Brachiaria Hybrids with Larger Root Length Densities Show Greater Shoot Vigor under Drought

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Brachiaria hybrids with larger root length densities show greater shoot vigor under drought

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Introduction

Brachiaria grasses are the most widely planted forages in Tropical America, and their demand is increasing across Africa and South-East Asia. One of the most limiting factors affecting productivity of *Brachiaria* forage grasses is seasonal drought. Genotypic variation for drought resistance has been found among *Brachiaria* forage grasses, making possible to genetically improve the productivity of *Brachiaria* forage grasses under water-limiting conditions (Rao, 2014). The on-going *Brachiaria* breeding program at the International Center for Tropical Agriculture (CIAT) has been developing and testing *Brachiaria* hybrids that combine resistance to biotic constraints with adaptation to abiotic stresses such as drought.

Adaptation to drought conditions greatly relies on an efficient root system that facilitates water capture in drying soil. Among root traits, greater root length density (the length of roots per unit volume of soil, RLD cm/cm^3) generally indicates greater ability for water uptake in drying soil (Wasson *et al.*, 2012). Screening of forage germplasm for resistance to drought conditions has often overlooked root traits. This is because of the difficulty to separate roots out of soil, which inevitably ends up in a very low-through-put system. However, new imaging techniques allow rapid estimation and quantification of RLD within the soil (*i.e.*, without the need to separate roots from soil). The following work was therefore performed to evaluate the variation in dry mass, water uptake and RLD of 103 hybrids of *Brachiaria* after three weeks of growth under drought conditions. We hypothesized that hybrids with greater RLD could extract (particularly with increasing depth) more water in drying soil, which in turn is reflected in greater shoot dry mass production after three weeks of drought treatment.

Materials and Methods

One hundred and three (103) hybrids from an interspecific *Brachiaria* population (*B. ruziziensis/B. brizantha/B. decumbens*) and seven checks (*B. humidicola* cv. Tully, *B. ruziziensis*, *B. brizantha* cv. Toledo, *B. brizantha* cv. Marandú, *B. decumbens* cv. Basilisk, *B.* hybrid *cv*. Mulato II *and B.* hybrid *cv*. Caymán) were evaluated under greenhouse conditions at CIAT. Top soil (an Oxisol) from Santander de Quilichao, Colombia was used. This soil was mixed with river sand in a proportion of 2:1 (w/w) and fertilized to avoid nutrient deficiencies. After that, 5 kg of soil mixture was loaded into transparent plastic cylinders that were inserted into PVC pipes of 80 cm high and 7.5 cm diameter. Plants were planted into these soil cylinders, watered daily to maintain field capacity of soil and allowed to grow for five weeks prior to establishing the drought treatment. The trial was established as a randomized complete block design with three replications grown under drought conditions. Drought treatment consisted of cessation of watering to 35 days-old plants for 3 weeks until the harvest time (*i.e.*, for 21 days). During the experiment, the amount of extracted water by plants was monitored by weighing each cylinder every two days and at harvest date. At harvest, plants were separated into shoot and roots for their dry mass determination. Shoot and root biomass were determined after drying tissue in an oven at 60°C 72 hours. Prior to harvesting, two different views of each soil column were photographed using a digital camera (Nikon, Coolpix p6000, Nikon, Japan) mounted on a fixed tripod. The object (soil column) was placed at a distance of 1.5 m from the camera lens and evenly illuminated with halogen lamps. Recorded images were then processed to subtract background (i.e., soil) out of roots using a combination of image filter algorithms. RLD was estimated for the entire root column (0-80 cm) and for the 50-80 cm of soil depth. All images were processed and analyzed with ImageJ software (v. 1.38, National Institutes of Health, USA). Simple correlation (r) and regression (R^2) analysis were performed to test the association between RLD, shoot and root biomass and water uptake using R software.

Results and Discussion

Table 1 shows the correlation coefficient (r) values among measured traits and their significance. Hybrids with greater shoot biomass showed greater water uptake (Fig. 1). Hybrids with larger RLD showed greater water uptake (Table 1). The aforementioned suggests that there is a positive link between RLD and shoot biomass under drying soil conditions (Table 1). Furthermore, when testing the association of RLD at the 50-80 cm of soil profile with shoot biomass and water uptake, correlation values were greatly improved (Table 1). Identification of *Brachiaria* hybrids with greater RLD (particularly with increasing depth) suggest that these hybrids are better fitted to extract water that is stored in deep layers of soil. Moreover, several hybrids showed greater shoot vigor than current available cultivars (Figure 1). The identification of such hybrids is a valuable piece of information because access by roots to moisture stored in the bottom of deep soils could be the difference between availability or lack of forage to feed livestock over long dry seasons. Further testing of these promising hybrids need to be performed under field conditions.

Table 1. Correlation coefficients among principal traits of 103 *Brachiaria* genotypes after 21 days of drought.

	Shoot Biomass	Root Biomass	RLD (0-80 cm)	RLD (50-80cm)
Water Extracted	0.85**	0.75**	0.59**	0.70**
Shoot Biomass	-	0.76**	0.64**	0.78**
Root Biomass	-	-	0.62**	0.71**
RLD	-	-	-	0.97**

**, denotes P< 0.01.

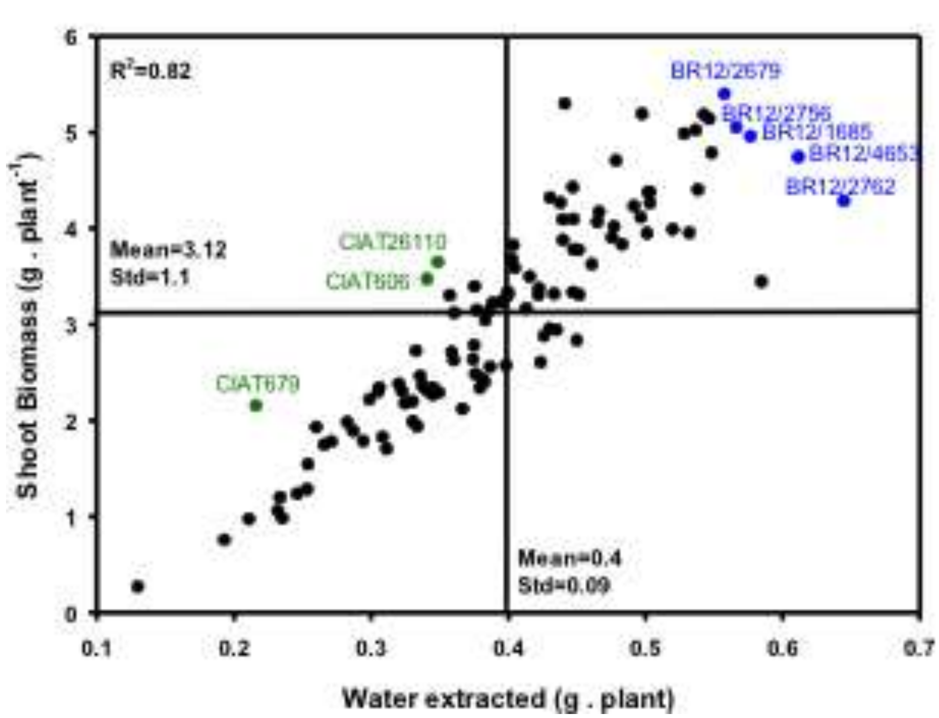

Fig. 1 Relationship between shoot biomass and water extraction of 103 *Brachiaria* genotypes after 21 days of drought stress conditions. *Brachiaria* genotypes that showed greater values of shoot biomass and water extraction were identified in the upper, right hand quadrant.

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