IMPACT OF DROUGHT ON MORPHOLOGICAL, PHYSIOLOGICAL AND NUTRIENT USE EFFICIENCY OF ELITE CACAO GENOTYPES FROM BAHIA-BRAZIL, TARAPOTO-PERU AND PUERTO RICO-USA.

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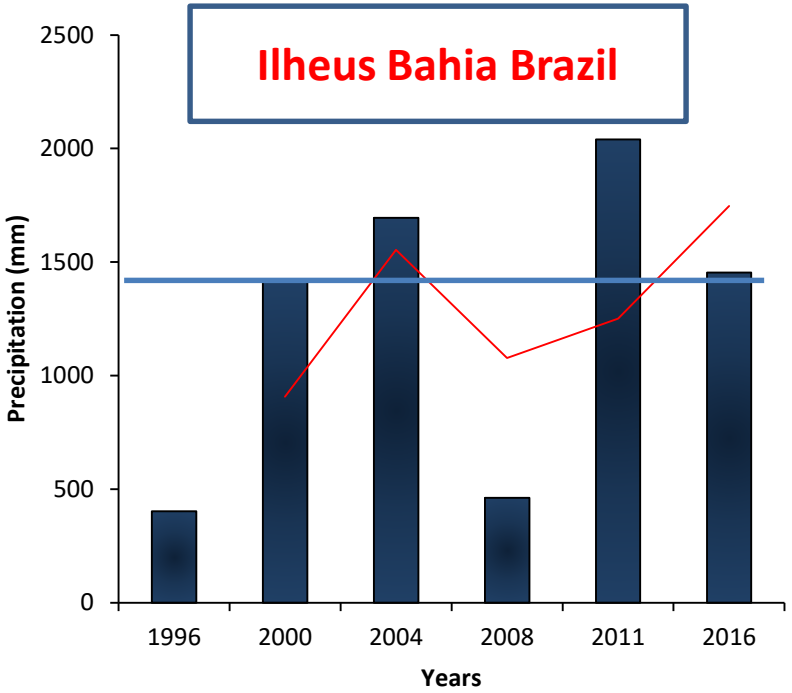
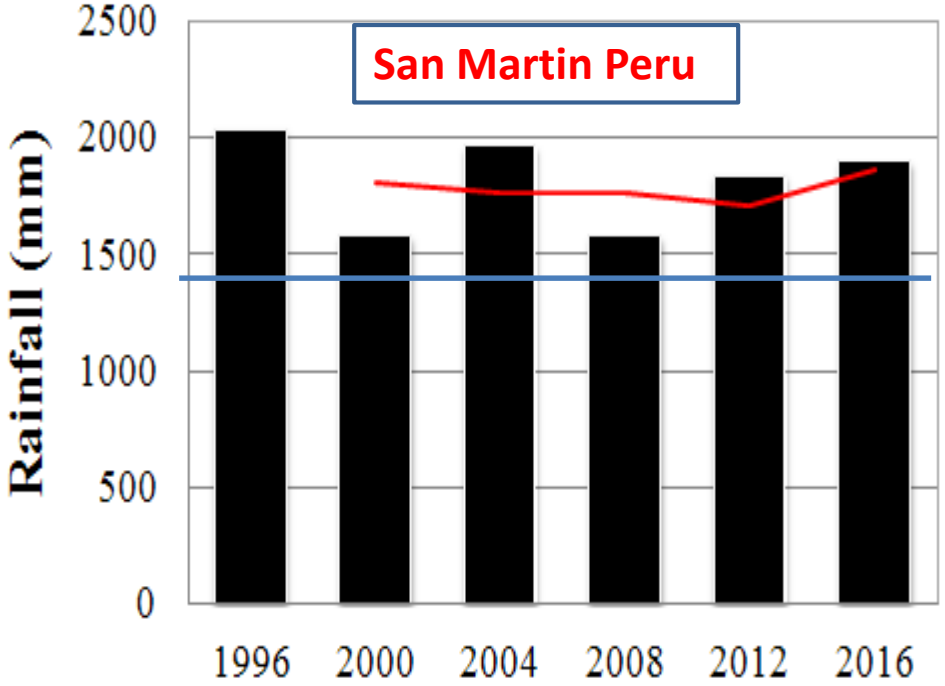
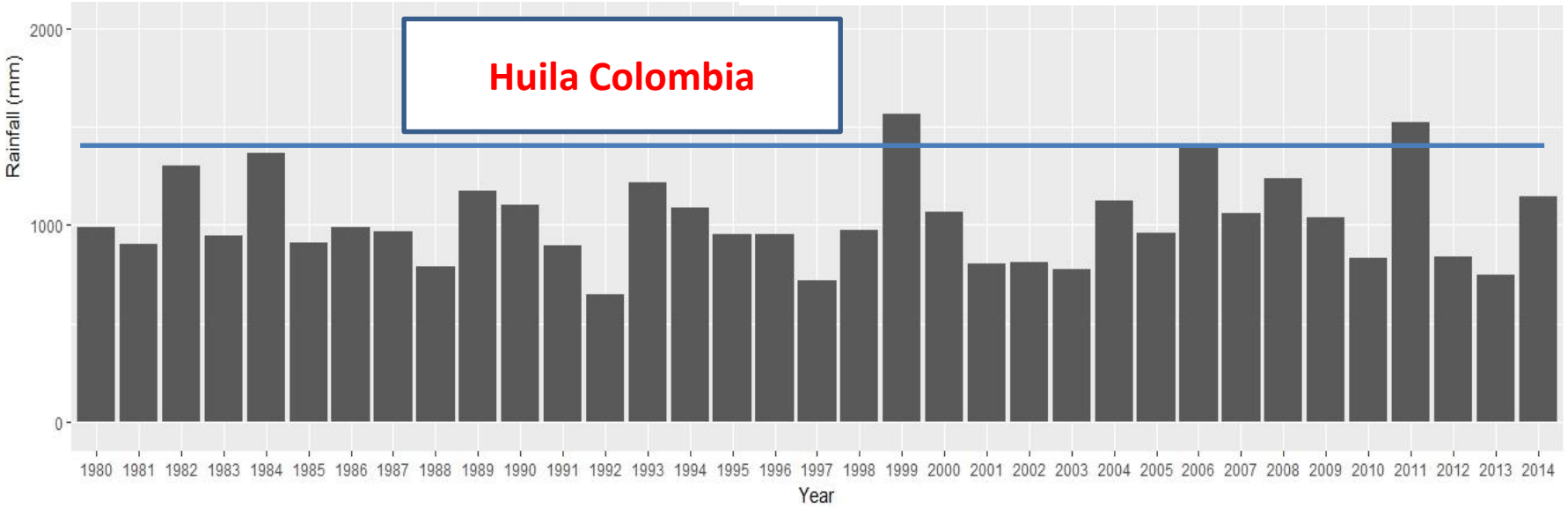
RAINFALL SELECTED CONTRIES







METHODS

Cacao Genotypes:

From Puerto Rico, USA:

- **TARS -14** (Hybrid, tolerant to soil acidity complexes) and
- **Amelonado** (Forastero, intolerant to acid soil complexes)

From Brazil, Bahia, Ilheus:

- **ICS 9** (Trinitario hybrid, resistant to drought),
- **EET 103** (Forastero, moderately tolerant to drought)
- **CC 40** (Hybrid susceptible to drought).
- **36 Genotypes**

From ICT, Peru

- **57 National and Inter National Clones**

- **For 64 days, plants were grown in a growth chamber at 30°C with -33 kPa soil moisture.**
- **On 65th day, plants were divided into two groups:**
  - **Control - Plants grown at -33 kPa soil moisture content for duration of experiment**
  - **Drought - Water withheld until the leaf stomatal conductance was less than 10% of control plants, determined by an SC-1 Leaf Porometer (Decagon Devices, Pullman, WA).**

Growth and Morphology:

Dry Weights, Stem Diameter, Leaf Area, Root Length

Physiological traits:

- Net photosynthesis rate
- Leaf Chlorophyll: Chl a and Chl b
- Total Water Use Efficiency (WUE_{TOTAL}):

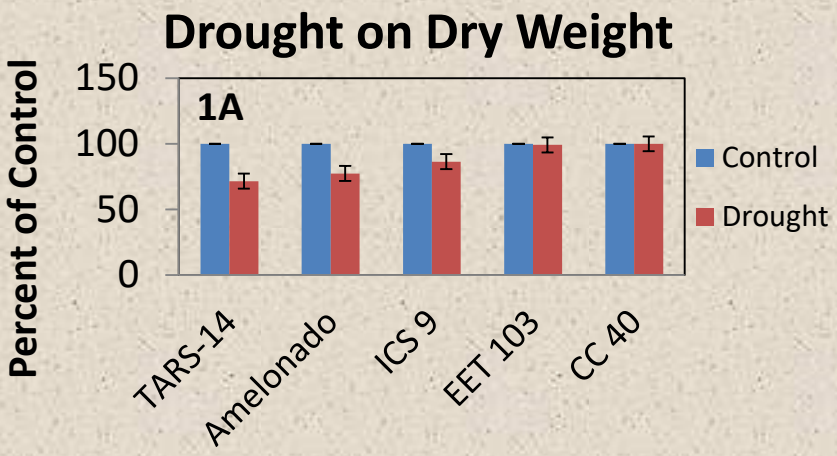
Nutrient Use Efficiency:

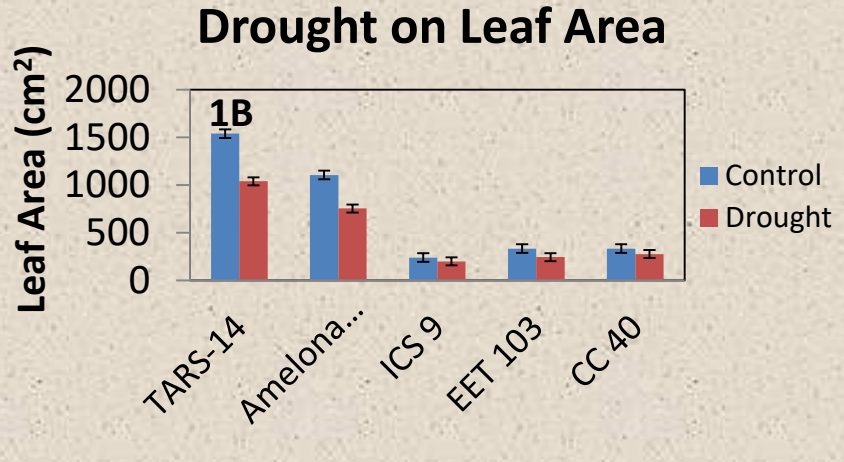
- Nutrient Use Efficiency For N, P, K, Ca, Mg:

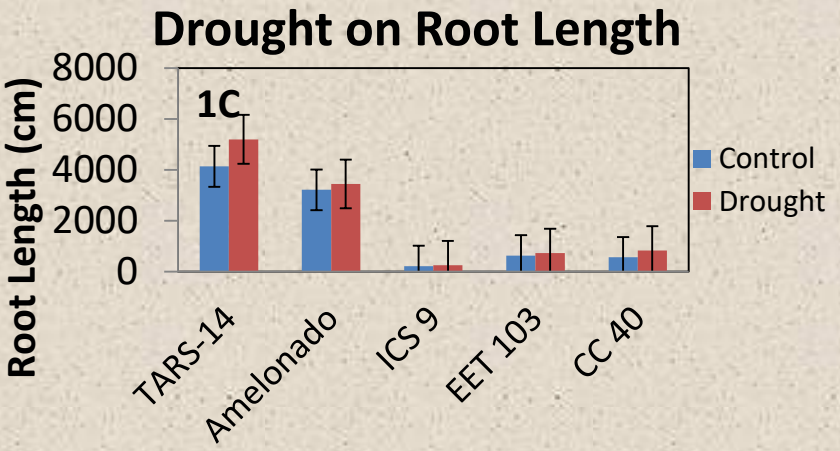
Drought Tolerance Index:

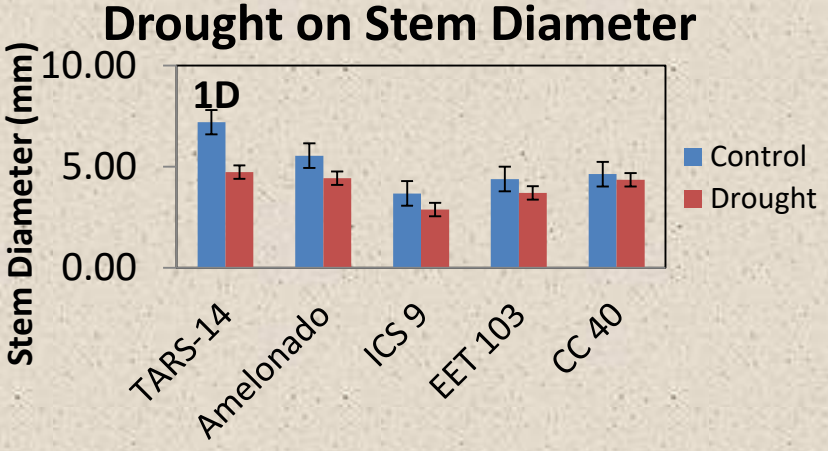
DTI = [(Shoot +root DB at drought)/[(Shoot +root DB at field capacity)] x 100.

Drought Effects on Growth Parameters:



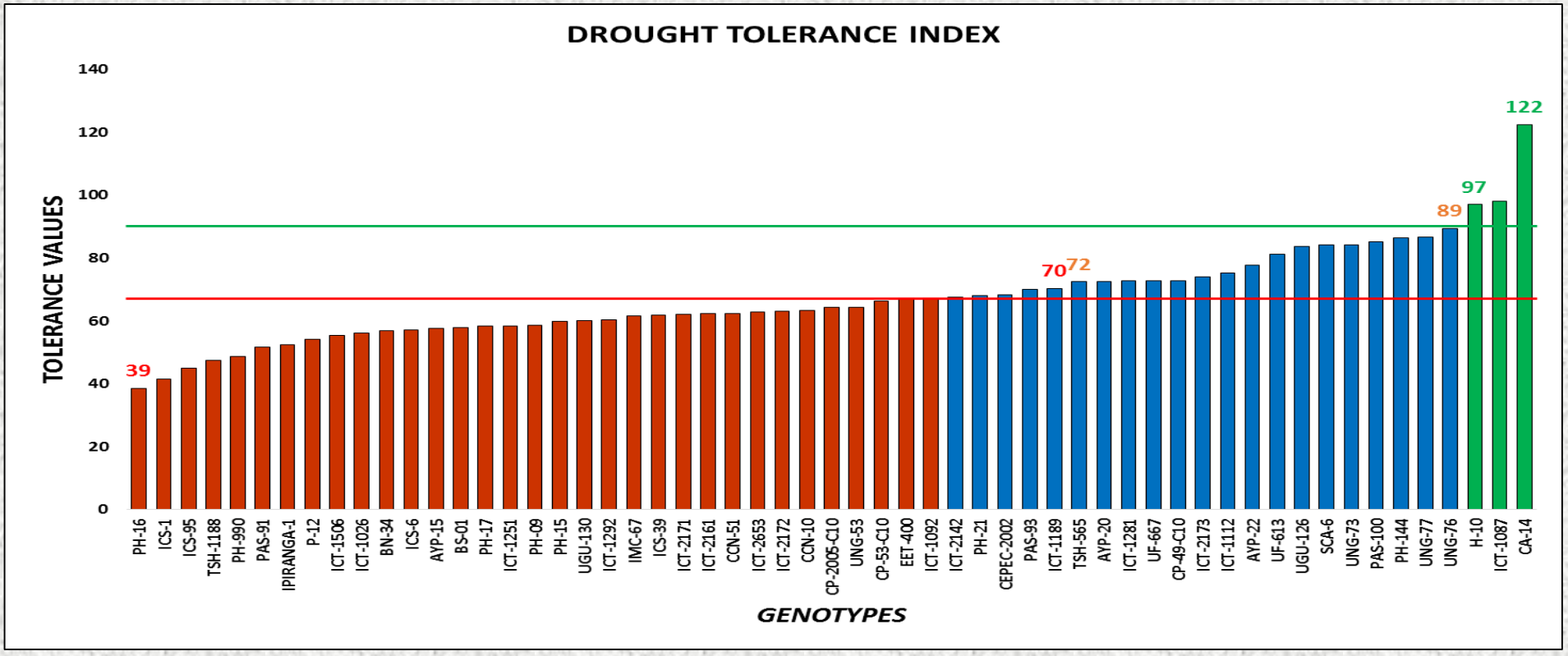






- **Significant intra-specific differences observed for growth parameters.**
- **Drought reduced total dry weight (shoot +root) and leaf area**
- **Drought increased root length and decreased stem diameter.**

DTI in wild and national and international cacao clones at ICT, Peru



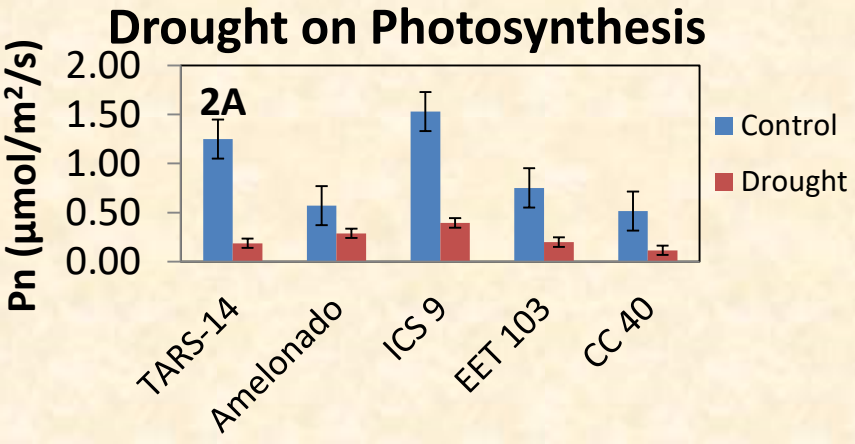
Drought tolerance index (DTI):

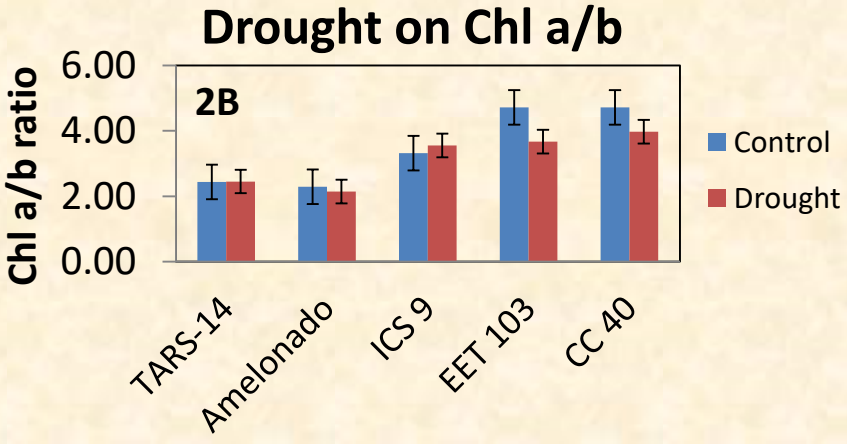
33 accessions - intolerant to drought,

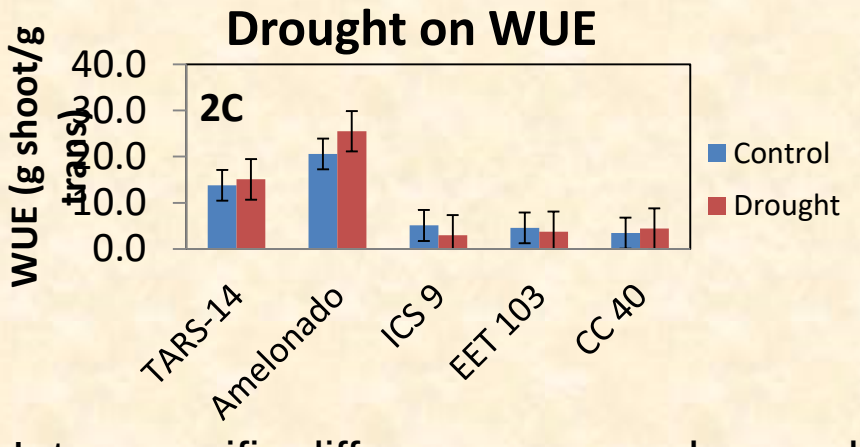
21 accessions - moderately tolerant to drought

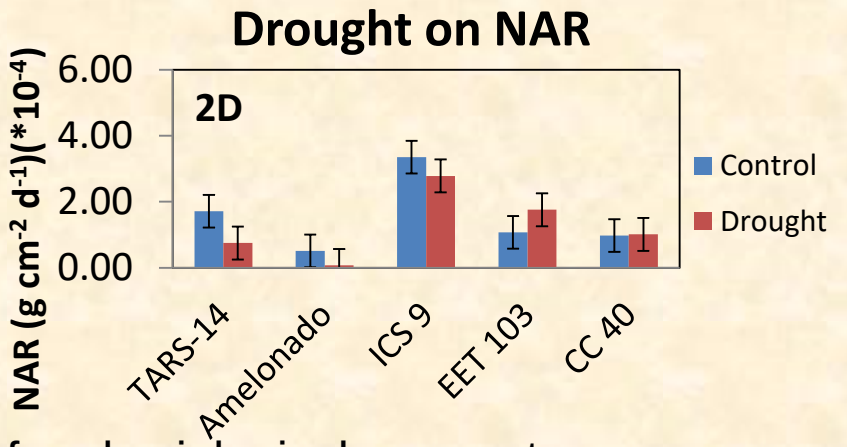
3 accessions (H10, ICT 1087, CA 14) - tolerant to drought.

Drought Effects on Physiological Parameters:





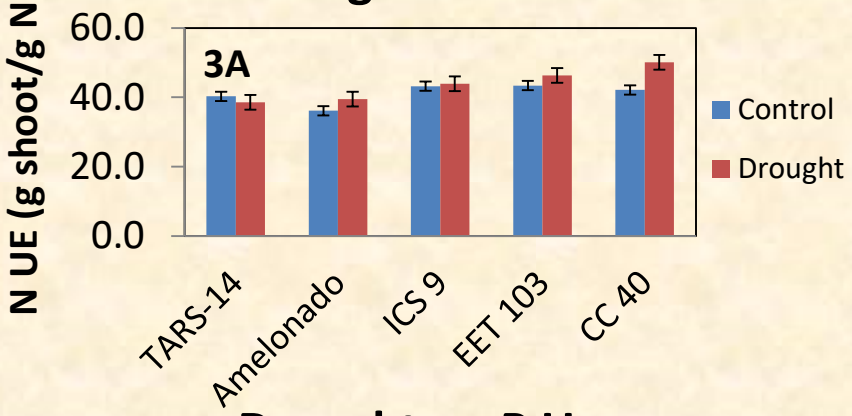




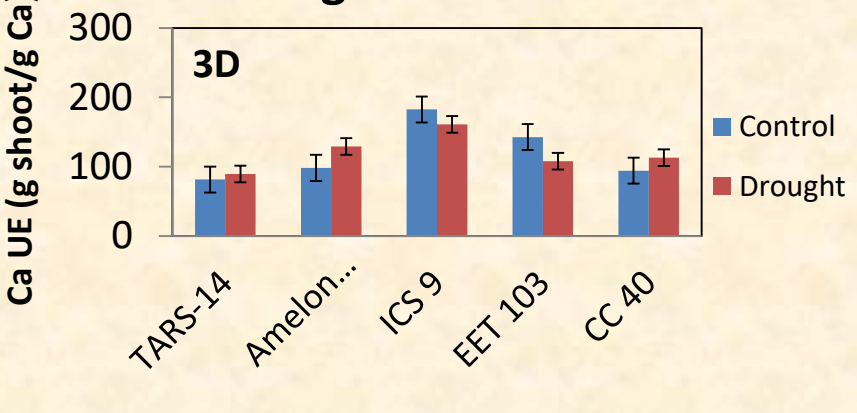
- Intra-specific differences were observed for physiological parameters
- Drought significantly reduced P_N, Chl a/b and NAR.
- Drought increased WUE.

Drought Effects on Macro-Nutrient Use Efficiency (UE)

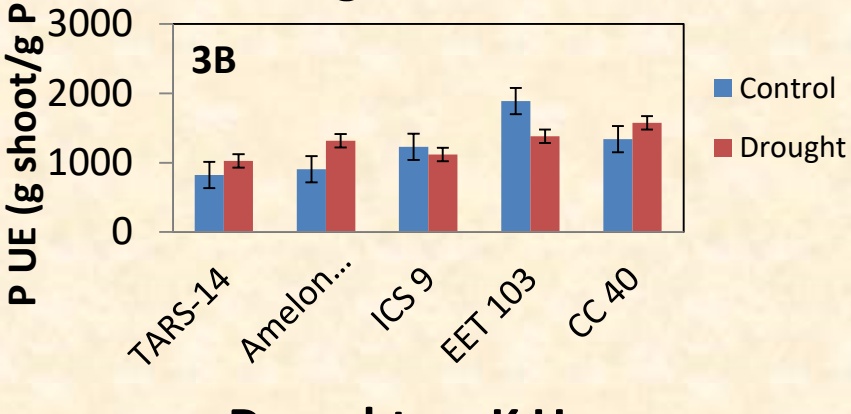
Drought on N Use



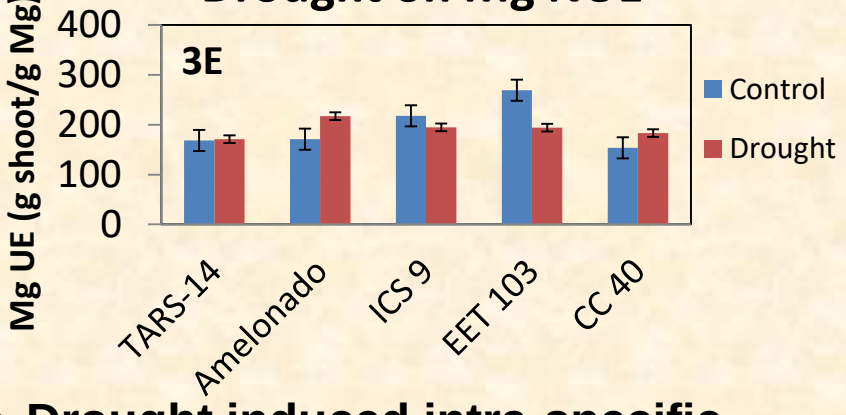
Drought on Ca NUE



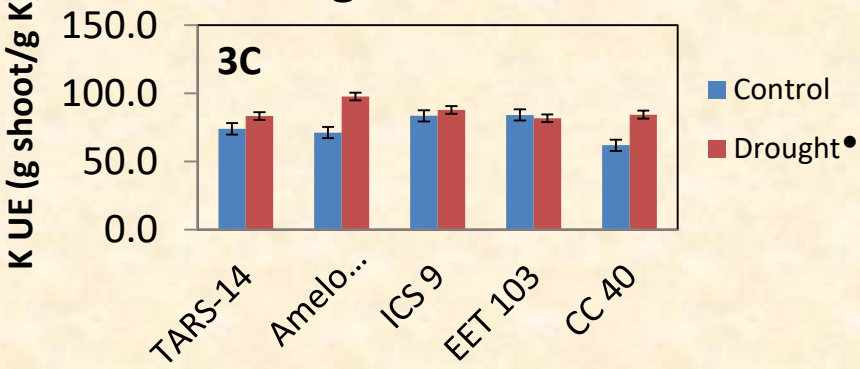
Drought on P Use



Drought on Mg NUE

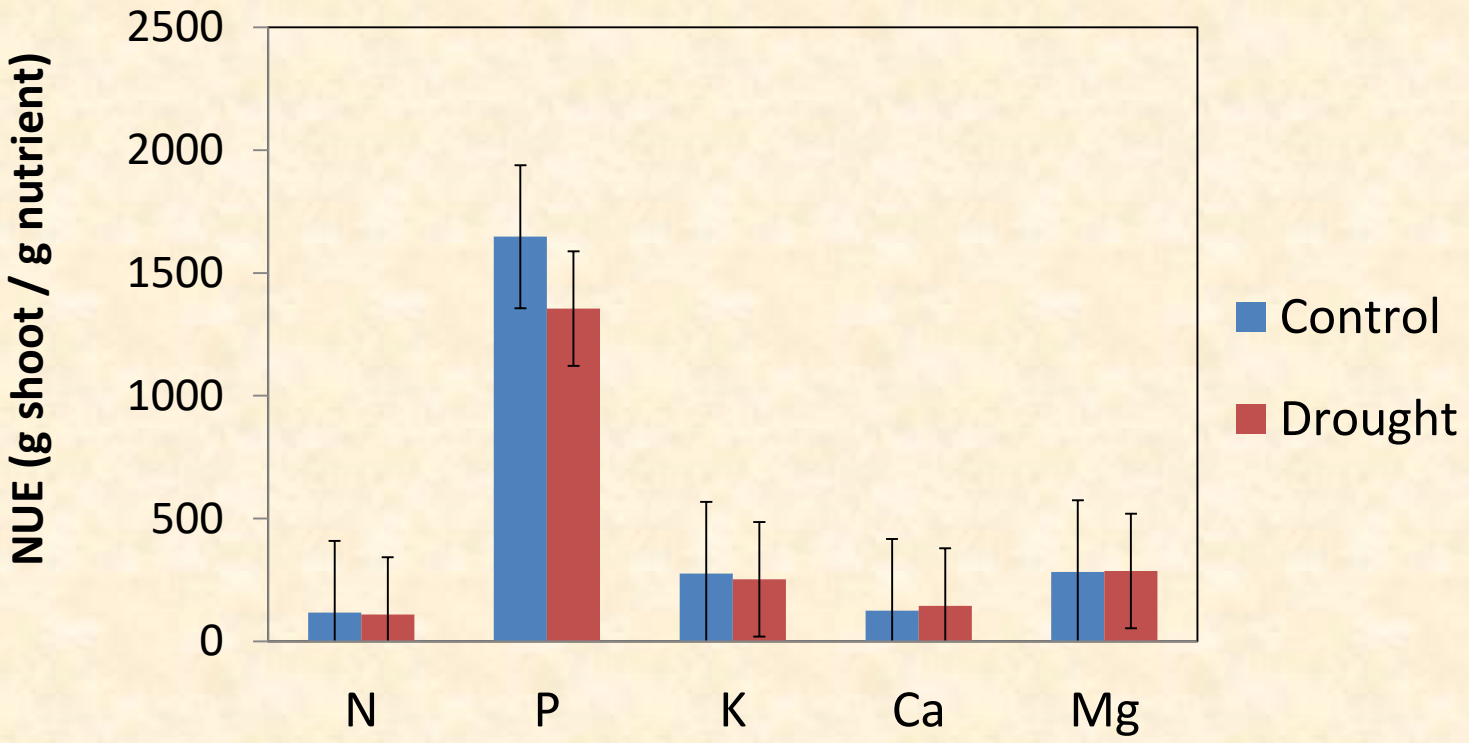


Drought on K Use



- **Drought induced intra-specific differences for Macro-nutrient UE**
- **In all the genotypes, UE for N, P and K increased and Ca and Mg decreased with drought.**

Drought Induced Intra-specific differences in nutrient use efficiency (NUE) of 36 cacao genotypes from Ilheus, Bahia, Brazil



CONCLUSIONS

- **Drought Induced intra-specific variations for:**

  Growth/morphology: leaf, stem, and root parameters
  Physiology: photosynthesis, Chl a/b, water use efficiency, NAR
  Nutrient use efficiency: N, P, K, Ca, and Mg.

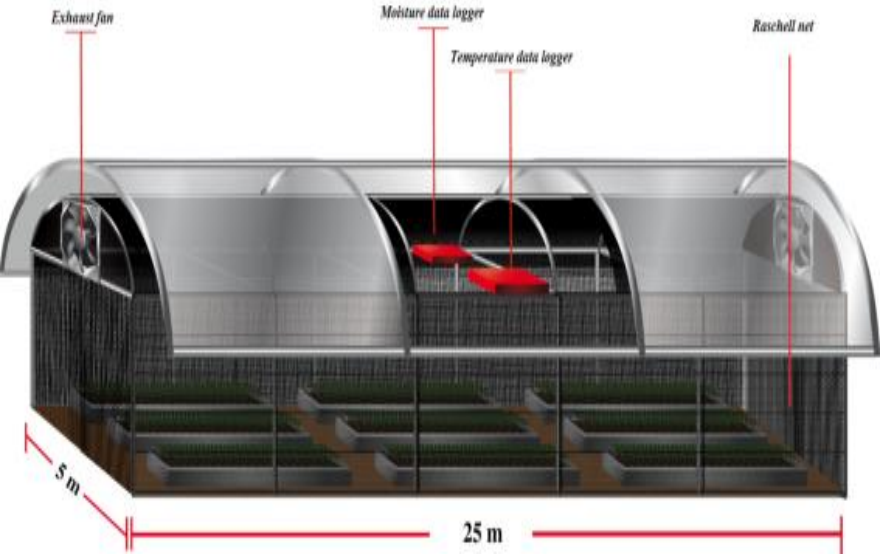
- **Reliable and Stable plant growth traits (morphology, physiology and nutrient use efficiency) will facilitate identification of cacao genotypes tolerant to drought.**

- **Drought tolerant genotypes are useful in crop improvement programs to breed superior cultivars for drought stressed ecosystems.**

- **Drought tolerant genotypes are useful as rootstock or as scion for establishment of new plantations or rejuvenation of old plantations in drought prone areas**

Abiotic Stress-Drought

Greenhouse methods developed are useful to identify drought stress tolerant cacao genotypes



FUTURE CHALLENGE

Inter-disciplinary and Multi-institutes (National/International) Approaches are Required in Devising Strategies at Multi-scalar levels to Mitigate Effects of Drought to Achieve Sustainable High Yielding Cacao Production

Highly Collaborative Multi-Institute and Multi-Disciplinary International Research

- Brazil (UESC, CEPLAC, EMBRAPA, UENF)
- Peru (ICT, UNALM)
- USDA-TARS, PR
- Univ. of FL- IRREC, TREC
- Univ. of Reading UK

Governo da Bahia
Universidade Estadual de Santa Cruz

CEPEC
Centro de Pesquisas do Cacau

UENF
Universidade Estadual do Norte Fluminense

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