Phenotypic differences in adaptation to drought stress in *Brachiaria* grasses

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Introduction

Brachiaria grasses are the most widely planted forages in the tropics. Seasonal drought affects both quantity and quality of forage in tropical subhumid environments. Although ***Brachiaria*** grasses are known to differ in drought resistance (Baruch, 1994; Rao, 2001; Guenni et al., 2002; De Mattos et al., 2005), there is very limited knowledge on the physiological bases of adaptation of Brachiaria grasses to drought. ***B. brizantha*** CIAT 6780, ***B. decumbens*** CIAT 606, Mulato and Mulato 2 are known to be relatively more adapted to drought stress. Our objective was to determine differences in shoot and root growth responses among 12 ***Brachiaria*** genotypes that are subjected to three different watering regimes for a period of 21 days using the soil tube method under greenhouse conditions.

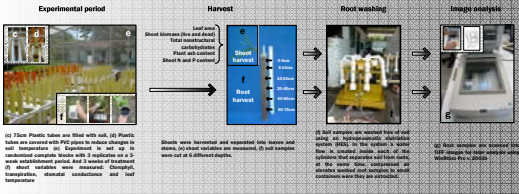
Materials and methods

A greenhouse experiment was conducted to determine differences in shoot and root attributes of 12 ***Brachiaria*** genotypes (3 parents of the breeding program: ***Brachiaria decumbens*** CIAT 606, ***Brachiaria ruziziensis*** 44-02, and ***Brachiaria brizantha*** CIAT 6294 cv. Marandú; 2 commercial hybrids: Mulato (CIAT 36061) and Mulato 2 (CIAT 36087); 4 apomictic hybrids: BR02/1372, BR02/1752, BR02/0465 and BR02/1485; and 3 sexual hybrids: SX03/0881, SX03/0846 and SX03/2367) that were subjected to drought conditions for 21 days. Matazul soil was mixed with coarse river sand in a 2:1 ratio to increase drainage and reduce Al saturation.

Three watering levels were maintained: 100% field capacity (FC) as control or well watered, 50% FC to simulate intermittent drought and terminal drought by withholding water after establishment. The treatments of 100% FC and 50% FC were kept at their respective levels by weighing the soil tubes at every 2 days and applying water to the surface of the soil. Terminal drought treatment was imposed at three weeks after planting (Figure 1).

(a) Experiment was established at one of CIAT's greenhouses. Average maximum and minimum temperature values were 35°C and 21°C, respectively with a maximum photon flux density of 1000 µmol m^{-2} s^{-1}.

(b) Soil from Matazul (Meta) was fertilized with high levels of nutrients (kg/ha: 80 N, 50 P, 100 K, 66 Ca, 28 Mg, 20 S and micronutrients)



(c) 75cm Plastic tubes are filled with soil. (d) Plastic tubes are covered with PVC pipes to reduce soil temperature (e) Experiment is set up in randomized complete blocks with 3 replicates on a 3-week establishment period. And 3 weeks of treatment (f) shoot variables were measured: Chlorophyll, transpiration, stomatal conductance and leaf temperature

Shoots were harvested and separated into leaves and stems, (e) shoot variables are measured, (f) soil samples were cut at 6 different depths.

(f) Soil samples are washed free of soil using an hydropneumatic elutriation system (HES). In the system a water flow is created inside each of the cylinders that separates soil from roots, at the same time, composed of elevated washed root samples to small containers where they are extracted.

(g) Root samples are scanned into TIFF images for later analysis of: Root length, Mean diameter, Root Volume

Figure 1. Methodology for screening *Brachiaria* genotypes under drought conditions

Results

Highly significant differences were found among genotypes and treatments ($p<0.01$) on live shoot biomass production (Figure 2). However, there was no effect on genotype x watering level interaction in shoot biomass production. Among the 12 genotypes tested, ***Brachiaria decumbens*** CIAT 606 performed better under water stress conditions while the sexual hybrid SX03/0881 was the poor performer in terms of shoot biomass production. Among the hybrids, Mulato (CIAT 36061) performed better under both intermittent and terminal drought stress. The sexual parent ***Brachiaria ruziziensis*** 44-02 was outstanding in producing shoot biomass under control treatment but its shoot growth was markedly affected by drought stress, particularly with terminal drought stress (Figure 2)

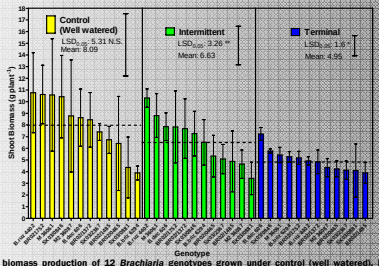


Figure 2. Live shoot biomass production of 12 *Brachiaria* genotypes grown under control (well watered), intermittent and terminal drought stress conditions. M = Mulato, M2 = Mulato 2. **, *: Significant at the 0.01 and 0.05 probability level, respectively. N.S.= not significant. The bars indicate LSD values at the 0.05 probability level. Dotted horizontal lines indicate the mean values.

Brachiaria decumbens CIAT 606, BR02/1752, BR02/0465 Mulato (CIAT 36061) and ***Brachiaria brizantha*** CIAT 6294 cv. Marandú were found to be more efficient in using water for producing green leaf area under terminal drought stress (Figure 2). With intermittent drought stress, the level of leaf and stem total nonstructural carbohydrates (TNC) showed significant positive association with live shoot biomass indicating greater availability of photosynthates for new shoot growth.

Both intermittent and terminal drought stress reduced the genotypic mean values of total root length (Figure 4a). Among the hybrids, Mulato (CIAT 36061) and Mulato 2 (CIAT 36087) performed better in terms of total root length under drought stress, particularly under terminal drought stress (Figure 3b). One of the apomictic hybrids, BR02/1372 showed moderate values of total root length under both intermittent and terminal drought stress while one of the sexual hybrids, SX03/0881 showed the lowest values of total root length across the three treatments (Figure 4a).

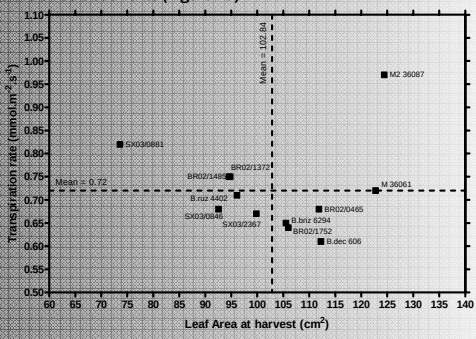


Figure 3. Relationship between leaf area at harvest and the rate of transpiration measured at 18 days of terminal drought stress for 12 *Brachiaria* genotypes. M = Mulato, M2 = Mulato 2. Vertical and horizontal dotted lines represent the genotypic mean values.

The genotypic mean values of total root length were reduced by both intermittent and terminal drought stress compared with control treatment (Figure 4a). Among the hybrids, Mulato (CIAT 36061) and Mulato 2 (CIAT 36087) (Figure 4b) performed better in terms of total root length under drought stress, particularly under terminal stress. One of the sexual hybrids, SX03/0881 showed the lowest value of total root length across the three treatments. One of the apomictic hybrids, BR02/1372 showed moderate values of total root length under both intermittent and terminal drought stress (Figure 4a).

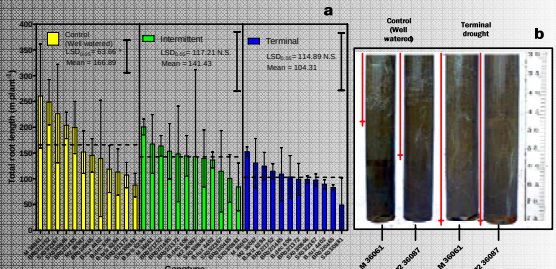
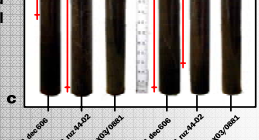


Figure 4. (a) Total root length of 12 *Brachiaria* genotypes grown under three waterin levels. M = Mulato, M2 = Mulato 2. **, *: Significant at the 0.01 and 0.05 probability level, respectively. N.S.= not significant. The bars indicate LSD values at the 0.05 probability level. Dotted horizontal lines indicate the mean values. (b) Rooting capacity of Mulato and Mulato 2. (c) Root distribution of *Brachiaria decumbens* CIAT 606, *Brachiaria ruziziensis* 44-02 and SX03/0881

The sexual parent, ***Brachiaria ruziziensis*** 44-02 had greater values of root length and root biomass under well watered conditions but drought stress decreased the values, particularly under terminal drought stress (Figure 4c).



Conclusions

- Results from this study indicate that ***Brachiaria decumbens*** CIAT 606 is well adapted to both intermittent and terminal drought stress conditions.
- The superior performance of ***B. decumbens*** under drought stress was associated with greater production of roots in subsoil layers.
- The superior performance of Mulato (CIAT 36061) was associated with greater ability for leaf expansion and rooting capacity under drought stress conditions.
- Among the 12 genotypes tested, the sexual hybrid SX03/0881 was least adapted to drought stress conditions.

Literature cited

BARUCH, Z. 1994. Responses to drought and flooding in tropical forage grasses. I. Biomass allocation, leaf growth and mineral nutrients. Plant and Soil. N° 164. p. 87-96.

DE MATTOS, J.L.; GOMIDE, J.A.; MARTÍNEZ y HUAMAN, C.A. 2005. Crescimento de espécies do gênero *Brachiaria*, sob déficit hídrico. em casa de vegetação. Revista Brasilera de Zootecnia. Vol. 34, N° 3. p. 746-754.

GUENNI, O.; BARUCH, Z. and MARIN, D. 2002. Responses to drought of five *Brachiaria* species. II. Water relations and leaf gas exchange. Plant and Soil. N° 243, p. 229-241.

RAO, I.M. 2001. Adapting tropical forages to low-fertility soils. Proceedings of the XIX international grassland congress – Grassland ecosystems: an outlook into the 21st century. p. 249. ISBN 85-7133-010-7.

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