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MINERAL ACQUISITION AND UTILIZATION STRATEGY OF THREE TROPICAL FORAGES AT DIFFERENT PHOSPHORUS AND NITROGEN SUPPLY

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Abstract

A glasshouse experiment was conducted to examine mineral acquisition and utilization strategies of *Brachiaria decumbens* (BD), *Brachiaria brizantha* (BB) and *Panicum maximum* (PM). The plants were grown under nine treatments resulted from the combination of three levels of phosphorus (0, 25 and 50 kgP/ha) and three levels of nitrogen (25, 150 and 300 kgN/ha). BD showed the lowest value of root weight and root length per pot, but the highest efficiency of P and N uptake (P and N uptake mg / unit root weight g). On the other hand, PM showed lower mineral uptake efficiency, but the highest mineral use efficiency (dry matter production g / absorbed P and N mg). Moreover, total P and N uptake in BB was the highest, and this seems to be achieved by the multiplicative effect of moderate mineral uptake efficiency and the moderate size of the root system.

Keywords: uptake efficiency, utilization efficiency, root structure, *Brachiaria decumbens*, *Brachiaria brizantha*, *Panicum maximum*

Introduction

Deficiency of soil nutrients is a major limitation of forage adaptation and production in the acid soils of the Cerrado region. It has been demonstrated by some researchers that several tropical forage grasses can adapt to the infertile acid soils because of their ability for mineral uptake and /or efficient mineral use in dry matter production (Kanno *et al*., 1999). However, the information on the adaptive strategies of the forage species is limited. The aim of the present study is to examine the N and P acquisition and utilization strategies of *Brachiaria decumbens*, *Brachiaria brizantha* and *Panicum maximum*.

Material and Methods

A pot experiment was conducted in a glasshouse at the National Beef Cattle Research Center of the Brazilian Agricultural Research Corporation (EMBRAPA Gado de Corte) in Campo Grande, Mato Grosso do Sul State, Brazil. The species examined were *Brachiaria decumbens* cv. Basilisk (BD), *Brachiaria brizantha* cv. Marandu (BB) and *Panicum maximum* cv. Tanzania-1 (PM). The experimental design was a completely randomized design with the three species, three levels of P (0, 25 and 50 kg/ha), three levels of N (25, 150 and 300 kg/ha) and four replications.

The plants were grown in pots with five and half kg of an Oxisol (dark red Latosol: 38-42% clay) collected from the 0-20 cm layer of a native savanna. Limestone (3 t/ha) and FTE (micronutrient, 80 kg/ha) were applied to the soil. The pots were fertilized with 0, 68.5 and 137 mg P/pot, using a H_3PO_4 solution for the equivalent treatments of 0, 25 and 50 kgP/ha; 68.5, 411 and 823 mg N/pot as ammonium sulfate solution for the equivalent treatments of 25, 150 and 300 kg N/ha. Additionally, 100 kg/ha of K was applied as a KCl solution to all pots.

Harvesting was conducted at 66, 112 and 157 days after transplanting. At the third harvest, the roots were washed and, from each pot, a sub-sample of root (approximately 1 g) was taken for the root length measurement using scanned images (Crestana *et al*., 1994).

P and total N contents of the top parts of each harvest, root samples of the third harvest and seeds of each species were measured. Based on the data of P and total N contents of the tops, roots, seeds, and their dry weight, the amount of P and N absorbed by the plants during the growing period was estimated for each treatment. P and N uptake efficiency was determined by dividing the total P and N uptake (mg) by the root dry weight (g). P and N use efficiency was estimated by dividing the total dry matter production (g) by the total P and N uptake (mg).

Analysis of the variance was calculated with the SAS Computer Program (SAS/STAT, 1993). A probability level of 0.05 was considered statistically significant.

Results and Discussion

The increase in the level of P applied improved the total dry matter production of all the three species (Table 1). The increase from 25 to 150 kg N/ha improved dry matter production of all three species. However, only PM improved its dry matter production with the increase of N from 150 to 300 kg/ha.

Dry weight of the top parts (an amount of dry matter yields in the first, second, and third harvests, and dry weight of the base of the stems), root weight, total root length, specific root length, P and N uptake efficiency, total P and N uptake, and P and N use efficiency are shown in Table 2. Dry weight of the top parts of BB was significantly larger than those of PM and BD. Root weight and root length per pot was in the order PM>BB>BD, and the differences were significant. These data suggests that, in this experiment, PM developed a much larger root system than BB or BD. However, total P and N uptake of PM was significantly lower than those of BB and at the same level as BD. Moreover, the P and N uptake efficiency of PM were significantly lower than those of BB and BD. Comparing specific root length (root length per unit dry weight), PM showed a significantly higher value than BD and BB, and this suggests that PM had a thinner root system than BD or BB. Thus, since PM showed a lower mineral uptake efficiency in spite of its thin root system, the difference in the root structure does not explain the difference in mineral uptake efficiency between PM and *Brachiaria* species. Since PM showed the highest mineral use efficiency, adaptability of PM to infertile soils seems to be due to its higher mineral use efficiency, rather than mineral uptake efficiency. On the other hand, BD had the smallest root weight, moderate total P and N uptake, but the highest mineral uptake efficiency. It appears that the adaptive strategy of BD to low fertility soils is due to more effective mineral acquisition than BB and PM. It is also well-known that the adaptability of BD to low fertility soils is superior to BB. The specific root length of BD was slightly higher than that of BB, and this result agreed with the work of Santos Junior *et al*. (1999). Thus, it is possible that this slight difference in root structure influences the mineral uptake efficiency. However, the fact that no significant difference was found in the specific root length between BD and BB suggests that other chemical and biological factors are responsible for the difference in the mineral uptake efficiency between BD and BB.

Total P and N uptake in BB was the highest, although BB showed moderate values for root weight, root length and mineral uptake efficiency. This suggests that BB's high mineral uptake ability may be achieved by the multiplicative effect of the moderate size of the root system and the moderate mineral uptake efficiency.

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Table 1 - Total dry matter production of *P. maximum, B. brizantha* and *B. decumbens* at different levels of P and N.

		P. maximum	*B. brizantha*	*B.decumbens*	Mean
		------------- Total dry matter production (g / pot) -------------			
P supply	0	7.6	8.8	6.2	7.5 c
kg/ha	25	49.0	50.6	41.8	47.1 b
	50	57.0	60.0	50.3	55.6 a
N supply	25	29.1	32.7	29.5	30.4 b
kg/ha	150	38.6	43.5	35.6	39.2 a
	300	45.9	43.2	33.2	40.8 a
Mean		37.9 A[1]	39.7 A	32.6 B	36.8

1 Means followed by different letters are significantly different at P=0.05, using the Tukey test. Upper case letters compare data within row, and lowercase letters compare data within columns.

Table2 - Mean values of some attributes for *P. maximum, B. brizantha* and *B. decumbens.*

	Species		
	P. maximum	*B. brizantha*	*B. decumbens*
Dry weight of top parts (g/pot) [1]	29.2 B[2]	33.2 A	28.4 B
Root weight (g/pot)	8.6 A	6.6 B	4.4 C
Total root length (m/pot)	716.2 A	477.3 B	387.6 B
Specific root length (m/g)	104.3 A	82.4 B	86.4 B
P uptake efficiency (mg/g)	2.4 C	3.9 B	5.0 A
Total P uptake (mg)	18.8 B	23.7 A	18.7 B
P use efficiency (g/mg)	2.0 A	1.7 B	1.7 B
N uptake efficiency (mg/g)	63.9 C	99.6 B	129.2 A
Total N uptake (mg)	419.7 B	481.5 A	402.7 B
N use efficiency (g/mg)	0.09A	0.08 B	0.08 B

1 Dry weight of the top parts was calculated as an amount of dry matter yields in the first, second, and third harvests, and dry weight of the base of the stems.

2 Means followed by different letters within rows are significantly different at P=0.05, using the Tukey test.