Response of Soybean Cultivars to Potassium Fertilization in Brazilian Entisol

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INTRODUCTION

Soybean (*Glycine max*) is an important grain legume for Brazilian economy. It is one of the most important agricultural commodities for export as well as home consumption in the country. Soybean cultivation in Brazil started in the early 1970s in the southern part, especially in the State of Rio Grande do Sul, and rapidly expanded in the central part, locally known as the Cerrado region. The Brazil is the second largest producer of soybean after United States of America, followed by Argentina (Fageria et al. 2011). Use of adequate amounts of essential nutrients, including potassium (K), is one of the main factors in determining productivity of crop plants. Potassium plays an important role in many physiological and biochemical processes with impact on water relations, photosynthesis, transport of other nutrients, respiration, and enzyme activation that can have direct consequences on crop productivity (Marschner, 1995; Fageria et al. 2012). The objective of this study was to evaluate different soybean cultivars for plant K uptake and its efficient use.

METHODS

A greenhouse experiment was conducted to evaluate K use efficiency in eleven Brazilian soybean cultivars: five indeterminate (BMX Potência RR, BMX Magna RR, BRS 284, NA 5929 RR, and V Max RR), one semi determinate (FTS Campo Mourão RR) and five determinate (BRS 232, BRS 295 RR, BRS 294 RR, TMG 1066 RR, and TMG 1067 RR) cultivated under deficient (low K - 50 mg kg^{-1}) and sufficient (high K - 200 mg kg^{-1}) soil K supply in an Ustoxix Quatzipsamment (Entisol) with 870 g kg^{-1} of sand. Experimental design was split plot, with two K concentrations in the main plots and eleven cultivars in the subplots with four replicates. Plants were harvested at physiological maturity. Pods were collected from each pot, and after threshing seeds were dried and weight was determined. Shoots were harvested from each pot, and harvested material was washed in distilled water and dried at 65°C to a constant weight to determine shoot dry-weight (SDW) accumulations (grain and aerial part). Shoot and grain were ground and analyzed for macronutrients {K [soil and plant], calcium (Ca) and magnesium (Mg) [soil]} by inductively coupled plasma (ICP). Grain yield efficiency index (GYEI) was calculated to classify cultivars for their K-use efficiency. Cultivars having GYEI values >1.5 were classified as highly efficient (HE), cultivars having GYEI values between 1.0 and 1.5 were classified as efficient (E), cultivars having GYEI between 0.5 and 1.0 were classified as moderately efficient (ME), and cultivars having GYEI values <0.5 were classified as inefficient (IE) in K use. Agronomic efficiency (AEK), Physiological efficiency (PFK), Apparent recovery efficiency (AREK), and Utilization efficiency (UEK) were also calculated. Analysis of variance (ANOVA), and F test were used to test for statistical significance of treatment effects. Means were compared by Tukey's test at the 5% probability level.

RESULTS AND DISCUSSION

Grain yields and yield components were significantly increased with K fertilization, and differences were observed for yield and yield components (Tables 1 and 2). The grain yield efficiency index (GYEI) had a highly significant quadratic association with grain yield. Based on GYEI, the most K use efficient cultivars were NA 5929 RR, VMAX RR and BRS 232, moderately efficient were TMG 1066 RR, BRS 294 RR, BR 295 RR, TMG 1067 RR, BRS 284 RR and BMX Potência RR and the most inefficient cultivar was FTS Campo Mourão RR (Table 1). The shoot dry weight (SDW), grain yield (GY), K concentration in leaves, exchangeable K, Mg and Ca were significantly positively

correlated with K quantity applied (Table 2). The results based on regressions equations, that the optimal K available obtained in Mehlich 1 extraction solution was 0.15 $cmol_c$ dm^{-3} and an optimal K total leaf was 35.0 mg kg^{-1} for maximal soybean yield. The results showed that plant characteristics by using appropriate soil fertilization and plant management practices can improve soybean yield.

Table 1. Potassium use efficiency in eleven cultivars of soybean [(1)]*.

Cultivars	AEK	PFK	AREK	UEK	GYEIK**
	-- g g^{-1} --	-- g mg^{-1} --	--- % ---	-- g mg^{-1} --	
BMX Magna RR	52.5abc	0.035bc	1.464bc	0.053abc	1.33 (E)
BMX Potência RR	99.8ab	0.049ab	2.033ab	0.100ab	0.86 (ME)
BRS 232	114.8a	0.050ab	2.258a	0.115a	1.10 (E)
BRS 284	53.3abc	0.039bc	1.365bc	0.053abc	1.03 (E)
BRS 294 RR	50.5bc	0.041abc	1.208c	0.051bc	1.00 (E)
BRS 295 RR	57.3abc	0.032bc	1.745abc	0.057abc	0.82 (ME)
FTS Campo Mourão RR	101.2ab	0.050bc	2.018ab	0.101ab	0.49 (IE)
TMG 1066 RR	80.8abc	0.058bc	1.539abc	0.081abc	0.85 (ME)
TMG 1067 RR	92.3abc	0.058bc	1.663abc	0.092abc	0.91 (ME)
NA 5909 RR	34.7c	0.024c	1.467bc	0.035c	1.36 (E)
V Max RR	68.2abc	0.035bc	1.888abc	0.068abc	1.23 (E)
Average	73.2	0.043	1.695	0.073	1.00
DMS	63.68	0.018	0.751	0.064	-
CV	25.56	17.38	18.86	35.61	-

[(1)]Means followed by the same letter in the same column are not significantly different at the 5% probability level by Tukey's test.*Agronomic efficiency (AEK), Physiological efficiency (PFK), Apparent recovery efficiency (AREK), Utilization efficiency (UEK) and index efficiency (GYEIK). **1.0 and 1.5 were classified as efficient (E), cultivars having GYEI between 0.5 and 1.0 were classified as moderately efficient (ME), and cultivars having GYEI values <0.5 were classified as inefficient (IE).

Table 2. Shoot dry weight (SDW), grain yield (GY), K concentration in the foliar diagnostic, and exchangeable K, Mg and Ca in soil. Values are averages across eleven cultivars of soybean*.

K concentration	SDW	GY	K	K	Ca	Mg
	-------- g pot^{-1} --------		--- g kg^{-1} ---	---------- $cmol_c$ kg^{-1} ----------		
Low K (50 mg kg^{-1})	43.2	16.1	9.77	0.05	0.50	0.45
High K (200 mg kg^{-1})	62.1	27.1	27.41	0.10	0.67	0.54
Average	52.6	21.6	18.59	0.08	0.59	0.50
CV	9.78	12.74	8.24	20.93	16.54	17.80

F test						
K concentration (a)	117.43*	351.27*	2820.32*	149.65*	32.41*	24.24*
Cultivars (b)	6.18*	4.70*	6.84*	16.9*	17.77*	18.85*
a × b	7.47*	4.02*	13.01*	7.53*	14.28*	16.78*

*significant at 5% according to F–test. CV: coefficient of variation. Eleven brazilian soybean cultivars: five indeterminate (BMX Potência RR, BMX Magna RR, BRS 284, NA 5929 RR, and V Max RR), one semi determinate (FTS Campo Mourão RR) and five determinate (BRS 232, BRS 295 RR, BRS 294 RR, TMG 1066 RR, and TMG 1067 RR) growth habit grown.

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