Improving plant adaptation to drought in Africa

Examples of cotton, groundnut and sorghum

New plant growth in cracked soil.
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Producing varieties more resilient to adverse environmental conditions is a challenge for geneticists. Breeding is based on the one hand on exploring the broad genetic diversity that exists within cultivated species and wild relatives, and on the other hand on screening tests of adaptive traits. Multi-disciplinary approaches that associate ecophysiology, genetics and marker-assisted selection (MAS) serve to define varietal ideotypes that combine adaptive and productivity traits and can respond to the major issues for the future.

Contacts

Cotton: Jean-Marc Lacape
marc.lacape@cirad.fr

Groundnut: Daniel Foncéka
daniel.fonceka@cirad.fr

Sorghum: Michel Vaksmann,
michel.vaksmann@cirad.fr

CIRAD, UMR AGAP,
Genetic Improvement
and Adaptation of Mediterranean
and Tropical Plants
Montpellier, France

http://umr-agap.cirad.fr

Adapting crops to drought may use any of three strategies: escape, by adjusting the development cycle; avoidance of drying out, by controlling water losses and/or maintaining absorption; and tolerance, thanks to the plant's ability to overcome the deterioration of its water status. In plant improvement, marker-assisted selection (MAS), which consists in simultaneously characterizing the genotype, using DNA markers, and the plant's response to contrasting conditions (stressed versus unstressed) serves to identify the genome regions involved, or QTL (quantitative trait loci) and to select progenies indirectly.

Cotton, groundnut and sorghum, species that are of major importance in Africa and elsewhere, are a good illustration of the research being done by CIRAD and its partners.

Study of the cotton root system in a rhizotron.
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Diversity of wild and cultivated cotton varieties

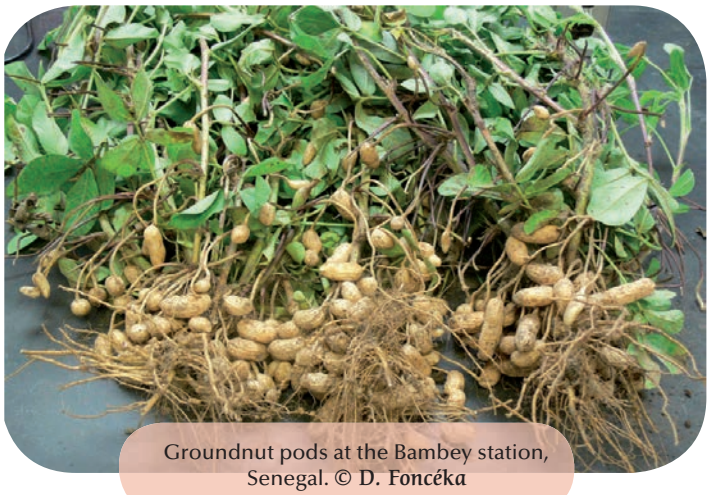
Perennial *Gossypium hirsutum* cotton plant populations from Mesoamerica and the Caribbean have been described and georeferenced: of 950 cotton populations, around a hundred are wild, tied to coastal environments with high constraints as regards water availability or salt stress. These wild populations represent a reservoir of environmental stress tolerance genes for improving cultivated cotton, *G. hirsutum*. Association genetics studies are under way at EMBRAPA in Brazil and at CIRAD, with the support of the Agropolis foundation, to determine the response to water deficits within the cultivated *G. hirsutum* pool. A panel of 250 varieties of various origins is undergoing morphological and physiological characterization under controlled conditions, on the one hand using rhizotrons (analysis of the root system) and on the other using a high-throughput measurement system developed by INRA in Montpellier (Phenoarch platform).

What the distant parents of groundnut can contribute

In Senegal, work by ISRA and CIRAD on groundnut drought tolerance led to the creation in 1989 of CERAAS, the *Centre d'études régional pour l'amélioration de l'adaptation à la sécheresse,* which federates research efforts on a regional level.

CIRAD, CERAAS, the CNRA (*Centre national de recherche agronomique,* Bambey) and EMBRAPA (Brazil) have established a programme to broaden the genetic base of cultivated groundnut through hybridization with wild species of the genus *Arachis,* for their adaptive traits (diseases, environmental stress). The Fleur11 variety and a tetraploid hybrid between two wild diploid species, *A. duranensis* and *A. ipaensis,* have been used for marker-assisted population construction to produce:

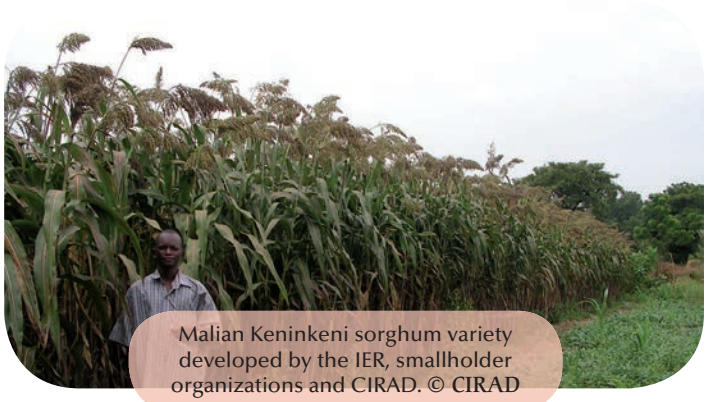
- an "AB-QTL" (Advanced Backcross-QTL) population used to map numerous QTL involved in morphology and yields under water stress conditions;
- a population of "CSSL" (chromosome segment substitution lines), comprising lines very closely related to the cultivated genome, each integrating a small chromosome segment of wild origin, used in several groundnut genetic improvement programmes (Senegal, Mali, Niger, Malawi, India and Brazil).



Groundnut pods at the Bambey station, Senegal. © D. Foncéka

Sorghum: sharing knowledge

African farmers have long experience of managing irregular rainfall patterns, the most spectacular aspect of which is making use of photoperiodism. In particular, photoperiodism serves to synchronize flowering with the end of the rainy season, independently of sowing date. This mitigates the effects of climate variability in the event of drought or excess water and avoids many biotic constraints (insects, birds and moulds). CIRAD's sorghum improvement programmes are using the broad genetic base of local varieties, or landraces, to combine the yield potential of modern varieties and the specific properties of local varieties. A molecular marker-assisted recurrent selection programme is under way in Mali and a broad experimental population including local and modern varieties has been built up. A major photoperiodism QTL was recently identified and could be used to develop varieties specifically adapted to the climatic variability of Sudano-Sahelian Africa.



Malian Keninkeni sorghum variety developed by the IER, smallholder organizations and CIRAD. © CIRAD

Prospects

CIRAD's genetic improvement research highlights the importance of making use of as much of the diversity that exists within plant resources related to cultivated species as possible.

Partners

Cotton: EMBRAPA, IMAmt, Brazil; UMR CEFE, Agropolis Foundation, France; **Groundnut:** CERAAS, CNRA, Senegal; EMBRAPA, Brazil; ICRISAT (CGIAR); **Sorghum:** NARS (IER, ISRA, INERA, etc), ICRISAT, GCP, Syngenta Foundation, NGOs (AMEED, etc) CERAAS, Agropolis and Cariplo (BIOSORG) Foundations.

For further information

Lacape J-M. et *al.*, 2015. Enhanced drought adaptation in African savanna crops. *In:* Torquebiau E. (ed.). Climate change and agriculture worldwide. Springer (in press)

See also: http://publications.cirad.fr