Drought Tolerance Mechanisms in Cassava

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Abstract

Cassava is considered a food security crop in drought-prone regions. The goals of our work are to determine which traits contribute to its maintenance of yield in water stress environments. Our studies in controlled environments indicate that cassava stomata close in response to slight decreases in leaf water status and maintain leaf water potential at values near those of well-watered controls. This is associated with rapid and large increases in abscisic acid (ABA). Also, as stress continues, a substantial fraction of leaves abscise, thereby decreasing transpirational surface area and further conserving water during stress periods. New leaf production and expansion growth is also highly sensitive to water deficit, due to inhibition of leaf cell division, and cell expansion. However, growth recovers rapidly after renewed water supply, thereby permitting rapid re-establishment of leaf area. Carbon use is down-regulated by limiting growth. Accumulation of sugars and other osmotically active solutes is not substantially stimulated by stress. Also, petiole and stem carbohydrate reserves are gradually utilized and translocated to sinks throughout the plant. The amount of starch stored in stems is considerable, representing a large share of the total non-structural carbohydrate in a plant at the initial period of storage root growth.

What functional traits does cassava use to achieve its drought tolerance and yield performance?

Summary

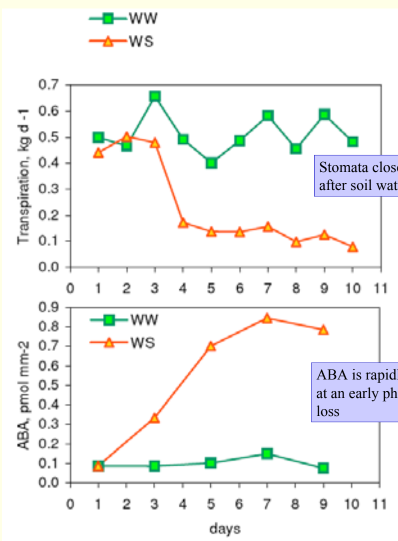
Mechanisms used by cassava to tolerate water deficit episodes include:

1) rapidly limit transpiration such that its tissues are not exposed to injurious low water potential stress,

2) down-regulate growth and carbon consumption in leaves and storage roots

3) supply metabolic needs via remobilization from reserves in petioles and stems.

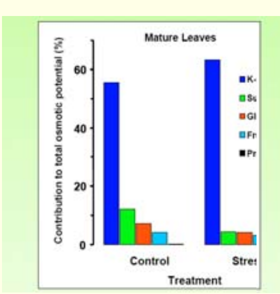
Stomata are responsive to small decreases in water status



Stomata close on Day4 after soil water is depleted

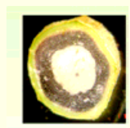
ABA is rapidly produced at an early phase of turgor loss

Osmoticum accumulation, primarily K^+, is limited



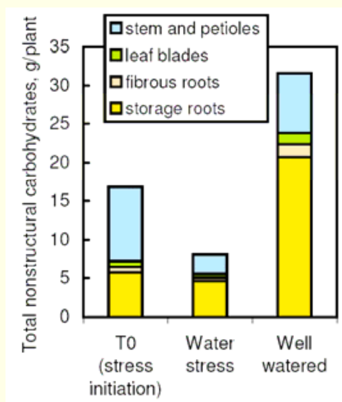
Substantial amounts of starch are stored in stems and petioles which is remobilized during stress

Cassava stem

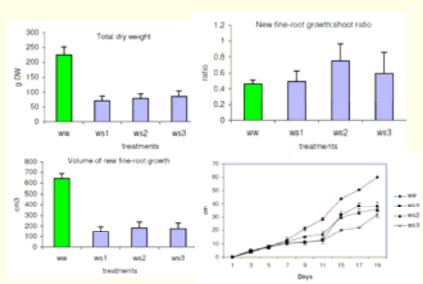


Starch (iodine stain)

Stems can contain >30% DW in starch

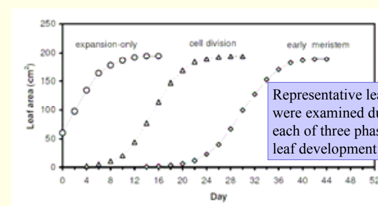


Fibrous root proliferation decreases during water stress, but depth growth tends to be maintained

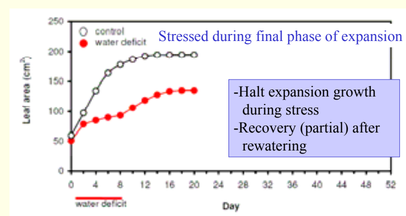


Duque and Setter 2007

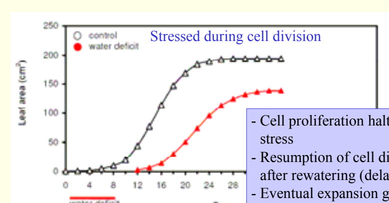
Flexible leaf growth: responsive to water loss, but capable of rapid recovery



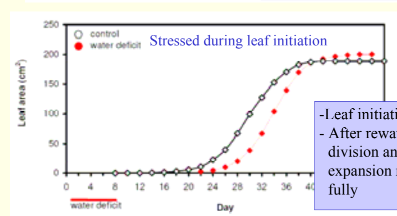
Representative leaves were examined during each of three phases in leaf development



-Halt expansion growth during stress
-Recovery (partial) after rewatering



- Cell proliferation halted during stress
- Resumption of cell division after rewatering (delayed)
- Eventual expansion growth (partial)



-Leaf initiation delayed
- After rewatering, cell division and expansion recover fully