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Effect of Different Levels of Potassium and Green Manure on Available K, Uptake of K and Potassium Use Efficiency of Rice (*Oryza Sativa*. L)

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A field experiment was carried out at Agricultural College Farm, Mahanandi in Kurnool district of Andhra Pradesh to study the effect of different levels of potassium and green manure on yield, dry matter production, content, uptake of potassium, available K and potassium use efficiency of rice during *kharif* 2015. The results revealed that the yield, dry matter production, content, uptake of potassium, available K and potassium use efficiency were significantly increased with increase in K fertilizer application and also due to green manure incorporation. The highest yield, dry matter production, content and uptake of potassium, available K were obtained with incorporation of green manure (*Dhaincha* @ 5 t ha^{-1}) +120 kg K_2O ha^{-1} which was on par with (*Dhaincha* @ 5 t ha^{-1}) +80 kg K_2O ha^{-1}and (*Dhaincha* @ 5 t ha^{-1})+40 kg K_2O ha^{-1}. Among all the treatments the highest KUE was observed with T_6 ((*Dhaincha* @ 5 t ha^{-1}) +40 kg K_2O ha^{-1}) followed by T_7 ((*Dhaincha* @ 5 t ha^{-1}) + 80 kg K_2O ha^{-1}) and T_8 ((*Dhaincha* @ 5 t ha^{-1}) +120 kg K_2O ha^{-1}). Among the levels of K fertilizer, the highest potassium use efficiency was recorded at 100% RDK (80 kg K_2O ha^{-1}) followed by 150% RDK (120 kg K_2O ha^{-1}).

Key words: Rice, Available K, Green Manure, Potassium use efficiency, Uptake of Potassium.

Rice is an important food crop in the world. It is the staple food in South-East Asia and at present more than half of the worlds population depends on this crop. It is also one of the most important cereal in India and occupies second position in cultivation after wheat. Rice is one of the major field crops in Kurnool district and is cultivated in an area of 91,568 ha (Department of Agriculture, 2014). Incorporation of Dhaincha at flowering stage before transplanting of rice was followed by most of the farmers in major rice growing areas of Kurnool district.

The available K content was increased by the incorporation of *Dhaincha* (Singh *et al*., 2009 and Singh *et al*., 2006). The soils of Agricultural college farm, Mahanandi were high in available K and K supplying power of rice growing soils of canal ayacut in Kurnool district is low as indicated by PBCK. Hence judicious application of potassic fertilizer is required for better crop production were reported by Prasad (2014) and Swamanna (2015). Though much work has been reported on green manure in combination with N and P in rice crop but no investigation have been carried out in green manure along with K fertilizer of rice crop.

Hence, present investigation will be carried out to know the effect of different levels of potassium and green manure on content, uptake of K, available K and potassium use efficiency of rice.

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Material and Methods

A field experiment was conducted at Agricultural college farm, Mahanandi in Kurnool district of Andhra Pradesh during *Kharif*, 2015.The soils of experimental field was sandy loam with soil pH 7.9, EC 0.33 dSm^{-1} ,organic carbon 0.55%, low in available N(239 kg ha^{-1}), high in P_2O_5(82 kg ha^{-1}) and K_2O (1075 kg ha^{-1}) respectively. There were eight treatments consisted of 0, 40, 80 and 120 kg K_2O ha^{-1} alone and in combinations with green manure which were laid out in randomized block design and replicated thrice. A common required dose of Nitrogen (240 kg ha^{-1}) and phosphorus (80 kg ha^{-1}) applied to all the treatments. Nitrogen in the form of urea was applied in three equal splits as basal, at tillering and at panicle initiation stages. Phosphorus in the form of single super phosphate was applied basally. Potassium in the form of muriate of potash was applied in two equal splits as basal and at panicle initiation stage as per the treatments. Green manure (*Dhaincha*) was grown in the treatments T_5, T_6, T_7 and T_8 ploughed *in situ* at flowering before transplanting. The content of N, P and K in green manure were 3.5 percent, 0.3 percent and 1 percent respectively. The grains from each net plot was cleaned and sun dried until constant weight was recorded and expressed in kg ha^{-1}. The yield from sample plants from net plot was added to the net plot yield. The straw from each net plot was allowed to dry in the field until a constant weight obtained and the final weight was recorded and expressed in kg ha^{-1}. Plants were collected for destructive sampling at tillering and panicle initiation stage in m^{-2} area in each plot .The collected plants were dried in oven at 65°C till constant weights recorded and expressed in kg ha^{-1}. After recording the dry weights, the straw and grain samples were grounded in a willey mill and were analyzed for the concentrations of major nutrients as per the procedures out lined by Tandon (1993). The uptakes of K and KUE were computed with using the formula

$$\text{Uptake of K} = \text{K concentration (per cent)} \times \text{dry matter yield (kg ha}^{-1}\text{)} / 100$$

Potassium use efficiency (KUE) =

$$\frac{\text{K uptake in fertilizer plot (kg ha}^{-1}\text{)} - \text{K uptake in control plot (kg ha}^{-1}\text{)}}{\text{K fertilizer applied (kg ha}^{-1}\text{)}} \times 100$$

Results and Discussion

Dry matter production

The data on dry matter production at tillering, panicle initiation and harvesting stage are presented in Table 1. The results showed that the dry matter production increased with age of the crop in all the treatments.

The graded levels of K application from 0 to 120 kg K_2O ha^{-1} increased the dry matter production at all stages of crop growth. But significant difference was observed at 80 kg K_2O ha^{-1}(T_3) and 120 kg K_2O ha^{-1}(T_4), both these treatments were equally effective in increasing dry matter production and similar increase was also reported by Kanthi *et al.* (2014). Green manure in combination with potassium applied treatments recorded higher dry matter production than when applied alone at all the stages of crop growth.

Table 1. Dry matter production (kg ha^{-1}) of rice as influenced by different levels of Potassium and green manure.

Treatments	Tilleringstage	Panicle initiation stage	Harvest stage
T1 : 0% RDK (Control)	1468	3080	6173
T2 : 50% RDK (40 kg K_2O ha^{-1})	1577	3133	6716
T3 : 100% RDK (80 kg K_2O ha^{-1})	1786	3320	7664
T4 : 150% RDK (120 kg K_2O ha^{-1})	1854	3404	7829
T5 : GM (*Dhaincha*@5t ha^{-1})*in situ* only	1903	3489	8979
T6 : *Dhaincha* @ 5 t ha^{-1} + 40 kg K_2O ha^{-1}	1956	3538	9617
T7 : *Dhaincha* @ 5 t ha^{-1} + 80 kg K_2O ha^{-1}	2036	3631	10403
T8 : *Dhaincha* @ 5 t ha^{-1} + 120 kg K_2O ha^{-1}	2159	3773	10931
SE(m)±	103	78	465
CD(p=0.05)	314	238	1424
CV %	9	4	9

Among all treatments, the treatment T_8 ((*Dhaincha* @ 5 t ha^{-1}) +120 Kg K_2O ha^{-1}) recorded the highest dry matter production (2159 at tillering, 3773 at panicle initiation stage and 10931 kg ha^{-1} at harvesting stage). But this treatment was on par with T_7, T_6, T_5 and T_4 at tillering stage and with T_6 and T_7 at panicle initiation and harvesting stages.

Incorporation of green manure *in situ* (T_5) was also found advantageous in producing higher dry matter production than K fertilizer treatments alone. The higher dry matter production associated with manures might be due to improved the soil aggregation, enhanced the soil microbial activity and there by higher nutrient availability which leads to more vegetative growth resulting in higher dry matter accumulation similar higher dry matter production was also observed with green manure by Yadav *et al*. (2005).

Concentration and uptake of K

Application of potassium gradually increased the concentration of rice crop at all the stages of crop growth up to 120 kg K_2O ha^{-1} (Table 2). However, 40 kg K_2O ha^{-1} with 80 kg K_2O ha^{-1} and 80 kg K_2O ha^{-1} with 120 kg K_2O ha^{-1} were on par with each other. Similar increase in concentration of K due to the levels of K fertilizer application in rice crop was also reported by Surekha *et al*. (2003) and Swamanna (2015).

Green manure either alone or in combination with K fertilizer showed higher K concentration than K fertilizer alone. The highest potassium concentration was observed at T_8 ((*Dhaincha* @ 5 t ha^{-1}) +120 kg K_2O ha^{-1}) which was on par with T_7 ((*Dhaincha* @ 5 t ha^{-1}) +80 kg K_2O ha^{-1}) at all the stages of crop growth. The results further showed that concentration of K in rice was highest at tillering and gradually decreased there after mainly due to dilution as the dry matter accumulated.

Application of potassium gradually increased the uptake of rice crop at all the stages of crop growth up to 120 kg K_2O ha^{-1} (Table 2). Uptake of K increased with increase in rates of application of K and also due to green manure incorporation. Among all treatments the highest K uptake was observed with T_8 ((*Dhaincha*

@ 5 t ha^{-1}) +120 kg K_2O ha^{-1}) which was on par with T_7 ((*Dhaincha* @ 5 t ha^{-1}) +80 kg K_2O ha^{-1}) at all the stages of crop growth.

Yield

All the treatments recorded significantly higher grain and straw yield than control except T_2 (40 kg K_2O ha^{-1}) (Table 3). Grain and straw yield increased with increasing levels of K up to 120 kg K_2O ha^{-1}. However, there was no statistical difference between the three levels of K (40, 80 and 120 kg K_2O ha^{-1}) in increasing the grain and straw yield. The increased grain and straw yield by the application of 1K fertilizer was due to the continuous supply of K during crop growth period which might be due to increased total no of tillers, dry mater accumulation, effective tillers, number and weight of filled grains and fertilizer use efficiency. These findings were in close conformity with those of Meena *et al.* (2003) and Surekha *et al.* (2003).

Table 2. Effect of different levels of potassium and green manure on concentration and uptake of K at different stages of rice crop.

Treatments	Contentration of K (%)				Up take of K(kg ha^{-1})			
	Tillering	Panicle initiation Stage	Harvest stage		Tillering stage	Panicle initiation stage	Harvest stage	
			Grain	Straw			Grain	Straw
T_1 : 0% RDK (Control)	1.96	1.22	0.32	1.31	28.70	39.31	15.93	80.87
T_2 : 50% RDK (40 kg K_2O ha^{-1})	2.20	1.26	0.33	1.36	34.66	40.98	17.26	91.34
T_3 : 100% RDK (80 kg K_2O ha^{-1})	2.34	1.31	0.36	1.36	42.37	44.56	19.56	104.44
T_4 : 150% RDK (120 kg K_2O ha^{-1})	2.44	1.33	0.38	1.40	45.00	45.48	20.76	112.68
T_5 : GM (*Dhaincha*@5 t ha^{-1}) *in situ* only	2.48	1.32	0.39	1.49	47.21	46.61	21.51	133.41
T_6 : *Dhaincha* @ 5 t ha^{-1} + 40 kg K_2O ha^{-1}	2.64	1.32	0.40	1.56	50.41	47.81	22.39	149.05
T_7 : *Dhaincha* @ 5 t ha^{-1} + 80 kg K_2O ha^{-1}	2.71	1.38	0.48	1.57	55.08	50.56	27.03	163.37
T_8 : *Dhaincha* @ 5 t ha^{-1} + 120 kg K_2O ha^{-1}	2.74	1.42	0.49	1.60	59.22	54.40	28.17	176.83
SE(m)±	0.03	0.03	0.01	0.01	2.32	1.32	0.52	6.88
CD (P=0.05)	0.10	0.10	0.02	0.04	7.11	4.05	1.58	21.08
CV(%)	2.40	4.15	3.17	1.64	8.86	4.95	4.14	9.42

Application of green manure in combination with K recorded higher grain and straw yield than when applied alone. The highest grain and straw yield were obtained with T_8 ((*Dhaincha* @ 5 t ha^{-1}) + 120 kg K_2O ha^{-1}), but on par with T_7 ((*Dhaincha* @ 5 t ha^{-1}) + 80 kg K_2O ha^{-1}) and T_6 ((*Dhaincha* @ 5 t ha^{-1}) + 40 kg K_2O ha^{-1}). Green manure in combinations with K fertilizers increased the grain yield due to long stature of plants, higher number hof tillers m^{-2}, higher dry matter production and decomposition of succulent green manure crop, which favoured for release of nutrients and their continuous availability in soil for sustaining higher grain and straw yield of rice.

Highest grain yield with green manure along with NPK fertilizers in rice was also reported by Sharma *et al*. (2001) and Singh *et al*. (2002). Green manure in combinations with K fertilizers increased the straw yield due to the highest plant height and dry matter accumulation. This might be due to immediate release of nutrients through inorganic sources and later by mineralization of nutrients through green manure leading to steady supply of nutrients. Similar findings were reported by Sharma *et al*. (2001) and Patra *et al.* (2000).

Available K

The data presented in Table 3 indicated that the available K significantly increased with the application of potassium fertilizer or green manure incorporation either alone or in combination at all the stages of crop growth. However 50 % RDK (40 kg K_2O ha^{-1}) increased the available K when compared with control (T_1) but no significant difference was observed.

Among all treatments, the higher available K (642 kg ha^{-1}) was observed with T_8 ((*Dhaincha* @ 5 t ha^{-1})+ 120 kg K_2O ha^{-1}) but it was on par with T_7 ((*Dhaincha* @ 5 t ha^{-1})+80 kg K_2O ha^{-1}) and T_6 ((*Dhaincha* @ 5 t ha^{-1})+40 kg K_2O ha^{-1}) at tillering stage and harvesting and with T_7 ((*Dhaincha* @ 5 t ha^{-1})+ 80 kg K_2O ha^{-1}) at panicle initiation stage.

Higher buildup of available K was observed due to application of green manure along with K fertilizers due to additional K applied through it and also solubilizing action on certain organic acids produced during the decomposition and greater capacity to hold K in available form. These results were in conformity with findings of Yaduvanshi *et al*. (2013).

The results further showed that depletion of available K_2O in all the treatments at three stages of crop growth in comparison with initial soil (1075 kg K_2O ha^{-1}). The depletion of available K_2O might be due to higher removal by crop, inadequate addition of K through fertilizer and green manure and leaching losses.

However the depletion of available K higher in control when compared with fertilizer or green manure either alone or combined treatments. Kavitha *et al*. (2012) also observed the significant depletion of available K_2O in control plots as compared with fertilizer and manure treated plots in tomato- cabbage cropping sequence.

Table 3. Yield, Available K content and Potassium use efficiency of rice as influenced by different levels of potassium and green manure.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Available K (kg ha^{-1})			Potassium use efficiency (KUE)
			Tillering stage	Panicle initiation stage	Harvest stage	
T_1 : 0% RDK (Control)	5008	6173	567	577	562	-
T_2 : 50% RDK (40 kg K_2O ha^{-1})	5281	6716	582	593	591	29.43
T_3 : 100% RDK (80 kg K_2O ha^{-1})	5433	7664	596	628	614	33.97
T_4 : 150% RDK (120 kg K_2O ha^{-1})	5517	7830	620	640	636	30.53
T_5 : GM (*Dhaincha* @ 5 t ha^{-1})*in situ* only	5493	8979	559	622	602	-
T_6 : *Dhaincha* @ 5 t ha^{-1} + 40 kg K_2O ha^{-1}	5552	9617	613	722	667	186.54
T_7 : *Dhaincha* @ 5 t ha^{-1} + 80 kg K_2O ha^{-1}	5671	10403	626	738	688	116.98
T_8: *Dhaincha* @ 5 t ha^{-1} + 120 kg K_2O ha^{-1}	5748	10931	642	743	713	90.35
SE(m)±	95	465	11	6	20	-
CD (P=0.05)	292	1424	34	18	60	-
CV%	5	7	3	6	5	-

Potassium use efficiency

Green manure in combination with K fertilizer showed higher potassium use efficiency (KUE) (Table 3). Among all the treatments the highest KUE was observed with T_6 ((*Dhaincha* @ 5 t ha^{-1}) +40 kg K_2O ha^{-1}) followed by T_7 ((*Dhaincha* @ 5 t ha^{-1}) + 80 kg K_2O ha^{-1}) and T_8 ((*Dhaincha* @ 5 t ha^{-1})+120 kg K_2O ha^{-1}). Among K fertilizer levels, the highest potassium use efficiency was recorded at 100% RDK (80 kg K_2O ha^{-1}) followed by 150% RDK (120 kg K_2O ha^{-1}).

Conclusion

It was concluded that the highest yield, dry matter production, concentration, uptake of K and available K were increased with increasing levels of K up to 120 kg K_2O ha^{-1} but significant difference was observed at 80 and 120 kg K_2O ha^{-1}. However, the highest potassium use efficiency was recorded at 80 kg K_2O ha^{-1}. Application of green manure in combination with K fertilizers recorded higher yield, dry matter production, concentration and uptake of K, available K were obtained with incorporation of green manure as *Dhaincha* @ 5 t ha^{-1} + 120 kg K_2O ha^{-1} but which was on par with *Dhaincha* @ 5 t ha^{-1}+80 kg K_2O ha^{-1} and *Dhaincha* @ 5 t ha^{-1} + 40 kg K_2O ha^{-1}. However, the highest potassium use efficiency was recorded at *Dhaincha* @ 5 t ha^{-1} + 40 kg K_2O ha^{-1}. Hence, the incorporation of green manure (*Dhaincha*) at flowering stage before transplanting along with 40 kg K_2O ha^{-1} may be recommended for rice crop. However, the results will have to be confirmed by conducting extensive field trails in farmers fields on long term basis.

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