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POTASSIUM DYNAMICS IN IRRIGATED LOWLAND PADDY SOILS AND ITS RELATION TO PLANT K AND GRAIN YIELD OF RICE *

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INTRODUCTION

Potassium is a major plant nutrient which plays a critical role in regulating assimilate transportation and protecting rice plants form biotic and abiotic stresses (Williams and Smith, 2001, Chau and Heong, 2005). After crop harvest, the content of exchangeable K in soils was below the critical levels, showing the depletion of exchangeable K due to cropping. Therefore, short supply of potassium in soil could affect the productivity of rice (Salisbury and Ross, 1978). Soil test based fertilizer recommendation, which was introduced to supply K fertilizer when and where necessary, considered exchangeable K level as an indicator of the K supplying capacity of paddy soils (DOA, 1997). According to soil test based fertilizer recommendation, fertilizer K application has been recommended when exchangeable soil K levels were below 80 mg/kg.

There is accumulating evidences that non-exchangeable soil K also has a role to play in providing potassium to plants. Experiments have demonstrated that as levels of exchangeable soil K are depleted, non-exchangeable K makes a significant contribution to plant uptake (Uddini *et al.,* 2011). Under Sri Lankan conditions, application of K even 150 kg K_2O/ ha has not significantly affected the grain yield of rice in some of the soils because non-exchangeable K fraction of these soils is in a sufficient range. When amount of exchangeable potassium in soil is depleted there is a possibility to replenish non - exchangeable potassium to exchangeable potassium. So it is useful to find out the changes of non-exchangeable K and exchangeable K fraction of the soils with the application of K fertilizer and rice straw in rice cultivation and effect of non-exchangeable K and exchangeable K fraction on plant K content and grain yield of rice. The objective of this study was to quantify exchangeable and non-exchangeable K in an irrigated low land paddy soils and their relation to grain yield and K content of rice plants.

* *See "Tropical Agriculturist" Volume 163 for details.*

MATERIALS AND METHODS

The experimental site was situated in a continuous rice producing area at the Rice Research and Development Institute, Batalagoda in the low country Intermediate zone. The soil in the experimental site is sandy clay loam with 38% sand, 15% clay and 47% silt, and poorly drained. At the commencement of the study, the soil pH was 5.9, and the soil contained 0.18% total Nitrogen (N), 43 mg/ kg exchangeable K, 185 mg/kg non-exchangeable K, and 8.7 mg/kg available Phosphorus (P). This study was initiated in *Yala* 2011 and continued with same treatments for seven consecutive seasons until *Yala* 2014 without changing original plot arrangements. Treatments tested in the experiments were T1- Control – (no fertilizer and straw application), T2- straw 5 t/ha, T3- straw 5 t/ha+ 15 kg K_2O (basal) + 20 kg K_2O 6 weeks after establishment (6WAE), T4- straw 5 t/ha + 15 kg K_2O (basal), T5- straw 5 t /ha +20 kg K_2O (6 WAE) and T6- 15 kg K_2O (basal) + 20 kg K_2O (6 WAE). Treatments were arranged in a randomized complete block design and replicated four times. Crop management and N and P applications were done uniformly across all treatments as recommended by the Department of Agriculture. Total grain weight was recorded in each plot at 13% moisture and plant K content was determined at maturity. Exchangeable K content and non-exchangeable K in soil were determined at the beginning of the crop establishment. The analysis of variance and mean separation were performed for the experimental data using SAS statistical package.

RESULTSAND DISCUSSION

Results of this experiemnt revealed that non-exchangeable K content was significantly different between control plots and treated plots and lowest value of 100.8 mg/kg was recorded in control plots and the highest value (160.2 mg/kg) was recorded in plots treated with straw at 5 t/ha and K at 35 kg K_2O/ha. Exchangeable K contents were significantly low at the beginning irrespective of the treatments. It was the lowest (25.3 mg/kg) in control plots while highest (46.2 mg/kg) in plots treated with straw 5 t/ha and K at 35 kg K_2O/ha (Table 1). Exchangeable K has been considered as an indicator to decide K supplying capacity of soil (DOA, 1997). Results show the linear relationship between non-exchangeable K content and exchangeable K contents. As such non exchangeable K content plays a significant role in rice production.

Results presented in Table 2 revealed that application of rice straw and chemical K fertilizer increased grain yield and plant K contents. Grain yields were non-significant among the treated plots revealing that rice straw can provide considerable amount of K to paddy fields. This is an agreement with the findings of Senaratne *et al.* (2006) that K provided by rice straw is similar to K supplied by the MOP fertilizer. As such, application of rice straw and chemical K fertilizer increased grain yield significantly over control.

Table 1. Non exchangeable K contents and exchangeable K contents of the paddy soils at the beginning of 7th season.

Treatments	Non-exchangeable K (mg/kg)	Exchangeable K (mg/kg)
No K	100.8b	25.3d
Straw 5 t/ha	131.0ab	33.4 c
Straw 5/t ha+ 15 kg K_2O/ha (Basal) + 20 kg K_2O/ha (6 WAP)	160.2a	46.2a
Straw 5 t/ha+ 15 kg K_2O/ha (Basal)	158.7ab	42.9ab
Straw 5 t/ha+ 20 kg K_2O/ha (6 WAP)	132.4ab	38.7abc
15 kg K_2O/ha (Basal) + 20 kg K_2O/ha (6 WAP)	126.7ab	35.3bc

* Mean values within a column with different letters are significantly different at $p<0.05$.

Table 2. Grain yield and plant K content of the plots treated with rice straw and different rates of chemical K fertilizer.

Treatments	Grain yield (t/ha)*		Plant K contents (%)*
	Average of the past 6 seasons*	7th season*	
1. No K	4.25c	4.78 b	0.57d
2. Straw 5 t/ha	4.49bc	4.90 ab	0.74c
3. Straw 5 t/ha+ 15 kg K_2O/ha (Basal) + 20 kg K2O (6 WAP)/ha	4.78 a	5.07 ab	1.02a
4. Straw 5 t/ha+ 15 kg K_2O/ha (Basal)	4.90a	5.30 ab	0.81bc
5. Straw 5t/ha+ 20 kg K_2O/ha (6 WAP)	4.90 a	5.42 a	0.80bc
6. 15 kg K_2O/ha (Basal) + 20 kg K_2O/ha (6 WAP)	4.72ab	5.19 ab	0.86ab

*Note: Mean values within a column with different letters are significantly different at $p<0.05$.

According to the above results presented in Table 1, application of chemical K fertilizer is necessary to maintain exchangeable K and non exchangeable K in soil. Similarly it is observed in this experiment that application of chemical fertilizer enhanced the plant K contents as well (Table 2). Therefore, even with the application of rice straw application with K fertilizer is important not only to get higher grain yield but also to get higher K content in plant tissues. Application of rice straw along with chemical K fertilizer in long run significantly increases exchangeable as well as non exchangeable K content in paddy fields. It also increases grain yield of rice as well as plant K contents.

CONCLUSIONS

The removal of K from basal fertilizer mixtures, promotion of straw recycling to return K removed by the rice crop and maintenance of high soil K content in rice soils are logically related to each other. Application of rice straw along with chemical K fertilizer in long run significantly increases exchangeable as well as non exchangeable K content in paddy fields. It also increases grain yield of rice as well as plant K contents. Non-exchangeable K content has a positive relationship with grain yield and highly relates to plant K content and as such non-exchangeable K content is a better indicator in the soil test based fertilizer recommendations to decide the K supplying capacity of paddy soils. Further, frequent testing of soil also required.

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