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(Activity 2). Composite population breeding

I. Upland savannas ecosystem

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Abstract

Since 1996, following CIAT's recommendations, CIAT and CIAT/CIRAD projects have phased out *"Japonica" Oryza sativa* by *"Japonica" Oryza sativa* conventional crossbreeding activities and concentrate on broadening the genetic base of upland rice.
The development of rice populations with broad genetic base and their enhancement through recurrent selection are new breeding strategies to achieve this objective.
Using a recessive male-sterile gene (ms) from a mutant of IR36, the development of rice population was eased. Site-specific populations were developed with NARS.
In Colombia upland basic populations were enhanced using two recurrent selection-breeding methods. At each enhancement cycle, fertile plants are selected. They are the starting-point of segregating progenies therefor selected by conventional pedigree method.
In 2001, more than 90% of the lines under evaluation and selection come from recurrent populations.
The most advanced lines are evaluated in yield trials in Colombia where very promising results are coming-out

Key words: Rice populations, genetic base, male-sterile gene, enhancement, recurrent selection, promising lines.

Highlights

- 291 segregating Upland lines evaluated
- 3 promising Upland lines identified
- First International Upland workshop in Colombia
- 3 Upland populations enhanced for total leaf blast and hoja blanca by 3 cycles of recurrent selection
- Starting the third cycle of recurrent selection of population PCT-4 for acid soil tolerance
- Registration of site-specific composite populations (China and CIAT/CIRAD)

List of cooperators

- **Latin America and the Caribbean**

Argentina
- Marta Nicosia, University of Tucumán
- Alberto Villegas, University of Tucumán

Bolivia
- Roger Taboada, CIAT Santa Cruz de la Sierra
- Jorge René Guzmán, CIAT Santa Cruz de la Sierra

Brazil
- Elcio Perpetuo Guimarães, Embrapa, Rice and Beans Center

Colombia
- Hernando Delgado, Corpoica Regional 8

Cuba
- René Pérez Polanco, Instituto de Investigaciones del Arroz (IIA)
- Rubén Alfonso, Instituto de Investigaciones del Arroz (IIA)

Venezuela
- Carlos Gamboa, DANAC Foundation
- Ramiro de la Cruz, DANAC Foundation
- Eduardo Graterol, DANAC Foundation (currently in the U.S)
- Gelis Torrealba, Instituto Nacional de Investigacion Agricola (INIA former Fonaiap)

➢ **Africa**
- Through CIRAD – France –
- Monty Jones, WARDA – Cote d'Ivoire –

➢ **Asia**

IRRI – The Philippines –
- Peter Kerridge, CIAT Asian Office

China
- Tao Dayun, Food Crop Research Institute of the Yunnan Academy of Agricultural Sciences (FCRI / YAAS – Yunnan Province)
- Lee Kai Mian, Chinese Academy of Tropical Agricultural Sciences (CATAS – Hainan Province)

1. Introduction

Conventional upland rice cross breeding have permitted the release of enhanced lines in different Latin American countries, as well as in Asia.

But, the released lines have a narrow genetic base and there is a need for broadening it, using new breeding strategies.

Since 1996, following CIAT's recommendations, the CIAT and CIAT/CIRAD projects are phasing out *"Japonica" Oryza sativa* by *"Japonica" Oryza sativa* conventional cross breeding activities and concentrate on broadening the genetic base of upland rice.

The development and the enhancement of populations with broad genetic base are new breeding strategies to achieve this objective.

By using a recessive male-sterile gene (ms) from a mutant of IR36, rice population development was eased.

Basic populations were enhanced using two recurrent selection-breeding methods.

Form the basic germplasm and at each enhancement cycle, fertile plants are selected and are the starting point for the generation of segregating progenies, then evaluated and selected by conventional pedigree method.

The number of progenies developed from population breeding has steadily increased from 1997 on. In 2001, more than 90% of the lines under evaluation and selection come from recurrent populations.

We shipped basic and enhanced populations, as well as segregating lines to regional Latin American (Bolivia, Brazil, Colombia) and Asian (China) NARS for evaluation and selection.

Site-specific populations are developed with partners.

The most advanced lines are evaluated in yield trials in Colombia where very promising results are coming-out

2. Materials and Method

The upland rice population breeding activities aims at developing, adapting and improving tropical *"Japonica" Oryza sativa* populations.

2.1. Material

The first upland and lowland rice populations were created in the framework of a collaborative project (1984-1991) between Embrapa Rice and Beans Center in Brazil and CIRAD (formerly IRAT).

In 1992, at the beginning of the CIAT/CIRAD rice collaborative project, two upland basic germplasm, CNA-IRAT 5 and CNA-IRAT A were introduced in Colombia. They were characterized and CNA-IRAT A, showed better adaptation to the Colombian Upland Savannas Ecosystem.

Site-specific populations were then created by introduction into CNA-IRAT A of new -targeted variability existing at CIAT. This resulted in the creation of PCT-4.

The population PCT-4 was then used as basic germplasm to develop the population PCT-11.

At the same time, the introduced populations were enhanced for tolerance to blast and *tagosodes orizicolus*.

In the last few years, population improvement by recurrent selection was concentrated on PCT-4 and PCT-11 as well as the development of segregating lines.

2.2. Methods

Population breeding by recurrent selection is very efficient for traits improvement showing low heritability. Through short selection-recombination cycles, linkage blocks are break down and favorable genes are accumulated. This is a smooth process of continuous improvement. Numerous examples of the efficiency of the method are reported in the literature for open-pollination crops like Maize.

Carrying a recessive male-sterile gene, rice populations behave partly as an open-pollination crop. At flowering, the pollen produced by fertile plants is at the same time auto pollinating the fertile plant by witch is was produced (selfing) but also fertilizes the neighbors' male-sterile plants showing same flowering time (cross-pollinating).

At each cycle of population improvement, fertile plants are selected for developing segregating lines

2.2.1. Sowing rice populations

Rice populations are highly segregating for numerous traits and are made of fertile (Msms) and male-sterile plants (msms) allowing natural cross-pollination. Planting is made in individual hill plots facilitating the identification of male-sterile plants where recombination occurs. To allow complete recombination between early and late flowering material, two to three sowing dates are made in the same physical plot.

To avoid pollen contamination from other rice plots, each population is fenced by Maize rows.

2.2.2. Recombining and multiplying populations

Grains produced by male-sterile plants are Msms and msms (pollen produced by fertile plants are ms or Ms and female organs of male-sterile plants are ms).

Harvesting the male-sterile plants represents a new cycle of recombination as well as seed multiplication of the population.

2.2.3. Selecting fertile plant for line development

The selection of S0 fertile plants (Msms) is the starting point for segregating line development.

Each selected fertile plant is individually harvested and its seeds sown the next season (S1 generation). Seeds harvested on fertile plants are Msms, MsMs and msms and the S1generation will show segregation of fertile (Msms and MsMs) or male-sterile (msms) plants in the proportion ¾ and ¼ respectively.

Through out the selection process, selecting and harvesting only fertile plants allows elimination of the male-sterile gene. Advanced progenies are 100% fertile (MsMs).

Line development follows traditional evaluation and pedigree selection.

The major characteristics bred for savanna conditions are early vigor, tolerance of soil acidity, resistance to rice blast (*Pyricularia grisea* Sacc.) and rice plant-hopper (*Tagosodes orizicolus*), good grain quality (translucent, long-slender grain) and early maturity (total cycle about 115 days).

2.2.4. Yield trials

Promising lines from different breeding populations were selected during the last years. Some of them were evaluated in preliminary experimental trials in Colombia, at “La Libertad” and “Matazul” Experimental Stations (LES and MES respectively).

Land preparation was by a cross pass of chisel plough.

Fertilization was of 300kg/ha of dolomite lime applied 30days before sawing and 178 Kg/ha of Nitrogen (59 Kg/ha at 20, 35 and 45 days after sawing respectively), 155 Kg/ha of Phosphorus at sawing, and 116 Kg/ha of Potassium (58 Kg/ha at sawing and 29 Kg/ha at 20 and 35 days after sawing respectively). No chemical control was used for pest and disease.

The experimental design was of complete random blocks, with 3 replications and individual plots of 5,2 m^2 (4 lines of 5 m long and spaced by 0,26 m.) Agronomic characteristics were recorded and individual plots of 4,16 m^2 harvested for grain yield evaluation.

2.2.5. Improving rice populations by recurrent selection

Recurrent selection is a cyclic process involving three main steps: plant selection (selection unit), evaluation and recombination (recombination units) of the best performing selection units.

Two recurrent selection methods where used (i) mass recurrent selection and (ii) S_2 progenies evaluation. For the last method, fertile plants were selected and harvested in the population(s) during the cropping season 2000A, and S_1 generation advanced during off-season at “Palmira” Experimental Station (PES). S_2 seed harvested at PES were sown at LES in 2001A and evaluated compare to local checks, using the Augmented blocks design proposed by Federer. Each individual S_2 progeny was made of 2 rows of 5 m long

3. Results and discussion

The results reported here were conducted off-season 2000 (2000B, October 2000 - March 2001) at PES - CIAT Palmira – Valle, and during the upland rice- cropping season 2001 (2001A, April - September 2001) at PES and MES - Villavicencio – Meta.

3.1. Line development from recurrent populations

During the enhancement of populations through recurrent selection, fertile plants are selected. These genotypes are the starting point for the development of promising fixed lines for variety release and/or potential parents for our regional partners (Argentina, Bolivia, Brazil, Colombia, Cuba, Venezuela and the Caribbean through CRID Net).

During the cropping season at LES, a total of //////// segregating and advanced lines were evaluated and selected. They come from different populations in different stages of enhancement and are presented in the table 1.

Table 1. List of segregating and fixed lines evaluated and selected ( ) . LES, cropping season 2001A.

Population	Generation				
	S_1	S_3	S_4	S_6	S_8
PCT 4\SA\4\1	21 (15)				
PCT-4\0\0\2 PCT-4\SA\2\1 PCT-4\SA\4\1		114 (23)			
PCT-4 \0\0\0			44 (7)		
PCT-11\0\0\1				2 (2)	
PCT-4\SA\1\1 PCT-4\0\0\1 PCT-A\0\0\0 PCT-4\0\0\1\S3 PCT4\PHB\1\1, PHB\1					110 (178)

3.2. Line selection by LAC NARS breeders

The CIAT/CIRAD project jointly with Embrapa-Brazil organized the First International Upland Rice Workshop, in Villavicencio-Meta, Colombia in August 2000, aiming at:

- Promoting the integration of the upland rice breeders of the region.
- Sharing experiences in the management of breeding populations and the development of fixed lines.
- Selecting at field condition segregating and fixed lines to be introduced in each respective country (much better than only shipping-out lines).
- Training breeders that are starting using recurrent selection (Argentina and new partners in Colombia - University of Tolima and CENICAFE -).
- Having the concept from the group about the outputs and results of the CIAT/CIRAD project.
- Knowing in a near future (next year) the behavior and adaptation of the selected lines in each country.

Breeders from six countries attended the workshop (Table2.)

Table 2. List of participants, Countries and Institutions represented

Name	Country	Institution
Marta Nicosia	Argentina	FAZ, Univ. Nacional de Tucumán
Roger Taboada	Bolivia	CIAT/Santa Cruz
Juana Viruez	Bolivia	CIAT/Santa Cruz
René Guzmán	Bolivia	CIAT/Santa Cruz
Elcio Guimarães	Brazil	Embrapa Arroz e Feijão
Sebastião Honorato	Brazil	Embrapa Arroz e Feijão
Javier F. Osorio	Colombia	Univ. del Tolima
Hernando Delgado	Colombia	CORPOICA
Marc-Henri Châtel	Colombia	CIAT/CIRAD
Yolima Ospina	Colombia	CIAT/CIRAD
Argemiro Moreno	Colombia	CENICAFE
Ruben Alfonso	Cuba	IIA
Gelis Torrealba	Venezuela	FONAIAP

Depending on breeders, between 8 and 21% of the total number of lines was selected (Table 3.) Colombia, Brazil and Bolivia selected a greater number of lines. The main characteristics of the selected lines are earliness, modern plant type, long slender grains (of special importance for Brazil), tolerance to rice blast and potential promising yield.

Table 3. Results of the selection of upland lines. LES, Villavicencio-Meta, Colombia. August 7-11, 2000.

Generation	Lines	Number of selected lines and %					
		Bolivia	Brazil	Colombia	Cuba	Venezuela	Argentina *
S_1	229	14 6 %	10 4.4%	14 6,1%	14 6,1%	5 2,2%	14 6,1%
		Average: 11,8 lines		Selection Intensity: 5,1%			
S_2	237	0	8 3,4%	15 6,3%	0	14 5,9%	0
		Average: 6,2 lines		Selection Intensity: 2,6%			
S_4	7	0	1 14,3%	3 43%	0	2 28,6%	0
		Average: 1 line		Selection Intensity: 14%			
S_6	289	61 21,1%	52 18%	133 46%	47 16,2%	33 11,4%	61 21,1%
		Average: 64,5 lines		Selection Intensity: 22%			
S_7	78	4 5,1%	20 25,6%	15 19,2%	3 3,4%	8 10,3%	4 5,1%
			Average: 9 lines	(11,5%)			
S_9	307	41 13,3%	66 21,5%	56 18,2%	38 12,3%	30 9,8%	41 13,3%

	Average: 45,3 lines		Selection Intensity: 14,8%			
Total 1147	120 10,5%	157 13,7%	236 20,6%	102 8,8%	92 8%	120 10,5%
	Average: 137,8 lines		Selection Intensity: 12%			

* Lines selected by Argentina are the same as those selected by Bolivia. Bolivians breeders trained the Argentinean who was starting working with upland rice.

The selected lines were harvested and the seeds shipped to each respective country's breeders.

A set of 147 lines was also prepared and shipped to Bolivia to be grown as core nursery demonstration plot, during the next year upland rice breeders' workshop to be held in Santa Cruz de la Sierra.
These lines show different phenotypes, like plant height, tillering ability, cycle duration, grain shape and yield potential and are representative of the variability found in segregating progenies coming from rice population breeding.

3.3. Yield Trials
Advanced generations are promising fixed lines that passed through all agronomic selection process. Selection of the best yielding lines also showing excellent grain quality was made at LES and PES during 1999A and B semesters respectively.
During the cropping season 2000A, a yield trial was set-up at LES. It was repeated during 2001A at LES and MES (Colombian savannas). Twenty-four (24) best promising lines were compared to 3 checks coming from conventional breeding (Oryzica Sabana 6, released in 1992; Oryzica Sabana 10, released in 1994, and "Línea 30" -CIRAD 409- not yet officially released.)

3.3.1. Cropping season 2000A at LES
Twenty-four advanced lines (S_4 generation) from the first cycle of enhancement of population PCT-4 (PCT-4\SA\1\1 nomenclature means one selection for "Suelos Acidos" -Acid Soils-, followed by one recombination) and 3 checks were evaluated. Results are presented in table 4.
Grain yield ranked between 1240 and 3644 Kg/ha.
Twenty-one (21) lines yielded more than Oryzica Sabana 10 (1240 kg/ha), three (3) more than Orizica Sabana 6(2140 Kg/ha) and one (1) more than "Línea 30"-CIRAD409-, (3332 Kg/ha).
Three very promising lines were identified (table 5). They are high yielding, and 10 to 18 days earlier than the medium-cycle checks Oryzica Sabana 6, and Oryzica Sabana 10. This means that it is possible to break down the correlation between earliness and poor yielding potential.

PCT-4\SA\1\1>975-M-2-M-3, is yielding 56%, 70% and 194% more than "Línea 30"-CIRAD409-, Oryzica Sabana 6, and Oryzica Sabana 10, respectively.
PCT-4\SA\1\1>1044-M-3-M-4 and PCT-4\SA\1\1>975-M-3-M-3, yields as much as "Línea 30"-CIRAD 409-, but 57% and 171% more than Oryzica Sabana 6 and Oryzica Sabana 10, respectively.

Table 4. Yield trial 2000A. LES, Villavicencio-Meta, Colombia

Line from population * PCT-4\SA\1\1	Yield (Kg/ha)	Ranking	Days to Flowering
PCT-4\SA\1\1 >975-M-2-M-3	3644	A	71
PCT-4\SA\1\1 >1044-M-3-M-4	3379	AB	74
PCT-4\SA\1\1 >975-M-3-M-3	3367	AB	74
PCT-4\SA\1\1 >975-M-3-M-4	3321	ABC	76
PCT-4\SA\1\1 >982-M-3-M-5	3277	ABC	69
PCT-4\SA\1\1 >975-M-2-M-2	3275	ABC	74
PCT-4\SA\1\1 >1479-M-1-M-6	3265	ABC	71
PCT-4\SA\1\1 >1479-M-1-M-1	3239	ABCD	78
PCT-4\SA\1\1 >975-M-3-M-2	3115	ABCD	71
PCT-4\SA\1\1 >516-M-6-M-3	3095	ABCD	80
PCT-4\SA\1\1 >1479-M-1-M-3	3028	ABCD	72
PCT-4\SA\1\1 >1479-M-1-M-5	3016	ABCD	74
PCT-4\SA\1\1 >1044-M-3-M-2	3003	ABCD	73
PCT-4\SA\1\1 >975-M-2-M-1	2947	ABCDE	71
PCT-4\SA\1\1 >1036-M-6-M-2	2868	ABCDE	71
PCT-4\SA\1\1 >1479-M-1-M-2	2832	ABCDE	67
PCT-4\SA\1\1 >540-M-3-M-5	2781	ABCDE	69
PCT-4\SA\1\1 >982-M-3-M-4	2771	ABCDE	71
PCT-4\SA\1\1 >1837-M-2-M-3	2352	BCDE	75
“Línea 30” - CIRAD409	2332	BCDE	71
PCT-4\SA\1\1 >1260-M-6-M-6	2313	BCDE	75
PCT-4\SA\1\1 >1837-M-2-M-2	2273	BCDE	79
PCT-4\SA\1\1 >540-M-3-M-3	2243	CDEF	81
PCT-4\SA\1\1 >1576-M-4-M-1	2237	CDEF	79
Oryzica Sabana 6	2140	CDEF	83
PCT-4\SA\1\1 >540-M-3-M-4	1878	EF	81
Oryzica Sabana 10	1240	F	89

* PCT-4\SA\1\1 nomenclature means one selection for “Suelos Acidos” (Acid soils) followed by one recombination corresponding to one cycle of recurrent selection.

Table 5. Best-yielding lines. Yield trial 2000A. LES, Villavicencio-Meta, Colombia

Outstanding Line	Yield (Kg/ha)	Ranking	Days to Flowering
PCT-4\SA\1\1 >975-M-2-M-3	3644	A	71
PCT-4\SA\1\1 >1044-M-3-M-4	3379	AB	74
PCT-4\SA\1\1 >975-M-3-M-3	3367	AB	74
"Línea 30" - CIRAD409-	2332	BCDE	71
Oryzica Sabana 6	2140	CDEF	83
Oryzica Sabana 10	1240	F	89

3.3.2. Cropping season 2001 at LES and MES

To confirm the results from last year, the same yield trial was repeated in two different sites. Results are not yet available.

3.4. Population Improvement

Population enhancement was made through recurrent selection. Two different methods were used. Mass recurrent selection on both sexes for resistance to total rice leaf blast and Hoja Blanca virus and selection of S2 lines for main agronomic traits.

3.4.1. Mass recurrent selection on both sexes for Hoja Blanca Virus, rice blast, and major agronomic traits

Populations PCT-4, PCT-A and PCT-5 were submitted to 3 cycles of mass recurrent selection.

At vegetative stage, plants showing susceptibility to leaf blast and Hoja Blanca Virus were eliminated (without knowing if they were male-sterile or fertile because identification can only be made at flowering time).

At harvesting time, male-sterile plants showing good agronomic traits were selected. Seeds produced by these healthy male-sterile plants were the result of fertilization by pollen produced by neighbor healthy fertile plants.

Total resistance to leaf blast (Table 6).

Original populations presented about 40% of susceptible plant.

From the first cycle of selection on, a drastic reduction in the number of infected plants occurs.

Table 6. Total leaf blast resistance of the enhancement populations PCT-5, PCT-A and PCT-4. PES 1999B.

Cycles of mass recurrent selection	Year of evaluation	PCT-5	PCT-A	PCT-4
Basic Population	1995	47.8 *	35.3	42.7
First cycle	1996	1.5	1.0	0.5
Second cycle	1997	3.7	3.3	4.5
Third cycle	1998	0.3	0.2	0.1

* % of plants with leaf blast symptoms

Resistance to rice “hoja blanca” virus (Table 7).
After 3 cycles of mass recurrent selection, 107 S_2 lines from the 3 populations were evaluated in 1999 at PES, for Hoja Blanca virus resistance.
The result of the S_2 evaluation of the enhanced populations showed that 97.2% have resistant to intermediate reaction to rice “Hoja Blanca”.

Table 7. Resistance to rice “hoja blanca” of the enhancement populations PCT-5, PCT-A and PCT-4.

	Reaction to rice Hoja Blanca Virus (1-9 scale)		
	Resistant (1-3)	**Intermediate (5)**	**Susceptible (7-9)**
S_2 lines of enhanced populations	54.2*	42.9	2.8
FEDEARROZ Lines	59.1	30.6	10.2
ICA Lines	51.4	4.0	44.4
IRRI Lines	5.6	4.6	89.7
Colombia 1 (R check)**	90.3	9.7	0.0
Blue Bonnet (S check)**	0.0	3.8	96.2
CICA 8 (I check)**	0.0	86.4	13.6

* % of evaluated lines
** R, S and I: Resistant, Susceptible and Intermediate

The enhanced populations are considered good reservoirs of genotypes for the development of resistant fixed lines.
During the cropping season 2001A, the 3 enhanced populations were cropped at LES, and S_0 fertile plants selected for line development.

3.4.2. Recurrent Selection Based on S_2 Line Evaluation

Population PCT-4\SA\3\1
After the first selection cycle for acid soil (SA), population PCT-4 was recombined 3 times (\3\). The resulting population was grown at LES during 2000 A, and S_0 fertile plants selected. Generation S_1 was grown and evaluated at LES during the cropping season 2001 A.
Population PCT-4\SA\1\1, SA\1
Population PCT-4\SA\1\1 with one cycle of recurrence (SA\1) was submitted to a second cycle of recurrent selection. The resulting enhanced population (PCT-4\SA\1\1,SA\1) was grown during the year 2000 at LES. A third cycle of recurrent selection started through the selection of S_0 fertile plants. Generation S_1 was grown at PES during off-season 2000B and the S_2 evaluated during 2001 A at LES.

3.4.3. Genetic Progress Evaluation through Recurrent Selection process. Study case of Population PCT-4

Master Degree Thesis of Yolima Ospina assistant to the CIAT/CIRAD project.

Evaluation of genetic progress for acid soil tolerance and main agronomic traits (flowering time, plant height and grain yield components), after one selection cycle and different recombination cycles.
Method
Evaluation: S_1 lines in two contrasted plots for soil acidity.
Statistical design: Augmented Federer blocks composed by S_1 lines from 4 populations and 6 checks (3 susceptible - CICA 8, CICA 9 y Oryzica Llanos 5 - and 3 tolerant - Oryzica Sabana 6, Oryzica Sabana 10 and CIRAD 409 - to soil acidity).
Data were collected and are currently processed.

4. Registering new site-specific upland composite populations

Since 1993 and following a recommendation of the First International Upland Rice Breeders Workshop held in Montpellier – France, the CIAT/CIRAD Rice Collaborative Project is in charge of managing a registration catalogue were rice populations are described, including genetic constitution and process of creation. Each rice breeder involved in population breeding can apply for registering the population he develops. The catalogue is annually issued and circulated.
In 2001, new site–specific populations were registered, on request from two breeders.
Dr. Tao Dayun from FCRI/YAAS, Province of Yunnan - China, who applies for the registration of a *Japonica* population showing restoring ability and good grain quality. The germplasm was registered as PYN-3 and was developed from the CIAT/CIRAD population PCT-5.
Dr. Michel Valès from CIAT/CIRAD rice project, Cali-Colombia, who applies for the registration of recurrent populations with narrow genetic base.

5. Upland Line Registration

CIRAD has a mechanism by which breeders can register specific material not necessarily release as variety. It receives a consecutive CIRAD catalogue number and the corresponding local identification where it was bred. In 2001 we applied for the registration of the upland savanna line PCT-4\SA\1\1 >975-M-2-M-3 that performed very well in the 2000 LES yield trial.

6. Upland population Breeding by LAC NARS

Population breeding activities directly conducted by NARS and monitored by the CIAT/CIRAD project can be found in the book untitled Advances in Rice Population Breeding (Avances en el Mejoramiento Poblacional en Arroz), published in 2000 by CIAT/CIRAD (Colombia), Embrapa (Brazil) and DANAC Foundation (Venezuela).
Brazil, Bolivia, Colombia, China, Cuba and El Salvador are reporting research activities on upland population breeding.

7. Conclusion

Populations with broad genetic base were developed and enhanced.
By using mass recurrent selection, 3 populations were enhanced for total leaf blast and Hoja Blanca virus resistance. They are good reservoirs of potentially good genotypes for line development. Selection of S_0 fertile plants was made. Enhancement of population PCT-4 is going on using S_2 line evaluation, selection and recombination.
During population enhancement, fertile plants were selected and their progenies evaluated and selected by traditional pedigree method.

Three very promising lines were identified. They show high yielding potential, and are as early as “Línea 30”-CIRAD409-, and 10 to 18 days earlier than the medium-cycle checks Oryzica Sabana 6, and Oryzica Sabana 10.
One of them, PCT-4\SA\1\1 >975-M-2-M-3, selected after the first cycle of recurrent selection of population PCT-4, yielded 3644 Kg/ha (56%, 70% and 194% more than “Línea 30”-CIRAD409-, Oryzica Sabana 6, and Oryzica Sabana 10, respectively).
This result means that it is possible to break down the correlation between earliness and poor yielding potential that generally occurs.

8. Future activities
- Following population enhancement, line extraction, evaluation and selection.
- Confirming the behavior of the best identified promising upland lines.

II. Lowland rice ecosystems

Marc Châtel and Yolima Ospina

Abstract

As for upland rice, CIAT and CIAT/CIRAD rice project concentrate on broadening the genetic base of lowland rice.
The development of lowland rice populations with broad genetic base and their enhancement through recurrent selection are new breeding strategies to achieve this objective.
Using a recessive male-sterile gene (ms) from a mutant of IR36, the development of rice population was eased. Basic populations were developed at CIAT and distributed to LAC NARS for evaluation. Site-specific *indica* and *japonica* populations for the tropics and temperate areas respectively (Southern Cone of Latin America) were developed with NARS. They are the starting point of rice recurrent selection projects. Networking activities are made through GRUMEGA network and FLAR.

Key words: Lowland rice, rice populations, genetic base, male-sterile gene, enhancement, site-specific populations, recurrent selection.

Highlights
- Site specific populations developed at CIAT Palmira for Argentina (1) Uruguay (3)
- One site specific population developed by Chile and China
- Registration of composite populations (Argentina, Uruguay, China and CIAT/CIRAD)
- Book publication: Avances en el Mejoramiento Poblacional en Arroz), published in 2000 by CIAT/CIRAD (Colombia), Embrapa (Brazil) and DANAC Foundation (Venezuela)
- Project submitted to FONTAGRO

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- Fernando Pérez de Vida, INIA Treinta y Tres (currently in the U.S)

Chile

- Santiago Hernaiz, INIA Quilamapu-Chillán
- Roberto Alvarado, INIA Quilamapu-Chillán

FLAR

- Luis Sanint

➢ **Asia**

China

- Tao Dayun, Food Crop Research Institute of the Yunnan Academy of Agricultural Sciences (FCRI / YAAS)

➢ **Europe**

- Guy Clement, CIRAD – France –

1. Introduction

Population Breeding for Lowland irrigated rice is made in close collaboration with FLAR partners in Latin America (CIRAD is a member of FLAR) and CIRAD partners in Europe and Asia.

The breeding population project started by introducing to Colombia, different gene pools and populations previously developed in Brazil by CIRAD/Embrapa –Rice and Beans Center, and by CIRAD in French Guyana.

Germplasm was characterized at Palmira Experimental Station, Valle-Colombia (PES). The best-adapted ones were used to develop new populations. This resulted in three *indica* populations that were registered in the recurrent selection catalogue as PCT-6, PCT-7, and PCT-8. This work was conducted at CIAT with Drs. C. Martínez and E. P. Guimarães.

A *japonica* population, developed by CIRAD for temperate areas, was registered as GPIRAT-10.

From late 1996 this basic germplasm was dispatched to our regional partners and outside Latin America. It was the starting point of population breeding activities in different countries.

In 1999 the II International Workshop on Rice Recurrent Selection, held in Goiânia-Brazil, was the occasion for the regional NARS to present updated information on the use of population breeding. A book edited by Dr. Elcio Guimarães was published jointly by CIRAD/CIAT(colombia), Embrapa (Brazil) and the DANAC Foundation (Venezuela).

At the Workshop' final plenary session, it was decided to create a formal group named Rice Advanced Rice Genetic Breeding Group (Grupo de Mejoramiento Genético Avanzado de Arroz – GRUMEGA) coordinated by CIAT/CIRAD and Embrapa Rice and Beans Center.

Activities presented here after were conducted at PES and correspond to special services provided to NARS.

Population breeding activities directly conducted by NARS and monitored by the CIAT/CIRAD project can be found in the book untitled Advances in Rice Population Breeding (Avances en el Mejoramiento Poblacional en Arroz), published in 2000 by CIAT/CIRAD (Colombia), Embrapa (Brazil) and DANAC Foundation (Venezuela).

Argentina, Brazil, Chile, China, Colombia, Cuba, Venezuela and Uruguay, are reporting research activities on lowland rice population breeding.

2. Materials and method

In 1996, populations crated by CIAT/CIRAD were shipped to regional NARS for evaluation and selection. From the best-adapted germplasm new site-specific populations were developed by introduction of local variability. The site-specific populations were registered in the recurrent selection catalogue.

CIAT/CIRAD populations were seed increased at PES to ensure good disposability of fresh seed.

3. Results and discussion

3.1. Developing site-specific composite populations

3.1.1. Argentina

During 2000 and the first semester of 2001, a new population was developed at CIAT by introducing into the population PCT-8, six parents selected by the Argentineans.

The new site-specific population was identified as PARG-3 and shipped to Argentina where it will be grown during the cropping season 2001/2002.

3.1.2. Chile

A new population is being developed in Chile by INIA. It is targeting cold tolerance, grain quality and yield potential. It is identified as PQUI-2.

3.1.3. Uruguay

The Uruguayan breeder dealing with population breeding is currently in the US and his return to Uruguay is planned for next year. Before he leaves Uruguay it was decided to create 3 site-specific populations with the following objectives.

One is for short/medium grain breeding (export market to Asia)

One is for long slender grain and high quality (export market to Middle East)

One is for long term enhancement

The 3 populations were developed at CIAT Palmira and were identified as PURG-1, PURG-2 and PURG-3. They are ready for shipping.

3.1.4. China

The Food Crops Research Institute (FCRI), of the Yunnan Academy of Agricultural Sciences (YAAS), have developed a site-specific *japonica* population both for lowland and upland conditions. The male-sterile source is from the CIAT/CIRAD upland population PCT-5 crossed with 8 lines (2 from China with restoring gene Rf-1, 3 inter-specific lines from WARDA and 3 CIRAD upland lines).

The new site-specific population is identified as PYN-3.

3.1.5. France and Chile

In Europe, scented rice is very praised by consumers and is of high added value for rice producers.

Rice aroma is a very difficult trait to breed by conventional crossbreeding.

It is polygenic and involves major and minor genes. Population breeding is a suitable method to enhance the characteristic.

The development of a new population for temperate areas started during the second semester of 2001.

The new germplasm correspond to a new population by introduction into the Chilean population PQUI-1 (well adapted to temperate climate) of 26 aromatic lines selected by CIRAD-France. At PES, individual crosses were made between each aromatic line and male-sterile plants of the Chilean population.

The new population is to be characterized and enhanced both in France (Camargue rice growing region) and Chile. Exchange of information and breeding material will be made between both breeding projects.

3.1.6. Colombia

Two new composite populations with inter-specific lines developed by Dr. César Martinez from CIAT is under way.

Inter-specific selected lines are crossed with PCT-6 and PARG-3 for tropical and sub-tropical conditions. In relation to existing composite populations they are characterized by new original genetic variability. Enhancement will at first be made in Colombia.

3.2. Maintaining Composite Populations

Because we manage the catalogue for rice germplasm for recurrent selection, we also have the responsibility to ensure presence of sufficient seed in the germplasm bank. During the second semester of 2001, at PES, we started the multiplication of different populations.

3.3. Line development from PCT-6 de salida Vales Santa Rosa 2001

Population PCT-6 was enhanced by Dr. Michel Vales (CIAT/CIRAD project) both for total and partial resistance to rice blast and main agronomic traits. The first cycle of enhancement is considered as a reservoir for fixed line development.

During 2001A, the enhanced population was grown at Santa Rosa Experimental Station under blast pressure and 148 sterile plants were selected for recombination.

3.4. Registering new Populations

In 2001, we registered the site-specific populations from NARS.

Argentina PARG-3

Uruguay PURG 1, PURG-2 and PURG-3

China PYN-3

CIAT/CIRAD (M. Vales)

4. Conclusion

Regional LAC NARS have a strong compromise in population breeding. They are developing site-specific populations and starting rice enhancement projects.

GRUMEGA as a regional network is promoting relations between breeders. A regional research project on rice population breeding involving Argentina, Brazil, Bolivia, Chile and CIAT/CIRAD was presented in June 2001 to Fontagro.

8. Future activities

- Completing the development of new site-specific populations
- Monitoring and networking population breeding activities
- Implementing activities of the FONTAGRO Project activities, if funded

Annex 1.

Publications
Eastern European Rice Genetic Resources for Rice breeding improvement in France. Clement Guy , Chatel Marc , Chantereau Jacques , Feyt Henri , Louvel D , Seguy Jean-Louis and Tharreau Didier

Composite Population Breeding using Recurrent Selection in Chile
Santiago Ignacio Hernaiz L; José Roberto Alvarado-A.; Marc Chatel and Yolima Ospina

To be publish in: Proceedings of the International Rice Symposium on Genetic Resources and Breeding for Europe and Temperate Area. Krasnodar-Russian Federation, 3-8 September 2001.

Training
"Evaluation of genetic progress for acid soil tolerance and different agronomic characteristics"
Master Degree Thesis at the "Universidad Nacional de Palmira".
Yolima Ospina. Assistant of the CIAT/CIRAD project

National breeder's Course. Held in Sancti-Spiritus, Cuba, June 18.

Workshops
First International Upland Rice Workshop. Villavicencio, Meta – Colombia. August 7-11, 2000.
Organized by CIRAD/CIAT-Colombia and Embrapa-Brazil.
Participants
Argentina (Universidad National de Tucumán)
Bolivia (CIAT - Santa Cruz)
Brazil (Embrapa - Arroz e Feijão)
Colombia (CORPOICA, CENICAFE and University of Tolima)
Cuba (IIA)
Venezuela (INIA)

Second International Upland Rice Workshop. To be held in Santa Cruz de la Sierra-Bolivia, in February 2002. Organization during 2001 by CIAT Santa Cruz-Bolivia, the Japanese Cooperation JICA-Bolivia, CIRAD/CIAR-Colombia and Embrapa-Brazil.

I Taller de Selección Recurrente en Arroz de Riego en Venezuela. To be held in October 29-31, 2001. Organization: Fundación DANAC-Venezuela, CIAT/CIRAD and Embrapa

Conference organization
Third Venezuela, International Conferences on Rice Recurrent Selection Breeding October 2003.
Organization: Fundación DANAC-Venezuela, CIAT/CIRAD and Embrapa

Travels
Bolivia
(In company of Dr. Guy Clement, CIRAD-CA, Calim, Montpellier-France)
Visit to CIAT Santa Cruz and field activities. February 26 - March 3, 2001.

Chile
(In company of Dr. Guy Clement, CIRAD-CA, Calim, Montpellier-France)
Visit to INIA Quilamapu, Chillán and field activities. March 5-13 , 2001.

Argentina
(In company of Dr. Guy Clement, CIRAD-CA, Calim, Montpellier-France)
Visit to La Plata and Corrientes Universities and field activities at the Experimental Stations of Concepción del Uruguay and Villaguay. March 12-17, 2001.

Brazil
Attending the REDBIO Conference. June 2-8, 2001

Cuba
(In company of Dr. Pierre Fabre, CIRAD-CA, Calim program leader, Montpellier-France)
Arroz Popular. June 17-23, 2001.

Russia
Attending the International Rice Symposium on Genetic Resources and Breeding for Europe and Temperate Area. Krasnodar-Russian Federation. September 2-9, 2001.

Reports
Achievements of the rice collaborative project between CIRAD-CA and CIAT.
Chatel, M and Ospina, Y. CIO-CIAT Meeting, Palmira-Colombia, CIRAD/CIAT document. June 13-14, 2000.

Activity 2. Population breeding for the savannas ecosystem. In: Population Breeding using gene pools and populations with recessive male-sterile gene, and conventional breeding. Chatel, M and Ospina, Y. Annual report CIAT/CIRAD/FLAR. CIRAD/CIAT document. October 2000.

Activity 3. Population breeding for lowland rice. In: Population Breeding using gene pools and populations with recessive male-sterile gene, and conventional breeding. Chatel, M and Ospina, Y. Annual report CIAT/CIRAD/FLAR. CIRAD/CIAT document. October 2000.

Travel report to Bolivia, Argentina and Chile. April 2001.

Travel report to Brazil. June 2001.

Travel report to Cuba. June 2001.

Libro de resúmenes. Primer taller internacional de selección: Mejoramiento poblacional de arroz de secano. Documento CIAT/CIRAD and Embrapa. Septiembre 2001. 33 p.

Oral presentations
Colombia
CIAT/CIRAD rice collaborative project. CIO/CIAT Meeting, Palmira-Colombia. June 13, 2001.

Brazil
Advanced tools for rice breeding: Composite population breeding using recurrent selection. REDBIO Goiania-Brazil. June 4-8, 2001.

Cuba
Herramientas avanzadas en mejoramiento genético del arroz: Mejoramiento poblacional por selección recurrente. Cuban breeder's workshop. Sancti Spiritus, 18 June 2001.

Russia
Composite Population Breeding using Recurrent Selection in Chile. In: session 4. Objectives and methods for rice breeding in the XXIst century.
International Rice Symposium on Genetic Resources and Breeding for Europe and Temperate Area. Krasnodar-Russian Federation, 3-8 September 2001.

Eastern European Genetic resources in rice breeding improvement in France. In: Session 2. Description, management and availability of rice genetic resources for Mediterranean and other temperate areas.
International Rice Symposium on Genetic Resources and Breeding for Europe and Temperate Area. Krasnodar-Russian Federation, 3-8 September 2001.

Concept notes
In response to the statement of the Plant Breeding Management Panel 2000: Quote: *"We recommend that CIAT strongly support the integration of MAS in the recurrent selection programs for useful genes tagged at CIAT and elsewhere"*
Unquote.
The following concept note was prepared
Monitoring genetic variability and progress in rice population improvement projects through molecular markers
Institutions involved: Embrapa and CIAT/CIRAD
Dr. Elcio P. Guimarães from Embrapa, Rice and Beans Center, spent one month in Montpellier September 15, October 15) for contacts with CIRAD, IRD and Universities. Final proposal of the project is to be presented late 2001.
Funding of the visit of Dr. Elcio Guimarães: French Embassy in Brazil and Embrapa.

Estudio de la cadena productiva del Arroz Popular y el mejoramiento Participativo para atender a este cultivo
Proposal to be submitted by IIA Cuba, CIRAD and CIAT/CIRAD
Funding: French Embassy in Cuba

Project proposal
Alternativa de manejo de germoplasma para romper el techo de rendimiento del arroz en America Latina"
Project proposal sent by Bolivia to FONTAGRO. June 2001.
Countries and institutions involved
-Bolivia (CIAT Santa Cruz)

-Argentina (Univ. La Plata and Corrientes)
-Brazil (Embrapa Arroz e Feijão)
-Chile (INIA)
-Colombia (CIAT/CIRAD)
-Venezuela (Fundación DANAC and INIA)

CIO/CIAT Meeting
Every two years takes place a meeting between CIAT and the 3 French research Institutions CIRAD, IRD (former ORSTOM) and INRA. This is the forum for reviewing on-going and new projects.

The on-going project on Population Breeding was confirmed for two more years.

A new collaborative project on Participatory Rice and Sorghum Breeding between CIRAD and CIAT was approved. CIRAD will outpost a senior breeder, and CIAT will finance the operational funds. Follow-up of the project is to be done previous the end of 2001, for effective starting early 2002.

Visits to the Project
During year 2001, the CIAT/CIRAD project received the following visitors:

Dr. Pierre Fabre, CIRAD-CA, Head of the Food Crops Program (CALIM)
Dr. Guy Clement, CIRAD-CA, CALIM Program
Dr. Elcio Guimarães, Brazil -Embrapa Arroz e Feijão
Dr. Carlos Gamboa, Venezuela - Fundación DANAC
Dr. Javier Osorio, National University of Tolima – Colombia
Dr. Argemiro Moreno, CENICAFE

Annex 2.
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Ospina,Y.; Châtel, M. y Guimarães, E.P. 2000. Mejoramiento poblacional del arroz de sabanas. In: Guimarães, E.P. (ed). Avances en el mejoramiento poblacional en arroz.Embrapa Arroz e Feijao. Santo Antonio de Goias , GO-Brasil. p .241-254.

Avances en el mejoramiento poblacional en arroz. Guimarães, E.P. (ed).2000. CIAT/CIRAD, Embrapa and DANAC Foundation. 311 p.