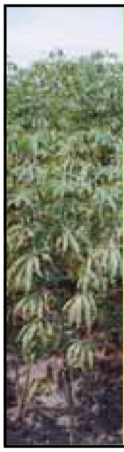
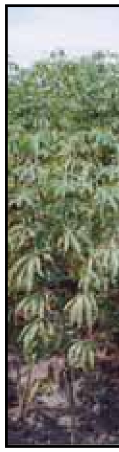


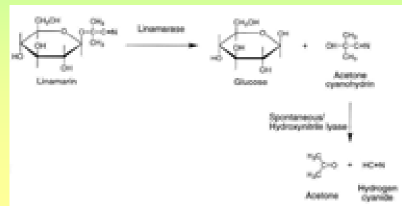
Drought-induced changes in photosynthesis & leaf linamarin level in cassava

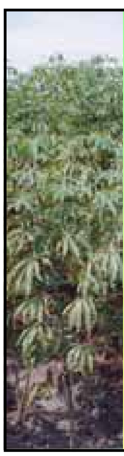
B. L. Ong, S.S. Chan and H.H. Yeoh
Department of Biological Sciences
National University of Singapore



Introduction

- Cassava is known for its ability to adapt to sub-optimal environmental conditions.
- Plant is highly tolerant of drought.
- Water stress can lead to an increase in cyanogen (linamarin) level in the storage roots.



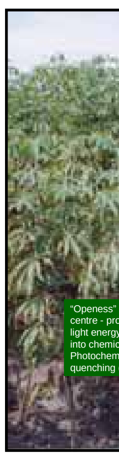


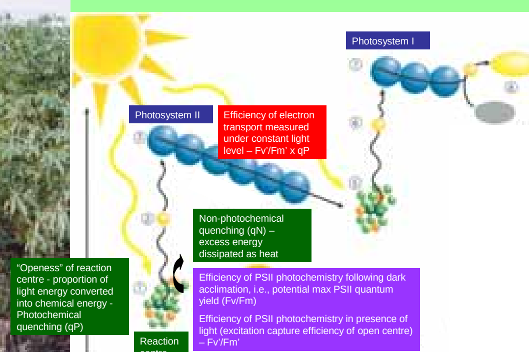
Objectives

To examine the impact of drought on

- Overall photosynthetic activity of cassava plants
  - Efficiency of photosystem II photochemistry
  - Efficiency of open photosystem II reaction centres
  - Electron transport at photosystem II
  - Photochemical and non-photochemical quenching
  - Carbon fixation activity

- Leaf linamarin concentration and linamarase activity.





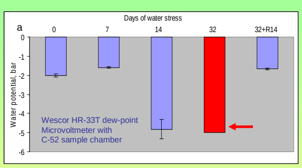
Treatment

- Plants grown from stem cuttings.
- 2.5 months old plants used
- Plants subjected to water stress for 32 days
- Recovery by re-watering plants daily for next 14 days
- Mature leaves counting from shoot apex used in analysis.

Some visual observations

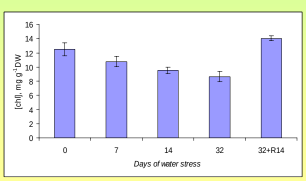
- Wilting of leaves
- Leaf senescence began with older leaves.
- 50% less leaves on water-stressed plants.
- Plants subjected to 7 days water-stress not distinguishable from well-watered plants.
- Plants re-watered for 14 days after 32 days water stress did not looked any different from plants at 32 days water stress
- Water-stress plants yielded none to few storage roots

Changes in water potential & total chlorophyll concentration of leaves in water-stressed cassava plants.



Water-stressed plants exhibited more negative leaf water potential
32 days WS, $\psi > -5$ bar

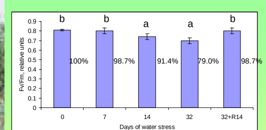
Re-watering of water-stressed plant reversed the situation



Water stress resulted in the decrease of total chlorophyll content.

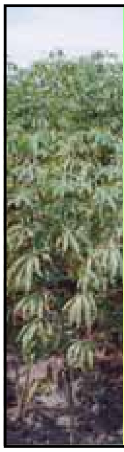
Re-watering of water-stressed plants led to recovery

Changes in Fv/fm, Fv/Fo & Fv'/Fm' in water-stressed plants.

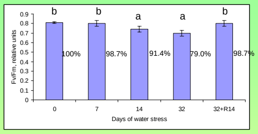


Efficiency of PSII photochemistry

Measured by Fv/Fm
Water stress caused a reduction in efficiency
Process reversible upon re-watering
Healthy plants = 0.80-0.83

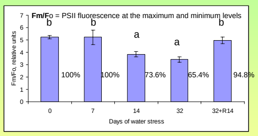


Changes in Fv/fm, Fv/Fo & Fv'/Fm' in water-stressed plants.



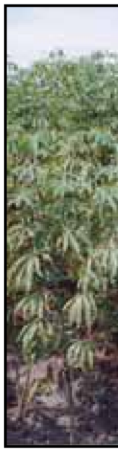
Efficiency of PSII photochemistry

Measured by Fv/Fm
Water stress caused a reduction in efficiency
Process reversible upon re-watering
Healthy plants = 0.80-0.83

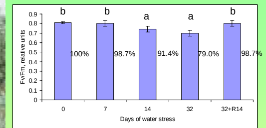


Fm/Fo, another measure of PSII photochemistry

Fm/Fo – better indicator of water stress in cassava plants.
Water-stressed plants exhibited decreased values.
Recovery possible by re-watering.

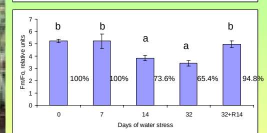


Changes in Fv/fm, Fv/Fo & Fv'/Fm' in water-stressed plants.



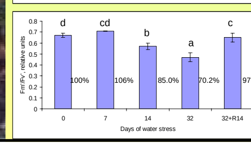
Efficiency of PSII photochemistry

Measured by Fv/Fm
Water stress caused a reduction in efficiency
Process reversible upon re-watering
Healthy plants = 0.80-0.83

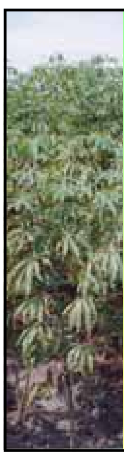


Fm/Fo, another measure of PSII photochemistry

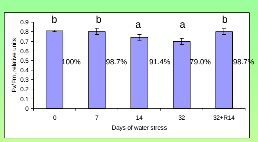
Fm/Fo – better indicator of water stress in cassava plants.
Water-stressed plants exhibited decreased values.
Recovery possible by re-watering.

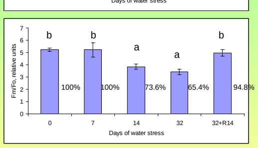


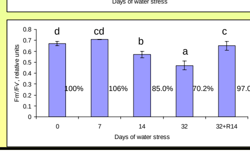
Efficiency of open PSII reaction centres in light
Measured by Fv'/Fm'
Water-stress resulted in reduction in the efficiency of absorbed photons to reach the reaction centres.
Returned to normal level of efficiency upon re-watering.



Changes in Fv/fm, Fv/Fo & Fv'/Fm' in water-stressed plants.







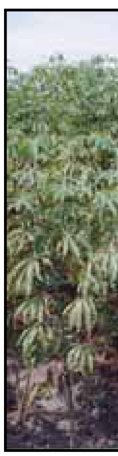
Overall, results suggested -

Down-regulation of photochemistry of photosynthetic apparatus

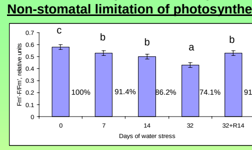
No chronic photo-damage

Recovery possible by re-watering

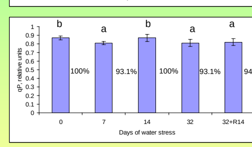
Resilient nature of cassava plants photochemistry



Reduction in the photochemistry of PSII
Non-stomatal limitation of photosynthesis

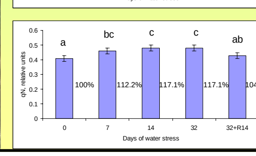


Quantum yield of electron transport at PSII (Fm'-F/Fm')
Water stress led to decline in efficiency of electron transport
Fm'-F/Fm = Fv'/Fm' x qP
= excitation energy capture by open reaction centres x reaction centre 'openness'



Photochemical quenching (qP)
Photochemical quenching remained at a high level, not affected by water stress.

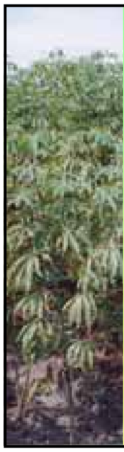
Declined in Fm'-F/Fm attributed to fall in Fv'/Fm' not to qP

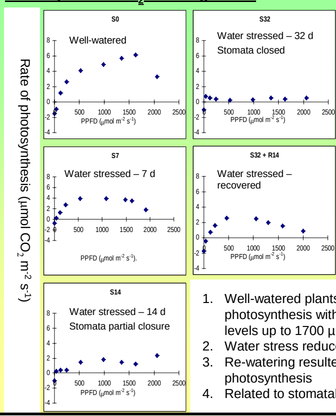


Non-photochemical quenching (qN)

Non-photochemical quenching (heat dissipation) increased with water stress, a common response also for many plant species.

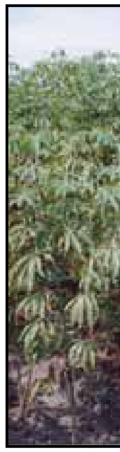
Photosynthetic CO_2-exchange rates

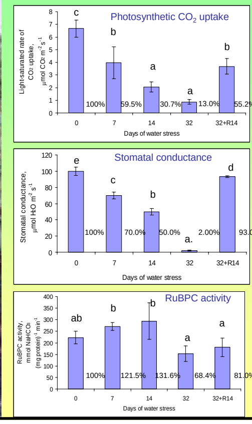




1. Well-watered plants - increased photosynthesis with increased PPFD levels up to 1700 µmol m^{-2} s^{-1}
2. Water stress reduced photosynthesis
3. Re-watering resulted in recovery of photosynthesis
4. Related to stomatal conductance

Photosynthesis due to both stomatal and non-stomatal factors





Light-saturated rate of CO_2 uptake

CO_2 uptake decreased with increased severity of water stress.
Re-watering resulted in partial recovery of activity.

Stomatal conductance

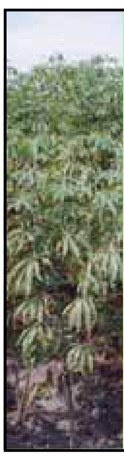
Sensitive to water stress
Recovery possible upon re-watering of water-stressed plants.

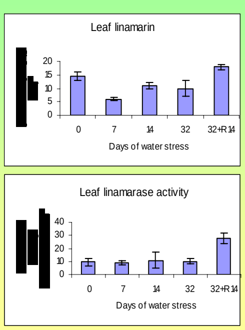
RuBPC activity

Enzyme activity reduced in 32 days water-stressed plants. Re-watering of plants resulted in some increase of activity.

RuBPC tolerant to some degree of water stress in cassava

Linamarin content and linamarase activity in cassava leaves





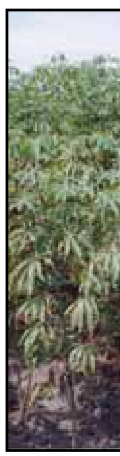
Linamarin content

Water stress led to decrease in linamarin content, possibly due to reduction in carbon allocation as photosynthesis decreased

Recovery possible upon re-watering of water-stressed plants

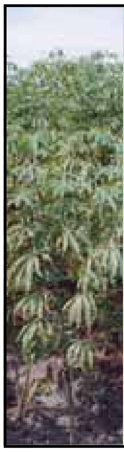
Linamarase activity

Not affected by water stress. Re-watering of water stressed plants apparently increase leaf linamarase activity.



Conclusion

- Water-stress affected cassava leaf photosynthesis in several ways but did not result in chronic photo-damage of the photosynthetic apparatus.
- There was a decrease in photosynthetic CO_2 uptake and a reduced ribulose-1,5-bisphosphate carboxylase activity.
- Leaf linamarin content decrease might be attributed to decreased carbon assimilation during water stress.
- Study re-affirmed the ability of cassava plants to withstand harsh environmental conditions.



Thank you