Participatory breeding of upland rice in Nicaragua: matching the needs of small rice producers

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Introduction

In Nicaragua, upland rice, otherwise known as aerobic rice, is an important food and cash crop. The total area of upland rice reaches about 55,000 ha, which represents 66% of the total rice area [1]. Upland rice is grown under diverse agro-climatic conditions and cropping systems [2], which are well representative of the upland rice production of the Central America region. The lack of modern, well-adapted and high-performing varieties with good grain quality is a common constraint, particularly for less favourable upland conditions and low-inputs CS, where farmers still use old varieties developed in the 50s. Other main constraints are the deficient weed control, drought stress in some areas of the Pacific plains, acid soils and low solar radiation in the Caribbean regions, pest and diseases constraints, particularly blast and gramine disorder clonalization.

In this context, CIAT and CIRAD have implemented since 2002 a collaborative research project on participatory breeding of upland rice addressed to small and medium-scale farmers. The specific objectives of this project are:

- To develop and apply new Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB) methods, including synthetic populations development and enhancement by recurrent selection.
- To identify and develop new germplasm matching the needs of the target farmers.
- To enhance the partners’ capacities on the participatory breeding methods.

Materials and Methods

Germplasm sources

The introduction and evaluation in Nicaragua of exotic genetic resources from CIAT and CIRAD as well as the local development of new germplasm lines and site-specific synthetic populations using a male-sterile gene form the core of the participatory breeding project.

Research sites

Three broad activities were implemented in five areas of upland rice production in Nicaragua representing diverse agro-climatic conditions and cropping systems (CS): mechanized intensified CS in favourable upland of the Chinandega area, manual CS in two semi-arid areas of the region Masaya and low-inputs CS in the favourable upland in the North (Jinotega) and North-East regions (Siuna) (see map).

Partnership framework

The project involves three types of partners: i) Farmers’ groups or organisations ii) NGOs and extension agencies iii) Agriculture research institutions. The “Instituto Nicaragüense de Tecnología Agropecuaria (INTA)” is involved through the Rice Program and the regional research teams.

Breeding strategies and methods

The project has applied the two generally differentiated approaches for participatory and decentralized plant improvement: Participatory Varietal Selection (PVS), i.e. selection among advanced inbred lines or varieties, and Participatory Plant Breeding (PPB), i.e. plant selection and lines development from segregating populations.

Implemented at first, the PVS strategy aimed to valorise the rice germplasm most recently selected and lines development from segregating populations. Implemented at first, the PVS strategy aimed to valorise the rice germplasm most recently selected and lines development from segregating populations.

The introduction and evaluation in Nicaragua of exotic genetic resources from CIAT and CIRAD represents a great diversity of phenotype and genetic background.

In the Siuna area, about 275 progenies were selected in 2007 from the single crosses PCT-9/18/Raizora Amarillo and PCT-18/Criolla, and from the PCT-11 and PCTNic-3 populations using a male-sterile gene form the core of the participatory breeding project. In the Siuna area, about 275 progenies were selected in 2007 from the single crosses PCT-9/18/Raizora Amarillo and PCT-18/Criolla, and from the PCT-11 and PCTNic-3 populations using a male-sterile gene form the core of the participatory breeding project.

The PVS strategy was started in 2003 and was implemented using broad-based and site-specific synthetic populations as source of genetic diversity and the pedigree method for lines development [2]. The two strategies applied three main common principles: definition and application of the farmers’ selection criteria for lines evaluation and plant selection, collegial research planning and decision-making and permanent feed-back of the research results from scientists to research farmers and other partners.

Results and Discussion

1. Participatory Variety Selection

- Mechanized cropping systems in favourable conditions (medium-scale farmers)

For this target CS, the promising lines CT 15679-17-1-1-4 and CT 15679-17-1-2-3-5, selected through a mixed conventional-PVS approach, and PORG 1-38, selected with a PVS strategy, were validated in 2007 in comparison with the commercial variety INTA Caracolito. CT 15679-17-1-1-4 and CT 15679-17-1-2-3-5 surpassed CT 15679-17-1-2-3-5 in yield (4.8 t/ha) and PORG 1-38 in yield (4.6 t/ha). Moreover, the latter line presents the best industrial grain quality. The INTA partner has decided to release the CT 15679-17-1-1-4-1-4 line for presenting high yield potential in both favorable upland and irrigated conditions, high level of resistance to main diseases (blast, sheath blight and others) and a good grain quality.

- Low inputs cropping systems in climatic favourable conditions

In the North-Jinotega region, the two CIAT varietals, IRAT 364 and IRAT 366, identified as the most promising cultivars for the local manual CS, based on the agronomic results at on-farm level and the farmers assessment for agronomic and post-harvest traits including grain quality (Table 1), are now in the final steps of registration and formal release. During the 2007 season, the Serviteca institution carried out a very successful field day for presenting the two varietals to local authorities and farmers (Photo 3).

In both the Jinotega and Siuna regions, the best two lines tested since 2004, CT 15944-10-4-3-3 and CIRAD 401, were evaluated during the 2007 season in a first cycle of on-farm validation trials (Table 2). These trials confirmed the high performance and farmer appraisal for these low inputs CS of the CT 15944-10-4-3-3 line, derived from a jatipecia/glaubereria cross (BC2 Caspao/UC 103344). After a second cycle of validations trials to be achieved during the 2008 season, this line could be the first variety with a glaubereria background to be released in Latin America.

Table 1: Agronomic results of the two rice varietals mostly tested in the CIAT-CIRAD participatory rice breeding project conducted in Nicaragua from 2001 to 2007. The numbers in brackets indicate the number of trials per variety.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Tropicoa 14 Farming</th>
<th>Plant height (cm)</th>
<th>Grain yield (t/ha)</th>
<th>Average score of farmers’ assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRAT 364</td>
<td>85 155 3.01 2.9</td>
<td>75 135 3.2</td>
<td>77 125 2.74 3.5</td>
<td></td>
</tr>
<tr>
<td>IRAT 366</td>
<td>75 145 3.18 3.0</td>
<td>95 145 3.2 3.5</td>
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</table>

2. Development of new lines through Participatory Plant Breeding

For the Chinandega area, in a preliminary evaluation for yield over other agronomic traits of 28 of the best 5, progenies derived from PCT-4, PCT-11 and PCT-18 populations, six achieved higher yield than the best commercial variety INTA N-1; among them, there also showed high farmers’ acceptance (Table 2). Other promising progenitors from the site-specific populations PCTNic-1 and PCTNic-2 are in phase of development.

In the Siuna area, about 275 progenies were selected in 2007 from the single crosses PCT-18/Rainier Amarillo and PCT-18/Crida, and from the PCT-11 and PCTNic-3 populations. The progenitors from the PCTNic-3 population present excellent plant types (adequate plant height, strong stems, good tillering and long panicles) for these manual low inputs CS.

Table 2: Data on breeding, plant height, grain yield and farmers’ appreciation of the most promising lines of participatory breeding programme carried out in Nicaragua, 2005-2007.

<table>
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<tr>
<th>Variety</th>
<th>Tropicoa 14 Farming</th>
<th>Plant height (cm)</th>
<th>Grain yield (t/ha)</th>
<th>Average score of farmers’ assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTA 1</td>
<td>98 145 3.18 3.0</td>
<td>75 135 3.2</td>
<td>77 125 2.74 3.5</td>
<td></td>
</tr>
<tr>
<td>INTA 2</td>
<td>95 145 3.2 3.5</td>
<td>95 145 3.2</td>
<td>75 135 3.2</td>
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</tr>
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</table>

Conclusions

The diversified new rice germplasm from CIAT and CIRAD associated with participatory breeding approaches succeeded in improving and diversifying rice varieties for the upland cropping systems of Nicaragua and Central America. The PVS strategy permitted to identify fairly fast better-performing lines for matching the needs of existing upland CS (manual as well as mechanized systems) and for giving new variety options to avoid drought constraints. Among these lines, IRAT 364-Klinik and IRAT 366-FLORA for the manual low inputs CS of the North and North-East regions, CT 15679-17-1-1-4-1-4 for the mechanized CS in favourable upland conditions and the very early line WAB 758-1-1-1HB-4 will be officially released in Nicaragua in 2008. Other new lines developed through a decentralized PVS strategy also gave very promising results for the future.

References


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