Evaluation of drought tolerance in contrasting cassava varieties under a Brazilian semi-arid environment

Alves, Alfredo[1]; Dita, Miguel[1]; Silva, Alineaurea[2]; de Oliveira, Ana[2]; Setter, Tim[3]

[1]Embrapa Cassava & Tropical Fruits (CNPMF), Cruz das Almas, Brazil (aalves@cnpmf.embrapa.br); [2]Embrapa Semi-Arid (CPATSA), Petrolina, Brazil; [3]Cornell University (CU), Ithaca, USA.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the most important staple foods in the human diet in the tropics, cultivated in areas considered marginal for other crops. Because of its remarkable tolerance to drought and great ability to survive uncertain rainfall patterns, it is considered a contributor to food-security against famine, requiring minimal inputs and making it an important crop for drought prone areas of tropical and sub-tropical Africa, Asia and Latin America.

Objectives:

In this work, cassava varieties considered contrasting for drought tolerance were field evaluated to study the effect of the water deficit on their performance and to identify the best traits to be used in breeding programs for drought tolerance.

METHODOLOGY

Location:

The experiment was conducted at the "Bebedouro" Experimental Station of ***Embrapa Semi-Arid***, in Petrolina, Pernambuco, Brazil (9º 09' S; 40º 22' W), characterized as a semi-arid environment, with annual average rainfall around 565 mm and potential evapotranspiration of 1500 mm. During experimental (Dec/2006 to Nov/2007) the basic local weather data (temperature, rainfall, and air relative humidity) were collected and soil water status was monitored with tensiometers installed in the field (20 and 40 cm) and by soil water content measurement (gravimetrically). The monthly average rainfall distribution in the last 30 years and the rainfall during experimental period.are presented in the **Fig. 1**.

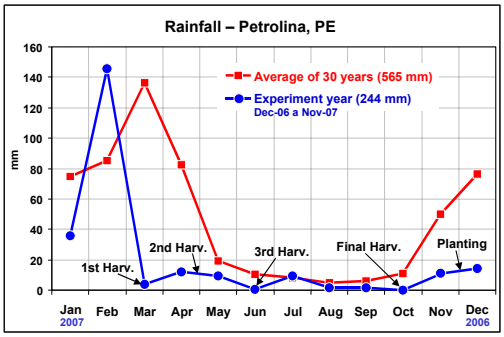

Fig. 1 - Monthly average rainfall distribution in the last 30 years and the rainfall during experimental year (Dec/2006 to Nov/2007). Petrolina, Pernambuco, Brazil.

Plant material:

Twenty-four cassava varieties, selected as contrasting for drought tolerance, were used in this study (**Table 1**). The varieties were seleted based on the data from Embrapa´s cassava breeding program.

Table 1 - Cassava varieties used in the experiment. TOL = tolerant to drought and SUS = susceptible.

#	Variety	Type	#	Variety	Type
01	Aipim Bravo	TOL	13	Brasília	TOL
02	Engana Ladrão	TOL	14	Curvelinha	TOL
03	Cigana Preta	TOL	15	Formosa	TOL
04	São João	TOL	16	Gema de Ovo	TOL
05	Saracura	TOL	17	Guaíra	TOL
06	Maragogipe	TOL	18	Mulatinha	TOL
07	Rosa	TOL	19	Abacate	SUS
08	Manteiga	TOL	20	Cacau	SUS
09	Sacaí	TOL	21	Fio de Ouro	SUS
10	Do Céu	TOL	22	Mocotó	SUS
11	Macaxeira Preta	TOL	23	Pretinha V	SUS
12	Amansa Burro	TOL	24	Recife	SUS

Treatments and experimental design:

The cassava varieties were planted in seven 5-plant blocks, and submitted to two water treatments: 1) Well watered (WW), fully irrigated and 2) Water stressed (WS), irrigated only until 3 MAP.

Experimental design

Randomized completed block design
Five plants / plot (3 experimental plants = 3 reps)
24 varieties x 5 plants x 7 blocks (4 for controls and 3 for stresses) with total of 850 plants
Planting date: 01/Dec/2006 - Four harvest times: 3; 4.5; 6 and 11 months after planting (MAP)
Spacing: 1.5m x 1m

Measurements and sampling:

After stopping irrigation (3 MAP), ***non-destructive measurements and sampling*** were, periodically, collected, such as:

- Growth parameters – Number of primary stems; number of the branching levels; stem length (**SL**)
- Leaf retention (**LR**)
- Leaf area of the top fully expanded leaf
- Leaf conductance (**LC**) – Using the leaf porometer, model SC-1 (Decagon, Pullman, USA)
- Leaf and stem samples for abscisic acid-ABA and carbohidrates analyses

In the harvests (destructive measurements):

- Shoots fresh weight (**ShFW**)
- Storage roots fresh weigth (**SRFW**)
- Number of storage roots (**NSR**)
- Dry matter concentration (**%DM**) – by root specific gravity method (only in the final harvest, at 11 MAP)

RESULTS

In general, the parameters evaluated during different developmental stages, were negatively affected by the water deficit environment (**Figs. 2 and 3A**), with significant effect on storage root and shoots productivity in the final harvest at 11 MAP (**Figs. 3B, 3C**). The responses to water stress were significantly different among varieties, even at early developmental stage. At 4.5 MAP (45 days after stopping irrigation), the bulking and the establishment of storage roots, in some genotypes, were significantly affected, while other genotypes did not change de storage roots FW and shoots FW. The same effect was observed at 6 MAP (3.5 months without irrigation), with more contrasting differences (**Figs. 3B, 3C**). This preliminar result indicates that root evaluations performed within the probable critical period for water deficit in cassava (until 6-7 MAP) can be very useful to select drought tolerant varieties, with early bulking trait. Probably, the genotypes that present a good tolerance within this period will be successful in the next stages of resources translocation to the roots toward the final harvest. This can be observed by the positive correlations found in the root yield between the intermediate harvests (4.5 and 6 MAP) and final harvest (at 11 MAP), which were around 0.75 under control condition and around 0.42 in the water stress. Under WS, stem length, leaf area, leaf retention and leaf conductance, measured in different developmental stages, were positively correlated to root yield at 11 MAP (**Table 2**). Also, a positive correlation was found between storage root yield under WS and harvest index (HI). The data analyses for ABA and carbohydrates accumulation in leaves and stem are underway.

Out of the ten best varieties for storage root yield under WW e WS conditions, six of them ('São João', 'Fio de Ouro', 'Saracura', 'Mulatinha', 'Do Céu', and 'Formosa') were selected in both treatments. The root yields of these varieties varied from 3 to 7 kg in WS and 5 to 19 kg in WW.

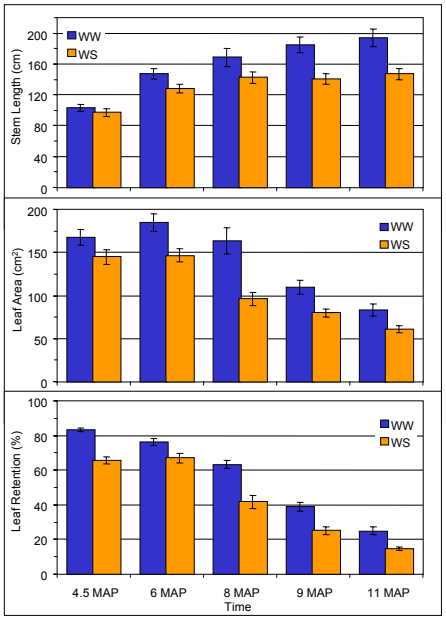

Fig. 2 - Effect of water deficit on growth parameters during different developmental stages of 24 cassava genotypes cultivated under Brazilian semi-arid region and submitted to well watered (WW, full irrigation) and water stress (WS, no irrigation from 3 MAP to harvest, 11 MAP). Mean of 24 genotypes (3 plants/genotype). The bars correspond to standart error of the mean. Petrolina, Pernambuco, Brazil, 2007

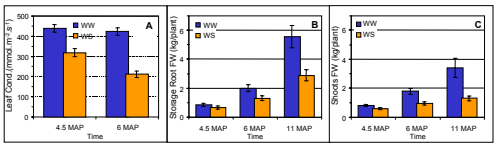

Fig. 3 - Effect of water deficit on leaf condutance (A), storage root (B) and shoots (C) yields, during different developmental stages of 24 cassava genotypes.

Table 2 – Correlation index (r) between storage root yield and several parameters determined in different developmental stages of 24 cassava varieties cultivated under water stressed (rainfed with no irrigation from 3 MAP to harvest) and well watered (full irrigation) conditions in the Brazilian semi-arid region. Petrolina, Pernambuco, 2007 (n = 72, three plants per variety).

Parameter	Storage Root FW (11 MAP)	
	Water Stress	Well Watered
Stem length (6 MAP)	0.45	0.54
Stem length (8 MAP)	0.67	0.53
Stem length (9 MAP)	0.69	0.51
Leaf area (4.5 MAP)	0.58	0.59
Leaf area (6 MAP)	0.43	0.44
Leaf area (8 MAP)	0.47	0.45
Leaf retention (4.5 MAP)	0.51	0.40
Leaf retention (6 MAP)	0.60	0.43
Leaf retention (8 MAP)	0.47	-0.14
Leaf retention (9 MAP)	0.61	-0.09
Leaf retention (11 MAP)	0.40	-0.12
Leaf conductance (4.5 MAP)	0.41	0.30
Leaf conductance (6 MAP)	0.41	0.28

Generation – Cultivating Plant Diversity for the Resource-Poor
Embrapa – Cassava & Tropical Fruits
Ministry of Agriculture, Livestock and Food Supply
BRASIL – BRAZILIAN GOVERNMENT