Pak. J. Agri. Sci., Vol. 40(3-4), 2003

DIFFERENCES AMONG RICE CULTIVARS IN POTASSIUM UPTAKE AND ITS UTILIZATION

Muhammad Sabir, M. A. Gill, Rahmatullah, Tariq Aziz & M. Aamer Maqsood
Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad

Crop species and varieties differ genetically in response to root medium K. We evaluated growth response of rice genotypes to K applied at adequate and deficient levels (3 mM & 0.3 mM K, resp.) in hydroponics. The genotypes differed significantly ($p<0.001$) in their shoot and root growth, root: shoot ratio, K concentration in shoot, K uptake and K use efficiency. Shoot dry matter yield, root dry matter yields and total biomass production correlated significantly ($p<0.001$) with their total K uptake and K utilization rate. The various rice genotypes differed significantly for their relative tolerance to K-deficiency stress.
Keywords: Potassium, rice, genotypic variability, utilization efficiency.

INTRODUCTION

Rice is an important cereal crop produced around the globe. It is grown mostly under submerged soil condition. Soil submergence provides free leaching for ions other than several physical, chemical and microbial changes in soil properties (Ponnamperuma, 1965). Rice wheat rotation is mostly followed in rice growing areas of South East Asia. Cereals need more K than legume crops.

Selection of crop genotypes adapted to low nutrient input is relatively a new strategy to cope with the situation of low nutrient concentration in root environment. Considerable genetic differences in K uptake and utilization efficiency exist in field crops/cultivars (Glass et al., 1981, Gill et al., 1997 and Mahmood, 1999). Therefore, selection and use of rice genotypes capable of growing under low K availability might offers an alternate approach to enhance productivity of rice in K deficient areas or where K fertilizers are costly or unavailable. For the present paper we have compared some of our local varieties of rice with IRRI genotypes for their growth behavior and K relation in hydroponics.

MATERIAL AND METHODS

Seeds of ten rice genotypes (seven local and three IRRI) were germinated in polyethylene lined iron trays, containing pre-washed riverbed sand and irrigated with canal water in a rain-protected wire house. Fifteen days old seedlings were transplanted in foam plugged holes of thermopal sheets, floating on modified Johnson's nutrient solution (Johnson et. al., 1957), in two polythene lined iron tubs of 200-L capacity each, containing 0.3 and 3 mM K, respectively. The pH of the solution was monitored and maintained daily at 5.5 ± 0.5 with HCl or NaOH. The experiment was laid out according to completely randomized factorial design (Steel et al., 1996) with eight repeats of each genotype, consisting of two plants per repeat. The plants were harvested after six weeks of transplanting. The harvested plants were thoroughly washed with distilled water and separated into root and shoot. Washed samples were dried at 70°C in a forced-air driven oven to a constant weight for dry matter yield. Dried plant samples were ground to 40-mesh before digesting their 0. 5 g portion with 10 ml of di-acid mixture of perchloric and nitric acids (3:1) (Miller, 1998). Potassium concentration in plant digest was estimated by Flame photometer (Jenway PFP-7).

RESULTS AND DISCUSSION

There were significant ($p<0.05$) main and interactive effects of potassium level and genotypes on shoot growth, root development and total biomass production by the rice plants (table 1). Genetic differences in response of different crop cultivars to K application have also been reported by other researchers (Gill et al., 1997; Mahmood. 1999).

On an average shoot dry matter (SDM) production in rice genotypes reduced 1.5 folds due to K deficiency in rooting medium. Maximum SDM production was exhibited by rice genotype DM-25 at both K levels. Minimum SDM was produced by the rice genotype IR 6 at deficient level of K (Table 1). Genotype DM-25 was highly responsive to K deficiency followed by IR-6. Both genotypes reduced their SDM significantly at deficient K level.

There was significant main and interactive effect of rice genotypes and K levels on root dry matter (RDM) production (Table 1). Root dry matter production was reduced 1.5 fold due to K deficiency (table 1). It was ranged between 0.17 to 0.39 g at deficient while it ranged between 0.25 to 0.71 g at adequate K supply. At deficient K supply DM-25 produced highest RDM while IR-6 and Shaheen Basmati produced lowest RDM. Higher root dry matter at adequate K supply was attributed to adventitious root system of plants ample

Table 1. Growth performance of twelve rice genotypes grown at adequate and deficient levels of K supply

Genotype	Shoot Dry Matter (g plant^{-1})		Root Dry Matter (g plant^{-1})		Root Shoot Ratio		Percent reduction in SDM
	Adequate	Deficient	Adequate	Deficient	Adequate	Deficient	
Shaheen Bas.	2.50c	2.02bc	0.28c	0.17d	0.12d	0.09e	13.57c
Bas. Super	2.40c	2.23bc	0.27c	0.24c	0.16cd	0.13d	0
Basmati-2000	3.72b	1.73c	0.40b	0.25c	0.12d	0.16ce	22.29bc
Basmati-370	3.61b	2.60b	0.44b	0.31b	0.15cd	0.12d	13.57c
DM-25	5.70a	3.24a	0.71a	0.39a	0.13d	0.12d	41.57a
IR-28	3.43bc	2.80ab	0.31c	0.30b	0.11d	0.11d	0
IR-6	1.23dc	0.70dc	0.27c	0.17d	0.22a	0.29a	40.0a
KSK-133	1.70d	0.93d	0.30c	0.20cd	0.20ab	0.31a	28.29b
NR-1	2.13cd	1.23cd	0.34bcd	0.22cd	0.24a	0.18ce	22.43bc
IR-36	1.70d	1.40cd	0.25cd	0.21cd	0.16cd	0.16ce	2.57e
Mean	2.81A	1.90B	0.36A	0.25B	0.16	0.17	

supplied with K (Zhao et al., 1991). Shoot dry matter correlated significantly to RDM (r =0.90) at deficient level of K supply.

Potassium concentration in shoot and utilization efficiency

Various rice genotypes and K levels had a significant ($p<0.05$) main and interactive effect on K concentration in plant shoots (Table 2). It ranged between 32.57 and 46.32 mg g^{-1} at adequate level of K supply. At deficient level of K supply it ranged between 6.7 and 14.19 mg g^{-1} which is lower than its critical concentration at this ontogenic stage (Reuter et. al., 1997). Averaged over all genotypes, K concentration decreased 3.5 fold in rice shoot due to K deficiency. At deficient K supply, K concentration was lowest in a local genotype Shaheen Basmati, while K concentration was slightly higher in shoot of IRRI varieties.

Table 2. Potassium concentration, uptake and utilization efficiency of rice genotypes grown at adequate and deficient K levels

Genotypes	K concentration (mg g^{-1})		K uptake (mg K 2 plant^{-1})		K utilization efficiency (mg SDM g^{-1} K)	
	Adequate	Deficient	Adequate	Deficient	Adequate	Deficient
Shaheen Bas.	36.79c	6.70	17.51hi	13.80 c-e	0.08 bc	0.35 a
Bas. Super	37.09c	11.52bc	27.13 g	27.11 b	0.10 b	0.20 bc
Basmati-2000	46.32ab	11.21bc	43.12 e-f	18.94 cd	0.08 bc	0.16 c
Basmati-370	40.83	10.61c	38.83 e-g	26.88 b	0.09 bc	0.25 bc
DM-25	49.71a	11.10bc	63.53 c	36.05 a	0.12 ab	0.29 b
IR-28	41.84b	12.08b	38.27 e-g	30.53 ab	0.17 a	0.23 bc
IR-6	42.98b	14.16a	53.14 d	9.94 d	0.03 cd	0.05 de
KSK-133	43.97b	13.87ab	74.61 b	15.04 cd	0.04 cd	0.08 d
NR-1	41.24b	13.46ab	83.60 a	16.22 cd	0.06 c	0.10 cd
IR-36	32.57cd	14.19a	54.16 d	20.19 c	0.06 c	0.10 cd
Mean	41.34A	11.89B	49.39A	21.47B	0.08A	0.18B

Values are means of eight repeats.

Various rice genotypes and K levels had significant main and interactive effect on shoot K uptake of rice plants. At deficient K level, DM-25 showed maximum shoot K uptake while IR-6 showed lowest K uptake. Higher K uptake by rice genotypes was attributed to higher root dry matter as indicated by their significant positive correlation (r = 0.53). Genetic differences in K uptake were earlier reported by Jorgensen (1997) and Mahmood et al. (2001) in different crops.

Potassium use efficiency significantly differed among rice genotypes at both levels of K supply which was higher at deficient level of K supply. At deficient rate of K supply, it ranged between 0.35 (Shaheen) and 0.05 mg K g^{-1} SDM (IR-6). Averaged over both K levels, Shaheen Basmati and DM-25 showed the highest KUE while IR-6 and KSK-133 showed the lowest KUE. Genetic differences for KUE in different crop cultivars was also reported by Mahmood et al., (2001), Mahmood (1999), Gill et al., (1997).

CONCLUSION

Shoot dry matter, root dry matter and total biomass significantly differed among all genotypes and root dry matter correlated with K uptake and utilization efficiency. Local varieties accumulated higher SDM, RDM and exhibited higher root:shoot ratio compared to IRRI varieties. However, verification of solution culture results under field situation is warranted.

REFERENCES

Gill, M.A., I. Ahmad and M. Yaseen. 1997. Potassium deficiency tolerance and potassium utilization efficiency in wheat genotypes. pp. 33-35. In: plant Nutrition for Sustainable Food Production and Environment. T. Ando et. al., (Ed.)

Glass, A.D.M., M.Y. Siddiqui and K.I. Giles. 1981. Correlation between potassium uptake and hydrogen efflux in barley varieties. A potential screening method of isolation of nutrient efficient lines. Plant Physiol., 68: 457-459.

Johnson, C.M., R.R. Stout, T.C. Broyer and A.B. Carlton. 1957. Comparative chlorine requirements of different species. Plant Soil 8: 327-353.

Jorgensen, U. 1997. Genotypic variation in dry matter accumulation and content of N, K and Cl in Mischanthus in Denmark. Biomass and Bio Energy 12: 155-169.

Mahmood, T. 1999. Differential potassium use efficiency and potassium substitution by sodium in wheat genotypes. Ph. D. thesis. Department of Soil Science, University of Agriculture, Faisalabad.

Mahmood, T., M.A. Gill, A.M. Ranjha, Z. Ahmad and H. Rehman. 2001. Potassium deficiency stress tolerance in wheat genotypes I: Sand culture study. Int. J. Agric. Biol. 3(1): 113-116.

Miller, R. O. 1998. Nitric-Perchloric Wet Digestion in an Open Vessel. pp. 57-62. In Handbook of Reference Methods for Plant Analysis; Kalra, Y. P., Ed.; CRC Press Washington, DC.

Ponnamperuma, F.N. 1965. Dynamic aspects of flooded soils and the nutrition of the rice plant. pp. 295-328. In: International Rice Research Instititute. The mineral nutrition of the rice plant. Proceedings of a symposium at the International Rice Research Institute, February, 1964. The Johns Hopkins Press, Baltimore, Maryland.

Reuter, D.J., D.G. Edwards and N.S. Wilhelm. 1997. Temperate and tropical crops. Pp.83-257. In: Plant Analysis: An Interpretation Manual. Reuter et. al., (ed.) Colling wood, VIC, Australia.

Steel, R., J. Torrie and D. Dickey. 1996. Principles and procedures of statistics. A biometrical approach. 3rd Eds. McGraw Hill Book Co., New York.

Tisdale, S., W.L. Nelson and J.D. Beaton. 1984. Soil fertility and fertilizers. 4th Ed. McMillan Co. New York, USA.

Zhao, Z.R., G.R. Li and G.Q. Haung. 1991. Promotive effect of potassium on adventitious root formation in some plants. Plant Sci. 79: 47-50.