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Art direction: G Antonio Luna Avila
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## Acronyms and abbreviations

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<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AfricaRice</td>
<td>Africa Rice Center</td>
</tr>
<tr>
<td>Agropolis–CIRAD</td>
<td>Centre de coopération Internationale en Recherche Agronomique pour le Développement, France</td>
</tr>
<tr>
<td>Agropolis–IRD</td>
<td>Institut de Recherche pour le Développement, France</td>
</tr>
<tr>
<td>CIRAD</td>
<td>see Agropolis–CIRAD</td>
</tr>
<tr>
<td>DEM</td>
<td>digital elevation model</td>
</tr>
<tr>
<td>IER</td>
<td>Institut d’Economie Rurale, Mali</td>
</tr>
<tr>
<td>INERA</td>
<td>Institut de l’Environnement et de Recherches Agricoles, Burkina Faso</td>
</tr>
<tr>
<td>IRD</td>
<td>see Agropolis–IRD</td>
</tr>
<tr>
<td>IRIS</td>
<td>International Rice Information System</td>
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<tr>
<td>MARS</td>
<td>marker-assisted recurrent selection</td>
</tr>
<tr>
<td>MAS</td>
<td>marker-assisted selection</td>
</tr>
<tr>
<td>NCRI</td>
<td>National Cereals Research Institute, Nigeria</td>
</tr>
<tr>
<td>PhD</td>
<td>Doctor of philosophy (also philosophiae doctor or doctorate)</td>
</tr>
<tr>
<td>QTL(s)</td>
<td>quantitative trait locus (loci)</td>
</tr>
<tr>
<td>SAMARA</td>
<td>a hybrid model between the SARRAH and EcoMeristem models</td>
</tr>
<tr>
<td>SARRAH</td>
<td>Système d’analyse régionale des risques agro-climatiques – Habillé</td>
</tr>
<tr>
<td>t ha(^{-1})</td>
<td>tonnes per hectare</td>
</tr>
<tr>
<td>TPE</td>
<td>target population of environments</td>
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</table>
Rice: Improving rice productivity in lowland ecosystems through marker-assisted recurrent selection for drought tolerance and yield potential

**Introduction**

Rice production is severely constrained by various biotic and abiotic stress factors in West Africa. Drought is one of the most important abiotic constraints and several studies have demonstrated its impact on the performance of rice genotypes, especially when it occurs during the reproductive phase of the crop.

Initial attempts at marker-assisted selection (MAS) for drought tolerance, based on introgression of quantitative trait loci (QTLs) detected in models mapping populations into elite cultivars, have been disappointing. Recently, new breeding schemes have been developed, one of which is marker-assisted recurrent selection (MARS). In these schemes, QTLs for target traits are detected within the segregating progenies of elite lines crossed for their complementarities. The marker–phenotype information derived guides the subsequent breeding process.

This project focuses on the rainfed lowland ecosystems in Burkina Faso, Mali and Nigeria, establishing a long-term capacity-building initiative, with the objective of institutionalising, in West Africa, a modern breeding programme for complex traits such as drought.

Within four years the project is expected to: (i) establish the drought profiles in the target inland valley lowlands; (ii) perform MARS for the development of drought-tolerant rice cultivars with medium to high yields (in normal years) for rainfed lowlands of Sudanean and Guinean savanna in Burkina Faso, Mali and Nigeria; (iii) build capacity for modern plant breeding; and (iv) introduce new tools and breeding approaches in the breeding programmes of developing-country partners and AfricaRice.

The work is organised into five ‘work packages’ described in the next section.
**Progress**

**Work Package 1:** Characterisation of drought profile in the target population of environments (TPEs), establishment of drought evaluation sites and description of ideotypes fitting major sub-classes of TPEs

The first objective was to conduct characterisation through farmer surveys, to identify drought evaluation sites. Inland valleys in the three target countries were mapped using a digital elevation model (DEM) derived from the Japanese–American ASTER satellite. In close collaboration with partners, a survey was designed (in French and English) for characterising drought in inland valleys based on farmers’ knowledge.

The second objective was to adapt, validate and apply eco-physiological rice growth models to characterise the inland valley TPEs and define rice ideotypes. Towards this aim, data were generated from a drought experiment and will be used to calibrate the SAMARA model (SAMARA is a hybrid between the SARRAH and EcoMeristem models). Modelling work and other work on this project has been partially delayed (see details in Challenges and lessons learnt).

**Work Package 2:** Phenotyping for yield potential and drought tolerance

Drought-phenotyping field facilities were established in the three target countries and a new rainout shelter at AfricaRice in Cotonou (Benin). Advanced progenies (ie, the third to fifth filial generations, or F$_{3:5}$) have been developed for crosses proposed by breeders from partner countries. Preliminary evaluation revealed a wide range of yield performance among the parental lines: upland japonica varieties were poor yielders, apparently due to poor adaptation to lowland conditions, while lowland indica varieties gave much better yields. The IR64 × B6144F-MR-6-0-0 was chosen to undergo the MARS procedure first. In each of the three target countries, including at AfricaRice in Ibadan (Nigeria), 200 F$_{3:5}$ lines were phenotyped for yield potential in two hydrologic conditions (during the rainy seasons in 2011 and 2012) and for drought tolerance (during the dry season in 2012). The same population was evaluated for drought response using the rainout shelter in Cotonou. In Ibadan, the grain yields of the MARS population ranged from 0.6 to 3.0 t ha$^{-1}$ under drought stress and from 3.0 to 7.0 t ha$^{-1}$ under controlled irrigated conditions. The performance of the four best lines
under drought ranged from 2.5 to 3.0 t ha⁻¹. A good level of variability was observed among the MARS progenies in all locations, regardless of the water regime (the data on yield under drought conditions are, however, still being processed). Promising lines showing good yield under normal rainy season conditions were identified in the lowlands of Nigeria and at AfricaRice in Ibadan, and promising lines showing good yield under drought conditions were selected by country partners using conventional breeding. A conventional breeding programme using the first MARS population is under way at AfricaRice, Ibadan.

**Work Package 3: Developing improved lines combining favourable QTL alleles for drought adaptation and productivity for target environments**

The first MARS population was genotyped with 484 SNP (single-nucleotide polymorphism) markers evenly distributed along the genome. Preliminary analysis revealed 20 QTLs related to yield and yield components (1,000 grain weight, spikelet fertility, biomass, harvest index, panicle weight, etc). QTL analysis for yield potential and drought tolerance is ongoing. The first round of crossing of complementary lines is scheduled for mid-2013.

**Work Package 4: Rice drought molecular biology and breeding community of practice for West Africa**

With the objective of building capacity and developing relationships among project participants, two training courses for country partners were held during 2012 on the following topics: (i) ‘Implementation and monitoring of the Rice Challenge Initiative’s first drought-tolerance experiments – theoretical and practical aspects’ (January–February, in Sikasso, Mali, involving 11 participants from Burkina Faso, Mali and Nigeria); and (ii) ‘Use of two specific phenotyping methods for drought resistance – infrared thermal imaging and fluorescence’ (May, in Cotonou, Benin, involving eight trainees from Benin, Burkina Faso, Côte d’Ivoire, Mali and Niger).

During these courses, project partners from Mali and Burkina Faso also met and exchanged information on the protocols for phenotyping for drought in the lowlands, the related difficulties and potential solutions. In addition to the training, AfricaRice scientists assisted local partners in Mali (Sikasso, 5–7 February 2012) and Burkina Faso (Banfora, 7–9 February 2012) to equip their fields with devices for monitoring soil moisture in preparation for the 2012 dry season drought trials. A monitoring visit was also organised from 21–23 June 2012 to Badeggi (Nigeria), during which the AfricaRice breeder shared his experience on rice drought phenotyping with staff and students at the National Cereals Research Institute (NCRI).

Three students from the three target countries have been identified to start a three- to five-year PhD programme: they are Abdourhaman Konaté from Burkina Faso, Jean Sangaré from Mali and Abraham Shaibu from Nigeria.

**Work Package 5: Project and information management**

The data obtained after the evaluation of the first MARS population for yield potential and drought tolerance in the three countries and at AfricaRice during the 2011 wet season and the 2012 dry season are being entered into the International Rice Information System (IRIS) database.
Challenges and lessons learnt

There have been partial delays on Work Package 1 due to the sad demise of Youssouf Dembele, who was responsible for survey implementation. It is expected that the farmer surveys will take place in 2013. Experimental data for modelling work are now available. AfricaRice will calibrate the SAMARA model with the support of the newly recruited crop modeller. With regard to conducting characterisation of the drought profile in the TPE and description of ideotypes fitting major sub-classes of TPE, the methodological developments needed were underestimated; additional human resources are needed.

There is also a delay of approximately one year in the implementation of the MARS process, apparently due to over-optimistic scheduling of the phenotyping, database development and data analysis activities. The challenge is to find the right equilibrium between keeping a good pace on activities, and involving country partners.

Conclusions and perspectives on 2013

The project has succeeded in developing a drought-phenotyping network for rice, in terms of establishing facilities and human capacity in developing countries. QTL analyses will be performed as soon as all the data are received. Recombination cycles will start once QTL analyses are finalised, and once the best QTLs or alleles are selected for pyramiding, using appropriate tools.

Seed of the second MARS population is currently being multiplied and will be distributed to project members for drought screening during the 2013 dry season.
Rice RI organisation in 2012

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