.60	45.20	40.32	41.34	5.10	5.26	6.65	6.78
Crop residue incorporation + fungal consortium	2.82	3.13	45.13	46.47	41.34	43.81	5.25	5.43	6.79	6.93
SEm±	0.07	0.06	0.38	0.13	0.35	0.54	0.03	0.04	0.04	0.04
CD (P =0.05)	0.26	0.22	1.49	0.51	NS	2.11	0.13	0.15	0.17	0.18
Potassium management										
Control	2.44	2.55	42.56	43.67	39.23	40.71	4.20	4.32	6.30	6.41
KSB	2.58	2.69	43.67	44.33	39.58	41.13	4.36	4.49	6.58	6.70
100% RDK (60 kg/ha)	2.77	3.07	45.22	46.33	41.77	42.95	5.61	5.80	6.94	7.07
50% RDK + KSB	2.43	2.68	44.67	45.00	40.63	42.16	5.12	5.29	6.64	6.76
75% RDK + KSB	2.75	2.91	45.22	46.56	41.69	42.51	5.36	5.53	6.81	6.95
SEm±	0.05	0.05	0.33	0.24	0.36	0.33	0.08	0.08	0.05	0.05
CD (P =0.05)	0.15	0.15	0.97	0.71	1.05	0.96	0.22	0.24	0.15	0.14

Table.5 Interaction effect of crop residue and potassium management on yield of wheat during both years

Treatments	Grain yield (t/ha ⁻¹)					
	2014-15			2015-16		
	No crop residue	Crop residue incorporation	Crop residue incorporation + fungal consortium	No-crop residue	Crop residue incorporation	Crop residue incorporation + fungal consortium
Control	4.11	4.17	4.32	4.21	4.30	4.45
KSB	4.32	4.33	4.42	4.45	4.46	4.56
RDK	4.82	5.87	6.15	4.97	6.05	6.38
50 % RDK + KSB	4.43	5.43	5.49	4.54	5.60	5.73
75 % RDK + KSB	4.50	5.72	5.85	4.64	5.90	6.06
SEm±	0.17			0.18		
CD (P = 0.05)	0.49			0.52		

These results are also in close conformity with Juan *et al.*, (2009) and Grzebisz *et al.*, (2010) Xue *et al.*, (2000) and Sheng *et al.*, (2003).

Yield attributes and yield

Data revealed that the application of residue and K management practices had a positive effect on different yield attributing parameter of wheat compared to its control. The maximum effective tiller, spike length and a number of grain/spike were recorded with crop residue + fungal consortium treatment during both years and significant over no crop residue. The lowest values of these attributes were observed with no crop residue. However, test weight was found non-significant during the first year. Further data showed that application of 100% RDK and 75% RDK + KSB was at par to each other found significant over rest of the treatments during both years into effective tillers, spike length, spike weight, number of grains/spike and test weight of wheat. However, application of 50% RDK + KSB was significantly superior over control and KSB treatment in all yield attributes during both years. The improvement in yield attributing character was due to the response of applied K as it is vital to many plant processes including photosynthesis, translocation of photosynthates, protein synthesis and activation of plant enzymes etc. Tabatabaie *et al.*, (2011) also reported that application of K increased the number of grains/cob and 1000-grain weight, grain number/row, grain weight/row in maize. Polara *et al.*, (2010) reported that K application at different doses significantly increased the number of tillers/plant, number of grain/spike. Seed inoculation with KSB increased the yield attributes of maize (Basavexsha *et al.*, 2016) and wheat (Muralikaman, 1996). These findings are also conformity with Basavexsha *et al.*, (2016).

The data pertaining to grain yields and straw yield of the wheat crop are presented in table 4. The application of residue management practices and potassium management practices showed significant improvement in grain, straw and biological yield over control in wheat during both the years of experimentation. The treatment with crop residue incorporation + fungal consortium was significantly superior with respect to grain yield (5.25 and 5.43 t/ha) in wheat as compared to no crop residue and crop residue incorporation during both years. However, crop residue incorporation was also recorded significant effect over no crop residue during both years. Maximum straw yield were noted with crop residue incorporation + fungal consortium but statistically at par with crop residue incorporation and significantly superior over no crop residue during both years of investigation. However, crop residue incorporation was found significant over no crop residue with respect to straw.

The consortium of different hypercellulytic fungal culture can be used to lower C: N ratio of crop residue to quickly decomposable to avail nutrient at early stages of plant growth. Bijay Singh *et al.*, (2008) have concluded that application of rice residues to wheat with residue decomposing fungi typically has a small effect on wheat yields in short-term (1 to 3 years). Shafi *et al.*, (2007) reported that crop residues incorporation significantly increased grain yield (23.7%) of maize by as compared to residues removed treatment. Many researchers have reported the higher value of yield attributes under residue retention (Jat, 2010; Ram *et al.*, 2010; Arif *et al.*, 2011; Meena, 2015; Saad *et al.*, 2015).

Further, data indicated that crop yields and harvest index of wheat were considerably affected by K management practiced during both years of experimentation. Application of 100% RDK showed significant superiority in

grain yield of wheat (5.61 and 5.80 t/ha) over all other treatment during both years of study. However, this significant superiority treatment was observed with 75% RDK + KSB, 50% RDK + KSB and KSB during both years over control. A similar trend was recorded of straw yield, maximum was recorded with 100% RDK during both years but it was statistically at par with 75% RDK + KSB. However, 50 % RDK + KSB and KSB application were significantly superior to control during the period of testing. Mobilization of K from soil by bacterial strain through secretion of organic acids, protons, siderophores, exopolysaccharides and organic ligands, increased the availability of both essential macro and micronutrients for crop uptake in soil by maintaining good health of soil which might have resulted the improvement in the biomass yield (Basak and Biswas, 2009). Interaction effect of residue and K-management practices on grain yield of wheat was found significant in both the years of experimentations (Table 5). The treatment with crop residue incorporation + fungal consortium and 100% RDK were significantly superior with respect to grain yield of wheat (6.15 and 6.38 t/ha) as compared to no crop residue and control during both the year. Meena *et al.*, (2016) also reported that microbial inoculants of potassium solubilising bacteria were able to dissolve K from mineral and rocks that enhanced plant growth and yield. Inoculation with KSMs have been reported to exert beneficial effects on growth of cotton and rape (Sheng, 2005), pepper and cucumber (Han *et al.*, 2006), khella (Hassan *et al.*, 2010), sorghum (Badar *et al.*, 2006), wheat (Sheng and He, 2006).

On the basis of the results illustrated by the present investigation, it can be concluded that growth parameter vis. DMA, LAI, Mean crop growth rate, and, net assimilation rate, of wheat, was noticed with treatment receiving fungal consortium incorporation which was

statistically at par with Crop residue incorporation. Similar results were also recorded for grain yield and straw yield during 2014–15 and 2015–16 years. Further evaluation of revealed significantly improved due to K management practices during both years of experimentation. Potassium management in mungbean of results revealed that significantly highest plant height, DMA, LAI, Mean crop growth rate, net assimilation rate, yield attributes, grain yield, straw yield wheat were noticed with treatment receiving 100% RDK which were statistically at par with 75% RDK+ KSB. Interaction effect of residue and K-management practices, the treatment with crop residue incorporation + fungal consortium and 100% RDK were significantly superior with respect to grain yield of wheat as compared to no crop residue and control during both the year.

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