Analysis of phenotypic plasticity in response to water constraints in coffee plants growing under field conditions

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In a context of climate change, adaptation of perennial plantations to water constraints becomes a major concern for wood and fruit productivity. Adaptation depends on the level of genetic diversity in breeding and natural populations, as well as their plasticity. This project plans to describe adaptive mechanisms under water constraints for three perennial plants of temperate and tropical regions, including *Pinus, Eucalyptus* and *Coffea,* through a combined analysis of plant architecture, physiology, anatomy and molecular responses to drought stress.

Experimental approach

Germplasm

The project's coffee field trial has been set up in the experimental fields at Embrapa Cerrados (Fig.2) located near Brasilia, because that region is always subjected to a long and regular dry season during the winter. Field trials will be conducted with *Coffea arabica* cultivars IAPAR59 (drought tolerant) and Rubi (drought susceptible).

Field experiment

Three water treatments will be applied (Fig.1): T1, an unlimited watering treatment (irrigated during the dry season), T2, a limited watering treatment (not irrigated during the dry season) and T3, limited watering in year 1 and unlimited watering in year 2 (recovering). There will be six measurement points (P1 to P6) over the two years of the experiment (2008-2009).

Planned activities

For all conditions, molecular plasticity will be investigated for leaves, stems and roots (Fig.3) by analysing gene expression by quantitative PCR (qPCR), but also with microarrays using meristematic cells. Excavated plants (Fig.4) will be used to analyse phenotypic plasticity by measuring leaf area, leaf thickness and stomata number. On an anatomical level, xylem vessel structure and parenchyma thickness will be assessed. These data will be correlated with ecophysiological measurements such as biomass estimations (for leaves, stems and roots), hydraulic conductivity, stomatal conductance, and water-use efficiency ($\delta^{13}C$). Leaf stomatal density will also be compared between cultivars and the different water treatments (Fig.5). We will also characterize the root and aerial architecture of coffee plants.

A multidisciplinary network

A network of scientists and technicians in molecular biology, genetics, ecophysiology, anatomy and developmental biology from different research organizations and universities is involved in this project.

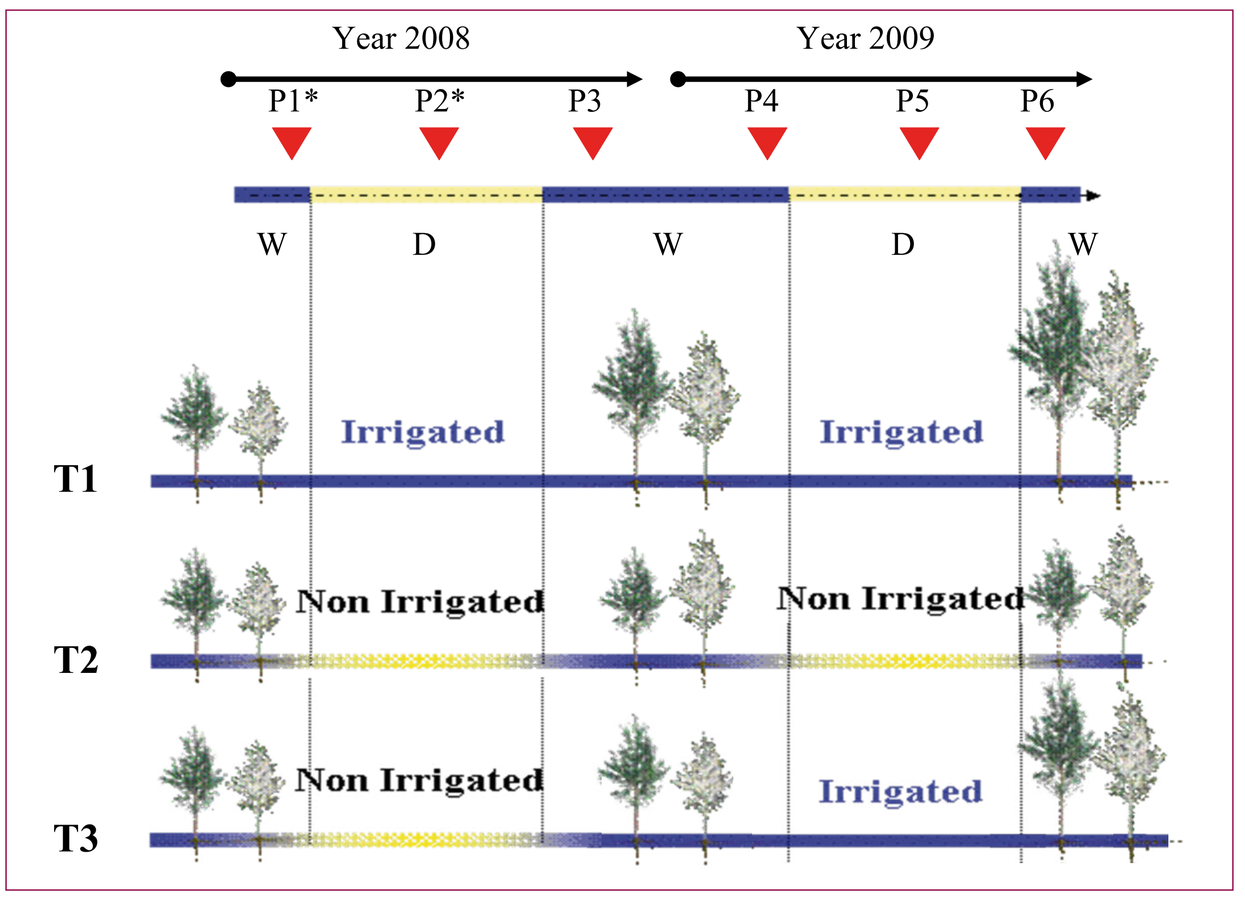

Fig. 1. Schematic representation of water treatments applied to coffee plants. W: wet season (October > April); D: dry season (May > September). The different tree colours represent the two cultivars (tolerant of and susceptible to drought). P1 to P6: analysis points; *: points already measured.

Expected results

Overall, the results should enable (1) the identification of dynamic changes on molecular, morphological and ecophysiological levels, (2) an analysis of their correlations, and (3) identification of GxE for coffee plants.

Finally, the results obtained for coffee will be compared to those for *Pinus* and *Eucalyptus* in order to see if common mechanisms are found between these three plant models.

Understanding of ecophysiological and molecular mechanisms for water stress adaptation

- Identification of adaptive traits.
- Identification of candidate genes for adaptation to water stress.
- Identification of common mechanisms between biological models.

Technological and technical innovations

- Experimental field trials monitored for two growing periods.
- Microarrays for particular cells sampled by microdissection.

Sustainable management of perennial plants

- Genes and traits for diversity analysis to estimate the adaptive potential of breeding and natural populations.

Fig. 2. Field trial (EMBRAPA CPAC-DF).

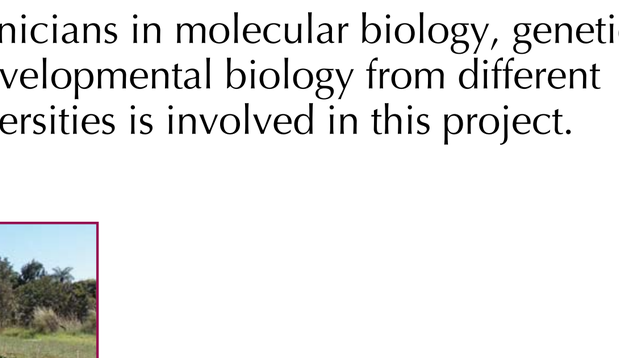

Fig. 3. Tissues (leaves, stems, roots and meristems) collected for anatomical and molecular analyses.

Fig. 4. Plant excavation for biomass and architectural analyses.

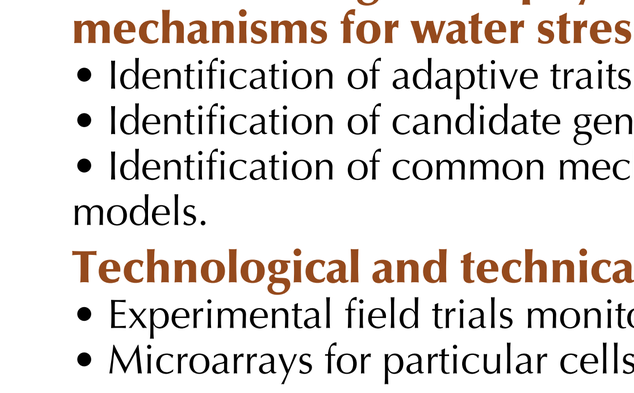

Fig. 5. Determination of stomatal density.

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