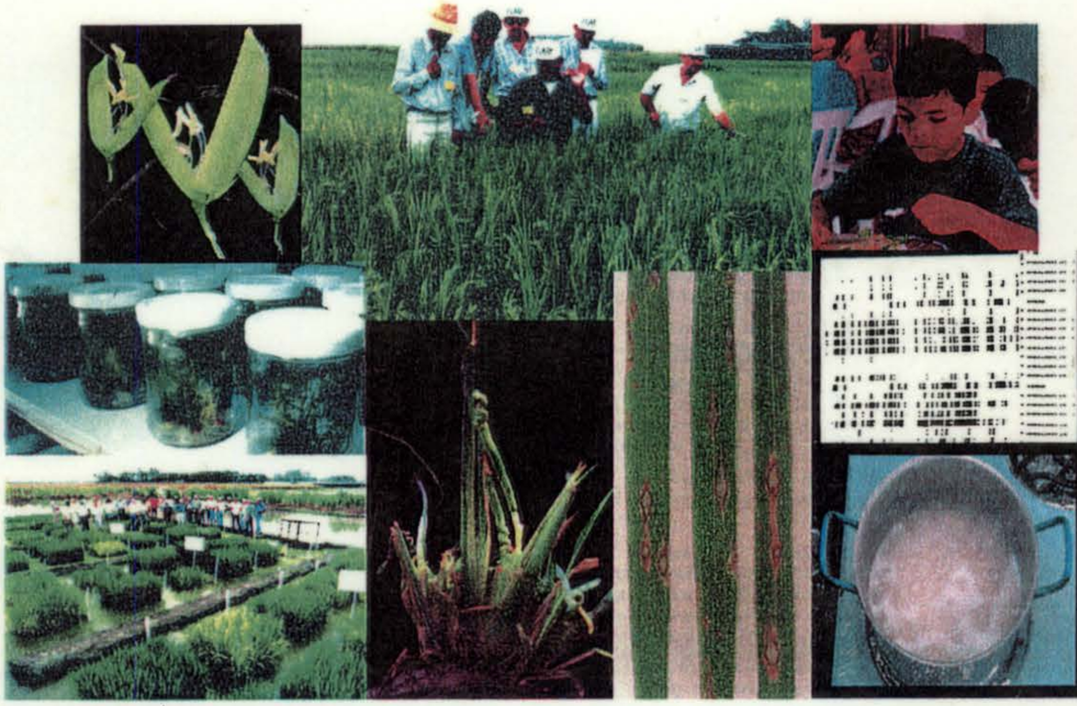
Annual Report 1998

Project IP-4:
Improved Rice Germplasm for Latin America and the Caribbean



For Internal Circulation and Discussion Only

October 1998

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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Project IP-4 Improved Rice Germplasm for Latin America and the Caribbean Annual Report 1998 Centro Internacional de Agricultura Tropical (CIAT) Cali Colombia October 1998

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Annual Report 1998

IP-4 Improved Rice Germplasm for Latin America and the Caribbean

Executive Summary

OUTPUT 1 ENHANCED GENE POOLS

Germplasm development

Genetic uniformity or lack of genetic diversity is of major concern to breeders geneticists and the agricultural community in general In many crops genetic improvement is usually accomplished by reducing genetic diversity in the gene pools used to develop new varieties CIAT breeding strategies focus on developing and improving populations Such population development and enhancement aims to provide national programs (NARS) with sources of potential parents having specific traits

The expertise of the collaborative project on recurrent selection is shared with CIRAD and with NARS through providing sources of fixed lines or potential parents with specific traits required by national breeding programs activity reports didactic documents field visits and training courses In 1998 the upland rice recurrent selection project for the savannas was directed towards the improvement of tolerance to soil acidity resistance to pests and diseases good grain quality and early maturity Line selection and development from recurrent selection came from the evaluation of S2 S4 and S6 of several populations and advanced generations developed in previous years A high number of lines have been selected for recombination and multilocal evaluation in Brazil Bolivia and Venezuela New populations have been started by introducing new germplasm and source of male sterility The best CIAT breeding lines and commercial varieties from Brazil Bolivia and Colombia will be pooled in this population Breeding lines derived from recurrent selection at CIAT as well as introductions from Madagascar by CIRAD have also been selected for the upland hillsides of Colombia These lines are being evaluated in farmers fields in collaboration with the hillsides and farmer participatory research projects at CIAT Populations are being evaluated for medium to high altitude Upland rice germplasm bred by recurrent selection have also been distributed to West Africa and Asia In 1998 the VIOAL nursery for acid soils dispatched to different countries in LAC included the 31 best lines from this project

The participation of CIAT/CIRAD materials in different trials conducted in Brazil is very high 89% in advanced trials 28% in preliminary trials and 19% in observation trials During 1994-1997 two out of 4 lines released in different states of Brazil came from the CIAT breeding program Three new CIAT lines are very promising candidates for release in 1999 As part of a collaborative project savanna lines have been sent to China CIAT lines are very promising and are being used as parents in the Chinese upland breeding program

Breeding populations developed through recurrent selection for lowland rice in the tropics and template ecosystems are being advanced at CIAT and sent to national programs in the region for evaluation and selection Results for 1998 are still pending

The *Oryza* wild species represent a potential source of new alleles for improving yield quality and stress resistance of cultivated rice Crosses between wild rices and commercial cultivars have been realized and an advanced backcross QTL method guided by marker assisted selection has been implemented for the development of improved cultivars Transgressive segregation for grain yield was detected in the Bg90 2/*O rufipogum* cross with several BC2F2 families having between 5 and 25% higher yields than Bg90 2 The results were confirmed from replicated trials of BC2F3 families Molecular analysis indicated positive association between yield and QTLs located on chromosomes 2 3 5 and 12 In the cross betweenLemont/*O barthii* several families yielded up to 30% more than Lemont and QTLs associated with yield were located on chromosomes 1 and 7 Several other interspecific populations including crosses with *O glaberrima* are in the process of development or field evaluation Results suggest that both *O rufipogum* and *O barthii* have genes that contribute positively to yield increase in cultivated rice

Rice lines derived from interspecific crosses are also being characterized to identify other useful traits (plant architecture panicle size grain type yield disease resistance etc) suitable for our partners in the region Although all lines derived from the cross between Lemont/ *O barthii* were susceptible to rice hoja blanca virus 48% (237 lines) exhibited resistance to blast Twenty three high yielding rice lines from the cross between *O rufipogum* and the high yielding variety Oryzica 3 were resistant to the virus and 35 to blast Best lines will be distributed to the region through INGER

Desired characteristics (heavier grains longer grain filling period late leaf senescence and sturdy stems) identified in the new plant type (NPT) from IRRI under our conditions are being incorporated into LAC s gene pools A total of 433 crosses were made during 1998 between selected lines and LAC genotypes including 226 155 and 52 crosses for tropical irrigated temperate irrigated and upland rice parents respectively Anther culture will be used to accelerate the development of fixed lines from upland and temperate crosses in order to make available this new material to partners as soon as possible

Embryo Rescue and Anther Culture

Anther culture (AC) and In vitro culture is an important activity for the enhancement of gene pools in the rice project AC is used to fix enhanced traits inbackcrossed populations from rice x wild species hybrids A total of 1711 green plants have been produced Production of double haploid lines will be used to accelerate the introgression of QTL s associated with high yield potential from the wild species into selected cultivated varieties of*O sativa* AC accelerates the development of breeding populations Double haploid lines produced for FLAR and CIAT will be distributed to several LAC countries for field evaluation Somaclonal variation is being tested to determine if it is possible to improve some of the traits of selected breeding lines A total of 3758 somaclones were produced for Venezuela and 4440 for Colombia The S1 seed has been harvested and will be used for grain quality and disease resistance evaluation

OUTPUT 2 PHYSIOLOGICAL BASIS FOR RICE TRAITS UNDERSTOOD

Weed control enhancement by the use of new genotypes and practices

One of our main objectives is to develop methodologies that retard or reduce the establishment of weeds in order to increase the competitive advantage of the rice crop with respect to the weeds Previous experiments in the project indicated that anaerobic conditions impede germination emergence and establishment of weed species in the rice crop Under direct seeding conditions early flood establishment can retard and reduce weed development thereby permitting rice plant development under less weed competition We are identifying rice cultivars that exhibit the capacity to develop under submergence conditions Tolerance to submergence could be useful both under direct seeding of dry or pre germinated rice seed Results indicate that pre germinated systems give the rice an advantage over weeds due to early crop establishment Several varieties within our LAC germplasm and IRRI introductions were identified during 1998 exhibiting appreciable levels of submergence tolerance that could be used in an integrated crop management strategy Various complementary studies are under way to refine certain aspects of this concept

Preliminary studies at CIAT using early flooding at 3 different dates after planting and 2 depths of planting with dry seeds have given indications that it is possible to develop planting systems that reduce the effect of weed competition in the first stages of crop development using varieties with submergence tolerance When the flood was applied 4 days after planting only 22% of *Echinochloa colona* emerged while 100% emergence was observed for the submergence tolerant variety Submergence tolerance is a characteristic which combined with other required traits of modern rice cultivars is very desirable for utilization in a crop management program including early flooding for reducing weed competition

OUTPUT 3 RICE PESTS AND GENETICS OF RESISTANCE CHARACTERIZED

Blast

Understanding population dynamics of the blast pathogen for the development of breeding strategies for durable blast resistance is in progress We have detected genetic structure and virulence changes within blast pathogen populations over time Greater gains in virulence were associated with changes in genetic structure within existing genetic lineages Blast populations with narrower spectrum of virulence tend to predominate compared to those with broader spectrum Rice lines exhibiting complete and complementary blast resistances have been identified in the field and greenhouse These lines are being used in proper combinations or crosses to assure accumulation of resistance genes in a common background Fifteen rice lines combining two resistance genes (Pi 1 and Pi 2) that exclude the entire blast pathogen population in Colombia and other countries continue being stable under greenhouse and field evaluations in the F7 generation These genes are being incorporated in commercial cultivars of LAC

The blast resistance of cultivar Oryzica Llanos 5 exhibited since the time of its release in 1989 continues stable Partially compatible isolates detected in the past few years did not increase in aggressiveness under greenhouse inoculations In collaboration with the BRU we are identifying blast resistance genes in the cultivar Oryzica Llanos 5 using PCR based cloning with degenerated primers that are making possible the identification of resistance gene analogs in rice Blast resistance with potential novel genes has been identified in the wild rice species *O rufipogum* and *O glaberrima* Identification of these genes with the aid of molecular markers will be initiated soon The possibility offered by induced mutations for generating resistance to the different genetic lineages of the blast pathogen is being explored Mutants with resistance to three genetic lineages were identified in 1998

The characterization and use of partial resistance to rice blast was initiated in greenhouse and field studies Blast isolates with adequate virulence were identified for evaluating rice germplasm from different sources for their level of partial resistance Selection for partial resistance is also being performed on populations developed in the recurrent selection activities for lowland rice We aim to identify and combine good levels of complete and partial resistance for the development of a more durable and stable blast resistance

Rice Hoja Blanca Virus (RHBV) and *Tagosodes oryzicolus*

The main activities conducted on RHBV and its vector are directed towards lessening the losses caused by this complex and break the recurring cycles characteristic of this disease Research on RHBV require great efforts for the maintenance of both vector and non vector colonies of the insect used for the characterization and identification of resistant germplasm More than 12000 rice lines were screened for resistance to RHBV and about 3000 for resistance to the vector during 1998 Forty eight percent were resistant to the virus and 54% to the insect The increased number of resistance observed over the years indicate the use of resistant parents by the breeding section Mechanisms of resistance to the insect and the virus are being studied to determine its role in the breakdown cultivar resistance Surveys of RHBV incidence and *T oryzicolus* were conducted in epidemiological studies of the disease to determine areas of greatest risk for outbreaks of RHBV During the last year the incidence of both has increased in Colombia A new variety FEDEARROZ 50 with resistance to the insect and the virus has been released and will be planted extensively during 1999 in Colombia The change from susceptible to varieties with intermediate reaction to RHBV has been a key element in the control strategies that CIAT FEDEARROZ and Corpoica are promoting in Colombia

Another strategy for the control of RHBV being developed in the project in collaboration with the BRU and BRU is through nucleoprotein mediated cross protection in transgenic rice One or two genes normally control resistance to the virus To ensure stable and durable resistance additional sources need to be identified and incorporated into rice Transgenic plants developed through this technique are showing stable RHBV resistance on T2 progeny plants Resistant plants show a significant delay in the development of the disease and reduced severity of the symptoms in contrast to the non transgenic controls Individual T3 progeny plants from resistant T2 are being used in different crosses with resistant intermediate and susceptible rice lines for studying the inheritance and expression of the RHBV nucleoprotein cross protection in different genetic backgrounds Results suggest that the protection conferred by the RHBV N transgene is expressed independently of the genotype background and that the transgene can be used to complement the natural resistance source Higher levels of resistance of transgenic F1 s were noted on the crosses with the susceptible intermediate and the highly resistant genotypes

Rice stripe necrosis virus

Activities in the study of this new virus have included the characterization of the disease isolation of the virus from infected rice plants physical and chemical characterization molecular characterization of the virus and its fungus vector and the implementation of control methods The wide distribution of RSNV found in Colombia is a clear demonstration of the rapid dissemination potential of the virus and vector in tropical environments and mechanized rice cropping systems An improved purification method was developed during 1998 A polyclonal antiserum was developed for the characterization of the antigenic properties of the virus A high relation ship between the African and Colombian isolates of RSNV was found Molecular characterization of the fungus supports the identity of the Colombian RSNV associated fungus as *Polymyxa graminis* Control measures are being investigated in collaboration with FEDEARROZ and other institutions Growers have the perception that they can manage the disease now that the causal agent is now by improving soil fertility and microbial activity Climatic factors as well as soil texture seem to have very important effects on the fungus vector and incidence of the disease

OUTPUT 4 PROJECT PRIORITIES AND RESEARCH CAPACITIES ENHANCED

Analysis of the Colombian National Rice Sample

This is an ongoing collaborative effort between CIAT and FEDEARROZ that started in 1998 The sample includes 180 farmers from Colombia that represent the mechanized sector with a confidence of 97% This year we analyzed the seasonal patterns to establish the differences between the two main growing seasons in the country Semester A (harvested around May June) and Semester B (harvested around October November) Results show that yields are higher in the first semester and so are seed use nitrogen and potassium applications as well as labor and machinery use Pesticide applications are not significantly different in each semester This tells us that input use is variable and it is related to the yield component which has a seasonal effect most likely linked to climatic conditions However for pesticide use there is no significant differences in the levels of applications between the two seasons

Creation of a network of rice economists in Latin America (RECAL)

The CIAT rice project together with FEDEARROZ and CIRAD took the initiative of formalizing the interchange of data and knowledge among colleagues working in this area The network met in Quito last July Eight countries sent a total of 27 representatives form several countries (Brazil Colombia Chile Ecuador France Panama Uruguay Venezuela)

One of the objectives of the network is to increase participation form the private sector in the exchange of data About half of the participants in the meeting come from private sector organizations One of the objectives of the network is to increase participation form the private sector in the exchange of data About half of the participants in the meeting come from private sector organizations

Collaboration with IFPRI in a study of varietal adoption in Latin America and the Caribbean

Varietal adoption and the Impact of rice research in LAC is a continuous activity in the rice project given the dynamism and complexity of the adoption process

The rates of adoption for new High Yielding Varieties (HYVs) in irrigated rice are close to 100% This is a region where yields in this ecosystem are rather high and are still growing as the region exhibits the highest rate of growth in rice production and yield increase in this decade By 1997 it is estimated that irrigated rice area reaches 2 4 million ha and over 2 3 million of them are under HYVs With respect to rice production irrigated rice supplies 12 6 million tons with an average yield of 5 2 t/ha over 98% of that production comes from HYVs Lowland rainfed rice occupies 1 1 million ha And contributes with 4 2 million tons per year for an average yield of 3 9 t/ha About 90% of that production comes from HYVs In contrast with those numbers upland rice reaches 2 6 million ha And supplies 3 4 million tons for an average yield of 1 3 t/ha Only one fourth of the upland area is under HYVs It is important to document these processes in detail to measure the impact of rice research the collaborative study with IFPRI includes ten countries This year data on varietal release from Colombia from 1991 was sent to IFPRI (see table 5A) and similar efforts are on the way for the Brazil (Table 5B) and other eight countries

It is important to document the adoption processes in detail to measure the impact of rice research a collaborative study with IFPRI includes ten countries This year data on varietal release from Colombia from 1991 was sent to IFPRI (see table 5A) and similar efforts are on the way for the Brazil (Table 5B) and other eight countries

FLAR

During 1998 two more members joined FLAR Uruguay (in June) and Bolivia (in August) Earlier the state of Santa Catarina in Brazil had also signed an agreement with IRGA to participate in FLAR The ten countries that currently form FLAR contributed in 1998 a total of US$382 500 CIAT and IRRI contributed $50 000 each The annual contribution from members will reach $482 500 For 1999 it is expected that Argentina Chile Ecuador and Nicaragua will also join bringing an additional income of $157 500 and a total income of $640 000 for the year FLAR is in the process of hiring a breeder for the Southern Cone which will be based in South Brazil (Rio Grande do Sul)

FLAR organized two IPM courses one in Paraguay (March) with the assistance of 90 persons and one in Guatemala (May) with 76 participants A breeders workshop was organized in August for participation of the regions breeders in selection of early generation breeding lines at the Santa Rosa Station Breeders from Brazil Colombia Venezuela Costa Rica and Bolivia attended Currently breeders from Venezuela are assigned to FLAR on a rotating basis for six months for training specific research and breeding activities Thesis work by 3 M Sc candidates is being carried out with cooperation of CIAT scientists and Ph D work by a student at The University of Rio Grande do Sul is being carried out in cooperation with IRGA in Brazil A breeders workshop for members of the tropical region is planned for November in Costa Rica A similar workshop for members in the temperate region will take place in Santa Catarina (Brazil) in March 1999

IP-4 Improved Rice Germplasm for Latin America and the Caribbean

Introduction and overview

The structure of the Rice Project Annual Report 1998 conforms to the guidelines set by the Program Committee in order to standardize the reports of the different projects as described in the Medium Term Plan 1998 2000 Rice research in Latin America and the Caribbean (LAC) has emphasized growth equity and the enhancement of the resource base Technological progress improved efficiency marked production increases and important linkages with the rest of the economy have put rice at the top of priorities for agricultural growth policies in most countries of LAC The research strategy of the project is designed to fulfill the essence of our goal which is to improve the nutritional and economic well being of rice growers and low income consumers in LAC through sustainable increases in rice production and poverty More than eighty percent of the growth in rice production (at the annual rate of 2 5%) in the 1967 1997 period was due to growth in productivity releasing the pressure on land expansion in the quest for additional food

Our research is focused on our project purpose To increase genetic diversity and enhance gene pools for higher more stable yields with lower unit production costs and reduce environmental hazards Research has been produced through a process involving the participation of a wide spectrum of scientists Collaboration with a range of partners has been a key for the success of our research By doing research with partners we are strengthening not only our research team but the capacities of national research institutions We have had many examples during the year showing our integration with partners in the region and the results of this partnership Integration and collaboration with the public and private sector CIRAD and FLAR have been very important to our contribution to sustainable agriculture and poverty alleviation in the region Countries in the region which have weak national programs and benefited very little in the past are now integrated in our research system due to the presence of FLAR and CIRAD

Important processes on this aspect that occurred during 1998 include several training courses organized by FLAR in different countries focused mainly on management of the rice crop and breeding techniques High qualified scientists from different institutions participate as trainers complementing for those areas where CIAT has not expertise anymore A rice entomologist from the national rice institution from CUBA has been outpost at CIAT to strengthen this area of research and to share his knowledge and experiences in other countries of the region In germplasm enhancement we have incorporated another scientist from CIRAD with expertise in the development of partial resistance to rice blast recurrent selection and development of rice germplasm for the hillsides of LAC We have reached an agreement with IRRI to have a joined position focusing on weed management strengthening our collaboration and presence of this sister institute in LAC Support and recognition to our mission has been given by the Colombian government continuing being a member of the CG system and by the government of Peru who became a member during this year having included rice as one of their main priorities in agriculture development

Fernando Correa

Research Highlights in 1998

OUTPUT 1 ENHANCED GENE POOLS

Recurrent selection populations for upland savanna rice were developed with the following characteristics tolerance to soil acidity resistance to blast RHBV and its vector good grain quality and early maturity

- High percentage of CIAT/CIRAD upland lines used in Brazil

Two CIAT lines are being released in Brazil (CANASTRA and MARAVILHA) and three are very promising candidates for release in 1999

CIAT rice lines are being adopted in China and used in their breeding programs

One CIRAD line is being released in China and another in Bolivia

- Recurrent selection populations for lowland have been developed and distributed for selection to Colombia Costa Rica El Salvador Panama Venezuela Argentina Chile and Uruguay

Methodologies for populations with a broad and narrow genetic base have been developed

- *Transgressive segregation* for yield increase (5 to 30%) has been observed in families developed in crosses between cultivated rice and the wild species *O rufipogum* and *O barthii*

QTL s associated with higher yield increase in the crosses of cultivated/wild rice have been identified

Positive traits in new plan type have been incorporated into CIAT's rice germplasm

Anther culture has been implemented for fixing enhanced traits in backcrossed populations from rice/wild species

OUTPUT 2 PHYSIOLOGICAL BASIS FOR RICE TRAITS UNDERSTOOD

- Weed control enhanced by the use of new genotypes and practices

Rice varieties have been found to differ largely in their capacity to develop under submerged conditions

Early flooding in tolerant to submergence cultivars can contribute significantly to reduce population of several weeds

LAC rice germplasm contains an appreciable level of submergence tolerance that can be used in an integrated weed control management

OUTPUT 3 RICE PESTS AND GENETICS OF RESISTANCE CHARACTERIZED

Genetic structure and virulence changes in the blast pathogen leading to resistance breakdown have been detected over time

Greater gains in virulence in the blast pathogen were associated with changes in genetic structure

Rice lines exhibiting complete and complementary resistance to rice blast were identified in the field and greenhouse

- Rice lines combining complementary resistance genes to blast remain stable under field evaluations after seven generations
- Level of partial resistance in existing rice germplasm is being characterized
- A rice cultivar with resistance to RHBV and its vector has been released
- Sources of resistance to RHBV and its vector were identified
- Epidemiological studies on RHBV are helping to manage the disease in the field
- RHBV is being controlled through nucleoprotein mediated cross protection in transgenic rice
- The rice stripe necrosis virus and its vector have been isolated and physically chemically and molecularly characterized

OUTPUT 4 PROJECT PRIORITIES AND RESEARCH CAPACITY ENHANCED

- A Colombian national rice sample has been analyzed
- A network of rice economists for Latin America was created
- An analysis of variety adoption in collaboration with IFPRI is being conducted
- The rates of adoption for new High Yielding Varieties in irrigated rice are close to 100%
  In the 1970 97 period a total of 297 new varieties have been released in LAC 88% are high yielding varieties targeted for irrigated conditions
- Yields in irrigated and lowland rainfed areas have increased substantially
- Two more countries have joined FLAR during 1998 They are Uruguay and Bolivia for a total of 10 members
- FLAR evaluated a total of 9715 rice lines and 861 crosses during 1998
- FLAR organized 2 IPM courses in 1998 and several breeding activities in the region

Project IP 4 Improved Rice Germplasm for Latin America and the Caribbean

Project Goal
To improve the nutritional and economic well being of rice growers and low income consumers in Latin America and the Caribbean through sustainable increases in rice production and productivity

Project Purpose
To increase genetic diversity and enhance gene pools for higher more stable yields with lower unit production costs and reduce environmental hazards

Enhanced Gene Pools

Rice improvement for upland and lowland using recurrent selection and conventional breeding
Evaluation of savannas upland rice lines in Latin American countries
Population maintenance through recombination
Registration of new populations
Distribution of breeding populations to LAC countries
Conventional and recurrent selection breeding for hillsides upland rice
Identification and selection for useful traits in wild rices with the aid of molecular markers Improvement of yield potential in interspecific crosses
Evaluation of interspecific populations Introgression of new plant type into LAC s gene pols
Use of anther and in vitro culture and somaclonal variation for enhancement of gene pools

Physiological basis for rice traits understood

Weed control enhanced by the use of new genotypes and practices
Identification of rice cultivars with tolerance to submergence
Identification of rice cultivars exhibiting high weed competition
Characterization of useful traits in new plant type derived populations

Rice pests and genetics of resistance characterized

Monitoring changes in genetic structure and virulence diversity of the rice blast pathogen
Characterization of rice germplasm for blast resistance
Genetics and dissection of blast resistance genes using molecular markers
Improving methods for developin durable blast resistance
Characterization of partial resistance to blast in existing germplasm
Characterization of resistance to RHBV and *Tagosodes oryzicolus*
Maintaining and establishing colonies of *T oryzicolus*
Epidemiology for RHBV
Control of RHBV through nucleoprotein mediated cross protection in transgenic rice
Physical chemical and moleculars characterization of the rice stripe necrosis virus

Project priorities and research capacities enhanced

Analysis of national rice samples in Colombia
Creation of a network of rice economics in Latin America (RECAL)
Collaboration with IFPRI in varietal adoption studies in Latin America and the Caribbean
FLAR breeding and crop management activities in Latin America and the Caribbean (training)
Germplasm characterization for yield milling quality blast resistance iron toxicity tolerance RHBV resistance cold tolerance by FLAR
Crosses and evaluation of segregating populations by FLAR and country members
FLAR Interactions with CIRAD/CIAT/IRRI
Collaboration with Forest Margins project for the development of improved upland rice cultivars for the Peruvian selva

LOGICAL FRAMEWORK PROJECT IP-4

Project Title Improved Rice Germplasm for Latin America and the Caribbean Project Manager Fernando Correa

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To improve the nutritional and economic well being of rice growers and low income consumers in Latin America and the Caribbean through sustainable increases in rice production and productivity	Improved access of rice growers and consumers to standard goods and services Reduction in pesticide use and increase yield average/ha Increase in the number of ha planted with new cultivars	National statistics on agriculture and development of LAC Rice production statistics	Donors governments and NARS continued interest in sustainable increase in rice production
Purpose To increase genetic diversity and enhance gene pools for higher more stable yields with lower unit production costs and reduce environmental hazards	Evaluations of yield potential of F2BC2 end 1998 Increased use of improved populations from recurrent selection by NARS at the end of 1997 Rice lines selected with desired gene traits Potential donors high levels of blast resistance	Database on seed exchange Project CIAT and NARS annual reports	Improved/diversed populations are adopted/used by NARS policies favor adoption Farmers are willing to reduce pesticide use
Output 1 Enhanced Gene Pools	Seed of best gene pools distributed to FLAR and 50% of other partners by the end of 1998	Project progress report for 1998	Continued demand for these populations NARS willing to try out/use improved lines
Activities Introduce identify generate and evaluate germplasm from different sources Multiply seed to FLAR/ other partners Use AC/ embryo rescue (MCh MV CM CB ZL) Identify and select for useful traits with the aid of molecular markers (linked to Project SB 2) (JT FC CM)	First evaluation of the yield potential of 3 F2BC2 populations conducted by 1998 in 3 sites Number of field trials planted Number of crosses made DH obtained hybrid plants recovered by embryo rescue and traits identified QTLs identified	Project progress report for 1998 Field visits to testing sites Budget	Adequate funding and timely release of budget Continued support from CIRAD CA Useful traits in wild germplasm can be incorporated in improved populations NARS willing and capable to try out/use new improved populations
Output 2 Physiological basis for rice traits understood	Main 5 agronomic/physiological traits measured beginning 1998	Project progress report for 1998 Two publications	Continued demand by NARS for these populations and knowledge
Activities Characterize new plant Introgress new plant type into LAC s gene pools (CB CM JG) Understand the physiological mechanisms for tolerance to low P and acid soils (CB) Weed control enhanced by the use of new genotypes and practices Identification of rice cultivars with tolerance to submergence	First BC to new plant type made by end 1997 Mechanism for tolerance to low P/acid soils proposed Weed competitive varieties developed	Project progress report for 1998	Adequate funding and timely released of budget Rice support staff in plant physiology in place Post Doc in place Germplasm adoption is higher and more consistent than of agronomic changes

Output 3 Rice pest and genetics of resistance characterized	Isolates characterized for their virulence and genetic structure	Project progress reports	Collection of blast infected samples gives viable isolates Molecular markers available from BRU
Activities Monitoring genetic and virulence diversity of pathogen Testing breeding methods for durable blast resistance (CM FC) Dissecting blast resistance genes in highly resistant cultivars and make new crosses (CM FC linked to project SB 2)	Isolates	Assigned budget	Rice crosses and populations developed by rice breeders Biotechnology unit continues identifying molecular markers associated with resistance
Evaluation of rice germplasm including transgenic plants for resistance to *T orizicolus* and to RHBV (CM FC ZL) Studies of RHBV colony vs date vs variety (LC CM) RHBV surveys in rice fields and epidemiological studies Biocontrol of *T orizicolus* (LC CM FC) Collaboration with NARS to transfer evaluation technics (LC CM FC)	Rice lines with diversified resistance to *Tagosodes orizicolus* and to RHBV More effective colony management Baseline information for understanding and prediction RHBV epidemics crop management Increased capacity of NARS to screen germplasm Effective entomopathogens for insect control Transgenic lines with RHBV viral genes w/reduced disease symptoms		Collaboration with FEDEARROZ FLAR Depends partially on special project funding
Isolation and characterization of the causal agent and vector of entorchamiento (FC FM) Development of diagnostic methods and germplasm screening technique to implement control measures (FC FM)	The causal agent of the entorchamiento disease of rice and its vector are characterized managed Different control strategies are implemented	Publications and diagnostic kits available Resistant germplasm selected under artificial conditions	Available infected material can be maintained and propagated by artificial measures Recommendations issued and adopted by farmers Special funding COLCIENCIAS and ODA
Output 4 Priorities and research capacity enhanced	One workshop conducted by 1998 for NARS 15-20 trained people from NARS Farmers surveys in LAC	Project progress and workshop report for 1998	NARS continued interest in specialized training and information exchange Linkages with NARS
Activities Coordinate research training activities with NARS Establish priorities (LS MCh FC ZL) Apply questionnaires to rice farmers (LS)	Research plans written Number of scientists trained Costs of production production coefficients Budget	Progress report for 1998	Adequate funding and timely released of budget

OUTPUT 1 ENHANCED GENE POOLS

A Rice Improvement Using Recurrent Selection and Conventional Breeding

CHAPTER I
PRESENTATION
1 HIGHLIGHTS

THE CIRAD/CIAT/FLAR COLLABORATIVE PROJECT

The third Collaborative Meeting between CIAT CIRAD INRA and ORSTOM was held at CIAT headquarters in May 1997 At this meeting the ongoing activities of the CIRAD/CIAT Rice Collaborative Project were confirmed and the project was reinforced by

- *The appointment of a new CIRAD CA scientist at CIAT headquarters*
- *Starting the adaptation of the ADVENTROP software to Latin America in March*

The 4th Collaborative Meeting will be held in 1999 in Montpellier France We are working at the implementation of a new collaborative initiative between the CIRAD/CIAT/FLAR rice project and EMBRAPA Arroz e Feijao –Brazil in rice economics with the appointment of a CIRAD CA scientist to Latin America

THE CIAT RICE PROJECT

CIAT is developing its research activities according to a project management system

UPLAND SAVANNA CONVENTIONAL RICE BREEDING

During 1996 A and B the activities developed by the conventional breeding project for upland savanna rice were at first reduced but then reactivated to a certain extent during 1997 A

In 1998 we sent upland lines to the new partners we identified during 1997 **Colombia** Ministry of Agriculture and small farmers of the Atlantic Coast **Argentina** Universidad Nacional de Tucuman **Paraguay** Associacion de Productores de Arroz de Itapua and **Venezuela** FONAIAP and the Universidad Nacional Experimental de los Llanos Orientales EZEQUIEL ZAMORA
We continue maintaining strong relationships with **Brazil** (EMBRAPA Arroz e Feijao Goiania) and **Bolivia** (CIAT Santa Cruz Bolivia)

In the **Caribbean** new partners were identifie **Cuba Guyana and Belize** (through CRIDNet)

UPLAND RICE FOR THE HIGHLANDS OF COLOMBIA

From 1993 we started as an informal collaborative effort with the Centro Nacional de Investigaciones de Cafe (CENICAFE) and the CIAT hillsides project to adapt rice as a new crop for the Colombian highland ecosystem Results so far are very promising (see Upland Rice Improvement for the Highlands of Colombia 1996 Report")

Two upland rice lines were proposed for release One is a CIAT savanna upland rice for the mid altitudes (about 1300 masl Colombian Coffee Region) and the other is an introduction from

Madagascar (CIRAD/FOFIFA Highlands Breeding Project) for the higher altitudes (1600 masl Cauca Region)

In 1998 we wrote a project that was presented in June to the Colombian institute COLCIENCIAS by the Centro Internacional de Agricultura Organica (CIAO)

The hillsides breeding activities developed during 1998 are presented in the annual report by Michel Vales now in charge of this part of the Collaborative Project

RECURRENT SELECTION BREEDING

CIAT and CIRAD s breeding strategies focus on developing and improving populations and phasing out the development of finished lines Such population development and enhancement aim to provide national programs (NARS) with sources of potential parents having specific traits

The expertise of the collaborative project on recurrent selection is shared with the NARS through activity reports didactic documents field visits and training courses The first International Course on Rice Recurrent Selection Breeding was held at CIAT in 1996 Fifteen scientists from 13 countries attended the course Back in their home countries many began using recurrent selection in their breeding programs

In 1998 two populations developed by the CIRAD/G4I project in Rio Grande do Sul Brazil were registered in the germplasm catalog for recurrent selection as PCIRAD 23 and PCIRAD 24

We are monitoring with our partners in Latin America the use of the basic populations developed by the project We also help them doing special work at CIAT Palmira development of specific populations for future local use (Argentina Uruguay and Venezuela) and generation of recombination cycle (Chile)

The first Venezuelan National Course on Rice Recurrent Selection was held at San Felipe – Venezuela in September 21 26 and organized by Fundacion DANAC CIRAD/CIAT and EMBRAPA

The Second International Workshop on Rice Recurrent Selection to be held in Goiania –Brazil in September 1999 is in preparation

Recurrent selection germplasm crosses continents On request we have shipped populations to Europe (France) and Asia (China)

FONDO LATINOAMERICANO Y DEL CARIBE PARA ARROZ DE RIEGO (FLAR) *(FUND FOR LATIN AMERICAN AND CARIBBEAN IRRIGATED RICE)*

In September 1996 CIRAD signed an agreement with the Fund and became a member Beginning in 1997 the CIRAD/CIAT collaborative project developed research activities with FLAR on

- *Recurrent selection breeding*
  Adaptation to Latin America of the CIRAD s ADVENTROP software (Thomas Le Bourgeois Montpellier – France)
- Durable resistance to blast The activities developed during 1998 are presented in the annual report by Michel Vales now in charge of this part of the Collaborative Project

In 1998 Argentina (State of Corrientes) Bolivia Guatemala and Uruguay became members of FLAR Conversations are well engaged with Chile Ecuador and Peru to be members in 1999

2 ACKNOWLEDGMENTS

This document reports the research activities developed during 1997 B and 1998 A at CIAT headquarters (Palmira Department of Valle Colombia) and La Libertad Experiment Station (Villavicencio Department of Meta Colombia)

In Colombia we try to maintain close collaborative ties with CORPOICA and CENICAFE It is not so easy because of the changes occurred in the definition of research activities of these institutions
We could not find out if CORPOPICA Regional 8 in Villavicencio is still interested in doing research in Savanna Upland Rice (or even in Rice !!!)
For CENICAFE we know that the project named Diversificacion del cultivo del cafe was reduced That is why we developed the hillsides activities mainly with CIAO who continues to show great interest in the adaptation of Upland Rice in the Colombian hillsides and with different CIAT s projects (Hillsides and Participatory Research)

At the regional level (Latin America) we conduct research activities in close collaboration with scientists of different institutions and universities

We would therefore like to acknowledge the excellent work and collaboration of the following people

Maria Antonia Marassi	Argentina Universidad de Corrientes
Juan Antonio Marassi	Argentina Universidad de la Plata
Marta Genoveva Nicosia	Argentina Universidad de Tucunan
Jose Alberto Villegas	Argentina Universidad de Tucunán
Roger Taboada Paniagua	Bolivia CIAT Santa Cruz
Orlando Peixoto de Morais	Brazil EMBRAPA Arroz e Feijao
Emilio da Maia de Castro	Brazil EMBRAPA Arroz e Feijao
Elcio Perpetuo Guimaraes	Brazil EMBRAPA Arroz e Feijao
Roberto Alvarado	Chile INIA Quilamapu
Santiago Ignacio Hernaiz Lagos	Chile INIA Quilamapu
Hernando Delgado Huertas	Colombia CORPOICA Regional 8
Randolph Campos Morera	Costa Rica Ministry of Agriculture
Ramón Eduardo Servillon	El Salvador CENTA
Ariel E Jaén Sanchez	Panamá Universidad de Panama
Alberto Herrera G	Venezuela Universidad (UNILLEZ)
Eduardo Graterol	Venezuela DANAC – Fundacion Polar

Fernando Blaz Perez de Vida | Uruguay INIA Treinta y Tres

Rene Perez Polanco | Cuba IIA Sancti Spiritus

3 BACKGROUND INFORMATION

Genetic uniformity or lack of genetic diversity is of major concern to breeders geneticists and the agricultural community in general In many crops genetic improvement is usually accomplished by reducing genetic diversity in the gene pools used to develop new varieties But genetic uniformity is now considered as increasing a crop s potential vulnerability to disasters caused by biotic or abiotic constraints

In Latin America the genetic diversity of rice varieties depends on a small genetic core of landraces (1 in Appendix 6) One way of broadening the genetic base of Latin American rice and assessing the genotype by environment interaction is to identify specific potential parents and pool them to develop new genetically broad based breeding material

CIAT and CIRAD s new breeding strategies focus on developing and improving populations to provide sources of fixed lines or potential parents with specific traits required by national breeding programs One suitable breeding method to achieve this goal is recurrent selection

Started in 1992 the CIRAD/CIAT rice improvement collaborative project introduced from Brazil and French Guyana and developed in Colombia (CIAT Palmira and Villavicencio) gene pools and populations segregating for a male sterile recessive gene (2 in Appendix 6) At first he main objectives of the project were

- To understand the performance of the introduced germplasm in the upland acid soils of the Colombian savannas
- To maintain the germplasm by harvesting fecundated male sterile plants
- To identify adapted fertile genotypes for use in breeding programs for fixed lines
- To start recurrent selection by recombining the best selected genotypes in the introduced germplasm
- To create new populations by incorporating the best locally adapted lines of the CIAT upland rice breeding program into the best adapted introduced germplasm that also provides a good source of male sterile background

Since 1995 we are mainly focusing with ours regional partners on line development and enhancement of different upland and lowland populations especially for blast resistance earliness tolerance to acid soils and grain yields for upland ecosystem For lowland conditions (tropical sub tropical and temperate climate) the objectives are resistance to rice blast and Hoja Blanca virus tolerance to cold and grain yield and quality
As International Centers we also develop germplasm with broad genetic base in order to gather and maintain variability To these germplasms we apply a low selection pressure in order to maintain variability and adaptation to broad ecoregional regions

CHAPTER II

RECURRENT SELECTION FOR UPLAND SAVANNA RICE

Marc CHÂTEL Yolıma OSPINA and *Jaıme BORRERO*

1 INTRODUCTION

The upland rıce recurrent selectıon project aıms to adapt develop and select upland rıce gene pools and populatıons The major characterıstıcs that we look for ın germplasm for savanna condıtıons are

- Tolerance of soıl acıdıty
- Resıstance to dıseases maınly rıce blast (*Pyrıcularıa grısea* Sacc)
- Resıstance to pests maınly rıce plant hopper (*Tagosodes orızıcolus*)
- Good graın qualıty (translucent long slender graın)
- Early maturıty (total cycle about 115 days)

2 UPLAND SAVANNA RICE

The actıvıtıes we report here were conducted at two experıment statıons

- Off season (1997 B) October 1997 to March 1998 at the Palmıra Experıment Statıon (PES)
- Croppıng season (1998 A) Aprıl to September 1998 at La Lıbertad Experıment Statıon (LES)

2 1 Lıne Development from Recurrent Populatıons

Durıng the enhancement of gene pools and populatıons through recurrent selectıon we selected fertıle plants to develop promısıng fixed lınes or potentıal parents for regıonal NARS

Generatıon S2

Cycles

Durıng 1997 A *fertıle plants were selected for lıne development In each populatıon PCT 5\PHB\1\0 PHB\1 PCT A\PHB\1\0 PHB\1 and*
PCT 4\PHB\1\1 PHB\1   41 13 and 12 S0 fertıle plants respectıvely were harvested

During 1997 B *the S1 generatıon was grown at PES*

Croppıng Season 1998
The 69 S2 lınes were evaluated at LES and 8 (11 6%) were selected
In each selected lıne 6 fertıle plants were harvested

2 1 1 Generatıon S4

The generatıon S4 came from S0 fertıle plants selected durıng 1996 A at LES and the selectıon of S2 lınes durıng 1997 A at LES and seed ıncrease durıng 1997 B at PES

2 1 1 1 Populatıons PCT 5\PHB\1\0 PCT A\PHB\1\0 and PCT-4\PHB\1\1

Cycles

Durıng 1996 A *from the fırst recurrent selectıon cycle for leaf blast and hoja blanca vırus (see 1996 report 4 2) we selected 211 S0 fertıle plants dıstrıbuted as follows*

- *49 ın PCT 5\PHB\1\0 (11 5% of the total number of fertıle plants)*
- *48 ın PCT A\PHB\1\0 (12 4% of the total number of fertıle plants)*
- *114 ın PCT 4\PHB\1\1 (17 3% of the total number of fertıle plants)*

Durıng 1996 B *the S1 generatıon (211 S1 lınes) were grown at PES and the S2 seeds sent to LES to grow the S2 generatıon durıng 1997 A*

Durıng 1997 A *from the 211 S2 lınes evaluated at LES 25 were selected*

- *PCT 5\PHB\1\0 -- 1 lıne selected (2%)*
- *PCT A\PHB\1\0 -- 2 lınes selected (4%)*
- *PCT 4\PHB\1\1 -- 22 lınes selected (19%)*

In each selected lıne 6 ındıvıdual plants were selected

Durıng 1997 B *the 150 S3 lınes (25 famılıes of 6 lınes) were grown at PES*

Croppıng season 1998 A

From the 150 S4 lınes evaluated at LES 35 (23 3%) were selected

- PCT 5\PHB\1\0 no selectıon
- PCT A\PHB\1\0 no selectıon
- PCT-4\PHB\1\1 35 lınes selected (23 3%)

2 1 2 Generatıon S6

The generatıon S6 came from fertıle S0 plants selected durıng 1995 A at LES The generatıons S1 S3 and S5 were grown durıng 1995 B 1996 B and 1997 B respectıvely at PES The S2 and S4 generatıons were selected durıng 1996 A and 1997 A at LES

2 1 2 1 Populatıons PCT 5\0\0\0 PCT A\0\0\0 and PCT-4\0\0\1

Cycles

Durıng the 1995 A croppıng season *at LES we selected 55 85 and 18 S0 fertıle plants ın PCT 5\0\0\0 PCT A\0\0\0 and PCT 4\0\0\1 respectıvely and durıng the off season (1995 B) we grew the S1 generatıon at PES*

Durıng the 1996 A croppıng season *we observed 158 S2 and 3 checks (Oryzıca Sabana 6 IAC 165 and CIRAD 409) at LES and selected maınly for plant type and yıeld potentıal dıscardıng 102 S2 lınes (64 5%) A total of 56 S2 lınes (35 4%) were selected*

- *PCT 5\0\0\0 -- 21 lines (38 1%)*
- *PCT A\0\0\0 --26 lines (30 6%)*
- *PCT 4\0\0\1 9 lines (50 0%)*

From the 56 selected lines we harvested 178 fertile plants 62 from PCT 5\0\0\0 91 from PCT A\0\0\0 and 25 from PCT 4\0\0\1

We applied different selection intensity to each selected S2 line according to the phenotypic value of the lines (grain yield potential and plant and grain type) For example the highest average selection intensity in three PCT 5\0\0\0 S2 lines was 14% and the lowest average was 1 6% in 14 S2 lines

The S3 generation was grown during 1996 B at PES and the S4 seeds will be sent to LES to grow the S4 generation during 1997 A

***During 1997 A** from the 178 S4 lines evaluated 47 were selected*

PCT 5\0\0\0 3 lines selected (5%)
- *PCT A\0\0\0 -- 35 lines selected (38%)*

PCT 4\0\0\1 9 lines selected (36%)

From each selected line 6 individual plants were selected

***During 1997 B** the 282 S5 lines (47 families of 6 lines) were grown at PES*

Cropping Season 1998 A

From the 282 S6 lines 64 (22 7%) were selected
- PCT 5\0\0\0 no selection
- PCT A\0\0\0 45 lines selected (16 0%)
- PCT-4\0\0\1 19 lines selected (6 7%)

2 1 2 2 Population PCT-4\0\0\1>S2

Cycles

***During 1996 A** we started enhancing this population by first evaluating the S2 line We took advantage of the 1996 S2 line trial to select S2 lines and individual fertile plants for line development From 152 S2 lines evaluated we selected 19 (12 5%) and 74 individual plants based on plant and grain type and grain yield potential*

***During 1996 B** the S3 generation was grown at PES and the S4 seeds were sent to LES to grow the S4 generation during 1997 A*
***During 1997 A** from the 74 S4 lines evaluated 16 were selected (22%)*
In each selected line we harvested 6 individual plants
***During 1997 B** the 96 S5 lines (16 families of 6 lines) were grown at PES*

Cropping Season 1998 A

From the 96 S6 lines evaluated 12 (12 5%) were selected

2 1 2 3 Populatıons PCT 5\0\0\0 PCT A\0\0\0 and PCT-4\0\0\1 Plant Selectıon ın S3 Lınes at PES 1996 B

Cycles

Durıng 1996 B *at PES we selected 12 ındıvıdual fertıle plants wıth suıtable characterıstıcs from S3 lınes The S4 seed was sown durıng 1997 A at LES*

Durıng 1997 A *from the 12 S4 lınes evaluated only 3 were selected ın one populatıon*

- *PCT 5\0\0\0 -- no selectıon*
- *PCT A\0\0\0 no selectıon*
- *PCT 4\0\0\1 3 lınes selected (75%)*

In each selected lıne 6 ındıvıdual plants were selected

Durıng 1997 B *the 18 S5 lınes (3 famılıes of 6 lınes) were grown at PES* ***durıng 1998A*** *and 2* (11 1 5%) were selected

2 1 3 Advanced Generatıons

The advanced generatıons (AGs) came from the S0 fertıle plants selected from the germplasm we ıntroduced ın 1992 from Brazıl (wıth male sterıle gene) and from the gene pool and populatıons prevıously developed at CIAT (no male sterıle gene)

2 1 3 1 AGs from Populatıons wıth a Male Sterıle Gene

Cycles

Durıng 1995 B *at PES we ıncreased seed of 2 and 4 advanced lınes selected from CNA IRAT 5 and CNA IRAT A respectıvely*

Durıng 1996 A *we observed these 6 lınes at LES From each of the 6 lınes we selected 5 ındıvıdual plants*

Durıng 1996 B *we ıncreased seed of the 30 plants at PES to set up a yıeld trıal durıng 1997 A*

Durıng 1997 A *a yıeld trıal was conducted and analyzed 8 lınes presented a hıgh yıeld potentıal and good mıllıng characterıstıcs*

Croppıng Season 1998 A the best lınes were used to set up the VIOAL acıd soıl nursery of INGER LAC to be dıspatched to ours partners and for regıstratıon applıance ın the CIRAD s Rıce catalogue

2 1 3 2 AGs from Populatıons wıth No Male Sterıle Gene

Cycles

The first lowland populatıons used ın recurrent selectıon breedıng had been developed by manual crossıng by the CIAT Rıce Program ın the early 1990s (Drs E P Guımaraes and F Correa) The populatıons were developed from Indıca and Japonıca parents and used to target *blast resistance One gene pool and three populations were registered in the recurrent selection catalog as GPCT 1 PCT 2 and PCT 3 (Appendix 7)*

Fixed lines were selected from GPCT 1 and PCT 3 at the Santa Rosa Experiment Station (a hot spot for blast evaluation)

***In 1996 A** we selected 89 individual plants showing good characteristics for savanna conditions*

***During 1997 A** the 89 progenies were evaluated under savanna acid soil conditions at LES A total of 36 lines were selected Because these lines come from an Indica Japonica recombination Dr J Gibbons from FLAR shows interest in this material as having potential for lowland conditions*

Cropping Season 1998 A

Four (4) lines showing very good adaptation to acid soil condition were evaluated and seed increased at LES

2 1 4 Upland Line Registration

CIAT does not register lines when a specific line does well in a given country the national institution of that country may decide to name and release it for commercial cultivation

CIRAD has a mechanism by which breeders may register a specific material in a catalog The line is named CIRAD (and is also given its local synonym if it is the result of collaborative work) and is registered as working material

History

***During 1996** two advanced lines--CNA IRAT 5 \SA\0\3>127 2 M 2 M and CNA IRAT A\SA\0\3>1 M 2 M 4 M selected from the populations CNA IRAT 5 and CNA IRAT A--were proposed for registration in the CIRAD rice catalog They are registered as CIRAD 410 and CIARD 411 respectively*

***During 1997** the results of a yield trial showed that 3 lines were very promising They were selected from two recurrent populations They were remitted to INGER LAC to be part of the VIOAL trial for acid soil condition*

During 1998 we apply for their registration in the CIRAD rice catalog

3 POPULATION MAINTENANCE THROUGH RECOMBINATION

3 1 Cycles

Until now the upland populations were maintained under irrigated conditions at Palmira But results obtained in Madagascar under similar conditions show that a possible genetic drift toward an increased frequency of the Indica plant type may occur in the population Such a drift can be explained by a more effective cross pollination among genotypes with an Indica background We must remember that the male sterile line used to build up populations is an irrigated Indica line (IR 36 male sterile mutant)

During the 1996 A cropping season *we decided to maintain and increase seed of upland populations under savanna conditions We maintained the following 6 populations CNA IRAT 5/0/4 CNA IRAT A/0/2 CNA IRAT P/1/1 PCT A\0\0\0 PCT 5\0\0\0 and PCT 4\0\0\1*

All male sterile plants were identified harvested individually and their seeds mixed in equal proportions Fertile plants were also harvested individually and their seeds mixed in equal proportions

The populations were sent to CIAT Palmira and stored in a cold chamber until further use by the project or requested by regional NARS breeding programs

During 1997 and 1998 no new maintenance of recurrent germplasm was made

4 POPULATION ENHANCEMENT BY RECURRENT SELECTION

The CIAT rice project emphasizes the enhancement of populations and is phasing out the production of fixed lines for direct release by the NARS of the region The strategy is to develop and enhance gene pools and populations for well targeted traits for use as sources of potential parents by national breeding programs

In the first 2 years of the recurrent selection project we concentrated on introducing germplasm from Brazil (EMBRAPA Arroz e Feijao and CIRAD) and French Guyana and characterizing and mass selecting it From 1995 onward we concentrated our activities on enhancing and developing new populations

4 1 Recurrent Selection Based on S2 Line Evaluation Population PCT-4\0\0\1

4 1 1 Cycles

During 1995 A *at LES 159 S0 fertile plants were selected*
During 1995 B *the S1 generation was grown at PES*
During 1996 A *we started the first recurrent selection cycle*

Evaluation *152 lines of S2 and 2 checks (Oryzica Sabana 6 and CIRAD 409) were evaluated and selected at LES under the Augmented Blocks statistical design (7 Appendix 6)*

Selection *Results of the S2 trial were analyzed and 53 S2 lines were selected*

- ***Recombination In 1996 B*** *at PES remaining seeds from the S0 plants from which originated the selected S2 lines were mixed and grown to develop the recombined enhanced population*
- ***Identification*** *The enhanced recombined population was identified as PCT 4\SA\1\1*

During 1997 A *the population PCT 4\SA\1\1 was grown at LES to go through a second selection cycle*
Harvest of Male-Sterile Plants *Male sterile plants were harvested individually and their seeds mixed in equal proportions to complete the second cycle of recombination of the population selected one time The second cycle of recombination is identified as PCT 4\SA\2\1 Seed will be stored in the cold chamber for future use*

Selection of Fertile Plants *A total of 155 S0 plants were selected and a sample of each S0 seed was stored in the cold chamber*

During 1997 B *the S1 generation was grown at PES and S2 seeds harvested*

Cropping Season 1998 A

From the 155 S2 lines 152 were evaluated during 1998 A at LES in a trial named Augmented Blocs of Federer" (BAF) With a selection index of 42 8% we selected the 65 best lines for recombination from the original S0 selected plants
The recombination will be made at PES during 1998 B by the sowing of the balanced mixture of S0 seed (equal proportion of seed of each S0 plant) and harvest of the seeds produced by the male sterile plants

Multilocal evaluation of S2 s lines
The S2 set of lines was remitted to **Brazil** (EMBRAPA Arroz e Feijao) **Bolivia** (CIAT Santa Cruz) and **Venezuela** (UNILLEZ) for evaluation and selection for line development

4 2 Mass Recurrent Selection for Both Sexes for Hoja Blanca Blast, and Major Agronomic Traits Populations PCT-4\0\0\1 PCT A\0\0\0 and PCT-5\0\0\0

4 2 1 Cycles

During 1995 A *at LES we eliminated at the vegetative stage all plants showing symptoms of leaf blast and HBV At harvest we selected male fertile plants Seeds produced by these plants were the result of fertilization with pollen produced by healthy fertile plants We selected 102 99 and 96 male sterile plants from PCT 5\0\0\0 PCT A\0\0\0 and PCT 4\0\0\1 respectively and their seeds were mixed in equal proportions*

The first mass recurrent selection cycles (selection and recombination) were identified as PCT 5\PHB\1\0 PCT A\PHB\1\0 and PCT 4\PHB\1\1 respectively

During 1996 A *the seed mixture of each population with one mass recurrent selection cycle was grown at LES*

To develop the second recurrent selection cycle the same selection method as that used during 1995 A was applied We selected 304 341 and 442 healthy male-sterile plants fertilized with pollen of fertile healthy plants from PCT 5\PHB\1\0 PCT A\PHB\1\0 and PCT 4\PHB\1\1 respectively and mixed their seeds in equal proportions

The second mass recurrent selection cycles (selection and recombination) were identified as PCT 5\PHB\1\0 PHB\1 PCT A\PHB\1\0 PHB\1 and PCT 4\PHB\1\1 PHB\1 respectively

During 1997 A *the seed mixture of each population with two mass recurrent selection cycles was grown at LES*
To make the third recurrent selection cycle the same selection method as that used during 1995 A and 1996 A was applied (all plants with symptoms of leaf blast and hoja blanca were eliminated during their vegetative stage) We selected 218 253 and 165 healthy male-sterile plants fertilized with pollen from fertile healthy plants from PCT 5\PHB\1\0 PHB\1 PCT A\PHB\1\0 PHB\1 and PCT 4\PHB\1\1 PHB\1 respectively and their seeds mixed in equal

proportions The third mass recurrent selection cycles (selection and recombination) are identified as PCT 5\PHB\1\0 PHB\1 PHB\1 PCT A\PHB\1\0 PHB\1 PHB\1 and PCT 4\PHB\1\1 PHB\1 PHB\1

Cropping Season 1998

Fourth Cycle of Recurrent Selection

The seed mixture of each population with 3 mass recurrent selection cycles was grown at LES To make the fourth recurrent selection cycle the same selection method as that used during 1995 A 1996 A and 1997 A was applied (all plants with symptoms of leaf blast and hoja blanca were eliminated during their vegetative stage) We selected 180 200 and 240 healthy male sterile plants fertilized with pollen from fertile healthy plants from PCT 5\PHB\1\0 PHB\1 PHB\1 PCT A\PHB\1\0 PHB\1 PHB\1 and PCT-4\PHB\1\1 PHB\1 PHB\1 respectively and their seeds mixed in equal proportions The fourth mass recurrent selection cycles (selection and recombination) are identified as PCT 5\PHB\1\0 PHB\1 PHB\1 PHB\1 PCTA\PHB\1\0 PHB\1 PHB\ PHB\1 and PCT-4\PHB\1\1 PHB\1 PHB\1 PHB\1

Selection of S0 fertile plants

30 24 and 55 fertile plants were selected in the respective populations PCT 5\PHB\1\0 PHB\1 PHB\1 PCT A\PHB\1\0 PHB\1 PHB\ and PCT-4\PHB\1\1 PHB\1 PHB\1 for the future development of lines The generation S1 will be grown during 1998 B at PES

5 DEVELOPMENT OF NEW POPULATIONS

The development of new populations is a major activity of the project and provides the main source of new recombined variability for population enhancement and line development We need to be well focused in our choice of variability and recombine in new germplasm as well as in the source of male sterility available (usually a well adapted existing population or gene pool)

In 1996 B we decided to build up at PES two new Japonica populations targeting upland savannas and hillsides The source of male sterility background is the best Japonica population previously developed by the project

5 1 Upland Savanna Population

The idea behind developing that population is to pool the best lines from the CIAT conventional rice breeding project and the commercial varieties released in Brazil Colombia and Bolivia

5 1 1 Cycles

In 1996 B *18 lines were selected according to their performance for early maturity blast and acid soil tolerance and grain quality Male sterile plants from the best adapted upland Japonica population (PCT 4) were used as female parents Each line was crossed with at least four male sterile plants of the population PCT 4*

During 1997 A *at PES each resulting F1 was grown individually evaluated and individual plants selected The F2 seed of the selected F1 plants were bulked in equal proportions Each*

F2 bulk was mixed in balanced proportions to build up a new basic population identified as PCT 11\0\0\0

During 1997 B *at PES the basic population will be recombined once The first cycle of recombination of the basic population will be identified as PCT 11\0\0\1*

Cropping Season 1998

The PCT 11 Population was grown at LES starting its evaluation and selection
95 fertile plants were selected for future line development

Off season 1998
The 95 S1 s were planted at PES and the S2 seed harvested

5 2 Upland Hillside Population

The idea is to develop a population for the Andean highlands of Colombia with early maturity cold tolerance and adaptability to high altitudes (1300 1600 masl)

5 2 1 Cycles

In 1996 B *11 lines--6 from the CIRAD/FOFIFA hillsides program of Madagascar 4 from the CIAT upland savannas program and 1 IRAT line--were selected according to their previous evaluations at high altitudes for early maturity and spikelet fertility*

We used the best adapted upland Japonica population (PCT 4) as a source for male sterility Each line was crossed with at least 4 male sterile plants of PCT 4

During 1997 A *at PES each resulting F1 generation was grown individually evaluated and individual plants selected The F2 seeds of the selected F1 plants were bulked in equal proportions Each F2 bulk was mixed in balanced proportions to build up the new basic population identified as PCT 13\0\0\0*

During 1997 B *at PES the basic population will be recombined once The first cycle of recombination of the basic population will be identified as PCT 13\0\0\1*

Cropping Season 1998

The second cycle of recombination of the population was made at PES and the recombined population will be remitted to M Vales for evaluation at medium to high altitude in the Colombian Andes

6 REGISTERING NEW POPULATIONS

In 1998 two CIRAD populations developed by Dr James Taillebois for yield potential and grain quality were proposed for registration in the Recurrent Selection Catalogue managed by our project The populations were built up in Brazil as part of the collaborative project between CIARD and G4I They were registered as PCIRAD 23 and PCIRAD 24

7 DISTRIBUTING GERMPLASM TO BRAZIL

Breeding lines were sent to EMBRAPA Arroz e Feijao for evaluation and selection Unfortunately for unknown reasons the lines were not delivered to EMBRAPA Rice and Beans Center by EMBRAPA CENARGEN and we don t have enough seed for an other shipment

8 DISTRIBUTING UPLAND RICE GERMPLASM BRED BY RECURRENT SELECTION

Since 1995 we started to release recurrent populations and gene pools to NARS in Latin America West Africa and Asia

USE OF RECURRENT GERMPLASM IN BOLIVIA

The populations were characterized and fertile plants selected to develop fixed lines The results are not yet available

TRIALS

EVALUATION OF S2 LINES FROM THE POPULATION PCT-4\SA\1\1

152 S2 lines selected in the population PCT 1\SA\1\1 were evaluated using a statistical trial named Augmented (or hoonuiahu) designs
The trial is made of 8 blocks in witch are randomly distributed 19 S2 lines and 3 checks (O Sabana 6 O Sabana 10 and CIRAD 409) Each block is fenced by rows of blast spreeders
The same trial was sent to Brazil Bolivia and Venezuela

YIELD TRIAL

8 advanced lines developed by the project were evaluated for different agronomic traits and yield potential

INGER LAC TRIAL

The 1998 VIOAL Suelos Acidos is made of 31 lines from our project and was dispatched to different countries in Latin America
The results in the different countries will be reported by INGER LAC

CHAPTER III

CONVENTIONAL BREEDING FOR UPLAND SAVANNA RICE

1 SAVANNA UPLAND RICE

Marc CHATEL Yolima OSPINA and *Jaime BORRERO*

As was stated earlier we are gradually phasing out most of the activities involved in the development of fixed lines for direct release by NARS

In 1996 B we sent savanna upland lines (F4 and F5 generation) to EMBRAPA Arroz e Feijao for observation and seed increase These lines were sent back to CIAT Palmira in 1997

In 1997 B the lines were seed increased and dispatched to different countries

1 2 Use of CIAT/CIRAD Savanna Lines in Brazil

During our visit to EMBRAPA Arroz e Feijão we had the opportunity to track back the use of CIAT lines in the breeding program of this Center The results of the survey for the 1997/1998 cropping season showed that the CIAT/CIRAD savanna materials continue to be very useful for the Brazilians at each step of their breeding program

The participation of CIAT/CIRAD material in the different trials is expressive 89% in the advanced trials 28 % in the preliminary trials and 19% in the observation trials The main characteristic the Brazilian praised from CIRAD/CIAT material is earlyness plant and grain type

Trial type	Nb of accessions	CIAT/CIRAD	Participation
ObservaçaoEO S	168	26	15%
ObservaçaoEO SF	176	39	22%
Preliminar II	22	5	23%
Preliminar III	24	8	33%
Avançado II	15	13	87%
Avançado M T	2	2	100%
Avançado III	12	11	92%

1 3 Line Release in China

In 1995 we sent China the first set of savanna lines from Brazil and CIAT/CIRAD as part of a collaborative project between the Foods Crops Research Institute (of the Yunnan Academy of Agricultural Science Kunming) and CIRAD Preliminary results are highly promising showing good immediate adaptation and acceptability

In 1997 Dr Tao Dayun told us that the savanna upland line CT 9278 11 14 2 1 M was very promising as parent for the Chinese upland breeding program

In 1998 we were invited to China to a monitoring tour New CT lines are under evaluation in different trials and sites A CIRAD line (IRAT 359) is conducted in field demonstration and is about to be released

1 4 Line Release in Brazil

During the period 1994 1997 4 lines were released in diferent States of Brazil They are CONFIANÇA (States of Roraima and Minas Gerais)
CANASTRA (States of Minas Gerais Goias Tocantins Piaui and Maranhao) MARAVILHA (Goias Mato Grosso Tocantins Para Roraima and Rondonia) and PRIMAVERA (States of Goias Tocantins Maranhao Piaui Mato Grosso and Mato Grosso do Sul)
From these 4 released lines 2 comes from the CIAT breeding program

CANASTRA CT7415 6 5 1 2 B
MARAVILHA CT6516 23 10 1 2 2 B

Three new CIAT lines are very promising candidates to be released in 1999
CNA8172 CT11614 1-4 1 M
CNA8305 CT11251 7 2 M M
CNA8436 CT11251 7 2 M 1 M M

Line Release in Bolivia

A CIRAD line (IRAT 170) is to be released in Bolivia

2 HIGHLAND UPLAND RICE

Marc CHÂTEL and Jaime BORRERO

The Andean Mountains range across Colombia from south to north rising to almost as high as 6000 masl The most important agricultural activity in the mid altitudes (1000 2000 masl) of this area is coffee planted by small farmers This crop takes at least 3 years to reach commercial productivity but in the meantime farmers must use considerable resources to control weeds and prevent erosion With this cropping system in mind CENICAFE has been working on different alternatives for crop diversification to help farmers earn income while waiting for the coffee to reach commercial productivity

Another area of significant agricultural activity by small farmers is in the Department of Cauca southwestern Colombia where new crops are being incorporated into existing cropping systems or new ones developed by CIAT to ensure local food security

2 1 History

To identify upland germplasm adapted to the hillside areas of Colombia the CIAT/CIRAD rice project together with CENICAFE started in 1993 to evaluate 31 selected savanna lines in the heart of the coffee growing area at 1300 masl Climatic data collected at the main site show annual average temperatures ranging from 23 1 to 20 6 °C The monthly average maximum (28 5 °C) occurs in February and the minimum (16 9 °C) in September The germplasm for this region must therefore tolerate cold (i e have high spikelet fertility)

The lines used for the first trial were selected from the savanna upland germplasm collection at CIAT Selection was based on knowledge previously gained from the CIRAD/FOFIFA Highland Rice Project in Madagascar Upland lines must be early maturing and tolerate cold (as measured by panicle fertility)

Results obtained in La Catalina Department of Risaralda showed that the percentages for empty grains ranged from almost 100% to 12% indicating that the germplasm presented variability for cold tolerance Growing period extended to about 150 days after sowing (DAS) compared with 120 DAS under savanna conditions

Selection concentrated on lines with at least 60% fertility The average grain yield of the six best adapted lines was higher than expected ranging from 3775 to 5592 kg/ha

2 2 Coffee Region CENICAFE and CIAO

In 1993 *upland lines developed by CIRAD/FOFIFA for the highlands of Madagascar were introduced to Colombia and seed increased The new germplasm was distributed to CENICAFE and the hillside project at CIAT*

In 1994 *line evaluation started in the Department of Cauca*

In 1995 *the Centro Internacional de Agricultura Orgánica (CIAO) began evaluations at 1600 masl*
The first results were presented at the Conference on Rice for the Highlands in Madagascar in April 1996

In 1997 *in the Coffee Region we identified with CENICAFE and CIAO the line*
CT 10069 27 3 1 4 with excellent adaptation to the mid altitudes Considering the potential of this line over time (average yield grain production of 4 t/ha) we decided to register it in the CIRAD Rice Catalog

Germplasm Introduction *Forty one new lines were introduced from Madagascar to Colombia and seed increased at CIAT Palmira and then dispatched to CENICAFE CIAO and CIAT s hillsides project*

Crosses *Eleven single crosses were made at PES between line CT 10069 27 3 1 4 and 10 lines from Madagascar and CIRAD previously selected for their good performance under highland conditions The F1 generation was grown during 1997 A at PES and the F2 seed sent to our partners*

Cropping Season 1998

Dr Michel Vales from CIRAD arrives at CIAT in August 1997 and took the responsibility of the breeding activities for the Highlands of Latin America For more information about the activities developed during 1998 report to his annual report

2 2 2 Department of Cauca and Central America

In the Department of Cauca the five best lines were selected last year and with one savanna upland check (CIRAD 409) tested this year on farm by five smallholders The best line (Latsidahy/FOFIFA 62 3) from last year's experiment was also the best in this year's on farm trial with an average grain production of 1400 kg/ha at 1600 masl The savanna upland check showed complete sterility at each farm If these results are confirmed in this semester s trials we will register line Latsidahy/FOFIFA 62 3 in the CIRAD Rice Catalog

A survey was conducted with the five farmers to know what are the most desirable characteristics of a rice line Ranking at first and second places respectively are a high number of panicles and a short cycle At the vegetative stage the line that scored as having the highest acceptability was also the one that had the highest yield

The same set of 41 lines introduced from Madagascar was dispatched to the CIAT hillsides project for testing in Colombia and Central America

Cropping Season 1998
Dr Michel Vales from CIRAD arrives at CIAT in August 1997 and took the responsibility of the breeding activities for the Highlands of Latin America For more information about the research activities developed during 1998 report to his annual report

CHAPTER IV

RECURRENT SELECTION FOR LOWLAND RICE

1 INTRODUCTION

The recurrent selection breeding project started by introducing different gene pools and populations developed in Brazil to Colombia by EMBRAPA Arroz e Feijao and CIRAD and to French Guyana by CIRAD

The germplasm was characterized at CIAT Palmira and the best adapted populations were used to develop new populations by introducing new variability This resulted in three populations that were registered in the recurrent selection catalog as PCT 6 PCT 7 and PCT 8 This work was conducted at CIAT in close collaboration with Drs C Martinez and E P Guimaraes

A gene pool was also built up using a different source for the gene of male sterility The gene pool was registered as GPCT 9

Finally a second gene pool developed by CIRAD for temperate climates was registered as GPIRAT 10

Descriptions of these populations and gene pools are presented in Appendix 7

2 FLAR/CIRAD RECURRENT SELECTION Recurrent Selection for Both Sexes for Hoja Blanca

Marc CHATEL James GIBBONS Jaime BORRERO and *Monica TRIANA*

2 1 Introduction

One of FLAR s objectives is to focus on breeding Recurrent selection is an alternative method to conventional breeding and can be incorporated into FLAR s breeding activities

We applied the recurrent selection breeding method to existing germplasm for resistance to the hoja blanca virus vector (rice plant hopper *Tagosodes orizicolus*) and the blast fungus both considered as the most important biotic problems in the tropics

2 2 Cropping Season 1997

Three populations PCT 6\0\0\2 PCT 7\0\0\0 and PCT 8\0\0\0 and the gene pool GPCT 9\0\0\0F were evaluated for resistance to the hoja blanca virus according to the methodology developed by CIAT

Each germplasm matenal and check were sown ın the hoja blanca nursery At 45 days after sowıng the populatıons and checks were evaluated and the number of healthy and dıseased plants counted In the nursery the four orıgınal germplasm materıals showed ıntermedıate susceptıbılıty to hoja blanca (the same level as that of the check Oryzıca 1) After transplantıng PCT 7 and GPCT 9 presented a hıgh number of plants wıth hoja blanca symptoms The two least susceptıble germplasm materıals were PCT 7 and PCT 8 wıth 18% and 19% of ımmune plants respectıvely These plants wıll be recombıned to complete the fırst cycle of recombınatıon

Healthy plants of each germplasm materıal were transplanted separately for recombınatıon wıth male sterıle plants The selected populatıons were PCT 6\HB\0\2 PCT 7\HB\0\0 PCT 8\HB\0\0 and GPCT 9\HB\0\0F The recombıned populatıons after the fırst cycle of selectıon were ıdentıfıed as PCT 6\HB\1\2 PCT 7\HB\1\0 PCT 8\HB\1\0 and GPCT 9\HB\1\0F

2 3 Croppıng Season 1998

Two more recurrent cıcles were performed at PES for PCT 7 and PCT 8
The Populatıon PCT 6 after two cıcles of recurrence was remıtted to Dr Mıchel Vales Thıs enhanced germplasm ıs the startıng poınt of hıs recurrent selectıon breedıng project for partıal Resıstance to rıce blast

3 RECURRENT SELECTION IN COLOMBIA

Hernando DELGADO Marc CHATEL and *Yolıma OSPINA*

Last year we sent four germplasm materıals (PCT 6\0\0\2 PCT 7\0\0\0 and PCT 8\0\0\0 populatıons and the gene pool GPCT 9\0\0\0F) to CORPOICA Regıonal 8 Each materıal was grown separately at LES for recombınatıon characterızatıon and selectıon of S0 fertıle plants for lıne development The four materıals performed well wıth the PCT 6 and PCT 7 populatıons presentıng the best potentıal Next year these populatıons wıll be evaluated for blast resıstance at the Santa Rosa Experıment Statıon

3 1 Croppıng Season 1998

The populatıons were sown ın Vıllavıcencıo and the results are not yet avaılable

4 RECURRENT SELECTION IN COSTA RICA

Randolph C MORERA Marc CHATEL and *Jaıme BORRERO*

In 1996 we sent Costa Rıca the Indıca gene pool GPCT 9 and the populatıon PCT 7 That same year Dr Randolph C Morera of the Natıonal Rıce Program attended the Internatıonal Course on Rıce Recurrent Selectıon Breedıng held at CIAT The germplasm was characterızed under Costa Rıcan condıtıons and maıntaıned by harvestıng male-sterıle and fertıle plants ındependently In 1997 the germplasm was used for lıne development by selectıng S0 fertıle plants

4 1 Croppıng Season 1998

Results not yet avaılable

5 RECURRENT SELECTION IN EL SALVADOR

Ramon Eduardo SERVELLON Marc CHÂTEL and *Jaime BORRERO*

In 1995 we sent three populations (PCT 6 PCT 7 and PCT 8) and the gene pool GPCT 9 to the Centro Nacional de Tecnologia Agropecuaria y Florestal (CENTA) El Salvador

Line development In 1996 141 and 97 S0 fertile plants were selected from the PCT 7 and PCT 8 populations respectively

Population enhancement for grain yield plant type blast resistance and grain quality The recurrent selection method used is based on S2 progeny evaluation and recombination from the remaining S0 seeds One hundred S2 lines from the PCT 7 population were evaluated at two different sites

New population development The population CNA IRAT ES 1/0/2 was developed by introducing 4 lines (X 10 CENTA A 1 CENTA A 2 and CENTA A 5) into the Brazilian population CAN IRAT 4/0/6 The new population has already passed through 2 cycles of recombination and S0 fertile plants were selected during 1997 B

5 1 Cropping Season 1998

Results not yet available

6 RECURRENT SELECTION IN PANAMA

Ariel E JAÉN SANCHEZ Marc CHATEL and *Jaime BORRERO*

In 1996 we sent Panama the Indica gene pool GPCT 9 and the population PCT 7 That same year Dr Ariel E Jaén Sanchez of the Faculty of Agricultural Sciences Universidad de Panama attended the International Course on Rice Recurrent Selection Breeding held at CIAT The introduced germplasm was grown and its characterization started But because of water shortages irrigation was a problem The materials suffered and the work could not be completed Nevertheless from each material the earliest S0 fertile plants were harvested New samples from the recurrent populations were sent to Panama

6 1 Cropping Season 1998

Results not yet available

7 RECURRENT SELECTION IN VENEZUELA

Eduardo GRATEROL Marc CHATEL and *Yolima OSPINA*

After attending the International Course on Rice Recurrent Selection Breeding three populations (PCT 6 PCT 7 and PCT 8) and three gene pools (IRAT 1/420P IRAT MANA and GPCT 9) were sent to Dr E Graterol for characterization under local conditions in Calabozo Guárico State The objective of the characterization was to select the best adapted germplasm to start a recurrent selection program The traits evaluated in each germplasm material were time to flowering tillering ability plant height and disease tolerance (of leaf and neck blast brown spot sheath blight and sheath rot)

Two populations PCT 6 and PCT 7 were selected as the best introduced material to be used as sources of male sterile background to develop two new local populations identified as PFD 1 and PFD 2

PFD 1

Male sterile plants of PCT 6 were crossed with 5 lines

FONAIAP 1	*CT9868 3 2 3 1 4P M 1 1P*
IR62140-48 3 1 2 3	*CT9509 17 3 1 1 M 1 3P M 1*
CT10310 15 3 2P 4 3	

PFD 2

Male sterile plants of PCT 6 were crossed with 4 lines

CT9868 3 2 3 1 4P M 1 1P	*IR62140-48 3 1 2 3*
CT10310 15-3 2P 4 3	*CT9509 17 3 1 1 M 1 3P M 1*

7 1 Cropping Season 1998

Results from Venezuela are not yet available
At CIAT Palmira the built up of the population PFD 2 is ongoing as planed

8 RECURRENT SELECTION IN THE SOUTHERN CONE

8 1 Recurrent Selection in Argentina

Maria Antonia MARASSI Juan E MARASSI Marc CHATEL and *Jaime BORRERO*

In December 1996 we supplied the Universidad de Corrientes with the populations PCT 6\0\0\0 PCT 7\0\0\0 and PCT 8\0\0\0 They were sown at the experimental field of the Company La Arrocera Argentina Villaguay State of Entre Rios They were observed and characterized The populations were multiplied by harvesting male sterile plants The resulting populations were identified as PCT 6\0\0\1 PCT 7\0\0\1 and PCT 8\0\0\1

Fertile plants showing potential were selected and harvested individually for line development From the respective populations 17 14 and 34 S0 fertile plants were selected and given the following identification PCT 6>Arg 1 to 17 PCT 7>Arg 1 to 14 and PCT 8>Arg 1 to 34

For 1997 B we plan to develop a specific population by crossing 6 varieties (IRGA 417 CYPRESS R P 2 TAIM Don Juan INTA and CH 4 7) with male-sterile plants of each population

Argentina has a project for developing the Pampas Region where climatic conditions are similar to those present in Chile along the latitude with Chillan City 400 km south of Santiago The Universidad de la Plata has consequently expressed keen interest in our collaborative effort with Chile The gene pool GPIRAT 10 and the population PQUI 1 together with Chilean and European lines may be useful for the Pampas

8 1 2 Cropping Season 1998

Results from Argentina are not yet available
At CIAT Palmira the built up of the population ARG 3 is going on as planed

8 2 Recurrent Selection in Chile

Santiago HERNAIZ Roberto ALVARADO Marc CHATEL and Jaime BORRERO

In 1996 we sent Chile the Japonica gene pool GPIRAT 10 which was especially developed by CIRAD for temperate climates That same year Dr Santiago Hernaiz from INIA Quilamapu attended the International Course on Rice Recurrent Selection Breeding held at CIAT

In 1997 the gene pool was grown for characterization and selection of the best fertile plants for line development It was also used as a source of male sterility to build up a local population by crossing five Chilean lines (Qui 67108 Diamante Buli CINIA 609 and CINIA 606) with male sterile plants of the gene pool Some of the hybrid seeds were sent to CIAT Palmira for growing the F1 generation (Chile has only one cropping season per year) The F2 seed was shipped back to Chile in September 1997 The basic Chilean population was named PQUI 1\0\0\0

At CIAT Palmira during 1997 B we will conduct the first cycle of recombination to ensure seed increase for future use The first cycle of recombination will be identified as PQUI 1\0\0\1

8 2 1 Cropping Season 1998

Results from Chile are not yet available
At CIAT Palmira the recombination of two Chilean populations is going on as planed

8 3 Recurrent Selection in Uruguay

Fernando PÉREZ DE VIDA Marc CHÂTEL and *Jaime BORRERO*

In 1996 we sent Chile the Japonica gene pool GPIRAT 10 That same year Dr Fernando Perez de Vida from INIA Treinta y Trés attended the International Course on Rice Recurrent Selection Breeding held at CIAT

In 1997 the gene pool was grown for characterization and selection of the best fertile plants for line development It was also used as a source of male sterility to build up a local population by crossing selected Uruguayan lines with male sterile plants of GPIRAT 10

8 3 1 Cropping Season 1998

Results from Uruguay are not yet available
At CIAT Palmira the build up of different populations for this country is going on as planed

9 MAINTAINING GERMPLASM BRED BY RECURRENT SELECTION

Because we manage the catalogue for rice germplasm bred by recurrent selection we also have the responsibility to ensure the presence of sufficient seed in the germplasm bank Because of the sufficient disposability of seed no multiplication was done this year

10 DISTRIBUTING LOWLAND RICE GERMPLASM BRED BY RECURRENT SELECTION

Since 1995 we started to release recurrent selection populations and gene pools to NARS in Latin America and in countries of West Africa Asia and Europe

11 LINE DEVELOPMENT THROUGH ANTHER CULTURE

Zaida LENTINI Marc CHATEL James GIBBONS and *Yolima OSPINA*

In 1994 we introduced the population IRAT CT from French Guyana This population comes from the enhancement of the Indica gene pool GPCNA 18 for anther culture response

11 1 Cycles

One cycle of selection recombination for anther culture response was previously made in Brazil at EMBRAPA Arroz e Feijao This gave rise to the population identified as IRAT CT From 1995 the anther culture laboratory at CIAT processed the population IRAT CT and R2 lines were developed

11 2 Cropping Season 1997

The R2 lines were evaluated by FLAR at the Santa Rosa Experiment Station and five were selected

11 3 Cropping Season 1998

11 4 R2 lines

The 5 lines selected by FLAR were evaluated

12 Conventional breeding

In the framework of the collaboration CIRAD CA rice project have with the Romanian institution FUNDULEA two crosses from Romania were processed at the CIAT anther culture laboratory 100 double haploid lines by cross were produced observed and dispatched back to FUNDULEA We kept a sample of each DH line for seed increase These lines will be sent to Chile Argentina and Uruguay They can also be useful as parents for the hillside upland rice breeding project

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2 Chatel M E P Guimaraes 1995 Recurrent selection in rice gene pools and populations review of present status and progress CIRAD/CIAT Cali Colombia 30 p

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4 Chatel M E P Guimaraes 1996 Upland rice improvement using gene pools and populations with recessive male sterile gene CIRAD/CIAT Cali Colombia 31 p

5 Chatel M E P Guimaraes 1995 Nomenclature system for rice gene pools populations and recurrent selection breeding General use and catalogue registration CIRAD/CIAT Cali Colombia 10 p

6 Chatel M E P Guimaraes 1995 Catalogue registration to manage rice gene pools and populations improvement CIRAD/CIAT Cali Colombia

11 Federer W T 1956 Augmented (or hoonuiaku) designs Hawaiian Planter's Record 55 191 208

12 Chatel et al CIRAD/CIAT/FLAR annual reports 1996 1997

RECIPROCAL VISITS FROM SCIENTISTS

From CIRAD CA to Latin America

Marcel de RAISSAC Deputy Program Leader Cultures Alimentaires
Visit to CIAT and FLAR Headquarters Palmira Colombia

Christian POISSON Rice Project Leader and **Brigitte COURTOIS** Rice Breeder CIRAD/IRRI Collaborative Project
They attended the RENAPA and Third International Upland Rice Breeders Workshop held in Goiania-Goias Brazil

Thomas LE BOURGEOIS weed scientist Participation to the I Seminario Latinoamericano sobre Arroz Vermelho Porto Alegre Brazil September 23 25 1998

Patricio MENDEZ del VILLAR Economist Participation to the I Taller Latinoamericano de Economia del Arroz Quito Ecuador July 14 15 1998
Contacts with EMBRAPA Arroz e Feijao July 16 17 1998

Didier THARREAU Rice Pathologist Visit to CIAT rice Project Palmira September 26 – October 3 1998

From Latin America to CIRAD CA

Fernando CORREA Rice Project Leader and Pathologist
Luis SANINT Director of FLAR
James GIBBONS Breeder of FLAR
Yolima OSPINA Research Assistant of the CIRAD/CIAT Collaborative project

Contacts with CIRAD scientists and participation to the 2 nd International Rice Blast Conference Montpellier France August 4 8 1998

TRAINING

Direction of Thesis

PROGRESO GENETICO MEDIANTE SELECCION RECURRENTE EN LA POBLACION PCT 4 DE ARROZ DE SECANO (Oriza Sativa L) PARA EL ECOSISTEMA DE SABANAS
Yolima Ospina Rey

Posgrado Ciencias Agrarias
Enfasis Genetica y Fitomejoramiento
Universidad Nacional de Colombia sede Palmira Vicerectoria de Ciencias Agrarias

International Courses

BRAZIL
International Course on Rice Breeding
CURSO INTERNACIONAL SOBRE MELHORAMENTO GENETICO DE ARROZ Organized by EMBRAPA Arroz e Feijao Goiania Goias Brazil March 16 28 1998

BELIZE (CRID Net)
INTERNATIONAL TRAINING COURSE IN GERMPLASM MANAGEMENT Organized by CRID Net in collaboration with CRA CARDI CTA and CIRAD/CIAT Belize October 26 30 1998

National course
VENEZUELA
National Course on Rice Recurrent Selection Breeding
CURSO NACIONAL DE SELECCION RECURRENTE EN ARROZ
Organized by DANAC CIRAD CIAT and EMBRAPA Arroz e Feijao San Felipe Yaracuy Venezuela September 21 26 1998

PARAGUAY
First Course on Lowland Rice
PRIMER CURSO AVANZADO SOBRE EL CULTIVO DEL ARROZ DE RIEGO
Organized by the Asociacion de Productores de Arroz de Itapua (APAI) the Ministerio de Agricultura y Ganaderia (MAG) and FLAR
Itapua Paraguay March 24 26 1998

TRIPS

National Trips (Field work)

Marc Chatel Yolima Ospina Jaime Borrero
Villavicencio Coffee Region Cauca Region

International Trips
Jaime Borrero
BOLIVIA
Visit and field work with CIAT/ Bolivia Santa Cruz de la Sierra January 12 16 1998

BRAZIL
RENAPA Goiania Goias March 9 13 1998

Third IURBW Goiania Goias March 10 12 1998
International Rice Course Goiania Goias March 16 18

Yolima Ospina
BRAZIL
RENAPA Goiania Goias March 9 13 1998
Third IURBW Goiania Goias March 10 12 1998

FRANCE
2 d International Rice Blast Conference Montpellier France August 4 8 1998

Marc Chatel
USA
Rice workshop Reno Nevada February 28 March 5 1998
BRAZIL
RENAPA Goiania Goias March 9 13 1998
Third IURBW Goiania Goias March 10 12 1998
International Rice Course Goiania Goias March 16 18
FLAR Monitoring Tour States of Rio Grande do Sul and Santa Catarina
March 19 22
PARAGUAY
First Course on Lowland Rice Itapua Paraguay March 24 26 1998
BOLIVIA
Presentation of FLAR to the Producers Associations and the Centro de Investigacion Agricola Tropical (CIAT Bolivia) Santa Cruz de la Sierra Bolivia March 25 26 1998
FRANCE
2 d International Rice Blast Conference Montpellier France August 4 8 1998
CIRAD s September days Montpellier France August 31 September 4 1998
CUBA
I Congreso Nacional de Arroz and I Encuentro Internacional de Arroz La Habana Cuba June 9 11 1998
VENEZUELA
National Course on Rice Recurrent Selection Breeding
San Felipe Yaracuy Venezuela 21 26 September 1998
PERU
I Seminario –Taller Internacional Semilla Insumo Esencial en la Agricultura Moderna
Chiclayo Peru 11 13 May 1998

CHILE
Visit to INIA Quilamapu Meeting with seed producers and millers Chillan Chile and INIA Headquarters Santiago Chile 14 16 May 1998
ARGENTINA
Visit to Partners Universidades de Corrientes y de Tucuman
Corrientes and Tucuman Argentina 17 22 May 1998
CHINA
Visit to the Food Crops Research Institute Yunnan Academy of Agricultural Sciences Kunming China September 9 17 1998
Field visit to Upland Hillside breeding sites Simao Menglian Menghai and Jinghong
BELIZE
Field visit and International Course on Germplasm Management Belize October 26 31

COSTA RICA
FLAR Steenng Comity meeting San Jose Costa Rica November 3 5

VISITS FROM LAC SCIENTISTS

From BRAZIL to CIAT Colombia and CIRAD France
Dr Elcio P Guimaraes EMBRAPA Arroz e Feijao Goiania Goias February 3 6 1998

(1) Planing of the Second International Workshop on Rice Recurrent Selection Breeding to be held in September 1999
(2) Planing of the Venezuelan Course on Rice Recurrent Selection Breeding to be held in Venezuela September 21 26 1998
(3) International Rice Blast Conference and contacts with CIRAD scientists at Montpellier Headquarters August 3 10 1998

From COLOMBIA to CIRAD France
Yolima Ospina Research Assistant of the CIRAD/CIAT Collaborative Rice Project

International Rice Blast Conference and contacts with CIRAD scientists at Montpellier Headquarters August 3 10 1998

From VENEZUELA to CIAT Colombia
Dr Eduardo Graterol DANAC Venezuela February 2 –6 1998

(1) Planing of the Venezuelan Course on Rice Recurrent Selection Breeding To be held in Venezuela September21 26 1998
(2) Field work Build up at CIAT Palmira of the Venezuelan Population PFD 1
(3) Research activity planing for recurrent selection in Venezuela

SPECIAL SERVICES FOR NARDS

Anther culture of two crosses from Romania

Seed increase of lines from Romania for temperate climate ecosystems (Cold tolerance)

Second recombination of the Chilean populations PQUI 1\0\0\1 and PQUI 1\Co\0\1
Sinthetization of the population PFD 2 for Venezuela
Sinthetization of populations for Uruguay
Sinthetization of the population PARG 3 for Argentina

92535

OUTPUT 1 ENHANCED GENE POOLS

B Hillsides Upland Rice Conventional and Recurrent Selection Breeding

Michel Valès Marc Henri Châtel Jaime Borrero

Subproject Collaborative Rice Project between CIAT and CIRAD

Executive Summary

The Collaborative Program of CIRAD and FOFIFA (National Center for Research Applied to Rural Development Madagascar) created a new type of upland rice for the highlands When Marc Henri Chatel first used this material on Colombian hillsides the preliminary results were so promising (CRH 1996) that a subprogram for indigenous farmers of the Andean region was developed In August 1997 Michel Vales came from Madagascar to CIAT to reinforce this activity

We used recurrent selection to obtain suitable material for pedigree selection During 1998 A we recombined once more the PCT 13 population which has a broad genetic base and was developed by Marc Henri Chatel We made the first crosses to constitute a new population with a narrow genetic base (a new concept)

We introduced 61 F_1 from CIRAD/FOFIFA s Upland Rice Program for the Highlands (URPH) in 1997 B During 1998 A we obtained 57 promising F_3 populations

During 1998 A five F_2 populations were evaluated in the Cauca region (with the collaboration of the CIAT Hillsides Project) and in the Caldas district (with the collaboration of the Centro Internacional de Agricultura Organica (CIAO) Selection however will be possible only in the Caldas populations

Also in 1998 A 40 lines from the URPH were evaluated by CIAT s Hillsides and Participatory Research Projects and the CIAO At one site Indian farmers selected three varieties that had higher yields than the check and had 99% fertility Information still has to come from other sites

A collaborative CIRAD/CIAT/CIAO project has been submitted for funding from the Instituto Colombiano para el Desarrollo de la Ciencia y la Tecnologia Francisco Jose de Caldas (COLCIENCIAS) A new collaborative program with the University of Tucuman Argentina will begin for upland rice for cold highlands for Indian farmers We also expect to develop contacts with Honduras (through CIAT) and Cuba

Presentation

Because no traditional upland rice varieties were available for cold highlands CIRAD in collaboration with FOFIFA developed upland rice lines for this environment Because these new lines were highly successful in some countries (CRH 1996) Marc Henri Châtel tried them out on Colombian hillsides The preliminary results were so promising that a subprogram for indigenous farmers of the Andean region was developed

Background

In 1993 Marc Henri Chatel introduced the upland lines developed by CIRAD/FOFIFA for the Madagascan highlands to Colombia and multiplied seed The new germplasm was distributed to CENICAFE and the CIAT Hillsides Project In 1994 line evaluation started in the Department of Cauca Colombia

In 1995 CIAO started evaluations at 1600 masl and the preliminary results were presented by Marc Henri Chatel at the Conference on Rice for the Highlands held in Madagascar in April 1996 (CRH 1996)

In June 1998 CIAO submitted a proposal of a CIRAD/CIAT/CIAO collaborative project to COLCIENCIAS

For more information consult the 1997 annual report written by Marc-Henri Châtel former coordinator of this collaborative project (Châtel 1997) In July 1998 Michel Vales became coordinator he had spent 3 years with the URPH in Madagascar and 1 year with CIRAD in Colombia

Activity 1 Recurrent Selection Population Development

Michel Valès Marc Henri Châtel Jaime Borrero

Objectives

- Recurrent selection is an excellent method for obtaining improved materials for pedigree selection and thus elite varieties Marc-Henri Châtel therefore created a population with a broad genetic base for the Colombian Andean highlands (1300-1600 masl) In 1998 A the population was recombined once more

- Recurrent selection of populations with a broad genetic base is a long term activity We also made other populations but with a narrow genetic base for the medium term Work with F_2 populations is short term (Figure 1 A 1 1)

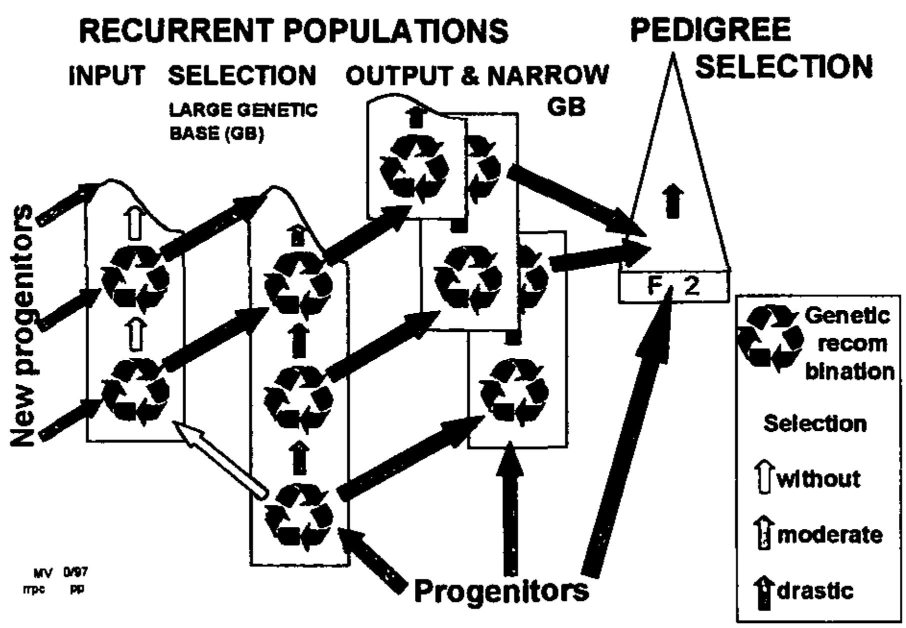


Figure 1 A 1 1 General Breeding Program Schema

Materials

- **Population with a broad genetic base**

In 1996 B 11 lines that is 6 from the URPH 4 from the CIAT upland savannas project and 1 IRAT line were selected according to their previous evaluations at high altitudes for early maturity and fertility

Marc Henri Chatel used the best adapted upland Japonica population (PCT-4) as a source for male sterility Each line was crossed with at least four male sterile plants of PCT-4

During 1997 A at the Palmira Experiment Station (PES) each resulting F_1 generation was grown individually evaluated and individual plants selected The F_2 seeds of the selected F_1 plants were bulked in equal proportions Each F_2 bulk was mixed in balanced proportions to build up the new basic population identified as PCT 13\0\0\0

During 1997 B at PES the basic population was once more recombined The first cycle of recombination of the basic population was identified as PCT 13\0\0\1

- **Population with a narrow genetic base**

The idea (see Output 3 B Activity 2 Specific Germplasm Development) is to choose the minimum number of progenitors according to the main selection objectives and without considering their other characteristics

			Final genetic participation
Source population for male sterility		PCT 13\0\0\1	25%
Progenitors for			18 75% × 4
	Yield	CT10069 27 3 1-4	
	Grain quality	CT10069 27 3 1-4	
	Grain quality	Inca	
	Cold tolerance	Inca	
	Durable resistance to blast	IRAT 13	
	Complete resistance to blast	Oryzica Llano 5	

Methods and Results

Population with a broad genetic base

During 1998 A the PCT 13 was recombined once more after male sterile plants were harvested We obtained the basic population which was identified as PCT 13\0\0\2

Population with a narrow genetic base

During 1998 A the first cycle of crossings was done

Female		×	Male
PCT 13\0\0\2 male	[ms]	/	CT10069 27 3 1-4
sterile plants	[ms]	/	Inca
	[ms]	/	IRAT 13
	[ms]	/	Oryzica Llano 5

Prospects

Population with a broad genetic base

Two recombinations however are not enough so we will do another during 1998 B

- **Population with a narrow genetic base**

During 1998 B we expect to do a second cycle of crossings

Female	x	Male
CT10069 27 3 1-4	//	[ms] / Inca
Inca	//	[ms] / IRAT 13
IRAT 13	//	[ms] / Oryzica Llanos 5
Oryzica Llanos 5	//	[ms] / CT10069-27 3 1-4
[ms] / CT10069 27 3 1-4	//	IRAT 13
[ms] / Inca	//	Oryzica Llanos 5
[ms] / IRAT 13	//	CT10069 27 3 1-4
[ms] / Oryzica Llanos 5	//	Inca

With this method the contribution of each progenitor is high so that drastic selection within the population is possible without reducing genetic variability and yet obtaining results for the medium term (Figure 1 A 1 1)

We need an experiment site with basic infrastructure and personnel to conduct a recurrent selection for hillside environments The CIAT station at Popayán (1700 masl average annual temperature of 17°C) is a possibility Another possibility is ICA s experiment station near Bogota (2400 masl)

Activity 2 Conventional Breeding

Michel Valès Marc Henri Châtel Jaime Borrero Edmundo Barrios[1] Alberto Melendes[1]
Ramón Dario Zuluaga[2] Sigifredo Salgado Echeverry[2] Alberto Roa[3]

(1)CIAT Hillsides Project (2)CIAO (3)CIAT Participatory Research Project

Introductions of Fixed and Segregating Materials from URPH Madagascar
During 1998 A we introduced into Colombia 40 F_1 80 F_7 F_{11} and 71 varieties

Prospects

We expect to obtain traditional upland rice varieties from Japan through our contact Dr Kazutoshi Okuno of the National Institute of Agrobiological Resources (NIAR) Kannondi 2 1 2 Tsukuba Ibaraki 305 8602 Japan e mail <okusan@abr affrc go jp> We first contacted him during the International Symposium on Rice Germplasm Evaluation and Enhancement held during August 30–September 2 1998 in Stuttgart Arkansas USA

We also expect to receive very soon improved segregating materials from URPH Madagascar

Seed Increase (Palmira)

Materials

Sixty one F_1 lines were introduced from Madagascar on August 17 1997 and sown in the greenhouse to obtain F_2 seeds The resulting 57 F_2 families were left to head and reach grain filling stage before the self pollinated progeny were rogued

Prospects
Balanced mixtures of F_3 seeds will be sent to FOFIFA (Madagascar) who is co owner of this material CIRAD CFR (France) FLAR (Palmira Colombia) and Upland Rice/Hillsides of CIRAD/CIAT (Colombia)

During the first steps of pedigree selection we need to control factors such as soil type cultural practices levels of fertilization and planting density and to ensure close follow up We are studying the possibilities to working at either the Popayan Experiment Station (1700 masl) or the ICA experiment station near Bogota (2400 masl)

Evaluating and Selecting from Five F_2 Populations with the Collaboration of the CIAT Hillsides Project and CIAO

Materials
Five F_2 populations are evaluated

CT14870 M	IRAT 104 / CT10069 27 3 1-4
CT14875 M	(HD (IRAT 112 / APURA) / IAC25) / CT10069 27 3 1-4
CT14871 M	LASTIDAHY / FOFIFA 62 3 // CT10069 27 3 1-4
CT14873 M	LASTIDAHY / FOFIFA 62 2 // CT10069 27 3 1-4
CT14878 M	LASTIDAHY / FOFIFA 62 1 // CT10069 27 3 1-4

Methods
They are evaluated in two Andean areas

Pescador 1500 masl (Cauca CIAT Hillsides Project) F_2 #1 and #2
Santa Rosa CIAO Park 1700 masl (Caldas) F_2 #1 #3 #4 and #5

Each population was formed by 5000 plants

Results
The Pescador trial failed because of unusual climatic conditions resulting from the phenomenon El Nino and weed pressure The F_2 in Santa Rosa looks promising and we are waiting for the crop to mature before selecting

Prospects
Selected progenies will be evaluated in 1999 A during the pedigree selection trial

Because of the loss of the F_2 populations in Pescador we are now looking for an experiment site with better trial conditions similar to those of the Palmira Experiment Station

Field Trials with CIAT Partners (Hillsides and Participatory Research Projects) and CIAO Materials

Forty two lines from Madagascar (CIRAD/FOFIFA) were evaluated

1 LATSIDAHY X FOFIFA 62 2
2 LATSIDAHY X FOFIFA 62 1
3 C106 F17 9 2 3
4 C8 F129 3 8 6 7
5 C29 F267-4 8 5 4
6 C2 F21 3 2 7-4
7 C115 F26 9 3 8
8 C8 F46 7 4 6
9 C30 F53 6 2 5 7
10 C8 F230 6 6 5 7
11 C119 F142 3-4
12 C8 F363 8 7 6 8
13 C30 F250-4-4 3 7
14 C8 F322 8 8 5 3
15 FOFIFA 116 X SHIN EI
16 C102 F70 9-4 9
17 C8 F169 6 3 2 6
18 LATSIDAHY X FOFIFA 62 3
19 C29 F353 7 7 9 3
20 C29 F267-4 8 5 4
21 FOFIFA 151 no 4128 = CIRAD 391
22 FOFIFA 152 no 4129 = CIRAD 392
23 FOFIFA 153 no 4130 = CIRAD 393
24 FOFIFA 154 no 4131 = CIRAD 394

	# 95 6 Madag	Generation	Cross	Genealogy
27	129	F8	PRA 221	FOFIFA 114 / DANIELA
25	17	F7	PRA 308	PRATAO PRECOCE / DANIELA
26	119	F8	PRA 218	IRAT 146 / DANIELA
28	139	F9	PRA 122	IRAT 353 / SHIN EI
29	152	F9	PRA 211 bis	DANIELA / AS 25
30	162	F9	PRA 212 bis	DANIELA / DOURADO PRECOE
31	177	F10	PRA 102	IRAT 351 / SHIN EI
32	189	F10	PRA 102	IRAT 351 / SHIN EI
33	202	F10	PRA 106	FOFIFA 116 / SHIN EI
34	207	F10	PRA 106	FOFIFA 116 / SHIN EI
35	212	F10	PRA 112	KAGOSHIMA HAKAMURI / SHIN EI
36	227	F10	PRA 112	KAGOSHIMA HAKAMURI / SHIN EI
37	232	F10	PRA 116	IRAT 351 / NOIKU 1517
38	257	F11	PRA 2	LATSIDAHY / SHIN EI
39	271	F11	PRA 29	LATSIBAVY / DANIELA
40	286	F11	PRA 51 bis	DANIELA / IAC 25
41	291	F11	PRA 58	IAC 25 / SHIN EI
42				IRAT 351/ SHIN Ei 3

The best performing lines in earlier trials conducted in the Department of Cauca and Coffee Region Colombia

Methods and results

The 42 introduced lines were evaluated in plots of two rows 3 m long with another row for the check in different sites during semester 1998 A

CIAT Hillsides Project at Pescador 1500 m (Cauca)

This evaluation was conducted in a cropping system/agronomic trial that included rice bean rotation However the trial failed because of unusual climatic conditions (El Nino) and weed pressure

CIAT Participatory Research Project involving a Committee for Local Agricultural Research (CIAL its Spanish acronym)

Chambimbe 1200 m (near Buenos Aires Cauca)

Sowing was carried out in April 3 1998 For six indigenous farmers three of the lines were better than the check The check which was the best line of the previous year also came from Madagascar Latsidahy / FOFIFA 62 3 The three lines were

No 10	C8 F230 6 6 5 7	Latsidahy / FOFIFA 62
No 29	F9 211 bis 125	Daniela / RS 25 T
No 30	F9 212 bis 162	Daniela / Dourado Precoce

The three lines have a high level of fertility (99%) and their yield so far looks good but when the farmers evaluated the lines on July 30 it was too late for them to appreciate the yield of the earlier lines

Betania 1480 masl (Caldono)

Cattle ate the rice

Altamira 2450 masl (Totoro) (very cold)

In this indigenous community the lines were sown in a poor field on April 1 1998 Rain fell only during the first two weeks but some lines were still alive on July 30 indicating they had high drought and cold tolerance We are waiting for more information

CIAO

CIAO Park 1700 masl (Santa Rosa de Cabal Caldas)

The trial appears to have been successful (July 31 1998) but because it is now being harvested we are waiting for the data

Castillo 1800 masl (Santa Rosa de Cabal Caldas)

This site was inaccessible when we tried to visit (July 31 1998) So we are waiting for information

Alto de la Cruz 2000 masl (Santa Rosa de Cabal Caldas)

The first planting was killed by weeds A second sowing was programmed for August Again the weed problem is clearly important

Prospects
Although we are waiting for data the collaboration between breeding and agronomic activities clearly must be improved

Forty three lines from Madagascar (CIRAD/FOFIFA) are being evaluated in Pescador in 1998 B (sowing date was September 9 1998) This evaluation was conducted in a cropping system/agronomic trial that included rice bean rotation

Activity 3 Transfer and Adaptation of Results

Michel Valès Marc Henri Châtel Jaime Borrero

Identification of Partners in Central America and the Andean Region
We are enhancing collaboration with the Hillsides and Participatory Research Projects of CIAT for the Colombian highlands

In Colombia a project in collaboration with CIAO has been submitted for funding by COLCIENCIAS

A collaborative project with the University of Tucuman Argentina will begin on upland rice for cold hillsides for indigenous communities

We have also made promising contacts with Honduras (through CIAT) and Cuba (Chatel 1997)

Germplasm Release to Identified Partners
No new releases occurred during 1998 A but we have good prospectives (see above)

92536

OUTPUT 1 ENHANCED GENE POOLS

C Identify and Select for Useful Traits with the Aid of Molecular Markers

Cesar Martinez

Executive summary

The *Oryza* wild species represent a potential source of new alleles for improving yield quality and stress resistance of cultivated rice We have initiated the implementation of a marker assisted breeding program using the Advanced Backcross QTL method that will lead to the development of improved cultivars Two improved rice cultivars (Bg90 2 and Lemont) were crossed to *O rufipogon* and *O barthii* respectively 300 BC2F2 (Bg90 2/*O rufipogon*) and 326 BC3F2 (Lemont/*O barthii*) familes were developed and evaluated for main agronomic traits including grain yield under irrigated conditions at CIAT Palmira Transgressive segregation for grain yield was detected in the Bg90 2/*O rufipogon* cross with several BC2F2 families having between 5 and 25% higher yield than Bg90 2 The results were confirmed from replicated trails of BC2F3 families Molecular analysis using 90 RFLPs and 14 microsatellites from the RF Cornell map indicated positive association between yield and QTLs located on chromosomes 2 3 5 and 12 In the Lemont/*O barthii* cross data from 326 BC3F2 showed that several families yielded up to 30% more than Lemont Molecular analysis based on 54 microsatellites from the RF Cornell map indicated positive association between yield increase and QTLs located on chromosomes 1 and 7 Besides 300 BC2F2 families from the cross between Caiapo an upland cultivar from Brazil and *O rufipogon* were evaluated in an upland site in Villavicencio Colombia with experiments designed to compare performance with and without weed (pasture) competition Using single point interval and composite interval analysis 7 putative QTL were detected for yield 5 for maturity 7 for plant height and 25 for yield components Several other interspecific populations including crosses with *O glaberrima* are in the process of development or field evaluation
Results suggest that both *O rufipogon* and *O barthii* have genes that can contribute to yield increase in cultivated rice

Twenty one wild species and two cultivated species (*O sativa* and *O glaberrima*) represent ample genetic variability for rice breeding programs It has been suggested that the *Oryza* wild species represent a potential source of new alleles for improving yield quality and stress resistance of cultivated rice However limited use of this variability has taken place Barriers still exist in effectively utilizing genes from wild species and molecular mapping techniques are needed to readily detect these new alleles in segregating populations

CIAT started in 1994 a collaborative project aimed at characterizing and utilizing wild rice species for the improvement of cultivated rice We here report on progress made in the identification of QTLs associated with yield increase in *O rufipogon* and *O barthii*

Materials and Methods

Three improved rice cultivars (BG90 2 Caiapo and Lemont) were crossed *to O rufipogon* and *O barthii* respectively Few plants (2 3) in each of the wild species were hybridized to several plants of each of the improved cultivars (recurrent parents) Single crosses were obtained and grown in the greenhouse at CIAT in 1994 Three F_1 hybrid plants were backcrossed to the improved cultivar 153 198 BC_1F_1 seeds were obtained per cross combination The resulting BC_1F_1 plants were transplanted (30x50 cm) and evaluated based on phenotype negative phenotypic selection for undesirable agronomic traits (spreading plant type excessive shattering long awns dark color grains high sterility etc) was used to narrow the selection down to the best (30 50) individuals Each selected BC_1 individual was back crossed again to the recurrent parent and approx 30 BC_2F_1 seed were sown in wooden trays in the screenhouse and later on transplanted (30x40 cm) under irrigated conditions A negative phenotypic selection was applied again and best individuals per cross were selected and harvested individually to generate BC_2F_2 seed 300 BC_2F_1 plants were selected in the BG90 2/ O *rufipogon* and Caiapo/ O rufipogon crosses for field testing whilst high sterility was found in the Lemont / O *barthii* cross Therefore another BC to Lemont was done and 326 BC_3F_1 plants were selected for field testing as BC_3F_2 families

Field trials

The 300 BC_2F_2 families derived from the cross BG90 2/ O *rufipogon* and the 326 BC_3F_2 families from the cross Lemont / O *barthii* were planted in replicated yield trials in CIAT Palmira under irrigated conditions Transplanting (20x30) was done and a completely randomized design with two reps 2 row plot 5 m long was used Data on 12 agronomic data including plot yield/family were taken on 10 randomly selected plants/plot

Based on yield potential and good agronomic traits 38 BC_2F_2 families from the cross BG90 2 / O *rufipogon* were selected and further evaluated for grain yield a completely randomized design with four reps 4 row plot and 5 m long was used

Two different experiments were carried out with the 300 BC2F2 families from the cross Caiapo/ O rufipogon cross these experiments were designed to compare performance with and without weed(pasture) competition under upland conditions in Villavicencio Direct seeding was done and a completely randomized design with two reps two row plots 5 meter long was used Data on 12 agronomic traits including grain yield were taken

Molecular characterization

DNA of young leaves from the parent genotypes the BC_2F_2 and BC_3F_2 families was extract by the Dellaporta Method (McCouch et al 1988) modified for PCR assay by CIAT Biotechnology Research Unit (unpublished data) Parental surveys filters containing O *rufipogon* O *barthii* BG90 2 and Lemont were prepared (Fig 1) using five restriction enzymes (EcoRI EcoRV HindIII XbaI and DraI) Approximately 140 markers from the rice molecular framework linkage map were selected at 10 20 cM intervals throughout the genome A set of 78 mapped rice microsatellite markers developed at Cornell University was also used to complement the RFLPs in QTL analysis

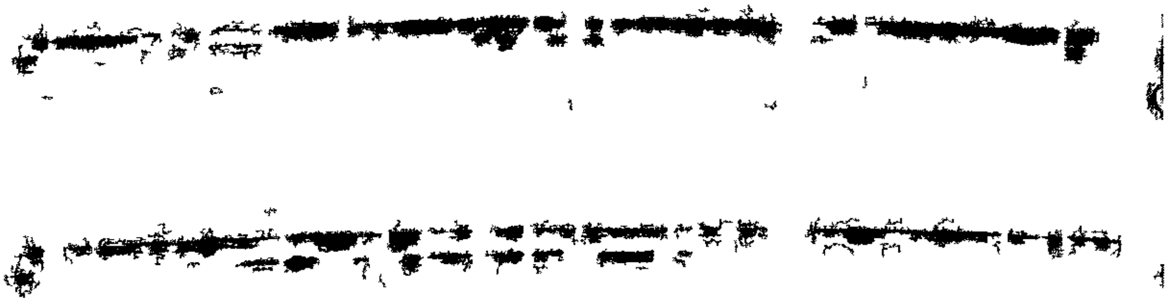


Fig 1 Screening the BC_3F_2 families of the Lemont x O *barthii* cross First two lanes correspond to O *barthii* and Lemont respectively For the evaluation of polymorphism 78 microsatellites were amplified at an annealing temperature of 55 C in a PTC 100 Programmable Thermal Controller with hot bonnet (MJ Research Inc) The primers were radioactive labeled using the T4PNK method From those 78 microsatellites 54 were selected For the display of each microsatellite a BIO RAD SequiGen equipment was used The gels (6% polyacrilamide) were loaded four times with an interval of 20 or 30 minutes allowing the evaluation of the whole mapping population with one gel (modified method of Chen et al 1997)

The population from the cross Caiapo/ O rufipogon was analyzed at Cornell University using a total of 125 markers

RESULTS AND DISCUSSION

The distribution of grain yield (kg/ha) of 300 BC_2F_2 families (BG90 2/O *rufipogon*) derived from plot yields of 40 plants (20 plants/row x 2 row) averaged over two replications is shown in Fig 2

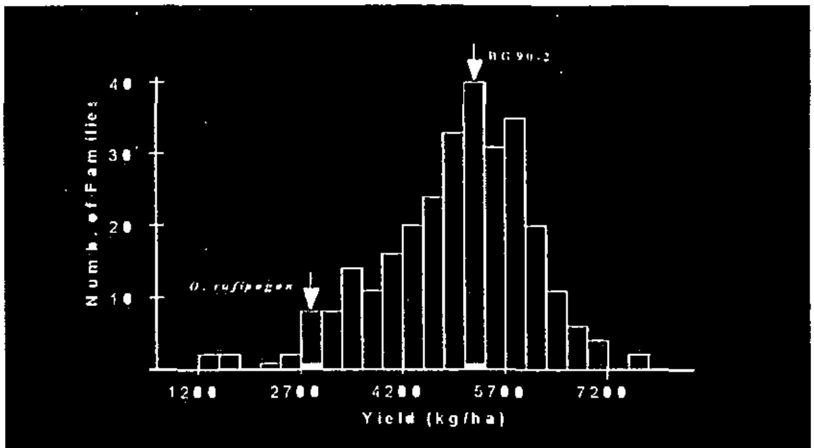
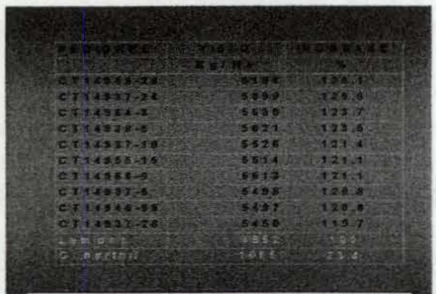


Fig 2. Frequency distribution of yield for the Advanced Backcross BC2F2 families of the O. rufipogon/BG90-2 cross

Transgressive segregation can be observed with several lines (11%) having between 5 and 25% higher yield than the recurrent parent BG90 2 (Fig 2) Transgressive segregation for other yield components was also observed Grain yield data taken on 38 BC_2F_3 families (Table 1A) confirmed results obtained in the BC_2F_2 generation

Based on the 88 RFLP and 14 microsatellites from the RF Cornell framework map screened on 300 BC_2F_2 families putative linkages were identified with yield and yield components from replicated data available for the whole mapping population Preliminary results using one way anova and t test indicate associations between markers and yield on chromosome 2 similar to J Xiao and S McCouch results (Fig 3) No linkage for yield was detected on chromosome 1 as reported by J Xiao and S McCouch Other associations were also identified for yield and the various yield components (Fig 3) These data from different groups working with diverse recurrent parents suggest that DNA introgressed from *O. rufipogon* can contribute positively to yield in elite rice cultivars.

The distribution of grain yield (kg/ha.) of 326 BC_3F_2 families (Lemont / *O. barthii*) derived from plot yields of 40 plants (20 plants/row x 2 row) averaged over two replications is shown in Fig. 4.



GENOTYPE	YIELD Kg/Ha	INCREASE %
CT[illegible]	[illegible]	126.1
CT14537-24	[illegible]	[illegible]
CT[illegible]	5630	123.7
CT[illegible]	5621	123.6
CT[illegible]	5526	121.4
CT[illegible]	5514	121.1
CT[illegible]	[illegible]	121.1
CT[illegible]	[illegible]	120.8
CT[illegible]	[illegible]	[illegible]
CT[illegible]	5450	119.7
Lemont	[illegible]	[illegible]
O. barthii	[illegible]	[illegible]

Table 1. Yield increase in some BC2F2 families from the Lemont/ O.barthiii cross

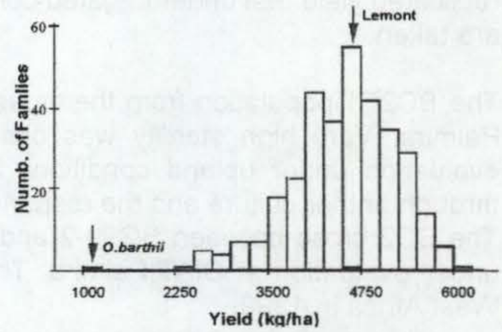
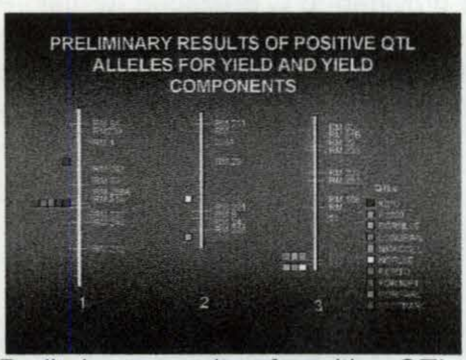


Fig 4. Frequency distribution of yield for the Advanced Backcross BC2F2 of the O. barthii/ Lemont cross

Transgressive segregation can be observed, with several lines having up to 30% higher yield than Lemont (Table 1). Based on the 54 microsatellites from RF- Cornell framework map screened on 326 BC_3F_2 families derived from the cross Lemont / *O. barthii* putative linkages were identified. Preliminary results using one way anova and t-test indicate association between markers and yield on chromosome 2 similar to Xiao et al. and on chromosome 7 (Fig. 5).



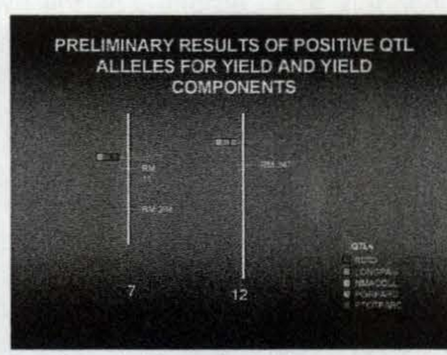


Fig. 5. Preliminary results of positive QTL alleles for yield and yield components in the Lemont / *O.barthii* cross.

Sixty percent of the RLFPs and 90% of the SSLPs were polymorphic for Caiapo and O. rufipogon.The BC2F2 population from this cross was evaluated using 82 RFLPs and 43 SSLPs and correlations among traits was evaluated at the 5 and 1 percent level of significance. Using single point, interval and composite interval analysis, 7 putative QTLs were detected for yield, 5 for maturity, 7 for plant height, and 25 for yield components.
Results suggest that both O. rufipogon and O. barthii have genes that contribute to yield increase in cultivated rice.

OTHER ACTIVITIES:
Agronomic evaluation of 346BC2F2 families from the cross Oryzica3/*O.rufipogon* under irrigated conditions at CIAT.Palmira. Grain yield data showed that several lines outyielded Oryzica 3. Molecular characterization needs to be done.

Seed multiplication and agronomic evaluation of 350 doubled haploid lines from the cross Lemont/ *O barthii* These lines were developed from BC3F1 plants and evaluated under irrigated conditions at CIAT Palmira Bulked seed from each line was harvested for further evaluation in a replicated yield trial

Two hundred ninety six BC2F2 families from the cross Bg90 2/ *O barthii* are being evaluated in a replicated yield trial under irrigated conditions at CIAT Palmira Data on main agronomic traits are taken

The BC2F1 population from the cross Progresso/*O barthii* was planted and evaluated at CIAT Palmira Very high sterility was observed and 320 fertile plants were harvested for further evaluation under upland conditions in a replicated yield trial This population was also run through anther culture and the response in terms of callus production has been very good
The BC2 cross between BG90 2 and *O glaberrima* was completed and the BC1 population is under evaluation at CIAT Palmira The F2 seed will be shared with WARDA for evaluation in West Africa in 1999

One hundred advanced lines were received from WARDA s rice interspecific hybridization project (*O sativa/O glaberrima*) and evaluated under upland conditions at La Libertad Experiment Station Villavicencio in collaboration with M Chatel and Yolima Ospina Data on main agronomic traits disease reaction tolerance to acidic soil conditions and grain yield were taken 15 lines were selected for further evaluation in 1999

Seed of aprox 600 F3 lines from several interspecific crosses (BG90 2/*O rufipogon* Oryzica 3/*O rufipogon* and Lemont/*O barthii*) was provided to C Bruzzone for field evaluation in Santa Rosa and Palmira On the other hand seed of 305 BC2F2 families from the cross BG90 2/*O rufipogon* was sent to WARDA and evaluated in an observational nursery in Ivory Coast Many lines were selected by WARDA s breeders for further evaluation in several ecologies next year

Funding proposals and concept notes for Colciencias the European Community CIDA and South Korea were developed and presented to potential donors
Main collaborators
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OUTPUT 1 ENHANCED GENE POOLS

D Evaluation of Interspecific Populations

D Co Co

Carlos Bruzzone

Interspecific crosses between cultivated rice (*O sativa*) and some wild species (*O rufipogon O glaberrima O barthii* and *O minuta*) was initiated in CIAT in 1994 with the goal of increasing the yield potential and broadening the genetic base of cultivated rice The strategy is based upon the use of wild germplasm through a backcrossing scheme and the identification of desirable transgressive alleles linked to moleculars markers that could be used in a marker aided selection process Progress made in this project is reported elsewhere

With the aim to identify useful lines suitable for our partners two populations of lines developed by this project are being evaluated for a number of traits using a conventional breeding approach

During 1998A 332 individual plants out of 82 lines from a population of 329 BC_3F_2 lines developed from a cross between Lemont (US tropical japonica variety) and *O barthii* were selected based on their general phenotypic appearance (plant panicle and grain type) An additional group of 62 lines was selected from the same population based upon their yield performance The resulting 494 BC_3F_3 lines were planted in May and then evaluated for their reaction to the rice Hoja Blanca virus (RHBV) days to flowering and yield performance in Palmira and for fungal diseases reaction in Santa Rosa All lines were rated as susceptible to RHBV while 237 lines (48%) had scores lower than or equal to 3 in both leaf and neck blast evaluations Data on yield performance are been collected and evaluations for grain quality will be carried out in order to select those lines that combine superior yielding ability with grain quality and a good level of rice blast resistance This material can be useful for temperate areas and after further characterization will be distributed through INGER to partners in the Southern cone

One hundred sixty two BC_3F_2 lines from a cross between *O rufipogon* and Oryzica 3 (Colombian indica variety) were selected for their yield performance in 1998A Then were planted in May and evaluated for their reaction to the rice Hoja Blanca virus (RHBV) days to flowering and yield performance in Palmira and for fungal diseases reaction in Santa Rosa Twenty three lines were rated as resistant to RHBV and 35 had a leaf blast score lower than or equal to 3 Only three lines combined resistance reactions to RHBV and blast (Table 1) Yield and grain quality evaluations in Palmira are under way This material is more suitable for the tropical areas and after further characterization will be distributed to partners in the tropical zone

Introgression of new plant type into LAC s gene pools

IRRI has developed a new rice plant type (NPT) which reportedly is characterized by having fewer but all fertile tillers larger panicles more and heavier grains darker green leaves lower spikelet sterility higher harvest index and therefore higher yield than modern semi dwarf rice varieties However two semester evaluations carried out in 1996 at CIAT Palmira failed to show any yield advantage of this NPT over the best Latin American (LAC) varieties suggesting that the NPT lines are not yet ready for use under LAC conditions (CIAT Rice Project Annual Report 1996) Nevertheless these lines posses some interesting agronomic characteristics such as heavier grains longer grain filling period late leaf senescence and sturdy stems that could be incorporated into our locally adapted germplasm

Therefore a crossing program was initiated in 1996 and 215 simple crosses were made to introgress some of these traits into LAC germplasm (CIAT Rice Project Annual Report 1996) The NPT lines and the LAC parents that were used in those crosses are shown in the Table 2 and 3 respectively In 1998 this program was continued by crossing the F_1 s to LAC adapted genotypes and 433 crosses were made involving 226 155 and 52 crosses to tropical irrigated temperate irrigated and upland rice parents respectively Some of these crosses involved a backcross to the F_1 LAC parent but most of them were hybridized to a new set of LAC parents listed in Table 4

We will use anther culture to accelerate the development of fixed lines from upland and temperate crosses which can be highly responsive to this technique in order to make available to partners this new genetic material as soon as possible

Table 1 Disease reaction and agronomic traits of BC_3F_2 lines from a cross between *O rufipogon* and Oryzica 3 scored as resistant to both RHBV and blast in 1998

Genotypes	Palmira 98A RHBV	Santa Rosa 98[1]							
		BL1	BL2	LSc	BS	NBl	GD	Ht (cm)	days Flow
CT 14544 1 M	3	4	3	3	1	3	1	80	97
CT 14545 6 M	3	3	3	3	3	3	1	81	102
CT 14545 15 M	3	4	3	3	1	3	1	86	96
Checks									
CICA 8	7	5	4	1	1	7	3	108	
Oryzica 1	5	5	5	3	5	7	3	96	
O Llanos 5		4	3	1	1	1	3	102	

[1]Standard evaluation system for rice where 0 = highly resistant and 9 = highly susceptible
BL = leaf blast LSc = leaf scald BS = brown spot NBl = neck blast GD = grain discoloration

Table 2 IRRI s new plant type lines used as parents in F1 crosses

Lines	**Parents**
IR 65564-44 2 3	Takaneshiki / Bali Onkjev
IR 65598 27 3 1 2P	Shen Nung 89 366 / Genhah Wangkal
IR 65600 32 4 6 1	Shen Nung 89 366 / Ketan Lumbu
IR 65600 61 3 1 3	Shen Nung 89 366 / Ketan Lumbu
IR 65600 96 1 2 2	Shen Nung 89 366 / Ketan Lumbu
IR 66158 38 3 2 1	Shen Nung 89 366 / Bali Ontjev
IR 66160 5 2 3 2	Shen Nung 89 366 / Jimbrug
IR 66160 134 1 3 1	Shen Nung 89 366 / Jimbrug
IR 66165 24 6 3 2	Shen Nung 89 366 / Aren
IR 66738 118 1 2 2P	*Shen Nung 89 366 / Soponjono*

Table 3 Genotypes used as parents in F1 crosses to IRRI s new plant type lines

Genotype denomination	**Ecosystem**	**Origin**
BULI INIA	Temperate irrigated	Chile
PANDA	Temperate irrigated	Chile
INDIO	Temperate irrigated	Chile
ESTRELA	Temperate irrigated	Brasil
INCA (CT 6749 36 CA 2)	Temperate irrigated	Chile France
Lemont	Temperate irrigated	USA
Cypress	Temperate irrigated	USA
H 305 84	Temperate irrigated	Argentina
H 144 7	Temperate irrigated	Argentina
QUILLA 64129	Temperate irrigated	Chile
INIA Tacuari	Temperate irrigated	Uruguay
CT 11623 3 3 CA 17	Upland	CIAT
CT 6241 17 1 5 1	Upland	CIAT
CAIAPO	Upland	Brazil
CT 6515 18 1 3 1 2	Upland	CIAT
IR 54742 15 28 38-4 2 1 1	Tropical irrigated	IRRI
CT 9506 12 10 1 1 M 1 2P M 1	Tropical irrigated	CIAT
IR 54741 1-48 5 5 2	Tropical irrigated	IRRI
CT 9868 3 2 2 3 2P M	Tropical irrigated	CIAT
ICTA MOTAGUA	Tropical irrigated	Guatemala
ORYZICA CARIBE 8	Tropical irrigated	Colombia
IRGA 411 1 6 1F 1A	Tropical irrigated	Brazil
EMBRAPA 7 TAIM	Tropical irrigated	Brazil
CT 9737 5 2 1 2-4P M	Tropical irrigated	CIAT
CICA 8	Tropical irrigated	Colombia
IRGA 410	Tropical irrigated	Brazil
MORELOS A 88 (3?)	Tropical irrigated	Mexico
INIAP 12	Tropical irrigated	Ecuador
P 1274 6 8M 1 3M 1 (5685)	Tropical irrigated	CIAT
IRGA 318 11 6 9 2B (IRGA 417)	Tropical irrigated	Brazil
Oryzica Llanos 5	Tropical irrigated	Colombia
AMISTAD 82	Tropical irrigated	Cuba
ORYZICA YACU 9	Tropical irrigated	Colombia
PERLA	Tropical irrigated	Cuba
PNA 1004 F4 33 1	Tropical irrigated	Peru
CT 5746 18 11 2 2 2X	Tropical irrigated	CIAT
CT 9162 12 6 2 2 1	Tropical irrigated	CIAT

Table 4 Genotypes used as parents in top crosses to F1 s involving a IRRI s new plant type parent

Genotype denomination	Ecosystem	Origin
CT 10192 5 1 2 2T	Tropical irrigated	CIAT
CT 10310 15 3 2P-4 3	Tropical irrigated	CIAT
CT 10323 29-4 1 1 1 T 2P	Tropical irrigated	CIAT
CT 11275 3 F4 18P 2	Tropical irrigated	CIAT
CT 11280 2 F4 12P 5	Tropical irrigated	CIAT
CT 11782 F4 3 1P 3	Tropical irrigated	CIAT
CT 8008 3 5 1P M	Tropical irrigated	CIAT
CT 8008 3 5 8P M 2P	Tropical irrigated	CIAT
CT 8198 4 2 1P 1X	Tropical irrigated	CIAT
CT 8238 6 13 1P 1X	Tropical irrigated	CIAT
CT 8444 1 8 11P 1X	Tropical irrigated	CIAT
CT 8455 1 13 1M 2P	Tropical irrigated	CIAT
CT 9509 17 7 1P 1PT	Tropical irrigated	CIAT
CT 9748 13 2 1 M M 1 1	Tropical irrigated	CIAT
EPAGRI 108 (CT 8008 16 31 3P M)	Tropical irrigated	Brazil
EPAGRI 109	Tropical irrigated	Brazil
FB0007 3 1 6 1 M (Fedearroz 50)	Tropical irrigated	Colombia
PSBRc 2	Tropical irrigated	Philippines
WAB 99 1 1	Upland	WARDA
CT 11623 13 M 5 2 3 1 M	Upland	CIAT
CT 11862 2 7 2 1 1 1 M	Upland	CIAT
CT 11888 5 3 2 4 M 1 M	Upland	CIAT
CT 11891 2 2 5 2 M 1 M	Upland	CIAT
CT 11891 2 2 7 M	Upland	CIAT
TOX 1011-4 A2	Upland	IITA
TOX 1739 101 4 2	Upland	IITA
Vsta/Lbnt//L201/3/Skbt	Temperate irrigated	USA

OUTPUT 1 ENHANCED GENE POOLS

E Iron Toxicity Tolerance Screening

C Bruzzone (CIAT) J Gibbons (FLAR) and J Lozano (CIAT)

In order to evaluate breeding lines for tolerance to iron toxicity tolerance we are continuing to refine a method using acid soil from Santander de Quilichao in concrete tanks In 1998 we lined the tanks with black plastic to reduce leaking We divided the tanks into 8 equal sub-tanks The 8 tanks were flooded 4 and 2 weeks before planting at the same time of planting or two weeks after planting with two replications Thirteen different varieties were planted including resistant intermediate and susceptible checks Visual scoring was done at ten day intervals beginning at 30 DAP (days after planting) until 50 DAP The results of the evaluations at 40 DAP are shown in Table 1 BR IRGA 410 and PNA 343 showed consistent susceptibility whereas CICA 8 Metica 1 and CT 9155 2 were resistant The results of the test in 1998 however did not match with data from other tests For example the known tolerant Oryzica 1 showed an intermediate reaction and the known susceptible JUMA 58 was also intermediate We suspect that the lack of homogeneity of the soil and loss of iron due to leakage are contributing to the lack of consistent results Therefore we are unable to draw any conclusions from this test about the specific treatments

Table 1 Reaction to iron toxicity of rice genotypes at four different flooding treatments observed 40 days after planting in concrete tanks filled with Quilichao soil

Entry Number	Genotypes	Reaction to flooding treatments[1] 4 WBP[2]	2 WBP	At planting	2 WAP	Genotypes mean
1 t replication						
1	IRGA369 28	5	7	3	5	5 0
2	CT 9155 2	1	5	1	3	2 5
3	EMPASC 101	3	3	5	5	4 0
4	BR IRGA 410	5	7	7	7	6 5
5	EPAGRI 108	3	5	5	5	4 5
6	METICA 1	5	5	3	3	4 0
7	BR IRGA 409	5	7	5	5	5 5
8	ORYZICA 1	3	7	3	5	4 5
9	JUMA 58	3	5	5	5	4 5
10	CICA 8	1	5	3	5	3 5
11	PNA 343	7	5	7	7	6 5
12	P2053	7	5	3	5	5 0
13	P4127	5	5	5	3	4 5
1 st replication mean		**4 1**	**5 5**	**4 2**	**4 8**	
2 d replication						
1	IRGA369 28	5	5	5	7	5 5
2	CT 9155 2	7	5	3	3	4 5
3	EMPASC 101	7	5	5	5	5 5
4	BR IRGA 410	5	7	7	7	6 5
5	EPAGRI 108	5	5	5	5	5 0
6	METICA 1	3	3	3	5	3 5
7	BR IRGA 409	5	5	6	7	5 8
8	ORYZICA 1	7	5	5	5	5 5
9	JUMA 58	3	5	3	3	3 5
10	CICA 8	3	3	5	5	4 0
11	PNA 343	5	5	7	7	6 0
12	P2053	5	3	3	7	4 5
13	P4127	5	3	3	5	4 0
2 d replication mean		**5 0**	**4 5**	**4 6**	**5 5**	
Overall treatment mean		**4 5**	**5 0**	**4 4**	**5 2**	

[1] Standard evaluation system for rice 0 = highly tolerant 9 = highly susceptible
[2] WBP = weeks before planting WAP = weeks after planting

42539

OUTPUT 1 ENHANCED GENE POOLS

E The Use of Anther Culture and *In Vitro* Culture for Enhancement of Gene Pools

1 Use of anther culture to fix enhanced traits in backcrossed populations from rice X wild species hybrids

A Mora (IP4) Z Lentini (SB2 IP4) C Martinez (SB2)

- Three hundred eighty six lines from crosses and advanced backcross populations of Bg90/ *O rufipogon* Bg90/ *O glaberrima* and Progresso/ *O barthii* were processed through anther culture from January to September 1998
  About 100 plants per each line were planted in the field Thirty plants per line were selected by plant type and anthers of the selected individual plants were cultured in the laboratory
  Total of 1 711 green plants were produced
  Doubled haploids lines will be selected and evaluated for disease resistance and agronomic characteristics and analyzed by molecular markers
  The main objective of this activity is to determine if doubled haploids lines could be used to accelerate the introgression of QTL s associated with high yield potential from the wild species into the selected *O sativa* varieties

2 Use of anther culture (AC) to accelerate the development of breeding populations of FLAR

A Mora (IP4) Z Lentini (SB2 IP4) J Gibbons (FLAR) D Gonzalez (FLAR)

Total of 134 crosses were cultured from October 1997 to August 1998

- Plants per each line were first selected based on plant type earliness and grain length (as predicted by the floret size) and the anthers from all the selected plants were cultured by cross
- These crosses yielded a total of 7 732 plants
- Eight hundred fifteen doubled haploids plants generated from the crosses on 97 were selected both at Palmira Station for plant and grain type and at Santa Rosa Experimental Station for blast resistance Total of 46 (5 6%) doubled haploid lines were included in the VIOFLAR and will be sent to Brazil Paraguay and Uruguay for field evaluations

3 Somaclonal variation to increase genetic variability of advanced breeding lines

A Mora (IP4) Z Lentini (SB2 IP4) Rosa Alvarez/ G Torrealba (Fonaiap Venezuela) J Holguin (Fedearroz Colombia) D Gonzalez/ J Gibbons (FLAR)

- Somaclonal variation is being tested to determine if it is possible to improved some of the traits of selected advanced breeding lines
- Previous work conducted in the rice project indicated the generation of somaclones with increased blast resistance
  Traits of interest include one of the following improve grain milling and cooking quality rice hoja blanca resistance sogata resistance or blast resistance

Eight advanced lines selected by the breeding program of Fonaiap (Venezuela) and Fedearroz (Colombia) were culture *in vitro*

- Immature inflorescences (prior meiosis) were cultured to induced callus formation
- Callus was either transfer onto regeneration medium to induce the differentiation of plants or was subcultured on the same medium to increase the likehood of spontaneius mutation during the in vitro culture (somaclonal variation)
- Total of 3 758 somaclones for the Venezuelan National Plan of Rice leaded by Fundarroz with the participation of Fonaiap Danac and la Universidad de los Llanos were produced
- 4 440 somaclones plants for Fedearroz Colombia were generated
- The somaclones plants are being grown in the field
- The S1 seed (first self of the original somaclone S0) will be harvested and S1 plants evaluated for grain quality Disease resistance will be evaluated on the S2

Development and training staff

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Project proposals/ concept notes *prepared*

- Gene flow analysis at the ecological frontier Setting risk assessment for genetically modified plants Donor BMZ Participating institutions CIAT Federal Biology Institute Germany ICA and Institute Von Humbolt (Colombia) UNALM (Peru) DANAC (Venezuela) UCR (Costa Rica) Responsible Z Lentini W Roca D Debouck
- Plant genetic engineering to incorporate tolerance to iron toxicity and increase iron nutrional value in rice Donor Technical cooperation by the government of Japan Participating institutions CIAT and IDEA (Institute of Advanced Studies) Venezuela Z Lentini (CIAT) R Rangel (IDEA)
- Genetic transformation of venezuelan rice varieties for resistance to rice hoja blanca virus Donor Polar Participating institutions CIAT Rutgers University Danac and IDEA Venezuela Responsible Z Lentini (CIAT) Nilgun Tumer (Rutgers) Maria Angelica Santana (IDEA)

92560

OUTPUT 2 PHYSIOLOGICAL BASIS FOR RICE TRAITS UNDERSTOOD

A Weed control enhanced by the use of new genotypes and practices

A 1 Tolerance to submergence

C Bruzzone (CIAT) J Gibbons (FLAR) and J Florez (CIAT)

The competitiveness of a species whether it be rice or weeds is greater when the density (number of plants per square meter) is higher and the period of competition is longer When weeds emerge later than the crop their competitiveness is reduced (Fischer 1997) If the establishment of weeds in the field can be retarded or reduced the competitive advantage of the rice crop with respect to the weeds will be increased

Fisher (1997) has pointed out that anaerobic conditions impede germination emergence and establishment of weed species in the rice crop Under direct seeding conditions early flood establishment can retard and reduce weed development thereby permitting rice plant development under less weed competition

Rice varieties differ in their capacity to develop under submerged conditions Tolerance to submergence could be useful both under direct seeding of dry or pre germinated rice seed

A 1 1 Pre germinated seed

James Gibbons (FLAR) and Jaime Florez (CIAT Colciencias)

The pre germinated system gives the rice an advantage over weeds due to early crop establishment The use of varieties that could be rapidly flooded after seeding would constitute a valuable advantage to reduce weed competition in an integrated crop management

In 1995 132 genotypes identified as submergence tolerant at IRRI were evaluated at CIAT under anaerobic conditions Twenty lines were identified which showed more than 50% emergence after 14 days of submergence below 2 5 cm of soil and 4 5 cm of water from pre germinated seeds (radical length of 0 3 1 0 cm) The susceptible cultivars IR50 and CICA 8 showed only 11% emergence under the same conditions (CIAT Rice Program Annual Report 1995)

In 1997 11 genotypes from the above 20 were selected based on more acceptable grain characteristics for further testing They were pre germinated (2 5mm radical length) covered with 3 4 mm of soil and then flooded to a depth of 10 cm for 15 days after planting (DAP) Under these conditions these lines once again showed a high percentage of emergence (Table 1) In the same trial the commercial cultivars EPAGRI 109 O Llanos 5 FEDEARROZ 50 IRGA 417 and EPAGRI 108 showed more than 85% emergence in comparison to the check (without a flood) (Table 2) This indicates that in the LAC germplasm there exists an appreciable level of submergence tolerance that could be used in an integrated crop management plan

Various complementary studies are underway to refine certain aspects of this concept These include testing different depths of irrigation different times between planting and permanent flood and the effect of these practices on the weeds *Echinochloa spp* and red rice

A 1 2 Dry seed planting

C Bruzzone (CIAT) J Gibbons (FLAR) and J Florez (CIAT)

Preliminary studies at CIAT using early flooding at 3 different DAPs and 2 depths of planting with dry seeds give indications that it is possible to develop planting systems which reduce the effect of weed competition in the first stages of crop development using varieties with submergence tolerance

Emergence of *E colona* and IR8 planted at 2 5cm depth (similar to the depth recommended for commercial planting with grain drills) in dry soil (then watered in) was completely inhibited by establishment of a flood of 13 cm deep 2 DAP and maintained for 20 DAP Under these same conditions however the cultivar FR13A showed 35% emergence When the flood was applied 4 DAP 22% of the *Echinochloa* emerged while 90% and 100% emergence was observed in IR8 and FR13A respectively Emergence of *Echinochloa* increased up to 76% when the flood was applied at 6 DAP (Figure 1)

With depth of seeding increased to 5 cm the emergence percentage decreased for all materials tested (Figure 2) The emergence of *Echinochloa* was the following 0 with flood applied 2DAP 22% with flood at 4 DAP and 41% when submerged at 6 DAP IR8 emerged 0 0 and 30% respectively while the tolerant FR13A showed the highest emergence of 0 45% and 70% at the three DAPs

These results suggest that early flooding (2 4 DAP) of dry seeded rice could contribute to significantly lower the weed population of *E colona* in the early stages of crop establishment when the rice is most susceptible to the effects of weed competition Submergence tolerance is a characteristic which combined with the other required traits of modern rice cultivars would be very desirable for utilization in a crop management program which included early flooding for reduced weed competition

Other experiments are being established to determine the influence of different flood depths on emergence and the response of genotypes that combine submergence tolerance with enhanced elongation capacity under flooded conditions

Table 1 Response of rice genotypes to submergence under a flood of 10 cm during 10 days after planting Pre germinated seed

Genotype	Emergence[1]	Dry weight[1]	Height[1]	Origin[1]
JC 148	95	131	100	India
Taothabi	93	126	94	India
FR 13A	92	118	104	India
Ta Hung Ku	92	167	126	China
Backoia	91	141	117	India
ASD 1	89	123	107	India
Awaria Katica	89	103	93	India
Guan Yin Tsan	89	108	106	China
Jawegan	87	119	90	Indonesia
Rojofotsy 738	78	90	97	Madagascar
Karutha Vanan	72	76	71	Sri Lanka

[1] Given as percent of treatment without flooding

Table 2 Response of LAC cultivars to submergence under a flood of 10 cm during 10 days after planting Pre germinated seed

Genotype	Emergence[1]	Dry weight[1]	Height[1]	Origin[1]
EPAGRI 109	104	111	110	Brasil
O Llanos 5	94	116	115	Colombia
Fedearroz 50	91	106	116	Colombia
IRGA 417	90	118	100	Brasil
EPAGRI 108	89	130	118	Brasil
IR 8	85	116	105	Filipinas
FONAIAP 1	85	103	92	Venezuela
CR 750	81	112	124	Costa Rica
Perla	80	103	125	Cuba
Cimarron	75	88	95	Venezuela
Amistad 82	72	77	100	Cuba
CR 5272	71	81	83	Costa Rica
IR 50	67	89	85	Filipinas
O Yacu	65	81	72	Colombia
IR 74	63	77	79	Filipinas
BR IRGA 410	63	62	70	Brasil

[1] Given as percent of treatment without flooding

Figure 1 Seedlıng survıval 27 days after seedıng (DAS) of *E colona* and two rıce varıetıes planted at 2 5 cm depth wıth a 13 cm water layer placed at three dıfferent DAS

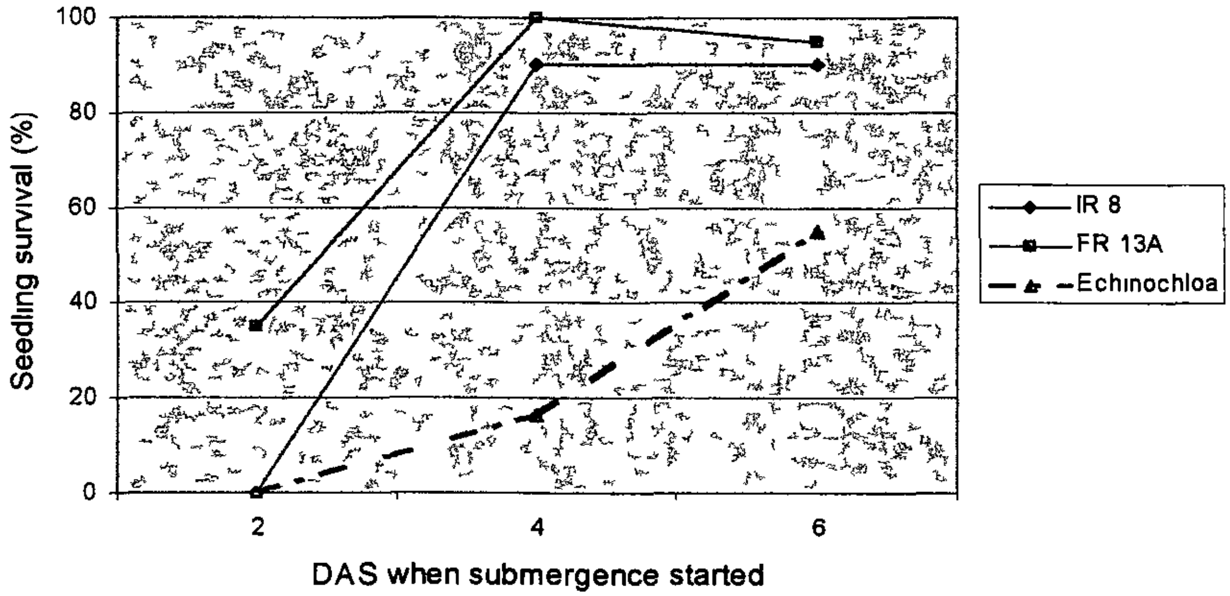
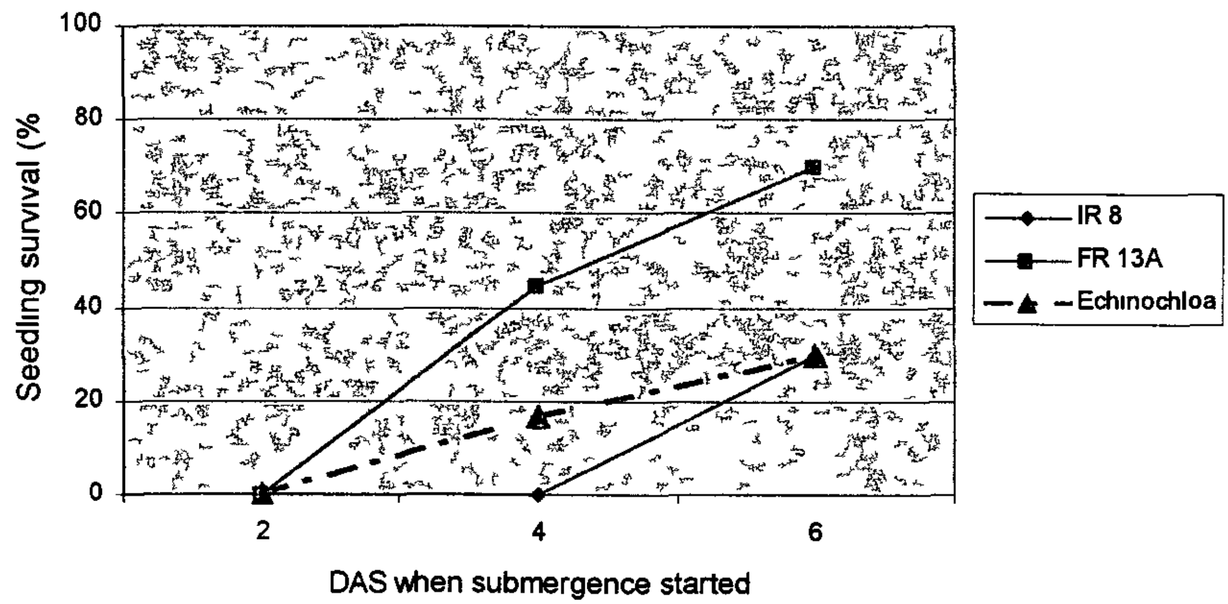


Figure 2 Seedling survival 27 days after seeding (DAS) of *E colona* and two rice varıeties planted at 5 0 cm depth with a 13 cm. water layer placed at three dıfferent DAS



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OUTPUT 3 RICE PESTS AND GENETICS OF RESISTANCE CHARACTERIZED

Fernando Correa

Executive summary

Understanding population dynamics of the blast pathogen for the development of breeding strategies for durable blast resistance is in progress We have detected genetic structure and virulence changes within blast pathogen populations over time Greater gains in virulence were associated with changes in genetic structure within existing genetic lineages Blast populations with narrower spectrum of virulence tend to predominate compared to those with broader spectrum Frequency of pathotypes lineages as well as expression of certain virulences seems to be associated with environmental changes Expression of all virulences detected in the population and a high blast pressure was observed for a March planting date Planting breeding nurseries in this month is critical to avoid escapes to infection Rice lines exhibiting complete and complementary blast resistances have been identified in the field and greenhouse These lines are being used in proper combinations or crosses to assure accumulation of resistance genes in a common background Fifteen rice lines combining two resistance genes (Pi 1 and Pi 2) that exclude the entire blast pathogen population in Colombia and other countries continue being stable under greenhouse and field evaluations in the F7 generation These genes are being incorporated in commercial cultivars of LAC The blast resistance of cultivar Oryzica Llanos 5 exhibited since the time of its release in 1989 continues stable Partially compatible isolates detected in the past few years did not increase in aggressiveness under greenhouse inoculations In collaboration with the BRU we are identifying blast resistance genes in the cultivar Oryzica Llanos 5 using PCR based cloning with degenerated primers that are making possible the identification of resistance gene analogs in rice Blast resistance with potential novel genes has been identified in the wild rice species *O rufipogum* and *O glaberrima* Identification of these genes with the aid of molecular markers will be initiated soon The possibility offered by induced mutations for generating resistance to the different genetic lineages of the blast pathogen is being explored Mutants with resistance to three genetic lineages were identified in 1998

A Rice Blast

Activity 1 Characterization of blast pathogen populations

1 1 Monitoring changes in the genetic structure and virulence diversity of the rice blast pathogen over time

Norma Flor Fernando Correa

Development of rice cultivars with blast resistance has been the preferred means to control the diasease however resistance breakdown occurs normally in very short periods of time (1 to 3 years) after cultivar release The great variability in virulence exhibited by the blast pathogen is associated with the quick breakdown of resistance Understanding the population dynamics of the blast pathogen is a very important process in the development of breeding strategies for durable blast resistance We have been studying the blast pathogen population structure over time in Colombia by characterizing race composition virulence frequencies and genetic structure using DNA fingerprinting

Monitoring changes within blast pathogen populations is a very important step for understanding plant pathogen interactions and mechanisms that might be leading to resistance breakdown as well as in identifying new sources of resistance to be used in breeding programs (See annual report 1997)

One of the ongoing activities in our section relates to the monitoring of changes in the genetic and virulence diversity of blast pathogen populations collected in single cultivars over time Characterization of collections of blast samples from different commercial cultivars since 1988 were initiated in 1997 We report here the results for the populations collected in the susceptible commercial cultivars Cica 9 (not grown commercially) and Oryzica 1 (still grown commercially) Figure 1 shows a phenogram of the population (66 isolates) based on the virulence spectrum of the isolates on 16 rice cultivars after performing a correspondence multiple analysis With a similarity of 96 1 within a group the blast population was classified in 5 virulence groups and 22 different pathotypes Groups 1 2 and 3 included the largest number of isolates Most isolates from group 1 were recovered from the cultivar Cica 9 between 1989 1996 and belong to the genetic lineages SRL 1 and SRL 2 reported before

Group 2 is also formed mainly by isolates collected from cultivar Cica 9 These isolates were recovered only after 1993 and were classified as lineage SRL-6B (Figure 1 Table 1) Group 3 isolates were recovered mainly from cultivar Oryzica 1 over the entire period (1988 1996) and all of them belong to lineage SRL 6 The other two groups were represented for few isolates and were characterized by exhibiting a larger spectrum of virulence than isolates in the other groups Isolates within group 4 were classified as lineages SRL 2 and SRL 6B The unique isolate found in group 5 was identified as lineage SRL-4 The most virulent isolates (SRL-6B) all recovered from cultivar Cica 9 infected 12 out of 16 rice cultivars inoculated while the least virulent (SRL 1) infected three

In general isolates recovered after 1993 exhibited a broader spectrum of virulence on the 16 rice cultivars inoculated in greenhouse studies (Table 1) These isolates were found in small frequency Isolates with a narrow spectrum of virulence are found during the entire period of collection and in larger frequency than isolates exhibiting more virulence The population recovered from cultivar Cica 9 was more diverse pathotypically than the population from Oryzica 1 In general the larger diversity observed is associated with the expression of virulence on this cultivar by isolates from different lineages in time and not by the gain in virulence of isolates detected in 1989 Most isolates detected in 1989 are lineage SRL 1 while isolates with a larger spectrum of virulence (SRL 6B) were detected after 1993 On the other hand gain in virulence was observed in isolates recovered in time from cultivar Oryzica 1 Most isolates were classified into the genetic lineage SRL 6 including those with narrow and broad spectrum of virulence The latter group appeared later in time while those with less virulence were detected mainly in 1988

Analyses of the virulence diversity indicate that pathotypes within each virulence group are highly similar with only small or single differences in virulence This means that a pathotype within a group may become another pathotype detected within that group by the gain or loss of a single virulence The smallest similarity was found within group 4 (87% similarity) The smallest virulence similarity (60%) between groups was detected for groups 1 and 2 with group 5 This value indicates however that a large number of virulence factors are shared among the blast isolates of the population studied The cultivars Oryzica Llanos 5 and C101 LAC (Pi 1) were resistant to all isolates

The genetic structure of the same blast population collected on the cultivars Cica 9 and Oryzica 1 *was studied using* the MGR DNA fingerprinting technique Using a correspondence multiple analyses and a similarity of 91 4% within a group the population was classified in eight genetic groups with 61 haplotypes (Figure 2) It is again observed a tendency of grouping by the cultivar of origin of the isolate and a preliminary classification of the SRL lineages based on visual observations of the DNA electrophoretic patterns
Groups 1 and 2 have the largest number of isolates while four groups have single isolates All isolates in groups 3 and 4 and most in group 1 were recovered from cultivar Cica 9 All isolates but 1 in group 2 came from Oryzica 1 Isolates originating from cultivar Cica 9 in genetic group 3 (SRL 1) were collected between 1989 and 1991 while isolates in groups 4 and 7 (SRL B) were found after 1993

A summary of the diversity of the blast populations collected on the two rice cultivars between 1988 1996 is presented in Table 2 There were more haplotypes than pathotypes More pathotypes were unique to a genetic group while a few were found in at least two genetic groups Pathotypes within genetic group 4 were the most virulent This group infected in total 13 out of 16 cultivars and one isolate was able to infect 12 of the cultivars Isolates from genetic group 3 were the *least virulent infecting only 3 cultivars*

A spatial representation of the population studied according to the genetic groups determined by multiple correspondence analyses and the preliminary classification on the known genetic lineages (SRL) based on visual observations of the fingerprints is presented in Figure 3 All *haplotypes found in* the 8 genetic groups are included A high correspondence between the groups and the know genetic lineages is observed Groups 1 6 and 8 which were previously classified as lineage SRL 2 appear very close Group 3 representing lineage SRL 1 is alone but close to lineage SRL 2 Group 2 (SRL 6) is in one extreme of the graph and close to group 5 which is lineage SRL 6 Lineage SRL-4 was included in group 2 (SRL 6) although a certain distance to most of the isolates in the group can be observed This isolate infected cultivar Oryzica Caribe 8 virulence known to be specific from lineage SRL-4 This particular isolate is being analyzed in detail (virulence/genetic structure) to clarify the results found here Groups 4 and 7 appear very distant from the other groups These isolates were also the most virulent in the present study and all were collected from the cultivar Cica 9 after 1993 They were preliminary classified as lineage SRL 6B due to visual similarities with the genetic lineage SRL 6 and sharing of some virulences with isolates from that lineage It is *more probably that this* group has evolved from lineage SRL 6 The genetic similarity detected in groups 4 and 7 with group 2 had a minimum of 74% and a maximum of 89% This change in time of genetic structure observed in groups 4 and 7 was also found to be associated with gains of virulence

This is *the first time we report evolution and significant changes* in the blast pathogen population in Colombia We had reported changes in frequency of already known genetic lineages including the no presence of lineages SRL 1 and SRL 3 at present times More studies are being conducted to understand the significance of the presence of the two genetic groups (4 and 7) which exhibit the same virulence spectrum and had been classified as lineage SRL 6B However this analysis detects some differences in their genetic structure and the genetic diversity within group 4 (0 088) was larger than in the other groups The total genetic diversity of the population studied was 0 266 being it larger for isolates collected on the cultivar Cica 9 (0 202) than on Oryzica 1 (0 154) the population studied was 0 266 being it larger for isolates collected on the cultivar Cica 9 (0 202) than on Oryzica 1 (0 154)

The haplotypic diversity (61 haplotypes in 66 isolates) was high in the total population (0 997) as well as in the sub populations from Cica 9 (0 991) and Oryzica 1 (0 997) The smallest genetic similarity (57%) was detected in groups 5 and 2 (SRL 6) with groups 1 and 8 (SRL 2)

Understanding and monitoring changes in blast populations is critical for the development of breeding strategies for durable resistance More studies are being conducted with blast isolates from lineage SRL 6 and all the other genetic groups collected from different cultivars over time to detect and understand the changes in genetic structure and virulence reported in this study Sources of resistance to the most virulent isolates of the new genetic group are being identified under greenhouse conditions
Modifications of field methodologies for screening for blast resistance will be implemented for assuring the presence of this genetic group in the field avoiding escapes of breeding lines being evaluated in the field at Santa Rosa

Activity 2 Characterization of rice germplasm for blast resistance
Edgar Tulande Gustavo Prado Girlena Aricapa Diana Delgado Fernando Correa

2 1 Field and greenhouse evaluation of rice germplasm for identification of blast resistance sources

Development of stable blast resistance is a priority in the rice project Evaluation and selection of breeding lines with true genetic resistance is conducted at the Santa Rosa experiment station in Villavicencio where all rice germplasm evaluated is exposed in the field under severe blast pressure and high diversity of the pathogen Assuring exposition of the breeding lines to all the diversity of the pathogen avoiding potential escapes to infection is attained by planting perpendicularly spreader rows 2 3 weeks earlier than the lines being evaluated Spreader rows include rice cultivars with resistance genes defeated by all the genetic lineages detected in Colombia Virulence analyses of blast populations collected on the spreader rows has detected the presence of virulence factors compatible with all resistance genes reported in the literature This field methodology for evaluating and selecting breeding materials is yielding rice lines with high and stable levels of blast resistance

Monitoring changes in the population structure of the blast pathogen is very important for maintaining the high efficiency of our field technique of evaluation Rice differentials and commercial cultivars are also planted monthly to monitor changes in disease pressure associated with changes in climatic conditions such as temperature and relative humidity These studies together with determination of the frequencies of genetic lineages and virulence factors help breeders to determine the best time for planting the breeding lines in the field Blast reaction of 25 cultivar differentials (carrying literature reported resistance genes) at different planting dates between 1997 and 1998 are presented in Table 3 It is observed that blast pressure changes in time during a year period Rice blast is able to infect a highly susceptible cultivar with practically no resistance genes (cultivar Fanny) independent on the planting date and environmental conditions Some virulence factors are also expressed on cultivars carrying specific resistance genes independent on the environmental changes during the year (cultivars Usen Zenith Pi No 4) However certain virulences are only expressed during few months of the year (Table 3)

A high blast pressure and expression of more virulence factors was detected when rice differentials were planted in the month of March (Table 3) Twenty one out of 25 cultivars exhibited a susceptible blast reaction equal or more than 5 (10% or more of leaf area affected) Although planting dates of April and May show also a high blast pressure on most rice differentials there are certain virulence factors which are reduced in frequency in the population or not even expressed under certain conditions Cultivar K 59 was susceptible only during the planting dates of March and April

Planting dates on those two months coincide with periods of more favorable temperature and relative humidity specially dew periods of more than 10 hours for sporulation spreading and infection by the blast fungus Planting date of October shows a low blast pressure where only cultivar Fanny was highly susceptible

Blast reaction during a year period of 28 rice cultivars including all commercial varieties released in Colombia is shown in Table 4 It is observed again that the highest blast pressure and virulence diversity is expressed for the March planting Nineteen rice cultivars were highly susceptible to blast during this planting date Virulence factors on some cultivars (Cica 9 IR 8) were present during the entire period of the study while virulence on cultivar Oryzica 3 was only present or in high frequency in the March planting The lowest disease pressure and virulence diversity was detected for the February August and September planting dates It is worth noting the high susceptibility of the private sector recently released commercial cultivars (Selecta 3 20 and Tailandia) On the other hand the commercial cultivar (FEDEARROZ 50) released through the convenio FEDEARROZ/CIAT/FLAR exhibits high level of resistance during the planting dates studied The cultivar Oryzica Llanos 5 which has exhibited a stable blast resistance since 1989 was mildly infected during the March planting Blast populations collected from this cultivar are under study Most rice cultivars (except FEDEARROZ 50) adapted to the savanna upland ecosystem (below Bluebonnet 50 in Table 4) are blast resistant to the blast population present in the irrigated/favored upland ecosystem represented at Santa Rosa

Due to the large number of rice lines being planted in Santa Rosa and the seed multiplication at CIAT/Palmira (October February) the plating season was performed from late March through June during 1998 We recommend according to our studies reported here that the seed multiplication begin as early as possible in order to plant most of the breeding material during the month of March in Santa Rosa In this manner we can assure the disease pressure needed to avoid escapes to blast infection

Identification of complete and complementary resistance sources to blast is being conducted under field conditions as well as in controlled inoculations in the greenhouse Blast isolates representing all of the genetic lineages (SRL 1 to SRL 6) and virulence diversity of the pathogen are used in the greenhouse inoculations In collaboration with FLAR and FEDEARROZ the blast resistance is characterized in rice germplasm carrying other positive traits Table 5 and Table 6 reports the number of potential sources of resistance identified in some of the evaluated nurseries during 1998 Rice lines exhibiting complete resistance to all lineages of the pathogen are used as primary sources in genetic crosses Lines exhibiting complementary resistance to different genetic lineages are used in proper combinations or crosses to assure accumulation of resistance genes in a common background

Genetic crosses to accumulate complementary resistance sources to blast and resistant lines selected in the field have been reported in the past (Annual reports 1996 1997) These crosses have been used to demonstrate that rice lines exhibiting susceptibility to one genetic lineage of the pathogen carry resistance genes to other lineages Crosses among these lines combining complementary resistance sources yield lines resistant to entire blast populations Table 7 shows the number of resistant lines selected in crosses between the rice cultivar Oryzica Llanos 5 and some susceptible commercial cultivars In previous reports we indicated the presence of blast isolates of lineage SRL 4 exhibiting some compatible interactions with the blast resistant cultivar Oryzica Llanos 5 both in the field and greenhouse Crosses were made with cultivars exhibiting resistance to lineage SRL 4 but susceptibility to other lineages F4 and F6 lines have been selected exhibiting blast resistance in the field and will be tested under controlled conditions in the greenhouse with blast isolates compatible with the original parents It is worth to note that a few resistant lines were selected from crosses between Oryzica Llanos 5 partially susceptible to lineage SRL-4 and the cultivars Metica 1 and Oryzica 1 which are susceptible to the same genetic lineage Tests will be conducted to determine if minor genes present in these cultivars are responsible for the resistance selected

Stable resistance to blast since the time of its release in 1989 has been exhibited by the commercial cultivar Oryzica Llanos 5 Detection of compatible interactions with genetic lineage SRL-4 in the field were detected in the last two years and documented in previous annual reports A compatible interaction was also found between isolates of this lineage and the cultivar in greenhouse inoculations although disease severity was very low and blast lesions were neither typical nor highly sporulating Fortunately a resistance breakdown of the cultivar did not occur under commercial rice fields The stability of the resistance of Oryzica Llanos 5 has been confirmed in the field Greenhouse tests have been conducted to determine if breakdown of the resistance and increase in severity occurs under controlled inoculations by isolating and reinoculating isolates inducing compatible interactions with Oryzica Llanos 5 in the greenhouse Table 8 shows the results of reinoculations of Oryzica Llanos 5 with 20 blast isolates recovered from different cultivars which induced initially blast lesions on cultivar Oryzica Llanos 5 All isolates were classified as lineage SRL-4 None of the isolates infected Oryzica Llanos 5 or reproduced similar lesions to those observed by the original isolates However the isolates were fully compatible with other cultivars like Fanny and C101 A51 (Table 8) producing typical lesions and high sporulation Apparently the compatible factors detected in the first inoculations are not stable in the pathogen and are lost in the population These results confirm the stability of the resistance exhibited by cultivar Oryzica Llanos 5 under field conditions Monitoring changes in the blast pathogen population leading to the breakdown of resistance continues being a main activity in the pathology section of this project

Activity 3 Genetics and dissection of blast resistance genes

Joe Tohme Fernando Correa Gerardo Gallego

3 1 Identification of Disease Resistance Gene Analogs (RGA) in rice

In the past few years several resistance genes have been isolated and cloned different plant species using either map based cloning or transposon tagging Molecular characterization of these genes uncovered common sequence motifs even though they confer resistance to a wide spectrum of pathogens i e viruses bacteria or fungi

The majority of cloned R genes are characterized by the presence of an N terminal nucleotide binding sites (NBS) and a C terminal stretch of leucine rich repeats (LRR) The presence of these conserved domains allowed the grouping of these genes into several classes and established their possible function in the defense response as part of the signal transduction pathway (Baker et al 1997) Proteins similar to serine threonine kinases are another group which has been suggested to interfere in protein phosphorylation one of the common mechanisms of protein control (Bent 1996) Other families include transmembrane receptors either with long extracytoplasmic LRR domains like Cf 2 and Cf 9 in tomato or with a LRR transmembrane region as seen in the product of $HS1^{pro-1}$ from sugar beet There are also transmembrane receptors with extracellular LRR domains and also an intracellular serine/threonine kinase like the one encoded by Xa21 in rice (Baker et al 1997)

PCR based cloning with degenerate primers made possible the identification of Resistance Gene Analogues (RGAs) in rice *A thaliana* and lettuce (Leister et al 1998 Aarts et al 1998 Shen et al 1998) Their sequences have shown high homology with R genes previously reported and they mapped within or near to disease resistance loci

We have initiated a project to use this strategy to identify potential R genes in rice

Identification of NBS and Protein Kinase type putative resistance genes to Rice Blast

Gerardo Gallego Marcella Santaella Fernando Correa and Joe Tohme

Introduction

In rice we are specifically interested in finding the resistance genes against *Pyricularia grisea* one of the most devastating and variable fungus that affect up to 85 countries where rice is cultivated Breakdown of resistance is quite common and most varieties One major exception is Oryzica Llanos 5 developed at CIAT This cultivar has been grown experimentally and commercially for more than 8 years without any symptoms of a breakdown Resistance remains stable because several resistance sources are combined in the lines which were selected through a long and complex breeding scheme Such characteristics make it ideal l to study blast resistance and to design breeding strategies incorporating source of resistance to the different blast lineages We are working 1) on the dissection of resistance of Llanos 5 using gene tagging and 2) on the identification of RGA linked to resistance genes

Methods

Materials and Methods

DNA was extracted from leaf tissues of Fanny and O Llanos5 PCR reactions were performed using degenerate primer combination These primers were designed based on Leister et al (1996) and on a personal communication from Dr Pam Ronald (UC Davis) The PCR products were separated by electrophoresis in a 1 2% low melting point agarose (LMP –GIBCO BRL) Each band was eluted and purified with the PCR Preps kit (Promega) PCR purified products

cloned into the pGEM T vector system (Promega) and transformed into *E coli* DH5α cells by electroporation following GIBCO BRL instructions
Groups for the different bands were established using restriction enzyme patterns following the methods used by Leister et al (1998)

Then five to ten clones of each group were tested by RFLPs in the parental lines and the polymorphic ones were hybridized to DNA from the progeny of the cross O Llanos 5 x Fanny Using the MapMaker program (Lander et al 1987) these probes were placed on the RFLP map generated for the F7 RILs population The fragments linked to known resistance genes were sequenced using the automatic ABIPrism 377 DNA sequencer (Perkin Elmer) and compared with the database of proteins (blastx) in GenBank

Results

So far we have sequenced 9 fragments from the 776 clones of the NBS library and 3 from the 140 clones in the protein kinase library All of them showed high percentage of homology with known resistance proteins like *Oryza longistaminata* receptor kinase *Oryza sativa* receptor kinase like protein or NBS LRR type resistance protein [*Oryza sativa*]

We have placed 11 of the identified resistance gene analogs (RGA) as new markers on the rice map derived from the cross of Llanos 5 and Fanny Many of them (6) map to chromosome 11 where Xa 21 as well as Pi 1 and Pi 7 are located suggesting that we might be getting close to resistance genes to *Pyricularia* in rice Another one map to chromosome 6 and one more map to chromosome 7

On going activities

1) fine map rice blast resistance genes in the O Llanos x Fanny cross
2) Sequence additional fragments and map them on the RIL populations
3) Initiate the isolation of the genes responsible for that resistance by screening rice BAC libraries with the different RGA obtained from degenerate primers
4) Initiate the isolation of the genes responsible for that resistance by screening rice BAC libraries with the different RGA obtained from degenerated primers

3 2 Improving breeding methods for developing durable blast resistance

Fernando Correa César Martinez Girlena Aricapa Gustavo Prado Edgar Tulande

One of the most important activities in this project is related to the development of a breeding strategy that allows to use rice cultivars with desirable agronomic traits (yield quality etc) but susceptible to blast in genetic crosses designed for the development of blast resistant lines This strategy is based on the identification of rice lines which are susceptible to only part of the pathogen population (one or two genetic families of the pathogen) but with resistance genes to the rest of the population Crosses and development of rice populations between these rice lines with complementary resistance genes to blast have allowed us together with researchers at IRRI and Purdue University to develop the lineage exclusion hypothesis These crosses give origin to rice lines combining complementary resistance genes that exclude all possible compatible interactions with the entire blast population at a particular site or region Accumulation of the resistance genes Pi 1 and Pi 2 in single rice lines confers resistance to the entire blast

The best fifteen F7 rice lines advanced during 1998 (Table 9) from the cross C101 A51 (Pi 2) x C101 LAC (Pi 1) were tested in the field and greenhouse inoculations with representative isolates of all genetic lineages of the pathogen corroborating the complete blast resistance We have initiated a study to determine the stability of the resistance conferred by the combination of these two resistance genes Blast isolates are being collected on 109 rice lines derived from this cross for determination of their genetic structure and virulence composition

Introgression of the resistance genes Pi 1 and Pi 2 into commercial rice cultivars of different countries was initiated in 1997 Breeding populations are being evaluated under field and greenhouse conditions for selection of resistant lines Table 10 shows the backcross protocol followed for the incorporation of the resistance gene Pi 2 into the blast susceptible cultivar IR 50 This project is being conducted in collaboration with Purdue University and FLAR Several blast isolates compatible with IR 50 are being used for the selection of resistant plants in each backcross Selected plants used in the baccross exhibit lesion types less than 3 and leaf area affected less than 4 % (Table 10) This project is in progress and more conclusive results will be presented after future studies including introgression of these genes into other commercial rice cultivars

In collaboration with the Biotechnology Research Unit (BRU) Dr Cesar Martinez has been working in the enhancement of gene pools using wild rice relatives in genetic crosses with commercial rice cultivars Identification and selection of useful traits with the aid of molecular markers is the main objective of this project The wild relatives species of rice represent a potential source of new alleles for improvement of yield quality and stress resistance of cultivated rice Characterization of the blast reaction in the field and greenhouse of the species *O glaberrima Oryza rufipogum* and *O barthii* indicated a highly resistant intermediate and susceptible blast reaction respectively BC2F2 families of the cross BG 90 2 and *O rufipogum* were evaluated in the field and greenhouse for their blast reaction Transgressive segregation for blast resistance was observed in several BC2F2 families having better resistance than the two parents (Table 11) The results were confirmed in the BC2F3 families Molecular analysis of this population will be initiated in 1999 to identify possible minor genes contributing to the resistance observed Results suggest that these wild species have genes that can contribute to the increase of resistance in cultivated rice Other populations are in the process of field and greenhouse evaluation to blast

We have initiated in collaboration with the International Atomic Energy Agency (IAEA) a pre project on the potential application of induced mutations for the development of durable blast resistance This technique is very well known in the development of resistance to pathogens in several crops Although this technique has been successful in many cases rapid breakdown of mutation induced resistance has also been reported very often One of the main reasons for the failure of resistance obtained through mutation is that in most cases single gene changes are responsible for the induced resistance against all the targeted pathogen population In this pre project we are proposing a different alternative which consists of developing mutants with a gene resistant to only one or a few genetic lineages of the pathogen The idea is to identify as many mutants as are needed so that by targeted crosses these mutants can contribute to the combination of different resistance genes that exclude all the genetic lineages of the blast pathogen

We believe that the possibility offered by induced mutations for generating resistance to blast as well as other constraints is a worthy alternative for the improvement of cultivated rice

The commercial rice cultivars Oryzica 1 Cica 8 Oryzica Caribe 8 susceptible to different genetic lineages of the blast pathogen and Oryzica Llanos 5 were irradiated with gamma rays at the Instituto de Energia Nuclear in Colombia M1 populations were advanced at Palmira and the M2 and selected M3 lines were evaluated for their blast reaction in the greenhouse Table 12 shows the number of mutants resistant to rice blast that were selected among 500 rice lines evaluated More lines will be evaluated during 1999 for selection Resistance of selected lines will be corroborated in the greenhouse and field during 1999 Crosses between mutants exhibiting resistance to different genetic lineages will be performed after confirmation of the resistance in the M6 generation

TABLE 1 MONITORING CHANGES IN VIRULENCE AND GENETIC STRUCTURE OF *PYRICULARIA GRISEA* ISOLATES COLLECTED FROM THE RICE CULTIVARS CICA 9 AND ORIZYCA 1 BETWEEN 1988 1996

ISOLATE ORIGIN	YEAR OF COLLECTION	NUMBER OF ISOLATES	COMPATIBILITY FREQUENCY /	CULTIVARS AFFECTED No	GENETIC LINEAGE SRL	PHATHOGENICITY GROUP
CICA 9	1993	1	75	12	6B	2
	1994	1	75	12	6B	2
	1996	1	75	12	6B	2
	1993	1	69	11	6B	2
	1995	1	69	11	6B	2
	1989	4	19	3	1	1
	1990	1	19	3	1	1
	1991	1	19	3	1	1
	1994	1	19	3	2	1
ORYZICA1	1993	1	63	10	6	2
	1993	1	56	9	2	4
	1996	1	56	9	4	5
	1989	3	25	4	6	3
	1990	4	25	4	6	3
	1991	2	25	4	6	3
	1992	2	25	4	6	3
	1993	1	25	4	6	3
	1994	4	25	4	6	3
	1995	3	25	4	6	3
	1996	2	25	4	6	3

TABLE 2 SUMMARY OF THE DIVERSITY OF *PYRICULARIA GRISEA* POPULATIONS COLLECTED ON TWO RICE CULTIVARS BETWEEN 1988 1996

GENETIC GROUP	NUMBER ISOLATES	ORIGIN OF ISOLATE [a]	NUMBER OF PATHOTYPES	NUMBER OF HAPLOTYPES	NUMBER OF UNIQUE PATHOTYPES [b]
1	20	1(2)	10	18	9
2	31	2(1)	7	29	5
3	6	1	1	5	1
4	5	1	4	5	3
5	1	2	1	1	1
6	1	2	1	1	1
7	1	1	1	1	1
8	1	1	1	1	1

1= Cultivar Cica 9
2= Cultivar Oryzica 1

[b] Pathotypes in only one genetic group

TABLE 3 BLAST REACTION OF CULTIVAR DIFFERENTIALS AT DIFFERENT PLANTING DATES (SANTA ROSA EXPERIMENT STATION)

DIFFERENTIAL CULTIVAR	PLANTING DATE IN 1997					PLANTING DATE IN 1998						
	AUGT	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY
KUSABUE	2	2	1	1	1	4	5	4	4	5	2	2
Pi No 4	5	3	7	7	7	7	7	9	7	6	5	6
K 59	3	1	2	1	1	4	2	7	7	1	3	3
FUJISAKA 5	3	2	2	1	1	4	5	7	6	7	4	4
SHIN 2	2	1	2	1	1	3	2	6	5	4	3	2
FUKUNISHIKI	2	1	2	2	2	3	2	5	4	4	3	2
K 1	2	1	2	1	3	3	3	7	4	5	2	3
K 8	2	0	2	1	1	1	1	3	1	1	2	2
CALORO	5	2	5	7	8	6	4	9	8	9	8	4
BL 1	3	2	5	4	4	6	3	9	6	7	5	4
USEN	4	4	7	7	6	6	5	7	6	6	7	6
KANTO 51	3	2	5	3	3	3	3	5	4	5	4	3
IR 42	4	3	7	6	7	4	3	5	7	4	3	4
ZENITH	4	4	7	7	7	7	6	9	7	9	8	7
A ASAHI	3	3	6	5	4	5	5	6	5	9	6	6
NP 125	3	2	4	4	4	4	3	5	4	6	4	4
PETA	3	2	3	2	4	2	2	4	3	4	3	3
CHOKOTO	4	2	4	1			2	3	4	2	3	3
RAMINAD STR 3	3	3	5	4	4	4	2	7	5	8	7	6
KDA 2	5	4	6	5	5	3	5	7	5	4	4	4
FANNY	8	9	9	9	9	9	9	9	9	9	9	9
DULAR	5	4	6	5	5	4	5	7	5	5	4	5
TETEP	3	4	4	3	3	4	3	7	5	4	2	5
TSUYUAKE							2	9	5	9	2	4
TAICHUNG							6	9	8	8	4	8
FREQUENCY (≥5)	5	1	12	9	8	7	10	21	17	16	8	9

Blast scale 1= highly resistant 9 = highly susceptible

TABLE 4 BLAST REACTION OF COMMERCIAL CULTIVARS AT DIFFERENT PLANTING DATES (SANTA ROSA EXPERIMENT STATION)

	PLANTING DATE IN 1997					PLANTING DATE IN 1998						
CULTIVAR	AUGT	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY
CICA 4	5	5	7	3	5	4	4	7	7	9	6	6
CICA 6	4	4	4	2	4	3	2	7	2	7	6	5
CICA 7	4	4	7	8	9	7	4	9	5	7	5	6
CICA 8	4	4	6	5	7	2	2	8	4	9	6	8
CICA 9	5	6	7	5	7	7	7	8	7	7	5	7
ORIZYCA 1	4	5	7	7	7	5	5	8	6	7	4	6
ORYZICA 2	3	3	5	2	5	3	2	4	3	3	2	4
ORYZICA 3	3	3	5	3	5	2	2	7	3	4	2	4
O CARIBE 8	4	4	8	6	7	7	4	8	5	7	4	8
O YACU 9	5	3	5	3	4	5	3	7	5	6	2	5
METICA 1	6	5	7	9	9	9	3	9	6	8	3	8
LINEA 2	4	4	4	2	4	4	3	7	5	5	3	5
SELECTA 320	3	4	7	6	5	4	3	7	5	5	5	6
O LLANOS 4	3	3	4	5	4	3	3	7	5	5	2	5
O LLANOS 5	3	2	4	4	4	3	2	5	4	4	2	4
IR 8	5	7	9	8	8	9	7	9	7	8	6	8
IR 22	3	2	5	7	5	4	3	5	5	6	2	4
TAILANDIA	3	4	6	5	5	5	3	7	5	5	5	6
BLUEBONNET 50	3	3	4	4	3	4	3	6	4	4	3	4
O SABANA 6	3	2	3	3	2	3	2	4	3	3	2	3
O SABANA 10	2	1	2	2	4	2	2	4	2	3	2	2
MOROBEREKAN	3	2	2	2	3	2	2	3	1	2	2	2
IRAT 13	3	2	2	2	2	2	2	2	1	2	2	2
IAC 165	2	2	3	2	4	3	2	4	1	2	2	2
CEYSVONI	3	1	2	2	3	3	2	3	2	4	2	2
COLOMBIA 1	3	3	4	4	3	3	2	7	5	4	3	5
FEDEARROZ 50						1	1	3	2	2	2	2
LINEA 30						1	1	3	2	2	2	2
FREQUENCY (≥5)	5	5	14	11	13	8	3	19	14	15	8	14

Blast scale 1 = Highly resistant 9= highly susceptible

TABLE 5 IDENTIFICATION OF POTENTIAL SOURCES OF COMPLETE AND COMPLEMENTARY BLAST RESISTANCE IN 100 RICE LINES (FLAR / CIAT)

BLAST ISOLATE	GENETIC LINEAGE	REACTION				
		HR	R	I	S	HS
		NUMBER OF LINES				
FANNY 54	SRL 6	38	17	5	8	33
SELECTA 3 20(1)	SRL 6	49	19	3	2	28
ISOL 6 (7 1)	SRL 5	80	9	2	6	4
FANNY 47 1	SRL 5	89	8	1	3	0
O CARIBE 8 (31 2)	SRL-4	53	17	0	8	23
O CARIBE 8 (33 1)	SRL-4	57	16	1	11	16
METICA 1 (33 18)	SRL 3	93	6	1	1	0
METICA 1 (33 20)	SRL 3	98	2	1	0	0
O LLANOS 5(237 2)	SRL 2	89	6	1	4	1
CICA 9 (151 1)	SRL 2	89	4	1	1	6
CICA 9 – 15	SRL 1	93	0	3	0	5
CICA 9 (52 1)	SRL 1	87	6	0	2	6

HR= HIGHLY RESISTANT

R= RESISTANT

I = INTERMEDIATE

S= SUSCEPTIBLE

HS= HIGHLY SUSCEPTIBLE

NUMBER OF LINES RESISTANT TO ALL ISOLATES 27

TABLE 6 BLAST REACTION OF POTENCIAL SOURCES OF STABLE RESISTANCE (SANTA ROSA 1998)

ORIGIN NURSERY	NUMBER LINES	BLAST REACTION LEAF/NECK		
		(1 3)	4	> 5
		NUMBER OF LINES		
FLAR	13	13	0	0
FEDEARROZ	69	33	29	7

TABLE 7 NUMBER OF RESISTANT LINES SELECTED IN CROSSES BETWEEN ORYZICA LLANOS 5 AND SUSCEPTIBLE COMMERCIAL CULTIVARS

COMMERCIAL CULTIVAR	COMPATIBLE LINEAGE	FIELD REACTION (1 9)	GENERATION	SELECTED LINES (No)
ORYZICA LLANOS 5	4	4		
CICA 9	1 2 6	9	F6	7
LINEA 2	2 6	7	F4	29
METICA 1	3 4	9	F4	2
ORYZICA 1	2 4 6	9	F4	3
CICA 8	5	7	F4	8
ORYZICA 3	6	5	F4	5

TABLE 8 COMPATIBILITY OF BLAST ISOLATES FROM DIFFERENT SOURCES REISOLATED FROM CULTIVAR ORYZICA LLANOS 5 IN GREENHOUSE INOCULATIONS

CULTIVAR	ISOLATES INOCULATED (No)	COMPATIBLE ISOLATED (No)
FANNY	20	17
ORYZICA LLANOS 5	20	0
C101 A 51 (Pi 2)	20	13
C101 LAC (Pi 1)	20	0

ISOLATES RETRIEVED FROM SINGLE SUSCEPTIBLE LESIONS EXHIBITED BY CULTIVAR ORYZICA LLANOS 5 IN GREENHOUSE INOCULATIONS WERE REINOCULATED TO DETECT POSSIBLE BREAKDOWN OF RESISTANCE

TABLE 9 RICE LINES (F7) FROM THE CROSS C101 LAC (PI 1) XC101A51(PI 2) RESISTANT TO BLAST IN THE FIELD AND GREENHOUSE INOCULATIONS (1998)

RICE LINES	FIELD REACTION		GREENHOUSE	
	LEAF (1 9)	NECK (1 9)	SRL 6 4 3 2 1	SRL 5
CT 13432 (PL2) 1 1 M M M	2	1	R	R
CT 13432 (PL2) 4 2 M M M	2	1	R	R
CT 13432(PL2) 11 1M M M	2	1	R	R
CT 13432(PL4) 2 1 M M M	2	1	R	R
CT 13432(PL4) 2 2 M M M	2	1	R	R
CT 13432(PL4) 14 1 M M M	2	1	R	R
CT 13432(PL5) 1 1 M M M	2	1	R	R
CT 13432(PL5) 1 2 M M M	2	1	R	R
CT 13432(PL7) 5 2 M M M	2	1	R	R
CT 13432(PL7) 7 1 M M M	2	1	R	R
CT 13432(PL7) 10 1 M M M	2	1	R	R
CT 13432(PL8) 7 2 M M M	2	1	R	R
CT 13432(PL8) 9 1 M M M	2	1	R	R
CT 13432(PL8) 10 2 M M M	2	1	R	R
CT 13432(PL8) 15 3 M M M	2	1	R	R
C101 A51(Pi 2)	9	9	S(9)	R(1)
C101 LAC(Pi 1)	6	9	R(1)	S(7)

R=resistant (1 3) S=susceptible(>4) SRL= Blast Genetic Lineage 1 to 6

TABLE 10 INTROGRESSION OF BLAST RESISTANCE GENE PI –2 (C 101 A 51) INTO SUSCEPTIBLE CULTIVAR IR 50

PROGENY	RESISTANT No	SUSCEPTIBLE No
C 101 A 51 (PI – 2)	84	6
IR 50 (PI –1)	8	82
F1 (IR 50/ C101 A51)	83	7
F1 (C101 A 51/ IR 50)	77	13
BC1 (IR 50/C101 A 51// IR50)	61	29
BC1 (IR 50//IR50/C101 A51)	61	29

	LESION TYPE	LEAF AREA AFECTED (%)
RESISTANT	1 2	≥ 0
	3	< 10
SUSCEPTIBLE	4	≥ 1
	3	≥ 10

NUMBER EVALUATED PLANTS PER PROGENY 90
INOCULATED ISOLATES (GENETIC LINEAGE SRL – 5) COMPATIBLE WITH IR 50 (ISOL 16–1–1 ISOL 22 3 1 ISOL 7-6 1)

BC1 SELECTED LINES FOR BC2 (LESION TYPE ≤ 3 LEAF AREA AFFECTED ≤ 4 %)

TABLE 11 TRANSGRESSIVE SEGREGATION TO RICE BLAST IN THE INTERSPECIFIC CROSS BG90 2/*O RUFIPOGUM*

LINE/CULTIVAR	FIELD (1 9)	BLAST ISOLATE (GREENHOUSE) BG 90 2 (4 2)		AMISTAD 82 (1 1)		O RUFIPOGUM (4 1)	
		LT	LAA(%)	LT	LAA(%0	LT	LAA(%)
CT 13 945 12	3	0 4	0 9	1 3	2 2	0 3	2
CT 13 962 11	4	3 4	4	3	5 5	3 4	6
B G 90 2	7	4	65	3 4	12 4	4	65
O RUFIPOGUM	4	3	3 8	4 3	16 6	3 1	2 5

LT= Lesion Type
0 1 = highly resistant
3 = Intermediate
4 = *Susceptible*

LAA= Percentage of leaf area affected

Percentage of resistant lines = 2/281 = 0 007%

TABLE 12 NUMBER OF MUTANTS RESISTANT TO RICE BLAST OR MORE SUSCEPTIBLE THAN THE IRRADIATED CULTIVAR

IRRADIATED CULTIVAR	COMPATIBLE LINEAGE (SRL)	RESISTANT LINES (No)	INCREASED SUSCEPTIBILITY (No LINES)
ORYZICA 1	6	26	440
ORYZICA CARIBE 8	4	9	444
CICA 8	5	2	140

NUMBER OF LINES EVALUATED = 500
ISOLATES USED IN GREENHOUSE INOCULATIONS

SRL-4	0 CARIBE 8 (33 1)
SRL 5	ISOL 22 3 1
SRL 6	ORYZICA 1 (305 1)

Figure 1 Phenogram of virulence diversity Correspondence Multiple Analysis and UPGMA

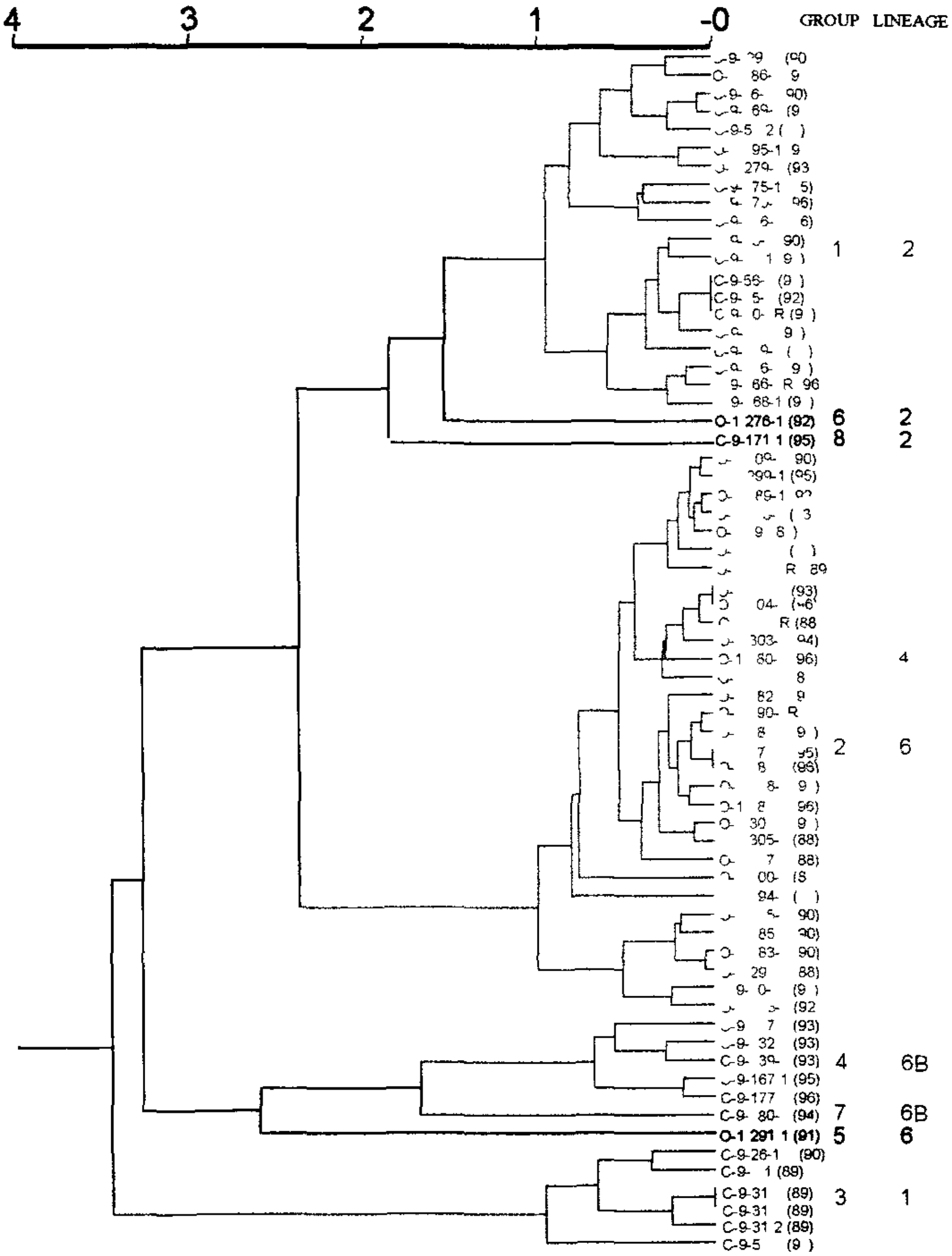

Figure 2 Phenogram of genetic structure using MGR 586 DNA fingerprinting Correspondence Multiple Analysis and UPGMA

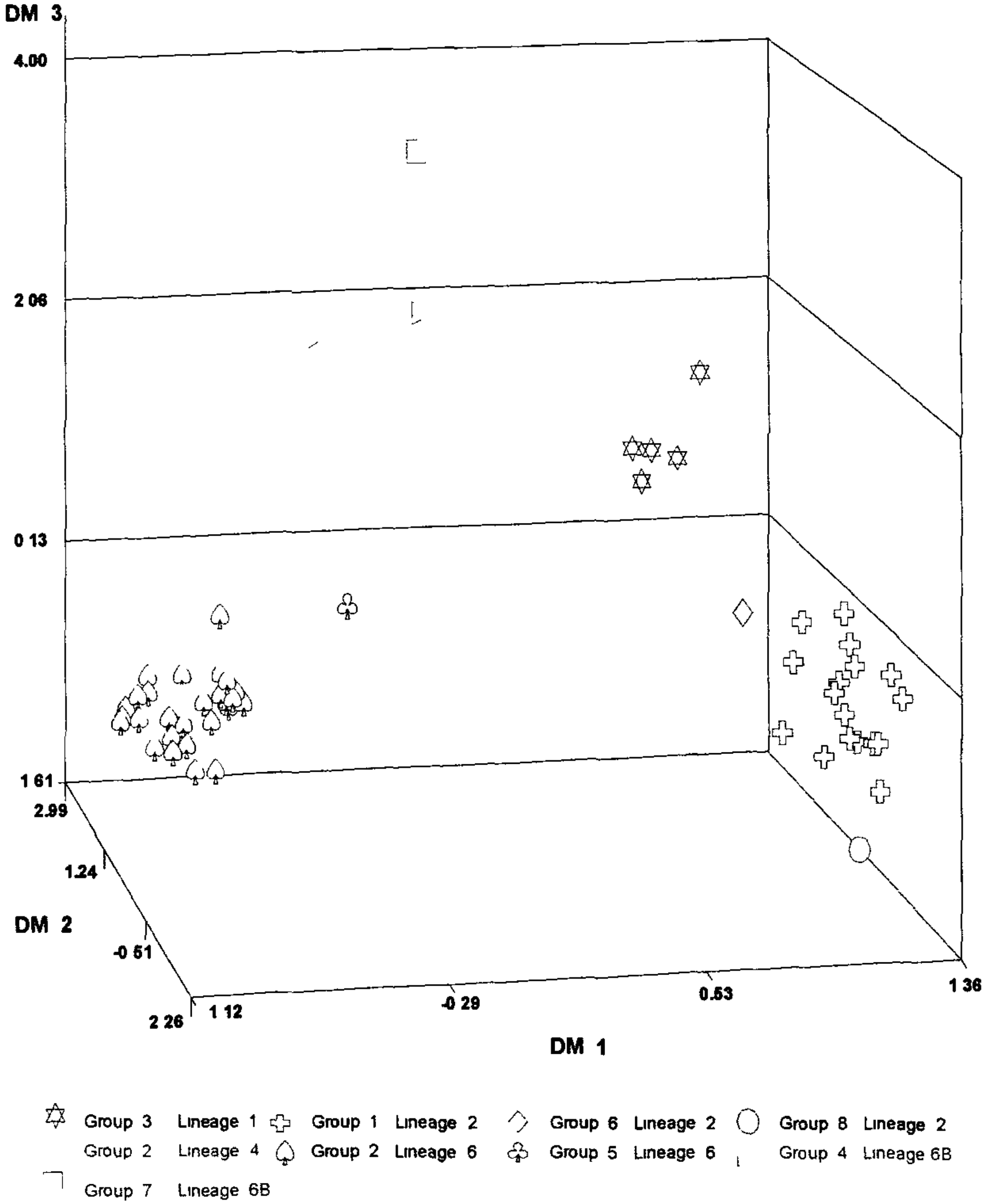

Figure 3 Spatial representation of genetic structure (haplotypes) Correspondence Multiple Analysis

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OUTPUT 3 RICE PESTS AND GENETICS OF CHARACTERIZED RESISTANCE

B Knowledge of the Level of Partial Resistance to Blast of Existing Germplasm

Michel Vales Jaime Borrero Diana Delgado Yolima Ospina Edgard Tulande

Executive Summary

During 1998 A the methods used by CIRAD in Cote d Ivoire were introduced and tried in the CIAT experiment stations To evaluate a large set for partial resistance to rice blast we constructed a dew chamber in the greenhouse at the CIAT Palmira Experiment Station and conducted control for one strain inoculation in the field

From the collection held at CIAT we identified two strains with an adequate virulence spectrum these are being used to evaluate partial resistance in 112 Latin American and Caribbean varieties and FLAR progenitors

At the time of writing (16/Sept/98) the rice is being harvested and the data collected The data have still to be analyzed

Presentation

Blast (*Pyricularia oryzae*) (a fungus that attacks cereals) is the most important disease of rice Widespread throughout the world it is particularly severe in Latin America

No entirely effective strategy for controlling blast has yet been found although CIAT is working on a potentially promising one that works by exclusion of blast lineages However we still do not have enough information to apply this strategy to all Latin America We are therefore taking advantage of CIRAD s experience with the strategy of durable resistance which we are now improving and which we can use in association with CIAT s strategy

The durable resistance strategy works on the theory that the likelihood of durability increases if resistance is general (requires knowledge and use of strains) polygenic (involves recurrent selection) and partial (involves establishing trial design and criteria) The first step is to characterize the level of partial resistance in commercial varieties and progenitors

Background

Michel Vales arrived at CIAT in August 1997 to reinforce the Collaborative Project CIRAD/CIAT/FLAR on blast resistance He has 15 years experience with blast 9 of which he obtained in Cote d Ivoire on recurrent selection for blast resistance CIRAD s first recurrent selection program This program was a collaborative project between CIRAD IDESSA (Côte d Ivoire) and CNPAF (Brazil with Elcio Guimaraes and Marc Henri Chatel)

Activity 1 Identifying Blast Strains for the Partial Resistance Study

Michel Valès Diana Delgado Jaime Borrero Fernando Correa

Objective

In the field where pathogen populations are typically variable distinguishing between complete and partial resistance is impossible because both can reduce lesion number and size To distinguish between the two mechanisms we must work with control and virulent strains We therefore chose appropriate strains from the collection built up by Fernando Correa

Material and Methods

First we had to adapt the greenhouse for the study of partial resistance by building a dew chamber capable of holding 288 lines inoculated by one strain

We inoculated 150 varieties 86 commercial Latin American and Caribbean (LAC) varieties including progenitors used by FLAR 40 other progenitors used by FLAR and 24 potential progenitors for rice blast resistance

Results

Two strains were identified as having a broad host spectrum and as being usable for partial resistance studies in the greenhouse or field The results of inoculating these strains on LAC commercial varieties and FLAR progenitors at CIAT s Palmira Experiment Station during the 1997/98 season are shown in the table below

Code	Progenitor	Origin	Blast strain[a]	
			Fanny 54	O Caribe 8
Commercial LAC Varieties				
1	BR IRGA 409	M97B/15	S	R
2	BR IRGA 410	M97B/16	S	R
3	BR IRGA 411	M97B/17	S	MR
4	BR IRGA 412	M97B/18	S	R
5	BR IRGA 413	M97B/19	S	R
6	BR IRGA 414	M97B/20	S	R
7	BR IRGA 415	M97B/21	S	R
8	IRGA 416	M97B/22	S	R
9	IRGA 417	M97A	R	R
10	EMPASC 105	M97B/28	S	R
11	EPAGRI 108	M97B/31	R	S
12	EMBRAPA 6 CHUI	M97B/37	S	R
13	EMBRAPA 7 TAIM	M97B/38	MS	R
14	BULI INIA	1996B	S	HS
15	DIAMANTE	1996B	S	HS
16	CICA 4	M97B/61	S	R
17	CICA 6	M97B/62	S	R
18	CICA 7	M97B/63	MS	MS
19	CICA 8	M97B/64	MR	R
20	CICA 9	M97B/65	S	R
21	COLOMBIA 1	M97B/66	MS	MS
22	ICA 10	M97B/67	S	S
23	LINEA 2	M97B/68	S	R
24	ORYZICA 1	M97B/70	S	S
25	ORYZICA 3	M97B/71	R	R
26	ORYZICA CARIBE 8	M97B/72	R	S
27	ORYZICA LLANOS 4	M97B/73	R	MR
28	ORYZICA LLANOS 5	M97B/74	R	R
29	ORYZICA TURIPANA 7	M97B/75	MR	MS
30	ORYZICA YACU 9	TARRO G	S	R
31	SELECTA 3 20	M97B/77	MS	S
32	CR1113	M97B/78	S	R
33	CR1821	M97B/80	S	R
34	CR201	M97B/81	MR	S
35	CR5272	M97B/82	MR	R
36	CR750	M97B/83	MR	S
37	CR751	M97B/84	S	S
38	CR8334	M97B/85	S	MS
39	INIAP 10	M97B/105	R	MR
40	INIAP 11	M97B/106	R	R
41	INIAP 415	M97B/107	S	S
42	INIAP 12	M97B/108	R	MR
43	CENTA A 4	M97B/111	MR	S
44	CENTA A 5	M97B/112	S	HS
45	IR8	M97B/116	MS	R
46	IR22	M97B/117	S	R
47	IR36	M97B/118	R?	MS
48	IR50	M97B/122	R	S
49	IR64	M97B/128	R	R
50	ICTA MOTAGUA	M97B/133	MS?	R
51	ICTA POLOCHIC	M97B/134	S	MS
52	RUSTIC	M97B/140	R	MS
53	MANA 3	M97B/141	MR	R
54	CAPI 93	M97B/142	S	R
55	CUYAMEL 3820	M97B/143	R	R
56	CAMPECHE A80	M97B/147	S	R
57	SINALOA A80	M97B/159	R	R

Code	Progenitor	Origin	Blast strain[a]	
			Fanny 54	O Caribe
Commercial LAC Varieties				
58	ALTAMIRA 9	M97B/162	S	R
59	ALTAMIRA 10	M97B/163	S	R
60	ANAYANSI	M97B/166	MS	R
61	DAMARIS	M97B/167	MS	R
62	PANAMA 1048	M97B/169	R	R
63	INTI	M97B/181	S	S
64	PA 2	M97B/182	S	R
65	SELVA ALTA	M97B/186	R	HS
66	JUMA 58	M97B/193	R	R
67	JUMA 62	M97B/195	R	R
68	BG90 2	M97B/199	R	R
69	CAMPONI	M97B/200	R	R
70	CEYSVONI	M97B/201	R	R
71	CIWINI	M97B/202	S	MS
72	DIWANI	M97B/203	R	R
73	ELONI	M97B/204	R	R
74	BLUEBELLE	M97B/209	MS	S
75	L 201	M97B/212	S	S
76	L 202	M97B/213	MS	S
77	LEMONT	M97B/218	MR	R
78	NEW REX	M97B/220	MS	MR
79	EL PASO L 144	M97B/226	S	R
80	EL PASO L 227	M97B/227	MS	R
81	INIA TACUARI	M97B/228	MS	R
82	INIA YERBAL	M97B/229	MS	S
83	ARAURE 4	M97B/233	R	R
84	CIMARRON	M97B/234	S	R
85	FONAIAP 1	M97B/235	R	R
86	PALMAR	M97B/237	MS	R
FLAR Progenitors				
87	82CAY21 / LMNT // L 202	WC361	MS	S
88	CNAx 5011 9 1-6 4 B	WC384	R	S
89	CT10588 CA 1 M	WC/350	R	MR
90	CT10865 CA 12 M	WC/351	S	S
91	CT10871 1 CA 1 M	WC/352	MS	MR
92	CT11685 7 F4-6 2P 1	WC/353	R	MR
93	CT11691 17 F4 1 1P 2	WC/354	S	S
94	CT11696 9 F4 10 2P 1	WC/355	R	R
95	CT11782 2 F4 3 1P 3	WC/356	S	S
96	CT11783 14 F4 1 1P 1	WC/357	R	MR
97	CT11800 22 F4 1 1P 1	WC/358	R	MR
98	CT7363 5 3 10	WC261	R	R?
99	CT8008 16 31 3P M	WC/365	R	S
100	CT8198-4 2-6P 1X	WC284	R	MR
101	CT8240 1 1 3P 1X	WC292	S	MR
102	CT8249 2 7 3 1X	WC295	MS	S
103	CT8285 13 5 2P 1X	WC272	R	MR
104	CT9868 16 3 1 2 3P M	WC386	R	MR
105	CT9882 16-4 2 3-4P M	WC385	R	S
106	CT9980 25 3 6 CA 1 M	WC/349	R	R
107	GFMT 2 / TQNG	WC363	R	R
108	IR65598 27 3 1	WC/366	MS	S
109	IR65600 96 1 2 2	WC/367	R	MR
110	IR66155 2 1 1 2	WC/368	R	R
111	IRGA 234 21 5-6 1	WC376	R	R
112	IRGA 284 18 2 2 2	WC380	S	MR
113	IRGA 369 31 2 3F A1 1	WC382	S	S

FLAR Progenitors				
114	IRGA 370-42 1 1F C 1	WC381	**MS**	**S**
115	IRGA 411 1-6 1F A	WC379	**MR**	**R**
116	IRGA 440 22 1 3 2	WC383	**R**	**R**
117	IRGA 659 1 2 2 2	WC378	**R**	**R**
118	IRGA 660 3 13 5 3	WC377	**R**	**R**
119	LBNT / STBN // NWBT / 3 / MILL	WC364	**MS**	**MR**
120	NWBT / KATY / RA73 / LMNT	WC362	**S**	**S**
121	P 2053 F4 169 8 1	WC75	**R**	**MR**
122	CT6948 8 11P	WC236	**R**	**S**
123	P 5166 F2 26 1 1X	WC/160	**S**	**R**
124	VSTA/LBNT // L 201 / 3 / SKBT	WC360	**S**	**S**
125	VSTA/LBNT // RSMT	WC359	**R**	**R**
126	P 3844 F3 22 1 1X	WC138	**R**	**R**
Other Potential Progenitors with Blast Resistance				
127	63 83	ACC872	**R**	**R**
128	IRAT 13	ACC394	**R**	**R**
129	IRAT 79	ACC411	**R**	**R**
130	CABACU	598 1	**R**	**R**
131	IRAT 112	ACC379	**R**	**R**
132	GUAPORE	ACC218	**R**	**R**
133	RIO PARANAIBA	1231 7	**R**	**R**
134	GUARANI	ACC1219	**R**	**MR**
135	DOURADAO	ACC143	**R**	**MR**
136	IRAT 216	ACC119	**R**	**S**
137	ORYZICA SABANA 6	TARRO G	**R**	**S**
138	MARAVILHA	88391A	**R**	**S**
139	SACIA 1	87A897	**R**	**HS**
140	SACIA 3	880045	**R**	**S**
141	SACIA-4	880050	**R**	**S**
142	ICTA IZABAL	1227 9	**R**	**MR**
143	MAKALIOKA	TARRO G	**S**	**S**
144	CT10069 27 3 1-4	TARRO G	**R**	**MS**
145	FB 0007 3 1 6 1 M	INGER	**R**	**R**
146	Inca	INGER	**S**	**S**
147	CT11891 2 2 7 M	BCO SR	**R**	**R**
148	CT11026 3 9 IT 2P 2P 2	INGER	**MR**	**R**
149	CIRAD 410	BCO SR	**R**	**MR**
150	CIRAD 411	BCO SR	**R**	**R**
151	PCT 6\0\0\0	BCO SR	Done	Done
152	PCT 11\0\0\0	BCO SR	Done	Done
Wild Rices				
	O rufipogon (1)			**R**
	O rufipogon (2)			**R**
	O rufipogon (3)			**R**
	O rufipogon (4)			**R**
	O rufipogon (5)			**R**
	O rufipogon (6)			**R?**
	O rufipogon (7)			**R**
	O rufipogon (8)			**R**
	O rufipogon (9)		**R**	
	O rufipogon (10)		**HS**	
	O glaberrima (1)			**R**
	O glaberrima (2)			**R**
	O glaberrima (3)			**R**
	O glaberrima (4)			**R**
	O glaberrima (5)			**R**
	O glaberrima (6)			**R**
	O glaberrima (7)			**R**
	O glaberrima (8)			**R**

Wild Rice		
O glaberrima (9)	S	
O barthii (1)		
O barthii (2)		
O barthii (3)		
O barthii (4)		
O barthii (5)		HS
O barthii (6)		HS
O barthii (7)		HS
O barthii (8)		HS
O barthii (9)	HS	

[a] R = resistant S = susceptible MR = intermediate resistance MS = intermediate susceptibility HS = highly susceptible

Prospects

Although the two identified strains can now be used for partial resistance studies in the greenhouse or field we still need to refine the MR and MS notation to an S or R notation We also have to search for a virulent strain for upland rice with durable partial resistance like IRAT 13

Activity 2 Identifying Partial Resistance to Blast in Commercial Varieties Released in LAC

Activity 3 Introducing Partial Resistance into Parents Already Used by the CIAT/FLAR Crossing Program

Michel Valès Jaime Borrero Yolima Ospina Edgard Tulande Diana Delgado James Gibbons

Both activities were conducted at same time

Methodological Trial

Objective

An inoculated control strain in field trials is essential for studying partial resistance We therefore studied the effectiveness of our selected control strain in the field

Materials and methods

We took advantage of the evaluation trial to study the inoculated control strain in the field at the Santa Rosa Experiment Station

A plastic film barrier was erected to isolate the trials Fifty days before sowing seeds of spreader rice lines were cleaned with Hinosan® 50 EC (Edifenphos 50%) at a rate of 750 ml pc/ha The lines were then sown Ten days after treatment the spreader lines were inoculated using dried leaves from plants inoculated in the greenhouse with the control strain used in the previous identification study

The susceptible variety Fanny was also sown as check

Results
Ten days after treatment the new leaves of the spreader lines were free of lesions even though the inoculation with dried leaves enabled us to obtain heavy disease pressure Although the inoculated control strain appears nonpathogenic we are still waiting on data to confirm this preliminary finding

Prospects
During this current semester (1998 B) in Santa Rosa conditions for an inoculated control strain are poor being highly favorable for the build up of an enormous pathogenic inoculum of epidemic proportions If control is possible under such conditions we can unreservedly recommend this method for other areas

Evaluation of Partial Resistance

Objective
The objective is to evaluate the partial resistance of varieties under conditions more like those found on farms than were those of the FLAR selection trials

Materials and methods
Two trials isolated by a plastic film barrier were inoculated with a control strain

For the first trial we planted 76 varieties inoculating them with the strain Fanny 54 (lineage SR 6) The spreader was Oryzica 1 which is specifically susceptible to SR 6 In the second trial we planted 72 varieties and inoculated them with the strain Oryzica Caribe 8 (31 2) (lineage SR 4) The spreader was Oryzica Caribe 8 which is specifically susceptible to lineage SR 4

A third trial was conducted under FLAR conditions with 112 varieties We used the same spreader inoculation method and so on as was used by FLAR

We used the Federer s trial design of incomplete blocks with 20 varieties and 5 checks forming each block The 5 checks were ICA 10 Oryzica 1 INIAP 415 WC 360 and WC 362 For each variety and check we used 2 rows 26 cm between rows and sowed 24 kg of seeds per hectare

Results
Harvest has just been completed with more data still coming in and analysis just beginning

Prospects
We will use the information on partial resistance among commercial LAC varieties to choose cultivars that presented the lowest levels of risk against the virulent strains used The information on partial resistance of the FLAR progenitors may lead to possibly different choices

If these methodological changes with respect to the control strain seem appropriate we will recommend this method to FLAR for its selection trials

Activity 4 Partial Resistance of Potential Parents Used in the CIAT/FLAR Project

Michel Valès Jaime Borrero Yolima Ospina Edgard Tulande Diana Delgado James Gibbons

Objective

Some varieties have durable partial resistance The objective is to demonstrate how high their level of partial resistance is under crop conditions by first identifying virulent strains

Results and Prospects

During 1998 A we have not found virulent strains for those varieties from Santa Rosa (see table above Activity 1) Fernando Correa suggested that for 1998 B we try to find virulent strains from the Altillanura one of four major geographical regions of the Colombian Eastern Plains and comprising an area of higher savannas Because of the different habitats we will not be able to inoculate rice lines in Santa Rosa with Altillanura strains We therefore need to establish an experimental site in the Altillanura

B Use of Breeding Strategies for Partial Resistance to Blast

Michel Valès Jaime Borrero Diana Delgado Marc Henri Châtel James Gibbons

Executive Summary

FLAR uses double haploids from three way crosses We propose a new complementary scheme to include partial rice blast resistance selection We are waiting for the first agronomic evaluations from national partners of FLAR to begin this scheme

During 1998 A the new recurrent selection scheme including complete and partial rice blast resistance selection was used for the tropical lowland population PCT 6 HB This scheme involved both strategies of lineage exclusion and durable resistance

We have not yet received the necessary information on blast lineages from Argentina A new recurrent scheme that includes complete and partial rice blast resistance selection was proposed for this country It permits the maintenance of complete resistance genes while the lineage information comes in

Using the new concept of a recurrent selection population with a narrow genetic base we will construct new gene pools for a large set of rice cropping situations

A collaborative CIRAD/CIAT project is proposed (to begin October 15 1998) by CIRAD CA Montpellier with funds for 3 years from Thematic Programmed Action (ATP its French acronym) It concerns blast pathogenicity adaptation

Presentation

See Output 3 A

This section of work on partial rice blast resistance concerns

Proposal and use of complementary selection criteria and schema for blast resistance selection according to existing FLAR methods

Background

See Output 3 A

Activity 1 Traditional Breeding Using Selected Parents Collaborative Work on FLAR Progenies Developed from Anther Culture

Michel Valès James Gibbons Zaida Lentini

Objective

To reinforce FLAR s existing breeding procedures by conducting new complementary activities on durable blast resistance These procedures involve anther culture

Materials and Methods

The materials will be derived first from three way crosses followed by anther culture to create double haploids and then selected at the Santa Rosa Experiment Station for complete rice-blast resistance and agronomic traits (Figure 3 B 1 1) These materials will then be sent to FLAR partners for agronomic evaluation

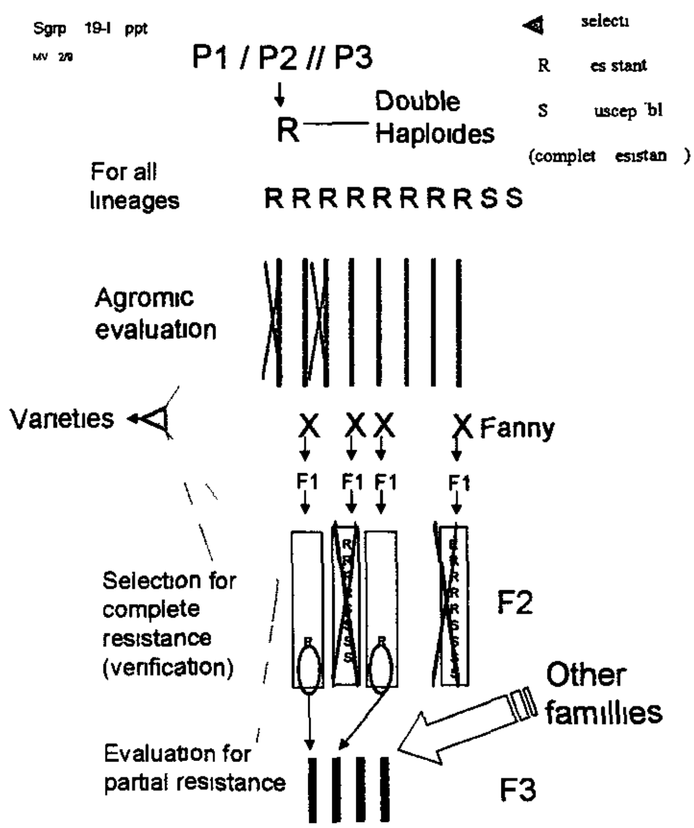


Figure 3 B 1 1 Selection for partial and complete rice blast resistance FLAR tropical lowland rice

Prospects
We are waiting for the results of this evaluation and to know the choices made by FLAR partners so we can evaluate the partial resistance level of the varieties selected (Figure 3 B 1 1)

Another scheme is being proposed for work on segregating progenies

Activity 2 Recurrent Selection Breeding
Michel Valès Marc Henri Châtel Jaime Borrero Diana Delgado

Use of Existing Germplasm

- **Tropical lowland population (PCT 6 HB)**

The breeding scheme outlined in 1997 has three parts (Figure 3 B 2 1) and a new scheme for the output population and the population with a narrow genetic base (Figure 1 A 1 1) is also being proposed The three parts of the breeding scheme are

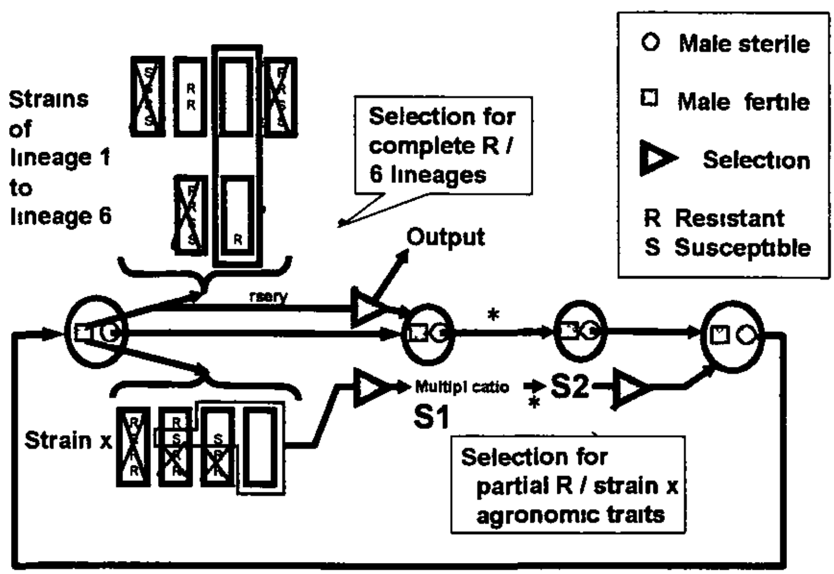


Figure 3 B 2 1 Recurrent Selection schema for Complete and Partial Rice Blast Resistance * H re for PCT6-HB, 9/15/98

Selection for complete resistance (lineage exclusion)
50/190 S_1 lines were selected for their complete resistance spectrum to 6 lineages (11 strains) in the greenhouse They are now being recombined with a sample of the field population (Palmira)

Selection for partial resistance
396 plants from 190 S_1 were selected for their absence of complete resistance to a strain in the greenhouse This strain will be used for the field trial

Not all the plants were male fertile with the result that we obtained 270 S_2 We are now preparing the 1998 B field trial for the evaluation of partial resistance in Santa Rosa (for methodology see Output 3 A Activities 2 and 3)

Conservation of the male sterility gene and of part of the variability
A recombination cycle will be performed during the second semester This cycle will also function as the beginning of a new complete cycle of recurrent selection

- **Temperate lowland population (PQUI 1)**

Some cycles of recombination in new populations must be performed before recurrent selection can be started For population PQUI 1 we are therefore performing another cycle of recombination

Tropical lowland rice for Argentina (Universities of Corrientes and La Plata)

Populations received from Marc Henri Châtel are being studied in Argentina and used to make a new one Because nothing is known of the blast lineages in this area a scheme of recurrent selection that includes selection for partial blast resistance was proposed Some arrangements have been made to maintain the genes for complete resistance until complete information on the lineages arrives A new recurrent selection scheme was also proposed (Figure 3 B 2 2 1)

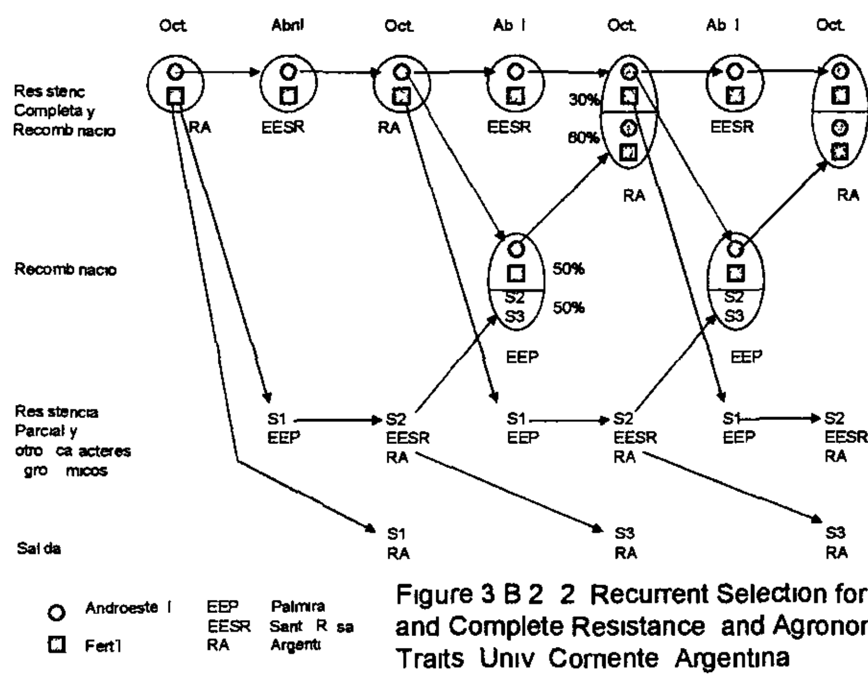


Figure 3 B 2 2 Recurrent Selection for Partial and Complete Resistance and Agronomic Traits Univ Corriente Argentina

Specific Germplasm Development

We used the new concept of a recurrent selection population with a narrow genetic base (see Output 1 A Activity 1 Material ii Population with a narrow genetic base) With the first cycle of crossings the following gene pools were developed

Temperate lowland rice

		Final genetic participation
Source population for male sterility	PCT 12	25%
Progenitors for		18 75% × 4
Yield	**BR IRGA 417**	
Grain quality	BR IRGA 417	
Cold tolerance	**Inca**	
Grain quality	**Inca**	
Durable resistance to *Pyricularia*	IRAT 13	
Complete resistance to *Pyricularia*	Oryzica Llano 5	

Tropical lowland savanna rice

Source population for male sterility	PCT 11	25%
Progenitors for		15% × 5
Yield	**CIRAD 409 (= line 30)**	
Resistance to entorchamiento	CIRAD 409 (= line 30)	
Grain quality	CIRAD 409 (= line 30)	
Early maturing	**CIRAD 409 (= line 30)**	
Tolerance of acid soils	**CIRAD 409 (= line 30)**	
Durable resistance to *Pyricularia*	IRAT 13	
Complete resistance to *Pyricularia*	Oryzica Llano 5	
Resistance to hoja blanca	FB 0007	
Resistance to *Tagosodes*	FB 0007	
Resistance to entorchamiento	CT11026 3	

- **Tropical lowland rice (1)**

Source population for male sterility	PCT 6	25%
Progenitors for		18 75% × 4
Yield	**Oryzica Yacu 9**	
Grain quality	Oryzica Yacu 9	
Durable resistance to *Pyricularia*	IRAT 13	
Complete resistance to *Pyricularia*	Oryzica Llano 5	
Resistance to hoja blanca	FB 0007	
Resistance to *Tagosodes*	FB 0007	

- **Tropical lowland rice (2)**

Source population for male sterility	PCT 6	25%
Progenitors for		15% × 5
Yield	**BG90 2 X *O rufipogon***	
Grain quality	Oryzica Yacu 9	
Durable resistance to *Pyricularia*	IRAT 13	
Complete resistance to *Pyricularia*	**Oryzica Llano 5**	
Resistance to hoja blanca	FB 0007	
Resistance to *Tagosodes*	FB 0007	

- **Upland rice for the cold highlands**

Source population for male sterility	PCT 13	25%
Progenitors for		18 75% × 4
Yield	**CT10069 27-3 1-4**	
Grain quality	CT10069 27 3 1-4	
Cold tolerance	**Inca**	
Grain quality	Inca	
Durable resistance to *Pyricularia*	IRAT 13	
Complete resistance to *Pyricularia*	Oryzica Llano 5	

Tropical upland rice

Source population for male sterility	PCT 11	25%
Progenitors for		15% × 5
Yield	**CIRAD 403**	
Drought resistance	CIRAD 403	
Grain quality	CIRAD 400	
Tolerance of acid soils	**CIRAD 409**	
Durable resistance to *Pyricularia*	IRAT 13	
Complete resistance to *Pyricularia*	Oryzica Llano 5	

Activity 3 Training

Michel Valés

National Recurrent Selection Breeding Course in Venezuela
A course is being prepared for DANAC San Felipe Venezuela (September 21–26 1998)

Visits and Fieldwork with NARS
Visit to the Rice Hybrid Program CIRAD G4I Pelotas Rio Grande do Sul Brazil (March 14 18 1998)

Participation in the FLAR monitoring tour of the Southern Cone (March 19 21 1998)

Discussions with partners of CONARROZ (ASPAR FENCA CIAT Bolivia and CAISY) on Bolivia s participation in FLAR Bolivia (March 25 26 1998)

Visit to the recurrent selection program at the INIA station Quilamapu Chile (May 14 15 1998)

Presentation of a proposed new recurrent selection scheme for rice blast resistance at the University of Corrientes Argentina (May 18 19 1998)

Presentation of a proposed collaborative project on upland rice with salt tolerance upland rice for favorable areas blast resistance and upland rice for cold highlands (see below) at the University of Tucuman Argentina (May 20 1998)

Revision of the DANAC research project revision of the National Plan for Rice Breeding revision of the course preparation on recurrent selection and oral presentation on durable rice blast resistance at FUNDARROZ Venezuela (July 19 23 1998)

Participation in Conferences 1998
(presented in chronological order)

27th Rice Technical Working Group Meeting March 1-4 Reno Nevada USA

6th RENAPA (National Meeting on Rice Research) March 9 13 Goiania Goias Brazil

Third Upland Rice Breeders Workshop March 9 13 Goiania Goias Brazil Oral presentation

First Advanced Course on the Irrigated Rice Crop March 24 26 Carmen del Parana Paraguay

First Internnational Workshop Seed Essential Input of Modern Agriculture May 11 13 Peru Oral presentation on the Collaborative CIRAD/CIAT/FLAR Rice Program

Second International Rice Blast Conference August 2 8 Montpellier France Presentation of three posters on durable rice blast resistance and recurrent selection We also discussed possible collaboration with CIRAD CA Montpellier with financial support from the French Thematic Programmed Action (ATP)

7th International Congress of Plant Pathology August 8 6 Edinburgh Scotland UK

International Symposium on Rice Germplasm Evaluation and Enhancement August 30–September 2 Stuttgart Arkansas USA Poster presentation on recurrent selection

Activity 4 Preparing a Manual on Partial Resistance to Blast

Michel Valés

Sound knowledge of agricultural and research practices in LAC is needed to write a technical manual The manual will be first presented as a slide show (with the slides made on PowerPoint) to test the clarity of technical information and recommendations and to ascertain reactions

92543

OUTPUT 3 RICE PEST AND GENETICS OF RESISTANCE CHARACTERIZED

C Rice Hoja Blanca Virus

A
Lee Calvert

Introduction

The objective of this project is to mitigate losses due to rice hoja blanca virus and impact is measured as the prevention of losses Since RHBV causes a cyclic disease the absence of the disease is not sufficient to claim impact RHBV has been present elevated levels in Colombia for the last three years without causing significant losses This contrasts with one region in Peru where a RHBV epidemic caused a loss of 70% throughout 30 000 hectares in 1996 In the Colombian llanos the farmers have switched varieties and the principle type of rice now grown is Selecta 320 In the Tolima valley of Colombia the farmer changed from growing Caribe 8 and Yacu 9 to Orizica 1 & 3 The change from susceptible to varieties with intermediate in resistance is a key element in the control strategies that CIAT Fedearroz and Corpoica are promoting

There has also been a change in the utilization of insecticides There are fewer applications of more expensive but more selective less toxic pesticides These changes apparently are changing the type of outbreak of RHBV The previous epidemics occur quickly with devastating results The current outbreak has been longer than expected with levels of RHBV remaining higher than normal Still with few exceptions the percentage of infected plants is low enough that there the economic losses in Colombia have been very minor The new variety Fedearroz 50 with a high level of resistance is now released in Colombia and is part of the strategy to continue to assure that this cycle of RHBV does not cause hardship to the farmers

At the beginning of 1998 an outbreak of RHBV was reported in Venezuela Although the varieties and cropping system are distinct expertise is being mobilized to try to help prevent an epidemic from occurring This is a challenge for the coming year This reports details many of the activities that are being done to lessen the losses by RHBV and finally break the recurring cycles of this disease

1 1 Development of Resistance to RHBV and *T orizicolus* in rice

Output 1 1 The release of varieties with resistance to both RHBV and its vector

In Colombia a new rice variety Fedearroz 50 was released to seed producers It is in the process of being multiplied as certified seed and will be in the field as a commercial variety by 1999 In Venezuela a line now designated PN (plan national) 004 has been selected for release as a new variety This variety will be need until 2000 before there will be sufficient certified seed Both these varieties were tested at CIAT for resistance to RHBV and tolerance to *T orizicolus* The release of these varieties is a milestone in the objective to reduce losses due to RHBV

Activities 1 1 1 & 1 1 2 Maintenance of both vector and non vector colonies of *T orizicolus*

The augmentation of the RHBV research has created increased demand for both viruliferous and non vector planthoppers To meet the research demands a new sequencial colony on non vectors was started Also a second colony of viruliferous planthoppers is now being maintained It is clear that the genetics of resistance of *T orizicolus* (the planthopper is a host of the RHBV) to the virus are more complicated than a single recessive gene

The development of a colony that remains consistently viruliferous is needed to reduce the workload to maintain the highly viruliferous colony and for genetic studies of resistance in the insect

Table 1 A preliminary study on the transmission of RHBV in successive generation of progeny of *T oryzicolus*

Population	Acquistion on RHBV infected plants		No individuals *T orizicolus* Analyzed	No *T orizicolus* positive for RHBV	% of virulent *T orizicolus*
	Yes	No			
Inicial Population		x	144	134	100
M1[1]		x	110	82	74 5
M2	x		157	112	81 5
M3	x		84	60[2]	76 0
M3		x	108	not used	67 9
M4	x		130	129	64 3
M4		x	133	not used	59 2
M5	x		172	147	98 7
M5		x	176	not used	95 9
M6	x		162	144	90 0
M6		x	142	not used	90 7
M7	x		170	124	75 6
M7		x	168	not used	86 3

[1] M masal
[2] The insects that were fed on RHBV infected plants and were positive for transmission of the virus were used to establish the next generation within the colony

In order to achieve a highly viruliferous colony vectors were selected for 8 generations The system was not closed until the forth generation and there is lower fecundity in the ninth generation Between generations the colony varied from 65% to 100% vectors (table 1) The selection during the first 7 generations included vectors that had acquired the virus by both transovarian transmission and feeding on RHBV infected plants While colonies with a high level of transmission can be maintained with constant care it appears more difficult to obtain colonies of planthoppers that are universally susceptible The planthopper resistance to RHBV is probably a multigenic trait and very little is known about the mechanisms of resistance Also there could be other factors such as endosymbiontic yeast that could influence the transovarian transmission There is a need to understand the relationship between mode of acquistion of the virus and the ability of the virus to replicate within the planthopper The host plant interaction is one of the key factors in the cyclic nature of this disease

1 1 3 & 1 1 4 Screening of germplasm for resistance to RHBV and *T orizicolus*

Cantidad de insectos con la cual se dio inicio a la progenie siguiente

Evaluatıons to ıncorporate sources of resıstance to RHBV are conducted twıce a year ın the field Trials from the second semester of 97 and the first semester of 1998 are ıncluded ın thıs report During thıs period more than of 12 000 lines were screened for resıstanct to RHBV (table 2) The number of lines that are beıng screened contınues to

Test	No of lines evaluated	Tolerant Reaction (0 1 3)	Intermediate Reaction (5)	Susceptible Reaction (7 9)	**Lines that need evaluation repeated**
RHBV	12300	5938 (48 3%)	1546 (12 6%)	4561 (37 0%)	255 (2 1%)
T orizicolus	2943	1589 (54 0%)	133 (4 5%)	862 (29 3%)	359 (12 2%)

= Standardized system of evaluation for resistance to RHBV and tolerance to *T orizicolus*

increase and this reflects the importance breeders are giving to RHBV The lines that were evaluated were from CIAT FLAR FEDEARROZ and Colombia CORPOICA INGER Costa Rica Venezuela NPAM Surinam Cuba IIA VIARC and USA LSU

Since the screening for tolerance to *T orizicolus* is in the greenhouse and is subject to more limitations only lines that have RHBV resistance and other desirable characteristics are eligible to be screened Nearly 50% of the materials being screened are classified as resistant materials This continues a three year trend in which the percentage of RHBV resistant materials were 27% in 1996 44% in 1997 and 54% in 1998 The increased number of lines that have resistance indicating better utitilize of the rice genepools The large number of resistance lines allow the breeder more chance to select for other desirable agronomic and pest resistant traits

1 1 5 Assistance in establishing colonies of *T orizicolus*

1 2 Studies of plant resistance to *T orizicolus*

The screening methods for breeding RHBV resistance include resistance to the virus and tolerance to the planthopper vector The experience with Llanos 5 has caused a major change in the development of RHBV resistance and has highlighted the need to understand how the different mechanisms of resistance interact Llanos 5 is resistant to RHBV but at the field level it appears to be susceptible to RHBV The principal component of RHBV resistance is the plant escapes infection and this effect becomes more pronounce at 20 25 days after planting Therefore resistant varieties like Llanos 5 can be infected with RHBV when the plants are young Tolerance is determined by subjecting the plants to high levels of planthoppers and determining the level of mechanical damage Those with little to no mechanical damage are considered to be tolerant materials In order to understand the interaction between insect and virus resistance the mechanisms of resistance must be determined The other activity that was started this year is a genetic analysis of the plant

By increasing our knowledge the host/pest interaction a more systemic selection of parental materials and progeny can be developed This is also a prerequist to develop marker aided selection

1 2 1 Evaluation of antibiosis to *T orizicolus* in advanced lines and commercial varieties
The mass screening using *T orizicolus* is highly efficient for selecting rice that is tolerant to the planthopper The type of screening is not forced feeding and it says little about the mechanism of tolerance The mechanism of resistance can influence the stability of the trait In general antibiosis is generally less stable because it places greater selective pressure on the insect The variety Fedearroz 50 was selected for testing because it is a new variety and it is estimate the stability for resistance to RHBV and the planthopper vector

Table 3 The mortality of *T orizicolus* when force fed on different varieties of rice

Variety	Plant reaction to	Number of days for 25 50 and 75% mortality of T orizicolus		
		25%	50%	75%
Irat 124	Tolerant (antibiotic)	6 1	12 8	27 0
FB0007	Tolerant	10 1	13 9	19 0
Oryzica 1	Tolerant	12 0	17 6	25 9
Bluebonnet 50	Susceptible	15 8	22 2	31 0

In the first set of experiments the variety Irat 124 was used as the variety that has antibiosis as a mechanism of resistance to *T orizicolus* Bluebonnet 50 was the susceptible control Orizica 1 and Fedearroz 50 were the test varieties The survival of *T orizicolus* was determined for four experiments using fifty insects on each variety for each experiment Individual insects were placed on single plants The results are reported as the time until 25% 50% and 75% of the insects died Since Bluebonnet is an excellent host for the insect the mortality on this variety was considered to be the natural mortality of the population There was an initial rapid mortality on Irat 124 with 25% of the insects dying in the first six days This rapid mortality continued and at 12 8 days 50% of the insects were dead After that the surviving insects appeared to be adapted to the variety Since Irat 124 is report as a variety with antibiosis the results were somewhat surprising Possibly there is tolerance in the planthopper population to the antibiotic factor in Irat 124 It took 10 days for 25% of the insects to die on Fedearroz 50 After this the mortality was very rapid with 50% at 14 days and 75% at 10 days One test was made with the accessions P1274 and O llanos 4 the parents of Fedearroz 50 In the single trial the mortality of insects was slowest on P1274 slight faster on O llanos 4 and most severe on Fedearroz 50 Is the mortality of insects due to antibiosis and will this lead to a rapid breakdown of resistance to *T orizicolus*? Further studies are being done to learn more about the mechanism of resistance in Fedearroz 50

1 2 2 Evaluation of settling preference of *T Orizicolus* in selected varieties of rice

In a preliminary investigation in order to understand mechanisms of replicated experiments using 5 varieties were done The major problem was a fairly high mortality of planthoppers The environment conditions are being modified to reduce the mortality The varieties tested were IR 8 Cica 8 Llanos 5 Fedearroz 50 and Makalioka The reaction of the varieties to the planthopper and RHBV are shown in table 2 The number of insects on each plant were counted at 2 4 8 24 48 and 72 hours after the release of the insects There were no clear differences until 48 and 72 hours Makalioka is a variety with the antibiosis as the mechanism of resistance to the planthopper This variety had significantly less insects per plant compared with the other varieties (table 2) There were no significant differences for settling preference between the other varieties If there is no settling preference for Llanos 5 then another explanation is needed to explain the field observations that under moderate pressure it is the variety in which RHBV is most prevalent These results are preliminary and the focus will be on reducing the mortality rate within the experiments and making observations for a longer period of time

1 3 Insecticide trials to determine the effect of insecticides on the planthopper and its natural enemies

An comparison of the effects of 9 different insecticides treatments to control *T orizicolus* was made The insectides include low cost general pesticides higher cost more selective pesticides and an entomopatogen The treatment with one exception were made a 15 days after planting The number of nymphs and adult planthoppers were counted If these were infected with parasites this was also noted The spiders were the indictor of the level of predators During this experiement there were heavy rains and the populations of planthopper was low during the first 40 days of the crop There were no differences between the insecticide treatments and the control In the later part of the experiment the planthopper populations were higher and there is useful information on the interaction between the predators parasites and the populations of the planthoppers This experiment is still being analyzed and the information is being used to design multilocational insecticide trials

1 4 Epidemiology for RHBV

1 4 1 Surveys of RHBV incidence in rice and *T orizicolus*

This year there was an increase in the level of vectors in the humid Carib e zone The percentage averaged 7 4% vectors and there were some pockets with up to 20% vectors that were experiencing outbreaks of RHBV There are still not enough samples from that region to make determine how widespread are the high levels of vectors The central region including the departments of Tolima and Huila continue to have an steady increase in the percentage of vectors (Figure 1) Huila has gone from less than 0 5% in second semester 95 to 2% vectors in the first semester of 97 This is still a very low level and no control recommendations are being made Tolima has increased from 2% in the first semester of 95 to 5 5% vectors in the second semester of 97 There is extensive information from these regions and RHBV is prevalent throughout Tolima especially in the northern region

During the survey three zones were identified as the areas at greatest risk for outbreaks of RHBV The northern region of the Tolima valley was one of the zones having high levels of RHBV infected plants and viruliferous vectors During the last year the incidence of RHBV and viruliferous vectors has increased in the central region of Tolima

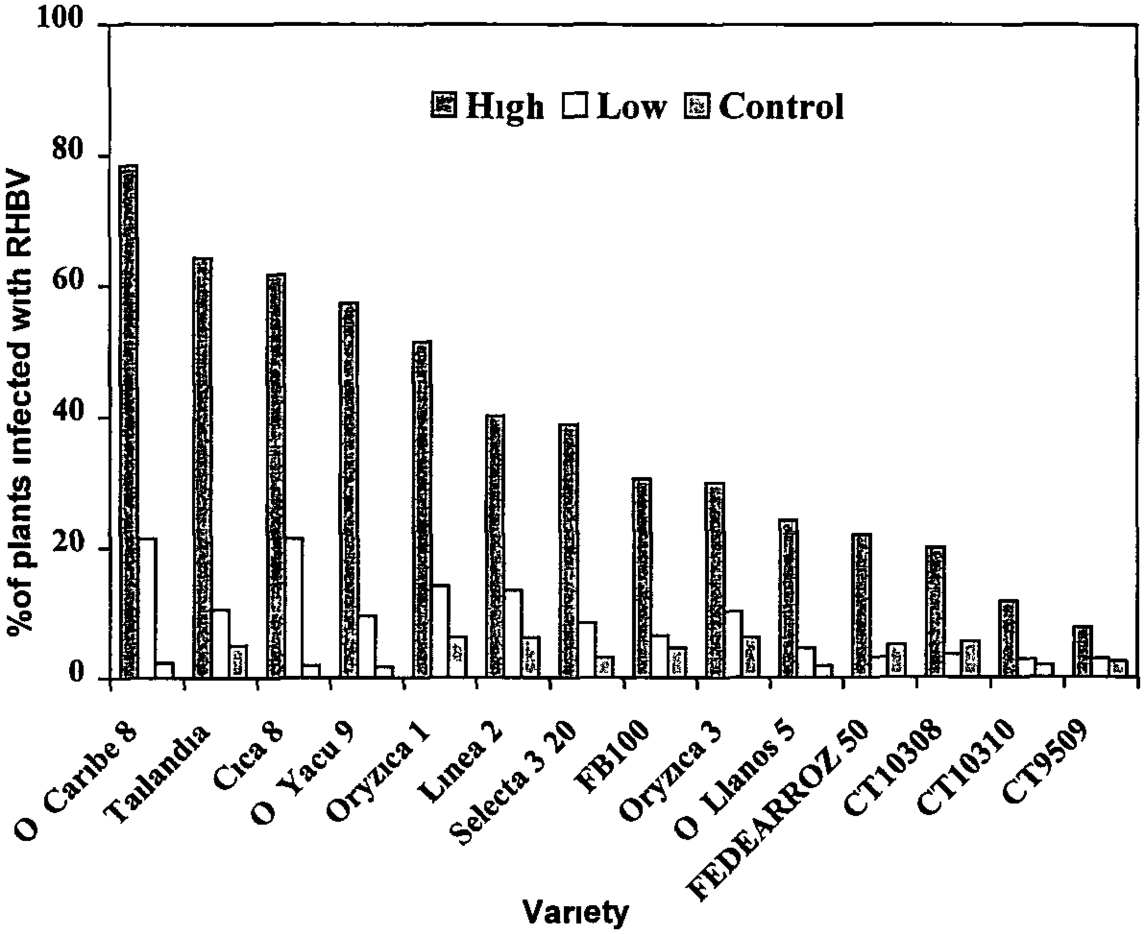
1 4 2 Trials for RHBV field resistance

The field experiments to simulate the infection levels and damage are done using a partially randomized plot design and different levels of vector pressure Each series of experiments are done with core varieties and a group of test varieties This year the most popular commercial varieties in Colombia and some promising new lines were the tested for their reaction to RHBV The estimate for the high RHBV pressure is 4 5 planthoppers per plant The low inoculum pressure is 1 2 planthopper per plant The control group has no planthoppers liberated within the plots The planthoppers are released at 15 days after planting To minimize the effect of movement of insects each vector treatment block is separated from the other This prevents it from be a completely randomized block design

The susceptible check varieties of O caribe 8 and Cica 8 had 78% and 63% of the plants infected in the block with the highest vector pressure Their reaction under lower pressure was 20% of the plants were infected A popular variety Thilandia had more than 60% of the plants infected under high pressure but only 10% under low pressure This variety is now classified as susceptible and is not recommended in areas at risk for outbreaks of RHBV The popular varieties Linea 2 and Selectra 3 20 were intermediate in their reaction to RHBV with about 40% of the plants infected under high vector pressure Oryzica 3 is one of the best intermediate varieties with about 30% of the plants infected under high vector pressure About 20% of the plant of the new variety Fedearroz 50 were infected in these conditions An advanced line that is to be released in Venezuela CT10310 (PN004) had only 10% of the plants infected This line is excellent and has now been tested in two experiments This contrasts with the advance line Fedearroz 50 in which about 30% of the plants were infected This has also been repeated in two experients and the variety shows only intermediate resistance

This type of trial give a direct comparison of the varieties under both high and low inoculum pressure The differences are greater under the high pressure and that is the most important block in this type of experiment Although it is not equilvalent to a natural infestation the results allow the ranking of varieties under fairly severe conditions This ranking is being used in the control recommendations that are being distributed in those regions with more than 3 5% of the plant in the field showing symptoms of RHBV These trails will continue to be able to make recommendations about commercial varieties throughout the regions where RHBV is present and to help determine which advanced lines have the greatest resistance to RHBV

Table 4 Field evaluation of commercial varieties and advanced line with three levels of vector pressure



1 4 3 Measuring the risk potential of selected rice growing regions

The monitoring of Colombia for RHBV incidence and the analysis of viruliferous *T orizicolus* population continued into the third year Over three hundred samples were collected and analyzed The tendency in the Departments of Huila and Tolima are for higher levels of RHBV and the corresponding higher percentage of vectors

There is some shift for higher levels of RHBV in the central and northern areas of the Tolima The majority of the observations are for levels of RHBV that are below the level that cause economic damage In Tolima there is both good chemical control of planthopper populations and much of the area is planted with varieties with intermediate resistance to RHBV There is also a tendency in the Llanos for higher incidence of RHBV

Both Tolima and the Llanos have had elevated levels of RHBV for the last three years The hypothesis for the cyclic epidemic is for increasing levels of RHBV that comes to a peak in which there are very high incidence of RHBV in the field and large economic losses After all the potential vectors are infected with the virus there is a change in the population and those insects with resistance to RHBV become dominant It is too early to predict if the cycle has been changed but it is possible that with only modest pressure the percent of the population with the genetic capacity to transmit RHBV will remain high for a much longer time Even though it will take extended vigilance to prevent an epidemic this tendency is a desirable change because the are no dramatic losses

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OUTPUT 3 RICE PEST AND GENETICS OF RESISTANCE CHARACTERIZED

D Control of RHBV (Rice Hoja Blanca Virus) through Nucleoprotein Mediated Cross Protection in Transgenic Rice

Zaida Lentini

Rice hoja blanca virus (RHBV) is one of the major diseases afecting rice in tropical Americas RHBV disease was first reported in 1935 and since then mayor outbreaks of the disease had caused up to 80% of yield loss Most popular varieties are resistant to the vector but are susceptible to the virus The breeding resistance is conferred by one or two genes but plants carrying this source of resistance are susceptible at younger ages than 25 day old The uncertainty of epidemics induces farmers to spray insecticides to control sogata the planthopper vector of RHBV There is a need to incorporate additional sources of resistance into improved germplasm to ensure stable and durable resistance since the resistance present in most varieties is from a single resistant source The main goal of this project is to provide new source(s) of resistance to minimize the possibility of an outbreak of the disease by (i) transforming rice with novel gene(s) for RHBV resistance and (ii) incorporating these genes into Latin American commercial varieties or into genotypes to be used as parents in breeding Previous reports described the particle bombardment genetic transformation protocol optimized for indica Latinamerican genotypes the preparation of gene constructs containing the RHBV nuclear (N) protein gene and the RHBV NS4 nonstructural protein antisense gene Last year we reported the generation and selection of RHBV N transgenic lines from the Colombian rice commercial variety Cica 8 showing stable RHBV resistance on T2 progeny plants The RHBV N transgenic lines A3-49 56 60 and –101 showed a significant delay in the development of the disease and reduced severity of the symptoms (disease reaction from 0 1 to 0 3) in contrast to the non transgenic control Cica 8 (disease reaction 0 8 when using a rating scale of 0 to 1) which was highly susceptible at 23 days after the RHBV infection These transgenic lines showed a yield potential of 46% to 64% higher than the non transgenic Cica 8 control

Following is reported the study in progress directed to determine the inheritance and expression of the N protection in other genetic backgrounds of interest for breeding This study aims to elucidate if the N transgene could be used to complement the breeding resistance source already available to fully protect plants younger than 25 days of age

Inheritance and expression of the RHBV nucleoprotein cross protection in different genetic backgrounds

In this work T3 progeny plants were selected based on the resistance level and agronomic traits from the corresponding T2 progeny line (Table 1) Individual T3 progeny plants from the selected Cica 8 N transgenic lines were first analyzed by nested PCR to detect the plants carrying the N transgene Those plants were chosen as female parents and crossed with 1) the breeding fixed line CT8008 3 12 3P M 1P highly susceptible to RHBV 2) the variety Oryzica 1 with moderate resistance and 3) the variety Fedearroz 50 (FD50) highly resistant to RHBV Controls consisted of F1 crosses between the non transgenic Cica 8 and CT8008 Oryzica 1 and FD50 respectively Plants 10 day old and 20 day old of each F1 cross were infected with RHBV under greenhouse conditions Viruliferous nimphs from a vector colony with at least 85% of virulence were used Five nimphs per plant were placed onto each plant contained within a plastic tube

Nimphs were allowed to feed on the plant for 5 days Plants were evaluated weekly and up to 54 days after infection for the development of RHBV disease and plant vigor Evaluations for performance of agronomic traits is still in progress

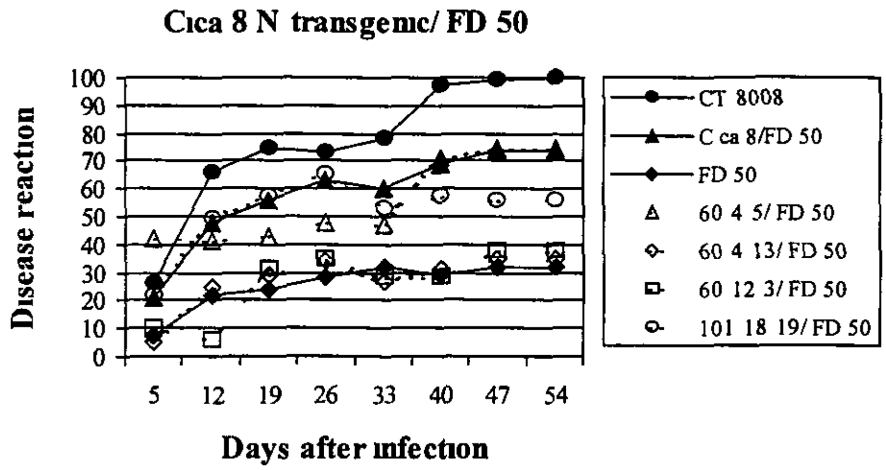
Table 1 Disease reaction and yield potential of T2 progeny plants from RHBV N Cica 8 transgenic lines selected as female parents

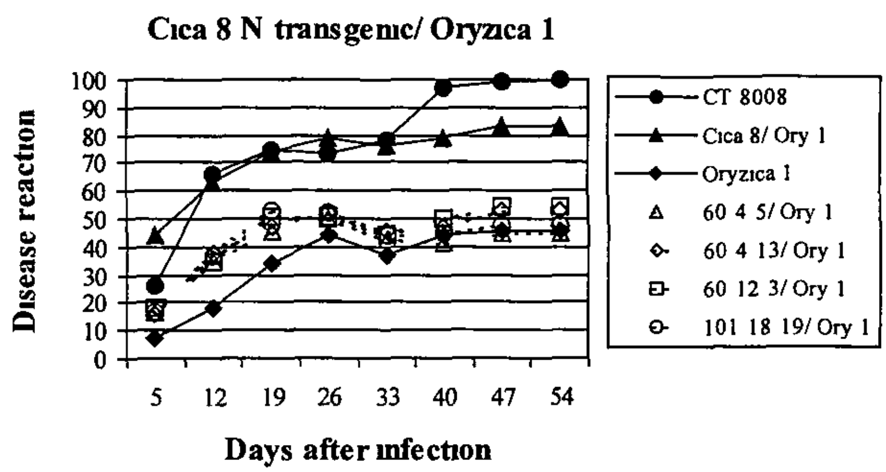
Line A3-49	Disease reaction	Grains/ plant
56 17	0 04	1332
60-4	0 09	728
60 12	0 04	582
101 5	0 00	1240
101 18	0 03	67
Cica 8 infected	0 51 (0 10)	70 (48)
Cica 8 non infected	0 00	1218 (343)

Numbers in parentheses refer to the standard error

Results showed that the non transgenic F1s were significantly more susceptible than the resistant parent suggessting that the natural resistance source is encoded by non dominant gene(s) Crosses with the transgenic lines A3-49 60-4 5 A3-49 60-4 13 A3-49 60 12 3 and A3-49 101 18 19 were significantly more resistant (about 40%) to RHBV than the corresponding F1 non transgenic cross when using 10 day old plants (Figure 1) A similar trend was obtained when plants were infected at 20 day old The higher level of resistance of the transgenic F1s was noted on the crosses with the susceptible the intermediate resistant and the highly resistant genotypes and in some cases the resistance level was similar to the resistant parent (Figure 1) These results suggest that the protection conferred by the RHBV N transgene is expressed independently of the genotype background and that the transgene could be used to complement the natural resistance source These crosses are currently being evaluated for its performance for agronomic traits Future work will include the evaluation of the resistance segregation in F2 population to determine the inheritance and stability of this trait through selfing and the initiation of a marker assisted selection backcross breeding scheme for the introgression of the RHBV N transgene into CT8008 3 12 3P M 1P Oryzica 1 Fedearroz 50 and Cica 8 parental genotypes The selection process will be aided by MAS using the presence of the RHBV N transgene as the trace marker In order to implement this type of molecular selection the correlation between the level of resistance and the presence of the transgene as well as the effect of the plant age on the level of the resistance conferred by the RHBV N gene are currently being analyzed

Collaborators C Gamboa (Danac Venezuela) L F Fory (IP4) Z Lentini (SB2 IP4) J Gibbons (FLAR) L Calvert (IP4) I Lozano (IP4) E Tabares (SB2)





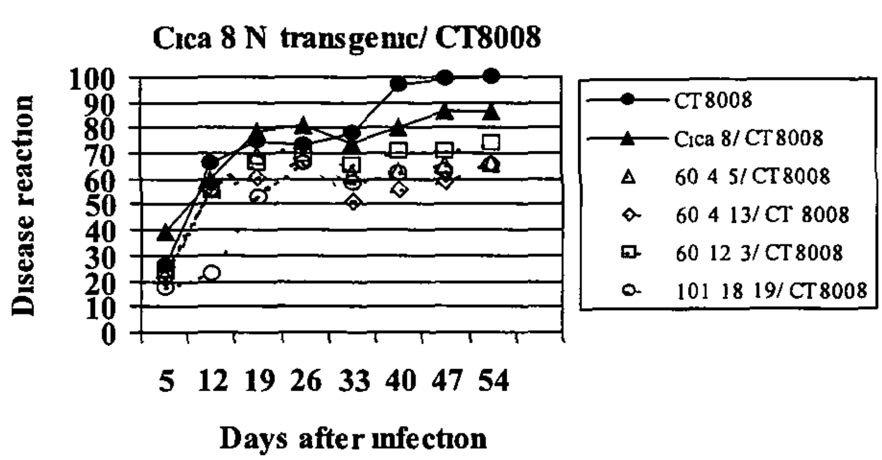


Figure 1 Disease development on 10 day old progeny plants from crosses between Cica 8 RHBV N transgenic lines and three genotypes with different levels of RHBV resistance Fedearroz 50 (FD 50) highly resistant Oryzica 1 intermediate resistant and CT 8008 highly suscess

Development and training of staff

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OUTPUT 3 RICE PESTS AND GENETICS OF RESISTANCE CHARACTERIZED

Francisco Morales

E Rice Stripe Necrosis Virus (RSNV)

Activity 3 1 Characterization of rice stripe necrosis virus

Rice stripe necrosis virus (RSNV) is a tentative member of the Furovirus group first observed as a rice pathogen in West Africa in 1984 The virus and its fungus vector *Polymyxa* sp emerged in Colombia in the early 1990s causing concern among rice growers in the Eastern Plains of Colombia Yield losses in rice fields located in the municipalities of Castilla la Nueva y San Carlos de Guaroa were estimated at 20% in 1991 Following three years of investigations conducted by different institutions in which different causal agents were proposed and millions of dollars in pesticides were applied without a clear target the etiology of the disease was elucidated by the Virology Research Unit of CIAT in 1994 Further characterization of the virus and fungus vector were undertaken in 1996 with the financing of the British Overseas Development Administration (ODA) and its Competitive Research Facility (CRF) This research seeks to determine the current distribution and potential threat of RSNV in West Africa and Latin America in collaboration with the West African Rice Development Association (WARDA) For the characterization of the fungus vector and its biological traits CIAT is working with Drs Michael Adams and Elaine Ward of Rothamstead England According to Dr David Johnson of WARDA RSNV has been observed in Senegal Guinea Sierra Leone Ivory Coast Ghana Togo and Nigeria

According to WARDA this disease is not considered an immediate threat to rice production in West Africa due to the artesanal rice production systems that predominate in that part of the Tropics However RSNV has significantly affected some mechanized rice crops in Ivory Coast and Sierra Leone forcing the withdrawal of susceptible upland rice varieties This observation clearly demonstrates that RSNV does have the potential to cause significant yield losses in West Africa should the mechanization of the crop become more widely adopted In Latin America rice production involves a great deal of mechanization and consequently the probability for rapid dissemination of RSNV in the main rice growing areas is high The wide distribution of RSNV in Colombia is a clear demonstration of the rapid dissemination potential of the virus and vector in tropical environments and mechanized rice cropping systems

3 1 1 Isolation of RSNV from infected rice plants

During 1998 an improved purification method was developed for the Colombian RSNV isolate The previous RSNV purification method developed in West Africa by French virologists resulted in low virus yield when utilized for the isolation of the Colombian isolate of RSNV The improved RSNV purification method does not use organic solvents but differential cycles of low and high speed centrifugation complemented with density gradient centrifugation The improved purification method is also complemented by the utilization of RSNV infected foliar tissue inoculated under controlled glasshouse conditions at CIAT This virus infected tissue is more suitable for isolation of RSNV because field grown plant tissue infected by RSNV rapidly oxidizes upon homogenization

3 1 2 Physical and chemical characterization of RSNV

Most of the physical and chemical properties of the Colombian RSNV have already been reported in the 1997 annual report The new purification method has made possible the isolation of enough RSNV to produce a polyclonal antiserum for the characterization of the antigenic properties of the virus Of particular interest is the relationship that exists between the African and Colombian isolates of RSNV Preliminary tests with the third bleeding of the immunized rabbit indicate that the polyclonal antiserum is specific and that it does not react with extracts from virus free rice plants Consequently this antiserum is being fractionated for the implementation of the highly sensitive ELISA technique This technique makes possible the detection of the virus in a large number of diseased rice plants including late infections when the virus is in low concentration

3 1 3 Molecular characterization of RSNV and its fungus vector

The molecular characterization of RSNV has only recently started following the development of an efficient virus isolation method Previous attempts to design degenerate primers for amplification of random and target genomic segments of RSNV and other related furoviruses did not yield satisfactory results With the purified RSNV the isolation of the viral RNA has now been accomplished for cloning experiments We are currently sequencing some of the clones obtained in order to determine whether they are real cDNA clones of random segments of the viral genome This work will proceed into 1999 as the ODA project has been granted an extension till the end of next year

During 1998 the molecular characterization of the fungus vector of RSNV in Colombia was accomplished by Dr Elaine Ward at Rothamstead U K as part of the collaborative activities of the ODA project on the characterization and control of RSNV in Colombia
RFLP analysis showed that there were two types of clones and initially one of each was sequenced using primer NS7 One clone showed a high homology to the plasmodiophorids with the highest homology (99 5%) being to *Polymyxa graminis* type II isolates This clone and a second clone of this type were then sequenced on both strands and found to be identical For sample 2 almost all of the clones had an RFLP type identical to the*Polymyxa* type clones from sample 1 The sequences were aligned with PILEUP and then analyzed using programs in PHYLIP The phylogenetic tree obtained strongly supports the identity of the Colombian RSNV associated fungus as *Polymyxa graminis*

Activity 3 2 Implementation of RSNV control methods

3 2 1 Development of efficient germplasm screening methods

In 1998 a hydroponic inoculation method was developed to investigate the possibility of screening a large number of rice genotypes for their reaction to RSNV To this end plastic trays were designed to contain a nutrient solution (IRRI 71) and the fungus vector/virus inocula A second tray is placed inside the tray containing the nutrient solution and the inocula but the smaller tray has orifices in the bottom to allow the growth of the root system of the test rice plants into the solution/inocula hydroponic medium The orifices are covered with mesh and over this mesh a layer of sterile sand as the plant supporting medium Each tray has a capacity of 140 seedlings This experiment has so far shown positive results resulting in inoculation efficiency rates equivalent to an LD_{50} used in experiments involving dose dependent treatments In this case the critical doses to be applied to the nutrient solution is the concentration of cystosori In the case of trays (5x33x28 cm) 100 g of infected rice roots are applied to one liter of nutrient solution

The second method of inoculation used by most researchers who work with furoviruses involves the use of dried root powder prepared from systemically RSNV infected rice roots The powder contains the resting structures of the RSNV vector *Polymyxa graminis* which give rise to zoospores once the cystosori encounter free water in the medium (sterile sand) The powder is placed in the sand medium together with the rice seed of the genotypes to be tested This method has been shown to be effective to transmit RSNV to up to 70% of test seedlings in the trays described above

3 2 2 Testing of RSNV control practices

Sustainable RSNV control practices can only be implemented once the biology of the fungus vector *Polymyxa graminis* is elucidated This study is being conducted under controlled glasshouse conditions at Rothamstead England by Dr Michael J Adams

Preliminary experiments conducted at CIAT on the effect of incorporating organic matter in soil infested by *Polymyxa graminis* suggest that the decomposition of organic material has a negative effect in the colonization of rice roots and/or infection of rice seedlings

In field experiments conducted by J A Fonseca and E Perez and J Velandia of the Universidad Pedagogica y Tecnologica de Colombia Tunja collaborators in the ODA CIAT Project rice seed was sown untreated or treated with a fungicidal mixture of Metalaxil 10% Mancozeb 49% and with and without organic matter (chicken manure) added to the soil The combination treated seed and soil with organic matter resulted in the lowest rate of disease incidence (11 2%)

Preliminary results obtained in the department of Tolima where the legume *Crotalaria* sp was incorporated as green manure to the soil also show a reduction in the incidence of RSNV (Ing Alvaro Salive FEDEARROZ)

3 2 3 Ecology of RSNV and its vector *Polymyxa graminis*

The entorchamiento (crinkling) disease of rice is currently present in 22 municipalities of the eight most important rice growing departments of Colombia (see map 1) The following is a list of the departments and municipalities in Colombia with experimentally confirmed RSNV cases

Table 1 Distribution of Rice Stripe Necrosis Virus in Colombia

Department	**Municipality**
Meta	Villavicencio
	Acacias
	San Carlos de Guaroa
	Castilla La Nueva
	Puerto Lopez
Casanare	Aguazul
	Nunchia
Tolima	Ibague
	Lerida
	Armero
	Ambalema
	Venadillo
	Prado
	Purificacion
Huila	Campoalegre
	Palermo
	Aipe
	Tello
Antioquia	Nechi
Cundinamarca	Paratebueno
Valle	Jamundi
Cordoba	Montelibano

One of the critical factors determining the incidence of the RSNV seems to be the effect of the environment on the fungus vector For massive virus/vector infection to take place alternate periods of water stress and free water are necessary in the rhizosphere of susceptible plants These wet and dry conditions induce the release of zoospores of plasmodiophorid fungi Thus it is not surprising that most RSNV outbreaks are associated with periods of water stress (drought) before planting time A look at the weather conditions preceding the first RSNV outbreak in the Eastern Plains of Colombia in 1991 and 1992 showed that the first quarter of both years had relatively low rainfall values (172 and 170 mm accumulated rainfall for the months January March) when compared to the total precipitation (332 mm) for the same period in 1990

Another predisposing factor in the emergence and dissemination of RSNV is soil texture the lighter the soil the higher the incidence of RSNV We will be testing this hypothesis in the Tolima department with the collaboration of Ing Alvaro Salive a soil specialist working for FEDEARROZ

Irrigation has also been observed to contribute to the rapid dissemination of RSNV creating a disease gradient that follows a path similar to the flow of water in the field

Finally the movement of soil particles contaminated with the fungus vector of RSNV is also associated with the use of agricultural machinery Map 1 also shows a relationship between the incidence of RSNV and the degree of mechanization of rice production in Colombia

3 2 3 Technology transfer

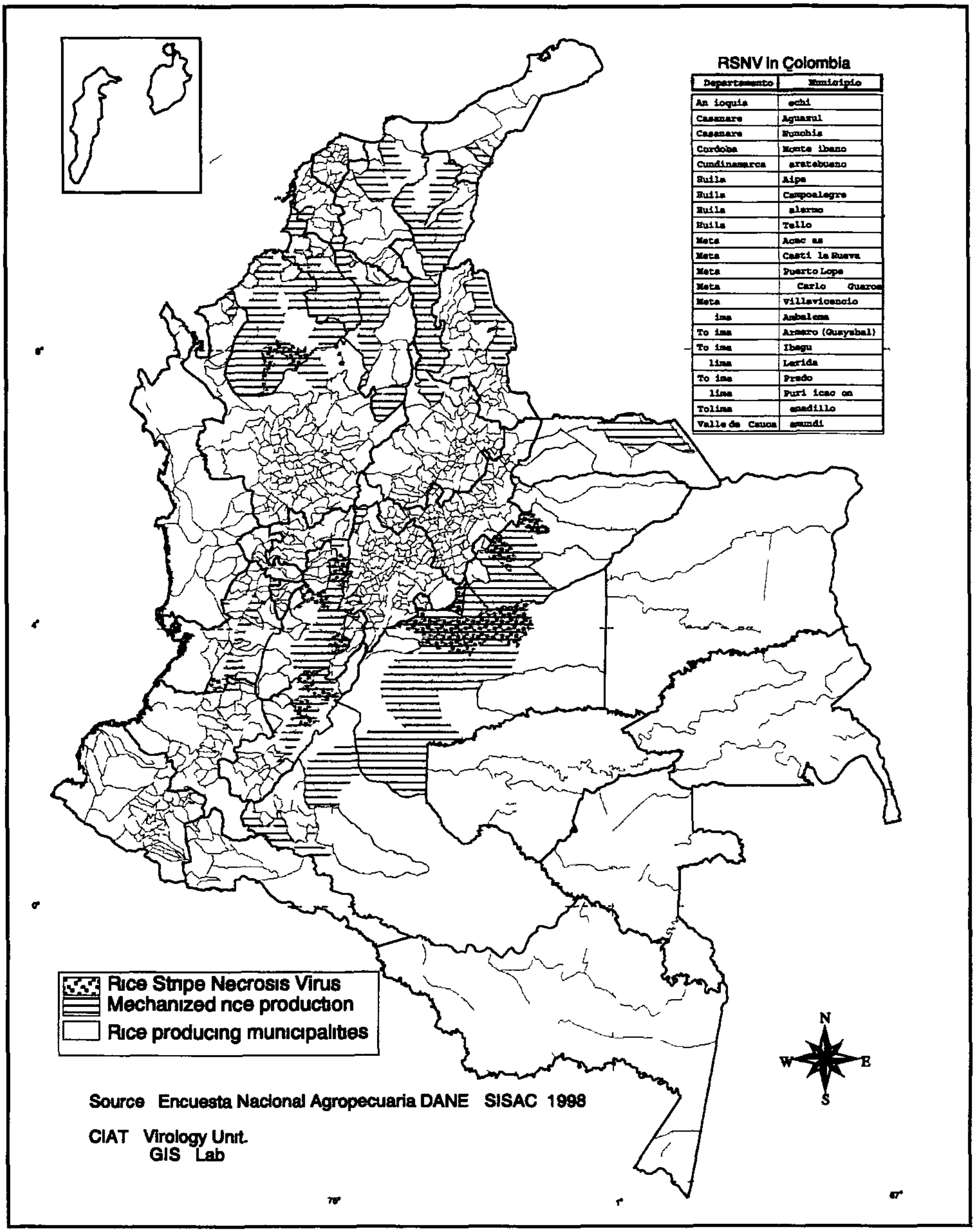
The CIAT ODA RSNV project has been collaborating with FEDEARROZ since the initiation of the project Last year in November (not reported in 1997) an informative meeting was planned with FEDEARROZ in Ibague Tolima to brief rice agronomists about the latest information available on the RSNV problem in Colombia At that meeting visual and written materials were distributed to all participants as a diagnostic aid to help them recognize the presence of RSNV in rice fields

A series of meetings were held with rice growers agronomists and agricultural technologists in two of the main rice growing departments of Colombia Tolima and Huila on March 18 20 1998 The meetings took place in Ibagué Tolima (53 participants) Lérida Tolima (42 participants) and in Neiva Huila (35 participants)
These meetings were designed to familiarize participants with the symptoms induced by RSNV to explain to attendees the futility of using pesticides to control this problem and to suggest some preliminary disease control measures aimed at arresting the dissemination of RSNV and its fungus vector

In April 7 8th 1998 a survey of the municipality of San Carlos de Guaroa was undertaken to follow up the epidemiology of RSNV from this original source of dissemination of the virus The perception of the growers is that they can manage the disease now that they know the causal agent by improving soil fertility and microbial activity and increasing seed density at planting time This latter practice is more a cosmetic measure that hides the incidence of RSNV and we hope to reduce the amount of seed used in the area once more economic virus/vector control measures are implemented (incorporation of green manure resistant varieties etc)

A fifth field trip was undertaken to assess the situation of RSNV in the department of Huila on July 27 28th 1998 This department had reported the presence of RSNV in the main rice producing municipalities back in 1996 No further reports had been received from Huila on the incidence of RSNV A survey of 9 rice fields in the municipalities of Palermo Campoalegre Aipe and Tello revealed the presence of RSNV at incidences ranging from 0 2 to 13 2% in all field visited Based on these observations we will be analyzing climatic data for this department from 1995 till present to investigate the possible effect of climatic factors on the incidence of the entorchamiento problem In this department again seed density is very high (250 350 kg/ha) probably to counteract the death of rice seedlings caused by the entorchamiento problem (which is not quantifiable in disease assessment surveys)

Map 1 Distribution of RSNV in Colombia



RSNV in Colombia

Departamento	Municipio
An ioquia	echi
Casanare	Aguazul
Casanare	Hunchia
Cordoba	Monte ibano
Cundinamarca	aratebueno
Huila	Aipe
Huila	Campoalegre
Huila	alermo
Huila	Tello
Meta	Acac as
Meta	Casti la Nueva
Meta	Puerto Lope
Meta	Carlo Guaroa
Meta	Villavicencio
ima	Ambalema
To ima	Armero (Guayabal)
To ima	Ibagu
lima	Lerida
To ima	Prado
lima	Puri icac on
Tolima	anadillo
Valle de Cauca	amandi

Source Encuesta Nacional Agropecuaria DANE SISAC 1998

CIAT Virology Unit.
GIS Lab

925U6

OUTPUT 4 PROJECT PRIORITIES AND RESEARCH CAPACITIES ENHANCED

A Economics

Luis R Sanint Roberto

Three activities were carried out in 1998

4 A 1 Analysis of the Colombian National Rice Sample
4 A 2 Creation of a network of rice economists in Latin America (RECAL)
4 A 3 Collaboration with IFPRI in a study of varietal adoption in Latin America and the Caribbean (LAC)

A brief summary of these activities follows

A 1 Analysis of the National Rice Sample in Colombia

This is an ongoing activity that started in 1988 with the implementation of the rice census The second step was the application each semester since 1991 of a survey of a representative sample nationwide of the mechanized rice farmers which account for about 50% of the total number of rice farmers (10 000 out of 20 000) and contribute to 98% of rice production in the country

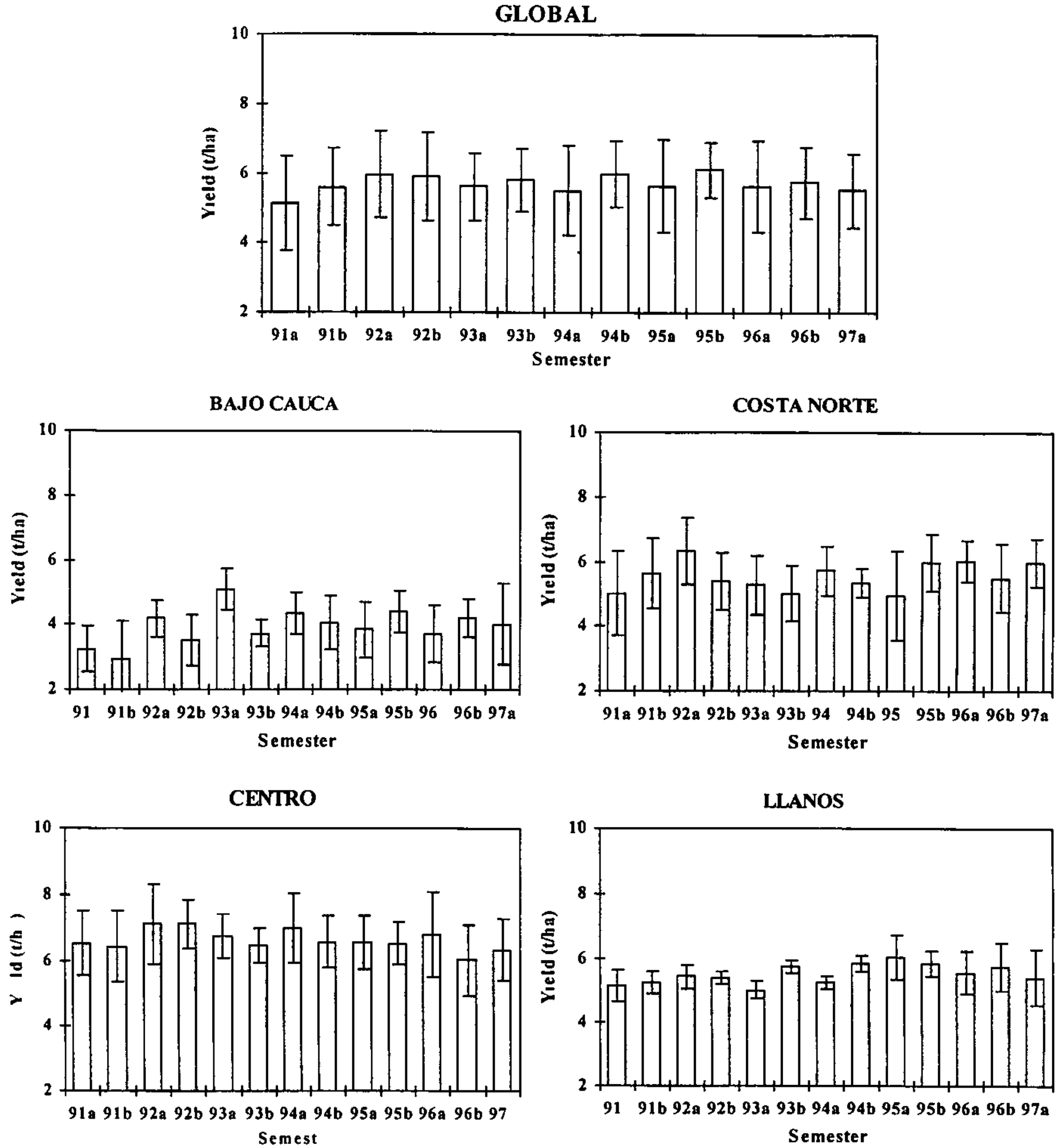
The technical coefficients were analyzed to establish seasonal patterns (Table 1) More desaggregate data is presented in the Annex (Tables A1 and A2)

Table 1 T test analysis for average technical coefficients in Colombia by semester 1991 1997

	Semester A	Semester B	PROB not different	SIGN
Rice Yield kg/ha	5868 3	5577 4	0 0001	
Seed use kg/ha	236 8	227 8	0 0004	
Nitrogen kg/ha	143 5	122 3	0 0001	
Phosphorus kg/ha	39 4	36 7	0 1325	NS
Potassium kg/ha	55 2	48 4	0 0019	
HERBICIDE Lts AI/ha	4 5	4 5	0 8453	NS
INSECTICIDE AI/ha	0 7	0 7	0 6718	NS
FUNGICIDE Lts AI/ha	1 5	1 5	0 7381	NS
Labor Hours/ha	69 5	58 7	0 0001	
Machinery Hours/ha	10 5	9 9	0 0112	

AI Active ingredient of pesticide
Sign means coefficients for each semester is significantly different

Yields are higher in the first semester and so is seed use nitrogen and potassium application as well as labor and machinery use Pesticide applications are not significantly different in each semester This tells us that input use is variable and it is related to the yield component which has a seasonal effect most likely linked to climatic conditions However for pesticide use farmers do not use the variable criterion by season



Average rice grain yield in the main rice growing regions in Colombia from 1991 to 1997a

Colombian National Rice Sample

Data for this survey has been collected by FEDEARROZ since 1991 according to the following stratification established in 1990

1 Farm size 3 lends less tan 3 ha 3 – 10 ha and more than 10 ha
2 Land tenancy 2 levels renters and owners
3 Rice growing systems 2 levels irrigated and mechanized favored upland
4 Regions 4 levels Bajo Cauca Costa Norte Centro and Llanos

The total sample had 48 cells resulting from four regions two types of rice growing systems the farm sizes and two types of tenancy

A 97% confidence interval was used in the stratification of rice grain yield and it was applied proportionally to the cells defined in the stratification Each selected farmer had the opportunity to choose from two similar options

A 2 Creation of a Network of Rice Economists for Latin America (RECAL)

The CIAT rice project together with FEDEARROZ and CIRAD took the initiative of formalizing the interchange of data and knowledge among colleagues working in this area The network met in Quito last July Eight countries sent a total of 27 representatives as follows

Brazil	3 people
Colombia	4 people
• Chile	1 people
• Ecuador	11 people
• France	1 people
• Panama	1 people
• Uruguay	1 people
• Venezuela	5 people

One of the objectives of the network is to increase participation form the private sector in the exchange of data About half of the participants in the meeting come from private sector organizations Several topics of common interest were brought to the table

Production data

- Production systems in each country characteristics comparative advantages
- Costs profitability
  Technical and Economic efficiency
  Technology adoption(varieties inputs management practices)
- Returns to investment in rice research (MODEXC DREAM)
- Characterization of rice producers resource endowment technology use etc
  Agroindustry efficiency indexes
  Rice consumption patterns
  Commercialization and input distribution systems
  Prices formation integration seasonality etc

Characterization of the rice chain
Institutional aspects

To establish priorities among this long and ambitious list a commission of five persons was appointed They have to meet later in the year to make a proposal for a plan of action that will be ratified by the members in the next meeting early in 1999 Patricio Méndez form CIRAD was appointed as coordinator of the network

The local costs for the meeting were covered by the host country (Ecuador) and every participant is sponsored by a local institution The cost for CIAT is therefore minimal (my own travel expenses)

A 3 Collaboration with IFPRI in Analysis of Varietal Adoption in LAC

Activity

Design a plan of action in our collaborative work on impact of rice research in Latin America which is being conducted as part of a Ph D dissertation by Nienke Beintema

Progress

a Varietal adoption and Impact of rice research in LAC This is a continuous activity in the rice project given the dynamism and complexity of the adoption process

The rates of adoption for new High Yielding Varieties (HYVs) in irrigated rice are close to 100% This is a region where yields in this ecosystem are rather high and are still growing as the region exhibits the highest rate of growth in rice production and yield increase in this decade (Table 2) By 1997 it is estimated that irrigated rice area reaches 2 4 million ha and over 2 3 million of them are under HYVs With respect to rice production irrigated rice supplies 12 6 million tons with an average yield of 5 2 t/ha over 98% of that production comes from HYVs Lowland rainfed rice occupies 1 1 million ha And contributes with 4 2 million tons per year for an average yield of 3 9 t/ha About 90% of that production comes from HYVs In contrast with those numbers upland rice reaches 2 6 million ha And supplies 3 4 million tons for an average yield of 1 3 t/ha Only one fourth of the upland area is under HYVs (Table 3)

Table 2 Rice annual rates of growth by continent 1990 97

	Asia	Latin America	North America	Africa
Production	1 5	3 8	1 8	3 7
Yield	1 4	3 7	1 0	1 0
Area	0 3	0 1	0 8	2 7

SOURCE FAOSTAT 1998

In the 1970 97 penod a total of 297 new vaneties have been released in Latin America (Table 4) The majority of them (262 or 88%) are HYVs targeted to irrigated conditions Both CIAT and INGER LAC have been key actors in these developments Of the new HYVs released for irrigated environments 43% came from crosses made at CIAT 5% came from local crosses using CIAT parents and 10% came from crosses made at IRRI The majority of the other varieties descend from progenitors that were interchanged through INGER LAC More than 60% of the varieties released in the countries entered through INGER LAC Another 22% came through the network and was used as progenitors to develop new varieties Only 17% of varieties released in LAC are not related to INGER LAC

In upland rice the impact of HYVs has been much lower In 1970 97 a total of 35 new varieties were released (Brazil 29 Bolivia 3 Colombia 2 and Mexico 1) Of them 29% entered the countries as advanced lines through INGER LAC while 34% use progenitors that came though this mechanism

Table 3 Share of HYVs in the rice sector of Latin America and the Caribbean (LAC) by ecosystem 1966 1997

	PRODUCCION				AREA				RENDIMIENTO			
	1966	*1981*	*1989*	*1997*	*1966*	*1981*	*1989*	*1 997*	*1966*	*1981*	*1989*	*1997*
Flooded systems												
Irrigated	4 328	7 710	11 022	12550	1 252	1 952	2 475	2 413	3 5	3 9	4 5	5 2
HYVs	0	6 110	9 708	12350	0	1 491	2 097	2 330		4 1	4 6	5 3
Rainfed Lowlands	2 026	2 178	2 840	4233	674	678	816	1 074	3 0	3 2	3 5	3 9
HYVs	0	1 162	1 968	3809	0	341	505	907		3 4	3 9	4 2
Subtotal	6 354	9 888	13 862	16783	1 926	2 630	3 291	3 488	3 3	3 8	4 2	4 8
Subtotal VMS	0	7 272	11 676	16159	0	1 832	2 602	3 237		4 0	4 5	5 0
Upland systems												
Mechanized	2 809	5 070	3 684	2434	2 812	4 786	3 146	1 667	1 0	1 1	1 2	1 5
HYVs	0	350	489	750	0	279	325	375		1 3	1 5	2 0
Manual	990	788	877	950	1 100	847	904	950	0 9	0 9	1 0	1 0
HYVs	0	236	263	290	0	220	255	290		1 0	1 0	1 0
Subtotal	3 799	5 858	4 561	3384	3 912	5 633	4 050	2 617	1 0	1 0	1 1	1 3
Subtotal VMS	0	586	752	1040	0	499	580	665		1 2	1 3	1 6
Total LAC	**10 153**	**15 746**	**18 423**	**20167**	**5 838**	**8 263**	**7 341**	**6 105**	**1 7**	**1 9**	**2 5**	**3 30**

Source CIAT Rice Project 1998

Table 4 Varieties released in LAC 1970 97 Contributions from CIAT IRRI INGER and Local Programs

Source of Released Variety	Total	Irrigated	Upland
Variety from a cross made at			
CIAT (INGER)	118	112	6
IRRI (INGER)	27	25	2
Other (INGER)	26	24	2
Variety from a progenitor from			
CIAT (INGER)	13	13	0
Other (INGER)	56	44	12
Variety with no relation to INGER	57	44	13
Varieties released 1970 97	297	262	35
Subtotal related to INGER	240	218	22
Share of INGER %	**81%**	**83%**	**63%**

Source Database Rice Project CIAT 1998

Yields in irrigated and lowland rainfed areas have increased substantially while those in upland rice have remained stagnant This explains the shift in production from the unstable lands of the savannas and the forest margins (upland rice) to the more stable lowlands (Table 4) Upland rice production reduced its regional share from 67% in 1966 to 22% in 1997

It is important to document these processes in detail to measure the impact of rice research the collaborative study with IFPRI includes ten countries This year data on varietal release from *Colombia from 1991 was sent to IFPRI (see table 5A)* and similar efforts are on the way for the Brazil (Table 5B) and other eight countries

There is a substantial amount of overlap of this study with the IAEG study on impact that TAC has contracted (R Evenson manages at the global level Nancy Johnson coordinates at CIAT) This is an excellent opportunity to document impact and build a reliable and complete database on the subject

Table 5A Rice area planted under each variety in Colombia by semester 1991A to 1997A

VARIETY	PERIOD 91A		PERIOD 91B		PERIOD 92A		PERIOD 92B		PERIOD 93A		PERIOD 93B		PERIOD 94A	
	AREA	%	*AREA*	%	*AREA*	%	*AREA*	%	*AREA*	%	*AREA*	%	*AREA*	%
Araure 4	--	--	--	--	--			--		--			--	
Oryzica Caribe 8		--		--		--	--			--	--	--	--	
Cica 4	250	0 15			441	0 24	441	0 36	992	0 55	441	0 38	898	0 43
Cica 8	10 965	6 42	31 229	25 07	33 314	18 14	37 237	30 47	27 372	15 19	30 126	25 70	51 131	24 77
Cica 9			407	0 33			--	--	--		1 011	0 86		
Cimarron		--	--	--	--		--	--	--		1 356	1 16	30	0 01
IR 22			--	--	--		221	0 18	4 864	2 70		--	--	--
Linea 2	2 952	1 73			22 701	12 36			8 702	4 83	--	--	3 054	1 48
Metica 1	--	--	--	--		--	--	--	--	--	--		8 057	3 90
Oryzica Llanos 5	9 011	5 28	6 880	5 52	18 135	9 87	6 958	5 69	35 500	19 70	14 874	12 69	19 793	9 59
Oryzica 1	135 810	79 56	72 316	58 05	86 110	46 88	65 785	53 84	86 438	47 96	61 147	52 16	99 092	48 00
Oryzica 3	11 656	6 83	12 985	10 42	18 709	10 19	10 855	8 88	15 896	8 82	7 800	6 65	23 789	11 52
Rioguayas		--	--				--	--	130	0 07	--			--
Roa 1	65	0 04	758	0 61	4 268	2 32	697	0 57	349	0 19	479	0 41	595	0 29
Selecta 3 20		--	--	--	--	--			--		--		--	--
Tailandia		--		--		--			--	--		--		--
Oryzica Yacu 9		--	--	--	--	--		--	--				--	--
TOTAL	**170 709**	**100 0**	**124 575**	**100 0**	**183 678**	**100 0**	**122 194**	**100 0**	**180 243**	**100 0**	**117 234**	**100 0**	**206 439**	**100 0**

VARIETY	PERIOD 94B		PERIOD 95A		PERIOD 95B		PERIOD 96A		PERIOD 96B		PERIOD 97A		PERIOD TOTAL	
	AREA	%	*AREA*	%	*AREA*	%	*AREA*	%	*AREA*	%	*AREA*	%	*AREA*	%
Araure 4	65	0 06	--	--	--				--		--	--	65	0 00
Oryzica Caribe 8	2 436	2 26	40 334	26 05	14 373	12 70	25 189	13 49	7 302	6 78	33 632	12 90	123 266	6 05
Cica 4	--	--	--	--			872	0 47	--	--			4 335	0 21
Cica 8	27 176	25 21	21 191	13 68	30 816	27 22	2 707	1 45	12 945	12 02	31 158	11 95	347 367	17 06
Cica 9	--	--	462	0 30	523	0 46			--		462	0 18	2 865	0 14
Cimarron	886	0 82	123	0 08	4 553	4 02	5 411	2 90	347	0 32	1 062	0 41	13 768	0 68
IR 22	3 755	3 48	3 755	2 42	130	0 11	6 701	3 59	26	0 02	26	0 01	19 478	0 96
Linea 2	221	0 20	1 190	0 77	10 163	8 98	2 112	1 13	3 503	3 25	16 840	6 46	71 438	3 51
Metica 1	--	--		--	--	--	--		--		--	--	8 057	0 40
Oryzica Llanos 5	27 096	25 13	12 871	8 31	8 305	7 34	22 570	12 09	3 023	2 81	3 182	1 22	188 198	9 24
Oryzica 1	37 023	34 34	51 575	33 30	30 254	26 73	70 188	37 58	38 706	35 95	70 262	26 95	904 706	44 43
Oryzica 3	4 511	4 18	11 471	7 41	6 137	5 42	1 115	0 60	4 526	4 20	4 039	1 55	133 489	6 56
Rioguayas	--	--		--	--	--		--	--	--			130	0 01
Roa 1	4 642	4 31	349	0 23	--		423	0 23	523	0 49	1 507	0 58	14 655	0 72
Selecta 3 20	--	--	523	0 34	7 946	7 02	31 801	17 03	3 565	3 31	48 779	18 71	92 614	4 55
Tailandia		--	11 017	7 11	--		6 671	3 57			31 803	12 20	49 491	2 43
Oryzica Yacu 9					--	--	11 000	5 89	33 195	30 83	17 934	6 88	62 129	3 05
TOTAL	**107 811**	**100 0**	**154 861**	**100 0**	**113 200**	**100 0**	**186 760**	**100 0**	**107 661**	**100 0**	**260 686**	**100 0**	**2 036 051**	**100 0**

Tabla 5B Vanedades comerciales sembradas en las zonas de producción de arroz RS – Brasil

VARIEDAD	FRONT OESTE	L SUR	CAMPAÑA	DEPRE CENT	PL COST INT	PL COST EXT
IRGA	*% de Area Sembrada*					
⇨ 409	26	0	7	12	9	19
⇨ 410	4	31	8	11	38	14
⇨ 412	0 8	0	0 3	2	0 9	0
⇨ 414	0	0	0 4	16	2	2
⇨ 416	7	4	13	20	15	27
⇨ 417	0 9	0 2	0 9	5	2	3
Total IRGA	*39*	*34*	*30*	*66*	*67*	*65*
Vanedades EMPRAPA						
⇨ TAIM	18	1	15	6	2	8
⇨ CHUI	17	7	15	5	6	3
⇨ 38	0	0	0	0 2	0	0 3
⇨ 39	0 1	0	0	0 1	0	0
Total EMBRAPA	*25*	*8*	*30*	*11*	*8*	*11*
Vanedades Importadas						
⇨ BLUEBELLE	0 1					
⇨ EL PASO 144	14	52	34	18	23	16
⇨ FORMOSA	0	0 1	0	0	0 2	0
⇨ TACUARY	0	0 5	0	0	0	0
⇨ YERBAL	0	0 8	0	0	0	0
⇨ EPAGRI 107	0	0	0	0	1	4
Total Var Importadas	*14*	*54*	*34*	*18*	*24*	*20*
Empresas Comerciales						
⇨ SUPREMO 1	0	0 9	0	0	0	0
⇨ Otras	13	1	3	4	1	3

OUTPUT 4 PROJECT PRIORITIES AND RESEARCH CAPACITIES ENHANCED

B FLAR

James Gibbons Luis R Sanint

During 1998 two more members joined FLAR Uruguay (in June) and Bolivia (in August) Earlier the sate of Santa Catarina had also signed an agreement with IRGA to participate in FLAR The ten countries that currently form FLAR will contribute in 1998 a total of US$382 500 CIAT and IRRI will contribute $50 000 each The annual contribution form members will reach $482 500 For 1999 it is expected that Argentina Chile Ecuador and Nicaragua will also join bringing an additional income of $157 500 and a total income of $640 000 for the year FLAR is in the process of hiring a breeder for the Southern Cone which will be based in South Brazil (Rio Grande do Sul)

Activities
Training

FLAR organized two IPM courses one in Paraguay (March) with the assistance of 90 persons and one in Guatemala (May) with 76 participants A breeders workshop was organized in August for participation of the regions breeders in selection of early generation breeding lines at the Santa Rosa Station Breeders from Brazil Colombia Venezuela Costa Rica and Bolivia attended Currently breeders from Venezuela are assigned to FLAR on a rotating basis for six months for training specific research and breeding activities Thesis work by 3 M S candidates is being carried out with cooperation of CIAT scientists and Ph D work by a student at The University of Rio Grande do Sul is being carried out in cooperation with IRGA in Brazil (see Table 1)

Following are the main activities of FLAR in breeding during 1998

Table 1 FLAR trainees at Palmira or Villavicencio Colombia 1998

Name	Country	Discipline	Length of stay[1]	MS Thesis
Rosa Maria Alvarez	Venezuela	Breeding	Long	
Gelis Torrealba	Venezuela	Breeding	Long	
Carlos Gamboa	Venezuela	Breeding	Long	X
Ramiro de la Cruz	Venezuela	Breeding	Short	
Maria Navas	Venezuela	Pathology	Short	
Eduardo Graterol	Venezuela	Breeding	Short	
Luis Eduardo Berrio	FLAR	Breeding	Long	X
Julio Holguin	Colombia	Breeding	Long	
Alberto Davalos	Colombia	Breeding	Long	
Edgar Corredor	Colombia	Breeding	Long	X
Juan Sierra	Colombia	Breeding	Short	
Pompilio Gutierrez	Colombia	Breeding	Short	
Alejandro Vargas	Colombia	Breeding	Short	
Luis Eduardo Dussán	Colombia	Breeding	Short	
Sergio Lopes	Brazil	Breeding	Short	
Roger Taboada	Bolivia	Breeding	Short	
Randolph Campos	Costa Rica	Breeding	Short	

Research Objectives

- Access and interchange of germplasm and information via INGER LAC
  Identify and characterize new progenitors for use in the regions breeding programs
- Develop new cultivars with stable resistance to major biological and edaphic stresses
- Investigate post harvest aspects
- Promote strategies of crop management which lead to a more sustainable production

Breeding Objectives

- High stable yield
- Acceptable grain and milling quality
- Blast disease resistance
- Iron toxicity tolerance
  Hoja Blanca disease resistance (Tropical zone)
- Cold tolerance (Temperate zone)

Germplasm Bank

FLAR maintains a germplasm bank of about 1280 entries a savanna upland working collection of 258 entries and an irrigated working collection (WC) of 470 entries The WC has been characterized for morphological and physiological traits such as plant height days to 50% flowering vegetative vigor grain quality brown spot leaf scald grain spotting Hoja Blanca virus and Sogata Field blast scores as well as compatibility to the six Santa Rosa blast lineages (Levy et al 1994) are also recorded This information is critical for the successful programming of crosses which result in lines adapted to the different rice agroecosystems of Latin America A duplicate set of all banks has been sent to the USDA rice germplasm evaluation and enhancement center at Stuttgart Arkansas

Crossing

FLAR uses the simplified crossing method of CIAT (Sarkarung 1991) Since our inception we have processed more than 950 triple crosses As a service to our members we rocess crosses on demand

F1 F3

The F1 and F3 generations are planted at Palmira Colombia Single plant selection in the F1 is based on plant and grain type In addition to plant and grain type F3 plant selections are based on data for grain quality and HBV (for tropical crosses)

F2 F4

FLAR uses the Santa Rosa Experiment Station in Villavicencio Colombia as the primary breeding site This blast hot spot provides for confident selection and characterization of local and introduced genetic materials

To ensure a uniform pressure for blast spreader rows of defeated commercial cultivars are planted perpendicular to prevailing winds several weeks prior to the test material (Pulver and Bruzzone 1985) The breeding lines are mixed 50/50 with the highly susceptible cultivar FANNY prior to drill seeding Blast evaluations are made in both the leaf and neck stages Due to the high uniform and diverse disease level a range of reactions results which facilitates targeting of test lines to specific agroecosystems FLAR germplasm planted at Santa Rosa and Palmira during the first semester of 1998 is shown in Table 7

Table 7 FLAR Germplasm Planted at Villavicencio and Palmira 1998A

Source	No Lines	No Crosses
• VIOFLAR 19971998	312	40
F4 Populations		
Tropical	522	6
Temperate	652	13
Subtotal	1174	19
• R2	620	58
• F2 Population		
Tropical	5833	202
Temperate	1776	136
Subtotal	7609	338
• F1 Triple Crosses		406
TOTAL LINES	**9715**	**861**

Includes 4 common crosses

Anther Culture

In cooperation with the CIAT Rice Project biotechnology laboratory FLAR passes F1 plants from selected crosses through anther culture (AC) to obtain doubled haploids Fifteen F1 plants from triple crosses are pre evaluated for the ability to produce calli and green plants The entire F1 population of between 100 and 150 plants which are responsive are planted 45 days after the first set then heavily harvested for AC This pre evaluation allows for more efficient use of the laboratory In 1998 over 620 R2 lines were field evaluated (Table 7)

CIRAD

The International Center for Cooperation in Agronomic Research and Development (CIRAD) of France has developed recurrent selection pools adapted to Latin America conditions FLAR selects lines from these pools characterizes and distributes them to national programs Germplasm from FLAR member countries also is incorporated into the gene pools to add additional quality traits for recombination within the pools A CIRAD scientist is assigned to FLAR to develop screening methods and germplasm specific for partial resistance to blast disease

CIAT National Programs IRRI

FLAR is characterizing about 650 lines originating from CIAT National Programs throughout the world and IRRI (Table 8) The selected lines from these public institutions will be distributed through the INGER LAC network to all participating national programs in LAC

Table 8 Introductions Planted at Villavicencio and Palmira 1998A

Materials		Lines
• Country		
	Brazil Itajai	23
	Nicaragua	10
	United States	1
	Guyana	27
	Thailand	77
	Argentina	5
	Dominican Republic	54
	CIRAD Aromatics	9
	VIARC 1996	2
Subtotal		208
• CIAT		
	Recurrent Sel – Pathology	144
		27
	CIRAD	
	F5 Wild Rice	24
	New Plant Type – IRRI	33
Subtotal		228
Nurseries INGER 1998		
	IIRON	75
	IRFAON	59
	IRLON	79
Subtotal		213
TOTAL LINES		**649**

Quality

Latin American consumers generally prefer white long grain rice The FLAR breeding program selects rice which has low white belly intermediate/low gelatinization temperature and intermediate/high apparent amylose content In 1996 and 1997 the quality lab analyzed an average of 12 620 samples per year for grain length white belly and gel temperature These samples include F3 F4 and F5 grain and samples from FLAR member countries Apparent amylose was evaluated for over 4 450 samples per year F4 and advanced lines from member countries are also evaluated for milling quality *FLAR evaluated more than 330 lines per year for* milling return in 1996/97 The experimental lines which do not meet quality standards are discarded in early generations

Iron Toxicity

Iron toxicity is a limiting factor for rice production in areas where the soils contain a high iron content such as the south of Brazil or in irrigated acid soils of the Llanos of Colombia and Venezuela The symptoms of toxicity include yellow/orange leaf coloration dwarfing low tillering and yield reduction FLAR uses an iron hot spot site in Santa Catarina Brazil for screening advanced temperate germplasm In collaboration with CIAT a method using concrete tanks filled with acid soil of high iron content is being developed for F4 generation lines

Cold Tolerance

Cold temperatures are a limit to rice production in the Southern Cone and some areas of the Caribbean During crop establishment cold air and water can reduce germination and retard early seedling growth Cold fronts that pass through rice crops during reproductive stage can induce spikelet sterility and reduce yield In collaboration with IRGA and CIAT we are combining sources of cold tolerance with sources for tolerance to other stress such as blast and iron toxicity We use anther culture to obtain doubled haploid lines which are then evaluated for diseases in Colombia and iron and cold in the south of Brazil In collaboration with the University of Rio Grande do Sul we are developing simplified screening methods using conventional and molecular techniques

Hoja Blanca Virus Disease

The disease caused by the Hoja Blanca Virus (RHBV) and its insect vector *Tagosodes orizicolus* is endemic to the tropics of LAC In Colombia and other countries the incidence of the disease has been increasing Integrated crop management and the use of resistant varieties is the best method of control for this disease

In cooperation with CIAT scientists FLAR is selecting breeding lines with tolerance to both the virus and the vector The results of our evaluations for 1996 and 1997 are shown in Table 9 Only those lines which are rated as tolerant are advanced and distributed to tropical countries

Table 9 Rice lines evaluated for resistance to RHBV and tolerant to mechanical damage caused by *Tagosodes orizicolus*

Test	No of materials evaluated	Resistance or tolerant	Intermediate reaction	Susceptible
RHBV 1996	8012	2702 33 7%	778 9 8%	4282 53 4%
RHBV 1997	12 300	5938 48 3%	1546 12 6%	4561 37 0%
Tagosodes 1996	3049	1428 46 8%	271 8 9%	1350 44 3%
Tagosodes 1997	2943	1589 54 0%	133 4 5%	862 29 3%

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ANNEX

Table A1 Technical coefficients for rice cultivation in Colombia entire country averages 1991 1997

Period	Farm Size Ranges	Area sampled	Yield	Seed	Nitrogen	Phosphorus	Potasium	Herbicide	Insecticide	Fungicide	Labor	Machinery
Year/Semester	*has*	*Has*	*kg/ha*	*kg/ha*	*kg ai/ha*	*kg ai/ha*	*kg ai/ha*	*kg ai/ha*	*kg ai/ha*	*kg ai/ha*	*hours/ha*	*hours/ha*
91a	92	170709	5129	208	123	40	41	4 4	1 2	1 4	53	10 2
91b	82	124575	5611	238	135	38	47	4 8	0 7	1 3	54	9 6
92a	98	183678	5958	236	126	38	37	5 1	0 7	1 7	53	11 2
92b	76	122194	5909	230	128	35	42	5 5	0 8	1 9	57	11 2
93a	126	180243	5626	225	140	29	36	5 0	0 5	1 3	65	9 9
93b	78	117234	5816	229	142	32	45	4 9	0 7	1 2	63	10 7
94a	127	206439	5518	227	103	24	32	4 9	0 5	1 0	61	10 0
94b	76	107811	6017	237	150	39	57	3 9	0 6	1 3	70	11 2
95a	96	154861	5653	224	113	52	54	4 3	0 6	1 2	64	10 2
95b	66	113200	6121	238	153	44	73	3 6	0 9	1 8	83	10 8
96a	97	186760	5634	230	127	36	59	4 3	0 8	1 3	70	9 5
96b	69	107661	5762	250	155	49	70	4 0	0 5	1 5	93	9 6
97a	117	260686	5530	239	125	40	72	3 6	0 7	2 1	49	9 2

Table A2 Technical coefficients for rice cultivation in Colombia by farm size ranges 1991 1997

Period	Farm Size Ranges	Area sampled	Yield	Seed	Nitrogen	Phosphorus	Potasium	Herbicide	Insecticide	Fungicide	Labor	Machinery
Year/Semester	has	has	kg/ha	kg/ha	Kg ai/ha	kg ai/ha	kg ai/ha	kg ai/ha	kg ai/ha	kg ai/ha	Hours/ha	hours/ha
91a	0 to <3	1222	4914	212	103	18	18	3 7	0 7	1 5	117	12 0
91b	0 to <3	1295	5715	247	135	17	26	3 8	0 6	1 5	146	12 6
92a	0 to <3	1084	5976	265	147	25	16	3 9	0 6	1 7	125	13 0
92b	0 to <3	842	7037	291	170	38	52	5 0	0 7	2 0	142	12 4
93a	0 to <3	1096	5768	260	129	36	22	4 1	0 5	1 1	141	10 9
93b	0 to <3	798	6264	292	202	36	35	4 3	0 3	1 4	155	13 5
94a	0 to <3	944	5706	264	156	20	38	4 2	0 5	2 1	147	16 5
94b	0 to <3	1060	6159	292	146	31	34	3 4	0 8	2 0	197	13 0
95a	0 to <3	1074	6150	269	174	48	58	4 6	0 6	2 4	190	14 0
95b	0 to <3	995	5781	270	158	61	57	4 2	0 6	1 4	181	12 5
96a	0 to <3	862	6289	298	177	45	40	4 4	0 5	1 1	192	12 8
96b	0 to <3	860	6494	272	189	43	60	4 1	0 6	1 9	195	14 1
97a	0 to <3	730	6467	278	185	62	41	4 5	0 6	1 2	170	12 6
91a	3 to 10	10709	5085	223	104	26	28	3 8	1 0	1 0	77	10 8
91b	3 to 10	11217	5791	240	143	32	37	4 3	0 6	1 1	96	11 7
92a	3 to 10	11432	5810	241	138	26	31	4 4	0 6	1 5	89	13 3
92b	3 to 10	10241	5723	247	143	32	31	4 1	0 6	1 3	88	12 8
93a	3 to 10	17740	5558	216	124	19	23	4 8	0 5	1 2	115	11 5
93b	3 to 10	12004	5371	230	130	31	36	3 0	0 6	1 0	93	11 5
94a	3 to 10	17639	5354	225	107	29	25	3 8	0 4	0 8	80	10 3
94b	3 to 10	9629	5913	245	144	42	44	3 3	0 7	1 5	97	11 2
95a	3 to 10	12874	5737	241	140	35	37	4 1	0 6	0 7	107	11 0
95b	3 to 10	8862	5794	247	160	36	48	4 4	0 6	0 9	101	8 8
96a	3 to 10	11050	5304	245	126	28	42	4 5	0 5	1 1	116	12 1
96b	3 to 10	9472	5409	250	167	38	49	4 5	0 7	1 3	108	9 0
97a	3 to 10	14464	5261	242	131	32	45	4 4	0 9	1 4	90	9 6
91a	>10	158778	5134	207	125	42	42	4 4	1 3	1 4	51	10 2
91b	>10	112063	5592	238	135	39	48	4 9	0 7	1 3	48	9 4
92a	>10	171162	5968	235	125	39	37	5 1	0 7	1 7	50	11 1
92b	>10	111111	5918	228	126	35	43	5 6	0 8	2 0	54	11 1
93a	>10	161407	5633	226	142	30	38	5 0	0 6	1 3	58	9 7
93b	>10	104432	5864	228	143	32	46	5 1	0 7	1 2	59	10 6
94a	>10	187856	5532	227	102	24	32	5 0	0 5	1 0	59	9 9
94b	>10	97122	6026	236	151	39	59	4 0	0 6	1 3	66	11 1
95a	>10	140913	5642	222	110	54	55	4 3	0 6	1 2	59	10 0
95b	>10	103343	6152	237	153	45	76	3 5	0 9	1 9	80	10 9
96a	>10	174848	5652	228	126	36	60	4 3	0 8	1 3	67	9 3
96b	>10	97329	5790	249	154	50	72	4 0	0 5	1 5	91	9 6
97a	>10	245492	5544	238	125	40	74	3 6	0 7	2 2	47	9 2

92548

OUTPUT 4 PROJECT PRIORITIES AND RESEARCH CAPACITIES ENHANCED

C Improved upland varieties for the Peruvian selva (contribution to Output 4 of Forest Margins 1998 Workplan New options for agro silvo pastoral systems)

Carlos Bruzzone

Pre-adaptive evaluation of upland rice germplasm

The aim of this work is to provide to the Forest Margins Group a set of improved rice germplasm that could be used in their participatory research activities in farmer fields in the Pucallpa site This work started in 1998 and has two primary activities a short term activity focused in the seed multiplication of upland varieties released in other countries and a mid term activity dealing with the evaluation in Pucallpa of 156 advanced upland lines developed by the CIAT/CIRAD collaborative research group

The seed increase of five upland varieties CIRAD 409 (Linea 30 CT11891 2 2 7 M) Progresso (Brasil) Oryzica Sabana 6 (Colombia CIAT) Oryzica Sabana 10 (Colombia CIAT) e IRAT 146 (Costa de Marfil IRAT) was carried out in EE Nueva Cajamarca (Province of Rioja Department of San Martin Peru) by Fundacion para el Desarrollo Agrario del Alto Mayo (FUNDAAM) These varieties will be used next season (starting in September) in farmer plots within the participatory research framework led by CIAT in Pucallpa

A set of 156 genotypes including 148 advanced upland lines and 8 international varieties was planted in May both in Calzada (Moyobamba Department of San Martin) by Ing Cesar Tepe (FUNDAAM) and Pucallpa (EE Pucallpa) by Ing Manuel Cancino (INIA) The Calzada trial failed after a wrong calibration of a herbicide application

Data from the Pucallpa trial is presented in Table 1 There was not a significant presence of leaf diseases in this trial Twelve advanced lines have been selected on the basis of agronomic performance and grain milling traits These lines showed greater lodging tolerance than the local variety Chancabanco that is widely grown in Pucallpa No yield advantage seems to have the introduced over the local genetic material Selected lines will be further tested in replicated trials in two locations (Pucallpa and Calzada) during the next planting season starting in next October

Table 1 **Agronomic traits and grain quality of selected upland rice advanced lines in comparison to local check and international varieties in Pucallpa 1998**

Pedigree	Days to heading	Days to 50 / flowering	Days to maturity	Plant height (m)	Lodging (/)	Yield (TM/ha)	Milled rice (/)			White Belly[1]
							Whole	broken	total	
CT 13370 2 2 M	69	72	105	0 90	0	6 285	43 8	28 1	71 9	1 5
CT 13370 19 4 M	69	72	105	0 95	0	5 673	41 1	29 9	71 0	2 5
CT 13370 18 5 M	78	83	111	0 90	0	5 602				
CT 13382 5 2 M	72	78	105	1 05	0	5 011	52 7	21 1	73 8	2 5
CT 11619 11 1 M	78	83	111	1 15	0	4 785				
CT 13382-6 1 M	69	78	105	1 05	0	4 643	41 5	32 5	74 0	2 5
CT 13370 18 M	78	83	111	0 90	0	4 564	43 4	22 5	65 9	2 5
CT 13364 7 1 M	69	83	105	1 10	0	4 251	47 5	22 6	70 1	2 0
CT 13370 9 1 M	69	83	111	0 80	0	4 233				
CT 13382 8 3 M	69	78	105	0 80	19	4 146	45 4	26 5	71 9	2 0
CT 13370 1 1 M	66	78	105	1 10	0	4 107	48 0	23 6	71 6	2 0
CT 13370 18 3 M	72	83	111	0 80	0	4 012	40 4	27 5	67 9	2 5
Local Check Chancabanco (12 plots)										
Average	60	65	97	1 09	70	5 140	46 4	27 6	73 9	2 0
Range	60	63-66	97	0 95 1 20	0 100	3 502 6 496	45 4 47 3	26 3 28 8	73 6 74 0	2 0
International checks										
CIRAD 409	56	61	97	0 70	0	5 388	48 8	25 7	74 5	3 0
IRAT 146	63	69	97	1 05	0	4 907				
CIRAD 411	63	69	105	0 75	42	3 590	29 3	44 6	73 9	2 0
CAIAPO	78	83	105	0 95	0	3 541	50 6	21 6	72 2	2 0
CIRAD 410	59	63	97	0 90	100	3 386	25 6	44 7	70 3	3 0
O Sabana 10	78	83	111	0 80	0	2 947				
O Sabana 6	78	83	111	1 00	0	2 516				
Progresso	83	86	111	0 80	0	2 046				

Scale 1 – 5 where 1 = 0 % grain chalkiness and 5 = more than 25% grain chalkiness

ANNEX 1

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Annex 2

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