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 (CS), 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 grain discoloration complex.

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 were:
- 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' capacity 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

The research 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 Pacific plains (Masaya-Carazo and Rivas) and low inputs CS in 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 Nicaraguense 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 developed by CIAT and CIRAD, representing a great diversity of phenotype and genetic backgrounds. The *in situ* PPB 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.


Participatory evaluation of advanced lines at Posoltega, Chinandega


Participatory plant selection in segregating progenies at Siuna

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 POBL 1-38, selected with a PVS strategy, were validated in 2007 in comparison with the commercial variety INTA Chinandega. CT 15679-17-1-1-1-4-M obtained the highest yields (5.1 t/ha), surpassing CT 15679-17-1-2-3-5-M (4.8 t/ha) and POBL 1-38 (4.6 t/ha); moreover the latter line presents the best industrial grain quality. The INTA partner has decided to release the CT 15679-17-1-1-1-4-M 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-East Jinotega region, the two CIRAD varieties, 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)[3], 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 varieties 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. 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 japonica/glaberrima cross (BC2 Caiapo/GC 103544). After a second cycle of validations trials to be achieved during the 2008 season, this line could be the first variety with a glaberrima background to be released in Latin America.

Table 1: Agronomic results of the two varieties most praised by farmers in 11 on-farm validation trials in manual cropping systems, Jinotega department, Nicaragua, 2005-2006.

Variety	Days to flowering	Plant height (cm)	Grain yield (t/ha)	Average score of farmers' assessment [1]
IRAT 364	85	140	3.01	3.2
IRAT 366	77	125	2.74	3.5
Local check	98	148	2.19	1.9

1 Farmers' assessment of the variety concerning the five most important plant traits using a 1-4 evaluation scale where: 1 = bad, 2 = acceptable, 3 = good and 4 = excellent


Photo 3: Field day of presentation of two upland varieties IRAT 364-Kilambé and IRAT 366-Flora soon released for manual cropping-systems (c Serviteca)

- **Low inputs cropping systems in areas with drought problems**
  In some less favourable areas of the Pacific plains of Nicaragua, very early materials (90 days or less to maturity) are particularly interesting because they can achieve their growing cycle only during the "primera" (May-July) or the "postrera" (mid-August to end of November) rainy seasons and thus can escape the drought stress due to the "canícula" intermediate dry season (mid-July to mid-August), compared with the current medium-cycle varieties planted in June.
  In 2007, the best two lines of the previous PVS phases [3], PCT-4\SA\1\1>1479-M-1-M-1 and WAB758-1-1-HB-4, were included in their last year of validation trials. On the average of 13 environments, WAB 758-1-1-HB-4 was the best-yielding and the earliest line (average yield of 2.7 t/ha and 61 days to flowering). For the small farmers in the marginal rice areas, the adoption of these very early varieties will permit a more secure production in a shorter time, thus contributing to food security. WAB 758-1-1-HB-4 will be release by INTA in June 2008.

2. Development of new lines through Participatory Plant Breeding

For the Chinandega area, in a preliminary evaluation for yield and other agronomic traits of 28 of the best S_4 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, three also showed high farmers' acceptance (Table 2). Other promising progenies 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/Raizora Amarillo and PCT-18/Criolla, and from the PCT-11 and PCTNic-3 populations. The progenies 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: Days to flowering, plant height, grain yield and farmers' appreciation of the most promising lines developed through PPB approach for the mechanized cropping systems in favourable upland conditions, Posoltega, Chinandega 2007

Line	Days to flowering	Plant height (cm)	Grain Yield (t/ha)	Index of overall farmers' assessment [1]	Frequency of farmers selection (%)
PCT-18>SG4-1G-2F-M	72	95	5.09	3.0	75
PCT-4>LM8-2P-2F-M	72	90	4.85	ne	ne
PCT-4>SG9-1G-29-M	83	99	4.36	3.5	100
PCT-4>BE8-1P-2F-M	72	110	4.36	ne	ne
PCT-18>SG5-1G-2F-M	83	110	4.31	ne	ne
PCT-4>LM4-2G-2F-M	79	84	4.30	3.0	50
INTA N-1 (Commercial variety)	75	102	3.87	2.8	31
INTA Chinandega (Commercial variety)	75	91	3.64	3.0	50

CIAT

1 Farmers' assessment of the variety concerning the five most important plant traits using a 1-4 evaluation scale where: 1 = bad, 2 = acceptable, 3 = good and 4 = excellent; ne: not evaluated because early harvested

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-Kilambé and IRAT 366-FLORA for the manual low inputs CS of the North and North-East regions, CT 15679-17-1-1-1-4 for the mechanized CS in favourable upland conditions and the very early line WAB 758-1-1-HB-4 will be officially released in Nicaragua in 2008. Other new lines developed through a decentralized PPB strategy also gave very promising results for the future.

References

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