Annual Report 1995

Rice Program

For Internal Circulation
and Discussion Only

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

Rice Program 1995 Annual Report 1995 Centro Internacional de Agricultura Tropical (CIAT) Cali Colombia 155p

TABLE OF CONTENTS

RICE PROGRAM ANNUAL REPORT 1995

Introduction and Overview

During 1995 the Rice Program had 4 7 core senior staff positions two breeders (lowlands and upland) one pathologist 0 7 of the physiologist and the leader (an agricultural economist) with a time share of a 50% as Director of the newly created Latin American Fund for Irrigated Rice FLAR There is a Senior Research Fellow in entomology on a 50 / basis (shared with the Tropical Forages Program) Two Associate members of the senior staff also collaborate with us a breeder from CIRAD CA (France) and a physiologist from JIRCAS (Japan) The team is completed with support from a Senior Research Fellow from the Biotechnology Unit (that works full time in rice genetics) a Senior Staff in that same unit (that devotes 20 /o of his time to rice) and a Senior Staff in the Virology Unit (that shares 40⁄ of his time with the Rice Program) In addition to this FLAR has also appointed an irrigated rice breeder located at CIAT s headquarters

Rice Program Agenda

The project approach continues to be the framework for planning and evaluating work progress Interaction with SRG s has been strengthened as those groups became more dynamic in 1995

Currently the Rice Program has seven project areas as follows

1 Improved lowland rice gene pools
2 Improved upland rice gene pools
3 Durable blast resistance
4 Rice traits to enhance weed control
5 Diversified Tagosodes/Hoja Blanca resistance
6 Integrated pest/crop management
7 Information and technology sharing

Overview of 1995

This was a year of transition The creation of FLAR in January 1995 opened up a new model of collaboration for rice research in Latin America The program collaborated with FLAR and INGER LAC to organize a rice breeders workshop that was the first ever to include germplasm from both tropical and irrigated ecosystems For the first time also participants were asked to pay their own costs Yet more than 80 scientists representing 20 countries attended the workshop

This was also the last year for core funding of the activities under improved lowland rice gene pools an activity that has been remarkably successful throughout the three decades of rice research at CIAT This year innovations in this area include the initial research on materials of the new plant type brought from IRRI the incorporation of back crosses with *O officianalis* also from IRRI that are resistant to *Tagosodes oryzicolus* and the work with wild rice crosses (*O rufipogon O glaberrima and O barthii*) with *O sativa* that includes upland materials as well conditions In upland rice our strategy will concentrate in contributing to CIAT s activities to develop viable and profitable agropastoral alternatives for the tropical lowlands and to a lesser extent for the hillsides of tropical America

In the short term however the emphasis should be on ensuring a smooth transition to devolve some current lowland rice research to FLAR avoiding the premature abandonment of research lines and the ensuing deterioration of the current installed capacity The strategy should concentrate on facilitating a smooth evolution and consolidation of the private sector initiatives as they assume partial responsibility and control of the regional rice research agenda IRRI has agreed to collaborate with us in the development of the new plant type Their contribution will be basic to continue the Rice Program involvement in lowland rice research during 1996 and maintain our highly qualified staffing on board Specific additional private sector support will be necessary to round up the needed operational resources as CIAT has agreed to place flexibility funds to cover the salary of the Senior Staff lowland rice breeder for 1996

Paradoxically the new autonomy of national systems is placing strong demands on CIAT s specialized training services as we continue to build up the research capacity of national programs Collaboration with other international centers and universities will continue to be crucial to maintain our capacity to respond to demands in this area

This annual report provides a detailed account of our activities in each of the project areas that were already mentioned We hope that this information will be most useful to other scientists and rice researchers as well as to other partners that share our common goal of doing relevant work that is useful to mankind

Luis R Sanint
Rice Program Leader

Executive Summary

I PROJECT 1 IMPROVED LOWLAND RICE GENE POOLS

A Activity RL01 Germplasm Development Research activities carried out in this project are summarized in four categories development of improved germplasm for the tropical lowlands and the temperate region population improvement for irrigated rice identification and utilization of genes from wild germplasm and evaluation/characterization of the IRRI new plant type The first two activities are conducted in collaboration with partners in the NARS advanced breeding lines were made available to them either directly or through INGER A Breeder s Workshop was held at CIAT in August participants had the opportunity to select by themselves from nearly 3 000 breeding lines Through recurrent selection scheme four new populations (PCT 6 7 8 and GPCT 9) were formed and characterized through the first recombination cycle these populations are already being made available to some NARS A collaborative breeding project with several institutions aimed at the identification and transferring of QTLs affecting grain yield and quality from wild rice species to improved Latin American cultivars was initiated Preliminary evaluations of the IRRI new plant type indicated that *a*) it possesses several desirable agronomic and physiological traits *b*) it offers good opportunities for the selection of lines suited to diverse conditions and *c*) represents a good source to enhance our regionally adapted irrigated germplasm

B Activity RL01 Genetic Generation of an Indica Gene Pool with High Response to Anther Culture This study aims to introgress the high AC response from japonicas into indicas to facilitate the application of AC as a routine tool for breeding indica rice A diallel study indicates that the low AC response shows incomplete dominance respect to the high response No maternal effects are noted Generation mean analyses suggest that the callus induction and the green plant regeneration are controlled by a simple genetic system (olygogenic) of different sets of genes Additive and dominant effects are highly significant for callus induction whereas just additive effects are statistically significant for green plant regeneration The co segregation analyses indicate that callus induction and green plant regeneration segregate independently from the grain type Six plants combining high response to AC from the japonica parent and long slender grains from the indica parent were selected Individual progeny plants from each selected line are being evaluated for their in vitro response and agronomic characteristics to select those indica types with high response to AC Selected plants will be used as parents in crosses with plants from a recurrent selection population to develop a genetic diverse indica gene pool with increased response to AC

C Activity RL52 Transfer of Rice Anther Culture Breeding to National Programs of Latin America A two year project financed by the Rockefeller Foundation was executed to transfer CIAT s experience using anther culture (AC) for rice breeding to various National Programs of Latin America Twenty nine scientists from 14 Institutions and 10 countries participated in this event After the first workshop held at CIAT last year several Programs showed progress in using anther culture (AC) for breeding The most advanced program is producing 2 000 doubled haploids (DH) per year Integration and cooperation is noted between the breeders and the tissue culture specialists There is interest in exchanging DH materials and strengthening the scientific collaboration between participant Programs A manual and a video summarizing the genetic and biological aspects of anther culture with a strong component of our experience using the technique in rice breeding will be ready by the end of 1995

II PROJECT 2 IMPROVED UPLAND RICE GENE POOLS

A **Activity RU 01 Germplasm Development** Project began in 1984 with the objective to develop germplasm adapted to acid soils savannas Breeding is concentrated in the development of fixed lines and population improvement The first strategy relies on germplasm introduction parent analysis management of segregating generations and observational yield trials Use of population improvement started in 1993 with introductions of gene pools and population from Brazil in 1994 CIAT created its own population (PCT 4\0\0\1) based on the most adapted introduced material To support these initiatives there are special studies (BS and MSc theses work) on different aspects related to the employed strategies The results of the project can be measured by the varietal releases in Colombia and Brazil These aspects are covered in this project report

B **Activity RU52 Mechanisms of Acid Soil Tolerance** For the sustainable development of tropical savannas the further improvement of upland rice which is already the important component of cropping systems for the ecosystem is needed Upland rice is more tolerant to acid soils than other usual crops requiring less lime application and therefore most suitable for the low input cropping systems with little disturbance to the environment It is already confirmed that rice has a large genotypic variation in terms of the tolerance to acid soil conditions Therefore the development of mass screening techniques which are more rapid and accurate than the on site screening may greatly contribute to the efficiency of upland rice breeding targeting the ecosystems This strategy of this project is 1) to identify the most important soil limiting factor 2) to understand the physiological mechanisms for the tolerance to the limiting factor and 3) to develop a screening technique based on the understanding of the mechanisms of the tolerance

III PROJECT 3 DURABLE BLAST RESISTANCE

A **Activity RP01 Blast Pathosystem Analysis and Blast Resistance** The main objective of this project during 1995 was to continue characterizing several components in the rice blast pathogen system for developing an effective resistance breeding and gene deployment strategy

Only four lineages were detected this year in the acid soil savannas of the Altillanura ALL 7 SRL 6 SRL 4 and ALL 10 Isolates from these lineages are now being used in greenhouse screening for selecting resistance donors to be used in genetic crosses by the upland breeding program Other lineages found in the past have apparently dissapeared from this site

Three new rice cultivars released in Colombia Selecta 3 20 Oryzica Caribe 8 and Oryzica Yacu 9 were highly susceptible to blast DNA fingerprinting analysis revealed that the first cultivar was infected by lineages SRL 2 SRL 4 and SRL 6 while the second and third cultivars were infected by lineages SRL 4 and SRL 6 respectively

Genetic lineages SRL 6 and SRL 5 were compatible with 80 / and 69 / respectively of 201 commercial rice cultivars mainly from Latin America Twenty four cultivars were identified within this group that exhibited resistance to all blast isolates used in the greenhouse inoculations and which also exhibited a field resistant reaction Other 23 rice cultivars from 12 countries exhibited complementary resitance to blast and could be used in specific crossess targeted to exclude the blast pathogen population in Colombia being also potentially useful for the rest of the region

Genetic studies of the control of blast in the highly resistant cultivar Oryzica Llanos 5 suggest the presence of up to four resistance genes to genetic lineages SRL 1 SRL 2 and SRL 3 three genes to SRL 4 two genes to SRL 5 and it was isolate dependent for genetic lineage SRL 6 In the latter case resistance was controlled by two genes to two isolates recovered prior to 1995 and only one resistance gene to two isolates recovered during 1995

A field methodology used in a recurrent selection project was evaluated in the field for the selection of resistance donors to different genetic lineages of the blast pathogen where a total of 12 breeding lines with high yielding capacity were selected and used in 74 crosses among themselves or with other rice lines exhibiting complementary resistance to blast

B Activity RP53 Incorporation of Protection to Rice Sheath Blight through Genetic Transformation We are interested in transforming indica rice with a barley type 1 RIP gene to confer increased protection against Rhizoctonia Such transgenics might be economically and environmentally desirable by leading to a reduction in the application of pesticides A construct containing the RIP gene driven by the 35S promoter and the 35S CaMV hph (hygromycin resistance) gene as the selective marker are being used The direct gene transfer of the RIP gene via the PDS 1000/He system is being conducted using immature embryos or immature derived callus of the indica varieties Cica 8 Inti and BR IRGA 409 and the upland line CT6241 17 1 5 1 A total of 183 plants with hygromycin resistance have been recovered Preliminary analyses by RT PCR suggest that 7 of these 10 plants are putative transgenics which contain and express the RIP gene The integrative transformation of these plants is being confirmed by detailed molecular analyses

IV PROJECT 4 RICE TRAITS FOR COMPETITIVENESS

A Activity RP52 Rice Traits for Competitiveness Rice Pasture System (Traits for Competing with an Associated Pasture) The objectives of this work were to identify morphological traits of rice that breeders could use to enhance the ability of this crop to compete with an associated species Two scenarios were contemplated a) that of upland rice growing in association with a pasture and b) that of irrigated rice growing with a weedy species (*Echinochloa colona*) The first aspect relates to a key component for the sustainable agropastoral systems being developed by CIAT and the second aspect seeks to reduce the overuse of herbicides in the irrigated rice ecosystem The experiments with the upland rice pasture associations (two seasons) showed that productive rice plant types can be bred to compete or tolerate an intersown pasture such as *Brachiaria decumbens* The late onset of competition favored rice over the associated pasture however average yield losses for rice growing in competition were 60 and 18 / for rice cultivars with the weakest and strongest competitive ability respectively Competition was strongly related to above ground light capture where rice leaf area (recorded after 45 days of emergence) was the key parameter followed by tillering while height showed no correlation with competitiveness Genetic studies for these parameters are being conducted A similar activity is being conducted in Brazil by EMBRAPA/CNPAF who are our partners in this ODA funded project

B Activity RP02 Germplasm with enhanced competitiveness against weeds

1 **Competitive Irrigated Rice** A similar study as in section A was conducted with direct seeded (pre germinated) irrigated rice Average rice yield reduction from *E colona* competition was 42 / within a range of 25 and 62% The most competitive varieties were CICA 8 Eloni and CICA 9 *E colona* growth recorded 60 days after emergence correlated negatively with rice leaf area index and tiller number (R^2= 0 83 and 0 76 respectively) All three varieties were among the best yielding ones in monoculture These parameters were closely related to canopy light interception Again height was not closely related to competitiveness Quick screening for rice competitiveness could be done by measuring the amount of light reaching the ground preferably with rice growing under competition Estimation of genetic parameters for the characteristics identified will be performed preliminary results are reported here

2 **Genotypes for Water Seeding** A total of 132 lines were screened for their ability to emerge through water Pre germinated seeds were covered by soil and put 7 cm below the water surface Redox potential and temperature in the water layer were 1 24 mV and 28 30 C respectively which resembled values recorded in the flood water of conventional rice crops Twenty cultivars with more than 50 / emergence through water were identified Nurseries have already been requested and sent to Surinam and Cuba

3 **EMBRAPA/CNPAF** Similar as activities described in paragraph 1 but conducted under moisture stress conditions

V PROJECT 5 DIVERSIFIED TAGOSODES/RICE HOJA BLANCA VIRUS

A **Activity RP03 Diversified Tagosodes/Rice Hoja Blanca Virus** The goal of this project is to reduce crop losses due to Rice Hoja Blanca Virus and *Tagosodes orizicolus* by diversifying the resistance genes deployed against them thus protecting against resistance breakdown stabilizing yields and reducing insecticide use In 1995 4 127 and 6 029 segregating and advanced rice breeding lines were evaluated for resistance to RHBV and *T orizicolus* damage respectively The lines evaluated were from the CIAT Irrigated and Upland Breeding and Rice Pathology Programs INGER FEDEARROZ CORPOICA and IRRI These evaluations provide valuable RHBV and *T orizicolus* resistance information for the CIAT and Latin American National Program germplasm pools Some of these lines represented new sources of resistance to both the virus and insect and they are being incorporated into advanced breeding materials The program also conducted studies to determine the effect of *T orizicolus* colony plant age and variety on rice susceptibility to RHBV in the greenhouse and field We also initiated studies in cooperation with FEDEARROZ and CORPOICA to survey for the occurrence of RHBV infected plants and active vectors in commercial rice fields in Colombia These studies will provide information on virus/insect/rice plant interactions which have important consequences for the development and occurrence of RHBV epidemics in the field Finally in order to create novel RHBV resistance sources that can potentially be transferred into popular varieties currently being grown in Latin America the project is working to genetically engineer RHBV resistant rice plants using RHBV coat protein and down regulation strategies Plants containing these constructs have been identified Following local safety regulations the progeny from the transgenic plants will be tested in the greenhouse under biosafety conditions for resistance to RHBV using viruliferous *T orizicolus*

B Activity RP53 Control of RHBV through Coat Protein Mediated Cross Protection and Anti Sense RNA Strategies Most Latin American varieties have the same RHBV resistance gene The main goal of this project is to provide new source(s) of resistance to minimize the possibility of an outbreak of the disease The coat protein cross protection and the antisense gene down regulation of the major non structural protein NS4 are being attempted The antisense gene strategy for the expression of the RNA4 is to determine the function of the major NS4 protein and to study the potential for a different and potential complementary method of producing viral resistant plants Direct gene transfer is performed using the particle bombardment onto immature embryos or immarure panicle derived callus Constructs containing the RHBV CP or the RHBV RNA 4 and the 35S CaMV hph gene are being tested Previous molecular and inheritance analyses indicate that about half of the regenerants have stable integration of the hph gene Preliminary Southern and Northern analyses show that some of the hph resistant plants also contain and express one of the RHBV genes

VI PROJECT 6 COMPONENTS FOR INTEGRATED PEST MANAGEMENT

A Activity RP04 Compoments for Integrated Pest Management

1 Resistance To Propanil in Populations of Junglerice (*Echinochloa colona*) The buildup of propanil resistant *Echinochloa colona* biotypes in Colombian rice fields has been documented and is associated to the repeated use of propanil Dose response data previously collected were re interpreted using non linear regression and fitted to a four parameter logistic model which allowed to estimate GR_{50} values for seven *E colona* populations GR_{50} values for the least and most resistant populations were 0 37 and > 4 kg propanil/ha respectively HPLC studies with plant extracts from propanil resistant and susceptible plants showed that resistant plants were able to metabolically degrade propanil to a greater extent than susceptible plants However in 30 40 days old plants a different mechanism for resistance may prevail which could imply another possibility for cross resistance with other herbicides a realistic situation given that farmers in Colombia often spray propanil to heterogeneous *E colona* populations when young and older plants coexist An in vitro test was developed to assay samples of *E colona* leaves from the field this is an essential tool that will be used in the monitoring of resistance in Colombian rice fields within the framework of activities to be conducted by the newly created Task Force for Herbicide Resistance Monitoring in Colombia (part of COMALIFI the Colombian society for plant physiology and weed science) Future work should study the possible patterns of cross resistance and develop concepts to overcome the problem

2 Weed Population Ecology within Prototype Cropping Systems for the Colombian Llanos Weeds are a problem when cropping systems replace degraded savannas in the Colombian Llanos Criteria should be developed to deal with this factor in a sustainable manner At the same time if the presence of adventitious species can be related to parameters of resource base degradation or enhancement then such species can serve as indicators of sustainability With these objectives a weed population dynamics study was initiated in 1994 within the prototype cropping systems being conducted at the Matazul farm Meta A multi variate approach (Canonical Discrimination Analysis) was used to relate weed populations with variables in the prototype cropping systems The species composition within populations of adventitious plants varied according to crop rotations and associations (intersown pastures) tillage and crop residue incorporation methods and soil nutrient levels Some species particularly those appearing in low frequencies (suggesting a narrow range of adaptability) appeared strongly associated with specific variables showing potential for use as indicator species The challenge ahead would be to understand the ecophysiological bases for such responses

VII PROJECT 7 COLLABORATIVE ACTIVITIES AMONG CIAT PROGRAMS

A **Activity ERF01 The Latin American Irrigated Rice Fund FLAR** As a result of the recent strategic changes CIAT received support from several national programs to create a Latin American irrigated rice fund (FLAR) mainly supported by the private sector and IARCs that could ensure continuity in rice research activities at the regional level Four countries (Brazil Colombia Uruguay and Venezuela) and three institutions (CIAT IRRI and IICA) signed the act that created FLAR in January 1995 A breeder has already been contracted under this arrangement and started part time activities in the second half of 1995

In the meantime countries of the Caribbean had been actively seeking funds to reactivate their rice network Early in 1995 the European community allocated indicative funds under the Lome IV program to support the Caribbean Rice Industry Development Network (CRIDNet) which is schedulled to start in December 1995 This network will be managed by the recently created Caribbean Rice Association (CRA) that gathers private and public institutions from the region at the levels of production milling distribution and research CIAT is a member of CRA and of CRIDNet s Technical Advisory Committee During 1995 TAC met on three occasions More recently the Central American countries have also taken the initiative to form a regional rice research fund similar to FLAR

The processes of private sector involvement in regional rice research have a strong dynamism and clearly show that Latin American rice producers are aware of the value of innovation and of new technologies These processes can be more successful and stable if an independent suitable and credible organization like CIAT also gets involved For CIAT there is a legitimate role to play as convener and catalyzer The remaining of this decade should see the consolidation of this innovative model

B **Other Activity CRIDNET** Countries of the Caribbean had been actively seeking funds to reactivate their rice network Early in 1995 the European community allocated indicative funds under the Lome IV program to support the Caribbean Rice Industry Development Network (CRIDNet) which is schedulled to start in December 1995 This network will be managed by the recently created Caribbean Rice Association (CRA) that gathers private and public institutions from the region at the levels of production milling distribution and research CIAT is a member of CRA and of CRIDNet s Technical Advisory Committee During 1995 TAC met on three occasions More recently the Central American countries have also taken the initiative to form a regional rice research fund similar to FLAR

C **Activity RL53 INGER LAC HIGHLIGHTS 1994/95** Germplasm and information exchange are key components of INGER It is possible to evaluate a national program s participation by its interest in sharing the results of the local evaluations Last year after a great effort the network s coordination achieved almost 55 / data return but in 1994/95 the level dropped again to 47 5 / a percentage a bit higher than the last 5 years average

The network has only one observational nursery (VIOAL) but there are several possible combinations of lines that the countries can request Within this VIOAL there are two types of germplasm one for irrigated and favored upland conditions (mainly indica lines) and the other for upland acid soils (japonica lines) The network has been monitoring the composition of these two sets of lines (origin of the lines) in order to keep a fear balance between the different germplasm sources

The Red Internacional para la Evaluación Genética del Arroz en América Latina y el Caribe (INGER LAC) formerly Programa de Pruebas Internacionales de Arroz para América Latina (IRTP) has been a responsibility shared by the International Rice Research Institute (IRRI) Los Banos Philippines the Centro Internacional de Agricultura Tropical (CIAT) Cali Colombia and the national rice programs in the region The network s main objective has been to exchange germplasm and information among its members (Figure 1) since its beginning in 1976

An IRRI staff member initially coordinated the network Dr Manuel Rosero was the head of IRTP from 1976 to 1986 followed by Dr Federico Cuevas Perez in 1986 who also worked as the Institution s Liaison Scientist for Latin America at CIAT He left in 1992 when IRRI closed this position for Latin America Since then the network has been going through a transitional period core funds from IRRI are no longer available and a new project proposal has not been yet funded by external donors Dr César Martinez rice breeder from CIAT s Rice Program coordinated the network during 1993 and Dr Elcio P Guimaraes has continued the duty since then

103785

I PROJECT 1
IMPROVED LOWLAND RICE GENE POOLS

PURPOSE

To strengthen lowland rice national programs and jointly contribute to sustainable increase in production from the *dominant* agroecosystem for rice in Latin America and the Caribbean (LAC) This in turn would lower rice prices for the region s poor

A ACTIVITY RL01 GERMPLASM DEVELOPMENT

SUMMARY

Research activities carried out in this project are summarized in four categories development of improved germplasm for the tropical lowlands and the temperate region population improvement for irrigated rice identification and utilization of genes from wild germplasm and evaluation/characterization of the IRRI new plant type The first two activities are conducted in collaboration with partners in the NARS advanced breeding lines were made available to them either directly or through INGER A Breeder s Workshop was held at CIAT in August participants had the opportunity to select by themselves from nearly 3 000 breeding lines Through recurrent selection scheme four new populations (PCT 6 7 8 and GPCT 9) were formed and characterized through the first recombination cycle these populations are already being made available to some NARS A collaborative breeding project with several institutions aimed at the identification and transferring of QTLs affecting grain yield and quality from wild rice species to improved Latin American cultivars was initiated Preliminary evaluations of the IRRI new plant type indicated that *a)* it possesses several desirable agronomic and physiological traits *b)* it offers good opportunities for the selection of lines suited to diverse conditions and *c)* represents a good source to enhance our regionally adapted irrigated germplasm

INTRODUCTION

It s estimated that by the year 2025 some 8 3 billions people will live on earth and 50 / of them will be rice eaters Current world paddy production (approx 530 million/tons) must rise by 70 / to meet this demand However this production increase must come from virtually the same land area Irrigated rice is planted on 53 / of the world s rice land but represents 73 / of the total production More than 90 / of the world s rice is grown and consumed in Asia while Latin America s rice production represents 3 5 / of the total over 70 / of rice production in Latin America (LAC) comes from irrigated and rainfed lowland ecosystems Regional rice production increased from 9 9 to 18 8 million tons from 1966 to 1994 while modern semidwarf varieties combined with appropriate management practices caused a 76 / regional average increase for the irrigated and rainfed lowland sectors from 2 5 to 4 4 t/ha since 1967 Furthermore while rice is the largest single source of calories to the diet in LAC the d line in purchasing power of the population also leaves rice as the major source of protein to the diet of low income groups in tropical America The percentage of CIAT generated germplasm achieving varietal release has increased steadily over the period from 2 / during 1967 71 to 50 / over the last five years During the last two years the rate reached 65% This trend would seem to indicate that some NARDs are not achieving the strength needed to supplant CIAT's role in the generation of improved germplasm

The irrigated rice breeding program at CIAT has evolved from one that relied mainly in conventional breeding methods to one that currently combines several breeding strategies such as population improvement wide hybridization anther culture molecular markers and characterization of the IRRI new plant type These activities are underway addressing major challenges ahead to increase yield potential enhance the genetic base of irrigated rice and achieve sustainable rice production However most of these activities are not included in the research agenda of the Fondo Latinoamericano de Arroz de Riego (FLAR) clearly there are opportunities for CIAT's Rice Program to interphase with FLAR

Research Activities

Improved germplasm for the tropical lowlands

This conventional breeding work is done in collaboration with the Rice Program of several national agricultural research programs specially with CORPOICA and Fedearroz in Colombia and ICTA in Guatemala The main objective is to develop high yielding germplasm adapted to irrigated and rainfed upland conditions tolerant of major diseases and insect pests with good grain quality and early to intermediate growth duration Hot spot sites are used to ensure good and uniform disease pressure Advanced breeding lines are made available to other NARDs through INGER and serve as potential varieties or as parents in crossing programs

A summary of breeding materials evaluated and selected in CIAT Palmira during 1994B 1995 and Santa Rosa is given in Tables 1 and 2 A total of 4 436 breeding lines in different stages of development were planted and 50 % of them (1 413) were selected for further evaluation in Santa Rosa Experimental Station (SRES) located in Villavicencio Selected lines were also available to participants from NARs and the private sector that attended the Breeder s Workshop held at CIAT in July 31 August 4/95

Similarly nearly 2 000 breeding lines were evaluated in Santa Rosa (Table 2) where 18 % of them were selected approximately 1 500 single plant selections were harvested for further evaluation by FLAR in 1996

It is noteworthy to mention that a Breeder s Workshop was organized and held in CIAT Palmira and Santa Rosa The main objective was to allow participants evaluate and select a wide range of breeding lines and cultivars particularly relevant to the irrigated and rainfed lowland ecosystems found in Latin America and the Caribbean in both tropical and temperate environments It featured nearly 3 000 advanced lines and cultivars including 44 lines of the new plant type developed by IRRI over the past 5 years Results show that a higher proportion of lines were selected in Palmira (86 %) than in Santa Rosa (53 %) A summary of the most preferred breeding lines and cultivars of at least 50 % of the participants is shown in Table 3 A more detailed information on this workshop is presented in the INGER section

Improved germplasm for the temperate region

It has been difficult in the past for our tropical based breeding program to produce sufficient improved breeding lines for this region specially in terms of earliness good grain quality and cold tolerance This difficulty has been overcame during recent years by using anther culture (AC) to produce doubled haploid lines (DHs) Therefore the main objective of this activity is to introgress the grain quality and tolerance to diseases of tropical indicas and japonicas into the early and cold tolerance background of temperate japonicas Indica/japonica crosses are passed through AC at CIAT (Table 1) and evaluated for disease reaction in Santa Rosa After that selected DHs are sent to collaborating institutions for local field evaluations Since only one generations/year can be grown in this region field generation advance would take many years but AC substantially reduces this breeding time Over 1 500 DHs were sent last year to INTA Argentina and IRGA Brazil (Table 4) places where a workshop on anther culture was held early this year Breeders and tissue culturists from 14 different labs comprising 10 countries attended 515 and 443 DHs were selected at both places respectively Field evaluations carried out on the same DH populations allowed people to select not only lines for their breeding programs but to evaluate the level of genetic variability obtained through AC its stability over time and through locations and to assess the number of DHs that can be produced for breeding This technology transfer project conducted in collaboration with the Biotechnology Research Unit and funded by the Rockefeller Foundation is the first attempt made by CIAT to transfer to national programs a biotechnology tool applied to breeding

F1 seed of 20 crosses made by IRGA were sent to CIAT in 1993 to be run through AC DHs obtained (209) had already been sent to IRGA for field testing However F2 F3 F4 and F5 generations from these crosses were evaluated and selected in Santa Rosa for disease resistance earliness and long/slender grains 14 F6 lines were identified as interesting and sent to IRGA for further evaluations

Populations improvement for irrigated rice

CIAT s irrigated rice breeding program has mainly used the pedigree method however the limited degree of recombinations obtained through this method may restrict the achievement of favorable new" gene combinations By using a population improvement approach novel combinations can be achieved and gradually pyramided into a continuously improving yet genetically broad based population This approach requires that a large number of crosses be made and manual crossing may be a limiting factor This can be overcome by using genetic male sterility The main objective of this activity is to use recurrent selection to form different new populations with high yield potential and tolerance to main diseases to suit diverse needs found in the irrigated and rainfed lowland ecosystems in LAC

It was reported last year that 485 fertile plants So were harvested in gene pools IRAT Mana IRAT 1/420P CNA IRAT 4/2/1 IRAT MEDA and CNA IRAT P1/0F These plants were subsequently evaluated in pedigree rows and for response to AC Results (Table 5) show that populations having a japonica cytoplasm (IRAT Med A and CNA IRAT P 1/OF) respond significantly better than those with an indica background (IRAT MANA IRAT 1/420 P and CNA IRAT 4/2/1) This result confirms last year s report On the other hand the resulting 553 DH lines were evaluated in Santa Rosa for disease resistance yield potential and general adaptability all of them were discarded due to poor performance and low potential After two semesters of evaluations and selection in pedigree rows in Palmira and Santa Rosa only 34 lines So remain and most of the material showed poor yield potential and adaptation Both type of data DHs and pedigree rows indicate that these populations were not suitable for both tropical irrigated and rainfed lowland ecosystems and that a further improvement was needed

Consequently three populations (PCT 6 PCT 7 and PCT 8) and one gene pool (GPCT 9) were formed and subjected to the first recombination cycle in 1995 These four populations were evaluated under transplanting (0 3 x 0 3 m) irrigated conditions at CIAT Palmira and under direct seeding rainfed conditions in Santa Rosa Over 2 000 plants were sown in each population and data on number of sterile plants flowering plant height tiller number and productive tillers were taken At the same time best fertile plants were also identified and harvested in each population (Table 6) for evaluation in pedigree rows next year Sterile plants were also harvested in bulks

Data from CIAT Palmira are presented in Fig 1 2 3 and 4 A large variability was found in all traits measured in terms of flowering 71 to 77% of the plants were intermediate (91 to 110 days) while 13 to 21% of them were early ones Semidwarf plants (80 100 cm) represented 74 to 88 % of the populations tiller number ranged from 6 to 25 but 59 to 67 / of the plants had high tiller number followed by intermediate tillering (10 19%) only 4% of the populations had less than 9 tillers Data also shows that plants with low tiller number had a higher percentage of productive tillers

More attention was paid in Santa Rosa to the evaluation and selection of these populations for resistance to leaf and neck blast leaf scald and grain decoloration Data show that PCT 7 and GPCT 9 had lower levels of resistance to rice blast

Novel approach for the identification and utilization of genes from wild germplasm

Considerable concern and priority has been placed on increasing the yield potential and broadening the genetic base of cultivated rice Different approaches (hybrid rice recurrent selection new plant type etc) are being pursued by different groups to address these concerns However another innovative strategy already proven in tomato offers a great potential in rice This strategy makes use of wild germplasm a backcrossing scheme and molecular markers for the genetic improvement of cultivated rice Molecular markers will be used to identify positive transgressive alleles in early generations and to introgress these alleles into selected cultivars via marker aided selection The goal is to implement a new strategy for the systematic discovery and utilization of genes associated with yield and quality from wild germplasm into irrigated rice Several advanced labs around the world and people from national research institutions will be our collaborators

Four improved cultivars (Morelos A88 BG 90 2 Oryzica 3 and Llanos 5) and four wild species (*O rufipogon O glaberrima* and two accessions of *O barthii*) were chosen and crossed using the wild species as the female parent F1 plants were backcrossed to the improved cultivar and approx 100 180 F1BC1 seeds were obtained Just two crosses *O rufipogon*/Bg 90 2 and *O rufipogon*/Llanos 5 were planted under field conditions to select best plants (40 50) based on phenotype (i e select against obvious negative characters) for the second backcross Approx 300 400 F1BC2 seeds will be produced/cross to form 300 400 F2BC2 families for multi location field testing All F2BC2 families should be planted in the field in completely randomized design along with parental and F1 controls to measure agronomic performance including grain yield flowering maturity date grain quality height panicle length panicles/plant grains/panicle fertility 1 000 grain weight etc F3BC2 seed from field plots will be saved and QTLs analysis will be done based on RFLP and field data Transgressive QTLs will be identified and used as the basis for selecting new lines that contains only the interesting transgressive QTLs Another backcross to the improved cultivar will be done and so on Anther culture could be used to speed up breeding time required to produce new improved cultivars

Expected outputs will not only be locally improved varieties with a broadened genetic base but also information sharing and training of local scientists

Evaluation and characterization of IRRI-new plant type

Yield improvement resulting from the Green Revolution was based on modifications of plant type converting a traditional tall leafy tropical rice plant into a high tillering semidwarf input responsive modern type It has now been shown that high tillering carries a cost as many tillers bear no grain at all and therefore reduce the harvest index The shift in Asia towards direct wet seeding enables farmers to increase panicles per unit area by broadcasting more seed By doing that at high seed density but under well managed conditions where good stands are achieved the need for high tillering varieties no longer exists IRRI has developed an ideotype for it called super rice it is characterized by having a low tillering capacity (3 4 panicles) 200 250 grain/panicle 90 100 cm plant height sturdy stems vigorous root system harvest index of 0 6 and a yield potential of 12 13 t/ha In LAC however dry seeding (not wet seeding) predominates and both water control and land leveling are poor These factors cause stand gaps Another important consideration between Asia and LAC has to do with diverse pressure and grain quality preferences Therefore there was a need to carry out a preliminary evaluation of the IRRI generated new plant type under CIAT s conditions and this was the main objective of this activity

Sixty four segregating lines (F5 F6) were planted under both transplanting (0 3 x 0 3 m) at CIAT Palmira and direct dry seeding rainfed conditions in Santa Rosa Small observational plots were established at both sites with two reps in Palmira and just one in Santa Rosa Fungicides were applied in Santa Rosa at the seedling and flowering stages to protect the material from diseases Field data from Palmira are presented in Tables 7 8 9 and 10 Statistical analysis is underway Results show no yield advantages of the new plant type lines over check varieties Oryzica 1 and BR IRGA 409 at wide spacing However at closer spacing (10 x 10 cm) it is expected that the 20 25 / yield advantage claimed by IRRI could be attainable This will be investigated in more detail next cropping season Data also indicate that further improvement is needed to increase the level of resistance to rice blast leaf scald and Tagosodes some of the new lines showed a high level of resistance to RHBV and they may possess new resistant genes for this disease

A high harvest index (0 56 0 59) is shown by some of the new lines as claimed by IRRI (Table 8) Oryzica 1 and BR IRGA 409 also had a high harvest index however values for these controls could be misleading since previous data from direct seeding experiments carried out at CIAT Palmira and with bigger samples showed a harvest index in the range of 0 46 0 50 for Oryzica 1 Some of the new lines had over 300 grains/panicle and heavier grains than Oryzica 1 and BR IRGA 409 there was also variability in the number of tillers/

plant flowering time and plant height Most of the new lines exhibited a fast germination and rapid early growth at the seedling stage these traits are very important for direct seeding specially under dry soil conditions

In Santa Rosa best lines (IR 65598 27 3 1 IR 66155 2 1 1 2 and IR 66746 76 3 2) yielded 4 6 t/ha while Oryzica 1 and BR IRGA 409 yielded 5 8 and 5 2 t/ha respectively with fungicide application This poor performance of the new plant type lines in Santa Rosa was expected because they have been selected for more farovable conditions However best lines showed a robust growth and good general adaptability in Santa Rosa specially line IR 66746 76 3 2

Another important consideration for LAC is grain quality Although some of the new lines had excellent milling recovery all of them present short to medium grains with chalky endosperm Therefore a further improvement in this area is needed as well

Among the breeding lines tested for the first time there were 20 lines selected out of a backcross program between an indica line (IR 31917 45 3 2) and *O officinalis* This program carried out at IRRI transferred genes for resistance to pests from *O officinalis* to cultivated rice All of them showed high levels of resistance to *Tagosodes* and some had tolerance to RHBV all of them have long and slender grain and good plant vigor Line IR 54742 20 38 5 yielded 9 5 t/ha (Table 9)

This preliminary evaluation of the IRRI new plant type indicates that *a*) it possesses several desirable agronomic and physiological traits *b*) it offers potential to select lines suited to diverse conditions and *c*) represents a good source to enhance our regionally adapted germplasm A further evaluation of its yield potential is needed a crossing scheme is being put together to start introgressing this new plant type into our genetic core

Table 1 Breeding lines evaluated and selected in CIAT Palmira 1994B 1995A

Breeding Lines	Total Evaluated No Lines	No Crosses	Total Selected Lines	/	Crosses	/	Lines evaluated in Breeder's Workshop	Santa Rosa
F4	149	68	37	25	32	47	37	617
F4 Rec Sel	12	1	12	100	1	100	12	41
F5 Rec Sel	107	7	57	53	3	43	57	12
F5 Sel Rec	40	6	5	13	2	33	5	1
F5[a/]	1754	106	110	6	39	37	110	450
F5[a]	74	18	8	11	3	17	8	32
F5[a/]	61	9	0	0	0	0	0	0
F5[b/]	234	27	110	47	21	78	103	49
F6	37	11	5	14	4	36	5	0
Hoja blanca Set	372	48	270	73	44	92	270	0
D H CIAT[c/]	1280	12	707	55	12	100	707	0
D H IRGA[d/]	310	13	92	30	6	46	92	0
Pobl Sel Rec	6	6	--	--	--		5	0
TOTAL	4436	332	1413	32	167	50	1411	1202

/ Germplasm for tropical conditions [b/] Germplasm for temperate conditions

Doubled haploids for tropical and upland savanna conditions [d/] doubled haploids from IRGA s crosses

Table 2 Breeding lines evaluated and selected in Santa Rosa 1995A

Breeding Lines	Lines Evaluated No Lines	No Crosses	Material Selected No Lines	%	No Crosses	/
F2 (Families)	677	53	106 (468)	16	26	49
F3 (Bulk)	62	10	7 (26)	11	3	30
F4 (Recurrent sel)	105	3	8 (34)	8	3	
F5	652	41	165 (605)	25	33	80
F6	531	62	90 (264)	17	28	45
Observational plots	85	79	13 (13)	15	13	16
Total	2112	248	389 (1410)	18	106	43

N mbe n parenthesis efers to single plant selections

Table 3 Most preferred selections by at least 50 % of the participants in the First Rice Breeder s Workshop for the Tropical and Temperate Zones of LAC

31 July 3 August/95

No	PEDIGREE	PARENTS	Di and I ect Reaction BL	NBL	LSC	GD	Crai Q lity TAG	AMY	CB	LG	TGEL	FLOW
PAI MIRA												
1	CT10166-2 5 3P 1 2 3P	P 3059-F4 79 1 1B/PDR 76-D10-D8-D1//P 5413-8-3-5-11 2X	1	1	1	5	3	29	0 4	3	B	95
2	IR47310-16 2 2 2	IR11418-15-2/IR21567 9 2 2 2 1	1	7	1	7						100
3	CT11008 12 3-1M 4P 4P	CT6919 4 2 2-6/CT7363-13-5 4//CT8285-13-5-2P 1X	1	1	7	3	3	30	1 0	3	B	106
4	CT9509 17 3 1 1 M 1 3P M 1	ECIA 24 107 1/IR25840-64 1 3//CT5746-18 11 4 1 3X	1	1	3	1						99
5	CT10166-16-1 2P 1 3	P 3059-F4 79-1 1B/PDR 76-D10-D8-D1//P 5413-8 3-5-11 2X	1	1	5	1	0	29	1 2	3	B	84
6	IR56383 35 3 2 1	IR28239 94 2 3-6-2/IR31802-48-2 2 2	3	9	1	5						100
7	CT10554 4 4 2 2 M	CT6749 5-1 1 M 3-M 4/P 5589 1 1 3P 4 M	1	3	1	3	3					100
8	ORYZICA YACU 9	PDR 34 2 1 2/P 3790-F4 6-1 1X//CT5746-18 11 2 2 2X	5	5	5	1	9					
9	CT9506 13 5-2P 2PT	P 2182 F4 39//IR5533 13-1 1/METICA	3	7	3	3						87
VII I AVICI NCIO												
1	CT9682 2 M 14 1 M 1 3P M 1	TOX 1859-102-6M 3/P 5446-6-6-2 1//P 5413-8-3-5 11 2X	3	1	5	1		30	1 4	3	I	
2	CT11623 3 3 CA 17 M M M	CT7179 31 1 1 4-4P/P 5589 1 1 3P 4 M//CT6196-33-11 1 3-AP	1	1	3	1						
3	CT11026-3 9 1T 2P 5P	CT6919-4 2 2-6/CT7363 8-2 2//CT8240-1 1 3P 1X	3	1	3	3	5	20	0 2		B	106
4	CT9682 2 M 14 1 M 1 3P M 1	TOX 1859-102-6M 3/P 5446-6 6-2 1//P 5413-8-3-5-11 2X	3	1	3	1		31	0 6	3	I	102
5	CT10825 1 2 1 1 M	CT6516 23 10 1 2 2/CT6750 9 2 4 M 1 M 1	3	1	1	1						102
6	CT10175-5 1 3P 1 1 2P	P 5166-F2 26-1 1X/P 5446-8-4 1 2//P 5413-8-3-5-11 2X	3	1	5	1		30	0 2	3	I	107
7	CT10175-5-1 3P 1 3 3P	P 5166-F2 26 1 1X/P 5446 8 4 1 2//P 5413-8-3-5-11 2X	1	1	3	3	3	25	0 4	3	I	
8	CT10175-5-10 2P 2 1 3P	P 5166 F2 26-1 1X/P 5446-8-4 1 2//P 5413-8 3-5-11 2X	3	1	3	3	3	24		3	B	103
9	CT9162 12 5 4 1	GZ864 2 3-1/P 3084 F4 56 2 2//CT5746-18-11 2 2 2X	1	1	3	1						104
10	CT11686 4 F4 2 M	P 5589-1 1 3P 5-2P/CT6749-21 4 5-M 1 M 2 M//CT6750 13 1 2 M 2 M 4/CT6515-18	1	1	3	1			1 0		B	9 1
11	CT10310-15-3 2P 4 3	P 3084 F4 56-2 2/ITA 306//CT8154 1 9-2	1	1	5	1	7	28	0 8	3	B	106
12	CT8837 1 17-6 3	PDR 34 2 1 2/P 3790-F4-6 1 1X//CT5746-18-11 2 2 2X	7	3	3	1						
13	CT9509-17 3 1 1 M 1 3P M 3 1P	ECIA 24 107 1/IR25840-64 1 3//CT5746-18-11-4 1 3X	1	1	5	1	7	32	0 8	3	B	

Table 4 Number of doubled haploids selected by participants to the Rice Anther Culture Workshop held in Argentina Brazil and Uruguay Feb /95

Institution	Concepcion del Uruguay Cachoeirinha IRGA	INTA Argentina Porto Alegre Brazil
IRGA	95	172
Cuba	74	65
CNPAF Goiania	42	78
CPACT Pelotas	45	62
INIA Uruguay	91	45
IDIAP Panamá	27	21
ICTA Guatemala	67	
FONAIAP Venezuela	61	
Univ Noroeste Argentina	13	
Total	515	443

Table 5 Number of doubled haploids obtained from five gene pools with distinct cytoplasm

		Anther Culture			
		No Plants			
Gene Pools	No Plant Selections	Processed	Responsive	Response	No Doubled Haploids
IRAT MANA	138	26	0	0	0
IRAT 1/420P	87	21	0	0	0
CNA IRAT 4/2/1	121	46	0	0	0
IRAT MED A	80	21	19	90 5	516
CNA IRAT P1/0 F	59	29	5	17 2	37
TOTAL	485	143	24	16 8	553

Table 6 Gene pools evaluated and number of plant selections CIAT Palmira 1995

Gene Pool	Original Populations	Population	Cultivars Introduced Source	No Plant
GPCT 9\0\0\1	WC 232 [5] Early (CT6047 13 5 3 4 M [5])	CIAT	B 4353C KN 7 0 0 2 CT6241 17 1 5 1 BG 989 Oryzica Turipana 7 PNA 1004F4 33 1 5685 OR83-23 Perla (Cuba) RP 2087 115 10 5 1 BR IRGA 410 BG90 2 El Paso 44 Oryzica 3 y Morelos A88	273
PCT 6\0\0\1	IRAT MANA	CIRAD CA	B 4353C KN 7 0 0 2 BG989 El Paso 144 PNA 1004F 4 33 1 Oryzica Llanos 4 OR83 23 Perla (Cuba) Oryzica 3 Morelos A88 RP2087 115 10 5 1	70
PCT 7\0\0\1	IRAT 1/420P	CIRAD CA	Oryzica 3 B 4353C KN 7 0 0 2 BG 989 PNA 1004F 4 33 1 OR83 23 RP2087 115 10 5 1	46
PCT 8\0\0\1	CNA IRAT 4/2/1	EMBRAPA/ CIRAD CA	Oryzica 3 Oryzica Llanos 4 BG989 Perla (Cuba) El Paso 144 y B 4353C KN 7 0 0 2	64

Table 7 Reaction to several diseases and *T oryzicolus* of IRRI new plant type top yielders CIAT Palmira September 1995

Pedigree	Yield	Diseases[1/] BL	NBL	LSC	HB	Insect TAG
IR66154 95 2 3 3	5 6	6	9	5	1	9
IR66158 38 3 2 1	5 6	3	5	5	9	9
IR66159 131 4 3 2	5 6	7	5	7	5	9
IR65600 42 5 2	5 9	3	5	5	1	9
IR65600 87 2 2 3	6 0	3	5	5	1	7
IR66160 121 4 5 3	6 2	6	3	5	9	9
IR66738 118 1 2	6 2	5	5	7	3	9
IR65600 61 3 1 3	6 5	6	3	5	1	9
IR66160 134 1 3 1	6 8	3	5	5	9	9
IR65600 96 1 2 2	7 9	7	5	7	9	7
ORYZICA 1	7 6	7	7	3	5	3
BR IRGA 409	7 2	8	7	5	5	0
ORYZICA 3	6 8	5	7	3	3	1
PERLA	6 7	1	3	3	5	0
BLUEBELLE	3 7	4	7	3	9	9

Tn/ha Transplanting (0 3 x 0 3 m) 2 Reps
Data from Santa Rosa except RHBV

Table 8 Some agronomic traits of the yielders among the IRRI new plant type lines CIAT Palmira September/95 Transplanting

Pedigree	Harvest Index[1]	Grains/ panicle	1000 grain weight[2/]	Head rice /	Tiller/ plant	Flowering 50 /	HT (cm)
IR66154 95 2 3 3	0 56	249	24	62 6	14	99	79
IR66158 38 3 2 1	0 59	216	32	63 6	10	101	95
IR65600 42 5 2	0 46	191	24	66 8	16	106	90
IR65600 42 5 2	0 54	230	28	62 4	11	112	105
IR65600 87 2 2 3	0 48	179	36	67 2	15	102	92
IR66160 121 4 5 3	0 52	170	28	65 2	17	102	85
IR66738 118 1 2	0 56	313	25	62 9	12	111	94
IR65600 61 3 1 3	0 56	219	33	61 0	13	110	97
IR66160 134 1 3 1	0 55	172	31	65 8	17	107	85
IR65600 96 1 2 2	0 55	237	29	61 4	15	112	93
ORYZICA 1	0 59[2/]	177	26	59 8	23	106	92
BR IRGA 409	0 57	190	23	65 6	21	105	89
ORYZICA 3	0 51	229	21	65 0	17	112	96
PERLA	0 54	193	25	55 5	19	100	94
BLUEBELLE	0 45	211	24	58 5	8	85	114

Sample size 3 plants/rep [2] Previous data 0 46 0 50 (direct seeding)

Table 9 Grain yield and reaction to several diseases and *T oryzicolus* among top yielders from the backcross IR31917 45 3 2 ³/*O officinalis* CIAT Palmira September 1995 Transplanting (0 3 x 0 3 m)

Pedigree	Yield(t/ha)	Diseases [1/]				Insect
		BL	NBL	LSC	HB	TAG
IR54742 15 28 38-4 2 1 2	6 5	5	3	3	1	1
IR54741 2 14 5	6 7	1	3	1	5	1
IR54741 2 14 5 2 1 2	6 8	4	5	3	9	0
IR54741 2 14 5 2 1	6 9	1	5	1	5	0
IR54742 18 3 8 10 3 3 1 3	7 0	6	7	3	9	0
IR54742 19 2 3 1 1	7 1	6	5	5	1	0
IR54741 1 48 5 5 2	7 2	2	5	3	3	1
IR54742 15 28 38 4 2 1 1	7 4	3	5	3	1	0
IR54742 20 38 5	9 5	6	7	3	9	1
Oryzica 1	7 6	7	7	3	5	3
BR IRGA 409	7 1	8	7	5	5	0
Oryzica 3	6 8	5	7	3	3	1
Perla	6 7	1	3	3	5	0
Bluebelle	3 7	4	7	3	9	9

Data from Santa Rosa except RHBV

Table 10 Some agronomic traits of top yielders among backcross lines IR 31917 45 3 2 ³/*O officinalis*

Pedigree	Harvest Index	Grains/ panicle	1000 grain weight	Head rice (/)	Tiller/ plant	Flowering (50 /)	HT (cm)
IR54742 15 28 38 4 2 1 2	0 35	173	25 4	61 6	22	123	108
IR54741 2 14 5	0 38	137	25 7	66 5	28	119	93
IR54741 2 14 5 2 1 2	0 41	149	25 7	68 0	24	120	90
IR54741 2 14 5 2 1	0 45	160	25 4	66 9	22	118	89
IR54742 18 3 8 10 3 3 1 3	0 45	133	27 9	67 5	23	121	95
IR54742 19 2 3 1 1	0 46	149	26 0	70 0	22	125	94
IR54741 1 48 5 5 2	0 43	146	24 8	60 6	29	120	100
IR54742 15 28 38 4 2 1 1	0 40	200	27 1	59 6	22	125	109
IR54742 20 38 5	0 43	143	27 0	69 0	21	118	86
Oryzica 1	0 59[1/]	177	24 3	59 8	23	106	92
BR IRGA 409	0 58	190	25 6	65 6	21	105	89
Oryzica 3	0 51	229	20 9	65 0	17	112	96
Perla	0 54	193	23 2	55 5	19	100	94
Bluebelle	0 51	211	25 9	58 5	8	85	114

Prev ous data 0 46 0 50 (direct seed ng)

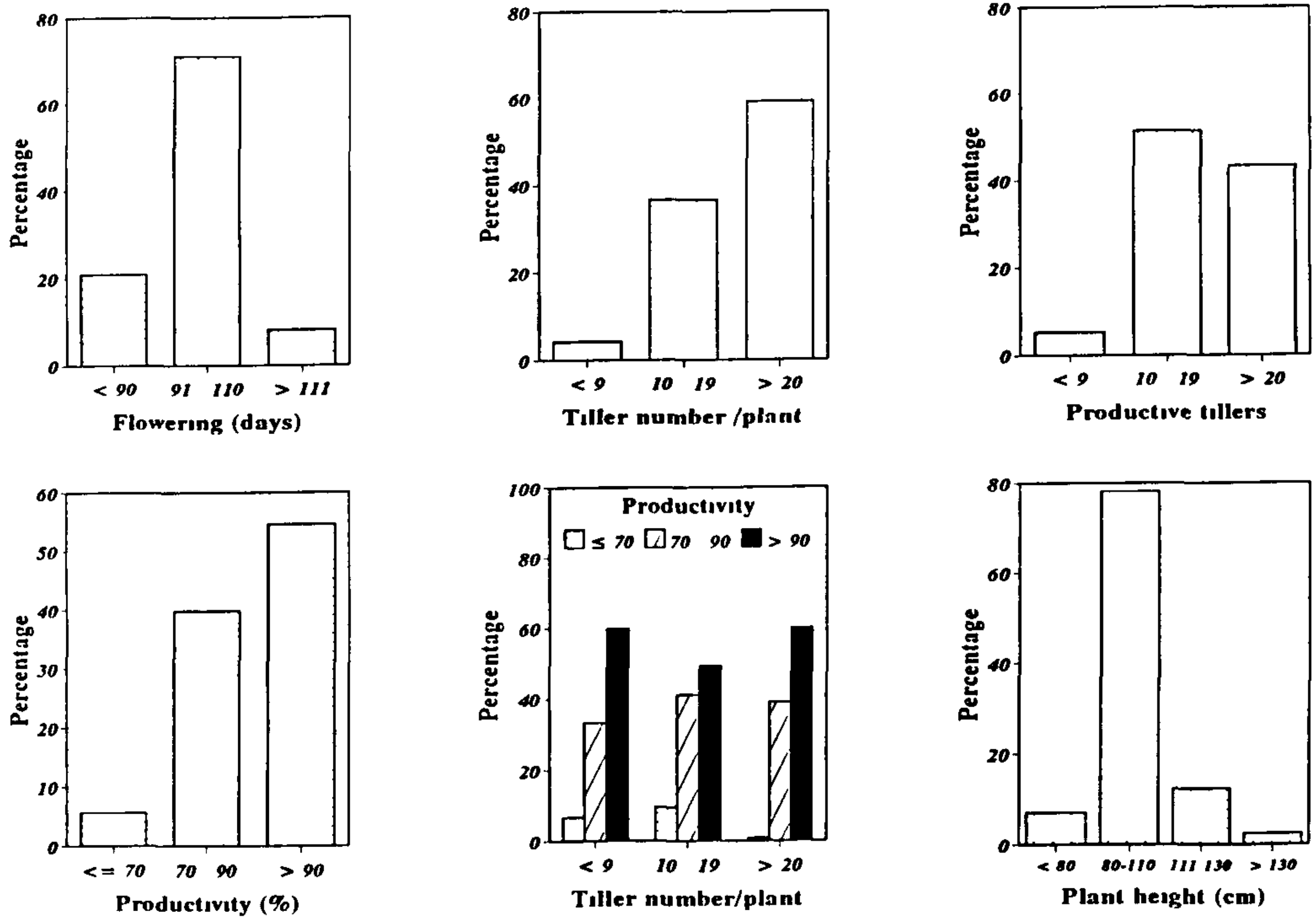


Figure 1 Frequency distribution of some agronomic traits in population PCT 6\0\0\0 Palmira, sept /95

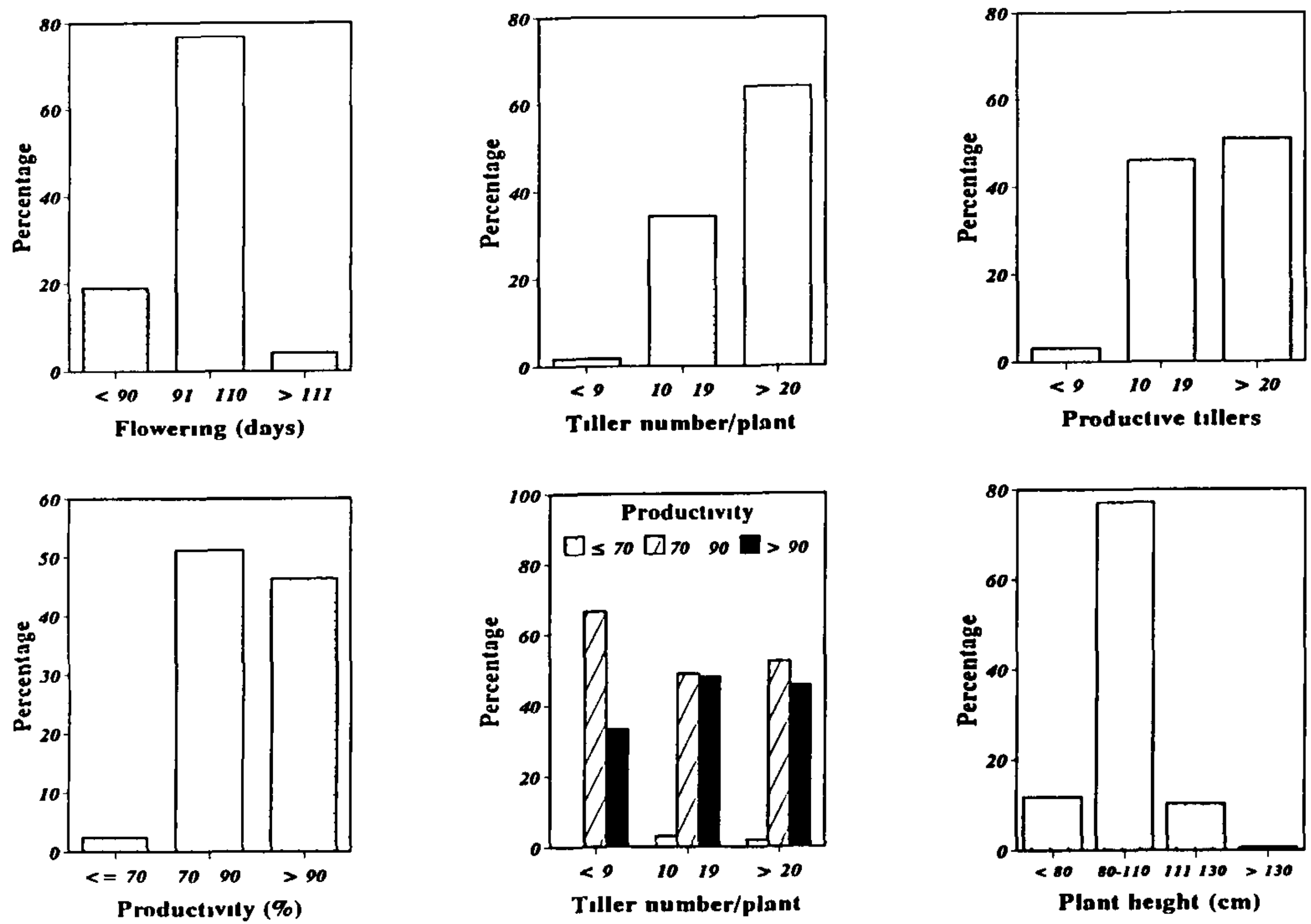


Figure 2 Frequency distribution of some agronomic traits in population PCT 7\0\0\0 Palmira, sept /95

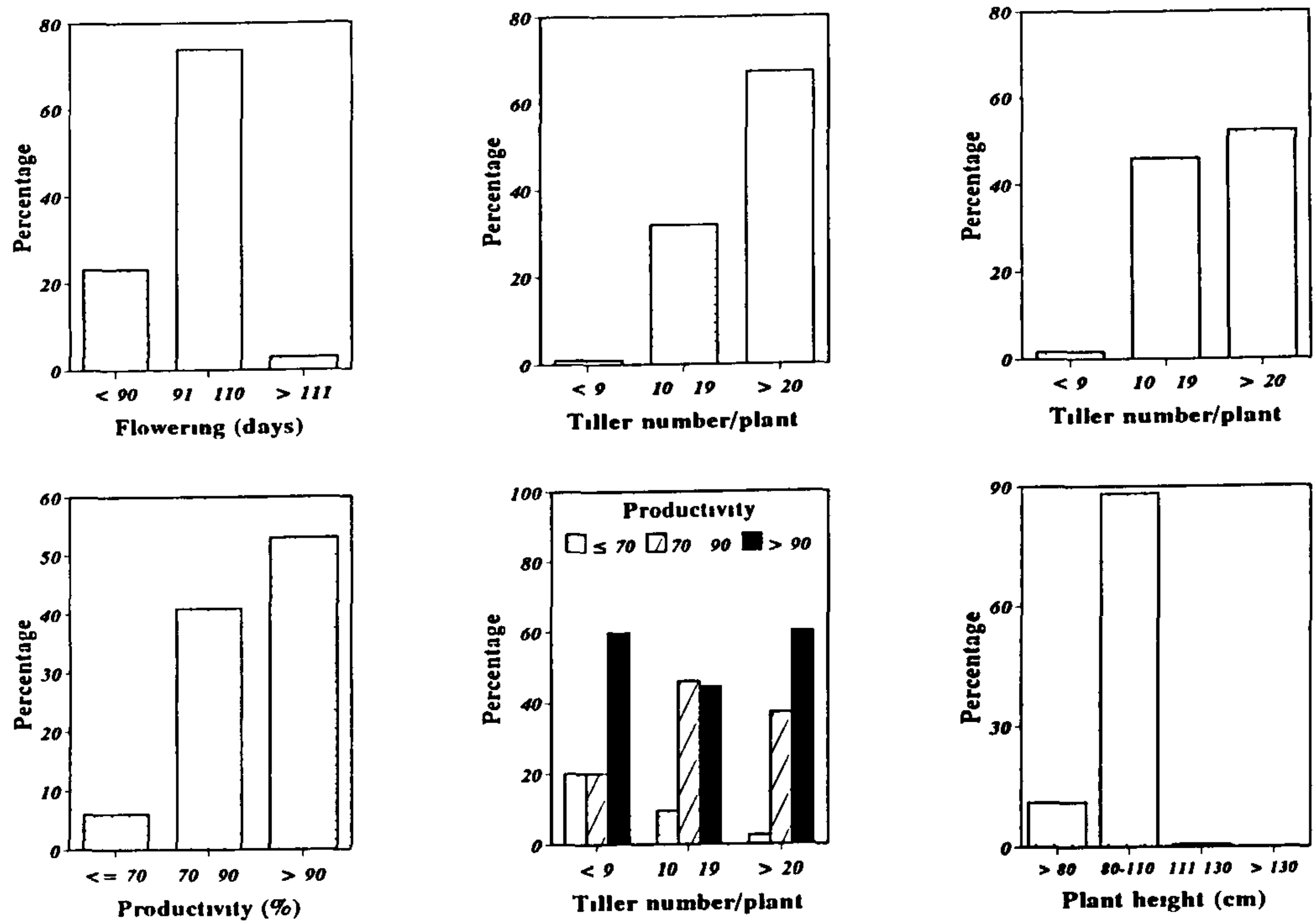


Figure 3 Frequency distribution of some agronomic traits in population PCT 8\0\0\0 Palmira, sept /95

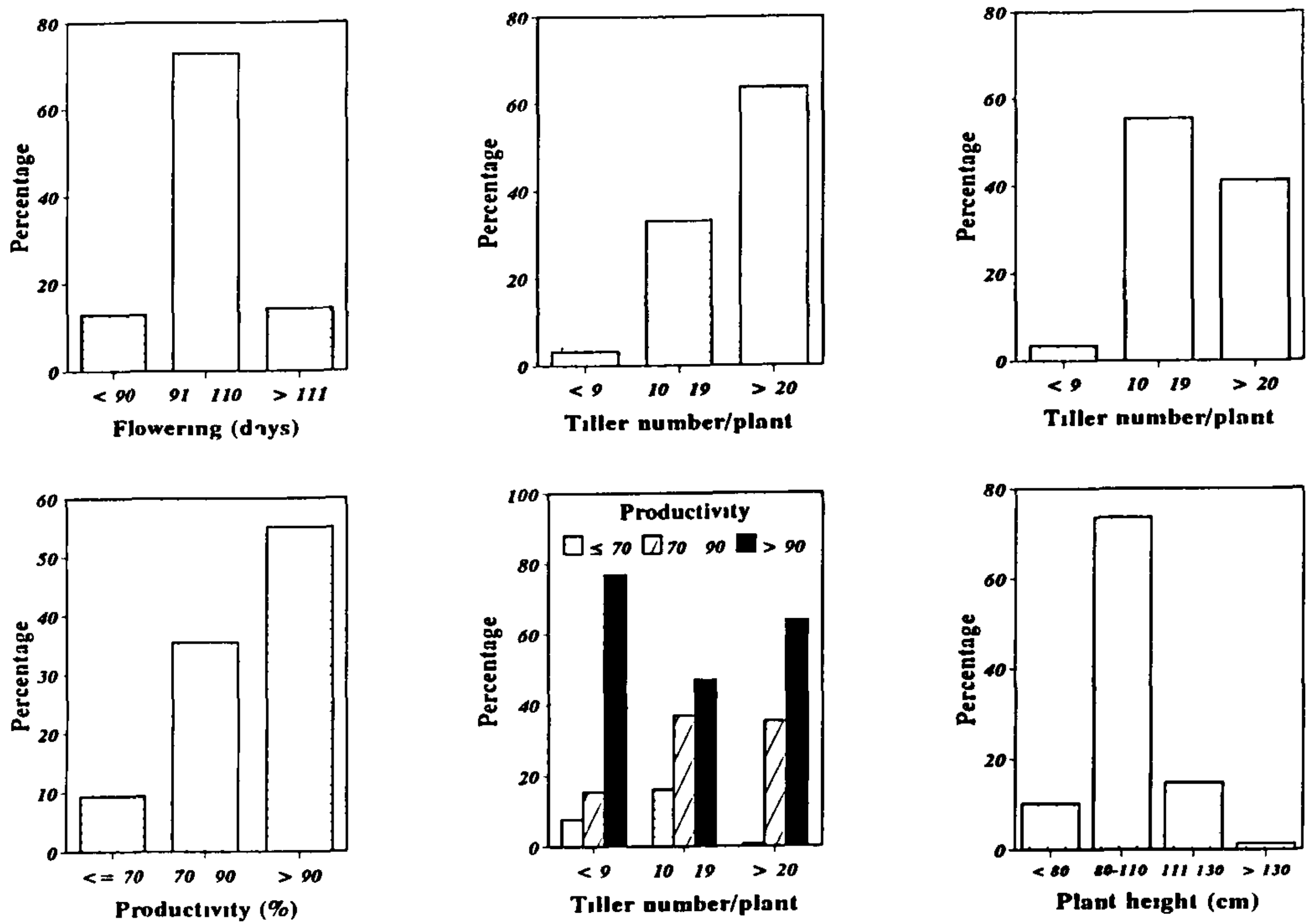


Figure 4 Frequency distribution of some agronomic traits in population PCT 9\0\0\0 Palmira, sept /95

B Activity RL01 Genetic Generation of an Indica Gene Pool with High Response to Anther Culture

Summary

This study aims to introgress the high AC *response from japonicas* into indicas to facilitate the application of AC as a routine tool for breeding indica rice A diallel study indicates that the low AC response shows incomplete dominance respect to the high response No maternal effects are noted Generation mean analyses suggest that the callus induction and the green plant regeneration are controlled by a simple genetic system (olygogenic) of different sets of genes Additive and dominant effects are highly significant for callus induction whereas just additive effects are statistically significant for green plant regeneration The co segregation analyses indicate that callus induction and green plant regeneration segregate *independently from the grain* type Six plants combining high response to AC from the japonica parent and long slender grains from the indica parent were selected Individual progeny plants from each selected line are being evaluated for their in vitro response and agronomic characteristics to select those indica types with high response to AC Selected plants will be used as parents in crosses with plants from a recurrent selection population to develop a genetic diverse indica gene pool with increased response to AC

Introduction

Anther culture (AC) is routinely used in our breeding program to reduce the generation time for broadening the genetic diversity of breeding gene pools and to facilitate the molecular tagging of genes Most of these applications have been mainly restrained to crosses containing at least one japonica parent due to the recalcitrance of indica genotypes The replacement of sucrose by maltose and the addition of silver nitrate into the callus induction medium substantially increases the AC response of indicas (Lentini et al 1995) however the yield of doubled haploids per anther from indicas is still about 20 fold lower than from *japonicas There* is evidence that the AC response in rice is controlled by few genes (Miah et al 1985 Quimio and Zapata 1990) Therefore the introgression of the high AC response from japonicas into indicas could facilitate the application of AC as a routine tool for breeding indica rice

Dialell and backcross (BC) inheritance analyses were conducted using crosses between the non AC responsive true indicas (Table 1) IR43 (P1) and CT8707 (P2) with long slender grain type and the highly responsive japonicas (Table 1) CT6241 17 1 5 1 (P3) with long slender grains and Todoroki Wase (P4) with short thick grain type $F_{1's}$ (and their corresponding reciprocal) F_2 and BC s populations with one BC *to each parent were* examined The co segregation of AC response and grain type was evaluated

The variance (Vr) and co variance (Wr) analyses from the diallel study shows the intercept of the regression line above the origin indicating incomplete dominance for the AC response (Figure 1) High callus induction and high green plant regeneration are recessive since P3 and P4 are above the Wr/Vr mean whereas the low response is dominant since P1 and P2 are below the Wr/Vr mean (Figure 1) The mean dominance (H1/D) values for callus induction (0 68) and green plant regeneration (0 49) corroborates the partial dominance of the low response Thus the AC response of the F1 s is between the low and high responsive parents (Table 1) Possible maternal effects but not statistically different were only noted in the crosses when CT8707 was used as the non responsive parent (Table 1)

The generation mean analyses show that the response models obtained for each trait are alike and independent of the cross analyzed The genetic models which explain the variability for callus induction and green plant regeneration are different suggesting that these traits are encoded by a different set of genes For callus induction additive and dominant effects were highly significant whereas for green plant regeneration only the additive effects were statistically significant (Table 2) The proposed genetic models (Table 3) required one type of gene interaction (additive X additive for callus induction and additive X dominance for green plant regeneration) (Table 2) Results suggest that these traits are controlled by a simple genetic system (olygogenic) of different sets of genes Both traits show high heretability (strict sense) values (0 81 for callus induction and 0 79 for green plant regeneration) The simple genetics and high heretability of AC response suggest that this trait could be easily transferred by crossing

The co segregation analyses on the cross between P1 and P4 indicate that callus induction (X^2= 0 034 p =0 853) and green plant regeneration (X^2= 0 033 p =0 978) segregate independently from the grain type Plants combining high response to AC from the P4 japonica parent (up to 70 / callus induction and 90 % green plant regeneration) and grain type from the indica P1 (up to 8 7 mm long and 2 9 mm wide) were recovered as early as in the F_2 generation and subsequently in the backcross indica generation Six lines from the crosses IR43/Todoroki Wase//IR43 and IR43/CT6241//IR43 with high response to AC (up to about 40% callus induction or 90 % green plant regeneration) and long slender grains (above 8 0 mm long and 3 0 mm wide) were selected Individual plants from the progeny of the selected lines are being evaluated for their in vitro response and agronomic characteristics to select those indica types with high response to AC Selected plants will be used as parents in crosses with plants from a recurrent selection population to develop a genetic diverse indica gene pool with increased response to AC

References

Lentini Z Reyes P Martinez C P and Roca W 1995 Androgenesis of highly recalcitrant rice genotypes with maltose and silver nitrate Plant Science In press

Miah M A A Earle E D Khush G S 1985 Inheritance of callus formation ability in anther cultures of rice Oryza sativa L Theor Appl Genet 70 113 116

Quimio C A Zapata F J 1990 Diallel analysis of callus induction and green plant regeneration in rice anther culture Crop Science 30 188 192

Table 1 Anther culture response of crosses between the japonicas CT 6241 17 1 5 1 and Todoroki Wase and the indicas IR 43 and CT 8707

Parent or cross	Callus per anther (%)	Green plants per callus (%)
IR 43	0 0 d	0 0 d
CT 8707	0 0 d	0 0 d
CT 6241	19 8 b	43 9a
Todoroki Wase	42 2 a	28 8 b
IR 43/CT 8707	0 0 d	0 0 d
CT 8707/IR 43	0 0 d	0 0 d
CT 6241/Todoroki	58 3 a	28 3 ab
CT 8707/Todoroki	2 2 bcd	0 0 d
Todoroki/CT 8707	15 9 bc	3 3 cd
CT 8707/CT 6241	6 6 bcd	3 3 cd
CT 6241/CT 8707	11 8 bcd	0 0 d
IR 43/ Todoroki	15 4 b	12 3 bc
Todoroki/IR 43	17 9 b	12 8 b
Todoroki/IR 43 F2	12 7 bc	11 7 b
Todoroki/IR 43//IR 43	5 2 c	7 2 c
Todoroki/IR 43// Todoroki	24 9 b	17 6 b
IR 43/CT 6241	13 9 bc	11 9 bc
CT 6241/IR 43	13 4 bc	22 1 b
CT 6241/IR 43 F2	4 5 cd	7 5 b
CT 6241/IR 43//IR 43	5 4 c	7 9 b
CT 6241/IR 43//CT 6241	12 3 bc	15 9 b

Means with the same letter are not significantly different according to Waller Duncan K ratio test p _ 0 01

Table 2 Generation mean analysis based on data from the populations P P_2 F F_2 BC indica and BC japonica of the crosses Todoroki x IR43 and CT6241 x IR43 [1]

	Callus per anther		Green plant per callus	
Parameter [§]	TodorokiXIR43	CT6241xIR43	TodorokiXIR43	CT6241xIR43
[m]	7 02	5 11	16 29	21 02
[a]	20 75	9 12	15 72	21 46
[d]	10 29	20 33	1 58	3 86
[axa]	13 79	14 76		
[axd]			17 85	28 19
[dxd]				
X^2 (2df)	1 20	3 70	3 90	4 10
p	0 55	0 16	0 14	0 13

[1] Accord ng to the simplest model that expla ns the observed values

[§] [m] mean alue between parents [a] add t ve effects [d] dominant effects [axa] [axd] and [dxd] interact ons between additive and/or dom nant effects Different from zero at p 0 05 and 0 01 respectively

Table 3 Observed and expected mean values according to the genetic model proposed by the generation mean analyses

	Callus / anther				Green plant / callus			
	TWxIR43		CT6241xIR43		TWxIR43		CT6241xIR43	
Generation	O	E	O	E	O	E	O	E
Female parent	42 73	41 56	19 34	18 76	33 57	32 01	43 12	42 48
Male parent	0 00	0 07	0 00	0 52	0 00	0 57	0 00	0 44
F	17 96	17 31	13 40	15 21	12 81	14 72	22 14	17 16
F_2	12 69	12 17	4 51	5 05	16 31	15 50	19 90	19 09
BC	24 87	25 99	12 32	13 30	19 78	18 90	21 61	22 77
BC_2	5 23	5 24	5 40	4 17	13 71	12 10	14 05	5 41
X^2 (2df)	1 20	3 70	3 90	4 10				
p	0 55	0 16	0 14	0 13				

TW=Todoroki Wase CT6241 CT6241 17 1 5 1 O=observed E=expected

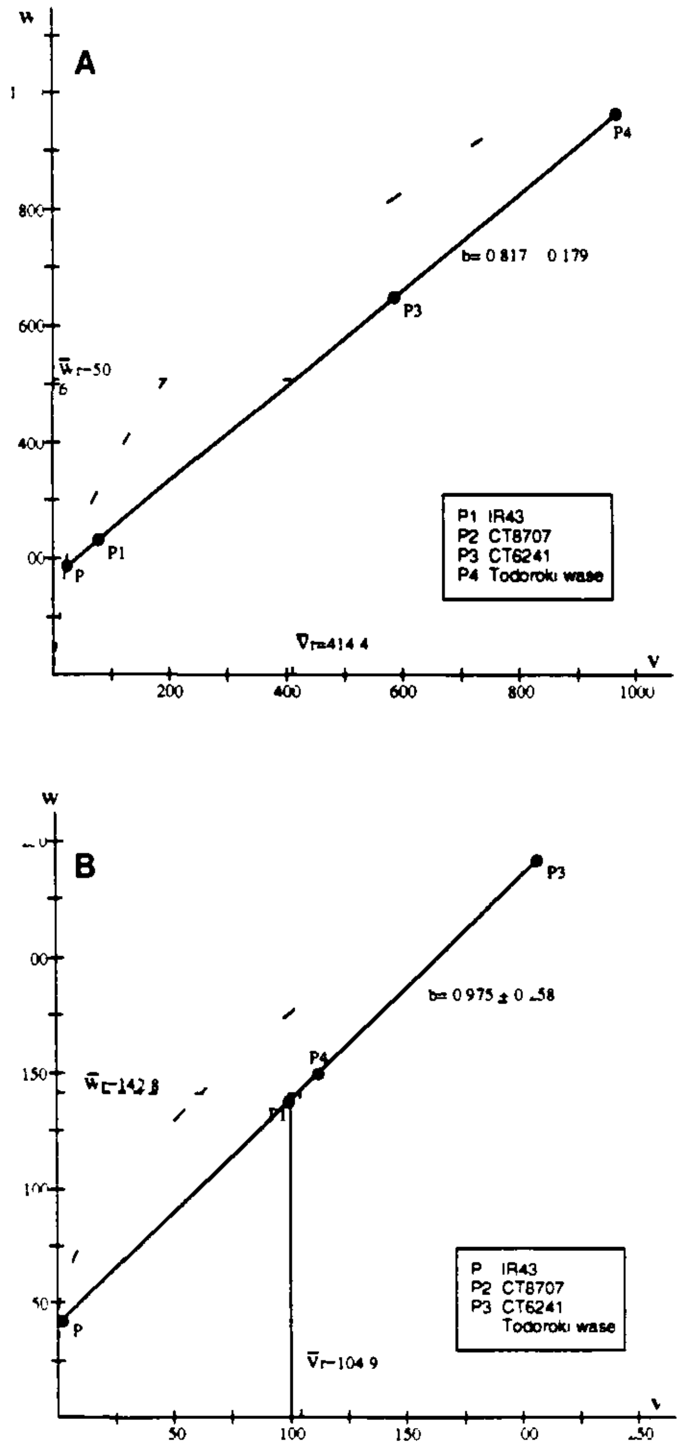


Figure 1 Diallel analysis of (A) callus induction and (B) green plant regeneration on crosses from between the indicas IR43 and CT8707 and the japonicas CT6241 and Todoroki Wase Vr= variance Wr= co variance

C ACTIVITY RL52 TRANSFER OF RICE ANTHER CULTURE BREEDING TO NATIONAL PROGRAMS OF LATIN AMERICA

SUMMARY

A two year project financed by the Rockefeller Foundation was executed to transfer CIAT s experience using anther culture (AC) for rice breeding to various National Programs of Latin America Twenty nine scientists from 14 Institutions and 10 countries participated in this event After the first workshop held at CIAT last year several Programs showed progress in using anther culture (AC) for breeding The most advanced program is pro ducing 2 000 doubled haploids (DH) per year Integration and cooperation is noted be tween the breeders and the tissue culture specialists There is interest in exchanging DH materials and strengthening the scientific collaboration between participant Programs A manual and a video summarizing the genetic and biological aspects of anther culture with a strong component of our experience using the technique in rice breeding will be ready by the end of 1995

INTRODUCTION

This workshop is part of a two year project financed by the Rockefeller Foundation to transfer CIAT s experience on anther culture (AC) in rice breeding to the National Programs of Latin America The main objectives of the technology transfer program included i) to transfer the AC methodology developed at CIAT for integration of doubled haploids (DH) into rice breeding ii) to contribute towards the formation of interdisciplinary eams on rice anther culture breeding comprising plant breeders and tissue culture specialists in each participant institutions and iii) to enhance horizontal research cooperation in rice breeding using anther culture at the sub regional and regional levels The project was initiated on February 1994 with a first workshop held at CIAT focused on technical discussions on rice breeding and rice anther culture intensive laboratory greenhouse and field exercises and discussions on logistical and economic aspects of implementing AC in rice breeding This year the second workshop was conducted from February 25 to March 10 in Argentina Brazil and Uruguay Twenty nine scientists from 14 Institutions and 10 countries participated in this event Most of the participants attended last year s workshop Activities included presentations by participants about their work during the last year visits to anther culture laboratories and field evaluations and selection of more than 2 000 doubled haploids lines produced by CIAT and some of the participant Institutions

Several Programs showed progress in using anther culture (AC) for breeding The most advanced program is INTA Argentina producing 2 000 doubled haploids (DH) per year followed by the Instituto de Investigaciones del Arroz Cuba with 1 500 DH and CNPAF Brazil with 600 DH INIA Uruguay started using AC last year just after the first workshop they could already produced 200 DH FONAIAP Venezuela showed a substantial progress in the AC response for various of the highly recalcitrant indica materials used in their breeding program Most laboratories are well equipped Integration and cooperation was noted between the breeders and the tissue culture specialists Participants express the need to continue sharing information as it was fostered by this two year project They also indicated their interest in exchanging DH materials and strengthening the scientist collaboration across Programs As a result of these needs a 3 year research proposal is going to be prepared

With this workshop this two year project "Technology Transfer on Anther Culture for Rice Breeding is completed The final version of a manual and a video summarizing the genetic and biological aspects of anther culture with a strong component of our experience using the technique in rice breeding will be ready by the end of 1995 Participant programs indicated the need for a continue collaboration from CIAT in facilitating the exchange of DH lines between programs training scientist for those programs that are currently building their laboratories (i e INIA Chile IRGA Brazil) and assisting this new initiative to facilitate and assure its implementation in breeding The adoption of AC by the National partners may aid to fill out the gap left by CIAT when moving from delivering finished lines to segregating populations and parents

II PROJECT 2
IMPROVED UPLAND RICE GENE POOLS

Purpose

To develop upland rice types for sustainable agriculture where they can act as nurse crops to protect the soil and enhance the establishment of perennials such as forages in the tropical savannas and hillsides and under tree crops in forest margins and hillsides

A Activity **RU 01** Germplasm Development

Summary

This project began in 1984 with the objective to develop germplasm adapted to acid soils savannas Breeding is concentrated in the development of fixed lines and population improvement The first strategy relies on germplasm introduction parent analysis management of segregating generations and observational yield trials Use of population improvement started in 1993 with introductions of gene pools and population from Brazil in 1994 CIAT created its own population (PCT 4\0\0\1) based on the most adapted introduced material To support these initiatives there are special studies (BS and MSc theses work) on different aspects related to the employed strategies The results of the project can be measured by the varietal releases in Colombia and Brazil These aspects are covered in this project report

Introduction

This project began in 1984 with the objective to develop germplasm adapted to acid soils savannas The main characteristics been bred into these materials have been

- tolerance to acid soils
- disease resistance mainly blast
- insect resistance mainly *Tagosodes orizicolus*
- good grain quality (translucent long and slender) and
- earliness (growth duration shorter than 115 days)

Improvement of upland rice gene pools is based on La Libertad Experimental Station (LLES) Villavicencio Meta and Matazul Farm eastern plains of Colombia (Altillanura) During 1994 to improve the LLES soil physically and chemically *Crotalaria juncea* L was used as green manure Both locations followed the same soil preparation early plowing was done with chisel and final preparation with disk arrows and chisel plow These practices were the same for all experiments mentioned in this report

Soil and climatic data for LLES are showed in Tables 1 and 2 It is clear from Table 1 that the soils are acid and the Aluminum saturation very high The O M is relatively high probably because the system goes through a cycle of fallow for one year Phosphorus (P) values are low in the second layer but are higher in the first 20 cm because of the green biomass incorporated Values of Calcium (Ca) Magnesium (Mg) and Potassium (K) are low characteristics from this soils

Line Development

Germplasm Introduction

The objective of this trial is to evaluate the introduced germplasm and select the most promising ones for further evaluation and crossing The introduction in 1995 came from 7 groups a) Australia (9) b) Hungary (19) c) CORAF network (436) d) INGER Africa nursery AURON 93 (84) and AURPSS 93 (140) e) INGER Global nursery IURON 94 (55) f) Brazilian upland (271) and irrigated (151) and g) 42 lines from different locations

The 1 207 lines were grouped in a trial called Introducciones The evaluations made were pant vigor reaction to soil acidity and diseases flowering date and plant height Only 89 (7 4 %) lines had potential for further studies 50 from Brazil 27 from CORAF 6 from AURON 4 from AURPSS and 2 from IURON The Brazilian germplasm and the lines from AURON presented earliness (78 2 and 72 3 days to flowering respectively) an important breeding objective

Within the selected lines thirty had leaf blast (Bl) reactions scores ≤ 3 twenty flowered with less than 76 days and eight had plant vigor ≤ 5 Only eight lines combined Bl resistance and earliness and only WAB 56 104 combined all three characteristics The 1996 plans for the selected lines are to continue under evaluation as members of the nursery Potential Parents

Potential Parents

This set is composed of introduced lines and germplasm developed within the project The main objective is to specifically evaluate the materials for several traits and select the best ones for crossing In 1995 the trial had 212 entries which were planted at LLES and Altillanura for blast lineage evaluation *and for morphological characterization*

The evaluations for morphological characterization were similar to what is done for the introduction adding a more detailed description of the weakness and strength of each line was made Looking at these evaluations there were 78 lines with potential for crossing but before crossing these information will be combined with the blast lineage analysis

Blast lineage evaluation A total of 185 parents were tested against 24 isolates collected by the Pathology Section in the Altillanura The objective was to identify their reaction to the Altillanura lineages (ALL) to guide the crosses to improve upland germplasm for blast resistance

The methodology used was described elsewhere in previous Rice Program Reports The results are reported in Table 3 Isolate Linea 2 62 obtained from CT10037 9 7 M 1 M and belonging to lineage ALL 7 was the most virulent one it was compatible with 83 (44 9 %) of the 185 materials tested The following one was isolate Linea 4 2 from CT9997 5 3 M 4 M also belonging to ALL 7 Nevertheless there were 9 isolates avirulent to all lines

An interesting observation was that *some of the crosses evaluated* even though with similar pedigree up to F_6 segregated for reaction to lineage ALL 7 For example CT11848 11 2 6 **1** and CT11848 11 2 6 **2** were resistant and CT11848 11 2 6 **3** and

CT11848 11 2 6-4 were susceptible This may have happened because the selection process was carried on at LLES and the lineages from Altillanura show a different composition to find out this it is necessary further analysis of segregating materials

Segregating Generations

F_2 Generation triple crosses Twenty crosses were made in 1993 after selection in the F_1 at Palmira Experimental Station (PES) they were reduced to 186 plants from 15 F_2 populations The selection criteria used was plant and grain type and growth duration (highly inheritable traits)

The F_2 lines were evaluated for reaction to soil acidity and diseases During selection 165 plants were chosen from 48 lines (25 8 /) and 13 crosses (92 8%) The CT13365 (Seratus Malam/HD 14//CT11231 2 2 1 M) and CT13369 (Nam Sagui 19/CT9997 5 3 M 4 M//CT10598 25 1 2P 1 1) were discarded due to susceptibility to neck blast (NBl) The most promising crosses were CT13370 CT13371 and CT13366 with 65 0% 53 3% and 37 5 / of the lines selected and 64 28 and 25 F_2 plants respectively Crosses CT13370 and CT13366 have CT11240 26 1M M as one of the parent contributing with 50% of its genes to the cross In total there were 3 6 plants selected per line and 14 1 per cross

The average flowering data for the selected lines was 80 days the combinations CT13366 and CT13380 flowered with 72 days Related to soil acidity the overall behavior was good almost all lines were resistant except lines from CT13369

F_2 Generation single crosses There were 18 combinations made in 1993 selection left 177 F_2 lines from 13 crosses Selection at LLES resulted in 655 plants from 129 lines (72 9%) and 13 crosses (100%) These crosses had better behavior than the triple thus more plants were chosen In the combinations CT13573 CT13581 CT13582 and CT13584 all lines were selected and 90 49 99 and 98 plants respectively were chosen In the last three combinations CT11242 3 3 M 1 1 was involved as one of the parents it is one of the most blast resistant parent In general there were 5 0 plants selected per line and 50 6 per cross

Earliness was a relevant trait in these populations the overall average was 72 days Combinations CT13573 and CT13583 were the extremes flowering with 69 0 and 86 3 days respectively

F_4 Generation This was the first year that early generations were planted in Altillanura The objective was to expose the germplasm to Altillanura disease pressure and environmental conditions and combine the information with LLES to improve selection efficiency

A set of 238 F_3 lines coming from 24 F_2 combinations were selected at LLES in 1994 At PES these materials were advanced to produce F_4 lines for 1995 planting The evaluations made at LLES and Altillanura were the same as for other segregating populations concentrating on disease reaction grain quality (type) and yield potential

Within the 238 populations there were 112 plants selected from 63 lines (26 5 /) and 14 crosses (48 3 /) In general the lines showed very early maturity averaging 72 6 days to flower The pedigrees CT13217 9 3 M CT13235 17 1 M and CT13234 4 2 M had only 62 63 and 64 days respectively

Table 4 presents the distribution of BI in each evaluation sites Altillanura trial with high fertility level had the highest pressure for BI 34 5% of the lines showed score 5 the lowest pressure was also observed in Altillanura but in the trial with normal fertilization

The results are indicating that some lines behave the same in both sites but there are some with opposite reaction At LLES 86 lines presented scores < 3 (resistant lines) out of them 40 were susceptible in Altillanura These results are suggesting that probably the lineage frequency distribution in these two sites is different thus supporting the breeding strategy of planting early segregating materials in the Altillanura

F_4 and F_5 Generation from CNA IRAT populations These groups of lines are originated from the population improvement component of the project In the populations CNA IRAT 5 A and P in 1994 there were 220 F_2 and 38 F_3 plants selected at LLES These lines were advanced at PES and planted at LLES and Altillanura in 1995 The objective is to continue the evaluation flow to produced fixed lines with improved traits

These lines are coming from only one and two cycle of mass selection in the introduced population therefore as expected their potential was limited only 4 F_3 plants were selected from 2 lines and 4 F_4 plants from 1 line

F_8 Generation The objective of this evaluation is to identify lines for the preliminary yield trials and the INGER LAC Observational Nursery for acid soils In 1995 there were 258 F_8 lines planted at LLES and Altillanura They were evaluated for soil acidity diseases reaction grain type growth duration and yield potential

Table 5 shows that the highest blast pressure was observed in the blast nursery planted in the Altillanura the average was 4 2 and 49 7 % of the lines presented score $\geq$ 5 (susceptible reaction) The LLES presented the lowest pressure consequently 75 % of the lines were resistant (score $\leq$ 3)

Combined analysis for the locations allow to identify 47 lines with high potential nevertheless 24 of them are originated from the same cross (CT11891) and only three F_2 plants Last year the best line in the preliminary trial which is under evaluation for release was CT11891 2 2 7 M also from the CT11891 cross

Preliminary Yield Trials

Thirty lines and two checks were evaluated to assess their yield ability and potential for release in Colombia The experiments were planted at LLES and Altillanura in association with pastures and without The evaluations were similar to the advanced lines adding the traits related to yield ability like number of panicles per m^2 number of spikelets per panicle 100 grain weight etc

At LLES the best line was CT12243 07 11 with 3 468 kg/ha and the worst was (TOx 1011 4 1/Cuiabana) 4 with 1 253 kg/ha both have short growth duration The early maturating check cultivar Guarani yielded 1 584 kg/ha The coefficient of variation for the trial was 10 4 %

The best line in the Altillanura without association with pasture yielded 3 066 kg/ha (CT11618 6 2 1 M 2) and the lowest yielding line was CT12243 22 9 with 987 kg/ha The checks had similar yield 2 280 and 2 430 kg/ha for Oryzica Sabana 6 and Guarani respectively The CV % was 11 0 The association with pasture did not reduce the yield potential the averages were 2 216 kg/ha for the association and 2 236 kg/ha for monocrop The highest yielding line in association was CT11251 9 M 2 3 5 with 2 910 kg/ha and the lowest was CT1243 22 9 with 1 050 kg/ha Both checks showed similar yielded between them and between trials for Oryzica

Sabana 6 it was 2 205 kg/ha and for Guarani 2 444 kg/ha The CV% was similar to other trials 10 6

One trial planted in the Altillanura received higher dosage of fertilizers but it did not presented a higher average yield it was only 2 327 kg/ha lower than LLES which had 2 511 kg/ha The highest yielding line was CT11891 2 2 3 6 M (3239 kg/ha) and the lowest was CT11232 35 2 M M (1198 kg/ha) The CV% was similar to all other preliminary trials 10 6

The combined analysis did no show significant differences between the four trials Nevertheless statistical differences were found between lines and for the interaction line by trial For example CT12243 07 11 was the highest yielding line at LLES and was in the 29th position in Altillanura monocrop

The interaction genotype by environment did allow to identify materials with uniform behavior across all sites therefore 7 lines were selected considering not only its yield potential but also its range of variability opinion given by farmers who visited the trial and other agronomic information gathered during the season This line will be multiplied and handled to CORPOICA for regional trials and possible variety release

Population Improvement

Introduction

The project has been increasing the emphasis on this component at the expenses of reduction in line development In 1995 four populations were evaluated with the objective to improve them for specific traits mainly blast resistance earliness and grain quality

During the initial years the work concentrated in introduction characterization and mass selection under acid soils conditions (details about these aspects are written in previous Rice Program Report) These populations have different origin but they all have the male sterile gene from IR36 From 1996 onwards the project will be working on evaluation of $S_{1\,2}$ progenies to improve the populations

The four populations were planted in the same way The 2 500 plants were spaced planted to allow plant selection All populations were surrounded by maize to avoid external pollination

PCT P\0\0\0

This population since its characterization has been going through a reduction in size because it has not presented good agronomic traits and also is susceptible to NBI This season there were only 357 plants representing the variability of the population The blast pressure at LLES determined the elimination of the population 92 4 / of the plants were susceptible to blast and the remaining plants did not have the agronomic potential for further improvement

PCT 5\0\0\0

Out of the 2 500 S_0 plants present in the population 1 193 (47 8%) were eliminated due to susceptibility to Bl and 155 (6 2%) to Hoja Blanca Virus (HBV) This population came from seeds harvested on male sterile plants thus it is expected a 1 1 segregation for fertile and sterile plants Counting plants which reached maturity there were 592 490 or 54 7 45 3% a relationship close to the expected one

In general this population presented plants with undesirable plant height and grain type thus the selection only picked 56 individuals (9 3 % selection intensity) for progeny evaluation and recombination to compose the next cycle population This reduced number affects the population size and the variability available for continuous selection it probably will limit the population to a short term usefulness

To find out the composition of the population for one of the important traits for the project a sample of 188 plants was picked and classified according to flowering data Table 6 shows that more than 27 0% of the plants flowered before 76 days and 38 9% between 76 and 80 days These data indicate that the population is skewed toward earliness which was the direction used in the selection process

PCT A\0\0\0

Similar to the previous population out of the 2 500 S_0 plants 882 (35 3 %) were eliminated in the early stages due to susceptibility to Bl and 198 (8 1%) to HBV The seeds used to generate this population also came from male sterile plant thus from the 1 309 plants left 696 were fertile and 548 sterile this gives a 55 9 to 44 1% relationship

This population had similar behavior as PCT 5\0\0\0 there were 87 plants selected for progeny testing which gives 12 5 % selection intensity This is also a small number of individuals to represent the population size of PCT A\0\0\0 thus the recurrent selection will be limited to short term gains

A sample of 159 plants was used to characterize the population for flowering The results on Table 6 are showing that more than 40 0% flowered before 76 days and that 29 6 % were between 76 and 80 days This is indicating that more than 50 % of the members of this population are considered early material Compared to PCT 5\0\0\0 this population had higher percentage of pants flowering bellow 80 days this was expected because the PCT A\0\0\0 was derived of introductions of early maturing lines in the male sterile background of PCT 5\0\0\0

PCT 4\0\0\1

This population was developed at CIAT using CNA IRAT A as source of male sterility On this background was introduced 7 breeding lines adapted to acid soils and with outstanding agronomic traits This germplasm should be the central focus in the population improvement component of this project

The selection for Bl and HBV on the 2 500 S_0 plants reduced 42 7% and 4 9 / respectively of the population size Out of the remaining plants 63 6% were fertile and 36 4% were sterile these numbers do not fit the 1 1 expected relationship In the literature there are several reports indicating that this may happen due to preferential gametic segregation

This was the best population among all four from the 852 fertile plants left there were 160 selections for S_1 progeny testing This number should allow after next year evaluation to come up with around 50 plants for recombination which is the number recommended in the literature to target for medium term gains

Similar to what was done for the previous reported populations a sample was used to characterize flowering distribution Table 6 indicates that there are 29 5 % of plants between 66 and 70 days 25 1 / between 71 and 75 days This population presents the strongest skewness toward earliness compared to the other three

The future plans are to seed increase the S_1 plants and progeny test the $S_{1\,2}$ at LLES and Altillanura in 1996 The recombination phase will be conducted at PES in 1996 to complete the first recurrent selection cycle

Special Studies

Hoja Blanca Virus (HBV)

This virus is an important disease in irrigated rice in several Latin American countries but it was not ever reported for upland under acid soils This year even though the severity was not high symptoms were observed in all trials Table 7 summarizes the number of lines observed with at least one infected planted in some of the trials carried on in 1995

Blast Nursery

To avoid planting F_8 and earlier generation in 5 0 meters two row plots in the Altillanura which requires a lot of resources this year the project is evaluating the possibility of using blast nurseries to assess the blast reaction of these lines under natural disease pressure (lineage composition) coming from the target area (Altillanura)

In 1995 the nursery Progenitores Potenciales the F_8 lines and materials included in the preliminary yield trial were grouped for this test The objective was to evaluate Bl in Altillanura under high blast pressure and compare the data with the results observed in the same trials conduced in larger plots

The trial was planted in 1 meter two row plot with higher level of fertilization (mainly nitrogen) high seed density and with late planting This strategy allows to get higher levels of disease pressure and inoculum coming from lineages present in germplasm planted in the area A summary of the results of this trial is presented in Table 5 It is pointing that the highest disease pressure was observed in this trial compared to the others

Population Size in Rice

Following the agreement between CIAT and the Escola Superior de Agricultura Luiz de Queiroz (ESALQ) Piracicaba Brazil the student Ana Claudia Carvalho Badan has been developing a Master degree thesis to determine the sample size required to characterize rice populations

Population PCT 4\0\0\1 is the subject of this study A sample of plants from each parent is under evaluation at LLES The parameter measured were tiller number flowering date plant height and yield The results will be presented in her thesis work which will be published by ESALQ

Breeding Strategy for Blast

This work is part of a Master degree thesis conducted by Eduardo Graterol from Universidad Central de Venezuela Maracay Venezuela The objective is to compare leaf and neck blast reaction of lines produced through six breeding strategies combining generation of selection (F_2 F_3 y F_4) locations and planting date (Annex 1)

A total of 486 lines were developed from eight combinations The crosses were chosen to combine different blast reaction (susceptible/susceptible susceptible/resistant and resistant/resistant) The experiment was planted at Santa Rosa Experimental Station (SRES) following a randomized block design with four replications

Preliminary data are indicating that the coefficient of variation for Bl is much lower than for NBl 17 3 / against 31 7 / For Bl there were significant statistical differences between strategies and for the interaction strategy by cross

The average Bl scores are indicating that strategies 2 (4 10) 5 (4 11) and 3 (4 16) are significantly different from 6 (4 72) which is similar to 1 (4 44) and 4 (4 34) These results are suggesting that there was limited effect in selecting in F_2 F_3 or F_4 when compared to bulk the materials for one or two generations at SRES The lowest number of resistant lines was obtained with strategy 6

All strategies together produced 86 resistant lines to Bl (scores < 4) the highest number (26) came from strategy 2 it was followed by 1 4 6 3 and 5 with 14 13 13 12 and 8 respectively

With respect to NBl the analysis indicated no significant difference between strategies but there was for the interaction strategy by cross

Looking at the number of lines from each strategy that contributed to the 110 lines with scores $\leq$ 2 it was found that strategy 1 and 2 had the highest contribution 30 lines each In the sequence there were the strategies 4 3 5 and 6 with 14 13 13 and 10 lines respectively

These results are not showing one strategy highly superior than the others Apparently the strategy 5 which postpones selection until F with generation advance at SRES taking advantage of the natural selection in the hot spot site provides an economic alternative to develop blast resistant lines Nevertheless strategies 1 and 2 which were similar to 5 produced the highest number of resistant lines for Bl and NBl It is worth mentioning that these two strategies require more effort from the breeder in keeping tracking the pedigrees of each line and resources for planting

In conclusion based on these preliminary analysis there are alternatives to produce blast resistant lines The relationship cost/benefit and the objectives of the program should be taking into account to decide which one has more potential

Field Day with Farmers and Extensionist

With the objective to hear farmers and extensionist s opinion on the type of materials the project is developing for Colombia it was organized a field day in the Altillanura In summary the main comments made were related to

Earliness a trait very much appreciated by the group the materials are better than the Oryzica Sabana 6 It allows growing two crops in the same season and faster availability of the pastures

Plant height the short stature of the lines presents two folds first it is useful for areas with higher humidity and association with not very aggressive pastures (*B dyctioneura*) second it may be deficient to compete with aggressive pastures (*B decumbens* and *B brizantha*)

Grain type excellent size and shape this may overcome the milling problems they are facing with Oryzica Sabana 6

Disease and pest resistance the blast resistance level observed was appreciated the main point was how long it will last under farmers field conditions HBV is a concern for the future thus resistance should be included The major concern was with pest mainly with the level of susceptibility presented by some materials to *Diatrea saccharalis*

In conclusion the materials are targeting their priorities and are showing progress for the traits relevant to them Based on what they saw the CIAT/CORPOICA project should be able to provide the region germplasm with high potential for varietal release

Progress in Germplasm Exchange with Brazil

Brazil has a well structured network for germplasm exchange and evaluation CIAT germplasm enter the network through EMBRAPA CNPAF Every year parents F_4 and advanced lines are shared with them as well as with IRRI WARDA and CIRAD CA

During the cropping season 1994/95 there were 54 (out of 170) lines included in the observational trial 15 (out of 34) in the preliminary yield trial and 12 (out of 34) that came from CIAT project The members of the network decided to promote 12 to preliminary (out of 34) and 8 to advanced (out of 18) trials in favorable areas and 3 to advanced (out of 14) trial for less favorable areas

Based on several years evaluation there are two CIAT lines been proposed for release

CNA 7475 TOx 939 107 2 101 1B//Col 1 x M312A/TOx 1780 2 1P 4
CT7/15 IRAT 216/IRAT 124//RHS 107 2 1 2TB 1 JM

These results are showing that there is an efficient mechanism in place to exchange germplasm with Brazil and that lines developed by the improved upland rice gene pools project have potential for the more favorable conditions in the Brazilian Cerrados

Varietal Release in Colombia

After several years of yield testing under experimental and farmers conditions CORPOICA decided to release the line CT6196 33 11 1 3 M with the name of Oryzica Sabana 10 It come from the cross Col 1 x M312A/IRAT 124//RHS 107 2 1 2TB 1JM The yield potential is similar to Oryzica Sabana 6 but the genetic basis is different and grain quality and blast resistance are superior A folder with complete information on this new variety is available in the offices of the Rice Program

It is important to mention that grain quality is one of the limiting factor for area *expansion* with agropastoril system in the Colombian Altillanura Oryzica Sabana 6 has been classified as other varieties and farmers area receiving around 10% less this is because the ratio length/width is 2 8 lower than the minimum required (3 0) The new variety will solve this problem because it has a reletionship equal to 3 2

Table1 Soil analysis of two depth (0 20 and 20 40) after incorporation of green manure (*Crotalaria juncea* L) in the breeding site at La Libertad Exp Station 1995

Depth	M O (/)	ppm P Bray II	pH	meq/100 g Al	Ca	Mg	K	C I C	ppm B	Zn	Mn	Cu	Fe	Sat Al (/)
0 20	3 9	12 1	4	2 5	0 3	0 1	0 1	2 81	0 1	0 39	10 52	0 38	29	87 9
20 40	4 1	3 8	5	2 3	0 2	0	0 1	2 54	0 2	0 33	7 74	0 3	12	91 7
0 20	5	12 9	4	2 4	0 3	0 1	0 1	2 88	0 2	0 39	9 17	0 44	32	84 2
20 40	3 8	5	5	2 2	0 2	0 1	0 1	2 38	0 2	0 3	8 02	0 38	16	91 6
0 20	3 6	17 4	5	2 6	0 3	0 1	0 1	3 02	0 2	0 34	14 56	0 43	31	85 7
20 40	3 1	5 1	5	2 5	0 3	0 1	0 1	2 87	0 2	0 36	7 64	0 4	20	88 5
0 20	3 5	9	5	2 5	0 2	0 1	0 1	2 84	0 2	0 3	11 32	0 37	20	89 4
20 40	4 3	5 7	5	2 6	0 2	0 1	0 1	2 77	0 3	0 2	9 12	0 39	17	92 4
0 20	3 5	8 9	5	2 9	0 4	0 2	0 1	3 36	0 3	0 32	15 0	0 27	39	84 8
20 40	3	5 5	5	3 1	0 3	0 1	0 1	3 44	0 3	0 27	9 91	0 28	27	88 9

So l texture 0 20 44 1 Sand 15 2 / Silt and 40 5 Clay
20-40 39 1 / Sand 16 9 / Silt and 45 0 / Clay

Table 2 Climatic data from Santa Rosa Experimental Station 1995 used as reference for La libertad Experimental Station

Data	Month Apr	May	Jun	Jul	Ago	Sep	Total
Rainfall (mm)	263 6	354 8	331 8	253 9	201 4	172 8	1578 3
Rainy days (#)	17	23	24	21	18	17	120
Maximum temperature (C)	30 9	30 1	28 4	29 4	31 2	32 1	
Minimum temperature (C)	21 7	21 5	21 7	20 9	21 5	20 6	
Relative humidity (/)	82	84	88	86	82	82	

Table 3 Evaluation of the lines included in the Progenitores Potenciales nursery against lineages SRL and ALL under greenhouse conditions Palmira Experimental Station 1995

Reg	Isolates	Lineage SRL	ALL	Susceptible line (#)
1	Cica 9 15	1		3
2	Cica 9 37 1	2		0
3	Selecta 3 20	2		4
4	Fanny 24 3	3		0
5	Isol 2 8 2	4		32
6	Isol 6 7 1	5		1
7	Colombia 1 15 1	6		4
8	Linea 2 62		7	83
9	Linea 2 95		7	0
10	Linea 4 2		7	74
11	Linea 4 14		7	0
12	O Sabana 6 21		7	59
13	O Sabana 6 64		7	8
14	L 201 6		7	2
15	Caloro 1 1		8	0
16	Raminad STR 3 23 1		9	0
17	Aichi Asahi 15 11		10	2
18	Fanny 28 1 1		11	3
19	IAC 165 7 1		12	3
20	Kanto 51 1 5		13	3
21	Linea 2 43 1		15	2
22	Tetep 5 1		16	0
23	Zenith 32 1		17	0
24	Chokoto 2 1		19	0

Table 4 Percentage distribution of F_4 lines according to their reaction to leaf blast

		Breeding sites	
		Altillanura	
Score	LLES	Normal fertilization	High fertilization
0	0	0	0
1	0	0	0
2	4 6	9 2	4 2
3	30 9	31 6	32 9
4	37 7	38 8	27 4
5	25 4	18 9	34 5
6	1 2	1 2	0 8
7	0	0	0
8	0	0	0
9	0	0	0
Average	3 88	3 71	3 95

1 Refers to ave age score in the 0 to 9 IRRI (1988) scale

Table 5 Percentage distribution of F_8 lines according to their reaction to leaf blast

		Breeding sites		
		Altillanura		
Score	EELL	Normal fertilization	High fertilization	Blast nursery
0	0	0	0	0 4
1	0	0	0	0
2	9	0 8	5 1	1 2
3	66	37 5	39 4	23 7
4	22 7	56 3	28 1	24 9
5	1 2	4 7	25 4	37 5
6	0 4	0	1 9	9
7	0 8	0 8	0	0 8
8	0	0	0	0
9	0	0	0	2 4
Average	3 2	3 68	3 8	4 2

1 Refers to average score in the 0 to 9 IRRI (1988) scale

Table 6 Percentage of plants from a sample obtained from populations PCT 5\0\0\0 PCT A\0\0\0 y PCT 4\0\0\1 for flowering behavior

Population	Number of days from planting to flowering						
PCT	≤ 60	61 65	66 70	71 75	76 80	81 85	≥ 86
5\0\0\0	0 5	1 6	11 2	14 9	38 9	15 4	17 5
A\0\0\0		1 9	10 1	28 9	29 6	17	12 7
4\0\0\1	1 2	9 2	29 5	25 1	14 1	16 2	4 3

Table 7 Number of lines in some of the 1995 trials that showed Hoja Blanca Virus (HBV) symptoms in at least one plant within the line La Libertad Experimental Station 1995

Trial	Total number of line	Number of lines with HBV	Percentage of lines with HBV
F Parents	24	2	8 3
F_8 Parents	37	13	35 1
F Lines	238	29	12 2
F_8 Lines	258	56	21 7
F CNA IRAT	39	6	15 4
F_5 CNA IRAT	19	4	21 0

Table 8 Strategies for selecting for *Pyricularia grisea* Sacc

Strategy	Generation	Location	Selection	Month/Year
1	F_2	SRES	yes	April 1990
	F_3	SRES/PES	yes	October 1990
	F	SRES	yes	april 1991
2	F_2	SRES	yes	April 1990
	F_3	SRES	yes	October 1990
	F	SRES	yes	April 1991
3	F_2	SRES	yes	April 1990
	F_3	SRES	yes	April 1991
	F	SRES	yes	April 1992
4	F_2	SRES	no	April 1990
	F_3	SRES	yes	April 1991
	F	SRES	yes	april 1992
5	F_2	SRES	no	April 1990
	F_3	SRES	no	April 1991
	F	SRES	yes	April 1992
6	F_2	PES	no	april 1990
	F_3	PES	no	October 1990
	F	SRES	yes	April 1991

PES means Palmira Experimental Station and SRES mens Santa Rosa Experimental Stat on

B Activity RU52 Mechanisms of Acid Soil Tolerance

Summary

For the sustainable development of tropical savannas the further improvement of upland rice which is already the important component of cropping systems for the ecosystem is needed Upland rice is more tolerant to acid soils than other usual crops requiring less lime application and therefore most suitable for the low input cropping systems with little disturbance to the environment It is already confirmed that rice has a large genotypic variation in terms of the tolerance to acid soil conditions Therefore the development of mass screening techniques which are more rapid and accurate than the on site screening may greatly contribute to the efficiency of upland rice breeding targeting the ecosystems This strategy of this project is 1) to identify the most important soil limiting factor 2) to understand the physiological mechanisms for the tolerance to the limiting factor and 3) to develop a screening technique based on the understanding of the mechanisms of the tolerance

In lime (calcitic lime) response experiments using both tolerant and susceptible genotypes found that the tolerant genotypes maintained constant yield over the wide range of lime application whereas the susceptible genotypes responded in the range between 0 and 300 kg/ha of liming In this range the Ca fertility increases but soil acidity does not change significantly The results therefore imply that the main trait which is different between tolerant and susceptible genotypes may be the tolerance to low Ca conditions rather than the tolerance to high soil acidity It was also found in other field experiments that the susceptible variety had high P uptake efficiency but low P use efficiency which can be another reason for the low performance of the susceptible genotype

In another field experiment the wide genotypic variation in the tolerance to low P fertility was confirmed using 29 genotypes Several genotypes which had highest yield potential had the lowest low P tolerance (LPT) whereas the high LPT genotypes with moderate yield potential were also found This implied the opportunity to breed new varieties which has both high yield potential and high LPT

INTRODUCTION

The genetic improvement of upland rice for the savannas in South America (Llanos and Cerrados) is progressing aiming to create varieties having good adaptation to the acid soils as well as high yield good grain quality and the resistance to biotic stresses The evaluation for acid soil tolerance started from 1982 under the field conditions with and without the application of lime on a typical Oxisol with Al saturation of higher than 80 / Since then the tolerance to the acid soil has been evaluated by the performance of the varieties under this natural acidic condition in the fields

Because the performance of genotypes were evaluated under such high acidity and because other fertilizers were applied adequately in general it has been assumed that the varieties which performed well have the tolerance to the high aluminum in the soil (exchangeable Al and soil solution Al) or low pH than the susceptible ones

Beside excess aluminum however the highly weathered savanna soils have other chemical limiting factors even if fertilizers were applied Although applied fractionally the leaching of both N and K due to the high rainfall and good drainage tend to cause the shortage of these nutrients Low P availability is the another problem because these high weathered soils have a moderate P sorbing capacity which makes it difficult for the plants to utilize The exchangeable Ca and Mg are also deficient with these soils because of the low cation exchange capacity Low availability of Si in the soil is another problem for these high weathered soils because the rice plants are known to absorb a considerable amount of Si from soil to support their normal growth

Therefore the tolerance to the shortage of such nutrients could also be the reason for the good performance of so called tolerant varieties in addition to the tolerance to higher Al Hence we have started to evaluate the tolerance of genotypes against the excess of Al as well as the shortages of the nutrients mentioned above From this physiological studies improved screening methods are being developed with which the tolerance to each soil chemical factor can be evaluated more accurately and thus contribute to the efficient breeding of more adapted varieties for savanna conditions

RESPONSE OF ACID SOIL TOLERANT AND SUSCEPTIBLE VARIETIES TO CALCITIC LIME APPLICATION

The yield of both tolerant and susceptible varieties were compared at the two rates of dolomitic lime application (0 3 and 3 t ha $^{-1}$) in the previous field experiments at La Libertad in 1933 and 1994 The application of 0 3 t ha $^{-1}$ of lime is not considered to ameliorate the soil acidity significantly but just supplies the Ca and Mg necessary and therefore the susceptible varieties were not expected to produce reasonable yield at the low rate Tthe two treatments did not cause significant yield difference even in the case of the susceptible varieties In a pot experiment using similar Oxisol it was found that the significant genotypic difference between susceptible and tolerant varieties occurred at the application range between 0 and 100 ppm (w/w dry soil) of same dolomitic lime (which corresponds to ca 250 kg ha $^{-1}$ in the field) Therefore it was assumed that the yield of tolerant and susceptible varieties differ at an application range lower than 300 kg ha $^{-1}$ in the field too To confirm this the yield of acid soil tolerant and susceptible varieties were compared with 5 levels of lime application

Materials and methods

The experiment was conducted on a Oxisol at the Matazul farm at altillanura in the eastern plain of Colombia The area had been a native savanna before the experiment The experiments was conducted with 4 replications with split plot design with 5 lime rates (calcitic lime as 0 150 300 600 and 3 000 kg ha $^{-1}$) as main plots and 4 rice varieties (Oryzica 1 and Oryzica Llanos 5 as susceptible and Oryzica Sabana 6 and IAC165 as tolerant varieties) as sub plots with 4 replication Soil and soil solution were sequentially sampled and measured The roots were harvested from all the plots at 90 days after sowing (DAS) The total shoots were sampled at 90 DAS as well at harvest

Results and Discussion

Fig 1 shows the changes of soil pH at 0 kg ha $^{-1}$ lime application As in the case with the experiment at La Libertad in 1993 and 1994 the pH decreased to the 4 3 4 4 only at the later stage of growth Although the data is not shown the pH of 300 kg ha $^{-1}$ plots decreased less than that of the 0 kg ha $^{-1}$ This decrease of pH occurred only at the plough layer of the soil (0 20 cm depth) again as in the previous experiments at La Libertad But in general the acidification in Matazul was less than that in La Libertad

The total growth at the flowering stage was not significantly affected by the lime application (data not shown)

At harvest there was a response of susceptible varieties (Oryzica 1 and Oryzica Llanos 5) at the application rate between 0 and 300 kg ha (Fig 2) There was a response for IAC165 too but not for Oryzica Sabana 6 Therefore it was confirmed that even at the field conditions the main effect of liming which brings about the genotypic difference is between 0 to 300 kg ha which suggests that the genotypic difference of the contrasting variety is more related to the tolerance to low Ca and/or low Mg rather than the tolerance to the direct effect of excess aluminum The Tropical Lowlands Program (1994) also reported the same response for Oryzica Llanos 5 and Oryzica Sabana 6 although the response was less in this experiment The final analysis including nutrients uptake is yet to be done

NUTRIENT UPTAKE AND UTILIZATION EFFICIENCY OF VARIETIES OF UPLAND RICE UNDER LOW AND HIGH APPLICATION RATE OF LIME

In 1993 five genotypes of upland rice including a susceptible genotype were tested on the acid savanna soil at La Libertad with low and high application rate of dolomitic lime (0 3 and 3 t ha^{-1} respectively) For this experiment the efficiencies for both nutrient uptake and nutrient utilization were analyzed

Materials and methods

The genotypes used were (1) Oryzica Llanos 5 (2) IAC47 (3) CT9997 5 3 M 4 M (4) Oryzica Sabana 6 and (5) CT10037 9 7 M 1 M

The nutrient uptake efficiency was evaluated at the flowering time using the following equation

[Nutrient uptake efficiency] = [Nutrient uptake by the plant top] /[Total root length (0 100 cm)]

The nutrient use efficiency was measured at the time of harvest using the equation

[Nutrient use efficiency] = [Panicle dry weight] / [Nutrient uptake by the plant top]

Results

The results of the nutrients uptake efficiency are shown in Fig 3 The N uptake efficiency was positively affected by the high lime application With acidic conditions of the soil the ammonium nitrogen is accumulated because the nitrification is inhibited due to low pH The liming increased the soil pH and may have enhanced the nitrification and liberated more nitrate nitrogen which is more easily utilized by plants The N uptake efficiency of both Oryzica Llanos 5 and CT9997 was slightly lower than the other genotypes Part of the reasons can be ascribed to the shallower rooting system of these genotypes (data not shown) P uptake efficiency was also higher with the high lime application except in the case of Oryzica Llanos 5 The higher P efficiency of Oryzica Llanos 5 is notable Par of its reason might be the longer growth duration of this variety (101 DAS to flowering) than of the other varieties (79 89 DAS to flowering) The K uptake efficiency of CT9997 was lower than that of the other varieties The uptake efficiencies of Ca and Mg were much higher with high lime application because of the composition of Ca and Mg in the dolomitic lime used (22% Ca and 10 % Mg) Liming increased the uptake efficiency of Mg more than that of Ca It was also reported that the increase of pH itself increases the uptake of Mg but not that of Ca (Rice Program Annual Report 1993)

Nutrient use efficiency had negative trend when compared with the uptake efficiency in general (Fig 4) The N use efficiency was lower with high lime treatment for most of the varieties P use efficiency of the susceptible variety Oryzica Llanos 5 was significantly lower than that of the other varieties although it had high uptake efficiency (Fig 3) The K use efficiency of IAC47 was the lowest among the varieties although this variety had high K uptake efficiency In contrast CT9997 had the lowest K uptake efficiency but had the highest K use efficiency For Ca and Mg the use efficiency was lower with higher lime application and again the effect of liming was more for Mg than for Ca

The non adaptation of Oryzica Llanos 5 to the savanna conditions can be partly explained by the low phosphorus use efficiency although it could take up high amount of phosphorus due to its long duration it could not utilize internal phosphorus to produce the grain efficiently CT10037 can be characterized by its higher uptake efficiency whereas CT 9997 has a higher use efficiency in general Oryzica Sabana 6 seems to have had the intermediate character between these

GENETIC VARIABILITY OF UPLAND RICE FOR THE TOLERANCE TO LOW PHOSPHORUS FERTILITY IN SOIL

Oxisols and Ultisols prevailing in the acid soils in tropical countries are usually very deficient in phosphorus The total amount of phosphorus is very low because of the long weathering and leaching process In addition the phosphorus in the soils are largely bound with Fe and Al oxides and not readily available to plants Even the freshly applied phosphorus is fixed by these Fe and Al oxides and becomes unavailable in a rather short time

However phosphorus fertilizers are more expensive than other fertilizers The low content of phosphorus in the fertilizers also causes problem of high transportation cost especially for the fields which are situated away from the cities or ports It is therefore very difficult to apply high amount of phosphorus fertilizers to the fields in a large scale Therefore the genetic improvement of the upland rice which grows relatively well even under the low phosphorus conditions (low P tolerance) will be sought

As the first year of the project we tested the genetic variability of the low P tolerance in the field of altillanura in the eastern plains of Colombia The soil was the typical Oxisol of savanna with strong acidity and low availability of nutrients

Materials and methods

The varieties used in the experiment are listed in Table 1

The experiment was conducted with the split plot design with three replication with phosphorus level as main plot and varieties as sub plot Phosphorus as triple super phosphate was applied at the rate of 5 20 and 80 kg P ha $^{-1}$ and was incorporated to the depth of 15 cm Dolomitic lime (55 / $CaCO_3$ and 35 / $MgCO_3$) were applied at the rate of 300 kg ha $^{-1}$ 15 days before the sowing All other nutrients were applied sufficiently At the flowering time and harvest plants were harvested and the dry weight of the parts were weighed

The yield at the highest rate of phosphorus fertilizer (80 kg ha $^{-1}$) was defined as the Yield Potential of each variety Since the yield at medium phosphorus fertility (20 kg P ha $^{-1}$) was not significantly different from Yield Potential for most of the varieties the yield at the lowest P fertility (5 kg ha $^{-1}$) was designated as the yield at the stress P level Low P Tolerance (LPT) index is defined as below

[Low P Tolerance (LPT) (/)] = 100 X [Yield at stress P level (kg ha $^{-1}$)] /[Yield potential (kg ha)]

Results and Discussion

The Yield Potential versus Low Phosphorus Tolerance (LPT) is plotted in Fig 5 The average yield potential was 287 g m ^{2} and the average LPT was 53 5 % Each quadrant in the figure separated by the average lines indicates

A High LPT but low in Yield Potential

B High in LPT and High in Yield Potential

C Low in LPT and low in Yield Potential

D Low in LPT but high in Yield Potential

In general the distribution of the varieties in the figure fitted to a negative linear correlation (r= 0 633) which is significant at 95 % confidence

The varieties located in the area B were WAB96 7 1 (Variety number 12) WAB 99 84 (13) CT 11614 1 4 1 M 4 (23) and TOX 1011 4 A2 (27) which were considered to have the desired traits in terms of phosphorus uptake and usage CNA 7013B (9) and Oryzica Sabana 6 (2) also had higher LPT with moderate Yield Potential The CT 11891 2 2 7 M (7) had the highest yield of 417 g m ^{2} but the LPT was the lowest among all the varieties used Statistically the varieties No 2 9 12 13 were significantly higher than the linear regression line with 95% confidence and varieties No 6 8 10 14 were significantly lower than that (data was not shown)

From these data both the tolerant and susceptible varieties in terms of low phosphorus tolerance will be selected and they will be tested in details for their response to phosphorus at more levels in order to find the traits which is physiologically associated with the low P tolerance

EFFECT OF THE APPLICATION OF RICE HULL ASH (RHA) AS AN ALTERNATIVE SI SOURCE

In the previous reports it was found that the application of silicon fertilizer benefits both the yield as well as the tolerance against diseases However the cost of silicon fertilizers and the transportation is high which makes it almost impossible to use silicon fertilizers The genetic variability for the tolerance to low Si was shown previously (Rice Program Annual Report 1994) Here however as an agronomic management to overcome this limiting factor the alternative silicon fertilizer was sought

In the rice production area around Villavicencio several industrial mill are located The rice hull which was discarded as the by product of the hulled is heaped up around the mills Since the rice hull contains 2 4 % of silicon this could be used as an alternative source of Si for the upland rice production If the hull is applied as it is the transport cost will be high because of its the volume and the incorporation of it might cause drought stress because the incorporation makes the soils very Therefore the ash of rice hull was used as the material

Materials and Methods

The rice hull which was collected from a mill at the suburb of Villavicencio contained 4 71% of Si and was heaped on the steel sheet by the quantity to be applied to each plots and was burned outdoors When it was ashed completely the crust of the heap of ash was black and the inside of the heap was gray These two kinds of ash were mixed thoroughly The Si content of the mixed dried ash was 16 4 % For the comparison wollastonite (VANSIL W 10 R T Vanderbilt Company) with 24 2% Si was also used

The upland rice (var Oryzica Sabana 6) was used as plant material The silicon sources were applied at the 4 rates (0 200 400 and 800 kg Si ha^{-1}) The experiment was conducted with split plot design with 4 replication with the source of Si as main plot and the rate of the application as sub plot Each plot had the dimension of 5 x 4 m The liming effect of silicon sources was compensated by the application of dolomitic lime (55 / $CaCO_3$ and 35 % $MgCO_3$) Wollastonite had the liming effect equivalent to 70 2 % of $CaCO_3$ were as rice hull ash (RHA) had nil The Si sources dolomitic lime and other fertilizers (P K Zn) were applied and incorporated into the soil to 15 cm depth Then the seeds were planted by planting machine with the row distance of 20 cm (80 kg seeds / ha) on the same day

Results and discussion

Both silicon sources significantly increased the total dry weight at the harvest (Table 2) In the case of rice hull ash (RHA) however the harvest index was decreased at the highest application rate with unknown reason and therefore the final yield was not increased significantly by the hull ash application (Fig 6) In the case of wollastonite the harvest index was constant across the application rates and the yield increased significantly by the application The number of tillers did not increased by the application of RHA but increased significantly by the wollastonite (Table 2)

These data indicate that the wollastonite stimulated the early growth of upland rice without affecting the processes at the reproductive stage and therefore produced more final yield The RHA on the contrary did not enhance the early growth as is seen from the number of tillers At the reproductive stage probably it stimulated the total accumulation of dry matter but some how the reproductive process was inhibited at the highest application and did not lead to the higher yield It has been speculated that the solubilization of silicon in the RHA was slower than that of the wollastonite and thus the silicon could not be used to enhance the plant growth at the proper timing as the silicon in wollastonite could The analysis of silicon for both plant tissue and soil would reveal further why the ash of rice hull did not show any effect on the plant yield formation

Although it was reported that the application of RHA on the seedbed of transplants increased the yield (Sawant and Patil 1994) it did not increase the yield under the upland conditions on the similar type of Oxisol in Nigeria (personal communication Dr Winslow)

The water soluble Si content of RHA for black and white RHA (554 or 412 ppm respectively) was that of comparable to the wollastonite (496 ppm) and more than the slug (140 ppm) they however represent less than 1 / of the total Si content in these Si sources Clearly the most of the Si in the RHA is in unavailable form (Mesa Lopez 1991) although the solubility increases if the rice hull was ashed at the higher temperature with the aid of the furnace (N K Savant personal communication)

References

Mesa Lopez Luis Jorge 1991 Efectos de la aplicacion de ceniza de cascarilla de arroz en la composición química y mineralógica de dos oxisoles de Colombia Agronomía Colombiana 8 (2) 322 335

Sawant A S and Patil V H 1994 Rice hull ash applied to seedbed reduces deadhearts in transplanted rice IRRI News Letter 19 (4)21 22

Table 1 Varieties used in the experiment of low P tolerance

1 Oryzica Llanos 5	12 WAB96 7 1	22 CNA 6680
2 Oryzica Sabana 6	13 WAB 99 84	23 CT 11614 1 4 1 M 4
3 Caiapo	14 (ARAGUAI/IRAT216) DH5A 3	24 CT 11891 3 6 4 3 M
5 Colombia 1	15 CT 11251 9 M 2 3 5	25 CT 6196 33 10 4 15 M
6 Progresso	16 CT 12243 22 9	26 CT 11626 22 1 M M 4
7 CT 11891 2 2 7 M	17 CT 11623 13 M 5 2 2	27 TOX 1011 4 A2
8 IAC 1204	18 (Tox 1011 4 1/ CUIABANA) 4	28 CT11231 35 2 M M
9 CNA 7013 B	19 (GUARANI / IR841 2)	29 CT 11608 8 6 M M 3
10 IR63380 09	20 CT11848 11 2 6 5 M	30 CT11846 24 5 2 4 M
11 IR63370 09	21 CT11891 3 3 3 1 1	

Table 2 Effect of silicon application in the form of both wollastnite and the ash of the rice hull on the total dry weight harvest index and number of tillers of upland rice (Oryzica Sabana 6) in the eastern plain of Colombia (May October 1994 at Matazul farm)

	Si Applied (kg ha [1])	Total Dry weight (kg ha)	Harvest Index	No Tillers (m [2])
Ash of rice hull	0	6069	27	325
	200	6045	26	323
	400	6453	26	335
	800	7458	22	351
Wollastonite	0	5760	25	292
	200	5590	28	303
	400	6869	25	341
	800	7964	25	373
LSD (0 05)		1030	04	49

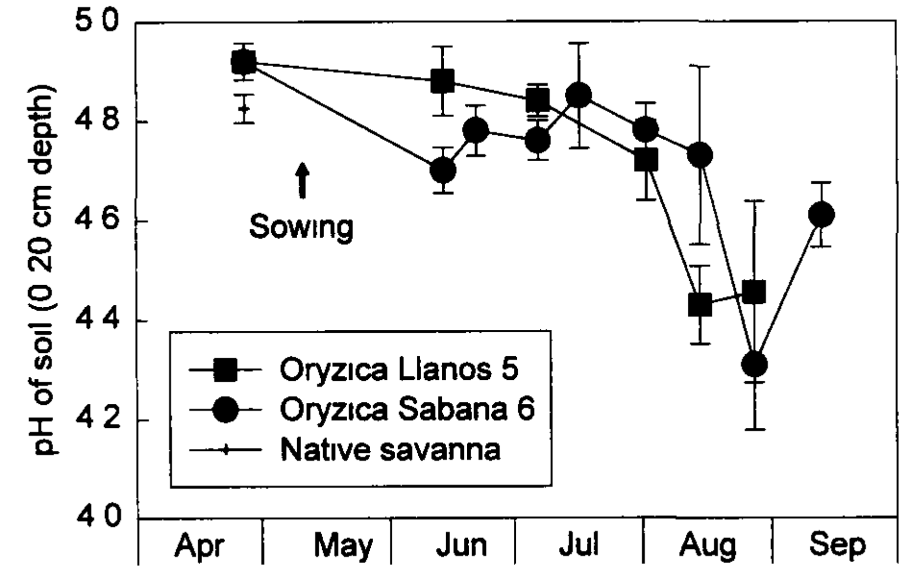


Fig 1 Changes of pH of soil (0 20 cm) in the field of upland rice with no lime application at Matazul farm in 1995
(Vertical bars indicate ±se)

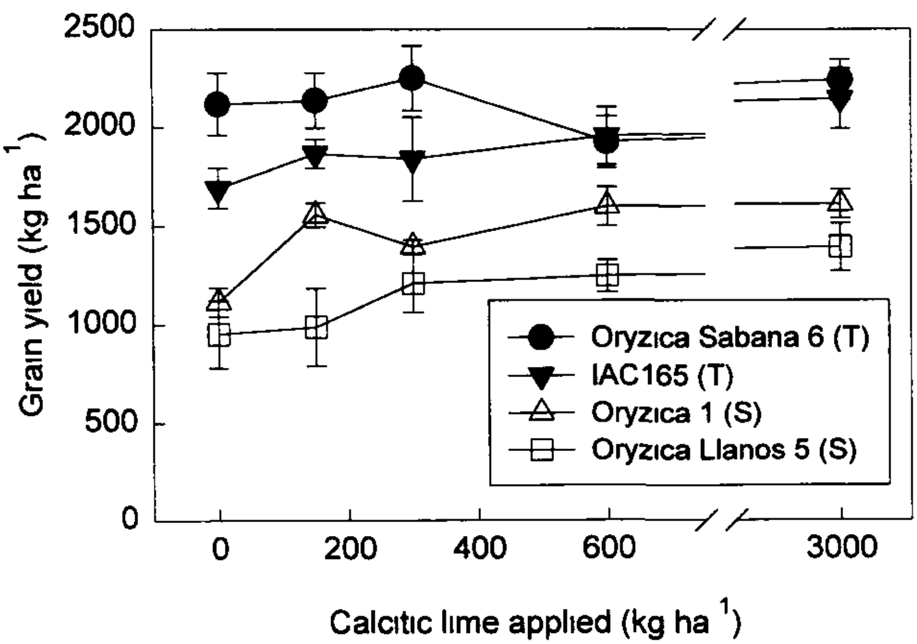


Fig 2 Effect of calcitic lime application on the gain yield of acid soil tolerant (T) and susceptible (S) varieties of rice (at Matazul farm 1995 Vertical bars indicate ±se)

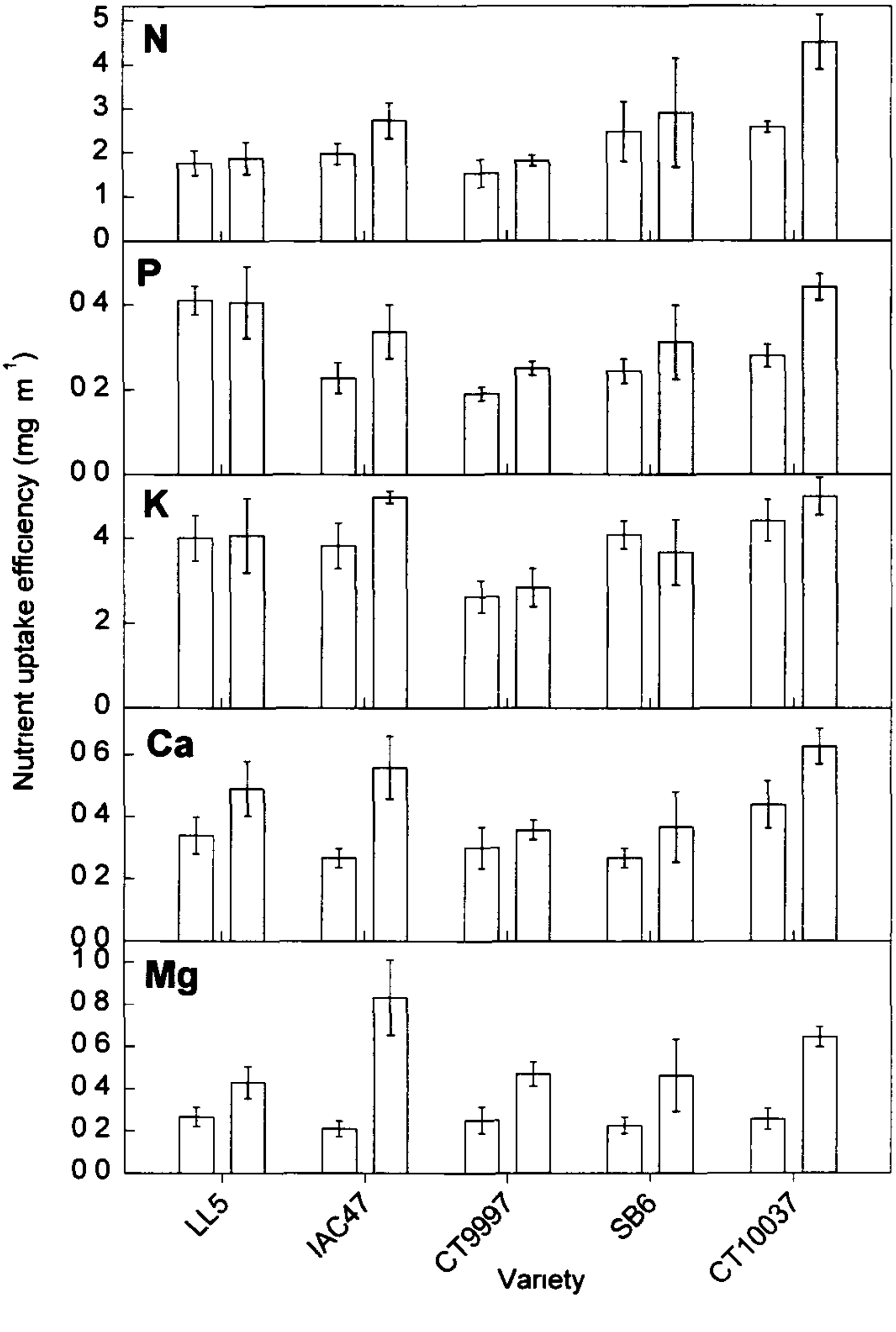


Fig 3 Nutrient uptake efficiency of five varieties of upland rice at flowering at ICA La Libertad station (Vertical bars indicate ±se see text for the definition of nutrient uptake efficiency)

Low lime (0 3 t ha⁻¹) High lime (3 t ha⁻¹)

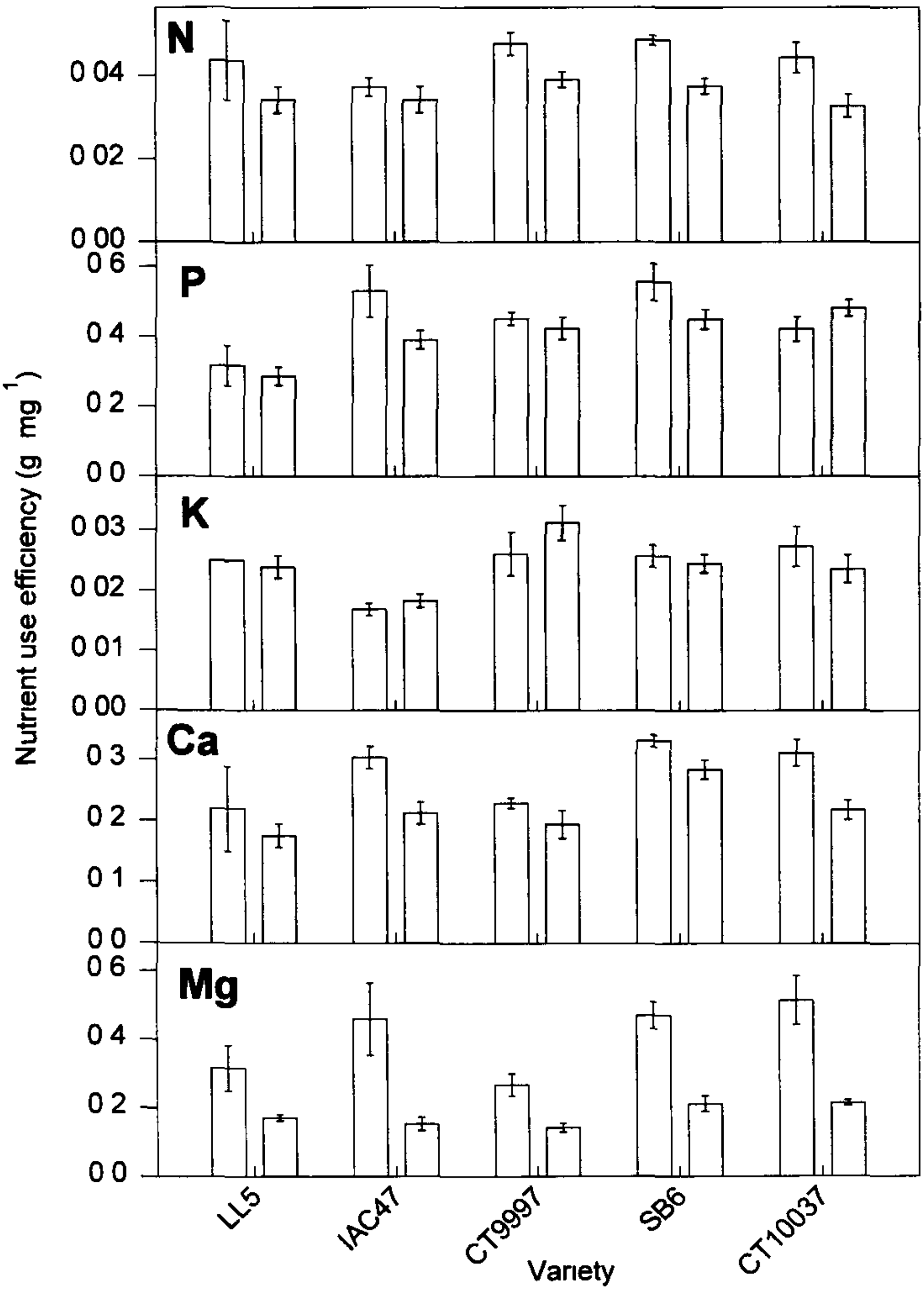


Fig 4 Nutrient use efficiency to produce grain yield for varieties of upland rice on an Oxisol of savanna in eastern plain of Colombia (in 1993 at ICA La Libertad station vertical bars indicate ±se see text for the definition of nutrient use efficiency)

Low lime ($0.3\ t\ ha^{-1}$) High lime ($3\ t\ ha^{-1}$)

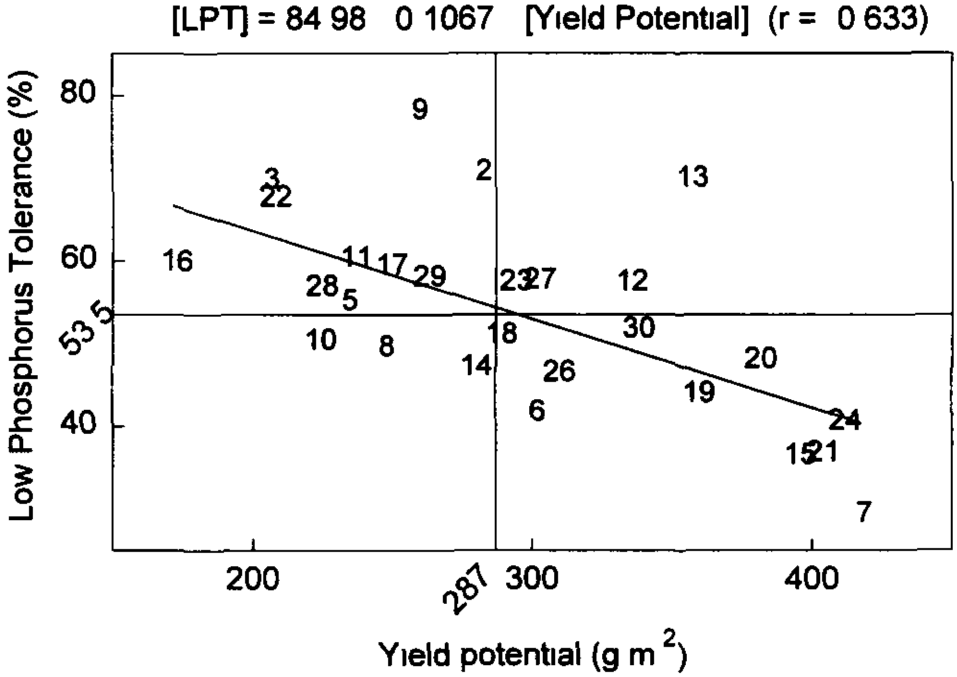


Fig 5 Relationship between the 'Yield Potential (yield at the highest level of phosphorus application) and Low Phosphorus Tolerance (see text) for varieties of upland rice on an Oxisol at Matazul

(Numbers indicates variety number explained in Table 2 and the numbers on the both axes indicate average for all the varieties The line indicate the linear regression)

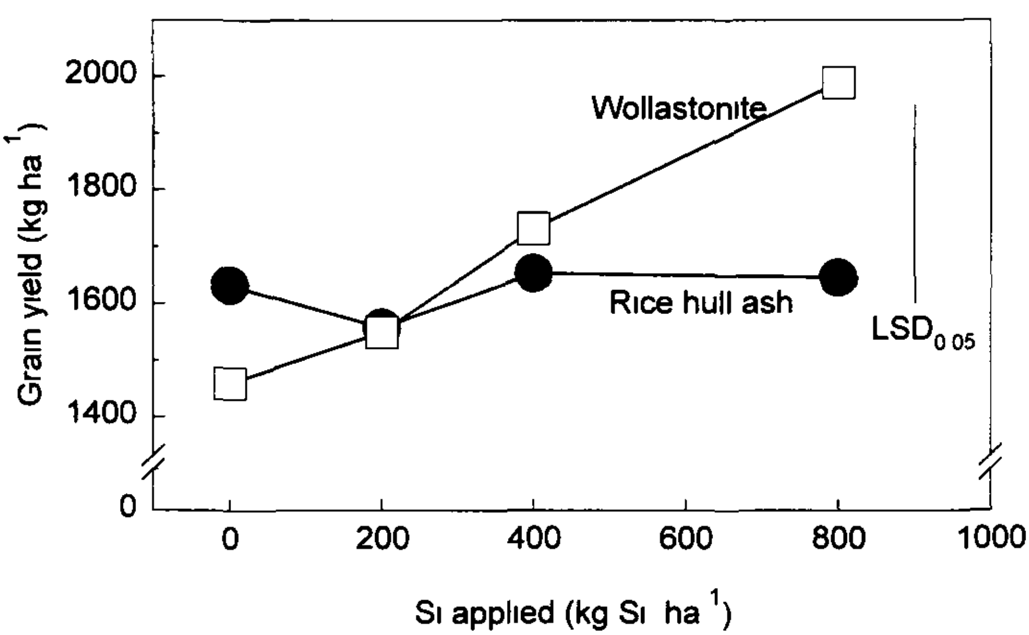


Fig 6 Effect of the application of silicon in the form of both wollastonite and rice hull ash on the grain yield of upland rice in 1994 at Matazul farm

105787

III Project 3
DURABLE BLAST RESISTANCE

PURPOSE

To work jointly with national programs to help stabilize rice yields and quality reduce pesticide use and production costs and close the gap between farm and station yields

A ACTIVITY RP01 BLAST PATHOSYSTEM ANALYSIS AND BLAST RESISTANCE

SUMMARY

The main objective of this project during 1995 was to continue characterizing several components in the rice blast pathogen system for developing an effective resistance breeding and gene deployment strategy

Only four lineages were detected this year in the acid soil savannas of the Altillanura ALL 7 SRL 6 SRL-4 and ALL 10 with similar frequency for the first three and a low frequency for the last one Isolates from these lineages are now being used in greenhouse screening for selecting resistance donors to be used in genetic crosses by the upland breeding program Genetic lineage SRL 4 continues increasing in frequency in the Altillanura while other lineages found in the past have apparently dissapeared from this site

Three new rice cultivars released in Colombia Selecta 3 20 Oryzica Caribe 8 and Oryzica Yacu 9 were highly susceptible to blast under greenhouse inoculations with isolates recovered from the three cultivars DNA fingerprinting analysis revealed that the first cultivar was infected by lineages SRL 2 SRL 4 and SRL 6 while the second and third cultivars were infected by lineages SRL 4 and SRL 6 respectively Isolates from lineage SRL 6 recovered from these cultivars in 1995 have gained virulence according to greenhouse inoculations However the highly blast resistant cultivar Oryzica Llanos 5 exhibited a resistant reaction to all of them These new isolates will be very important in selecting sources of resistance to the blast pathogen as well as in genetic studies of the control of blast resistance

Genetic lineages SRL 6 and SRL 5 were compatible with 80 % and 69 / respectively of 201 commercial rice cultivars mainly from Latin America Twenty four cultivars were identified within this group that exhibited resistance to all blast isolates used in the greenhouse inoculations and which also exhibited a field resistant reaction These cultivars will be used in the breeding program as potential donors of blast resistance genes for the Latin American region Other 23 rice cultivars from 12 countries exhibited complementary resitance to blast and could be used in specific crossess targeted to exclude the blast pathogen population in Colombia being also potentially useful for the rest of the region Greenhouse and field trials suggest that the heterozigous form of complementary resistance genes may not be effective in excluding the corresponding compatible genetic lineages of the pathogen exhibiting a normal susceptible reaction

Genetic studies of the control of blast in the highly resistant cultivar Oryzica Llanos 5 suggest the presence of up to four resistance genes to genetic lineages SRL 1 SRL 2 and SRL 3 three genes to SRL 4 two genes to SRL 5 and it was isolate dependent for

genetic lineage SRL 6 In the latter case resistance was controlled by two genes to two isolates recovered prior to 1995 and only one resistance gene to two isolates recovered during 1995 These genetic studies suggest that the blast pathogen could be one step away of breaking down the resistance in this cultivar specially those isolates recovered during 1995 which according to greenhouse studies have accumulated virulence factors

A field methodology used in a recurrent selection project was evaluated in the field for the selection of resistance donors to different genetic lineages of the blast pathogen where a total of 12 breeding lines with high yielding capacity were selected and used in 74 crosses among themselves or with other rice lines exhibiting complementary resistance to blast The recurrent selection method continues being very promising for accumulating and deploying resistance genes from different sources to the different genetic lineages of the blast pathogen

RATIONALE

Blast caused by the fungus *Pyricularia grisea* is the most widespread and damaging disease of rice The extreme variability in virulence exhibited by the rice blast pathogen as well as inadequate resistance screening methods are considered to be the main reason for rendering resistant varieties susceptible under commercial fields within 2 or 3 years after release Considerable efforts are being directed by many rice researchers towards developing stable blast resistant cultivars as a means to achieve low cost and environmentally safe blast management

The main objective of this project during 1995 was to study several components in the rice blast pathogen interaction system for developing effective resistance breeding and gene deployment strategies Characterization of the genetic diversity and variability in virulence of the blast fungus as well as the genetics of resistance in different rice cultivars are the principal components being studied on this integrated strategy which has been developed by an interdisciplinary and interinstitutional team from CIAT's Rice Program and Biotechnology Research Unit cooperating with Purdue University

BLAST PATHOSYSTEM ANALYSIS

Genetic structure and virulence frequencies of the blast pathogen Characterization of the blast pathogen population structure in the target area for future commercial savanna upland rice production indicates that different lineages compared to other rice growing areas of Colombia are present in this ecosystem We recomended that additional screening for upland rice should be conducted at a savanna site since 1994 A large collection of blast infected samples were obtained at this site from different upland breeding materials to determine the frequency of lineages being compatible with this germplasm and to charaterize the virulence composition of this population Specific compatible/imcompatible interactions between a genetic lineage and its virulence composition with a resistance gene or rice cultivar will be identified for recomending potential sources of resistance to be included in crosses that would yield blast resistant progenies for this upland ecosystem Blast isolates will be identified from this pathogen population to be used for screening for resistance of upland germplasm under controlled conditions More blast samples will be collected during 1995 in the field for continuing studies on the characterization of the pathogen population in the Altillanura

The rice growing season in the Altillanura Colombiana (Matazul Carimagua) was characterized by a low blast pressure even on the most susceptible rice cultivars during the last two years We had reported the breakdown of the commercial cultivar Oryzica Sabana 6 during the growing season of 1993 in the Altillanura however this cultivar as well as the susceptible check lines CT 10037 9 7 M 1 M (linea 2) and CT 9997 5 3 M 4 M (linea 4) exhibited a resistant reaction during 1994 and 1995 Monitoring pathogen population changes in the Altillanura was continued during 1995 to explain the low pressure of blast during the season

A total of 245 blast isolates were recovered from the Altillanura Colombiana during 1995 and their genetic structure characterized using the MGR DNA 586 probe All isolates were recovered from a total of 25 rice cultivars or breeding lines (Table 1) but the largest number of isolates were obtained from the susceptible checks Oryzica Sabana 6 (40 isolates 36 from Matazul and 4 from Carimagua) Linea 2 (28 isolates) and Linea 4 (23 isolates) Despite the large sample of isolates analized there were only four genetic lineages detected in the blast population studied These lineages were SRL 6 (87 isolates) ALL 7 (79 isolates) SRL 4 (75 isolates) and ALL 10 (4 isolates) as shown in Table 1 It is very interesting to note that several genetic lineages from the Altillanura and from Santa Rosa detected in the past were not detected during this year

It should be noted that the genetic lineage ALL 7 responsible for the breakdown of the cultivar Oryzica Sabana 6 during 1993 was only identified in one isolate out of 36 recovered from this cultivar in Matazul (Table 1) On the other hand the other 35 isolates retrieved from this cultivar were lineage SRL 6 which do not reinfect Oryzica Sabana 6 in greenhouse studies as reported before Although the genetic lineage ALL 7 was present in the Altillanura 35 isolates were recovered in Carimagua where this lineage was the predominant one ALL 7 in Matazul was associated mainly with very few cultivars compared to lineage SRL 4 It is interesting to note that in the years previous to the breakdown of the cultivar Oryzica Sabana 6 the genetic lineage SRL 6 was oftenly recovered from this cultivar in the field but it was unable to reinfect it in greehouse studies It was only in 1993 during the breakdown that a high frequency of lineage ALL 7 was recovered from Oryzica Sabana 6 in the field These isolates reinfected also the cultivar in greenhouse inoculations Similarly to Oryzica Sabana 6 the genetic lineage SRL 6 was recovered in high frequency from the cultivar IAC 165 while no isolates from ALL 7 were found in this cultivar We had reported before compatibility of this last lineage with IAC 165 and incompatibility of SRL 6

The genetic lineage SRL 6 was mainly recovered from the cultivars used as checks in the breeding plots (72 isolates) compared to only 15 isolates recovered from 3 of the breeding lines (Table 1) On the other hand 41 isolates of the genetic lineage SRL 4 were recovered from 7 breeding lines and 5 of the check cultivars It is highly recomended that for breeding purposes and selection of progenitors for genetic crosses for the acid soil savanas of the Altillanura the rice germplasm continues being screened for resistance under controlled conditions in the greenhouse against isolates of the genetic lineages SRL 4 which continues increasing in frequency in the Altillanura and the genetic lineage ALL 7 which has been found highly compatible with rice germplasm adapted to the acid soil savannas It is not yet understood why the genetic lineage ALL 7 was highly virulent during 1993 and not during the following years despite its presence in the field It is also not understood why the genetic lineage SRL 6 is recovered in high frequency from several cultivars adapted to the acid soil savannas however this lineage do not reinfect those cultivars in controlled conditions of greenhouse Monitoring of the genetic structure and virulence composition of the blast pathogen population in the Altillanura will continue being carried out during the coming years

Virulence analysis of blast isolates representing the most predominant lineages found in the Altillanura during 1995 was conducted for 38 isolates inoculated on 48 rice cultivars (Table 2) Isolates of genetic lineage ALL 10 found in the Altillanura during 1995 were not included in the table as they were not virulent on any of the cultivars tested In general blast isolates of the genetic lineage SRL 6 were more virulent followed by isolates of genetic lineage SRL 4 and the less virulent isolates being those of genetic lineage ALL 7 (Table 2) The rice cultivar Oryzica Sabana 6 was the only cultivar interacting specifically with the genetic lineage ALL 7 Other cultivars interacted specifically with lineages SRL-4 or SRL 6 (Table 2) There were several cultivars resistant to all isolates of all the three genetic lineages tested In general isolates of genetic lineage ALL 7 were less virulent than those found during the breakdown of the cultivar Oryzica Sabana 6 in 1993 as the new isolates did not infect the cultivars IRAT 13 or Moroberekan Similarly isolates from lineage SRL 6 were less virulent than those found in the experiment station of Santa Rosa during the same year as the isolates found in the Altillanura did not infect the near isogenic line C101 A51 Oryzica 2 and other cultivars

The narrower spectrum of virulence compared to previous years and the low aggressiveness exhibited by most of the isolates of the Altillanura tested together with a non identified environmental factor seems to be responsible for the low incidence and severity of rice blast during the years 1994 and 1995 in the Colombian Altillanura It is recomended however that sources of resistance to the genetic lineage ALL 7 continue being identified under greenhouse conditions using those isolates recovered during the blast epidemic of 1993 These isolates have proved to be very useful in greenhouse inoculations for selecting potential donors of blast resistance for genetic crosses in the upland breeding section (see Dr Guimaraes report)

Characterization of the genetic structure and virulence spectrum was also conducted for blast isolates recovered from the recently released rice cultivars Selecta 3 20 Oryzica Caribe 8 and Oryzica Yacu 9 (Tables 3 and 4) Three genetic lineages SRL 2 SRL 4 and SRL 6 were recovered from the cultivar Selecta 3 20 (Table 3) Two of these lineages recovered from this cultivar SRL 2 and SRL 6 reinfected severely the cultivar in greenhouse inoculations indicating that this cultivar is already highly susceptible to rice blast and that potential epidemics will develop in farmers fields as they increase the area planted with this variety Although the lineage SRL 4 isolates recovered from Selecta 3 20 did not reinfect at first the same cultivar in greenhouse inoculations Selecta 3 20 was severely infected by isolates of lineage SRL 4 recovered from the cultivars Oryzica Caribe 8 and Oryzica Yacu 9 (Table 4) Virulence spectrum of these isolates reveal that the pathogen has gained some virulence on some cultivars such as Oryzica Llanos 4 by the genetic lineage SRL 2 and the accumulation of virulence on the cultivar CICA 9 by the lineage SRL 6 (Table 3) It should be noted that the rice cultivar Oryzica Llanos 5 is resistant to the genetic lineages recovered from the cultivar Selecta 3 20 Similarly the near isogenic line C101 LAC carrying the resistance gene Pi 1 as well as the cultivar CICA 8 were resistant to these new blast isolates

Blast isolates recovered from the cultivars Oryzica Caribe 8 and Oryzica Yacu 9 exhibited also a highly compatible interaction with these cultivars in greenhouse inoculations indicating that these cultivars are susceptible to the blast pathogen Although two lineages (SRL 4 and SRL 6) were recovered from the two cultivars pathogenicity assays showed that the cultivar Oryzica Caribe 8 is more susceptible to the lineage SRL 4 while the cultivar Oryzica Yacu 9 is susceptible to lineage SRL 6 (Table 4) The cultivar Selecta 3 20 was also susceptible to isolates of the two lineages recovered from these two cultivars It is very important to note that isolates of the genetic lineage SRL 6 recovered from both Oryzica Caribe 8 and Oryzica Yacu 9 exhibited a large accumulation of virulence factors The highly virulent isolate identified as Oryzica Yacu 9 (OY9 5) was virulent on most rice cultivars tested except the cultivars Oryzica Llanos 5 Oryzica Caribe 8 and the near isogenic line C101 LAC (resistance gene Pi 1) It is interesting to note that the cultivars Oryzica Yacu 9 and Oryzica Caribe 8 exhibit complementary resistance to the blast isolates recovered from them suggesting that the genetic cross between these two cultivars could generate segregant lines combining resistance to the lineages SRL 4 and SRL 6 (Table 4) More blast isolates recovered from these two cultivars should be pathogenically analized to determine if this assumption is true The new blast isolates recovered from these cultivars will be used in greenhouse inoculations to identify potential donors of blast resistance genes

TESTING THE LINEAGE EXCLUSION HYPOTHESIS FOR DEVELOPING STABLE BLAST RESISTANCE

The hypothesis is based on evidence accumulated to date that there is a high degree of specialization between some resistance genes and all the pathogen isolates of a genetic lineage This interaction is most commonly seen as the resistance exhibited by a rice cultivar or resistance gene to most lineages of the blast pathogen while being susceptible to one or two lineages Crosses between those cultivars susceptible to few but different genetic lineages are expected to combine complementary resistance genes able to exclude all genetic lineages of the pathogen and then exhibiting a more stable and durable resistance to blast

This hypothesis is supported by virulence frequencies studies of blast pathogen populations in Colombia Philippines and Brazil which demonstrate that single isolates combining virulence genes compatible with those resistance genes which when combined exclude all lineages of the pathogen are not present in the pathogen population For example resistance gene Pi 1 from the near isogenic line C101LAC is highly susceptible to lineage SRL 5 but excludes all isolates within the other Santa Rosa lineages SRL 1 to SRL 6 on the other hand resistance gene Pi 2 from the near isogenic line C101A51 is highly susceptible to lineages SRL 1 SRL 2 and recently to SRL 6 but excludes all isolates of the other lineages found in Santa Rosa Although there is a high frequency of virulence genes compatible individually with each resistance gene there is no isolate combining both virulences as it would be expected therefore suggesting that resistance governed by the combination of both genes Pi 1 and Pi 2 would exclude all the blast pathogen population found in Santa Rosa being probably highly stable The combination of the corresponding two virulence genes in the same isolate seems to confer a deletereous effect on the pathogen with the concomitant absence of such isolates

Segregating lines of several crosses between near isogenic lines and between some commercial cultivars expected to combine complementary genes that exclude all or specific genetic lineages of the pathogen will be tested under greenhouse at CIAT and field conditions in Santa Rosa during 1995 and the coming years to test the lineage/ virulence exclusion hypothesis as an strategy to develop blast resistance that could be more durable and stable More than 200 commercial varieties from Latinamerica were also characterized for their resistance to all genetic lineages of the pathogen from Colombia under greenhouse and field conditions to explore the possibility of finding useful resistance genes in already desired genetic backgrouds Blast isolates were collected in the field directly from these populations to study the frequencies of individual and combinations of virulence genes

A total of 14 F1 plants of the genetic cross CT 13432 (C101 A51x C101 LAC) carrying the complementary blast resistance genes Pi 2 and Pi 1 respectively were tested for blast resistance in the field at the Santa Rosa experiment station during 1994 and 1995 (Table 5) The results observed in the field indicate that all F1 plants of this cross were susceptible to either leaf blast panicle blast or both depending of the year of field testing Exclusion of all blast genetic lineages as it was expected in this cross combining resistance genes Pi 1 and Pi 2 was not observed in the F1 (Table 5)

Several blast isolates recovered from infected F1 plants in the field were purified in the laboratory and tested for reinfectivity of the two parents and the F1 in the greenhouse Greenhouse results (data not shown) demonstrated that blast isolates recovered from the F1 plants reinfected either one of the parents but not both of them indicating that the pathogen had not accumulated virulence factors for both resistance genes in a single isolate of the fungus These isolates were weakly virulent or not virulent at all on some of the F1 plants in these inoculations These results suggest then that the heterozigous stage of each resistance gene Pi 1 and Pi 2 present in the F1 generation could not be effective in controlling the blast pathogen In general F1 plants were more susceptible in the field than in the greenhouse and it could be due to a more stress situation that F1 plants suffer in the transplanting process in the field compared to the greenhouse Individual F1 plants from the field were harvested to study the inheritance of blast resistance to different genetic lineages of the pathogen in the F2 generation

A total of 7 blast isolates representing three genetic lineages of the pathogen (SRL 1 SRL 2 and SRL 6) compatible with the resistance gene Pi 2 (C101 A51) but incompatible with the resistance gene Pi 1 (C101 LAC) were used to inoculate in the greenhouse 726 F2 plants of the genetic cross Pi 1 x Pi 2 (Table 6) Results after pooling the data for all the resistant and susceptible observed plants for all the isolates used indicated after performing a Chi square test the fitness of a 3 1 ratio for resistance vs susceptibility in the cross suggesting the presence of one dominant resistance gene in the parent C101 LAC (Table 6) Two isolates of the genetic lineage SRL 5 compatible with the resistance gene Pi 1 but incompatible with Pi 2 were used to evaluate the resistance of 194 F2 plants of the same cross (Table 7) The results after performing a Chi square test rejected the 3 1 expected ratio and revealed a 5 3 ratio of resistance vs susceptibility suggesting the possible interaction of two resistance genes The possible genotypes of the F2 plants of the cross CT 13432 are shown in Table 8 where the increase in susceptibility to the genetic lineage SRL 5 could be in the F2 plants with genotype r1r1R2r2 where the heterozigous form of the resistance gene Pi 2 seems to be uneffective against this lineage in the presence of the homozigous recessive gene Pi 1 (Table 8) All resistant and susceptible plants were transplanted to the field for production of F3 lines that will be used in inoculations in the greenhouse during 1996 to corroborate the results found in the F2 and to identify the double resistant plants carrying both resistance genes Pi 1 and Pi 2 Molecular markers associated with the resistance genes Pi 1 and Pi 2 are also being used to identify plants with both resitance genes by the Biotechnology Research Unit

Blast reaction of the F1 plants of several crosses of other near isogenic lines and rice cultivars were also evaluated in the Santa Rosa field experiment station during 1994 and 1995 As it was observed before F1 plants from all the crosses exhibited a field susceptible reaction to leaf or neck blast (Table 9) None of the F1 plants of crosses expected to exhibit a resistant reaction controlled by complementary resistance genes that would exclude all the genetic lineages of the pathogen present in Santa Rosa was resistant Inoculations of F2 plants are in the process to determine the genetic control of blast resistance in the corresponding parents and to explain the behaviour of the F1 plants in the field

Characterization of the resistance of 201 rice commercial varieties most of which have been released in Latinamerica to 15 genetic families of the blast pathogen in Colombia was conducted under controlled conditions in the greenhouse at CIAT headquarters and compared to their reaction under field conditions in Santa Rosa The results indicate that the genetic lineage SRL 6 infected the largest number of the commercial cultivars tested (80 6 /) followed by lineage SRL 5 (68 7%) There were at least 4 genetic lineages that infected less than 12 of the rice cultivars (Table 10) Twenty four rice cultivars from 10 countries were resistant to all genetic lineages of the blast pathogen in greenhouse inoculations and exhibited a leaf and neck blast resistant reaction in the field (Table 11) All of these cultivars which were derived from a diverse germplasm can be used as potential donors of resistance in the breeding program as many of them have already a desired genetic background

A total of 23 rice cultivars from 12 countries that showed in most cases a susceptible field reaction to blast exhibited a specific interaction with one or two genetic lineages of the blast pathogen and could be used as potential donors of complementary resistance genes in different genetic crosses of these cultivars (Table 12) This specific interation observed in these cultivars with the blast pathogen will be analized during 1996 by inoculating all the same cultivars with blast isolates retrieved from infected leaf and panicles collected in each one of the cultivars in the field during 1995 Identification of potential resistance donors with complementary resistance genes should give origin to several genetic crosses that would yield resitant lines to blast

A high specific interaction was also obseved between rice cultivars developed and/or released in the USA and Uruguay with blast genetic lineages relevant to the acid soil savannas of the Altillanura Colombiana specially the genetic lineages ALL 7 ALL 11 ALL 12 and ALL 13 (Table 13) As the table shows most of these cultivars exhibit only an intermediate reaction (+i) to most of the SRL (Santa Rosa) lineages while being susceptible to the ALL (Altillanura) lineages This is the first time that we observed a close relationship between the origin of the rice germplasm possible Japonicas which could be more adapted to the Altillanura and genetic lineages found mainly in the acid soil savannas of the Altillanura A similar case was observed for some rice cultivars from Brasil which are well adapted to the acid soil savannas

Dissection of blast resistance genes

We suspect that the earlier pyramiding of resistance genes which created the variety Oryzica Llanos 5 may have been the result of the combination of complementing genes which exclude all the genetic lineages of the pathogen present in Colombia Several crosses between Oryzica Llanos 5 and other susceptible cultivars were analized during 1995 for determining the inheritance of the resistance of this cultivar and for developing recombinant imbred lines suitable for identification of molecular markers linked to the resistance genes We will also continue looking at other resistance gene sources specially those found in double haploids of the cross between Fanny and the resistance sources IRAT 13 Carreon Colombia 1 LAC 23 and Ceysvoni Inoculation of these lines will be conducted during 1995 to confirm earlier evaluations and to determine correct ranges of resistant intermediate and susceptible genotypes that allow mapping of both major and minor resistance genes Resistant genes will be mapped on chromosomes using RFLP RAPD and AFLP molecular markers Markers linked to resistance genes will be sequenced and SCARS developed for PCR based screening Tagging resistance genes is expected to provide a tool for molecular marker assisted selection in breeding populations

The blast reaction of parents and F1 plants of several crosses of the blast resistant rice cultivar Oryzica Llanos 5 and 12 different susceptible cultivars was evaluated in the Santa Rosa field experiment station during 1995 In general most of the F1 plants exhibited an intermediate to susceptible leaf or neck blast reaction (Table 14) The resistant parent Oryzica llanos 5 exhibited for the first time an intermediate blast reaction with score 4 (less than 2 / of susceptible lesions) in the field The blast reaction of F1 plants and parents in crosses of the rice cultivar Oryzica Llanos 4 and several rice cultivars exhibiting a complementary resistance with this cultivar showed also for the first time a highly susceptible blast reaction of the cultivar Oryzica Llanos 4 and susceptibility in all the F1 plants of all crosses (Table 15) All F1 plants were individually harvested for conducting genetic studies on the inheritance of the resistance of the cultivars Oryzica Llanos 5 and Oryzica Llanos 4

The segregation of blast resistance in the F2 progeny of the cross between the resistant cultivar Oryzica Llanos 5 and the susceptible cultivar Fanny to six genetic lineages of the blast pathogen in Colombia (SRL 1 to SRL 6) was studied during 1995 The inferred resistance gene basis from the expected 27 1 F2 ratio after performing a Chi square test revealed that 4 unlinked loci with two dominant and two recessive genes controlled the resistance in Oryzica Llanos 5 to blast isolates of the genetic lineages SRL 1 SRL 2 and SRL 3 (Table 16) Segregation of blast resistance to genetic lineage SRL 4 fitted the expected ratio 57 7 for a genetic control of the resistance by three unlinked loci 1 dominant and two dominant complementary loci (Table 16) Resistance to genetic lineage SRL 5 is apparently controlled by 2 unlinked loci both dominant to two independent isolates of the pathogen fitting a ratio of 15 1 while resistance was explained as the action of two unlinked loci 1 dominant and epistatic on one recessive to another blast isolate of the same lineage SRL 5 fitting a expected ratio of 13 3

The genetic control of the resistance to 4 isolates of the genetic lineage SRL 6 in the cross Oryzica Llanos 5 and Fanny was dependent on the blast isolate used Resistance was controlled by 2 unlinked loci both dominant fitting a expected ratio of 15 1 for two isolates (Table 16) These two isolates were collected several years ago and are used in the section for screening purposes Resistance was apparently controlled by only one resistance gene to two other isolates of the same lineage SRL 6 (isolates Fanny 54 and Selecta 3 20 1) fitting a expected ratio of 3 1 (Table 16) These two isolates were recovered during 1995 and are particularly expressing a larger accumulation of virulence compared to other isolates of lineage SRL 6 The genetic cross of Fanny x Oryzica Llanos 5 and its reciprocal were analized sepparately in the inoculation with the isolate Selecta 3 20 1 as each population yielded a different segregation pattern of resistant to susceptible plants yielding in one case a 3 1 ratio for a genetic control by one dominant locus and in its reciprocal a 9 7 ratio for a genetic control of the resistance by 2 dominant complementary loci (Table 16) All susceptible and resistant plants were transplanted to the field for harvesting of F3 lines which will be used in inoculations to corroborate the findings in the F2 progeny

The results obtained in the genetic studies of the control of the blast resistance in the cultivar Oryzica Llanos 5 suggest that the blast pathogen specially isolates within the genetic lineage SRL 6 could be one step away of breaking down the resistance in this cultivar We have observed that pathogen isolates that yielded a 3 1 ratio in the segregation of resistance to susceptibility have accumulated a large number of virulence factors It is recomended that more isolates collected during 1995 specially those isolates collected from the same cultivar Oryzica Llanos 5 be analized to determine their spectrum of virulence and be used in future inoculations to determine the genetic control of Oryzica Llanos 5 to lineage SRL 6 They should also be used to identify potential donors of resistance It is possible on the other hand that cultivar Oryzica Llanos 5 carry similar resistance genes such as Pi 1 and Pi 2 conferring its durable resistance as the pathogen seems to be unable to express virulence on both genes in single isolates

Recurrent selection for blast resistance

This is an ongoing activity between the breeding and pathology sections of the program where several populations developed by recurrent selection are being advanced and selected to continue further intermating and new cycles for combining major and minor blast resistance genes (a more detailed description of the activity should be found under the annual report of Dr Elcio Guimaraes) A modified field methodology to evaluate and select resistant lines to each genetic lineage independently within these populations is being developed under field conditions in Santa Rosa Six rice varieties exhibiting specific reactions to the different lineages of the pathogen are being used in six individual plots as spreaders rows for evaluating the same breeding populations The purpose is to identify under field conditions rice lines that exhibit complementary resistance to the different genetic lineages of the pathogen and be able to incorporate them in crosses for the next intermating increasing the possibility of combining desired resistance genes We have started in 1994 to collect blast isolates from both the spreader rows as well as the segregating lines within each one of the six plots to determine their genetic structure during 1995 and evaluate the reliabilbity of the modified field methodology We expect that each variety used as spreader is multiplying large amounts of each lineage assuring that the breeding populations are being exposed to each lineage separately

Infected blast samples were recovered from each plot of the modified field methodology used in the recurrent selection project from both the spreader row expected to multiply a specific lineage of the pathogen and from the breeding lines evaluated within each one of the plots and expected to be infected mainly by the genetic lineage multiplied by its spreader row Characterization of the genetic structure of the blast isolates recovered from each individual plot indicated that the modified field methodology was not effective in the multiplication of the six main genetic lineages found in Colombia (Table 17) The same breeding lines of the recurrent selection population were surrounded by individual spreader rows in six different plots

Plot 1 had as spreader row the rice cultivar CICA 9 expected to multiply the genetic lineage SRL 1 however this lineage was not detected in those isolates recovered from this cultivar (six were SRL 2 and 3 were SRL 6) or from the breeding lines (four were SRL 2 and 5 were SRL 6) Lineage SRL 1 was not detected at all in this or any of the other plots (Table 17) In Plot 2 the spreader row was the rice cultivar Linea 2 expected to multiply the genetic lineage SRL 2 In this case the predominant lineage recovered from both the spreader cultivar and the breeding lines was SRL 6 (12 isolates) while only 3 isolates were SRL 2 Another isolate was identified as SRL 4 In addition one isolate was classified as lineage ALL 7 recovered from the breeding lines This is the first time that this lineage is detected in the Santa Rosa field experiment station (Table 17) In Plot 3 expected to multiply the genetic lineage SRL 3 the predominant lineage found was SRL 4 specially on the spreader cultivar Metica 1 while SRL 6 had similar frequency on the breeding lines Lineage SRL 3 was not detected at all in any of the plots

In Plot 4 using the cultivar Colombia 1 as spreader row and expected to multiply the genetic lineage SRL 4 both SRL 4 and SRL 6 were recovered from Colombia 1 with a little tendency from the first lineage while the second lineage was more recovered from the breeding lines (Table 17) The most extreme and opposite case was observed in Plot 5 were the cultivar CICA 8 used as spreader row and expected to multiply lineage SRL 5 was very effective in doing this as all seven isolates recovered from CICA 8 were lineage SRL 5 however eight isolates recovered from the breeding lines in this plot were lineage SRL 6 The most effective plot in multiplying its expected genetic lineage was Plot 6 were 17 isolates were lineage SRL 6 while only one lineage was SRL 4 (Table 17)

In general the most predominant lineage found in all the Plots was lineage SRL 6 This could be an effect of the high frequency of this lineage normally found in commercial fields The cultivars Metica 1 and Colombia 1 multiplied well lineage SRL 4 although they also multiplied lineage SRL 6 Linea 2 opposite to expected multiplied in very low frequency lineage SRL 2 being this lineage better multiplied by the cultivar CICA 9 Lineages SRL 1 and SRL 3 which always express a narrow spectrum of virulence were not detected in the trial Lineage SRL 5 was effectively multiplied by the cultivar CICA 8 and probably the frequency of resistance genes in the breeding populations to this lineage is high The lineage SRL 6 was efficiently multiplied by the cultivar Oryzica 1 however this lineage was detected in all the six Plots and therefore affects the objective sought in this modification of the field methodology These results suggest that in order to identify rice lines with coomplementary resistance the lines should be evaluated under greenhouse conditions by exposing them to each individual lineage

A total of twelve breeding lines with high yielding capacity were identified as resistant to blast in all the six Plots used in this recurrent selection project These lines were used in crosses among themselves or with other lines found susceptible in one of the Plots A total of 74 crosses were designed including crosses between some breeding lines found susceptible in different Plots but with potentially complementary blast resistance

TABLE 1 Frequency of genetic lineages of *Pyricularia grisea* detected in the Altillanura Colombiana

Cultivar	Site	Isolates tested #	Genetic Lineages SRL 6	SRL-4	ALL 7	ALL 10
Oryzica Sabana 6	Carimagua	4			4	
Guarani	Carimagua	9			9	
CT 9899 39 1 M 1 3 M	Carimagua	9		1	8	
CT 11240 20 7 M M	Carimagua	8			8	
CT 11614 1 4 1 2 1 M	Carimagua	6			6	
CT 10598 52 6 4P 3 1 M	Matazul	6	3		3	
CT 10041 3 2 M 1 2 M	Matazul	6		6		
CT 11231 1 3 M M	Matazul	9		9		
CT 11253 6 1 M M	Matazul	1		1		
CT 11608 14 2 M M	Matazul	6		6		
CT 11623 36 4 M M	Matazul	3				3
CT 11236 1 2 1 M	Matazul	7		7		
CT 11620 7 1 MP M	Matazul	4	3			1
CT 9899 32 5 1P 3 1 M	Matazul	8		8		
CT 9899 39 1 M 1 3 M	Matazul	9	9			
CT 9910 2 5 M 2 2 M	Matazul	8		8		
CT 11614 1 4 1 2 M M	Matazul	9		9		
CT 11626 21 M 3 4 M	Matazul	3		3		
Vandana	Matazul	10	10			
Oryzica Sabana 6	Matazul	36	35		1	
CT 10037 9 7 M 1 M	Matazul	28	6	10	12	
CT 9997 5 3 M 4 M	Matazul	23	1	11	11	
IAC 165	Matazul	14	11	3		
L 201	Matazul	10	9	1		
IRAT 216	Matazul	9		9		
TOTAL	245	87	75	79	4	

TABLE 2 Spectrum of virulence of *Pyricularia grisea* collected in the Colombian Altillanura in 1994

	Genetic Lineage/No Isolates				Genetic Lineage/No Isolates		
	SRL 6	SRL 4	ALL 7		SRL 6	SRL 4	ALL 7
Cultivar	12	13	13	Cultivar	12	13	13
Aichi Asahi	+++	++	+++	CICA 9			
BL 1	+++	++	++	IR 22	++		
Caloro	+++	++		CICA 8	++	++	++
Chokoto				Bbt 50	+++		
Dular	+++			IR 8			
Fukunishiki	++	++	+++	Tetep			
Fujisaka		++		Ceysvoni			
IR 42		++		O Llanos 5			
Kanto 51	(+)			Linea 2			
Kusabue	(+)	++		O Llanos 4			
K 1	+++	++	++	IRAT 13			
K 59				Moroberekan			
NP 125				O Sabana 6			++
PI No 4	+++	++		Colombia 1		++	
Raminad	++	++		C 101 A51			
Sha tiao tsao		+++	+++	C 101 LAC			
Tsuyuake				C 101 PKT	+++	+++	++
Usen	++	++	+	C 104 PKT		+++	++
Zenith	+++	+++	++	C 105 TTP4L23	+++	+++	
Fanny	+++	+++		O Caribe 8			
Metica 1	+++	+++	+	CT 11250 10 8 M M		++	+
Oryzica 1	+++	++					
Oryzica 2							
Oryzica 3	+						
CICA 4	+++						
CICA 6	++						
CICA 7	+++						

+++ = Disease severity > 20 / ++= Disease severity 5 20 / += Disease severity 1 5 /

(+) = infected by few isolates

TABLE 3 Virulence and genetic lineages of *Pyricularia grisea* isolates collected on the rice commercial cultivar Selecta 3 20

Cultivar	Selecta 3 20 (1) SRL 6[2/]	Selecta 3 20 (2) SRL 2	Selecta 3 20 (3) SRL 2	Selecta 3 20 (5) SRL 2	Selecta 3 20 (4) SRL 4
Selecta 3 20	+	+	+	+	
Linea 2	+	+	+	+	
Oryzica 1	+	+	+	+	
Oryzica 2					
Oryzica 3	+	$+_i$			
Metica 1	+	$+_i$	+		+
O Llanos 5					
O Llanos 4		+	+		
CICA 8					
CICA 9	+	+	+	+	
IR 8	+	+	+		
IR 22	+				
O Caribe 8		+			
C 101 A51	+	+	+	+	
C 101 LAC					
C 101 PKT	+	+	+	+	
C 104 PKT	+				
C 105 TTP 4L23	+	+	+	+	
FANNY	+	$+_i$	+		+

+ Susceptible reaction blank– resistant $+_i$ = intermediate reaction

Isolates recovered from Selecta 3-20

Genetic lineage determined by MGR 586 DNA fingerprinting

TABLE 4 Virulence and genetic lineages of *Pyricularia grisea* isolates collected on the commercial rice cultivars Oryzica Caribe 8 and Oryzica Yacu 9

	OY 9 (1)	OY 9 (2)	OY 9 (3)	OY 9 (4)	OY 9 (5)	OC 8(15)	OC 8(16)	OC 8(17)	OC 8(18)
Cultivar	SRL 6[2/]	SRL 4	SRL 6	SRL 6	SRL 6	SRL 4	SRL 4	SRL 4	SRL 6
O Caribe 8		+					+	+	
O Yacu 9	+		+	+	+				+
Selecta 3 20	+	+	+	+	+		+	+	+
Linea 2	+		+	+	+				+
Oryzica 1	+	+	+	+	+	+	+	+	+
Oryzica 2	+			+	+				+
Oryzica 3	+		+	+	+				+
Metica 1	+	+	+	+	+	+	+	+	+
O Llanos 5									
O Llanos 4	$+_i$			+				+	
CICA 8				+					$+_i$
CICA 9	+		+	+	+				+
IR 8	+		+	+	+				+
IR 22			+	+	+				+
C 101 A51	+	+	+	+	+		+	+	+
C 101 LAC									
C 101 PKT	+	+	+	+	+	+	+	+	+
C 104 PKT	+	+	+	+	+	+	+	+	+
C 105 TTP 4L23	+	+	+	+	+	+	+	+	+
FANNY	+	+	+	+	+	+	+	+	+

+ = Susceptible reaction blank– resistant = intermediatee reaction

Isolates recovered from Oryzica Yacu 9 (OY 9) and Oryzica Caribe 8 (OC 8)

[2/] Genetic lineage determined by MGR 586 DNA fingerprinting

TABLE 5 Rice blast reaction on F_1 plants of the cross CT 13432 (C 101 A51 (Pi 1) x C 101 LAC (Pi 2)) in Santa Rosa (Villavicencio)

Cross	Plant F_1 1994	Leaf Blast[1/]	Neck Blast[1/]	Plant F_1 1995	Leaf Blast[1/]	Neck Blast [1/]
CT 13432	2	4	5	9	2	7
CT 13432	3	2	7	10	5	7
CT 13432	4	2	7	11	5	7
CT 13432	5	3	7	12	7	7
CT 13432	6	3	3	13	9	7
CT 13432	7	3	7	14	9	7
CT 13432	8	4	7	15	9	3

Field reaction 1= highly resistant 9= highly susceptible

TABLE 6 Segregation for blast resistance of F_2 plants of the cross C 101 A51 (Pi 2) x C 101 LAC (Pi 1) to genetic lineages SRL 6 SRL 2 and SRL 1 of *Pyricularia grisea* in Colombia

	Genetic Lineage								X^2	
Reaction	SRL 6 (1)	SRL 6 (2)	SRL 6 (3)	SRL 2 (1)	SRL 1 (1)	SRL 1 (2)	SRL 1 (3)	Total	3 1	Probab
Resistant	70	82	72	87	76	86	87	560	1 76	0 25-0 10
Susceptible	35	16	29	20	26	17	23	166		
<u>Isogenic Line</u>				<u>Virulence</u>						
C 101 A51 (Pi 2)	+	+	+	+	+	+	+			
C 101 LAC (Pi 1)										
C 101 PKT (Pi 4a)	+	+	+	$+_i$	+					
C 104 PKT (Pi 3)	+	+	+		+		$+_i$			
C 105TTP4L23 (Pi 4b)	+	+	+	+	+		+			

Susceptible reaction = resistant reaction + intermeciate reaction
X Chi square and expected ratio 3 1 tested

TABLE 7 Segregation for blast resistance of F_2 plantas of the cross C 101 A51 (Pi 2) x C 101 LAC (Pi 1) to genetic lineage SRL 5 of *Pyricularia grisea* in Colombia

Reaction	Genetic Lineage SRL 5 (1)	Genetic Lineage SRL 5 (2)	Total	$X^2$5 3	Probability
Resistant	57	53	110	2 78	0 10 0 05
Susceptible	39	45	84		
Isogenic Line	Virulence				
C 101 51 (Pi 2)					
C 101 LAC (Pi 1)	+	+			
C 101 PKT (Pi 4a)	+	+			
C 104 PKT (Pi 3)	+	+			
C 105 TTP4L23(Pi 4b)	+	+			

+ = Susceptible reaction = Resistant reaction

X - Chi square and expected ratio tested

TABLE 8 Possible genotypes of F_2 plants in the cross C 101 A51 (Pi 2) x C 101 LAC (Pi 1) inoculated with genetic lineages SRL 1 SRL 2 SRL 5 and SRL 6 of *Pyricularia grisea*

Genotype		Avirulence Pi 1 [1/]		Avirulence Pi 2[2/]	
Gene Pi 1(R1)	Frequency in F2	SRL 1 SRL 2 SRL 6		SRL 5	
Gene Pi 2 (R2)	F2	Exp[3/] 3 1	OBS[3/] 3 1	Exp[3/] 3 1	OBS[3/] 5 3
R R R_2 R_2	1/16	R	R	R	R
R R R_2 r_2	2/16	R	R	R	R
R R r_2 r_2	1/16	R	R	S	S
R r R_2 R_2	2/16	R	R	R	R
R r R_2 r	4/16	R	R	R	R
R r r_2 r_2	2/16	R	R	S	S
r r R_2 R_2	1/16	S	S	R	R
r r R_2 r_2	2/16	S	S	R	S
r r r_2 r_2	1/16	S	S	S	S

Genetic lineages SRL 1 SRL 2 and SRL 6 are avirulent on Pi 1 and virulent on P 2

Genetic l neage SRL 5 is avirulent on Pi 2 and virulent on Pi 1

Exp- expected ratio OBS- observed rat o R res stant S= susceptible

TABLE 9 Blast reaction of F_1 plants in several crosses of rice cultivars in Santa Rosa (Villavicencio)

Cross	Parents	1994B LB	1994B NB	1995A LB	1995A NB
CT 13433	C 101 A51 x C 101 PKT	3 8	5 9		
CT 13434	C 101 A51 x C 104 PKT	4 7	7 9		
CT 13435	C 101 A51 x C 105 TTP4L23	4 6	5 7		
CT 13436	C 101 LAC x C 101 PKT	0 4	1 7		
CT 13437	C 101 LAC x C 104 PKT	0 5	1 7		
CT 13438	C 101 LAC x C 105 TTP4L23	2 5	1 7		
CT 13439	C 101 PKT x C 104 PKT	4 7	7		
CT 13440	C 101 PKT x C 105 TTP4L23	5 7	5 7		
CT 13441	C 104 PKT x C 105 TTP4L23	4 6	7		
CT 13550	Linea 2 x Oryzica 2	2 5	1 7	5 8	1 7
CT 13551	Linea 2 x CICA 8	2 7	1 7	7 9	1 7
CT 13552	Linea 2 x CICA 6	2 6	1 7	5 8	3 7
CT 13553	Linea 2 x Metica 1	2 7	1 7	4 9	7
CT 13554	Oryzica 2 x CICA 8	0 5	1 7	6 9	7
CT 13555	Oryzica 2 x CICA 9	0 5	3 7	6 9	7 9
CT 13556	Metica 1 x CICA 8	3 6	1 7	9	1 7
CT 13557	Metica 1 x CICA 9	2 6	1 7	9	5 7
CT 13558	CICA 9 x CICA 6	2 9	1 7	6 8	5 7
CT 13392	CICA 8 x CICA 9	2 6	1 7	7 9	7
CT 13393	Oryzica 1 x CICA 8	7 8	1 7	4 9	1 7
CT 12673	CICA 9 x IR 22			7 9	7
	IR 22 x CICA 9			5 9	5 7

LB Leaf blast NB Neck blast

TABLE 10 Compatibility frequency of Colombian genetic families of *Pyricularia grisea* inoculated on 201 Latin American rice cultivars [1/]

Genetic family	Infected cultivars (No)	Frequency(/)
SRL 6	162	80 6
SRL 5	138	68 7
ALL 8	71	35 3
SRL 1	61	30 3
SRL 2	52	25 9
ALL 13	52	25 9
ALL 17	49	24 3
ALL 11	47	23 3
ALL 12	37	18 4
SRL 4	34	16 9
SRL 3	12	6 0
OTHERS	< 12	< 6 0

Latin American cultivars inoculated in greenhouse with 33 isolates representing 15 genetic families of the fungus

TABLE 11 Latin American rice cultivars resistant in the field and in the greenhouse to all genetic families of *Pyricularia grisea* present in Colombia [1/]

No	Cultivar	Cross	Country	Field reaction[2/] Leaf	Neck
7	SACIA (TARI)	IR 1529 430/VNI IR 3223	Bolivia	1	1
12	BR 4	IAC 5544/Dourado Precoce	Brazil	2	3
23	CAIAPO	IRAT 13/Beira Campo//CNA x 104 B 18PY 2B/Perola	Brazil	2	1
25	EMCAPA 01	IAC 5544/Dourado Precoce	Brazil	3	1
34	IAC 101	Oryzica 1//IR 480 5 7 3 2 1/C Rica	Brazil	3	1
42	RIO PARAGUAY	IAC 47/6383	Brazil	1	1
43	RIO PARANAIBA	IAC 47/6383	Brazil	1	1
45	TANGARA	IAC 25/IRAT 13	Brazil	3	1
46	TRIUNFO	IAC 47/IRAT 13	Brazil	3	1
47	XINGU	IAC 47/IRAT 13	Brazil	3	1
68	Oryzica Llanos 5	COLOMBIA 1/P1274//P 2060	Colombia	1	
74	AMISTAD 82	IR 1529 ECIA/VNI IR 3223	Cuba	1	3
79	PERLA		Cuba	1	3
83	INIAP 11	IR 5657 33 2 1/IR 2061 465 1 5 5	Ecuador	1	3
105	ICTA CRISPO	IR 24/IR 747B2 6 3	Guatemala	3	3
119	CARDENAS A 80	C 4 63//GR 88/Sigadis	Mexico	3	1
122	COTAXTLA A 90	CR 126 42 5/IR 2061 213	Mexico	4	3
129	SINALOA A 68	NAHNG MON S4/TN 1	Mexico	3	1
139	PANAMA 1048	P 1221/P 1229	Panama	1	1
165	CAMPONI	SML 1010//APURA/IR 8	Surinam	3	3
166	CEYSVONI	SML 997/AWINI	Surinam	3	3
168	DIWANI	WASHABO/IR 454 1 17 1 1	Surinam	3	3
169	ELONI	ACORNI//KAPURI/IR 454	Surinam	1	3
198	FONAIAP 2	Colombia 1/P 1274//P 2060	Venezuela	1	1

Resistant cultivars among 201 Latin American rice cultivars inoculated in the greenhouse with 33 isolates representing 15 genetic lineages of the pathogen

Field reaction in Santa Rosa (Villavicencio) 1= Highly Resistant 9 Highly Susceptible

TABLE 12 Rice cultivars exhibiting a specific interaction with one or two genetic families of *Pyricularia grisea* in Colombia [1/]

	Cultivar	Cross	Compatible genetic families	Field reaction Leaf	Neck	Origin
33	Franciscano	CICA 7//CICA 8/PELITA 1 1	SRL 6 ALL-8	6	7	Brazil
38	Pesagro 101	IR 3265/IR 5//IR 2061	SRL 5	5	7	Brazil
41	Rio Doce		ALL 7	4	1	Brazil
61	Linea 2	P 1223/P 1225	SRL 2 SRL 6 (I)[3/]	5	3	Colombia
65	Oryzica 3	CICA 7//CICA 8/Pelita 1 1	SRL 6	4	5	Colombia
200	Selecta 3 20		SRL 6 SRL 2	6	5	Colombia
76	IIAC 15	CP C2/ECIA 13//CP 1C8/CE 4	SRL 5	4	3	Cuba
77	IR 1529-ECIA	IR 305/IR 24	SRL 5	1	3	Cuba
94	IR 42	IR 1561/IR 1737//CR 94 13	SRL 5 SRL 6 (I)	4	3	Filipinas
95	IR 43	IR 305/IR 24	SRL 5 SRL 6 (I)	3	3	Filipinas
99	IR 54	NAM SA GUI 19/IR 2071//IR 2061	SRL-4(I) SRL 5(I)	2	7	Filipinas
109	ICTA TEMPISQUE	P 761/P 881	SRL 6 ALL 8 (I)	6	3	Guatemala
113	CAPI 93	P 2062/IRAT 120//P 2057	SRL 6	5	7	Honduras
115	GUAYMAS A90	P 2053//P 1897/METICA 1	SRL 6 ALL 8(I)	5	5	Honduras
140	PANAMA 1537	CICA 7//S 12 30/P 901	SRL 6	6	9	Panama
146	ALTO MAYO 88	P 2030//IR 5533/METICA 1	SRL 6	5	1	Peru
156	JUMA 51	TONO BREA 91/IR 8	SRL 5 SRL 6(I)	4	3	Rep Dom
159	JUMA 61	J 212/CICA 9	SRL 1 SRL 6	6	7	Rep Domi
160	JUMA 62	IR 1541//IR 20/O NIVARA	SRL 5 SRL 2(I)	4	5	Rep Dom
164	BG 90 2	IR 262/REMADJA	SRL 5 SRL 6(I)	5	9	Sri Lanka
181	MARS	CI 9580/SATURN	ALL 12 SRL 4(I)	4	3	USA
193	ARAURE 2	P 1221/P 1230	SRL 6 SRL 1(I)	5	3	Venezuela
197	FONAIAP 1	P 1386//TAPURIPA/CAMPONI	SRL 5	5	3	Venezuela

Cultivars were inoculated with 33 isolates representing 5 genetic families of *P grisea*

Santa Rosa (Villavicencio)

(I)= Intermediate reaction

TABLE 13 Reaction of rice cultivars from USA and Uruguay to *Pyricularia grisea* lineages from Colombia

	Cultivar	Cross	Genetic Lineage									Origin
			SRL1	SRL2	SRL4	SRL5	SRL6	AL7	AL	AL12	AL13	
170	Belle Patna	CI 9122/Rexoro	+	+i	+	+	+	+	+	+	+	USA
171	Bellemont	CI 9881/PI 331581			+	+i	+	+		+	+	USA
172	Bluebelle	CI 9214//Century Patna/CI 9122			+	+	+	+	+	+	+	USA
173	Bluebonnet 50	Rexoro/Fortuna	+	+	+	+	+	+		+	+	USA
174	Dawn	Century Patna/HO 12				+	+		+		+	USA
175	L 201	CI 9701///R 134/R 48//R 50	+	+	+	+	+	+	+	+	+	USA
176	L 202	IR 456/72 32278//L 201			+	+i	+	+	+	+	+	USA
177	Labelle	Belle Patna/Dawn				+	+		+		+	USA
178	Lacrosse	Colusa/Bluerose// S Hoemed/ Fortuna	+			+	+		+		+	USA
179	Lebonnet	Bluebelle//Belle Patna/Dawn				+	+				+	USA
180	Lemont	Lebonnet//CI 9881/PI 331581				+i	+		+		+	USA
181	Mars	CI 9580/Satum			+					+		USA
182	New Rex	Bluebelle/Dawn/B Patna/ Dawn/Sel B 6122				+	+		+		+	USA
183	Skybonnet	Bluebelle//Belle Patna/Dawn				+	+		+		+	USA
184	Starbonnet	Century Patna/Bluebonnet			+	+	+	+	+	+	+	USA
185	Texas Patna	Rexoro/CI 5094			+	+	+	+	+	+	+	USA
186	El Paso L 48	Starbonnet/Bluebelle			+	+	+	+	+	+	+	Uruguay
187	El Paso L 94	Lebonnet/Bluebelle				+	+	+	+			Uruguay
188	El Paso L 144	IR 930/IR 665	+			+	+		+		+	Uruguay
189	El Paso L 227	CI 9902/Labelle				+	+		+		+	Uruguay
190	INIA Tacuari	Nwbt/Nr x L79				+	+	+	+	+	+	Uruguay
191	INIA Yerbal	L 58/Bluebelle			+	+	+	+	+	+i	+	Uruguay

+ = Intermediate reaction + = Susceptible reaction blank = resistant

TABLE 14 Blast reaction of parents and F_1 plants in several crosses of the rice cultivar Oryzica Llanos 5 (Santa Rosa Villavicencio 1995)

Cross	Parents			P_1		P_2		F_1	
	P	x	P_2	LB	NB	LB	NB	LB	NB
CT 12668	O Llanos 5	x	Fanny	4	1	9	9	3-9	7 9
	Fanny	x	O Llanos 5	9	9	4	1	4-9	7 9
CT 12670	O Llanos 5	x	CICA 9	4	1	8	7	4-7	3-7
	CICA 9	x	O Llanos 5	8	7	4	1	4 9	3 7
CT 12674	Zenith	x	O Llanos 5	6	1	3	1	5 6	1 7
	O Llanos 5	x	Zenith	4	1	7	1	4 6	1 7
CT 12675	Bbt 50	x	O Llanos 5	7	3	4	1	3-8	1 7
	O Llanos 5	x	Bbt 50	4	1	7	1	3-5	1 5
CT 13442	C 101 A51	x	O Llanos 5	9	7	4	1	4 7	1 7
CT 13443	C 101 LAC	x	O Llanos 5	4	3	4	1	3-4	1 7
CT 13560	O Llanos 5	x	Linea 2	4	1	6	5	3-6	1 7
CT 13561	O Llanos 5	x	Metica 1	3	1	9	7	2 5	1 7
CT 13562	O Llanos 5	x	Oryzica 1	3	1	8	7	2 5	1 7
CT 13566	O Llanos 5	x	IR 22	4	1	8	7	1-4	1 7
CT 13394	O Llanos 5	x	CICA 8	3	1	6	7	2 6	1 7
	CICA 8	x	O Llanos 5	6	7	3	1	1 4	1 7
CT 13396	Oryzica 1	x	O Llanos 5	8	7	3	1	4 5	1 7
CT 13399	Oryzica 3	x	O Llanos 5	6	7	4	1	4-5	1 7

LB = leaf blast Nb= Neck blast

1 = highly resistant 9 = highly susceptible

TABLE 15 Blast reaction of parents and F_1 plants in several crosses of the rice cultivar Oryzica Llanos 4 (Santa Rosa Villavicencio)

Cross	Parents P_1 x P_2	P_1 LB	P_1 NB	P_2 LB	P_2 NB	F_1 LB	F_1 NB
CT 13563	O Llanos 4 x Oryzica 1	6	7	8	7	7 9	5 7
CT 13564	O Llanos 4 x Oryzica 1	6	7	8	7	7 8	3 7
CT 13565	O Llanos 4 x CICA 8	6	7	6	5	7 9	3 7
CT 13567	O Llanos 4 x Linea 2	6	7	6	5	7 8	5 7
CT 13395	Oryzica 1 x O Llanos 4	8	7	6	7	6 9	5 7
CT 13398	Oryzica 3 x O Llanos 4	6	7	6	7	5 9	7

LB = Leaf blast NB = Neck blast

1 = Highly resistant 9 = Highly susceptible

TABLE 16 Segregation of blast resistance in F_2 progeny of the cross Oryzica Llanos 5 x Fanny inoculated with Colombian rice blast isolates

Isolate	Genetic lineage	F R	F S	Expected F ratio	$X^{2/}$	Probability	Inferred resistance gene basis
Isol 1 5 1	SRL 1	291	8	27 1	0 69	0 50 0 25	4 unlinked loci 2 dominant 2 recessive
CICA 9 15	SRL 1	211	9	27 1	0 18	0 75 0 50	4 unlinked loci 2 dominant 2 recessive
CICA 9 37 1	SRL 2	293	7	27 1	1 33	0 50 0 25	4 unlinked loci 2 dominant 2 recessive
Isol 1 10 3	SRL 2	292	8	27 1	0 92	0 50 0 25	4 unlinked loci 2 dominant 2 recessive
Metica 1 33 18	SRL 3	291	9	27 1	0 28	0 75 0 50	4 unlinked loci 2 dominant 2 recessive
Isol 12 5 3	SRL 4	184	26	57 7	0 08	0 90 0 75	3 unlinked loci 1 dominant and 2 dominant complem loci
Isol 6 7 1	SRL 5	284	16	15 1	0 43	0 75 0 50	2 unlinked loci both dominant
FN 47 1	SRL 5	273	27	15 1	3 87	0 05	2 unlinked loci both dominant
Isol 16 1 1	SRL 5	239	61	13 3	0 51	0 50 0 25	2 unlinked loci 1 domi and epistatic or and 1 recessive
CICA 8 104	SRL 6	182	13	15 1	0 05	0 90 0 75	2 unlinked loci both dominant
CV 19 1	SRL 6	150	10	15 1	0 00	1 0	2 unlinked loci both dominant
FN 54	SRL 6	173	59	3 1	0 03	0 90 0 75	1 dominant locus
Selecta 3 20 1	SRL 6	53	46[2/]	9 7	0 30	0 75 0 50	2 dominant complem loci
Selecta 3 20 1	SRL 6	85	22[3/]	3 1	1 12	0 50 0 25	1 dominant locus

Pooled from reciprocal crosses

Fanny is maternal parent for the F

Oryzica Llanos 5 is maternal parent for the F

R = Number of resistant plants

S = Number of susceptible plants

TABLE 17 Modified field methodology expected to multiply individual genetic lineages of the blast pathogen in the Santa Rosa Experiment Station Villavicencio

Plot	Spreader (lineage) Breeding lines	Isolates (No)	Genetic lineage detected/No of isolates SRL 2	SRL 4	SRL 5	SRL 6	ALL 7
1	CICA 9 (SRL 1)	9	6	3			
	Breeding line	9	4			5	
2	Line 2 (SRL 2)	9	2			7	
	Breeding line	8	1	1		5	1
3	Metica 1 (SRL 3)	8		7		1	
	Breeding line	9		4		5	
4	Colombia 1 (SRL 4)	10		6		4	
	Breeding line	8		3		5	
5	CICA 8 (SRL 5)	7			7		
	Breeding line	8				8	
6	Oryzica 1 (SRL 6)	9				9	
	Breeding line	9		1		8	
	TOTAL	103	13	22	7	60	1

B Activity RP53 Incorporation of Protection to Rice Sheath Blight through Genetic Transformation

Summary

We are interested in transforming indica rice with a barley type 1 RIP gene to confer increased protection against Rhizoctonia Such transgenics might be economically and environmentally desirable by leading to a reduction in the application of pesticides A construct containing the RIP gene driven by the 35S promoter and the 35S CaMV hph (hygromycin resistance) gene as the selective marker are being used The direct gene transfer of the RIP gene via the PDS 1000/He system is being conducted using immature embryos or immature derived callus of the indica varieties Cica 8 Inti and BR IRGA 409 and the upland line CT6241 17 1 5 1 A total of 183 plants with hygromycin resistance have been recovered Preliminary analyses by RT PCR suggest that 7 of these 10 plants are putative transgenics which contain and express the RIP gene The integrative trans formation of these plants is being confirmed by detailed molecular analyses

Background

Plant resistance to pathogenic fungi involves multiple response pathways including the accumulation of defensive enzymes These include B 1 3 glucanases chitinases thaumatin like proteins protease inhibitors and ribosome inactivating proteins (Collinge et al 1987 Linthorst 1991) The development of gene transfer systems has enabled testing the effects of expression of candidate anti fungal genes on the course of plant infection by pathogens Transgenic tobacco expressing a barley ribosome inactivating protein (RIP) showed an increased protection against Rhizoctonia solani (Logemann et al 1992) a major causal agent of sheath blight in the Americas RIP s are N glycosidases which cleave the N glycosidic bond of adenine in a specific ribosomal RNA sequence This barley RIP is a *single chain protein (type 1 RIP) which inhibits* protein synthesis in target cells by specific RNA N glycosidase modification of 28S rRNA RIP s do not inactivate self ribosomes but show varying degrees of activity towards ribosomes of distantly related species including fungal ribosomes (Logemann et al 1992)

Sheath blight is causing important crop losses in the Southern Cone of America and increasing spreads had been reported *in Colombia Mexico and Venezuela* All varieties are susceptible and there is not known source of resistance in rice Biological control has not been successful either At present the control depends on heavy use of fungicides We are interested in transforming indica rice with the barley RIP gene to confer increased *protection against* Rhizoctonia solani which is found in tropical America and to determine if the transgenic plants carrying the RIP are also protected against to Rhizoctonia oryzae and/or R oryzae sativae which are the species more commonly found in Argentina Southern Brazil Chile and Uruguay Such transgenics might be economically and environmentally desirable by leading to a reduction in the application of pesticides

A construct containing the RIP gene driven by the 35S promoter and the 35S CaMV hph (hygromycin resistance) gene as the selective marker are being used In order to ensure a constitutive expression of the RIP protein in the whole rice plant constructions were made encoding for the RIP gene under the control of the CaMV 35S promoter The RIP encoding gene was contained in the plasmid pPR69 (J Logemann) A ca 1 Kb EcoRI fragment containing the full length cDNA was subcloned in pUC19 to yield pRIP19 From the RIP sequence found in the GeneBank *(accession BLSCRIP3) it was observed the* presence of an NcoI restriction site encompassing the first ATG codon and an AccI site 12 bases dowstream of the termination codon It was decided to use these flanking sites for further manipulation of the RIP gene A cassette 35S OCS3 contained in the pA8 plasmid was subcloned into pUC19 as a ca 740 bp EcoRI HIII to obtain pUCA8 The 864 bp NcoI AccI fragment from pRIP19 was blunted with Klenow enzyme and subcloned into the SmaI site of pUCA8 to yield the plasmid p35SRIP Subsequently the cassette 35S Hyg tm13 from pTRA151 (a gift of N Murai Louisiana State University USA) was spliced into the HindIII site of p35SRIP to finally obtain p35SRIPHy1 and p35SRIPHy2 The numbers indicate the relative orientation of the hygromycin cassette (clockwise and counterclockwise respectively) to the RIP transcriptional fusion

The direct gene transfer of the RIP gene is being attempted using immature embryos or immature derived callus of the indica varieties Cica 8 Inti and BR IRGA 409 and the upland line CT6241 17 1 5 1 Gene delivery is performed using DNA coated gold particles accelerated by the PDS 1000/He system So far a total of 183 plants with hygromycin resistance have been recovered after the complete step wise selection process *throughout plant regeneration on 50 mg/l hygromycin* RNA was isolated from 10 plants and cDNA s were obtained and amplified by RT PCR This preliminary analysis suggest that 7 of these 10 plants are putative transgenics which contain and express the RIP gene The integrative transformation of these plants is being confirmed by Southern blot hybridizations and inheritance studies The expression of the RIP will be analyzed Northern and Western blots Following local regulations putative transgenic plants will be tested in the greenhouse for resistance to sheath blight

References

Collinge D B and A J Slusarenko 1987 Plant gene expression in response to pathogens Plant Mol Biol 9 389 410

Linthorst H 1991 Pathogenesis related proteins of plants Critical Reviews in Plant Sciences 10 123 150

Logemann J G Jach H Tommerup J Mundy and J Schell 1992 Expression of a barley ribosome inactivating protein leads to increased fungal protection in transgenic tobacco plants Biotechnology 10 305 308

103788

IV PROJECT 4
RICE TRAITS FOR COMPETITIVENESS

PURPOSE

To reduce rice yield losses from weeds and reduce production costs and hazards associated with herbicide use contributing to lower rice prices for consumers

A ACTIVITY RP52 RICE TRAITS FOR COMPETITIVENESS

RICE PASTURE SYSTEM (TRAITS FOR COMPETING WITH AN ASSOCIATED PASTURE)

SUMMARY

The objectives of this work were to identify morphological traits of rice that breeders could use to enhance the ability of this crop to compete with an associated species Two scenarios were contemplated a) that of upland rice growing in association with a pasture and b) that of irrigated rice growing with a weedy species (*Echinochloa colona*) The first aspect relates to a key component for the sustainable agropastoral systems being developed by CIAT and the second aspect seeks to reduce the overuse of herbicides in the irrigated rice ecosystem The experiments with the upland rice pasture associations (two seasons) showed that productive rice plant types can be bred to compete or tolerate an intersown pasture such as *Brachiaria decumbens* The late onset of competition favored rice over the associated pasture however average yield losses for rice growing in competition were 60 and 18 / for rice cultivars with the weakest and strongest competitive ability respectively Competition was strongly related to above ground light capture where rice leaf area (recorded after 45 days of emergence) was the key parameter followed by tillering while height showed no correlation with competitiveness Genetic studies for these parameters are being conducted A similar activity is being conducted in Brazil by EMBRAPA/CNPAF who are our partners in this ODA funded project

INTRODUCTION

Improved sustainable agropastoral systems are an escape valve in many tropical countries as alternatives to further expansion of their agricultural frontiers into fragile environments such as the rain forests Successful agropastoral alternatives are being developed for the savannas adjoining the margins of the rain forest These are rice based systems where acid soil adapted rice varieties are undersown with a pasture The breeding of high yielding rice varieties adapted to such environments is a recent achievement However rice traits for competitiveness against an associated pasture are poorly and empirically understood A better understanding of the basic mechanisms involved in rice pasture interference should lead to principles guiding selection for specific key traits early in the breeding process We need to know what specific traits are important and the tradeoffs among them and how they can be efficiently selected for perience acquired at CIAT in rice weed interactions (Fischer 1993 and Fischer et al 1993 1994) serve as a perspective to expand our understanding of the rice/pasture association

Objectives and procedures

The work we report here was involves two experiments conducted in 1993 [2] at the I C A Experiment Station at La Libertad in the Colombian Llanos seeking to understand the morpho physiological implications for a successful rice pasture association in terms of rice productivity and good pasture establishment and to identify those traits that allow rice to withstand pasture competition Eight upland cultivars (Colombia 1 Line 2 (CT 6196 33 10 4 15 M) Oryzica Sabana 6 CT 0037 9 7 M 1 M IRAT 216 TOX 1010 45 1 1 RHS 107 2 1 2TB 1JM LINE 3 (CT 6196 33 11 1 3)) were grown (70 kg seed/ha in rows 20cm apart) on an acid oxisol (4 4% organic matter pH 4 9 4 6ppm P 0 21meq/100g Ca 0 07meq/100g Mg 0 08meq/100g K 90 3% Al saturation) in monocrop and in competition with *Brachiaria decumbens* (1 5 kg seed/ha) The experiment was fertilized with 300kg/ha dolomitic lime 60kg P_2O_5/ha 60kg K_2O/ha and 75 kg N/ha Treatments were arranged within a randomized complete blocks design with split plots and four replications Competition or monocrop were the main plots treatments and the cultivars were in the 47m² subplots Above and below ground rice and pasture parts were sequentially sampled Rice and *Brachiaria* root dry matter were separated using the carbon isotope discrimination technique (Svejcar and Boutton 1985) Percent PAR interception was determined for rice plants growing in competition by reading the incoming radiation above and below the rice canopy (after removing the pasture growth between two rice rows)

Competition effects

Onset of interference

Interference presumably competition (Radosevich and Holt 1984) was more severe on rice in 1993 for most varieties with higher pasture growth in the competition plots than in 1994 (Table 1 Figures 1 and 2) This trend was less evident for the less competitive cultivar Colombia 1 Competition effects whether measured on rice or on pasture growth were detected only after 30 dae (Figures 1 to 4)

Growth parameters affected

Rice biomass LAI and tillering were affected by competition particularly in 1993 when pasture growth was more intense in most cases or in both years for a poor competitor such as Colombia 1 (Figures 5 and 6 and Table 1) The depressive effects of competition on above ground growth parametres was stronger in Colombia 1 than in the more competitive Linea 3 (Figures 1 2 5 and 6) Rice height was a growth parameter much less affected by the pasture s interference presumably rice plants etiolated under competition and height would thus not be a reliable indicator of competitiveness (Figures 5 and 6) Rice growth in competition began to be affected when the pasture gained an advantage to compete for light ie when either height LAI or tillering were superior to that of rice (Figures 1 to 6)

Root growth (so far only data for 1993 are available) either in monoculture or in competition did not reflect the outcome of competitive interaction between both species (Table 2) Therefore under favourable rainfall (1585 mm from May to September 1993) and nutrition interference in this system would be mainly an above ground process of light capture Data in Table 2 also suggest that resource allocation to very deep rooting may weaken rice competitive ability possibly by interfering with canopy growth

TABLE 1 Yield yield in competition as percent of yield in monoculture (relative yield) and growth parameters PAR interception and biomass of *Brachiaria decumbens* at 90 d a e when several rice cultivars grew in competition with the pasture species in two consecutive years

	Yield (kg/ha)		Relat yield (/)		Rice biomass (g/m²)		Height (cm)		Tillers (No./m²)		LAI		Pasture biomass (g/m²)²/		PAR Interception (%)	
Rice cultivar	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Colombia 1	870	1375	30	50	477	394	84	88	274	253	1 7	2 03	873	322	77	64
Linea 2	1208	2036	49	70	389	432	74	82	210	400	3 1	2 80	396	196	80	84
O Sabana 6	1975	2354	67	78	344	448	78	77	278	341	2 9	2 84	356	168	86	84
CT 10037	1687	2484	56	71	429	495	83	87	224	417	3 5	2 71	257	158	86	77
IRAT 216	1749	1638	61	65	390	411	65	69	261	301	4 2	2 75	563	200	86	76
TOX 1010	814	1412	53	54	328	396	74	69	204	350	1 7	2 74	386	222	79	76
RHS 107	279	1727	18	52	280	401	85	87	170	270	1 5	2 52	758	250	73	75
Linea 3	2063	2321	89	75	620	443	74	83	373	336	5 4	2 71	118	158	89	82
Caiapo		1886		69		406		72		358		2 55		179		82
CNA 7013 D		1746		54		397		87		298		2 49		219		70
LSD (0 05)	403	447	22	14	163	52	9	14	46	80	0 5	0 43	163	60	5	3
CV (/)	20	16	28	15	11	9	8	12	13	17	11	11	24	20	20	7

Days after emergence
Dry matter

TABLE 2 Correlations between rice root parameters determined in monoculture and in competition with *Brachiaria decumbens* biomass at 90 days after rice emergence when this species grew in competition with rice 1993

Root parameter	Depth(cm)	Monoculture	Competition
		r	
Root length density			
	0 20	0 68	
	20 40	0 38	
	40 60	0 21	
	60 80	0 03	
	80 100	0 89	
	0 100	0 79	
Root mass /			
	0 20	0 21	0 12
	20 40	0 10	0 10
	40 60	0 27	0 16
	60 80	0 29	0 86
	80 100	0 71 2/	0 43
	0 100	0 14	0 08

Root mass in competition was determined at harvestime
– P < 0 05   = P < 0 01

TABLE 3 Correlation coefficients between rice and pasture parameteres at two dates after emergence when both species grew in competition

Y	X	Days after emergence			
		1993		1994	
		63	90	63	90
Rel rice yield (at harvest)	Pasture biomass		0 86		0 86
Rel rice biomass	Pasture biomass		0 79 1/	0 75	0 92
Pasture biomass	PAR interception by rice		0 78		0 81
	Rice LAI	0 79	0 71 1/	0 70	0 86
	Rice tillering				0 72
	Rice height				
	Rice biomass	0 70	0 77 2/	0 84	0 73
PAR interception by rice	Rice LAI		0 90		0 85
	Rice tillering		0 79		0 63
	Rice height				

= P 0 05 = P < 0 01 = P 0 05

X = Ln (X)

Y = 1/Y

TABLE 4 Correlations between sequentially recorded rice growth parameters and the biomass of *Brachiaria decumbens* harvested 90 days after rice emergence when both species grew in competition

Growth parameter	Days after emergence											
	10		20		30		45		63		90	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
LAI	0 27	0 53	0 54		0 53	0 61	0 57	0 80	0 85	0 80	0 71	0 86
Tillering	0 48	0 48	0 87		0 65	0 91	0 29	0 03	0 30	0 12	0 67	0 72
Height	0 05	0 20	0 32		0 35	0 07	0 07	0 58	0 27	0 05	0 36	0 32
Biomass	0 34	0 77	0 65		0 43	0 38	0 63	0 51	0 83	0 74	0 77	0 73

Data not recorded at this date

= P 0 05 = P 0 01

TABLE 5 Correlation coefficients between rice growth parameters determined in monoculture at 90 d a e [1/] and pasture biomass determined at harvest in competition with rice and rice relative yield under competition (percent of monoculture yield)

	Y_1 = Pasture biomass		Y_2 = Rel rice yield	
X (monoculture)	1993	1994	1993	1994
PAR interception	0 42 ns [2/]	0 50 ns	0 62 ns	0 58 ns
LAI	0 30	0 19	0 00	0 18
Tillering	0 20	0 19	0 39	0 46
Rice height	0 24	0 42	0 30	0 19
Rice biomass	0 67	0 53	0 50	0 26

d a e – days after emergence

ns = P 0 05

TABLE 6 Estimates of heritability and selection progress for rice growth parameters and yield when these characteristics are recorded in monoculture or in competition in two consecutive years

		Heritability		Estim progress (/) for sel in	
	d a e [1]	Monoculture	Competition	Monoculture	Competition
Height	60	0 74	0 62	4 0	4 2
Tiller No	60	0 73	0 86	8 7	17 1
Leaf area	60	0 95	0 94	16 6	24 6
Biomass	60	0 90	0 90	10 6	17 0
Height	90	0 85	0 06	4 4	0 4
Tiller No	90	0 96	0 90	18 0	22 8
Leaf area	90	0 98	0 97	22 0	36 6
Biomass	90	0 97	0 92	15 5	21 2
Yield	120	0 93	0 96	13 5	36 3

Days after rice emergence

TABLE 7 Competitiveness (yield in competition with as percent of *Brachiaria decumbens* as percent of monoculture yields) and harvest indices (determined in monoculture and in competition with *B decumbens*) of several upland rice cultivars in two seasons

Cultivar	Competitiveness		Harvest Index			
			1993		1994	
	1993	1994	Monoculture	Competition	Monoculture	Competition
			(/)			
Colombia 1	30	52	38	13	29	35
Linea 2	49	70	39	25	34	38
O Sabana 6	67	78	45	30	36	40
CT10037	56	71	46	22	41	41
IRAT 216	61	65	48	36	32	36
Tox 1010	54	54	24	14	33	37
RHS 107	18	52	46	7	36	40
Linea 3	89	75	31	35	38	40
Caiapo		69			33	41
CNA 7013		54			39	48
LSD (0 05)	22	14	13	7	7	10
CV (/)	28	15	22	17	12	18
Correlation HI in monoculture vs HI in competition (r)			0 14 ns[1/]		0 74	

ns= P > 0 05 = P < 0 05

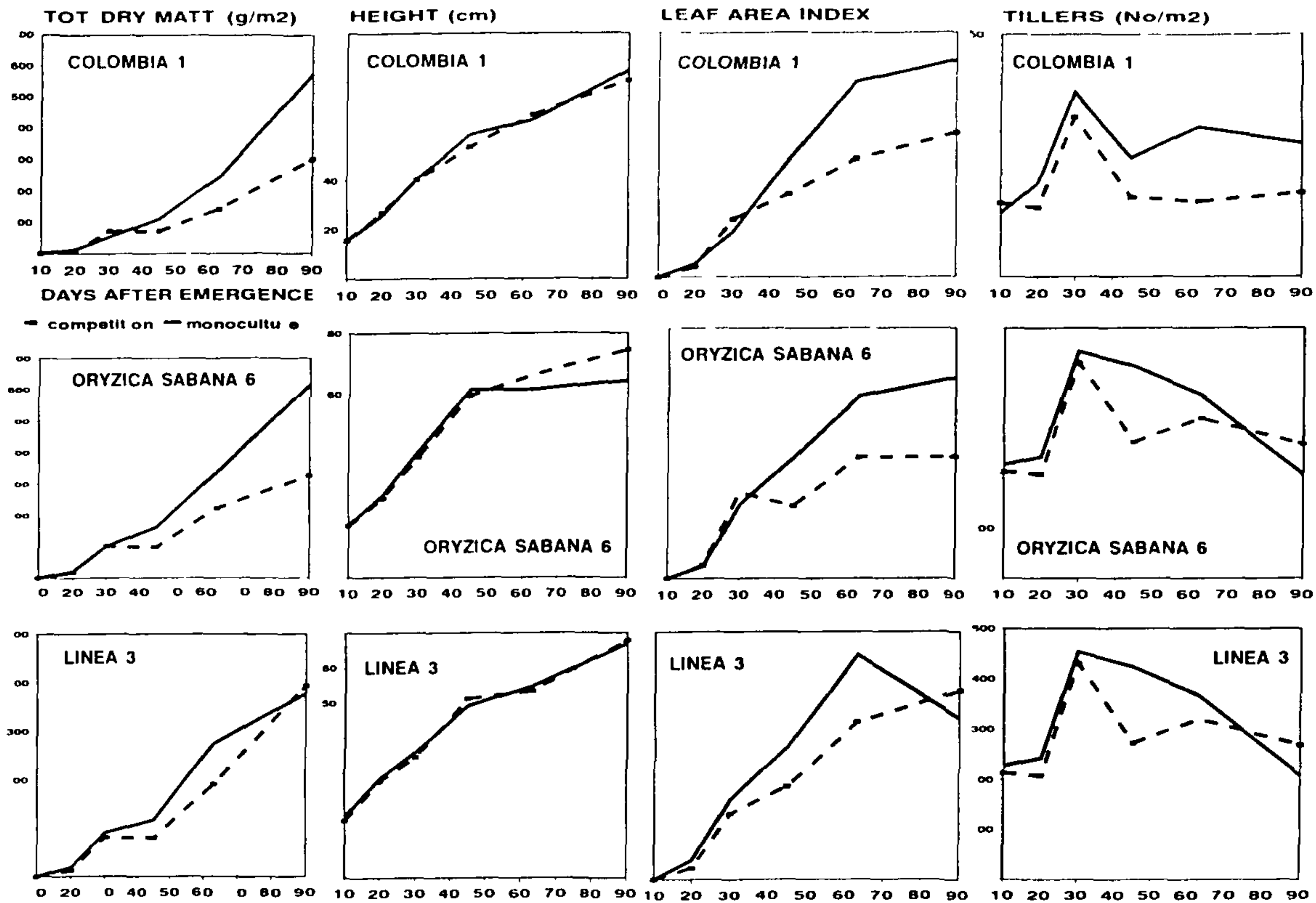


FIGURE 1 Biomass height leaf area index and tillering of three upland rice cultivars recorded sequentially in monoculture and in competition with *Brachiaria decumbens* La Libertad 1993

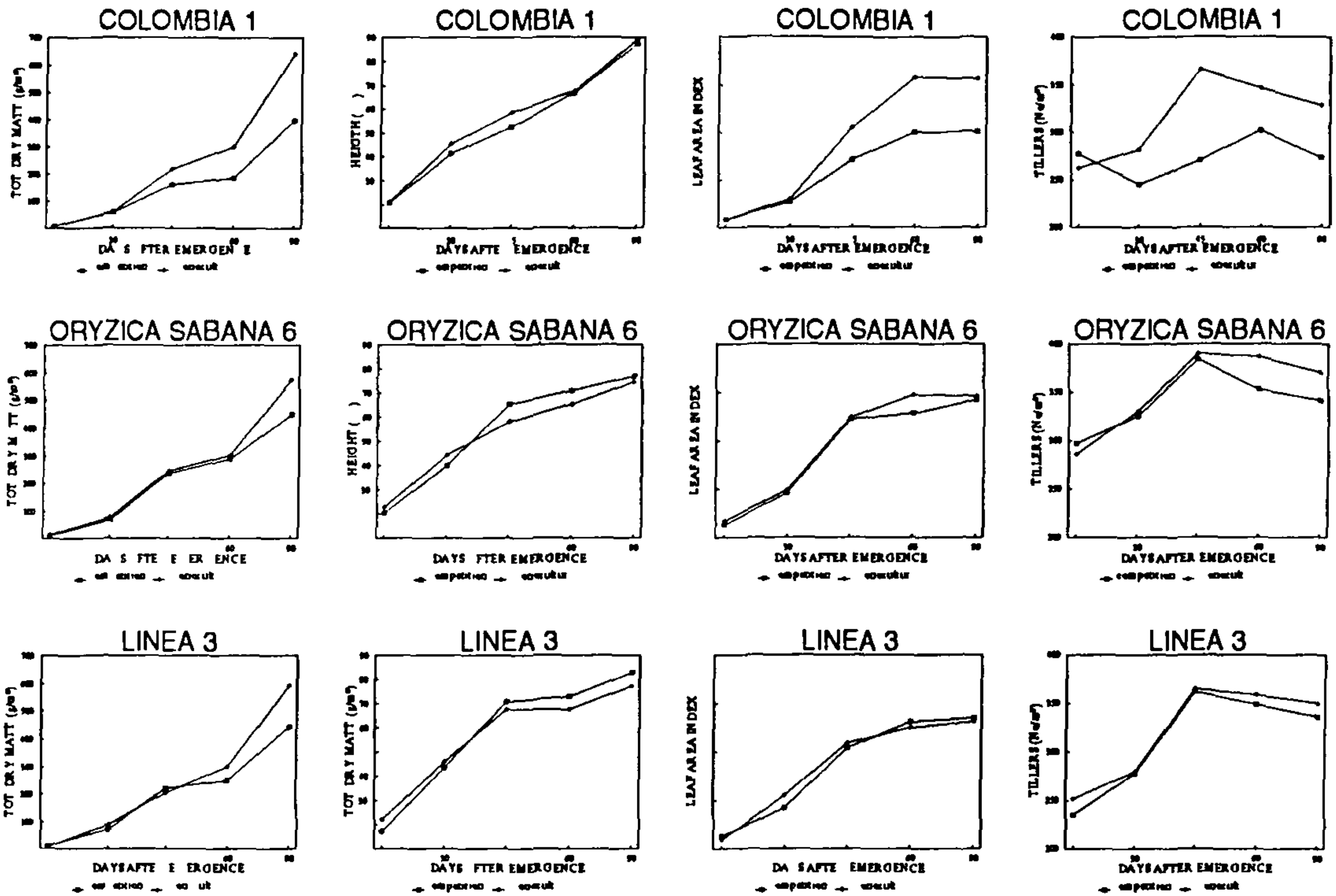


FIGURE 2 Biomass height leaf area index and tillering of three upland rice cultivars recorded sequentially in monoculture and in competition with *Brachiaria decumbens* La Libertad 1994

PASTURE GROWTH

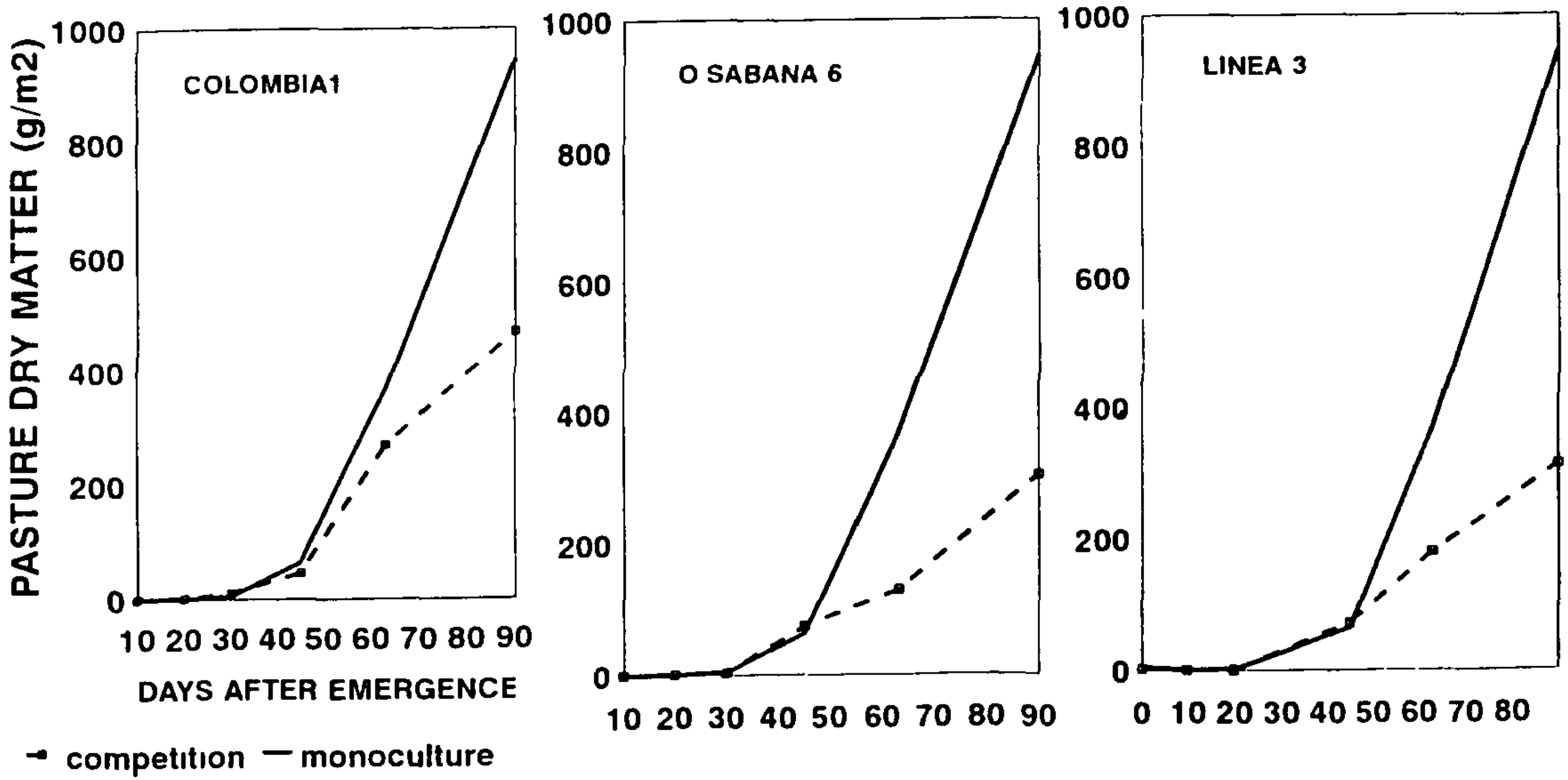


FIGURE 3 Sequential biomass of Brachiaria decumbens in monoculture and as affected by the competition of three upland rice cultivars

PASTURE GROWTH

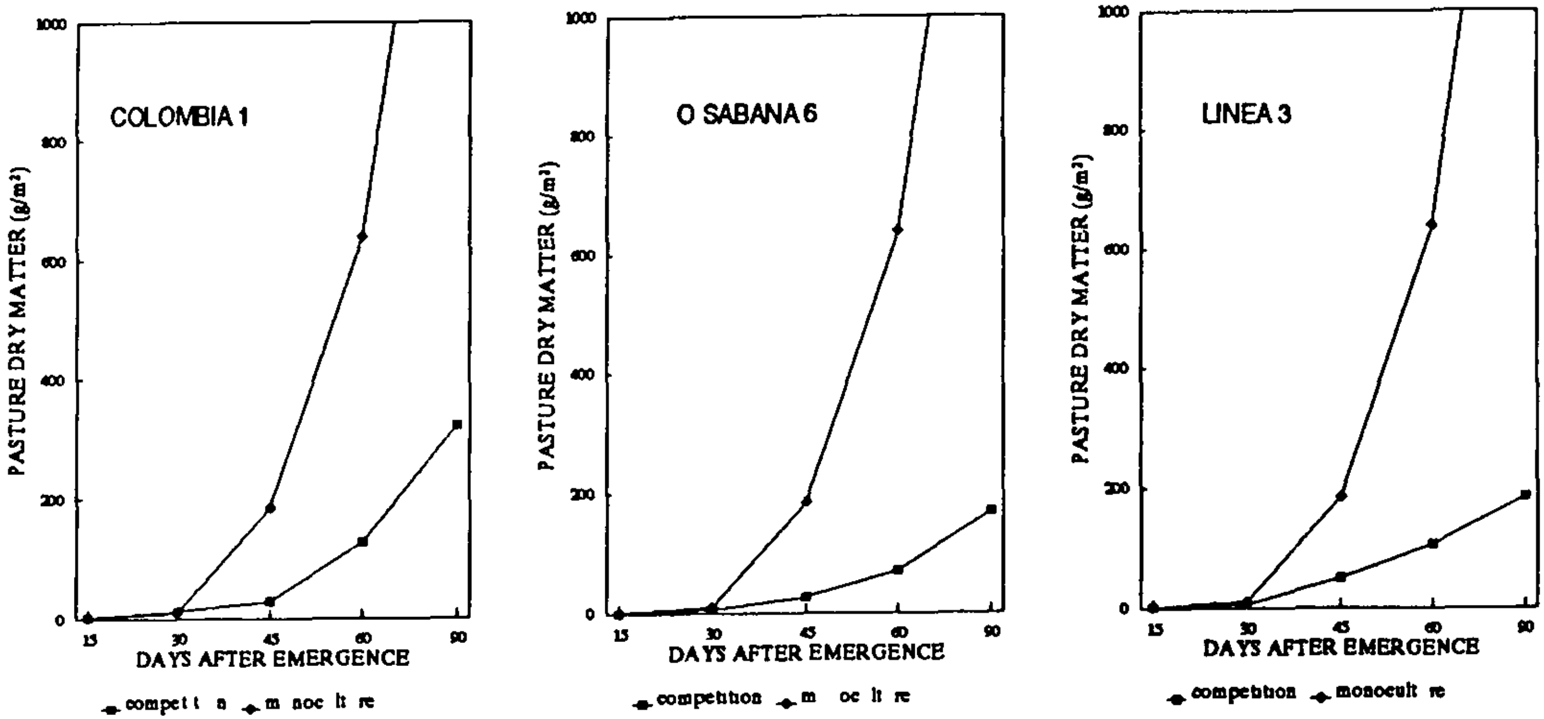


FIGURE 4 Sequential biomass of Brachiaria decumbens in monoculture and as affected by the competition of three upland rice cultivars

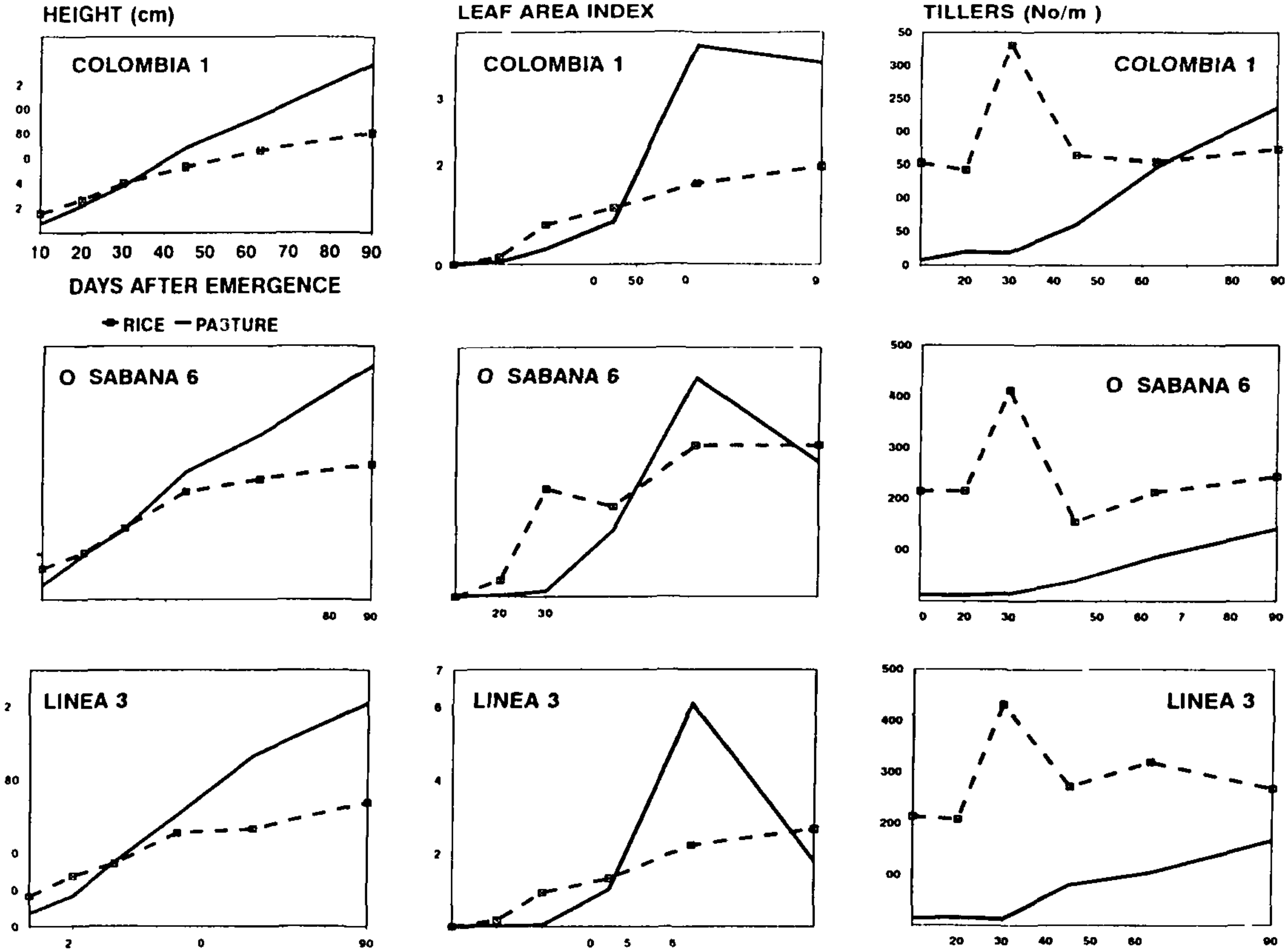


FIGURE 5 Sequential height leaf area index and tillering of *Brachiaria decumbens* and three upland rice cultivars when both species grew in competition

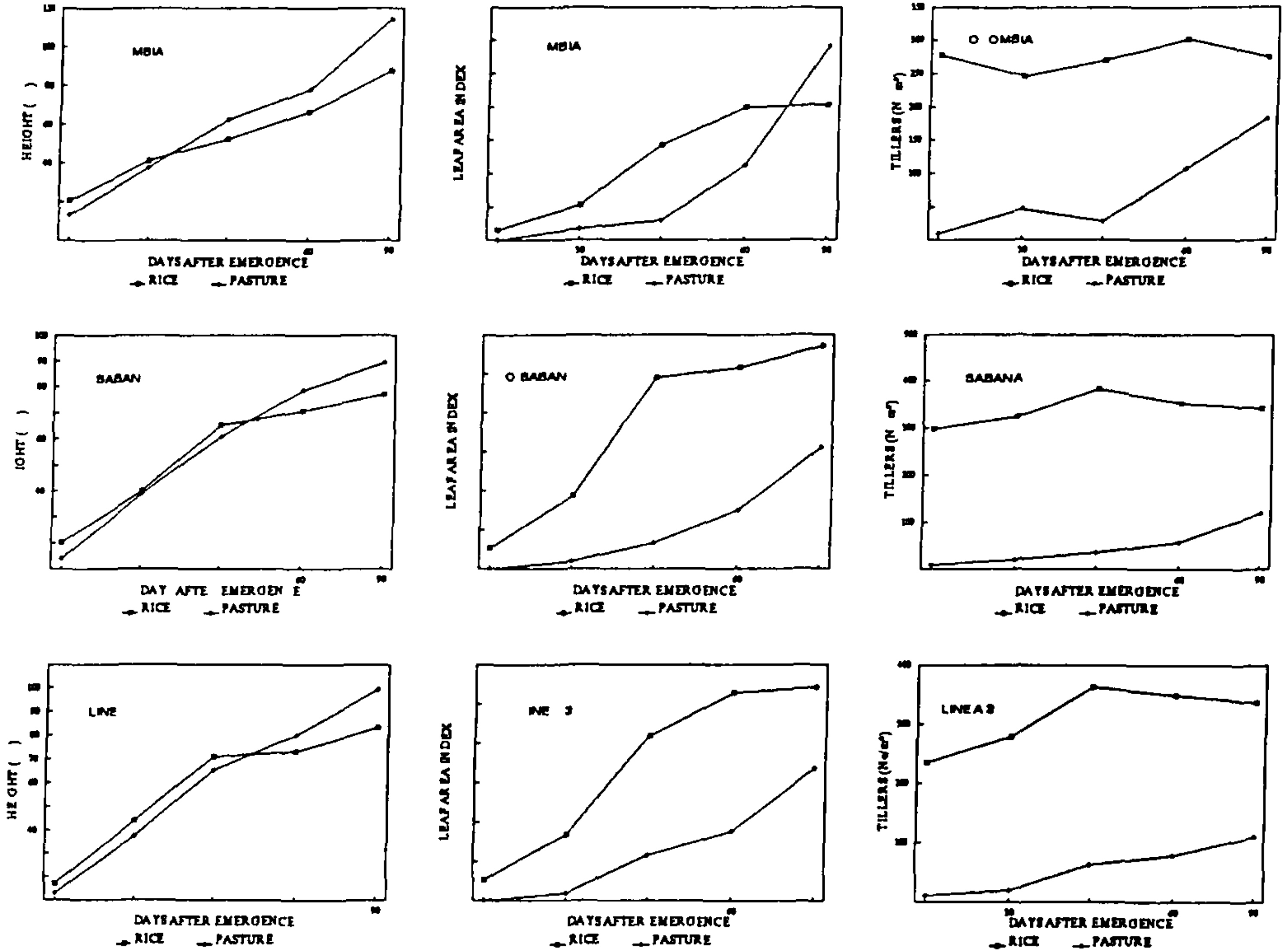


FIGURA 6 Sequential height leaf area index and tillering of Brachiaria decumbens and three upland rice cultivars when both species grew in competition

Greenhouse experiment

A greenhouse experiment was conducted to understand the genetic control of rice traits for competing favorably with an intersown grass pasture Based on Fischer et al (1995) work it was possible to identify 7 parental lines with different competition capabilities These lines were crossed using a diallel without reciprocal crosses what resulted in 21 hybrid combinations These 28 materials were grown in pots in the greenhouse in a randomized complete block design with 3 replications in monocrop and in association with *Brachiaria brizantha*

Forty five days after planting the following data were collected on rice plant height number of tillers leaf area and biomass of shoots and roots The analysis was done using the Hayman model (Hayman 1954) and further analyses are under way using the Griffing model (Griffing 1956) and the Hallauer and Miranda (1981) approach

The following components of the genetic variation were calculated (Table 1)

Average degree of dominance For rice in monoculture non additive effects for leaf area and leaf and stems dry weights were higher than the additive effects as opposed to the number of tiller and plant height where additive effects prevailed When rice grew in association with *B brizantha* all the characteristics exhibited a higher average degree of dominance than in monoculture

Average frequency of positive alleles for loci showing dominance effects There was no symmetry for allele distribution in the parents

Number of dominant and recessive alleles There were more dominant than recessive alleles for all characteristics especially for plant height and number of tillers

Number of alleles showing dominance The majority of alleles showed dominance for plant height leaf area and leaf and stems dry weight for rice in monoculture while most alleles were recessive for number of tillers

For rice in association with pasture the low values (around 1) show that there was an underestimation of the number of alleles that can be attributed to one or two alleles with very high effect of dominance

Narrow sense heritability For rice monoculture and in association the heritability is low for plant height number of tillers and leaf dry weight and higher for leaf area and stems dry weight

Type of dominance The results indicate that for plant height and number of tillers for rice in monocrop the dominance is incomplete for leaf dry weight for rice in monoculture and in association it is complete and for leaf area and stems dry weight for rice in monoculture and for all the characters for rice in association it is overdominance

CONCLUSIONS

Based on the information presented in Table 1 the following can be concluded

Dominant effects are predominant for most of the traits

Heritabilities are low for most of the traits The best values are for leaf area and the dry weight of stems which are important traits for competition
Heritability values for traits in monoculture are not affected when rice is in association with pasture
In a breeding program for rice competition with pasture careful choice of parents has to be made for leaf area and stems dry weight
As the main characteristics of the genetic control of the traits for competition do not present discrepancies for monoculture and association apparently breeding can be performed in monoculture

Field experiment

The varieties reported in section I were used to identify a practical scoring methodology that would allow breeders to select parental and segregating material without going through a long and expensive process of evaluation

The attempt used in 1994 was to try to correlate visual vigor scoring (1 to 9 where 1 is high vigor and 9 is very low vigor) with the physiological data presented in section I of this report Five weekly measures were taking starting 20 days after sowing (das) Table 2 present a summary of the data As can be seen there was no change during evaluation period At the time it was clear that competition effects were important only after 45 das (1993 in section I) May be this is why in this trial no differences were observed

In 1995 a similar study will be carried on taking into account these information

References

Fischer A J M Chatel H Ramirez J Lozano and E P Guimaraes 1994 Components of early competition between upland rice (*Oryza sativa*) and *Brachiaria brizantha* (Hochst ex A Rich) Stapf International Journal of Pest Management (in press)

Hallauer A R and J B Miranda 1981 Quantitative Genetics in Maize Breeding Iowa State University Press Ames Iowa 468 p

Hayman B I 1954 The theory and analysis of diallel crosses Genetics 39 789 909

Griffing B 1956 Concept of general and specific combining ability in relation to diallel crossing systems Australian J Biol Sci 9 463 493

Table 1 Parameters obtained from Hayman analysis

Parameters	Plant height		Leaf area		Leaf weight		Tiller weight		Tiller number	
	A	A+P	A	A+P	A	A+P	A	A+P	A	A+P
Degree of dominance	0 75	1 22	1 39	2 70	1 17	2 83	1 40		0 44	1 34
Positive dominant alleles	0 06	0 12	0 09	0 16	0 10	0 15	0 16	0 16	0 19	0 12
Dominant/recessive ratio	18 84	5 23	3 83	1 78	5 43	2 91	1 92	0 54	9 60	3 99
Number of dominant genes	5 18	1 29	3 52	0 70	2 42	0 78	1 45	1 00	3 38	1 00
Restricted heritability	0 12	0 10	0 31	0 46	0 17	0 28	0 50	0 36	0 27	0 24
Type of dominance	3 50	1 44	1767 18	1276 75	0 12	0 16	4 78	4 28	0 33	7 21

Table 2 Data of vigor obtained in La Libertad Experimental Station Villavicencio Colombia

Entry	Vigor 21 dds[1]	Vigor 28 dds	Vigor 35 dds	Vigor 42 dds	Vigor 45 dds
O Sabana 6	1	1	1	1	1
CT6196 33 11 1 3	1	1	1	1	1
RHS 107	3	1	1	1	3
Caiapo	1	1	1	1	1
CNA 7013 D	1	1	1	1	1
CT6196 33 10 4 15 M	5	3	3	3	5
Colombia 1	3	5	3	3	3
Linea 3	3	3	3	3	3
IAC 47	1	1	1	1	1
Dourado Precoce	1	1	1	3	3
TOx 1010	1	1	1	1	1
CT10037 9 7 M 1 M	3	1	3	3	3

1 dds means days after sowing

Table 3 Model used for the analysis of variance of the diallel

Source	df	df	E(MS) Fixed
Environment (E)	e 1	1	
Replications/E	e(r 1)	4	
Entries	m 1	27	
Parents (P)	n 1	6	
Parents x crosses (P/C)	1	1	
Crosses (C)	c 1	20	
E x entries	(e 1)(m 1)	27	
E x parents	(e 1)(n 1)	6	
E x P/C	(e 1)	1	
E x crosses	(e 1)(c 1)	20	
E x GCA	(e 1)(n 1)	6	
E x SCA	(e 1)		
Pooled error	e(r 1)(m 1)	108	
Total	erm 1	167	

e r m and c refers to the number of environments replications entries and crosses respectively

2 EMBRAPA/CNPAF

SUMMARY

Similar as activities described in paragraph 1 but conducted under moisture stress conditions

Identify rice components of rice-pasture interference

One experiment was installed at the Federal University of Goiás on a degraded pasture of *Brachiaria brizantha* At the onset of the rains in November the old pasture was incorporated with one pass of disk harrow Before sowing the soil was prepared with a moldboard plow followed by a harrow pass to level off the soil surface Fertilizer application and sowing was done on December 17 in a single operation Pasture seed (5 kg/ha) was mixed with the fertilizer (350 kg/ha) and banded 10 cm deep below the rice seeds (formula 5 30 15) this is a recommended practice to decrease early competition between rice and pasture Rice density was of 80 seed/meter row The experiment obeyed a split plot design with two basic treatments as main plots (rice monocrop and rice+pasture intercropping) and an additional plot of pasture in monoculture The rice monocrop and the intercropping included as sub plot treatments 8 contrasting rice genotypes with respect to plant type and growth duration Three of them i e IRAT 216 CNA 7013 D and Oryzica Savana 6 were also present in the CIAT trials reported here The subplots were constituted by 12 25 m long rice rows spaced at 0 40 m Starting at the 30th day after sowing and at a 15 day intervals rice row segments totalling 1 35 m per plot were sampled to determine leaf area tiller number and dry matter weight Root samples were taken with a soil auger (4 holes and 5 depths per plot) with 20 to 30 day intervals for measuring length density and dry matter weight At flowering light interception was measured in three positions in the canopy At this stage measurements of plant height leaf length width and angle were performed to better characterize the rice materials At maturity 4 rows of 10 m length were harvested to rcord rice grain and straw yield as well as pasture biomass Two early and 4 medium growth duration varieties were already harvested whereas the 2 late ones are being harvested The pasture monocrop plot was harvested at two different occasions following early and late rice varieties harvesting Harvested samples are being processed whereas data collected so far is being analyzed Root length density countings are waiting for the arrival of a scanner recently acquired for this purpose

Evaluating the effects of the association with pasture on rice drought tolerance (Objective #4)

One experiment was installed in a private farm nearby CNPAF headquarters In order to increase the probability of drought during reproductive development it was sown late Soil preparation was initiated in December with a pass of disk arrow The procedure was repeated in January a very rainy month to incorporate newly emerged weeds Just prior to installing the experiment on February 18 two differential soil treatments were applied as sub plots deep plowing with a moldboard plow or conventional harrowing using a disk harrow Both treatments were subsequently followed by a harrow pass to level off the soil Sub sub plots were composed by rice in monocrop or in association with the pasture species The fourth level treatments were the rice genotypes Rio Paranaiba and CNA 7066 drought resistant and susceptible checks respectively The same management practices described previously were used to install the experiment As main plots two water treatments will be applied during rice reproductive development a drought stress cycle and irrigated control The growth parameters already described for the previous experiment are being measured During the differential water treatments water relations parameters will also be measured

Other Activities

The experiment aimed at estimating water use efficiency was postponed until August due to problems with the rain shelter which was taken down by strong winds

The activities to fulfill objectives #2 and #3 were not initiated yet because they depend on availability of results from the first experiments

B Activity RP02 Germplasm with enhanced competitiveness against weeds

1 Competitive Irrigated Rice

Summary

A similar study as in section A was conducted with direct seeded (pre germinated) irrigated rice Average rice yield reduction from *E colona* competition was 42 / within a range of 25 and 62 / The most competitive varieties were CICA 8 Eloni and CICA 9 *E colona* growth recorded 60 days after emergence correlated negatively with rice leaf area index and tiller number (R^2= 0 83 and 0 76 respectively) All three varieties were among the best yielding ones in monoculture These parameters were closely related to canopy

light interception Again height was not closely related to competitiveness Quick screening for rice competitiveness could be done by measuring the amount of light reaching the ground preferably with rice growing under competition Estimation of genetic parameters for the characteristics identified will be performed preliminary results are reported here

Background and Objectives

Weeds are the main pest rice farmers in Latin America and the Caribbean (LAC) must manage Chronic losses of about 21% are estimated for the Americas with current control practices (Oerke 1992) Tillage water management and herbicides are the main weed control tools Weed control costs are high U$ 218 million are spent yearly in LAC on herbicides which amount to 45 % of pesticide expenditures Unlike fungicides and insecticides the use of herbicides is still increasing Sub optimal land levelling and water management complicate the use of flood water as a tool for weed suppression Therefore rice farmers must resort to herbicides which are not only costly but may also represent a threat to the environment It is thus important that alternative weed management be developed such that they be economical and environmentally compatible

A research activity has been devised to produce rice plants with traits allowing them to favourably compete with weeds given the existing variability for competitiveness among rice cultivars The challenge is to preserve yield potential while also enhancing competitiveness

Main activities

An experiment with ten varieties (Inti Eloni IRGA 409 CICA 4 CICA 8 CICA 9 Oryzica 1 Oryzica 3 Ceysvoni and IR 8) was conducted under intermittent irrigation with pre germinated seed direct seeded onto a puddled soil Two IRRI lines of reportedly high competitiveness had been also included but suffered from severe lodging and were not harvested Cultivars grew in monoculture and in competition with a saturating infestation of *Echinochloa colona* one of the worst weeds of irrigated rice in tropical LAC Throughout the growing season the following traits were periodically recorded Rice biomass leaf area height tiller number and light transmission through rice canopies

Progress achieved

The crop and the weed emerged together Although competition started early (Figure 1) consistent correlations between rice growth parameters and competitiveness (measured as *E colona* growth suppression or rice yield and growth reduction) were not recorded before 60 days after rice emergence (dde) (Table 1) CICA 8 Eloni and CICA 9 were the varieties suppressing *E colona* growth the most (Table 2) The average yield reduction of rice from *E colona* competition was 42 % within a range of 25 and 62 % (Table2) Weed growth at 60 dde correlated negatively with rice biomass leaf area index (LAI) and the number of tillers (Table 1) whereas height was not strongly related to rice competitiveness and was almost unaffected by competition (Figure 1 and Table 1) since rice plants elongated in response to shading by *E colona* CICA 8 the most competitive variety had a superior advantage over the weed in terms of biomass LAI and numbers of tillers compared to that of IRGA 409 which was the least competitive cultivar (Figure2) High light interception by rice canopies reduced *E colona* growth and competition and LAI and tillering were the parameters most closely related to low light penetration (Table 1) Therefore measuring the light reaching the ground below rice canopies with a line light meter can be a quick way to screen lines for competitiveness However such screening should preferably be performed on rice cultivars growing in competition with the weed since recordings made in the absence of competition did not correlate with those made under competition (Table 3) Studies on the heritability of traits for competition and estimates of selection progress will further clarify this point There was no significant negative correlation (r= 0 37 ns) between harvest index in monoculture and competitiveness (measured as yield loss from competition) and the most competitive varieties mentioned above were among the best yielders in monoculture (Table 2)

TABLE 1 Correlations between rice and *Echinochloa colona* parametres when both species grew in competition

Y	X	d.a.e. 20	40	60	Flowering	Harvesting
Rel rice yield	Weed biomass	0 56NS	0 32NS	0 94	0 94	0 77
Rel rice biomass	Weed biomass	0 34NS	0 33NS	0 88	0 94	0 54NS
Weed biomass	PAR interc by rice	0 34NS	0 06NS	0 82	0 85	0 83
	Rice LAI	0 19NS	0 40NS	0 91	0 51NS	
	Rice tillering	0 14NS	0 31NS	0 87	0 71	0 89
	Rice height	0 29NS	0 65	0 14NS		0 09NS
	Rice biomass	0 26NS	0 19NS	0 73	0 73	0 87
PAR interception by rice	Rice LAI	0 09NS	0 31NS	0 88	0 77	
	Rice tillering	0 01NS	0 80	0 87	0 58NS	0 83
	Rice height	0 62NS	0 71	0 55NS	0 43NS	0 22NS
	Rice biomass	0 07NS	0 30NS	0 52NS	0 79	0 81

Days after emergence
[2/] = P < 0 05 = P < 0 01 NS= P > 0 05

TABLE 2 Biomass of *Echinochloa colona* growth parametres and PAR interception at 90 d a e [1/] and yield of eight upland rice cultivars when both species grew in competition

Rice cultivar	Rice Yield in Monocult (kg/ha)	Rice Yield in Compet (kg/ha)	Yield in comp Rel to check (/)	Height (cm)	Tillers (No /m^2)	LAI	Pasture biomass (g/m)[2/]	Rice biomass (g/m)	PAR intercept
INTI	9175	4763	52 6	88 75	508 71	6 18	337 50	1152 5	93 99
ELONI	4518	3308	73 0	96 25	568 75	6 77	270 00	1137 5	94 88
IRGA 409	8271	3134	37 9	99 75	389 44	5 22	436 25	780 0	87 69
CICA 4	8589	5224	60 9	93 75	539 65	5 19	295 00	1075 0	93 97
CICA 8	8250	6111	75 4	105 00	494 91	6 74	275 00	1260 0	95 65
CICA 9	8709	5622	65 3	106 00	631 00	6 56	277 50	995 0	93 97
ORYZICA 3	9522	5641	59 4	90 50	591 75	6 72	302 50	895 0	95 00
CEYSVONI	7031	4410	63 0	86 00	447 29	5 25	292 50	920 0	93 68
BLUEBELLE	6052	3097	51 3	117 00	486 54	4 43	380 00	677 5	87 16
IR 8	8409	4121	50 9	77 50	465 88	6 44	380 00	795 0	92 68
LSD (0 05)	1174	1174	19 47	5 46	53 85	0 78	83 80	149 0	1 54
CV (/)	13 36	13 36	22 75	3 92	7 24	9 04	17 79	10 60	1 14

Days after emergence

Dry matter

TABLE 3 Correlations between rice parameters determined in monoculture (90 days after rice emergence) with *Echinochloa colona* biomass and relative rice yield in competition

X (monoculture)	Y Pasture biomass	Y Rel rice yield
	r	
PAR interception	0 01 NS	0 21 NS
LAI		
Tillering	0 01 NS	
Rice height	0 02	0 06
Rice biomass	0 07	0 12

P 0 05

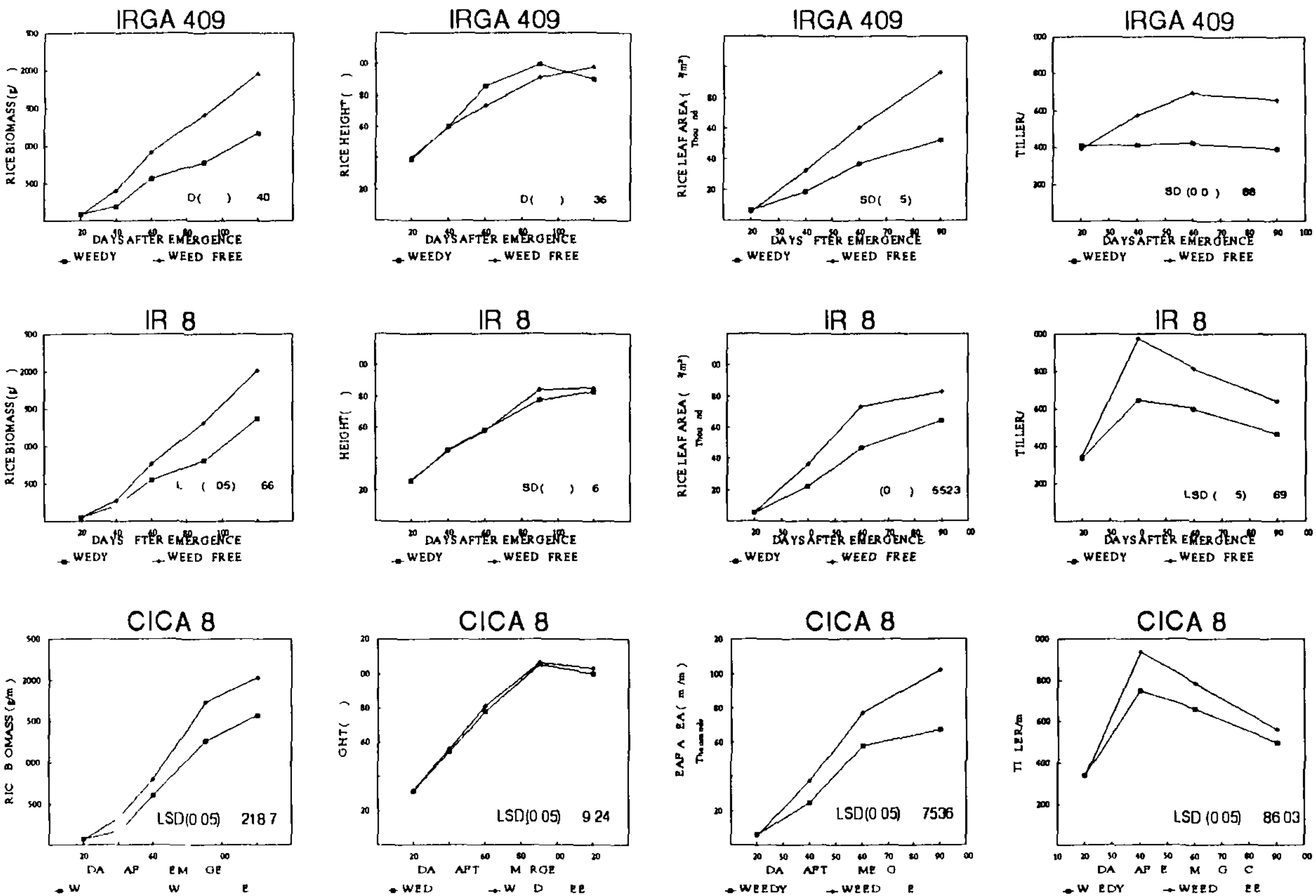


FIGURE 1 Biomass height leaf area and tillering of three lowland rice cultivars recorded sequentially in monoculture and in competition with Echinochloa colona

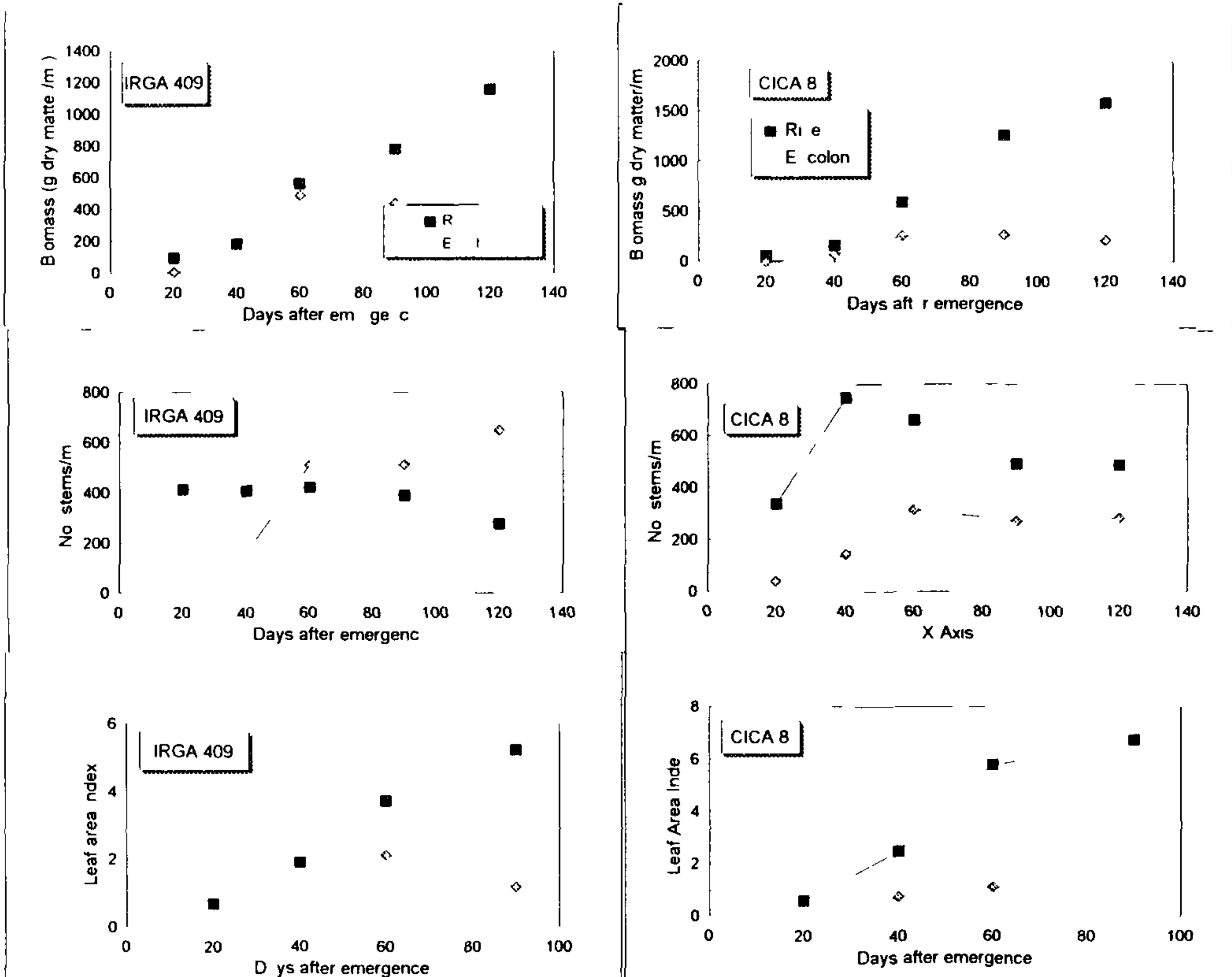


Figure 2 Secuential biomass tillering and leaf area index of Echinochloa colona and of the least and the most competitive lowland rice variety (IRGA 409 and CICA 8 respectively) tested while both species grew in competition

2 Genotypes for Water Seeding

Summary

A total of 132 lines were screened for their ability to emerge through water Pre germinated seeds were covered by soil and put 7 cm below the water surface Redox potential and temperature in the water layer were 1 24 mV and 28 30 C respectively which resembled values recorded in the flood water of conventional rice crops Twenty cultivars with more than 50 / emergence through water were identified Nurseries have already been requested and sent to Surinam and Cuba

Procedure

Three month old seeds from the same generation were pregerminated and seedlings with 1 to 0 3 cm radicles were placed in at the bottom of ice cube cells and covered with 2 5 cm soil plus 4 5 cm water (7 cm total depth) Non flooded checks were included Treatments were aranged in randimized complete blocks with three replications Fourteen days afte rseeding emerged plants (with more than 2 leaves) were counted their height recorded oven dried and weighted

Results

A redox potential of about 1 24 mV and 28 30 °C temperature were registered in the water layer throughout the experiment Several lines exhibited a remarkable capacity to establish under flooded conditions a feature not present in CICA 8 nor in IR 50 (Table 1) Thus donors for this relevant feature have been identified Nurseries have already been sent to Surinam and Cuba

Table 1 Growth under hypoxia relative to that under areobicconditions for lines with more than 50 % emergence and four checks

Cultivar	Emergence (%)	Height (%)	Dry matter (%)
DD91	100	73	51
KARUTHAVAN	100	89	69
JC 148	95	104	72
KHOTKOMUA	92	66	24
TAOTHABI	91	83	55
FR 13 A	87	79	52
AMAGHAD	82	85	55
ROJOFOTSY	82	76	45
GUAN YIN TSAN	82	105	41
VELLAIVANAN	77	82	40
B 2622E TB5 4 4	75	57	20
THAVALU	75	66	34
JC 178	74	97	47
ASDI	73	108	78
BANSBOG	68	64	27
JAWEJAN	60	73	34
SUDUWE	59	70	25
BACKOIA	58	60	14
AWARIA KATICA	55	61	15
PT B1	50	73	22
Checks			
O TURIPANA 7	17	47	5
CICA 8	11	57	7
IR 50	11	68	15
IR 49830 7 1 2 2	9	35	2

103789

V PROJECT 5
DIVERSIFIED TAGOSODES/RICE HOJA BLANCA VIRUS

PROJECT PURPOSE

To help poorer tropical re growing countries overcome these pests by diversifying the resistance genes deployed against them thus protecting against resistance breakdown stabilizing yields and reducing insecticide use

A ACTIVITY RP03 DIVERSIFIED TAGOSODES/RICE HOJA BLANCA VIRUS

SUMMARY

The goal of this project is to reduce crop losses due to Rice Hoja Blanca Virus and *Tagosodes orizicolus* by diversifying the resistance genes deployed against them thus protecting against resistance breakdown stabilizing yields and reducing insecticide use In 1995 4 127 and 6 029 segregating and advanced rice breeding lines were evaluated for resistance to RHBV and *T orizicolus* damage respectively The lines evaluated were from the CIAT Irrigated and Upland Breeding and Rice Pathology Programs INGER FEDEARROZ CORPOICA and IRRI These evaluations provide valuable RHBV and *T orizicolus* resistance information for the CIAT and Latin American National Program germplasm pools Some of these lines represented new sources of resistance to both the virus and insect and they are being incorporated into advanced breeding materials The program also conducted studies to determine the effect of *T orizicolus* colony plant age and variety on rice susceptibility to RHBV in the greenhouse and field We also initiated studies in cooperation with FEDEARROZ and CORPOICA to survey for the occurrence of RHBV infected plants and active vectors in commercial rice fields in Colombia These studies will provide information on virus/insect/rice plant interactions which have important consequences for the development and occurrence of RHBV epidemics in the field Finally in order to create novel RHBV resistance sources that can potentially be transferred into popular varieties currently being grown in Latin America the project is working to genetically engineer RHBV resistant rice plants using RHBV coat protein and down regulation strategies Plants containing these constructs have been identified Following local safety regulations the progeny from the transgenic plants will be tested in the greenhouse under biosafety conditions for resistance to RHBV using viruliferous *T orizicolus*

INTRODUCTION

RHBV is present throughout much of tropical America and there have been documented RHBV epidemics since 1935 Epidemics of RHBV are cyclic with outbreaks occurring every 8 15 years The last major outbreak of RHBV was during the early to mid 1980s When an outbreaks of RHBV occur yield losses have been estimated to be between 25 / and 50 / As new epidemics of RHBV occur similar losses can be expected throughout the affected areas The vector of RHBV is the planthopper *Tagosodes orizicolus* (Muir) The virus multiplies both in rice and in its planthopper vector The virus also causes a disease in the insect and those insects which harbor the virus are less fit compared to those that do not It is speculated that this phenomenon coupled with a slow progressive build up of plants infected with virus in the field is responsible for the cyclic nature of the RHBV epidemics

Besides being the vector of RHBV the planthopper insect *Tagosodes oryzicola* (Muir) is a serious pest of rice that causes direct damage The direct damage that is caused by the planthopper and the uncertainty of RHBV epidemics are the reasons that farmers to spray up to 5 6 times to control this planthopper vector of RHBV

The levels of RHBV detected in the field are currently increasing in Colombia Venezuela and Ecuador recently experienced outbreaks of RHBV and Costa Rica is currently experiencing an outbreak of RHBV The increases in reports of the incidence of RHBV may portent a new cycle of a RHBV epidemic Some of the objectives of this project include more complete monitoring of viruliferous planthoppers surveys of disease incidence and a better evaluation of rice cultivars and breeding lines that are resistant to the planthopper and/or the virus This should help mitigate losses should an epidemic occur and reduce the long term losses caused by recurring epidemics

Resistance to RHBV and *Tagosodes orizicolus* in Breeding Populations

The Entomology Program evaluated a total of 4 127 and 6 029 segregating and advanced rice breeding lines for resistance to RHBV and *T orizicolus* damage respectively during 1995 The results of these evaluations are presented in Tables 1 and 2 respectively The origin of the lines evaluated were CIAT Irrigated Rice Breeding Program (50 /) INGER (23 /) FEDEARROZ (14%) CORPOICA (7 /) CIAT Upland Rice Breeding Program (6%) CIAT Rice Pathology Program (1%) and IRRI New Plant Type lines (1 /)

Field and Greenhouse Evaluations for Resistance to RHBV

Screening Methodology

The RHBV evaluations are conducted twice yearly in the field and when requested in the greenhouse The greenhouse evaluations are conducted using methods similar to that described below for the *T orizicolus* mechanical damage evaluations The field evaluations for RHBV are conducted in a rice plot that is devoted exclusively to this purpose This plot is bordered with sugarcane plants to maximize containment of the vectors and minimize environmental variability within the plot Ten field cages for insect rearing and field inoculation also border the plot Vector colonies (75 80 /) are produced in the greenhouse transferred to potted rice plants in the 10 field cages and increased for ca 1 5 months prior to field release The test lines are planted into ca 1 25 m wide beds spaced ca 1 meter apart Three grams of seed of each test line (ca 100 seeds/line) are sown in 0 5 m rows spaced 15 cm apart To ascertain uniformity of planthopper infestation and RHBV pressure susceptible (CICA 8 Bluebonnet 50) intermediate (Orizica 1 Metica 1) and resistant check lines (Colombia 1) are planted every 40 rows When the test materials are ca 15 days old viruliferous insects are distributed evenly onto the test materials by removing the *T orizicolus* infested potted rice plants from the cages and shaking the insects onto the test material Plants are evaluated for RHBV symptoms 25 30 days after inoculation using a visual damage scale (0 9) with 0= 0 / 1=1 / 3=2 10 / 5=11 30% 7=31 60% and 9 60% of the plants infected with RHBV After the evaluations the plants are treated with carbofuran to eliminate insects

Results

Out of the total 3 467 lines evaluated in the field during the first semester of 1995 16 / were classified as highly resistant to RHBV (RHBV rating 1) while 15 / were classified as resistant (RHBV rating =3) and 10% were classified as intermediate (RHBV rating =5) The remaining 59 / were considered susceptible (RHBV rating 7) (Table 1) To assure that advanced lines have a good level of resistance only those lines that have a rating of 3 were recommended for further evaluation

The Second Semester planting for 1995 was timed to coincide with the CIAT INGER LAC FLAR Rice Breeders Workshop July 31 Aug 3 1995 In this evaluation 270 advanced RHBV tolerant lines from the CIAT Irrigated Rice Breeding Program and 99 lines from FEDEARROZ were tested 95 % of the CIAT Irrigated Rice Breeding of the CIAT lines *exhibiting* a RHBV *rating* 3 and 22 % of the FEDEARROZ lines exhibited a RHBV rating 3 The level of resistance in the FEDEARROZ lines was similar to the level of resistance in the total populations because these lines had not been previously screened for RHBV resistance This shows the importance of selective screening to assure high levels of RHBV resistance in advanced lines

It should be also be noted that the same 270 CIAT RHBV tolerant lines planted in the Second Semester were evaluated during the First Semester in the same plot and a high degree of variation was noted between these two evaluations The coefficient of *determination* (r^2) calculated for the two evaluations was 0 33 indicating that only 33 % of the variation in RHBV could be accounted for by knowledge of the prior RHBV rating The reasons for the high degree of variability are unclear Semester by semester insect population density vector capacity and random environmental variation are undoubtedly significant sources of error in these evaluations The current selection method is being evaluated to determine how to minimize the variation between separate trials

Greenhouse Evaluations for Resistance to T orizicolus damage

Screening Methodology

Evaluations for resistance to *T orizicolus* mechanical damage are conducted in greenhouse cages Plants are sown in flats each flat containing 34 rows of rice spaced 3 cm apart with each row containing 10 plants Resistant (cv Mudgo) intermediate (cv CICA 8) and susceptible (cv Bluebonnet 50) check rows are planted randomly in every flat When the plants are ca 15 days old (2 3 leaves) they are transferred to cages and inoculated with ca 10 nonviruliferous planthoppers per plant (adults and nymphs) Resistance evaluations are conducted when the susceptible checks die (ca 7 8 days after inoculation) using a visual damage rating scale (1 5)

Results

During 1995 6029 lines were evaluated for *T orizicolus* Forty four percent of the lines evaluated during 1995 were considered highly resistant (Damage Scale 1) 17 / resistant (Damage Scale 3) 8 / intermediate (Damage Scale = 5) and 30 / susceptible ((Damage Scale 7) (Table 2) There is a high level of resistance to *T orizicolus* in the lines evaluated and it is recommended that only lines with a damage scale of 3 be selected for further evaluation

Discussion

The screening for resistance to RHBV and to *T orizicolus* is providing an evaluation of rice lines both from CIAT germplasm pools as well as those from other institutions At CIAT new sources of resistance to RHBV and to *T orizicolus* are being tested Within the lines tested in 1995 there were multiple source of resistant to both pests

CHARACTERIZATION OF ISOLATES OF *T ORIZICOLUS* AND RHBV AND EFFECT OF PLANT AGE ON SUSCEPTIBILITY TO RHBV

Effect of plant age on susceptibility to RHBV

One of the factors that influences the degree of damage by a virus is plant age Plants infected early in the growing season are general more severely affected than those that are infected later In the case of RHBV there was previous data (see Rice Annual Report 1994) that younger plants may be more susceptible to virus infection These studies were carried out to confirm the effect of plant age on the susceptibility to RHBV Sets of replicated trials were conducted in the greenhouse and a trial was done to confirm the greenhouse results

Greenhouse Experiments

Methodology

Eight varieties of rice were tested for their susceptibility to RHBV at five ten fifteen and twenty days post planting The susceptible control was Bluebonnet 50 and the resistant control was Colombia 1 The 4 replications of 6 plants were inoculated at each date Each plant was inoculated in controlled conditions using two adult planthoppers that were proven to be viruliferous The planthoppers were eliminated after a five day inoculation period and the plants were observed at 2 3 day intervals for the presence of RHBV symptoms

Results

The data with the percentage of plants infected at the four different plant ages are shown in Table 3 Bluebonnet 50 and Balilla are both highly susceptible and a high percentage of plants became infected with RHBV at all four plant ages Fanny and IRAT 124 showed an intermediate reaction and over 20 % of the plants became infected with RHBV at 10 and 15 days The only date that Colusa had a moderate level of infection was at 5 days but 4 to 8 / of the plants continued to become infected even at 25 days Colombia 1 Llanos 5 and Blue Rose showed the highest level of resistance with few plants becoming infected with RHBV after the plants were 15 days old All varieties were partially susceptible at 10 days after planting

Field Experiments

Methodology

In conjunction with the CIAT INGER LAC FLAR Rice Breeders Workshop July 31 Aug 3 1995 a rice plot was planted to demonstrate the effect of plant age on the expression of RHBV in the field This study was conducted in the RHBV screening plot in the field using the same techniques as described below in section B However the plot size was 1 m^2 and the rice plots were planted sequentially every 5 days to achieve differential plant ages

Results

In general the results of the field evaluations reflected what was observed in the greenhouse studies earlier Resistance to RHBV and % RHBV incidence varied with plant age (Table 4) Cultivars that were considered to be resistant or moderately resistant (e g O Llanos 5 O Llanos 4 and Oryzica 1) suffer increased incidence of RHBV when inoculated with RHBV when they were younger (10 15 days post planting)

Discussion

The susceptibility of the most resistant varieties has important epidemiological implications If resistant varieties are planted next to established rice with high levels of *T orizicolus* and RHBV it is possible that a moderate (10 30) percentage of these plants can become infected with RHBV Further evaluation is needed to test if crop management strategies can be used to minimize early infections in resistant varieties Since the resistant varieties become less susceptible to the virus with age the majority of the infections occur when the plants are young Therefore the use of chemicals to control the vector probably is not effective more than 15 20 days after planting Many fields of the resistant variety Llanos 5 have had infection rates that *are alarming* to the farmers Most of these fields have less than 10 / of the plants affected by RHBV and the early susceptibility of this variety may be an explain these levels of infection

Greenhouse Experiments for colony and virus variability

In 1994 the program began studies focused on characterizing the variability of *T orizicolus* populations and RHBV isolates from Colombia in response to reports from the Tolima region that cv Llanos 5 was more *susceptible to RHBV than* previously expected The importance of variability in vector and virus populations affects both the selection methods for RHBV resistance and potentially the regional performance of resistant rice varieties

Methodology

These studies were continued during 1995 and will continue in 1996 In May 1994 *T orizicolus* and RHBV virus isolates from Tolima were collected and vector and nonvector colonies established in the greenhouse Nine varieties and advanced rice breeding lines (Bluebonnet 50 O Caribe 8 CICA 8 O Llanos 5 Colombia 1 Orizyca 1 IRAT 124 CT8008 and CT8837) representing a range of resistance reactions were selected as tester varieties and screened for resistance to RHBV at four different plant ages (10 15 20 and 25 days post planting) using the CIAT and Tolima vector colonies Plants were sown in flats sequentially over time to achieve the differences in plant age Each flat contained 18 rows of rice (9 randomly sown varieties replicated 2x) spaced 3 cm apart with each row containing 25 plants The plants were transferred to cages and inoculated with ca 4 5 viruliferous planthoppers per plant (adults and nymphs) and the insects were allowed to feed for 5 days Both of the colonies CIAT and Tolima were screened simultaneously to reduce experimental variation and ELISA measurements of / vector insects were taken prior to inoculation The studies were conducted on once in 1994 and were replicated in 1995

Results and Discussion

The results of the greenhouse RHBV experiments are shown in Figures 1 and 2 The current studies confirm those obtained in 1994 (see Rice Annual Report 1994) Compared to the CIAT colony and RHBV vector isolate the Tolima colony and RHBV vector isolate was more virulent Averaged across varieties plants exposed to the Tolima colony had a significantly higher average / RHBV infection level than those exposed to the CIAT colony (Fig 1) Also as described above and in 1994 all the lines tested including O Llanos 5 and Colombia 1 were more susceptible to RHBV infection when they were 10 days old compared to those that were 15 25 days old (data not shown presented in 1994 Report) Likewise averaged across dates varieties exposed to the Tolima colony had a higher average / RHBV infection level compared to the CIAT colony (Fig 2) This effect was most evident for moderately resistant to resistant plants

These studies were initiated to determine whether or not a new biotype of *T orizicolus* or strain of RHBV had developed in Tolima The current studies addressed the former and we have begun studies to address the later Because insect biotypes typically demonstrate differential performance on specific tester varieties and because the 9 tester varieties exhibited similar trends for both the CIAT and Tolima colonies (i e increased / RHBV incidence with the Tolima colony for all varieties except the highly susceptible BB 50 and O Caribe 9) we conclude that the *T orizicolus* collected from the Tolima area does not represent a new biotype Rather we believe that it is more likely that the CIAT *T orizicolus* colony needs to be reinvigorated with new insects collected from the field to increase genetic variability and hence colony vigor The Entomology program has commenced with these activities and will conduct our 1996 RHBV and *T orizicolus* mechanical damage evaluations with the reinvigorated colony It should also be mentioned however that these results do not preclude that possibility that the RHBV virus isolate in Tolima is more vigorous than the CIAT RHBV isolate To address this question we have commenced a series of studies in which the CIAT colony is being reared on plants containing the Tolima RHBV isolate and vice versa These studies should be concluded in 1996

As was mentioned these findings have practical implications for the management of *T orizicolus* in the field Given the fact that RHBV appears to be increasing in Colombia and that even resistant varieties such as Llanos 5 are susceptible to the virus at early growth stages (i e <10 days) if rice growers have high populations of *T orizicolus* in their fields during this period the utility of such varieties should be augmented by the judicious use of a single insecticide application during this critical period

SURVEY OF PREVALENCE OF PLANTS AND *T ORIZICOLUS* INFECTED WITH RHBV IN COLOMBIA

In response to a perceived increase of RHBV infected fields in Colombia a collaborative project with FEDEARROZ and CORPOICA was begun in July to survey for the prevalence of plants and *T orizicolus* infected with RHBV in various regions of Colombia To date samples have been obtained from the rice growing regions of Tolima (Tolima) Villavicencio (Meta) Cucuta (Norte de Santander) and Huila (Huila) Samples of *T orizicolus* were collected either by Field or Research Assistants from FEDEARROZ and CORPOICA or by members of the Rice Program frozen and sent to CIAT for ELISA analysis Table 5 contains the results of samples that are presently available RHBV has been detected in all regions sampled except Huila However few samples have been obtained from this department The region of Villavicencio currently has the highest level of RHBV with the average percent of *T orizicolus* infected with RHBV (actual vectors or viruliferous planthoppers) in rice fields being ca 4 7 / In comparison the percent of actual vectors averaged across all samples in the Tolima region is ca 1 8 / The level of RHBV present in Villavicencio region should raise some concerns as this level is approaching the level of actual vectors in the field (10 15 /) that is *typically encountered* during an epidemic of RHBV During 1996 CIAT and FEDEARROZ will continue to monitor the extent of RHBV present in Colombia and we will initiate studies focused on determining the number of potential vectors (i e planthoppers capable of transmitting the virus but not yet infected) present in the field during 1996

B Activity RP53 Control of RHBV through Coat Protein Mediated Cross Protection and Anti Sense RNA Strategies

Summary

Most Latin American varieties have the same RHBV resistance gene The main goal of this project is to provide new source(s) of resistance to minimize the possibility of an outbreak of the disease The coat protein cross protection and the antisense gene down regulation of the major non structural protein NS4 are being attempted The antisense gene strategy for the expression of the RNA4 is to determine the function of the major NS4 protein and to study the potential for a different and potential complementary method of producing viral resistant plants Direct gene transfer is performed using the particle bombardment onto immature embryos or immarure panicle derived callus Constructs containing the RHBV CP or the RHBV RNA 4 and the 35S CaMV hph gene *are being* tested Previous molecular and inheritance analyses indicate that about half of the regenerants have stable integration of the hph gene Preliminary Southern and Northern analyses show that some of the hph resistant plants also contain and express one of the RHBV genes

Purpose

To create novel resistant sources against RHBV to reduce losses caused by RHBV epidemics

Introduction

There is limited distribution of the varieties that are resistant to both the vector and the virus Some very popular varieties are resistance to the vector but are susceptible to the virus The addition of RHBV resistance to these varieties would make them even more attractive by lower the risk of losses that could be incurred during epidemics of RHBV Since the resistance to the virus that is present in a few commercial varieties is from a single resistant source there is a need to incorporate additional sources of resistance into improved germplasm to ensure stable and durable resistance *Moreover* the current source of resistance does not confer immunity in most commercial varieties and the plants are more susceptible when they are juvenile Since many farmers start applying insecticides as soon as they observe RHBV infected plants the use of resistant varieties is not reducing pesticide use as much as it should Additional effective resistance is needed to encourage the reduction of pesticide usage and to reduce the risk of RHBV epidemics

RHBV is a member of the tenuivirus group that consist of 3 8 nm wide nucleoprotein filaments that are found in both linear and circular forms The genome of RHBV consist of four ssRNA species The nucleotide sequence of RHBV RNA4 is known and the genome encodes two genes in ambisense manner The major NS4 protein is encoded by the viral (v) RNA strand The nucleoprotein (N protein) is encoded on the viral complementary (vc) RNA 3 The molecular characterization of RHBV and the preparation of cDNA libraries has led to the design of novel virus resistant strategies to genetically engineer commercially grown rice cultivar Two different strategies are being attempted a) N protein cross protection and b) the antisense gene down regulation of the major NS4 protein The N protein mediated cross protection has been successful for the rice stripe tenuivirus (RStV) The strategy for the expression of the RNA4 is to determine the function of the major NS4 protein and study the potential for a different method of producing viral resistant plants The hypothesis is that this protein which is expressed in the plant but cannot be detected in the vector may have function as a transmission factor The down regulation of this protein would be a novel method of producing virus resistant plants by breaking the cycle of transmission

Methods

The direct deliver of genes into immature embryos or immature panicle derived calli is conducted using DNA coated gold particles accelerated by the PDS1000/He system The tropical irrigated Latin American *indicas* varieties Oryzica 1 Cica 8 and Inti and the tropical upland japonica line CT 6241 17 1 5 1 are used as targets Constructs containing the RHBV NC or the antisense RHBV major NS4 genes driven by the 35S CaMV promoter are being used The 35S CaMV hph gene (for hygromycin resistance) is used as the selective marker The putative transgenic events are recovered using a step wise selection on culture medium containing 30 mg/l hygromycin B (hyg B) followed by 50 mg/l hyg B throughout plant regeneration

During the year a series of experiments were carried out to optimize the detection of single genes and to determine the most efficient method to isolate rice DNA Theoretically 2 5 ug rice DNA is sufficient to detect a single gene copy but in practice analysis revealed that between 10 to 15 ug DNA are needed to obtain a strong signal in the autoradiograms during a short period of exposure (overnight to 48 hr)(data not shown) Thus the availability of DNA becomes a limiting factor for replicating Southern blots

Various polymerase chain reaction (PCR) methods were used to determine the most efficient method to amplify low copy number genes Plants that had been transformed with the hph gene were used as control plants These plants not only expressed hygromycin resistance but also had be shown to contain the hph gene by Southern hybridizations Both direct PCR and reverse transcriptase of mRNA followed by PCR (RT PCR) were tested

Results

Analyses of various methods commonly used to isolate rice DNA including CTAB s Dellaporta s and various methods using urea indicate that the method by Gilbertson (Journal of General Virology V 72 1 6 1991) is the most efficient An average of 48 ug DNA/ gr fresh tissue from 71 day old plants is obtained with Gilbertson s method in contrast to 16 ug for Dellaporta s and below 10 ug for CTAB s and urea s methods The

DNA yield increases to 70 ug DNA/ gr fresh tissue when using 41 day old plants The DNA extracted by the Gilbertson method is cut easily with restriction enzymes and is suitable for use in Southern hybridization to detection of single genes (data not shown)

Both the direct PCR (Figure 3) and the RT PCR were able to amplify the hph gene in the transgenic rice The amplified band was confirmed to the part of the hph gene by Southern hybridization The amplification was shown to be consistent with all the plants tested Most of those plants did contain multiple inserts of the hph gene and this may have influence the level of detection In other plants that were found during the testing of plants transformed with the RHBV constructions some of the bands were not as strong When products of PCR reactions are analyzed using Southern hybridization the level of sensitivity increases and confirms that the products are not artifacts

Methods

After the complete step wise selection process throughout plant regeneration on 50 mg/l hyg B a total of 165 plants from the antisense RHBV NS4 and 187 plants from the RHBV NC bombardments had been recovered Preliminary analyses by Southern blot of genomic DNA and Northern blot of 38 plants recovered from the antisense RHBV NS4 bombardments indicated that 2 of these plants (5 3%) contain and express the antisense RNA4 gene (Figure 4) The identification of transgenic plants that express the RHBV antisense allows for the analysis of the affect of the major non structural gene and to determine the down regulation of this viral gene confers resistance to RHBV

Results

Twenty one of 31 plants analyzed from RHBV N protein experiments contain the RHBV gene (Figure 5) In all cases larger N protein fragments than the expected length were visualized on the Southern blots Apparently a variety of integration patterns had been obtained in other works when circular plasmid is used Therefore future experiments will include the linearization of the expression vector before bombardment These plants will be analyzed by Northern and Western analysis to determine if the N protein gene is being expressed correctly Recently PCR analyses indicate that twenty five plants recovered from the RHBV N protein bombardments contain the hygromycin resistance gene (Figure 6) Analyses of these plants to confirm the integrative transformation of the RHBV N protein gene is underway The analyses by PCR and Southern blot of the plants recovered from the hygromycin continues Those plants containing the RHBV gene(s) will be characterized by Northern and Western (RHBV N protein only) analyses

Discussion

During the last year most of the technical difficulties in the detection of low copy number gene were solved and reliable techniques were developed The detection of transgenic inserts into the chromosome are being detected by Southern hybridization and PCR assays The expression of the gene are being detected using Northern hybridization and RT PCR The major advantage of PCR method is that much less plant material is need for the assay therefore the plants can be tested at a much younger age The identification of younger plants is needed for the testing for virus resistance

Plants have been identified that are transformed with hph gene the N protein gene and the antisense major NS4 Inheritance studies of progeny from the already identified promising plants is in progress to confirm stability of the integrative transformation and expression for the RHBVNC and the antisense RHBV NS4 genes Following local regulations the progeny from transgenic plants will be tested in the greenhouse under biosafety conditions for resistance to RHBV using viruliferous plant hoppers

Table 1 Rice germplasm evaluated for Rice Hoja Blanca Virus Resistance CIAT 1995

Program	Total evaluated	No Lines with RHBV Rating						NG[1]
		0	1	3	5	7	9	
First Semester 1995 Field								
CIAT Irrigated	1153	13	115	127	87	119	692	
CIAT Upland Savanna	235	10	107	40	9	10	53	6
CORPOICA	342	12	125	38	21	18	125	3
FEDEARROZ	552	0	16	97	103	134	189	13
INGER	1182	4	156	217	142	216	447	
Total	3464	39	519	519	362	497	1506	22
First Semester 1995 Greenhouse								
CIAT Pathology	122	0	7	47	55	9	4	
IRRI New Plant Type	70	2	27	6	12	1	22	
FEDEARROZ	99	0	0	8	5	16	56	14
Total	291	2	34	61	72	26	82	14
Second Semester 1995 Field								
CIAT Irrigated	270	7	116	137	8	2	0	
FEDEARROZ	99	3	8	10	17	19	28	14
Total	369	10	124	147	25	21	28	14

RHBV Damage Scale 0 1 _1% plants infected (very es stant) 3 2 10 / plants nfected (res stant) 5 11 30 plants nfected (ntermediate) 7 31 60 / plants nfected (susceptible) 9 60 / plants infected (very susceptible)

Material d d not germ nate or packs without seeds

Table 2 Rice germplasm evaluated for resistance to *T orizicolus* damage CIAT 1995

Program	Total evaluated	No Lines with Damage Rating						NG
		0	1	3	5	7	9	
CIAT Irrigated	1153	362	281	187	84	169	70	
CIAT Irrigated	2457	506	841	512	168	256	171	3
CIAT Upland Savanna	174	4	5	5	3	42	109	6
CORPOPICA	342	9	46	31	17	76	161	2
FEDEARROZ	552	150	142	109	65	57	22	7
FEDEARROZ	99	20	11	25	8	15	6	14
INGER	1182	135	126	171	157	241	352	
IRRI New Plant Type	70	14	9	1	0	3	43	
Total	6029	1200	1461	1041	502	859	934	32

T orizicolus damage scale 0 no damage (very resistant) 1 slight discoloraiton of the plants and damage to leaves (resistant) 3 plant growing points yellow and leaves beg nning to curl and yellow 5 50 / dead plants yellow d scoloration pronounced 7 more than 50 / of the plants dead 9 all plant dead (very susceptible)

Material d d not germ nate or packs without seeds

Table 3 The effect of the age of the plant on the susceptibility to rice hoja blanca virus in nine rice varieties

Variety	10 days (/)[2/]	15 days(/)	20 days(/)	25 days( )
Bluebonnet	100	96	96	100
Balilla	92	96	92	83
IRAT 124	37	25	12	8
Fanny	33	21	4	4
Colusa	33	4	4	8
Blue Rose	21	4	4	0
Ory Llanos 5	17	0	0	0
Colombia 1	29	4	0	0

The age of ce plant at the inoculation with two virul ferous *Tagosodes orizicolus*
Percentage of the plantas that became infected with rice hoja blanca vi us

Table 4 Resistance of selected rice lines to RHBV in the field at 10 15 20 and 25 days post planting CIAT 1995

Line	RHBV Rating 10	15	20	25
Bluebonnet 50	9	9	9	9
O Caribe 8	9	9	9	9
CICA 8	9	7	9	9
Mudgo	9	7	9	5
CT8837	7	7	5	3
CT8008	7	7	5	5
Oryzica 1	7	3	3	1
IRAT 124	5	1	1	1
O Llanos 4	3	1	1	1
O Llanos 5	ng	3	1	1
Fanny	1	3	1	1
Colombia 1	1	1	1	1

RHBV Damage Scale 0 1 _ 1 / plants infected (very resistant) 3 2 10 / plants infected (resistant) 5 11 30 / plants nfected (intermediate) 7 31 60% plants infected (susceptible) 9 60% plants infected (very susceptible)

ng No germinación

Table 5 Prevalence of plants and *T orizicolus* infected with RHBV in various regions of Colombia during July Sept 1995 CIAT 1995

Region	Location	Variety	Insects Sampled(No)	RHBV Vectors (/)	
Cucuta		Oryzica 1	178	1 7	
Huila		Oryzica 1	89	0 0	
Huila		O Caribe 8	43	0 0	
Tolima	Ambalema	Oryzica 1	50	0 0	
		O Caribe 8	90	3 0	
		O Llanos 5	90	4 0	
		CICA 8	49	1 0	
		IR 22	61	0 0	
		IR 22	20	0 0	
		Oryzica 1	89	4 0	
		Oryzica 1	63	4 0	
		Oryzica 1	67	4 0	
		Oryzica 1	103	1 0	
		Oryzica 3	64	0 0	
		O Caribe 8	76	3 0	
		O Caribe 8	90	3 0	
		O Llanos 5	74	0 0	
		O Llanos 5	66	2 0	
VVC[2/]	Granada	CICA 8	178	3 4	
		Linea 2	178	3 3	
		O Caribe 8	178	4 5	
		O Caribe 8	178	2 2	
		O Llanos 5	90	5 0	
VVC	Puerto Lopez	CICA 8	178	9 5	
			CICA 8	178	5 0

Pe cent actual vectors determined by ELISA n the laboratory

V lla cencio

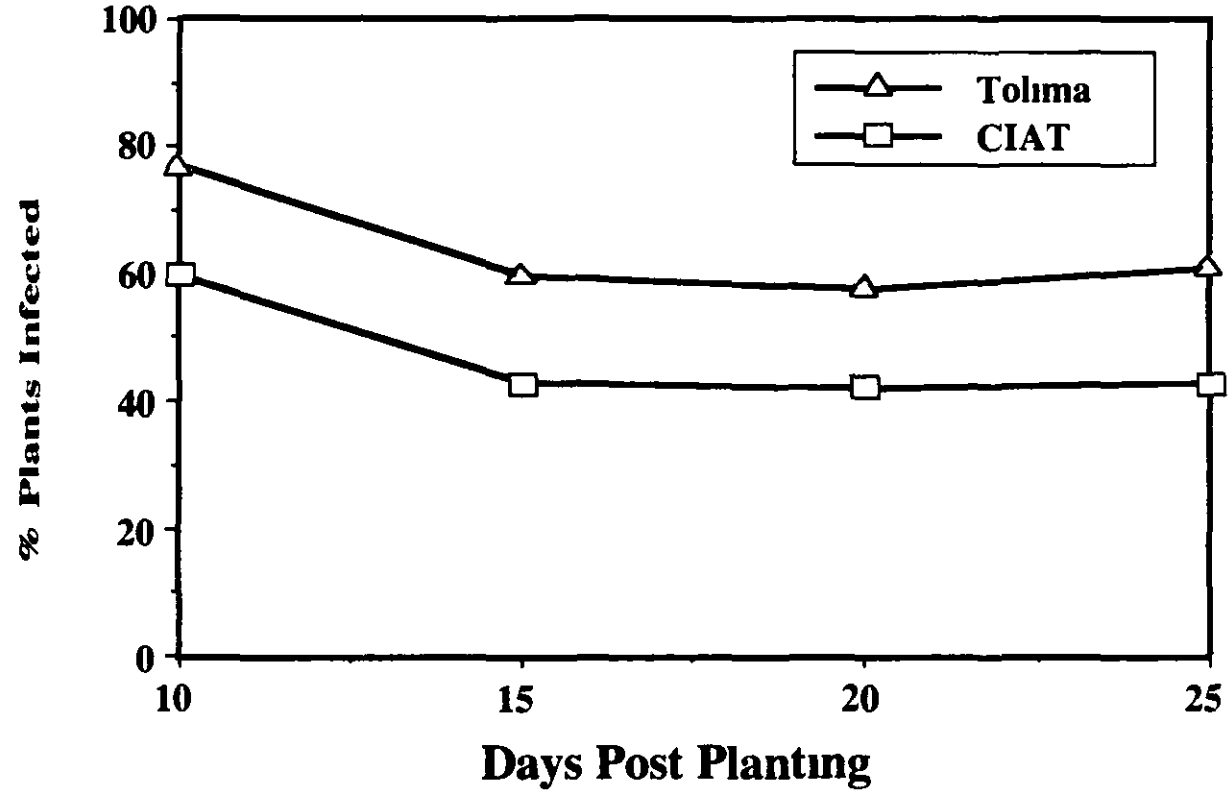


Fig 1 Effect of timing of RHBV infection on percentage of plants infected by RHBV Each point represents average response of nine varieties Plants were exposed to insects for 5 days and evaluated 15 days post inoculation CIAT 1995

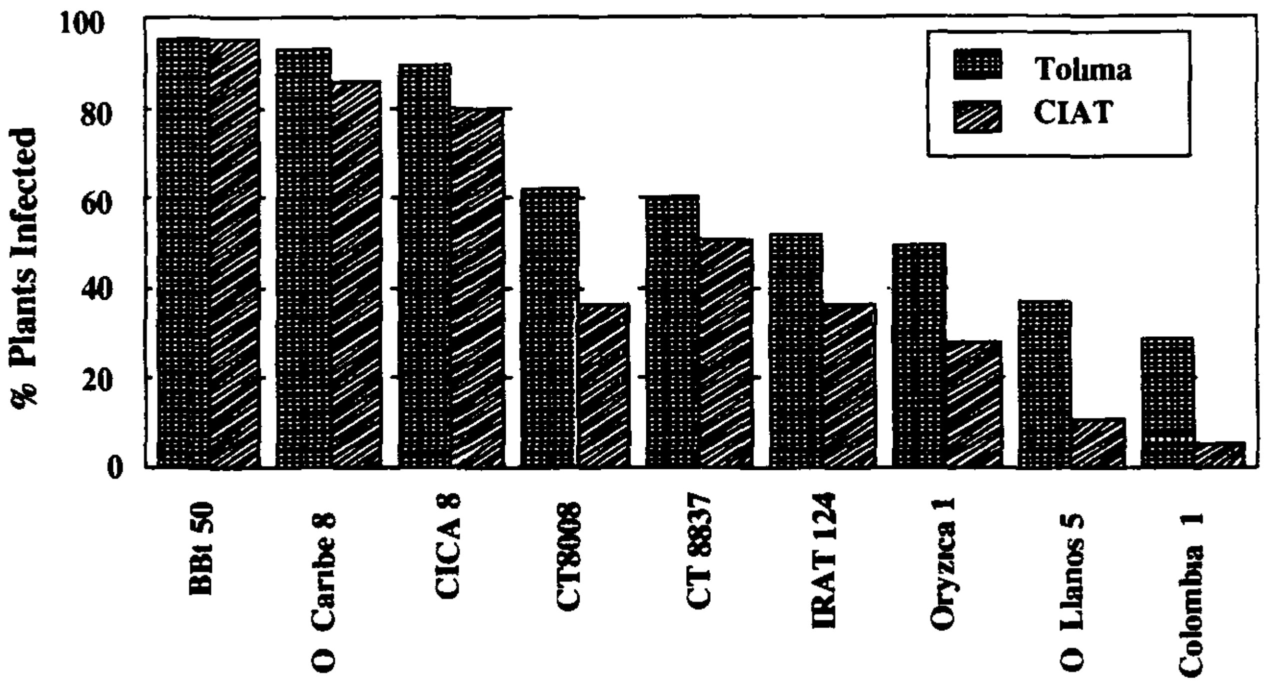


Fig 2 Response of 9 test lines to Tolima and CIAT *T orizicolus* RHBV vector/virus isolates Plants were exposed to insects for 5 days and evaluated 15 days post inoculation CIAT 1995

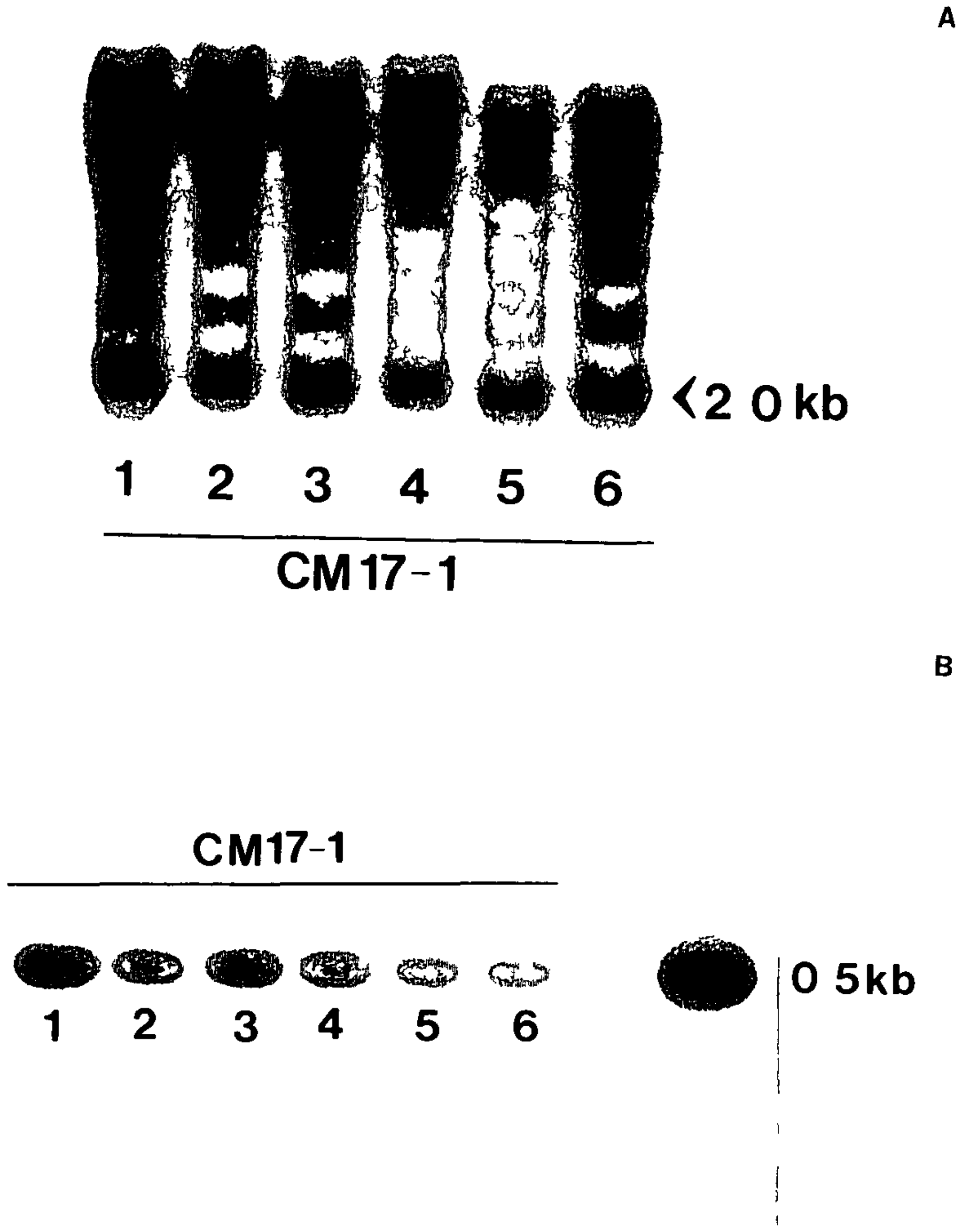


Figure 3 Hygromycin (hph) resistance gene detected in transgenic rice by Southern blot analysis at (A) genomic DNA and (B) PCR amplified gene fragment

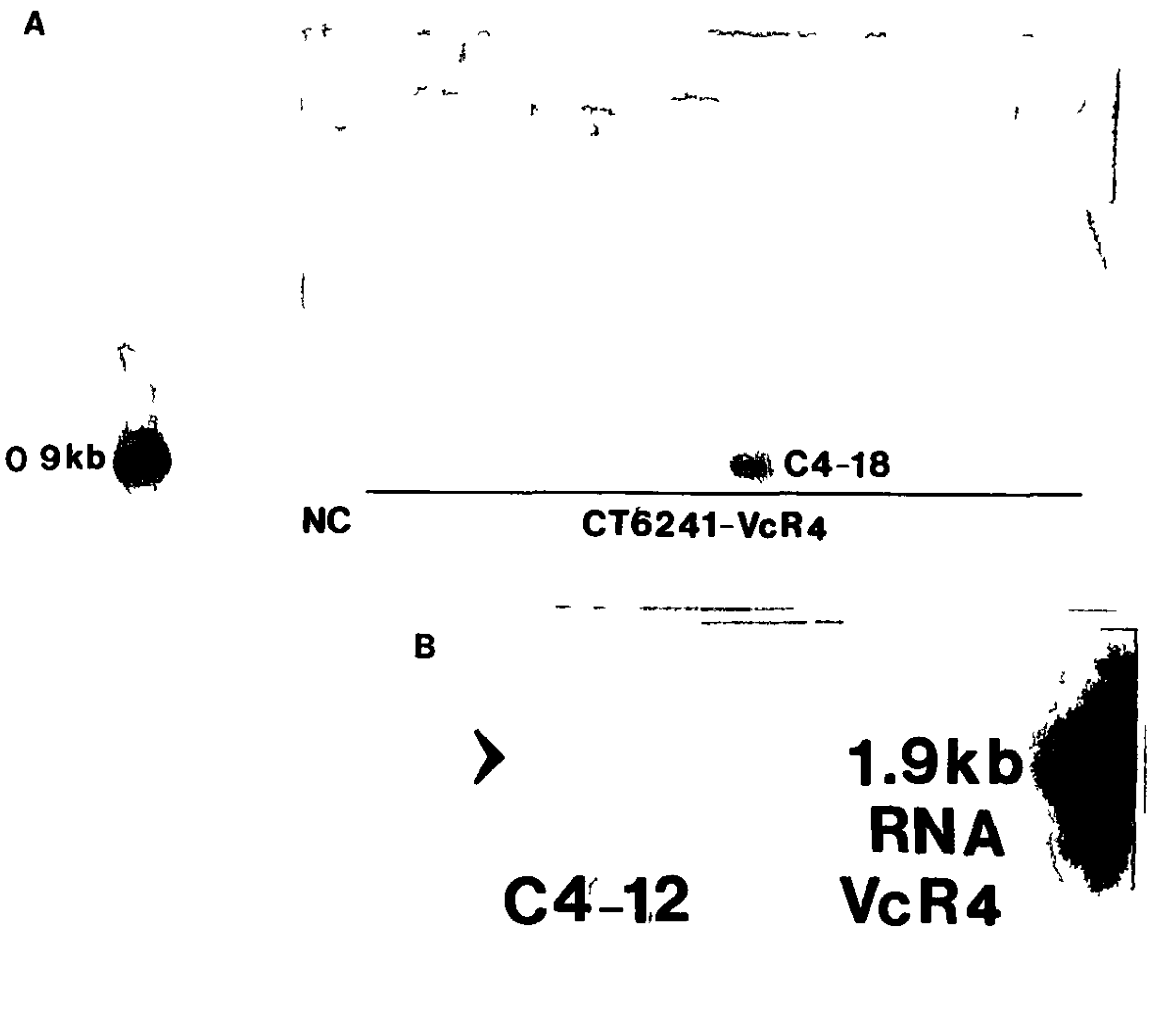


Figure 4 (A) Southern and (B) Northern blot analyses of plants recovered from RHBV NS4 bombardments

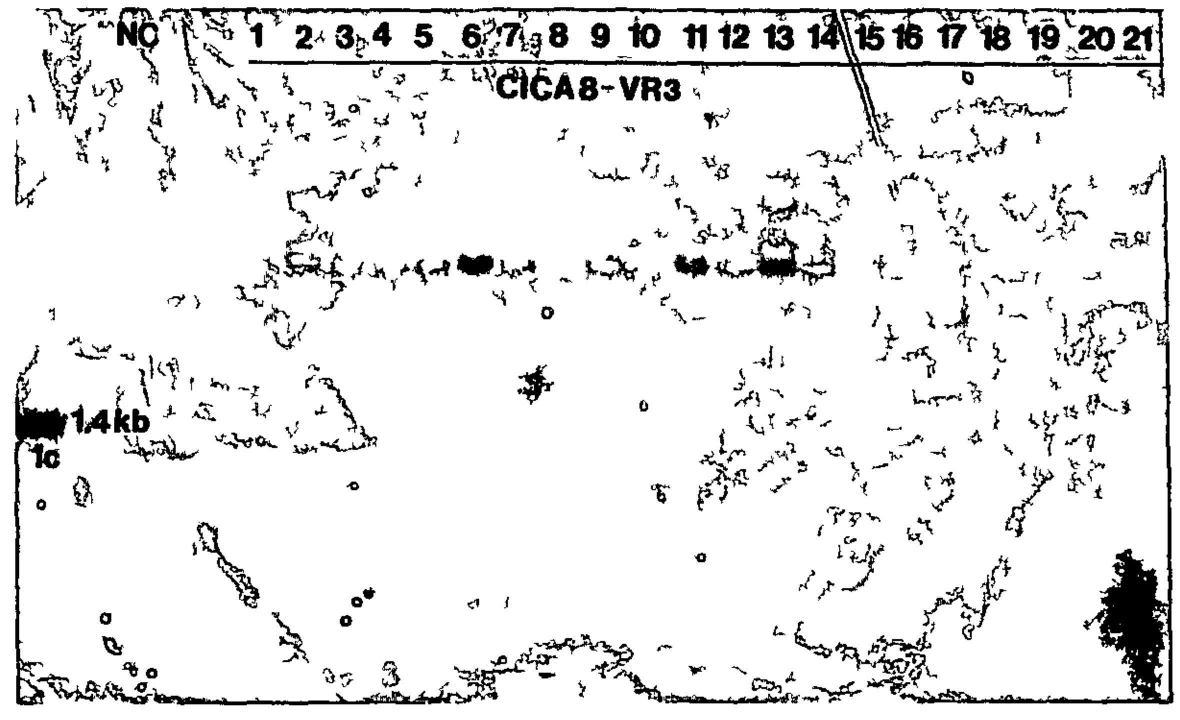


Figure 5 Southern blot analyses of putative transgenic plants containing the RHBV N protein

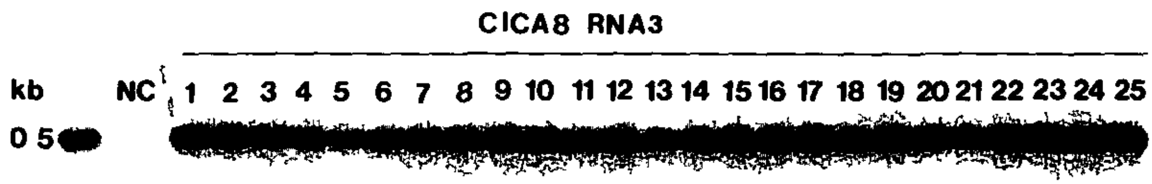


Figure 6 Southern blot analysis of hph PCR amplied fragment of putative transgenic plants recovered from RHBV N protein

105790

VI PROJECT 6
COMPONENTS FOR INTEGRATED PEST MANAGEMENT

PURPOSE

To reduce pesticide use and production costs increase production efficiency and narrow the yield gap in LAC

A ACTIVITY RP04 COMPOMENTS FOR INTEGRATED PEST MANAGEMENT

1 RESISTANCE TO PROPANIL IN POPULATIONS OF JUNGLERICE (*ECHINOCHLOA COLONA*)

SUMMARY

The buildup of propanil resistant *Echinochloa colona* biotypes in Colombian rice fields has been documented and is associated to the repeated use of propanil Dose response data previously collected were re interpreted using non linear regression and fitted to a four parameter logistic model which allowed to estimate GR_{50} values for seven *E colona* populations GR_{50} values for the least and most resistant populations were 0 37 and > 4 kg propanil/ha respectively HPLC studies with plant extracts from propanil resistant and susceptible plants showed that resistant plants were able to metabolically degrade propanil to a greater extent than susceptible plants However in 30 40 days old plants a different mechanism for resistance may prevail which could imply another possibility for cross resistance with other herbicides a realistic situation given that farmers in Colombia often spray propanil to heterogeneous *E colona* populations when young and older plants coexist An in vitro test was developed to assay samples of *E colona* leaves from the field this is an essential tool that will be used in the monitoring of resistance in Colombian rice fields within the framework of activities to be conducted by the newly created Task Force for Herbicide Resistance Monitoring in Colombia (part of COMALIFI the Colombian society for plant physiology and weed science) Future work should study the possible patterns of cross resistance and develop concepts to overcome the problem

INTRODUCTION

Echinochloa colona (L) Link junglerice is one of the most relevant weeds in tropical Latin American rice fields The intensive use of post emergence applications of propanil for more than 10 years to control selectively this weed in rice has resulted in increasing abundance of propanil resistant biotypes in junglerice populations (GARRO et al 1991 FISCHER et al 1993) Such biotypes showed different levels of resistance up to an eight fold increase (FISCHER et al 1993) Aryl acylamidase activity is responsible for the degradation of propanil to DCA in plants this hydrolysis occurs much slower in *E colona* (S) where propanil accumulates than in rice or R *E colona* biotypes organophosphate or carbamate insecticides can block this reaction resulting in rice and *E colona* (R) injury (YIH et al 1968 LEAH et al 1994 5) LEAH et al (1994 5) found that amidase activity and propanil metabolism in *E colona* decreases with age but resistance did not decrease as it would be expected the presence of a different mechanism of resistance to propanil was suggested

Identifying the fields where herbicide resistance has been developed knowing the proportion of resistant individuals in those fields as well as their levels of resistance is key for weed management The detection of resistance in the field often involves labour intensive and time consuming bioassay greenhouse studies (FISCHER et al 1993) Data interpretation from such experiments usually require non linear regression interpretation to fit logistic equations which provide biologically realistic regression parameters (STREIBIG et al 1993 SEEFELDT et al 1994 5) The use of ^{4}C labelled propanil has been successful in studies of uptake and metabolism of propanil (LEAH et al 1995) however the use of this technique is still somewhat limited in Latin America Therefore a quicker and safe to use tool for detecting and quantifying levels of resistance would be desirable for processing large amounts of plant samples collected in rice fields

The purpose of this study was to test an alternative procedure for detecting and monitoring the evolution of resistance to propanil in junglerice populations such assay should also serve to quantify the concentrations of propanil and its metabolites present in tissues of plants previously sprayed with a commercial rate of the herbicide allowing for further studies on the fate of propanil in older junglerice plants

Materials and methods

Levels of resistance in *Echinochloa colona* accessions In a previous study (FISCHER et al 1993) seven junglerice populations had been collected in Colombian rice fields with different histories of propanil use and subjected to dose response studies with propanil where the dry matter accumulation by plants sprayed with a range of propanil dosages was recorded Data from that study were re interpreted using non linear regression GR_{50} values were estimated using a four parameter logistic model (STREIBIG et al 1993 SEEFELDT et al 1994 5)

$$y=C+\{(D\ C)/[1+(x/G)]\}$$

where C = lower asymptote D = upper asymptote b = slope and G = GR_{50} dose estimate The upper asymptote was set as 100 in all cases since the dry matter accumulation is expressed as percentage of the untreated control value Regression analysis was conducted using the SigmaPlot statistical software

Propanil degradation HPLC studies HPLC assays were conducted with S and R junglerice plants (from accessions with the lowest and highest GR_{50} values respectively) at the 2 leaf stage and just before flowering (45 d a e) 24 hr after having been sprayed with 1 5 kg propanil/ha (in 200 l water/ha) in the greenhouse The plant extracts were prepared from 0 5g *E colona* leaves using 7 0 ml of 50 mM Tris HCl buffer (pH 7 0) and 2 ml 10 / trichloro acetic acid to stop the enzymatic reaction Samples were then homogenized at 4 C using mortar and pestle and 0 2 g quartz sand filtered through a Miracloth filter and centrifuged for 5 minutes at 5000 rpm Aliquots of the supernatant were analized immediately through HPLC A standard curve was prepared using 3 4 dichloropropionanilide (propanil)

Results and discussion

Levels of resistance to propanil The accessions collected differed markedly in their response to propanil rates (Figure 1) as shown by the corresponding range of GR_{50} values (Table I) of which those for accessions 2 and 5 were the extremes These two accessions would be sources of S and R plants respectively for the remaining studies reported in this paper The non parallel dose response curves obtained with accessions 2 (S) and 5 (R) (Figure 1) would suggest according to STREIBIG et al (1993) that resistance to propanil involved factors other than or in addition to a modification of the target site The logistic model used fitted some accessions better than others (Table I) for which poorer fits could partly be due to the theoretically heterogeneous nature of the individual genotypes within each accession (population) which may somewhat differ in their response to propanil

HPLC assays When young (2 to 3 leaf stage) junglerice plants were treated with propanil and assayed 24 hr after the propanil concentration in R plants was 80 / lower than in S plants (Figure 2a & b) Concomitantly an increase in the levels of other substances presumably propanil metabolites and their conjugates (YIH et al 1968 LEAH et al 1994 5) could be clearly differentiated in R plants such peaks were notoriously lower in S plants (Figure 2b) When older plants (just before flowering) were assayed no differences in propanil levels could be observed between R and S plants 24 hr after propanil application (Figure 2c & d) This agrees with LEAH et al (1994 5) who found slower rates of propanil metabolism and aryl acylamidase activity in 30 day old plants with no decrease in resistance suggesting that a different mechanism may be involved in conferring resistance to propanil at this stage

Table 1 Propanil rates for 50% growth reduction of seven *Echinochloa colona* accessions and the coefficients of determination of the regressions used to estimate them (Doses de propanil reduisant de 50 % la croissance de sept populations d *Echinochloa colona* et coefficients de determination des regressions utilisees pour les estimer)

Accession #	GR_{50}	R^2
1	0 53 (0 02)	0 99 [2]
2	0 37 (0 02)	0 99
3	0 78 (0 05)	0 98
4	1 71 (0 25)	0 98
5	> 4[3]	0 89
6	3 37 (2 62)	0 79
7	2 22 (2 62)	0 79

Values in parenthesis are standard errors of the estimate

P 0 5 P 0 01

L es outs de the range of dosages stud ed

Conclusions

The logistic model provided a better fit to the data than the log polynomial approach used earlier (FISCHER 1993) The HPLC assay seems adequate to detect resistance from field samples establish the proportion of resistant genotypes in a weed population and quantify their levels of resistance This technique can substitute for time and labour consuming pot bioassays and does not require the handling of radioactive material

The presence of an additional mechanism of propanil resistance is of concern given that farmers often spray propanil onto fully grown junglerice plants This implies a stronger selection pressure which could also represent an additional opportunity for cross resistance More studies are required to clarify the nature of this additional resistance mechanism

Acknowledgements

The authors wish to acknowledge the support of AgrEvo Bogota Colombia who kindly provided analytical grade propanil for this study

References

FISCHER A J E GRANADOS and D TRUJILLO 1993 Propanil tolerance in populations of junglerice *Weed Sci* XCI 201 206

GARRO J E de la R de la CRUZ and P J SHANNON 1991 Propanil resistance in *Echinochloa colona* populations with different herbicide use histories *Proc Brighton Crop Protection Conference* 8A XI 1079 1083

LEAH J M J C CASELEY C C RICHES and B VALVERDE 1995 Age related mechanisms of propanil tolerance in jungle rice *Echinochloa colona* *Pestic Sci* XCIII in press

LEAH J M J C CASELEY C C RICHES and B VALVERDE 1994 Association between elevated activity of aryl acylamidase and propanil resistance in jungle rice *Echinochloa colona* *Pestic Sci* XCII 281 289

SEEFELDT S S J E JENSEN and E P FUERST 1995 Log logistic analysis of herbicide dose response relationships *Weed Technology* IX 218 227

SEEFELDT S S D R GEALY B BREWSTER and E P FUERST 1994 Cross resistance of several diclofop resistant wild oat (*Avena fatua*) biotypes from the Willamette Valley of Oregon *Weed Sci* XCII 430 437

STREIBIG J C M RUDEMO and J E JENSEN 1993 Dose response curves and statistical models p 30 55 *in* J C Streibig and P Kudsk eds Herbicide Bioassays CRC Press Boca Raton FL

YIH R Y H McRAE and H H WILSON 1968 Mechanism of selective action of 3 4 dichloropropionanilide *Plant Physiol* XCV 1291 6

Figur 1 Response curves of seven *Echinochloa colona* accessions to propanil doses (courbes d r ponse de sept populations d *E. colona* a des doses croissan es de propanil)

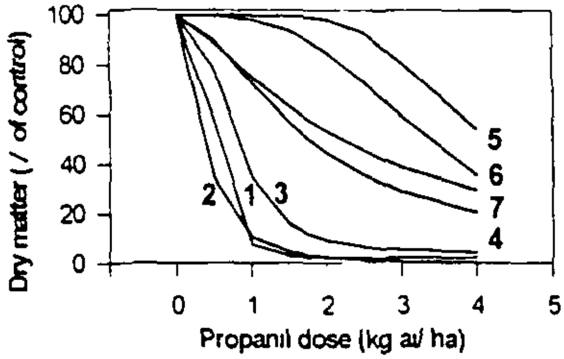
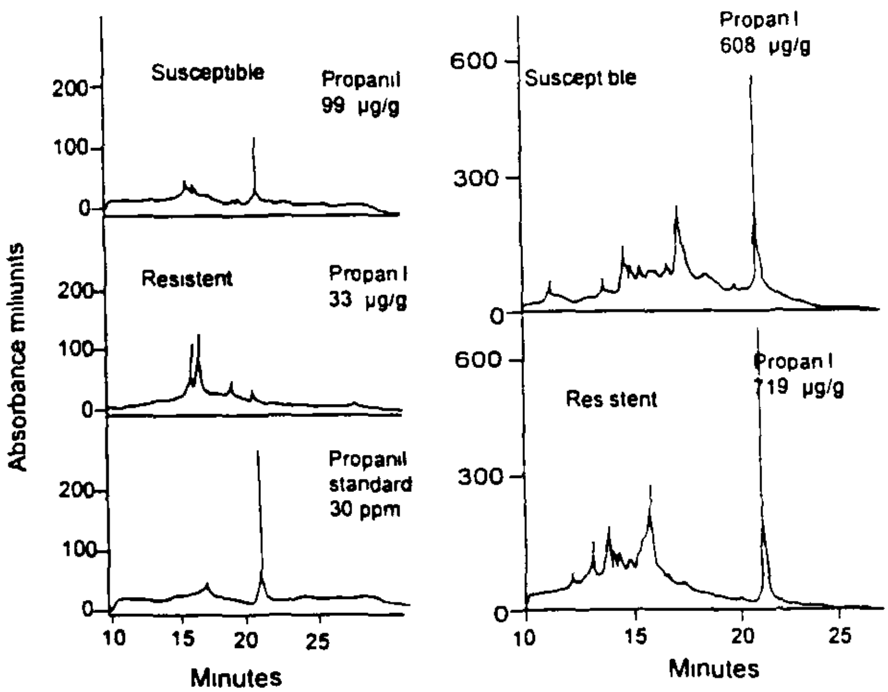


Figure 2 Chromatograms of *E. colona* leaf extracts after spraying young (a & b) and old (c & d) plants with propanil (chromatographies d'extraits foliaires de plantes jeunes (a & b) et adultes (c & d) d'*E. colona* apres traitement avec du propanil



2 WEED POPULATION ECOLOGY WITHIN PROTOTYPE CROPPING SYSTEMS FOR THE COLOMBIAN LLANOS

SUMMARY

Weeds are a problem when cropping systems replace degraded savannas in the Colombian Llanos Criteria should be developed to deal with this factor in a sustainable manner At the same time if the presence of adventitious species can be related to parameters of resource base degradation or enhancement then such species can serve as indicators of sustainability With these objectives a weed population dynamics study was initiated in 1994 within the prototype cropping systems being conducted at the Matazul farm Meta A multi variate approach (Canonical Discrimination Analysis) was used to relate weed populations with variables in the prototype cropping systems The species composition within populations of adventitious plants varied according to crop rotations and associations (intersown pastures) tillage and crop residue incorporation methods and soil nutrient levels Some species particularly those appearing in low frequencies (suggesting a narrow range of adaptability) appeared strongly associated with specific variables showing potential for use as indicator species The challenge ahead would be to understand the ecophysiological bases for such responses

RATIONALE

This is a progress report on the data analysis from a study seeking to study the population dynamics of adventitious species within prototype cropping systems in the Colombian Llanos as affected by crop intensification and patterns of resource base availability

PROCEDURE

The mothodology was outline in the 1994 Report of the Tropical Lowlands Program data from three experiments is presented here a) *Rice after soybean* after three years of fallow rice is planted followed by soybean in the second semester of 1993 in 1994 rice was sown alone (17 cm rows) or in mixture with pasture species (34 cm rows) b) *Residue Incorporation* after native savanna rice was planted following different methods for incorporating the savanna residues *Phosphorus rates* and d) *Ca Mg and K levels* Species composition within weed populations were expressed using a synthetic value Relative Abundance (RA) which is the average of a species relative density and relative frequency The RA values were used in a Canonical Discriminant Analysis (CDA) relating species composition of weed communities to the diverse experimental treatments Total canonical coefficients for each species represent the strength of association between a species and a given treatment

RESULTS

Rice after soyben experiment When weeds were surveyed 48 days after emergence (dae) and at rice harvest all species except for *Axonopus purpusii Paspalum minus* and *Hyptis* sp were excluded by stronger rice competition under narrower rowsand perhaps lower fertility in the rice only plots

Residue incorporation experiment The no till drastically altered species composition of the weed communities with respect to the other practices for residue management At harvestime species associated with no till were *Juncus dichotomus* *Gymnopogon folisus* and *Juncus bufonius*

Nutrient levels The effect of nutrient levels in the soil on the species composition of the weed flora was studied in all experiments Species showing strong association with high or low levels of a nutrient appeared in general at low frequencies indicating a narrow range of adaptation and thus potential for use as indicators of fertility if their behaviour is consistent across experiments and seasons According to our CDA analysis some of those species have already appeared associated with the same nutrients (and levels) in more than one experiment as is the case of *Hyptis* sp (low P) *Juncus dichotomifolius* (high P Fe Mg) *Croton trinitatis* (high Mg and Ca) and *Colocasia esculenta* (low Ca)

In the long term besides establishing associations between weeds and crop management variables as well as with nutrient levels the challenge ahead is to attempt to understand the ecophysiological bases for such associations thus being able to extrapolate conclusions beyond the working environment

103791

VII PROJECT 7
COLLABORATIVE ACTIVITIES AMONG CIAT PROGRAMS

PURPOSE

To exchange the region s and the world s elite rice germplasm as well as relevant information foster institutional collaboration among LAC national programs and train them in effective use of new technologies

A ACTIVITY ERF01 THE LATIN AMERICAN IRRIGATED RICE FUND FLAR

SUMMARY

As a result of the announced strategic changes CIAT received support from several national programs to create a Latin American irrigated rice fund (FLAR) mainly supported by the private sector and IARCs that could ensure continuity in rice research activities at the regional level Four countries (Brazil Colombia Uruguay and Venezuela) and three institutions (CIAT IRRI and IICA) signed the act that created FLAR in January 1995 A breeder has already been contracted under this arrangement and started part time activities in the second half of 1995

In the meantime countries of the Caribbean had been actively seeking funds to reactivate their rice network Early in 1995 the European community allocated indicative funds under the Lome IV program to support the Caribbean Rice Industry Development Network (CRIDNet) which is schedulled to start in December 1995 This network will be managed by the recently created Caribbean Rice Association (CRA) that gathers private and public institutions from the region at the levels of production milling distribution and research CIAT is a member of CRA and of CRIDNet s Technical Advisory Committee During 1995 TAC met on three occasions More recently the Central American countries have also taken the initiative to form a regional rice research fund similar to FLAR

The processes of private sector involvement in regional rice research have a strong dynamism and clearly show that Latin American rice producers are aware of the value of innovation and of new technologies These processes can be more successful and stable if an independent suitable and credible organization like CIAT also gets involved For CIAT there is a legitimate role to play as convener and catalyzer The remaining of this decade should see the consolidation of this innovative model

CIAT s Rice Program experienced a drastic strategic change in this decade The Program has been reduced from 8 0 Senior Staff (SS) positions and a total of 14 0 principal staff (PS) positions in 1991 to its current level of 4 7 SS or 7 2 PS by mid 1995 For 1996 there are only 3 7 core SS in CIAT s budget

As a result of the announced strategic changes CIAT received support from several national programs to create a Latin American irrigated rice fund (FLAR) mainly supported by the private sector and IARCs that could ensure continuity in rice research activities at the regional level Four countries (Brazil Colombia Uruguay and Venezuela) and three institutions (CIAT IRRI and IICA) signed the act that created FLAR on January 16 1995 A breeder has already been contracted under this arrangement and started part time activities in the second half of 1995

FLAR agenda in 1995

There were two meetings of the Technical Advisory Committee one in Porto Alegre Brazil in March and the other at CIAT in August The objective of these TAC meetings was to design a plan that will be executed by the new breeder selected by FLAR (Dr James Gibbons) in coordination with breeders from member countries (Brazil Colombia and Venezuela)

The discussions were centered around two main topics

themes of interest and their priorities
germplasm flows

Priorities In previous consultancies and meetings diseases had been established as a top priority for all members (mainly blast and rhizoctonia) It was decided that research topics that were specific only to the tropics or to the temperate zones were not going to be in FLAR s domain Therefore FLAR was not going to conduct activities in those areas Population development was determined to be the main focus of the breeder

After some discussion it was decided that the breeder will have to address priorities in each ecosystem with tropical as well as temperate targeted activities and that initially he will have to do several specific crosses that require a complete screening of the germplasm for the main traits desirable to each zone This is a major detour from the original plan

Breeding objectives are very similar in all member countries within each ecosystem For the tropics together with quality issues the main aspects are Piricularia Hoja Blanca and Sogata CIAT has a strong presence in all three areas In the temperate areas quality is a major concern as are problems of iron toxicity cold tolerance and straight head These problems are not as well known and will require specific additional actions to supplement our knowledge

Germplasm flows The complexity of the issues requires the flows be divided by ecosystems and specific problems

1 Tropical region

F1 The similarity of the programs makes it possible for Gibbons to plan and make several crosses at CIAT

F2 Evaluate at Santa Rosa for diseases and at CIAT for quality CIAT will put its quality lab at the service of these activities under the guidance of Dr Gibbons The lab is used by INGER as well as by CIAT's upland breeding program

F3 Send material to the country of interest for screening and evaluation

F4 Send back to CIAT for quality and to Santa Rosa for Blast HBV Sogata

F5 and on In the country that is interested in the line

F6 May be introduced in INGER nurseries provided FLAR members agree

2 Temperate region

The flow is more complex Brazil has a very active crossing program The tropics may be used to advance materials faster by having a continuing cropping season that alternates with the September April season of the South The cumbersome quarantine requisites in Brazil may make this schedule enviable A site in the Center West (Formosa in Tocantins) may be used for this purpose The FLAR breeder may also do some crosses on demand or on his own for that region

F1 In CIAT and in Brazil

F2 CIAT for quality Santa Rosa for blast This flow will have to be considered on a case by case basis given the extreme conditions of disease pressure in Santa Rosa

F3 Iron evaluation in Santa Catarina (with Richard Bacha and Takazi) IRGA has to explore this possibility additional resources will have to be channeled into Santa Catarina for that job

F3 Straight head evaluation in Argentina Cold tolerance

F4 Quality evaluation at CIAT

F5 on At country of interest

F6 May be introduced in INGER nurseries if FLAR members agree

Countries will send a list of materials that will have to be planted in the field during this semester to be used as progenitors for crosses in the first semester of 1996 They will be characterized at CIAT for quality (amylose gelatinization) HBV Sogata and Blast

Countries felt that a training session at CIAT for blast screening and characterization is highly strategic and recommendable The ideal training is one where a participant from each member country comes to CIAT for two months (April and May 1996) Funds have been approved for a Brazilian trainee Dr Habich Director of CIAT s Institutional Relations Division believes that there will be additional funds for that activity for the representatives from the other 3 4 countries

The FLAR breeder received lists of material from breeders of member countries (and seeds if they are not available in our germplasm bank) during August to characterize them for cooking and milling quality They were planted in Palmira to use them as progenitors during first semester of 1996 The next step is to coordinate flows within Brazil and be tween Brazil and Argentina

B Other Activity CRIDNET

The new Caribbean Rice Industry Development Network (CRIDNet) report of progress in 1995

At the 1994 Centers Week meeting CARDI officials approached CIAT s management (R Havener and W Scowcroft) to explore future steps towards the revival of CRIN the conversations were immediately followed by an invitation to CIAT to participate in a Workshop that would take place in Guyana Feb 20 21 1995 CIAT responded confirming the presence of staff members at the workshop

The workshop organized by CARDI had participants from four Caribbean countries (Guyana the host country Trinidad and Tobago Belize and Barbados) A representative from the Cuban Embassy was also present during the last session Other five countries that had been invited could not attend the Dominican Republic Surinam Haiti Jamaica and St Vincent

CRIDNet has been making good progress based mainly on the continued efforts of CARDI and the CRA CIAT has officially joined CRA and has also been appointed as a member of CRIDNet s TAC TAC s objectives are to define policies strategies and modi operandi for the implementation of the CRIDNet project It will also approve annual budgets and work plans and will review the progress reports prepared by the national programs and compiled by the network coordinator IRRI was also invited to a workshop in Trinidad last April and its presence was most welcome by all members given the role that they can play in strengthening the network particularly through training

CRIDNet will start to receive funds from the European Union by December 1995 At that time CRIDNet will also join FLAR at least to participate in the INGER activities with a flat annual group quota of US$50 000 The variable quota of about US$30 000 per year (based on a production of some 2 million metric tons) may also apply if CRIDNet decides to support FLAR s breeding activities in Colombia This later contribution will have to be discussed and approved by TAC

Recommendations from the working groups

The main recommendations with respect to institutional aspects were that

1 The new network will be called Caribbean Rice Industry Development Network or CRIDNet
2 CRIDNet will be planned to go beyond the two year funding offered by the EU
3 The network will work on the following subjects production milling distribution product development concern was raised as to the need to set clear and reason able workplans based on consensus of priorities and on funds available
4 Germplasm activities should start right away The GRDB offered testing of CIAT lines at Guyana starting as soon as possible
5 The issue of information and the distribution of the network newsletter can also start right away In this sense CARDI offered to make available to the network the CTA services from the EU Lome convention on information
6 CARDI will follow up on informing other countries of the region on results of the workshop and will invite them to participate in CRIDNet
7 After that the Steering Committee will be set up with the possible chair of the CRA to start working in the action plan
8 The seed production problems of Trinidad and Belize will also be top priority in the agenda of the group

The aspects of drying storage and milling are among the new interests to be covered by CRIDNet With respect to those points the workshop made the following recommendations

1. Start with a diagnosis of needs in drying capacity Hire an specialist for training staff on data collection at the mills The objective is to reach optimal operations of the mills
2. *Study* the various aspects of paddy storage pest management structure size aeration etc
3. Milling equipment information efficiency
4. Polishing how many polishers how to set them up etc
5. Packaging brands consumer preferences marketing
6. Standards most are USDA in the region Revise them to make them more practi cal
7. Market information shipping costs stocks costs of competitors etc
8. Information on trade policies and their effects
9. Food security and the role of rice
10. Databases for each country with a common protocol
11. Alternative uses of rice participate in US network on the subject

A Technical Advisory Committee (TAC) for CRIDNet was formed comprising the major rice producing countries (Guyana Trinidad Suriname Belize Dominican Republic Haiti) and of international institutions involved in rice research activities in the region (CARDI CIAT IICA IRRI) TAC will report to the CRA and was appointed for two years Mr Harri Persaud from Guyana was named Chairman of that Committee In the first meeting of TAC it was agreed that the summaries of the three working groups (germplasm post harvest and institutional aspects) were *going to be circulated* for comments by mid June and a subsequent meeting will be scheduled to refine the program for CRIDNet

One important decision from working group one (germplasm) was to recommend that CRIDNet should support the CIAT/FLAR initiative To this end there was a meeting of Hayden Blades (CARDI) Glenn Denning (IRRI) Azim Hosein (CARDI) and L Sanint (CIAT/FLAR) to discuss the FLAR initiative in detail As a result of that meeting Azim Hosein and I prepared a detailed breakdown of costs for INGER and for FLAR s breeding activities CRIDNet will participate at least in the INGER initiative with a base contribution (equivalent to a group "fixed quota) of US$50 000 per year If TAC considers also convenient for the network they will participate in FLAR s breeding activities contributir with the portion of the variable quota which is around US$30 000 per year (based on a regional production of some 2 million metric tons) (See Annex C)

Some guidelines to strengthen CRA These ideas have been shared with both CARDI and GRDB staff on their request given our experience in setting the Latin American Irrigated Rice Fund (FLAR) To have a stable and representative Caribbean Rice Association it is important to set out some basic principles In the decision making process all members in the Steering Committee and in the Technical Advisory Committee should have equal power *one member is equal to one vote* CRA should have the capacity to raise sufficient funds from members to ensure the continuity of CRIDNet through the contribution of matching funds from the EU Lome IV loan This implies that CRA should be able to raise some US$200 000 to have the minimum critical mass in the project Several principles can be applied to simplify the fund raising process

a Contributions should be set a the country level each country member has to contribute a certain amount of money irrespective of who is participating within the country Membership becomes a national rather than a regional issue each country designates the representative institution to CRA and that institution has to decide who joins and how much each member pays to raise the country quota *Country participation in CRA should not be compulsory*

b Contributions should keep some *congruency with the capacity of each country to produce* mill and distribute rice In this sense the basic quota can be composed of a fixed amount plus a variable amount that is congruent with the volumes of operations in the country in terms of production milling and distribution The underlying principle is that countries with more rice activity benefit more from CRIDNet activities than countries with small rice operations Projects have some central activities that are mainly in breeding and other activities that are executed in the participating countries Projects will have to be designed so that for in country activities *participation is proportional to the respective quotas of each country*

c Special provisions have to be designed to *allow the participation of international institutions in the new network* (CARDI IICA CIAT IRRI etc) and establish guidelines for quotas participation in the decision making process etc

CRA and CRIDNet In CIAT s opinion *CRA must undertake full responsibility for the CRIDNet project* A strong CRA that can assume both the responsibility and the control of the project is the real basis for a sustained and stable network Given that the EU project makes provision for a two year lead in period (when collateral money is not required for the network) and that the project will have to be formalized during 1995 *CRA has three years to gain the sufficient maturity* infrastructure and expertise to warrantee the continuity of the project By next year CRA should be in a position to manage by itself those aspects of the project that are fundamentally executed in Guyana In the first two years of the project the main activities are those related to germplasm exchange and evaluation (lines and varieties coming from outside of the region or from within the region to be distributed to member countries) and to breeding which are basically executed in Guyana They are conducted by the network coordinator who should be a breeder and by the Guyana Rice Development Board (GRDB) which even offered to start with germplasm work right away in the first semester of 1995 The germplasm component is an expensive part of the project for which the CRA can provide the required secretariat activities while charging 15 / to cover overhead costs of the project A reasonable cost for the germplasm component of the project is at least US$350 000 per year which would bring US$52 500 to CRA for its administration Towards the future it is most important that CRA can raise their own funds to finance in part the cost of the network The contribution from CRA can be presented as seed capital to donor agencies which can typically match every dollar from industry with one dollar (as the EU proposes) or even two dollars from themselves The interesting point here is that CRA can recuperate part of the contribution by charging overhead costs for managing the project money would go from one pocket to the other *with this arrangement CRA comes out stronger*

CARDI and CRIDNet For certain CRIDNet projects of wide international coverage there are two important considerations

Given the language disparities projects that involve intensive human participation and intercollaboration should be *restricted to English speaking participants* This requisite implies that few if any participation from the Dominican Republic Cuba or Haiti would take place in this type of projects The principle for cost effectiveness and efficiency should be an anglophone based operation while non english speaking countries can link to CIAT s activities and projects of similar topics for South and Central America

These are the activities where contracting the Secretariat activities with CARDI at the offered rate of 15 / will be advantageous for both CRA and CARDI Typically these activities relate to crop management information and databases market development training trainers etc A significant part of these activities will be directly executed by CARDI staff

CARDI has wide coverage of the region with offices in 13 of the Caribbean countries where they work in close collaboration with National Programs The Center have a valuable capacity in the field of information management and dissemination including socioeconomic support as well as in training trainers CARDI is also involved in 14 commodity networks that are administered on the basis of a single secretariat that way *CARDI reduces costs by achieving economies of scale* CARDI has good experience managing and implementing projects These strengths qualify CARDI as a top institution to provide back stopping capabilities in the administration of *certain aspects* of the CRIDNet project Note that I emphasize the words certain aspects since the Guyana based germplasm activities do not benefit from CARDI s advantages while CRA can administer those activities easily and cheaper

CARDI has provided back stopping during 1995 to identify main activities of the network and establish priorities so as to be in a position of reaching a consensus among participants with respect to the contents of the project It is important that CRA could contribute some funds to CARDI to complete this initial phase to gain a sense of ownership in the process and should be closely involved in the process to be coordinated by CARDI CARDI experience in project handling can be most valuable in presenting the project to CARIFORUM

CIAT and CRIDNet Given the regional mandate for rice research in Latin America and the Caribbean CIAT constitutes the link with IRRI and with the rest of the world rice research community CIAT is currently coordinating INGER LAC operations for the region while sustained funding is found for that vital network CIAT sent some 700 rice lines from INGER nurseries to be evaluated in Guyana during 1995

CIAT has provided scientific specialized training to four persons involved in rice activities in the Caribbean to strengthen the capacity of the region to implement network projects This training took place at CIAT it lasted three months Given the commitment made by Guyana to host the network trainees from this country will receive top priority

CIAT also participates in the Technical Advisory Committee of CRIDNet and will be available for advise to the Steering Committee when requested to do so Given our past experience within the activities of the previous CRIN CIAT can join forces with CARDI and IICA to conduct training of trainers activities in the framework of CRIDNet activities CIAT can become an institutional member of CRA if we are invited to join

CIAT s specialized infrastructure and human endowment can be contracted by CRIDNet to conduct rice research CIAT has a notable record of success and high quality in rice research biotechnology training and other activities relevant to the Caribbean that can serve the research purposes of the network

C Activity RL53 INGER LAC HIGHLIGHTS 1994/95

GERMPLASM EXCHANGE

Nursery Distribution Germplasm and information exchange are key components of INGER It is possible to evaluate a national program s participation by its interest in sharing the results of the local evaluations Last year after a great effort the network s coordination achieved almost 55 / data return but in 1994/95 the level dropped again to 47 5 / a percentage a bit higher than the last 5 years average (Table 1)

Table 1 Distribution of observational nurseries within INGER Latin America 1990 1994

Year	Number of nursery		Received
	Dispatched	Data received	/
1990	102	45	44 1
1991	86	32	37 2
1992	100	32	32 0
1993	81	44	54 3
1994	99	47	47 5
Total	468	200	42 7

The reasons for low percentage of nursery data return in 1994 were

a Late planting (in 18 nurseries)
b Quarantine related problems (8)
c Changes of coordination in national programs (6)
d Loss due to drought (1)
e Data return lost in the mail (1)
f Unidentified reasons (18)

Records show that some countries frequently request nurseries but seldom plant them or share the data with others As INGER LAC struggles for resources to continue working in the region it becomes clear that nursery dispatch should be determined not only by its potential benefit to the requesting country but also by the country s interest in sharing information and germplasm Perhaps members who routinely share germplasm evaluation and data should receive preference for seed shipment over less responsive locations

Nursery Composition The network has only one observational nursery (VIOAL) but there are several possible combinations of lines that the countries can request (Annex 1) Within this VIOAL there are two types of germplasm one for irrigated and favored upland conditions (mainly indica lines) and the other for upland acid soils (japonica lines) The network has been monitoring the composition of these two sets of lines (origin of the lines) in order to keep a "fear" balance between the different germplasm sources

Table 2 shows that the number of lines provided by the NARS for irrigated and favored upland conditions has decreased since 1992 Perhaps NARS have not continued providing lines to INGER LAC because they think its future is uncertain and it may be phased out Perhaps the quality of the materials provided does not meet the minimum standards or perhaps it is just a temporary phenomenon

Table 2 Origin of germplasm for irrigated and favored upland conditions included within INGER Latin American nurseries 1990 1994

	1990		1991		1992		1993		1994	
Origin	Line	/	Line	%	Line	/	Line	%	Line	%
CIAT	36	26 7	92	58 2	43	27 4	60	37 0	50	32 0
Asia	16	11 9	25	15 8	14	8 9	26	16 0	51	32 7
NARS	83	61 4	41	26 0	100	63 7	76	47 0	55	35 3
Total	135	100 0	158	100 0	157	100 0	162	100 0	156	100 0

In 1994 the set of lines for irrigated and favored upland conditions included for the first time an even number of lines from NARS Asian breeding programs and CIAT which could be a desirable balance However in the last 3 years neither NARS nor other international programs contributed to the acid soils germplasm except 9 4 / from Africa in 1992 (Table 3) Efforts have been made to revert this trend the 1995 set already has lines from WARDA and CNPAF/EMBRAPA

Table 3 Origin of germplasm for acid soils included within INGER Latin American nurseries 1990 1994

	1990		1991		1992		1993		1994	
Origin	Line	/	Line	/	Line	/	Line	/	Line	/
CIAT	31	73 8	44	78 6	48	90 6	46	100	46	100
Asia	3	7 1	5	8 9	0	0	0	0	0	0
Africa	1	2 4	6	10 7	5	9 4	0	0	0	0
NARS	7	16 7	1	1 8	0	0	0	0	0	0
Total	42	100	56	100	53	100	46	100	46	100

Nurseries 1994

A total of 99 sets were requested and dispatched to 16 countries in LAC in 1994 71 of these were for favored conditions Data of 47 nurseries were returned to INGER s coordination giving a return rate of 47 5 / a percentage a bit higher than the average of the last 5 years Of the 47 sets received 11 correspond to evaluations carried out with germplasm for acid soils

The VIOAL 1994 rice germplasm for favored conditions was planted in 36 locations in 12 countries of the region Twenty six locations reported use of the materials On the average in each site 60 5 lines were planted and 17 3 were selected that is 28 6 / of the materials The analysis of the data received shows that six lines[1] were the most popular of the group they were selected in more than 40 / of the locations where they were planted Their yield potential was similar to that of the checks CICA 8 (6 2 t/ha) and Oryzica 1 (5 8 t/ha) It is worth noting that a sister line of the crossing CT9682[2] which incorporated African genes to the Latin American rice genetic base was selected in Palmira and in Villavicencio for more than 13 participant institutions in the I Workshop of Evaluation and Selection of Rice Germplasm for the Tropical and Subtropical Zones of Latin America and the Caribbean Similarly two lines of the crossing CT9506[3] presented outstanding performance because of their earliness and high yield potential (7 7 and 7 1 t/ha) Two lines of this same crossing were the most popular and had highest yield of the group in the VIOAL 1993 (INGER Latin America Report 1994)

Seven lines were selected for crossings in Monteria and Bosconia (Colombia) four lines in Treinta y Tres (Uruguay) and eight lines in Tocumen and Rio Hato (Panama) Of these CT9506 12 10 1 1 M 2P M mentioned above stands out for its earliness and for having the highest yield

As for the material for acid soil conditions only 11 sites sent in data of evaluations for the 28 sets that were dispatched 9 of these indicated use of the materials This nursery included 46 lines an average of 12 9 were selected which is equal to 28 / of the material The most important lines were CT11626 2 5 M M and CT11251 7 2 M 1 M M with yields of 3 9 t/ha each The checks Oryzica Sabana 6 and IRAT 216 yielded 3 9 and 3 1 t/ha respectively A line of the crossing CT11620 and two of the CT11614 also showed good performance in the VIOAL Acid Soils for 1993 The tee lines of the crossing CT11891[4] included in the nursery were selected for crossing in Bosconia FEDEARROZ Colombia

---

1 CT9682 2 M 14-1M 1 3P M
CT6163 8 9 5-2 M 84 M
CT6163 8 9 5 2 M 85 M
CT9868 3 2 3 1 4P M
CT9506 44 2 1 2 M 1 3P M 1
CT9737 5 2 1 2 4P M

2 TOX 1859 102 6M 3/PDR 76 D10 D8 D1// P 5413 8 3 5 11 2X

3 ECIA 24 107 1/P2231 F4 13 2 1B// CT5746 18 11 4 1 3X

4 IRAT 146/CT6196 33 11 1 2 M//CT10035 43 4 M 3

Variety Releases

We continued monitoring new varietal releases in order to identify the usage trend for the germplasm sources and to share more efficiently the available information on the true genetic variability reaching the commercial areas Thanks to the information given by the national programs from Peru Nicaragua Brazil and the company Semenses de Provence from France we have compiled and registered in the database the release of 11 varieties for this year (Table 4) Four of these varieties were named by Peru all of them with germplasm developed at CIAT three of them materials exchanged through INGER LAC Nicaragua released two varieties with germplasm introduced from Cuba Brazil released another four three developed locally and the other introduced through INGER LAC nurseries The variety released in France comes from a line of the crossing CT6749 bred through anther culture with cold tolerance Another line of this same crossing was released as Buli INIA in Chile in 1991 The release of three lines originating from the crossing CT8008[2] is also note worthy Ecuador released a line from this same crossing last year under the name INIAP 12

Table 4 Rice varieties released up to September 1995

Variety	Designation	Cross	Country
Porvenir	CT5747 38 1 1 1A 1BRH 1P	Colombia 1/P 1274 6 8M 1 3M 1 2//P 2060 F4 2 5 2	Peru
Hualiaga	CT8008 AM 8 2 1	P 3050 F4 52/Oryzica 1//IR21015 72 3 3 3 1	Peru
Uquihua	CT5756 3 5 3 4	P 1274 6 8M 1 3M 1 2/Taichung 176//Campeche A80	Peru
Selva Alta	CT8008 16 10 10P M	P 3050 F4 52/Oryzica 1//IR21015 72 3 3 3 1	Peru
Altamira 11	2298 E 322 23 2	J 104//J 104/CICA 8	Nicaragua
Altamira 12	4158 E 337	CE4 10 1/Colombia 1	Nicaragua
EPAGRI 108	CT8008 16 31 3P M	P 3050 F4 52/Oryzica 1//IR21015 72 3 3 3 1	Brazil
Sambura	F2 13 B 1 B 3 (MG 431)	Nanicao/BG90 2//MG 1	Brazil
Mucuri	F2 19 B 1 B 1 (MG 447)	Nanicao/Cica 8//MG 1	Brazil
IRGA 417	IRGA 318 11 6 9 2	New Rex/IR19743 25 2 2//BR IRGA 409	Brazil
INCA	CT6749 36 CA 2	Lemont/Quilla 66304//Diamante	France

How NARS Are Using INGER LAC s Germplasm

The INGER LAC database made it possible to provide information on the number of nurseries and lines dispatched varietal releases and data returned for all Latin American countries This was done to estimate to what extent the national programs are using INGER LAC germplasm to develop their varieties

Table 5 shows how the data were calculated for Table 6 using Ecuador as an example Initially the number of dispatched nurseries that returned data to INGER LAC was identified The information showed how many lines Ecuador evaluated beginning in 1982 when the line

1 Lemont/Quilla 66304//Diamante

2 P 3050 F4 52/Oryzica 1//IR21015 72 3 3 3 1

that originated the first Ecuadorian variety based on INGER LAC germplasm was introduced The evaluation concludes in 1994 when the latest variety was released The number of lines evaluated during this period was obtained by adding the number of lines involved in each nursery from 1982 to 1994 this gives 3 201 an average of 267 per year Because the latest variety released was introduced in 1990 only the 2 746 lines evaluated from 1982 to 1990 were used to calculate the number required to release a variety in Ecuador giving an average of 915 Therefore Ecuador tested 915 lines to identify one that could be released commercially The time span for varietal release comes from the number of years needed from the introduction through the INGER LAC nursery to the year of release (for Ecuador it was 3 7)

Table 5 Utilization of germplasm introduced through INGER LAC nurseries for genetic improvement program of Ecuador

	Number of set				Released Varieties		
Year	Disp	Rec	Return (/)	Number of lines Evaluated	No	Year of Introduction	Time from Introduction to release
1982	9	1	11 1	409			
1983	6	2	33 3	411			
1984	6	2	33 3	373			
1985	6	2	33 3	336			
1986	3	2	66 7	381	1	1982	4
1987	5	0	0 0	290			
1988	5	0	0 0	217			
1989	8	3	37 5	235	1	1986	3
1990	7	0	0 0	94			
1991	3	0	0 0	214			
1992	1	0	0 0	157			
1993	5	0	0 0	84			
1994					1	1990	4
Total	64	12	—	3201	3	—	11
Average	5 3	1 0	18 8	267	0 2	—	3 7

To release a variety the program is introducing and evaluating on the average 915 lines (1982 1990) and requires 3 7 years from introduction to release

Table 6 shows a summary for 10 countries within two subregions in Latin America Ecuador needed to evaluate the greatest number of lines to identify a variety Conversely Paraguay needed the least only 119 Even though Ecuador required more lines it delayed the least between introduction and release averaging 3 7 years per variety Paraguay required fewer lines but had the greatest delay in releasing a variety This information gives us an idea of how diverse the breeding programs in LAC are The diversity can also be seen in the data return Some countries like Paraguay never share their results through the coordination others such as El Salvador Guatemala and Panama show return percentages above 80 /

Table 6 Rice germplasm introduced through INGER LAC nurseries to breeding programs of 10 countries

Region/ country	Rate of data return	Number of lines evaluated (period)	Number of varieties released	Lines per variety	Interval between line and variety (year)
South America					
Bolivia	63 6	1720 (1979 80)	6	287	6 3
Ecuador	21 8	2746 (1982 88)	3	915	3 7
Paraguay	0 0	357 (1980 81)	3	119	8 3
Venezuela	31 5	2979 (1980 88)	5	596	4 6
Central America					
Costa Rica	72 9	2490 (1980 87)	6	415	7 3
El Salvador	90 0	1590 (1979 83)	2	795	7 0
Guatemala	80 3	2751 (1979 87)	4	688	4 3
Honduras	58 4	3274 (1977 87)	5	655	5 6
Nicaragua	14 6	1340 (1982 86)	4	335	5 5
Panama	80 6	2469 (1980 86)	4	617	5 8
Total	—	21716	42	5422	58 4
Average	51 4	2172 (7 5)	4 2	542	5 8

1 Years of introduction of the lines that originated the varieties that have been released

Information Exchange

Meetings In this period two main events were held

1 I Taller Internacional de Selección Recurrente en Arroz Brazil March 13 17 1995

2 I Taller de Evaluacion y Seleccion de Germoplasma de Arroz para las ZonasTropical y Subtropical de America Latina y el Caribe Colombia July 31 August 4 1995

The first hosted by CNPAF/EMBRAPA Goiania Brazil brought together more than 100 participants from 10 Latin American countries The central topic recurrent selection in rice was covered in 16 oral presentations by invited scientists from national programs universities and CIAT

The second was a workshop for germplasm evaluation and selection There were two breeding sites CIAT Palmira and the Santa Rosa Experimental Station Villavicencio (both in Colombia) with contrasting environmental conditions This meeting was organized in collaboration with FLAR (Latin American Irrigated Rice Fund) and the CIAT Rice Program For the first time this type of workshop was planned for all regional rice researchers more than 100 scientists of 20 different nationalities representing 19 national programs 16 private companies (41 / of total participants) and 4 universities

There were 2 733 lines planted in the field for evaluation coming from 860 crosses These were summarized in 14 distinct sets of materials that ranged from commercial varieties and INGER Global nurseries to segregating recurrent selection populations including germplasm with industrial potential and materials of IRRI s newly developed plant type

Average line selection in Palmira was greater than in Villavicencio (86 / vs 53 2% respectively) The average of total selection was 90 4 / (Table 7) this percentage is quite high and accounts for the varied preferences of materials for the diverse predominant ecosystems in the region This suggests that institutions like CIAT and INGER are considered useful sources of genetic materials for several needs Table 8 shows the 13 most popular lines (selected in both sites by at least a third of the participating institutions) Three lines stand out from the cross CT10166[1] the line from cross CT9682[2] which incorporated African genes to the genetic base of the Latin American rice and the line CT13055 CA 18 M obtained through anther culture Another interesting case is the line CT10310 15 3 2P 4 3[3] which was selected in both populations where it was planted (Rice Hoja Blanca Lines No 211 and VIOAL 1995 No 49)

---

1 P3059 F4 79 1 1B/PDR 76 D10 D8 D1//P 5413 8 3 5 11 2X

2 TOX 1859 102 6M 3/P 5446 6 6 2 1//P 5413 8 3 5 11 2X

3 P 3084 F$ 56 2 2/ITA 306//CT8154 1 9 2

Table 7 Material evaluated and selected in Palmira y Villavicencio Colombia during the I Taller de evaluacion y seleccion de germoplasma de arroz para las zonas tropical y subtropical de America Latina y el Caribe July 31 August 4 /1995

				Total lines selected											
		Totall evaluated		Palmira				Villavicencio				Total different			
No	Class of material	Line	Cross	Line	/	Cross	/	Line	/	Cross	/	Line	/	Cross	/
1	Comercial Varieties	145	123	145	100 0	123	100 0	81	55 9	74	60 2	145	100 0	123	100 0
2	Lines Tolerant to Hoja Blanca	270	45	235	87 0	39	86 7	219	81 1	38	84 4	261	96 7	42	93 3
3	Lines for the Industry	89	69	89	100 0	69	100 0	40	44 9	30	43 5	89	100 0	69	100 0
4	Lines from National Programs	147	78	117	79 6	63	80 8	89	60 5	57	73 1	135	91 8	74	94 9
5	Advanced Lines														
	a Conventional Method	348	70	303	87 1	69	98 6	220	63 2	48	68 6	321	92 2	69	98 6
	b Recurrent Selection	74	6	71	96 0	6	100 0	74	100 0	6	100 0	74	100 0	6	100 0
6	IIRON 1995 Nursery	169	118	150	88 8	105	89 0	78	46 1	50	42 4	158	93 5	107	90 7
7	Lines F5														
	a Palmira	37	32	31	83 8	27	84 4	23	51 4	22	68 8	36	97 3	31	96 9
	b IRGA Santa Rosa	13	4	12	92 3	4	100 0	9	69 2		100 0	13	100 0	4	100 0
8	Lines F4 New Plant Type	64	18	50	78 1	17	94 4	35	54 7	12	66 7	55	85 9	18	100 0
9	VIOAL 1995	183	101	161	88 0	89	88 1	120	65 6	68	67 3	170	92 9	93	92 1
10	Best Lines VIOAL 1989-93 64	38	61	95 3	36	94 7	48	75 0	26	68 4	62	96 9	36	94 7	
11	Early Material and Anther Culture	988	48	790	80 0	47	97 9	282	28 5	36	75 0	811	82 1	48	100 0
12	USA Nursery	110	82	109	99 1	81	98 8	110	100 0	82	100 0	110	100 0	82	100 0
13	Nursery IRBN	24	20	19	79 2	16	80 0	17	70 8	15	75 0	23	95 8	20	100 0
14	Recurrent Selection	8	8	8	100 0	8	100 0	8	100 0	8	100 0	8	100 0	8	100 0
Total	General	2733	860	2351	86 0	799	92 9	1453	53 2	576	67 0	2471	90 4	830	96 5
	Different	2642	745	2269	85 9	699	93 8	1392	52 6	504	67 7	2384	90 2	724	97 2

Different total because there are common lines and crosses among materials

Table 8 Lines selected in Palmira and Villavicencio by at least a third of the participating institutions in the I Taller 1995

Reg	Plot	Pedigree	FL_PAL	HB	TAG	BL	NBL	LSC	GD	Material
1	149	CT10166-1 1E 3P-6 1 3P	102	5	0	3	3	5	1	HB
2	154	CT10166-1 1P 1P 1 1 2P	98	3	0	3	3	3	1	HB
3	211	CT10310-15 3 2P-4 3	106	1	7	1	3	5	1	HB
4	249	CT9509 17 3 1 1 M 1 3P M 1	97	3	3	3	1	3	1	HB
5	758	CT10554 4-4-2 2 M	100	5	3	3	1	1	3	F6
6	761	CT10825 1 2 1 1 M	102	3	0	3	1	1	1	F6
7	762	CT10825 1 2 1 3-M	103	3	0	3	1	1	1	F6
8	989	CT11008 12 3 1M 1P 4P	108	1	3	3	1	5	3	F6
9	990	CT11008 12 3 1M-4P 4P	106	1	3	3	1	7	3	F6
10	30	CT9682 2 M 14 1 M 1 3P M 1	91	3	0	5	1	5	1	VIOAL
11	33	CT10166-16 1 2P 1 3	84	3	0	1	1	5	1	VIOAL
12	49	CT10310-15 3 2P-4 3	84	3	1	3	3	1	1	VIOAL
13	1473	CT13055-CA 18 M	82			3	1	1	3	Early

It is important to note that both events mentioned above were organized and coordinated by INGER LAC but financed through funds from the national programs the private sector the CIAT Rice Program and FLAR

Publications In this period the INGER LAC Annual Report 1994 was completed and distributed to NARS In addition to the 1993 nursery evaluations it includes articles on varietal releases of six Latin American research institutions (CIAT Bolivia CNPAF/ EMBRAPA Brazil CORPOICA and FEDEARROZ Colombia NARI Guyana and INIA Uruguay)

FUTURE PLANS

The germplasm base of Latin American countries has broadened very notably in recent years as a result of the introduction of INGER materials The network has become the link to encouraging cooperation among rice researchers in the region It promotes exchange of information among them and facilitates the dissemination of research advances relevant to Latin America but conducted elsewhere Yet to keep INGER LAC alive it is neccessary to continue exploring the possibility of further strengthing cooperation with NARS and the private sector

Although renewed special project funding was not obtained the IRRI CIATcooperation in bridging the 94 95 funding gap has been exemplary Hopes of reactivating INGER LAC are enormous In fact at the beginning of 1995 the Latin American Irrigated Rice Fund (FLAR) was formalized with the objective of financing the international research in irrigated rice in Latin America FLAR recognizes the strategic importance of rice germplasm exchange within the region thus INGER is considered a priority among its activities CIAT was instrumental in coordinating the process that gave life to FLAR and gives the Fund the reliability and credibility needed for such an international effort FLAR has an initial funding commitment for 3 years and is actively searching for donors to support our International Network for Genetic Evaluation of Rice for Latin America and the Caribbean

ACRONYMS

CNPAF/EMBRAPA	Centro Nacional de Pesquisa em Arroz e Feijao/Empresa Brasileira de Pesquisa Agropecuaria
FEDEARROZ	Federacion Nacional de Arroceros (Colombia)
ICA	Instituto Colombiano Agropecuario
NARS	National Agricultural Research Systems
VIOAL	Vivero Internacional de Observacion de Arroz para America Latina (International Irrigated Rice Observational Nursery IIRON)
VIPAL	Vivero Internacional de Piricularia de Arroz para America Latina (International Rice Blast Nursery IRBN)
VIRAL	Vivero Internacional de Rendimiento de Arroz para America Latina (International Rice Yield Nursery IRYN)
VITBAL	Vivero Internacional de Arroz con Tolerancia a Temperaturas Bajas para America Latina (International Rice Cold Tolerance Nursery IRCTN)
WARDA	West Africa Rice Development Association

Annex 1

INGER RICE NURSERIES REQUEST FORM FOR 1995

Date ________ Name ____________ Station ____________ City Country ______________

A FAVORED CONDITIONS

1 For your region enumerate starting 1 (most important) to 4 (least important) the characteristics of the rice germplasm available in the VIOAL for 1995

_______ a Blast (leaf and neck) _______ c Cycle
_______ b Fungal diseases _______ d *Tagosodes* and RHBV

2 Considering the information on the performance of several Latin Amercian rice commercial varieties evaluated to the same characteristic of the previous question with the available material in the same location for your region the range of the reaction of those with potential is

Rice Blast (leaf and neck)

_______ a Reaction 1 3
_______ b Reaction 1 5
_______ c Reaction 1 7
_______ d Any reaction

Cycle

_______ g Flowering two weeks earlier than CICA 8 in Palmira Colombia
_______ h Any cycle

Tagosodes and RHBV

_______ e Reaction 1 3
_______ f Any reaction

Fungal diseases

_______ i Reaction 1 3
_______ j Any reaction

3 In accordance with the previous answers the germplasm you are requesting will major in (Please respond one of the two following alternatives)

_______ a One characteristic _______ b More than one characteristic

If your answer to question No 3 was a go to question No 4
if it was b go to question No 5

4 If you marked a (one characteristic) indicate the number of sets you are interested in (mark only one)

	Reaction	No of Lines	No of sets
a	Blast 1 3	108	_______
b	Blast 1 5	145	_______
c	Any reaction to rice blast	173	_______
d	Tagosodes and RHBV	12	_______
e	Cycle	30	_______
f	Fungal diseases	95	_______

5 If you marked b (more than one characteristic) indicate the number of sets you are interested in from the following available combinations (mark only one)

	Reaction	No of Lines	No of sets
a	Blast 1 3 and *Tagosodes* and RHBV (1 3)	10	_______
b	Blast 1 5 and *Tagosodes* and RHBV (1 3)	12	_______
c	Blast 1 7 and *Tagosodes* and RHBV (1 3)	12	_______
d	Blast 1 3 and cycle (2 weeks earlier)	17	_______
e	Blast 1 5 and cycle (2 weeks earlier)	23	_______
f	Blast 1 7 and cycle (2 weeks earlier)	30	_______

B NOT FAVORED CONDITIONS (ACID SOILS)

6 Indicate the number of sets of potential material for not favored conditions
58 _______

INGER LAC TWENTY YEARS OF SUCCESS

AN OVERVIEW

The Red Internacional para la Evaluacion Genetica del Arroz en America Latina y el Caribe (INGER LAC) formerly Programa de Pruebas Internacionales de Arroz para America Latina (IRTP) has been a responsibility shared by the International Rice Research Institute (IRRI) Los Banos Philippines the Centro Internacional de Agricultura Tropical (CIAT) Cali Colombia and the national rice programs in the region The network s main objective has been to exchange germplasm and information among its members (Figure 1) since its beginning in 1976

Its first phase in Latin America was to introduce nurseries from INGER Global Observational and yield trials were evaluated at CIAT Palmira the entries most adapted to the region s objectives were selected and grouped in regional nurseries Nurseries for specific problems (like blast and cold tolerance) were multiplied and redistributed to countries requesting them

Until 1985 the Latin American network had several nurseries and a structure similar to that of INGER Global The region evaluated various nurseries using observational (VIOAL) yield (VIRAL) and special problems trials (VIPAL blast VITBAL cold tolerance etc) Since the network members were questioning the number of lines in each nursery a modification in the nurseries organization was proposed and approved during the VI International Rice Research Conference for Latin America in 1985 The yield trials were eliminated and only observational trials were continued

The proposal required pre evaluation of entries at several sites in the region before including them in the new VIOAL The germplasm was evaluated at the Santa Rosa Experimental Station Villavicencio Colombia Goiania Brazil Entre Rios Argentina and Bagua Peru Based on these evaluations INGER LAC organized the VIOAL in sub groups so that each country could request only the group of lines that would meet their breeding objectives

An IRRI staff member initially coordinated the network Dr Manuel Rosero was the head of IRTP from 1976 to 1986 followed by Dr Federico Cuevas Perez in 1986 who also worked as the Institution s Liaison Scientist for Latin America at CIAT He left in 1992 when IRRI closed this position for Latin America Since then the network has been going through a transitional period core funds from IRRI are no longer available and a new project proposal has not been yet funded by external donors Dr Cesar Martinez rice breeder from CIAT s Rice Program coordinated the network during 1993 and Dr Elcio P Guimaraes has continued the duty since then

GERMPLASM EXCHANGE

The germplasm exchange from 1979 to 1985 involved the distribution of 3 646 lines During that period 1 563 nurseries were requested The data show requests for an average of 520 lines and 223 nurseries per year After the modification of the germplasm organization in 1986 the number of lines dropped to 2 014 and nurseries to 808 averaging 224 and 90 per year respectively (through 1994) As can be seen the number of lines decreased by 57 % and the nursery by 60 / in accordance with the request made by the members During the period the average rate of data return was 45 0 /

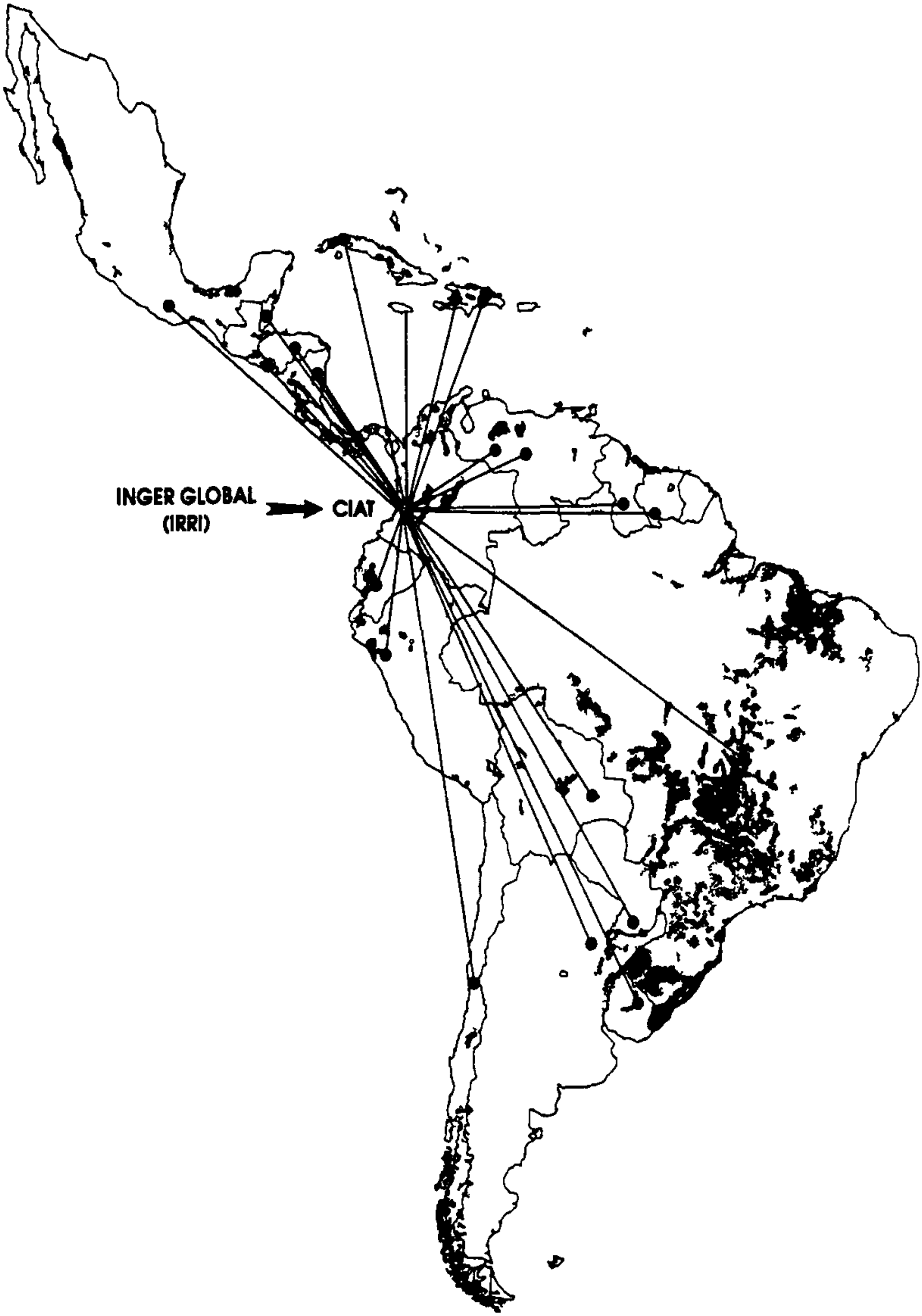


Figure 1 Countries participating in INGER LAC

A main objective of the network is to distribute useful advanced lines to national programs According to Table 9 there were 202 varieties released in the region from 1976 to 1994 of these 81 (40 1 /) came directly from INGER LAC lines Of the 121 remaining 79 (65 3 /) had one parent coming from germplasm introduced through INGER LAC These numbers indicate that only 42 varieties (20 8 /) were not obtained through the network Brazil released 16 of these In this period Brazil released more varieties (69) than any other country followed by Mexico (17) and Colombia (16) Half of the 22 breeding programs (6 in Central America) release varieties coming only from germplasm related to INGER LAC

INFORMATION EXCHANGE

Information exchange is another strong component of the network Most of the national programs acquired communication technology during the last 20 years and INGER LAC organized databases with the following information

a Latin American commercial varieties

b Rice scientists working in the region

c INGER LAC nursery data

d The IRRI germplasm bank

e Latin American crossing programs and

f A system to find and calculate parental percentage participation in breeding lines

There have been nine Latin American Rice Research Conferences the first seven held at CIAT Palmira Colombia the latest two in Mexico and Brazil respectively The first two were annual (1976 and 1977) in 1979 they became biannual (1979 1981 1983 and 1985) and since 1988 they have been held every 3 years (1988 1991 and 1994) In addition to the regional conferences different meetings have been held dealing with specific problems or subregions

a A panel on breeding for cold tolerance (1986)

b Utilization of INGER LAC nurseries (1987)

c Generation of genetic variability in the Southern Cone

d Germplasm evaluation and selection in Panama (1983 and 1984) Colombia (1986 and 1988) the Dominican Republic (1989) Guatemala (1989) Mexico (1991) Venezuela (1992) and Brazil (1994)

Since 1977 INGER LAC has been producing nursery reports they have turned out to be an important means of communication among network members The reports are intended to integrate all network activities and more recently have given collaborators the opportunity to report in short articles the progress of their research

INGER LAC s history has been a successful one The regional national programs consider it a unique mechanism for obtaining and disseminating their germplasm The new perspective for INGER LAC is a linkage with FLAR the Latin American Fund for Irrigated Rice which considers the network a priority

Table 9 Number of lines released as varieties in Latin America and the Caribbean during 1976 1994 indicating their origin and pathway to release

Country	Origin of the cross					Total number of varieties	Number introduced through INGER	
	America			Asia/Africa			Released directly as variety released	Used as parents of a released variety[3]
	Within Country	CIAT/ICA/ FEDEARROZ[1]	Others[2]	IRRI	Others[2]			
Argentina	3					3		1
Belize		1				1	1	
Bolivia		4	1	1		6	6	
Brazil	28	25	2	6	8	69	23	30
Colombia		15	1			16		10
Costa Rica		8				8	5	3
Cuba	5		1	2		8	1	3
Chile		1				1		
Dom Rep	4	1		1		6	2	3
Ecuador		4		1		5	5	
El Salvador		4				4	1	3
Guatemala		6			1	7	5	2
Guyana	1			1		2		1
French Guyana		1				1	1	
Honduras		5				5	5	
Mexico	10	3		2	2	17	6	7
Nicaragua		4				4	4	
Panama	3	5				8	2	6
Paraguay		2			2	4	3	1
Peru	7	3		1		11	4	6
Suriname	3					3		2
Uruguay	6					6		1
Venezuela		5			2	7	7	
Total	70	96	5	15	15	202	81	79
Percentage	35	47 5	2 5	7 5	7 5	100	40 1	65 3

1 Cooperati e breeding project based n Colomb a with both national (ICA/FEDEARROZ) and internat onal (CIAT) objectives

2 "Others mainly includes the national research programs of other countries in the reg on

3 Immed ate parent used n the cross

4 Percentage in relation to the number of lines not released directly through INGER

ANNEX 1

PUBLICATIONS 1995

REFERRED JOURNALS

Corrrea Victoria F J and Zeigler R S 1995 Stability of partial and complete resistance in rice to *Pyricularia grisea* under rainfed upland conditions in eastern Colombia Phytopathology 85 997 982

Cuevas Perez Federico E L E Berrio D I Gonzalez F Correa Victoria and E Tulande 1995 Genetic improvement in yield of semidwarf rice cultivars in Colombia Crop Sci 35 725 729

Lentini Z P Reyes C P Martinez and W M Roca 1995 Androgenesis of highly recalcitrant rice genotypes with maltose and silver nitrate Plant Science (accepted)

Lentini Z P Reyes C P Martinez and W M Roca 1995 Androgenesis of highly recalcitrant rice genotypes with maltose and silver nitrate Plant Science 110(1) 127 138

Martinez C F J Correa Victoria M C Amezquita E Tulande G Lema and R S Zeigler 1995 Comparison of rice lines derived through anther culture and the pedigree method in relation to blast (*Pyricularia grisea* Sacc) resitance Theoretical Applied Genetics 1995

PERIODICAL

Amezquita M C M Chatel E P Guimaraes J Silva e Y Ospina 1995 Analisis Estadistico de un Ensayo Exploratorio para toma de decisiones metodologicas En Sistemas Agropastoriles en America Latina

Berrio L E y E P Guimaraes 1995 Variabilidad genetica de las variedades de arroz liberadas en 1993 en America Latina y el Caribe *Informe INGER America Latina 1994 Variedades de arroz liberadas en America Latina y el Caribe en 1993 y su variabilidad genetica p 56 65*

Borrero J Y Ospina E P Guimaraes y M Chatel 1995 Ampliacion de la base genetica por la introduccion de variabilidad en poblaciones y acervos de genes segregando para un gene recesivo de androseterilidad En Seleccion Recurrente en Arroz

Chatel M E P Guimaraes Y Ospina y J Borrero 1995 Utilizacion de acervos geneticos y poblaciones de arroz de secano segregando para un gene de androesterilidad En Seleccion Recurrente en Arroz

Chatel M y Guimaraes E P 1995 Seleccion recurrente con androesterilidad en arroz Centre de cooperation internationale en recherche agronomique pour le developpement Departement des cultures annuelles (CIRAD CA) y Centro Internacional de agricultura Tropical (CIAT) Cali Colombia 70 p [Publicacion CIAT No 246]

Chatel M y E P Guimaraes 1995 Seleccion recurrente en arroz en Africa y Madagascar estado actual y progreso En Seleccion Recurrente en Arroz

Correa Victoria F E P Guimaraes y C P Martinez 1995 Caracterizacion de la estructura genetica y virulencia de *Pyricularia grisea* Sacc para el desarrollo de variedades resistentes al Anublo del Arroz En Seleccion Recurrente en Arroz

Fischer A M Chatel H Ramirez J Lozano and E P Guimaraes 1995 Components of early competition between upland rice and *Brachiaria brizantha* International Journal of Pest Management (en impresion)

Guimaraes E P L E Berrio and N M de Nivia 1995 Highlights of INGER Latin America Activities in 1993 1994 *Proceedings of the Advisory Committee Meeting of the International Network for Genetic Evaluation of Rice (Seventeenth Meeting) Yangon Myanmar November 28 December 3 1995 p 52 60*

Guimaraes E P L E Berrio y N M de Nivia 1995 Actividades destacadas de INGER America Latina en 1993 1994 *Informe INGER America Latina 1994* Variedades de arroz liberadas en America Latina y el Caribe en 1993 y su variabilidad genetica p 83 92

Guimaraes E P F Correa Victoria and E Tulande 1995 GC 91 broad based synthetic popualtion for blast (*Pyricularia grisea* Sacc) resistance Revista Brasileira de Genetica (en impresion)

Guimaraes E P M Chatel Y Ospina R y J Borrero 1995 Mejoramiento de arroz para suelos acidos Informe Anual 1993B 1994A 184p

Guimaraes E P M Chatel Y Ospina R y J Borrero 1995 Centro Internacional de Agricultura Tropical (CIAT s) upland rice germplasm development strategy International Rice Research Notes 20(2) 14 15

Guimaraes E P y F Correa Victoria 1995 Utilizacion de la seleccion recurrente para desarrollar resistencia a *Pyricularia grisea* Sacc en arroz En Seleccion Recurrente en Arroz

Martinez C P Z Lentini y M Chatel 1995 Uso de seleccion recurrente en combinacion con cultivo de anteras en el programa de arroz de riego del CIAT En Seleccion Recurrente en Arroz

Ospina Y J Borrero E P Guimaraes y M Chatel 1995 Ciclo de recombinacion y variabilidad genetica en poblaciones y acervos de genes segregando para un gene recesivo de androesterilidad En Seleccion Recurrente en Arroz

Perez I B Z Lentini y E P Guimaraes 1995 Variabilidad genetica de dos poblaciones de arroz desarrolladas por cultivo de anteras y pedigri Fitopatologia Venezolana 6(2) 56

Rangel P H N E P Guimaraes e P C F Neves 1995 Base genetica de arroz (*Oryza sativa* L) irrigado do Brasil Revista Brasileira de Genetica (en impresion)

Sanint L R 1995 FLAR un Fondo Latinoamericano de Arroz de Riego Arroz en las Americas Vol 16 No 2 August CIAT Palmira

Sanint L R 1995 1995 El programa de Arroz del CIAT en la Actualidad Arroz en las Amercias Vol 16 No 2 August CIAT Palmira

Sanint L R 1995 Produccion de Arroz en América Latina y el Caribe Foro Arrocero Latinoamericano Vol 1 No 1 FLAR Palmira

Sanint L R 1995 Precios Internacionales del Arroz Foro Arrocero Latinoamericano Vol 1 No 1 August FLAR Palmira

Sanint L R 1995 El Arroz en el Acuerdo General de Tarifas y Comercio (GATT) Foro Arrocero Latinoamericano Vol 1 No 1 August FLAR Palmira

Sanint L R 1995 Crop Biotechnology and Sustainability a Case Study of Colombia OECD Technical Paper No 104 OECD Development Centre 82 p Jan Paris France

Seminars Workshops etc

Amezquita M C M Chatel E P Guimaraes J Silva e Y Ospina 1995 Analisis Estadistico de un Ensayo Exploratorio para toma de decisiones metodologicas En Sistemas Agropastoriles en America Latina

Berrio L E y E P Guimaraes 1995 Utilizacion de germoplasma de arroz introducido a paises de America Latina y el Caribe a traves de los viveros INGER LAC Resumen p 17 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Borrero J Y Ospina E P Guimaraes y M Chatel 1995 Ampliacion de la base genetica por la introduccion de variabilidad en poblaciones y acervos de genes segregando para un gene recesivo de androseterilidad En Seleccion Recurrente en Arroz

Chatel M E P Guimaraes Y Ospina y J Borrero 1995 Utilizacion de acervos geneticos y poblaciones de arroz de secano segregando para un gene de androesterilidad En Seleccion Recurrente en Arroz

Chatel M y E P Guimaraes 1995 Catalogue Registration Proposal to Manage Rice Gene Pools and Populations Improvement Document CIAT/CIRAD Réunion du Programme Riz CIRAD CA

Chatel M y E P Guimaraes 1995 Rice collaborative special project between CIRAD CA and CIAT Second Collaborative Meeting Between CIAT CIRAD INRA and ORSTOM

Chatel M y E P Guimaraes 1995 Rice Selection Breeding Network Proposal Rice Breeding Worshop Among CIRAD CIAT IRRI and WARDA

Chatel M E P Guimaraes Y Ospina y J Borrero 1995 Programme Conjoint CIRAD CA/CIAT Selection Recurrente Riz Reunion du Programme Riz CIRAD CA

Chatel M y Guimaraes E P 1995 Selección reucrrente con androesterilidad en arroz Centre de cooperation internationale en recherche agronomique pour le developpement Departement des cultures annuelles (CIRAD CA) y Centro Internacional de agricultura Tropical (CIAT) Cali Colombia 70 p [Publicacion CIAT No 246]

Chatel M E P Guimaraes Y Ospina 1995 Caracterización de poblaciones de arroz para suelos acidos Resumen p 115 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Chatel M y E P Guimaraes 1995 Seleccion recurrente en arroz en Africa y Madagascar estado actual y progreso En Seleccion Recurrente en Arroz

Correa Victoria F J E P Guimaraes y C Martinez 1995 Caracterizacion de la estructura genetica y virulencia de *Pyricularia grisea* Sacc para el desarrollo de variedades resistentes al anublo del arroz En I Taller Internacional sobre Seleccion Recurrente en Arroz Goiania Brasil 13 17 marzo 1995 EMBRAPA CNPAF CIAT CIRAD CA e INGER p 103 113

Correa Victoria F J and C Martinez 1995 Genetic structure and virulence diversity of *Pyricularia grisea* for breeding for rice blast resistance FAO/IAEA International Symposium on the use of Induced Mutations and Molecular Techniques for Crop Improvement Vienna Austria 19 23 June 1995 (in press)

Correa Victoria F E P Guimaraes y C P Martinez 1995 Caracterizacion de la estructura genetica y virulencia de *Pyricularia grisea* Sacc para el desarrollo de variedades resistentes al anublo del arroz En Seleccion Recurrente en Arroz

Correa Victoria F and C P Martinez 1995 Genetic structure virulence diversity of Pyricularia grisea for breeding for rice blast resistance Proceeding International Symposium on the Use of Induced Mutations and Molecular Techniques for Crop Improvement Joint FAO/IAEA Division June 19 23 1995 Viena austria 28p

Delgado H y E P Guimaraes 1995 Aluminum toxicity inheritance in rice Third International Rice Genetics Symposium

Fischer A J E Granados and D Trujillo 1995 Resistance to propanil in populations of *Echinochloa colona* International Symposium on Weed and Crop Resistance to Herbicides April 3 6 Cordoba Spain

Fischer A J 1995 Desarrollo de resistencia a herbicidas en poblaciones de malezas Anais da XXI Reuniao do Arroz Irrigado Sept 1995 Porto Alegre Brazil

Fischer A J A L Chavez D N Varela and H V Ramirez 1995 Detection of resistance to propanil in *Echinochloa colona* populations Proceedings XVI International Conference COLUMA December 6 8 1995 Reims France

Fischer A J 1995 Sistemas de produccio de arroz Notas para un curso sobre Sostenibilidad y Manejo de Recursos Naturales Oct 1995 CATIE Turrialba Costa Rica

Fischer A J 1995 Introduccion in D Medina e I Dorante Manual de Indentificacion de malezas APROSCELLO Acarigua Venezuela

Gallego G J López F Correa C P Martinez y J Tohme 1995 Usos de marcadores moleculares en el mejoramiento de resistencia del anublo del arroz Memorias IV Congreso Nacional Sociedad Colombiana Mejoramiento y Produccion Cutivos Chinchina Caldas Mayo 8 10 1995 p 136

Guimaraes E P y F Correa Victoria 1995 Utilizacion de la seleccion recurrente para desarrollar resistencia a *Pyricularia grisea* Sacc en arroz En Seleccion Recurrente en Arroz

Guimaraes E P y F Correa Victoria 1995 Anublo de arroz (*Pyricularia grisea* Sacc) en Poblaciones correlaciones entre evaluaciones enlas hojas y en el cuello de la panicula Resumen p 17 XVI Congreso de Fitopatologia

Guimaraes E P M Chatel Y Ospina R y J Borrero 1995 Mejoramiento de arroz para suelos acidos Informe Anual 1993B 1994A 184p

Guimaraes E P M Chatel Y Ospina R y J Borrero 1995 Centro Internacional de Agricultura Tropical (CIAT s) upland rice germplasm development strategy International Rice Research Notes 20(2) 14 15

Guimaraes E P F Correa Victoria y E Tulande 1995 Desarrollo de poblaciones resistentes al Anublo del arroz (*Pyricularia grisea* Sacc) XVI Congreso de Fitopatologia Resumen p 18

Guimaraes E P M Chatel 1995 Estrategia de mejoramiento del arroz de secano para suelos acidos Resumen p 110 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Holguin J y C P Martinez 1995 Influencia del citoplasma sobre la expresion del centro blanco en arroz (*Oriza Sativa* L) Arroz Colombia vol 44 (396) 38 43

Lentini Z and C P Martinez 1995 Rice anther culture in germplasm development Proceding Second Latin American Meeting on Plant Biotech/Redbio 95 Puerto Iguazu Argentina June 4 9 1995 S 1

Lentini Z C P Martinez and P Reyes 1995 Rice anther culture in germplasm development Oral presentation invited speaker Proceedings of the Second International Congress of the Latin American Biotechnology Network (RedBio) Iguazu Argentina June 1995

Lentini Z E Tabares I Lozano L Calvert L Destefano and W Roca 1995 Rice genetic transformation for resistance to RHBV and sheath blight Oral presentation Proceedings of the Second International Congress of the Latin American Biotechnology Network (RedBio) Iguazu Argentina June 1995

Lentini Z E Tabares I Lozano L Calvert L Destefano and W Roca 1995 Direct gene transfer in recalcitrant rice Latin American varieties Poster Proceedings of the Second International Congress of the Latin American Biotechnology Network (RedBio) Iguazu Argentina June 1995

Lentini Z L Calvert E Tabares I Lozano and B C Ramirez 1995 Genetic transformation of rice with viral genes for novel resistance against RHBV Oral presentation Proceedings Third International Rice Genetics Symposium Manila Philippines October 16 20 1995

Lentini Z C P Martinez and E Nossa 1995 Introgression of high response to anther culture into indica rice Poster Proceedings Third International Rice Genetics Symposium Manila Philippines October 16 20 1995

Lentini Z E Tabares I Lozano L Calvert L Destefano y W M Roca 1995 Transformacion genetica en arroz por resistencia a RHBV y Rhizoctonia Oral presentation Memorias IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Producción de Cultivos Chinchina Caldas Mayo 8 10 1995

Lentini Z C P Martinez W M Roca and J A Reyes 1995 Coordination of the Second workshop on Rice Breeding with Anther Culture Corrientes Argentina Montevideo Treinta y Tres Uruguay and Pelotas Porto Alegre Brazil February 25 March 10 1995

Martinez C P F Correa Victoria M C Amezquita E Tulande G Lema and R S Zeigler 1995 Comparison of rice lines derived through anther culture and the pedigree method in relation to blast (*P grisea* Sacc) resistance Theor App Gen (accepted)

Martinez C P Z Lentini M Chatel D Gonzalez y D Mojica 1995 Uso de seleccion recurrente en combinacion con cultivo de anteras en el programa de arroz del CIAT 1995 Primer Taller Internacional sobre Selecao Recurrente en Arroz CNPAF/EMBRAPA 13 17 marzo Goiania Goias Brasil 129 141

Martinez C P Z Lentini y P Reyes 1995 El cultivo de anteras una herramienta util en el mejoramiento del arroz Memorias IV Congreso Nacional Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos Chinchina Manizalez Mayo 8 10 1995 125

Martinez C P Z Lentini y P Reyes 1995 Effect of the cytoplasm source on rice anther culture response Poster Proceedings Third International Rice Genetics Symposium Manila Philippines October 16 20 1995

Martinez C P Z Lentini y P Reyes 1995 Aplicaciones del cultivo de anteras en fitomejoramiento del arroz Oral presentation Memorias IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos Chinchina Caldas Mayo 8 10 1995

Martinez C P Z Lentini y M Chatel 1995 Uso de seleccion recurrente en el programa de arroz riego del CIAT Oral presentation Memorias IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos Chinchina Caldas Mayo 8 10 1995

Martinez C P Z Lentini y M Chatel 1995 Uso de seleccion recurrente en combinacion con cultivo de anteras en el programa de arroz de riego del CIAT En Seleccion Recurrente en Arroz

Mojica D C P Martinez y E P Guimaraes 1995 Extraccion de lineas de poblaciones mejoradas Memorias IV Congreso Nacional Sociedad Colombiana Mejoramiento y Produccion Cultivos Chinchina Caldas Mayo 8 10 1995 p 98

Mojica D C P Martinez y E P Guimaraes 1995 Extracción de lineas de poblaciones mejoradas para *Pyricularia grisea* Sacc Resumen p 98 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Moreno A E P Guimaraes M Chatel y J Borrero 1995 Adapatacion de materiales mejorados de arroz a la zona cafetera Colombiana Resumen p 4 5 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Ospina Y E P Guimaraes F Correa Victoria 1995 Seleccion de progenitores para resistencia al anublo del arroz Resumen p 97 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Ospina Y J Borrero E P Guimaraes y M Chatel 1995 Ciclo de recombinacion y variabilidad genetica en poblaciones y acervos de genes segregando para un gene recesivo de androesterilidad En Seleccion Recurrente en Arroz

Ospina Y J Borrero E P Guimaraes y M Chatel 1995 Potencial de la lineas mejoradas para el ecosistema de sabanas con suelos acidos Resumen p 114 IV Congreso Nacional de la Sociedad Colombiana de Fitomejoramiento y Produccion de Cultivos

Perez I B Z Lentini y E P Guimaraes 1995 Variabilidad genetica de dos poblaciones de arroz desarrolladas por cultivo de anteras y pedigri Fitopatologia Venezolana 6(2) 56

Sanint L R 1995 El Arroz de Riego en America Latina y el Caribe Nuevas Realidades Invited Paper to the IX FENARROZ April 25 Cachoeira do Sul Brazil

Sanint L R 1995 Intensive Cultivation while Protecting the Environment" Invited Comments Symposium on Rice a scientific challenge a worldwide market Oct 6 Montpellier France

Sanint L R C Martinez Z Lentini 1995 Anther Culture as a Rice Breeding Tool a Profitable Investment Concurrent Paper invited to the 3rd International Rice Genetics Symposium Oct 16 Manila Philippines

Sanint L R 1995 El Modelo del FLAR novedosa respuesta del sector arrocero Latinoamericano a los retos actuales Invited address Fedearroz Rice Congress Dec 11 Bogota Colombia

Zeigler R S Tohme J Nelson R Levy M Correa Victoria F J 1995 Lineage exclusion A proposal for linking blast population analysis to resistance breeding A proposed strategy for durable resistance (Proc Int Symp Rice Blast Disease Wisconsin 1994 (Leong S et al eds) CABI Wallingford U K (1994) 267 292

Thesis

Jose Didier Cabezas S E P Guimaraes 1995 Analisis de la variabilidad genetica entre lineas de arroz *Oryza sativa* L derivadas de la poblacion CNA IRAT 2 en diferentes ciclos de recombinacion Universidad Nacional de Colombia Tesis de Grado

Jaime Alberto Florez A J Fischer 1995 Umbrales economicos para el manejo de poblaciones multiespecificas en arroz de riego Tesis de Grado

Diego N Varela A J Fischer 1995 Estudio de resistencia a herbicidas en *Echinochloa colona* Tesis de Grado

Daneish Ramdeen A J Fischer E P Guimaraes M Chatel 1995 Development of competitive rice cultivars for the rice pastures association MS Thesis

Annex 2

RICE PROGRAM PERSONNEL

PRINCIPAL STAFF

Luis R Sanint Agricultural Economist Leader and FLAR Director
Lee Calvert Virology Unit
Marc Chatel Plant Breeder
Fernando Correa Plant Pathologist
Albert Fischer Plant Physiologist
James Gibbons FLAR Plant Breeder
Elcio P Guimaraes Geneticist for Upland Rice
Zaida Lentini Biotechnology Unit
Cesar P Martinez Plant Geneticist Irrigated Rice
Kensuke Okada Plant Physiologist (VS JIRCAS)
Joseph Tohme Biotechnology Unit
Craig Yencho Plant Entomologist

SUPPORT STAFF

Associates and Assistants

Luis E Berrio INGER
Jaime Borrero Genetics Upland
Fabio Escobar Biotechnology
Daniel I González Genetics Irrigated
Jaime Borrero Physiology
Maria del Pilar Hernández Entomology
Nelly Manosalva de Nivia INGER
Maria Nelly Medina Leader
Daniel Mojica Genetics Irrigated (Villavicencio)
Yolima Ospina Genetics Upland (Villavicencio)
Catherine Pardey Entomology
Gustavo Prado Pathology
Hector V Ramirez Physiology
Patricia Reyes Genetics Anther Culture
Miguel E Rubiano Pathology
James Silva Biometry
Mónica Triana Entomology
Edgar Tulande Pathology

Secretaries

Alba Ines Aguirre
Adriana Agudelo
Liz Deira Arango
Clara Ines Sánchez

Technicians and Field

Felix Acosta
Miguel Acosta
Maria Girlena Aricapa
Jesus E Avila
Jose Demetrio Arboleda
Diego Luis Arrechea
Jairo Barona
Jairo Basante
Leonardo Caicedo
Silvio James Carabali
Apolinar Cardenas
Marco Tulio Castillo
Nancy R Coral
Efren A Córdoba
Gerardo A Delgado
Luis C Figueredo
Jaime Gallego
Jairo Garcia
Aldemar Gutiérrez
Jorge I Hernández
Elsy Lasprilla
Luis Loaiza
Pedro Nel Lozano
Victor Hugo Lozano
Fabián Mina
Adriana Mora
Jaime Morales
Mauricio Morales
Rodrigo Morán
Reinaldo Mueses
Francisco Ortega
Fredys Pérez
Geremias Popo
Rosalba Reyes
Francisco Rodríguez
Humberto Rodríguez
Luis H Rosero
Sory H Sánchez
Pedro Nel Vélez
Jairo Vega
Carlos Tulio Vergara
Aldemar Villegas
Daniel Zambrano