IDENTIFYING THE PHYSIOLOGICAL AND GENETIC TRAITS RELATED TO DROUGHT TOLERANCE IN CASSAVA

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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.

When water is available, cassava maintains a high stomatal conductance with high internal CO_2 concentration; but when water becomes limiting, the stomata are closed in response to even small decreases in soil water potential. In addition, leaf area growth is decreased in response to water stress and is rapidly reversed following the release from stress. This suggests that the ability to regulate numerous plant processes to rapidly change course is the key for cassava success unfavorable weather.

This project aims to determine the best traits to be used in breeding programs for drought tolerance by elucidating the mechanisms of cassava's remarkable tolerance to drought and to identify trait-marker associations for the development of a more cost-effective breeding process for drought tolerance that can be used for cassava and other crops.

Specific Objectives:

1. Improve the understanding of the drought tolerance mechanisms in cassava and their potential use in other crops
2. Select contrasting cassava genotypes for tolerance to drought environments
3. Identify molecular markers for drought tolerance traits via QTL and candidate gene mapping in cassava
4. Assess the benefits of transgenic over-expression of a gene for improved leaf retention introduced into the *Manihot esculenta* gene pool and its potential use for other crops
5. Strengthen the partnership among institutions involved with plant breeding programs for drought tolerance

METHODS / ACTIVITIES

To understand the cassava drought tolerance mechanisms:

1. Selection of contrasting genotypes for drought tolerance
2. 30 contrasting genotypes → 20 tolerants and 10 susceptibles
3. Evaluations (field and greenhouse) under controlled conditions

Parameters:

- Leaf conductance; transpiration; photosynthesis
- Solutes accumulation
- Accumulation of specific low molecular weight proteins
- Abscisic acid (ABA) and phaseic acid (PA) accumulation
- Accumulation of nonstructural carbohydrate
- Leaf area; leaf retention; root depth; # of roots; root dry matter; starch; productivity; tolerance to cassava green mites (CGM) and other pests

Identification of cassava genotypes with wide diversity for drought tolerance traits:

1. Crosses 20 Tolerants (TOL) vs 10 Susceptibles (SUS); and self of TOL
2. Selection of the 4 best parentals combinations and progenies evaluation
3. 200 seeds of each cross germinated *in vitro* and multiplied to produce 40 copies → shared with Brazil, Colombia, Ghana and Tanzania
4. At each local: *in vitro* multiplication (rapid propagation) to evaluate the segregating populations.
5. In the segregating populations and parentals: evaluation of water deficit effects
6. Identification of genotypes with good drought tolerance → incorporate into breeding program or directly used by farmers

Identification of molecular markers associated with drought tolerance genes:

1. Four segregating populations (F_1); progenies from selfing (S_1) and parentals → evaluated in the replicated trials. The target sites will be in drought prone regions of Brazil, Colombia, Ghana and Tanzania (**Fig.1**)
2. Segregant parentals lines → genotyped with >600 SSR markers from cassava genetic map
3. Polymorphic markers evaluated in the F_1 and S_1
4. Phenotypic and genotypic data analyzed to identify genes involved
5. Candidate genes mapped
6. Identification of associations between markers and QTL for drought

Assessing the effect of the leaf retention gene for improving drought tolerance:

- At ETH-Zurich were developed transgenic cassava plants, expressing the isopentenyl transferase (*ipt*) gene encoding cytokinin production under the control of the senescence-regulated *SAG12* promoter from *Arabidopsis*
- Seven transgenic lines from clone TMS 60444 were obtained → two lines with significant reduction of senescence
- Transformed and non-transformed plants → evaluated in the field and greenhouse (Colombia) → to analyze the effect of transformation on drought tolerance attributes

ACTIVITIES ACCOMPLISHED:

Identification of contrasting drought tolerant cassava varieties:

Based on the outcomes from the cassava breeding programs carried out by Embrapa (Brazil) and CIAT (Colombia), in the last 15 years, 40 cassava varieties were identified as contrasting for drought tolerance attributes, being 28 tolerants and 12 susceptibles

In vitro multiplication of the contrasting drought tolerant varieties:

The selected contrasting varieties have been multiplied by *in vitro* micropropagation procedure at CIAT Headquarters. Around 50 individual copies of each contrasting genotype were produced and will be shipped to Embrapa for evaluation.

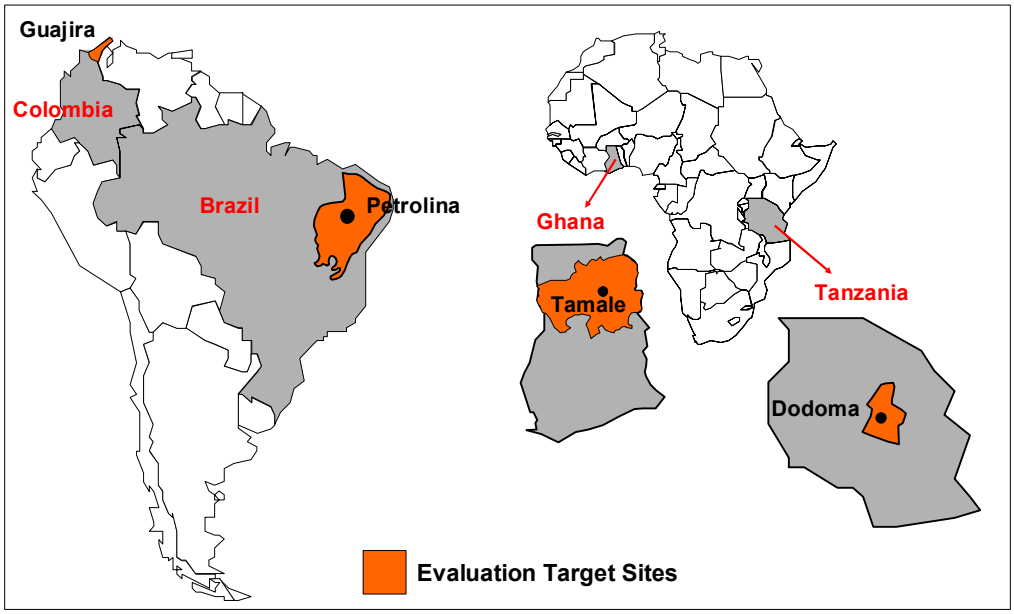

Fig. 1 – Target sites in Colombia, Brazil, Ghana, and Tanzania, where segregating populations will be evaluated for drought tolerance.

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