

International partnership for rice improvement in Latin America: CIRAD, a case study

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ABSTRACT

In Latin America and the Caribbean (LAC), rice is an important staple food. A significant increase in rice production has been achieved mainly through the release and adoption of high yielding varieties. During the last 40 years, about 300 varieties were released. They were developed by national and international rice research institutions. The Centre for International Cooperation in Agricultural Research for Development, Food Crop Department (CIRAD-CA), in Montpellier, France, worked in collaboration with Embrapa Rice and Beans, Goiânia, Brazil, and the International Centre for Tropical Agriculture (CIAT), Cali, Colombia, in the development of varieties for LAC. This study looks at the contribution made by CIRAD's international partnership to rice improvement, with emphasis in Latin America. The presence of CIRAD's lines was detected in the breeding programs in Brazil, Bolivia, Colombia, Mexico, Guatemala and Peru. The following results were obtained: a) 61 unique lines developed by CIRAD were used as parents in more than 2,000 crosses in the region; b) five CIRAD's lines were directly released as commercial cultivars; c) 25 varieties released to farmers in the region have at least one line from CIRAD participating on its crosses; and d) six breeding lines are in the pipeline for release in Brazil, Colombia, Nicaragua and Peru.

KEY WORDS: CIRAD, germplasm, variety, cultivar, Latin America.

INTRODUCTION

Rice is the most cultivated food crop in the world, right after wheat. Currently, the total production is approximately 592 million tons, coming from 151 million hectares (FAOSTAT, 2001). Rice is consumed by two-thirds of the world's population and is the staple food for most of it. Significant progresses have been made to increase rice production worldwide, and genetic improvement has had a major role in it. Looking at the prediction for the years ahead, in 2020 the world's population will be around 7,5 billion (Maclean et al., 2002); this will require a rice production increase of almost 50% to meet the demand (IRRI, 1996). Therefore, an increase in production by raising the yield potential is the main goal of almost all breeding programs.

Due to rice importance and distribution in the world, the International Agricultural Research Centres (IARC) have designated three of its 16 units to work on rice research. They are the International Rice Research Institute (IRRI), Los Baños, Philippines; the International Centre for Tropical Agriculture (CIAT), Cali, Colombia; and the Africa Rice Centre (former West Africa Rice Development Association

- WARDA), Bouaké, Côte d'Ivoire. In addition to the IARC's centres, there is CIRAD-CA, which has been working on rice research at an international level since the early sixties, focusing on upland ecosystems in West Africa (Jacquot, 1978) and irrigated ones in Madagascar (Arraudeau, 1974). The backbone of all these international programs was and still is genetic improvement.

In 1981, CIRAD started a joint project on rice improvement with Embrapa Rice and Beans. At that time the first institution was known as IRAT (Institute for Research in Tropical Agriculture) and the second as CNPAF (Rice and Beans National Research Centre). One of the objectives was to bring and use genetic resources developed in Africa to the Brazilian national breeding program (Châtel et al., 1982). In 1992 CIRAD started a collaborative project with CIAT rice project in order to foster and strengthen breeding activities for the Latin America's upland ecosystems (Châtel et al., 1996).

This paper analyses the contribution made by the germplasm developed by CIRAD's international partnership to rice improvement, with an emphasis in Latin America.

MATERIAL AND METHODS

The methodology used in this study to produce data considered all breeding lines and varieties developed by CIRAD (or former IRAT) in its rice breeding programs in Africa and in Latin America. The information was gathered based upon literature review and database surveys. All lines generated by CIRAD, which were used in crosses or as direct releases as commercial varieties in Latin America, were considered as CIRAD's contribution to rice improvement in the region.

Crossing program records were analyzed based on the information published by INGER-América Latina (1991) and Martínez and Cuevas-Pérez (1995). In Brazil, at Embrapa Rice and Beans, "Instituto Agrônomo de Campinas" (IAC), and Embrapa Temperate Climate; in Colombia, at the "Instituto Colombiano Agropecuario" (ICA) and CIAT; in Mexico, at the "Instituto Nacional de Investigaciones Forestales y Agropecuarias" (INIFAP); and in Peru, at the "Instituto Nacional de Investigaciones Agropecuarias y Agroindustriales" (INIAA). To develop these analysis, three sources of contributions were accounted for: a) participation as parental material in any combination made by national breeding programs; b) participation as parents of commercial varieties developed by national programs; and c) participation as breeding lines released as varieties.

To access the contribution in the crosses, the following information was recorded for a given breeding program and specific period: total number of crosses made by the institution, total number of crosses where CIRAD's line was involved in the combinations as female or as male parent, and the number of lines

from CIRAD used by the national program.

Variety release database was consulted to determine the number of lines from CIRAD that made directly to farmers' field or were involved in one of the crosses that produced such varieties. To attribute the contribution to CIRAD, we only looked at the parents and the grandparents of each variety released in the region.

RESULTS AND DISCUSSION

The results will be presented and discussed considering the three types of contribution mentioned before: as a source of parental lines in crosses, as part of the progenitors in released varieties and as commercially released breeding lines.

Source of parental lines for crossing programs

The "International Network for Genetic Enhancement of Rice" (INGER) was a powerful mechanism to exchange germplasm between international and national programs; and also for the exchange between national programs (INGER-América Latina, 1990). Most of CIRAD's germplasm came to Latin America through this mechanism. Based on the information collected from INGER-América Latina (1991) and Martínez and Cuevas-Pérez (1995), summarized in Table 1, it was possible to show the number of lines used by national programs as parental materials in their crosses. Brazil, after Colombia, used a larger number of lines taking more advantage of the germplasm developed by CIRAD, than the others, as shown in Table 1. To a certain extent, this result could be expected because upland ecosystem is priority for the Embrapa Rice and Beans breeding program, when

Table 1. Contribution of CIRAD's rice germplasm to a sample of Latin American's breeding programs.

Country	Breeding program	Period (year)	Total # of crosses	Crosses involving CIRAD's germplasm		CIRAD's germplasm used as parent (#)
				Number	Percentage	
Brazil	Embrapa Rice and Beans	1977-1990	4560	511	11.2	50
	IAC	1969-1989	1073	77	7.2	8
	Embrapa Temperate Climate	1972-1989	2663	15	0.6	3
Colombia	ICA and CIAT	1960-1991	2631	1092	41.5	16
Mexico	INIFAP	1967-1990	3729	277	7.4	17
Peru	INIAA	1966-1990	1935	74	3.8	8
Total	-	-	16591	2046	12.3	61 ^{1/}

^{1/} Total number of unique lines.

compared to other programs and countries in the region, as well as with CIAT in Colombia. Most CIRAD's work targeted this ecosystem.

Table 1 shows that more than 16 thousand crosses were made by the four countries using CIRAD's germplasm in their crossing programs. At least one line developed by CIRAD was present in 12.3% of the total combinations. Almost half of the crosses made in Colombia involved CIRAD's lines, and that is because the local and CIAT's breeding programs were counted together, and also because CIAT has the regional mandate to carry out activities for the tropical savannas ecosystem. In Brazil, Embrapa Rice and Beans used it in 11.2% of all crosses, followed by IAC and Embrapa Temperate Climate. This can be explained based on institutional priorities; Embrapa Rice and Beans and IAC are focusing more on upland ecosystems and Embrapa Temperate Climate on the irrigated ones.

A total of 61 unique lines were involved in 2046 crosses. Brazil used 53 (Embrapa Rice and Beans used 50, IAC had only one and Embrapa Temperate Climate had two lines which did not belong to the group used by Embrapa Rice and Beans); Colombia used 16 lines, but 11 were also used in Brazil; out of the 17 used by Mexico, only three were not present in the previous two countries; Peru did not use any material which was not previously used by the others.

Based on the number of crosses made we can say that most of those lines were used in at least one combination, but the majority participated in several crosses. Embrapa Rice and Beans, from 1977 to 1990, used CIRAD's lines in 511 combinations (227 times as female and 284 as male parents). The most frequently used line was IRAT 112, which was present 108 times; IRAT 195 follows with 56 participations. The other ones, which participated in at least 4% of the total number of crosses, were: IRAT 13 (49), IRAT 177 (42), IRAT 257 (36), IRAT 216 (30), IRAT 2 (22), and IRAT 101 (22). IRAT 112 is a breeding line developed in Bouaké, Côte d'Ivoire, from a combination between IRAT 13 and Dourado Precoce, materials from CIRAD and Brazil, respectively. IRAT 195 is an induced mutant on the Brazilian variety IAC 25. During the seventies and eighties, Dourado Precoce and IAC 25 were the most popular early maturing varieties used by Brazilian farmers for a long time. Since earliness was one of the priority traits for Embrapa's breeding program, mainly for the drought escape in unfavourable upland savanna region (EMBRAPA, 1981) it was no surprise to see these two varieties involved in the crosses of the most

frequently used CIRAD's lines.

IAC only used eight lines, seven of which are among the ones used by Embrapa Rice and Beans. The difference is that they were used in crosses involving others local progenitors. They were used in 77 combinations (10 times as female and 67 as male). Similar to what was observed for Embrapa Rice and Beans breeding program, the early maturing line IRAT 112 with 29 presences was the most used germplasm. Other important lines were IRAT 10 (11), IRAT 116 (10), IRAT 140 (10), and IRAT 146 (10), and none of them were among the most frequent ones in Embrapa's program.

Embrapa Temperate Climate only used three CIRAD's varieties in its breeding program, two (IRAT 104 and IRAT 135) were different from the other 58. Fifteen crosses were made with these three lines and they were always used as a male parent. This low presence in this breeding program is not surprising because the target ecosystem for this institution is the irrigated one and most of CIRAD's germplasm introduced in the country came from the upland ecosystem, as mentioned before.

The prevalence of lines such as IRAT 112, IRAT 195, and IRAT 13 in these breeding programs is justified by the fact that they have high yield potential, modern plant type, and earliness (CIRAD, 1993), priority traits for upland varieties in Brazil (EMBRAPA, 1981).

In the case of Colombia, during the 1957-62 period, the Rice Program of the Ministry of Agriculture was in charge of rice breeding. During the 1962-95 period, there was a close collaboration between CIAT and the program of ICA. Therefore, for this study we considered CIRAD's germplasm used by both Institutions as one program. From 1960 to 1991, a total of 16 lines were used in 1092 combinations (703 times as female and 389 as male). The most common line used by the Colombian programs was IRAT 13, which participated in 186 combinations. The lines that follow it were: IRAT 8 (120), IRAT 216 (58), IRAT 2 (50), IRAT 10 (48), IRAT 120 (31), IRAT 122 (27), IRAT 124 (23), and IRAT 121 (18). IRAT 13 is a mutant line from IRAT 2 or 63-83, a germplasm bred by CIRAD, in Senegal. The progenitors of IRAT 8 are Moroberekan and 63-105 from West Africa. The IRAT 120 series was selected in Madagascar, for local irrigated rice ecosystem, from crosses between the Malagasy line Makalioka and the Taiwanese line Chianan 8 (Table 6). CIAT identified this series as a source of resistance to Rice Hoja Blanca Virus (RHBV), an important disease in the region, and to

the insect vector *Tagosodes orizicola* (Muir) (Pardey et al., 1996). Even though the disease and its insect vector were never observed in that country, Makalioka was identified as the resistant gene source to *Tagosodes orizicola* (Muir) (Martínez et al., 1994). Sources of resistance to the RHBV were found in the IRAT 120 series coming from the japonica parent Chianan 8 (CIAT, 1989).

In Mexico, rice improvement started in 1949 and was responsible for the release of 42 varieties during the period 1956-1991 (Ortega Arreola et al., 1992). The savannas located between the States of Campeche and Tabasco have favourable ecological conditions for rice production under both irrigated and upland ecosystems (Rogriguez Avila and Orono Castro, 1992). During the period 1967-1990, a total of 17 lines were used in 277 combinations (140 times as female and 137 as male). The most common lines were: IRAT 13, IRAT 104, IRAT 112 and IRAT 136, used 27, 100, 54 and 19 times, respectively.

In Peru, where 95% of rice production is irrigated, the rice-breeding program used CIRAD's lines as parents. In fact the most used lines belong to the IRAT 120 series. As it was previously mentioned, this germplasm was developed in Madagascar for the irrigated rice ecosystem and was identified by CIAT as a source of resistance to the RHBV and *Tagosodes orizicola* (Muir). The Peruvian breeding objective was to have improved lines which were resistant to the RHBV as a preventive measure, since the disease is not important in the country as it is in Colombia or other tropical Latin American countries (Olaya Viera, 1983, 1984).

Parental lines in developed varieties or released directly

The use of CIRAD's germplasm in the national breeding programs allowed the countries to release, between 1982 and 2002, a total of 30 varieties. Brazil is the country where more varieties were released (17), followed by Colombia (5), Bolivia (5) and Guatemala (3). In Mexico and Peru there was not any commercial variety that came from selected progenies of crosses involving CIRAD's lines or direct releases. It is an interesting fact to see Guatemala listed among the countries where CIRAD's lines made a contribution to the farmers. In fact, this result is a spill-over from CIAT-Colombia's breeding project from where progenies were introduced and locally selected under favourable upland rice ecosystem with no acid soils and good rainfall distribution, present in Guatemala

(Ramírez, 1992).

Since Brazil had the national program that took more advantage of the genetic resource managed by CIRAD, it is expected to concentrate more attention. For the last twenty years (1982-2002) there were 22 rice varieties released for the upland ecosystem in Brazil. Out of these 22 varieties, 17 have CIRAD's contribution, seven came from the joint program with Embrapa, six were developed jointly with CIAT, three were CIRAD's lines directly released to farmers (IREM 16B, Cabaçu, and Rio Verde) and one was developed only by Embrapa (Table 2). These results stressed the importance of CIRAD's germplasm for Embrapa's upland breeding program; the lines from CIRAD were present in 77% of the upland rice varieties released in Brazil in the last two decades.

Among the parents that generated the 17 rice varieties we found nine lines that came from CIRAD. The most common one was IRAT 216, which was also directly released as a variety for the state of Mato Grosso (EMBRAPA, 1992). This line was used because of its modern plant and long grain type (CIRAD, 1993). Table 6 shows that IRAT 124, which also contributed strongly to the released varieties, is a line coming from Makalioka and Chianan 8 cross, resistant to the RHBV and *Tagosodes orizicola* (Muir) modern plant type and with a good adaptation to favourable upland conditions (present in the Mato Grosso State).

In Colombia, the exploitation of upland acid soil ecosystem in the Altillanura is new; rice germplasm has been seen as an alternative to stimulate it (Sarkarung and Zeigler, 1991). Currently the only upland rice varieties available to farmers are the ones released between 1989 and 2002 by CIAT (Table 3). All varieties came from crosses where there was at least one line from CIRAD involved. Similar to what has been observed for the Brazilian program, IRAT 216 is the most common parent.

Oryzica Llanos 4 is a variety which was released for irrigated and favourable upland ecosystems (Leal et al., 1988), without acidity or severe soil stresses, such as the ones observed in the Altillanura. The line IRAT 122 contributes to this variety because it is a source of tolerance to RHBV.

In Bolivia, favourable upland rice cultivation is based on two different systems: the mechanised and the manual system performed by small farmers (Manchego, 1992; Guzmán, 1994). During the period 1993-2002, five varieties were released in Bolivia attending both systems (Table 4). Three varieties were released for the mechanised system, which came from

progenies developed from CIAT's crosses and have IRAT 124 and/or IRAT 216 as parents. Two CIRAD lines bred in Africa were directly released as commercial varieties for the smallholder's system. They are rustic, show a taller plant type that make them better adapted to manual harvesting, and have a medium grain type praised by the producer/consumer.

For Guatemala there were three releases (Table 5). They all came from a local evaluation of selected introduced progenies of crosses developed by CIAT in Colombia, and distributed by INGER-Latin America (Ramírez, 1992).

Origin of the CIRAD's parents in commercial varieties released in Latin America

Fourteen CIRAD's lines have contributed to rice enhancement and further release of commercial varieties in Latin America (Table 6.). As it can be seen, they originated from CIRAD's breeding projects

in West Africa (Côte d'Ivoire and Burkina Faso), Madagascar, and Latin America (Brazil and French Guyana).

Promising lines to be released

The contribution of CIRAD's line to national breeding programs will still be important in the near future. Table 7 shows that there are six upland breeding lines performing well in Brazil, Colombia, Nicaragua and Peru. In Brazil, the line CNA 8812 (CT13226-11-1-M-BR1) was identified as promising for the upland ecosystem. The line shows good drought tolerance, earliness, and excellent grain quality (O. P. de Moraes, personal communication).

In Colombia, CIRAD 445 was identified as a potential variety for the coffee growing region with an altitude less than 1450 m (Moreno et al., 2002). The upland-hillside lines CIRAD 446 and CIRAD 447 were identified for the small holders in the Andeans (M.

Table 2. List of upland rice varieties released in Brazil in the 1982 to 2002 period where CIRAD's line were involved in the combination or directly released, including the year of release and the crosses.

Variety name	Year of release	Origin	Cross and Parents	CIRAD parent
IREM 16B	1982	CIRAD	Taichung Native 1/Moroberekan/IAC 25	IRAT 190
Rio Paranaíba	1986	Embrapa/CIRAD	IAC 47/IRAT 2	IRAT 2
Centro America	1987	Embrapa/CIRAD	IAC 25/IRAT 2	IRAT 2
Guarani	1987	Embrapa/CIRAD	IAC 25/IRAT 2	IRAT 2
Guaporé	1987	Embrapa/CIRAD	IAC 47/IRAT 13	IRAT 13
Cabaçu (IRAT 177)	1988	CIRAD	Mutant of IRAT 79	IRAT 79
Tangara	1988	Embrapa/CIRAD	IAC 25/IRAT 13	IRAT 13
Doradao	1989	Embrapa/CIRAD	IAC 25/IRAT 2	IRAT 2
Xingu	1989	Embrapa/CIRAD	IAC 47/IRAT 13	IRAT 13
Rio Verde (IRAT216)	1991	CIRAD	Colombia 1/M 312 A	IRAT 216
Progresso	1993	CIAT/CIRAD	CT6196 [IRAT 216/IRAT 124//RHS 107]	IRAT 124 IRAT 216
Canastra	1995	CIAT/CIRAD	CT7415 [Tox 939/IRAT 216//Tox 1780]	IRAT 216
Maravilha	1995	CIAT/CIRAD	CT6516 [IRAT 216//Tox 1010/IRAT 121]	IRAT 121 IRAT 216
Primavera	1997	Embrapa	IRAT 10/LS85-158	IRAT 10
Bonança	1999	CIAT/CIRAD	CT11614 [Tox 1780/IRAT 216//IAC47]/[Tox 1010/CIRAD 216//IRAT 122/IAC47]// [IRAT 216/IRAT 124//RHS 107]	IRAT 124 IRAT 216
Carisma	1999	CIAT/CIRAD	CT11251 [Tox 1780/IRAT 216//IAC47] / [IRAT 216/IRAT 124//RHS 107]//[Tox 1010/IRAT 216//Tox 1780]	IRAT 124 IRAT 216
Talento	2002	CIAT/CIRAD	CT11251 [[Tox 1780/IRAT 216//IAC47] / [IRAT 216/IRAT 124//RHS107] // [Tox1010/ IRAT 216//Tox1780]	IRAT 124 IRAT 216

Table 3. List of rice varieties released in Colombia in the 1989 to 2002 period where CIRAD's lines were involved in the combination, including the year of release and the crosses.

Variety name	Year of release	Origin	Cross and Parents	CIRAD parent
Oryzica Llanos 4	1989	CIAT	P5413 [CR1113/IRAT 122//P5003]	IRAT 122
Progreso 4-25	1989	CIAT	CT10532	IRAT 120
Oryzica Sabana 6	1992	CIAT	[P3084/P3844]/[P3472//P3304/IRAT 120]	IRAT 216
Oryzica Sabana 10	1996	CIAT/CIRAD	CT7244 [Tox 1780/IRAT 216/IAC47]	IRAT 124
Línea 30 (CIRAD409)	2002	CIAT/CIRAD	CT6196 [IRAT 216/IRAT 124//RHS 107]	IRAT 216
			CT11891	IRAT 124
			[IRAT 146/Oryzica Sabana 6//CT10035-43-4-M-3]	IRAT 146
				IRAT 216

Table 4. List of favourable upland rice varieties released in Bolivia in the 1993 to 2002 period where CIRAD's lines were involved in the combination or were directly released, including the year of release and the crosses.

Variety name	Year of release	Origin	Cross and Parents	CIRAD parent
Sacia-1 (Tacu)	1993	CIAT	CT5633	IRAT 216
			[Tox 1010/IRAT 216]	
Sacia-3 (Tutuma)	1994	CIAT	CT6196	IRAT 124
			[IRAT 216/IRAT 124//RHS 107]	IRAT 216
Sacia-4 (Jisumu)	1994	CIAT	CT6240	IRAT 124
			[Ngovie/IRAT 124//IRAT 216]	IRAT 216
Jasaye (IRAT 170)	1999	CIRAD	IRAT 13/Palawan	IRAT 13
Jacuú (IRAT 357)	2002	CIRAD	E 425/IRAT 257	IRAT 257

Table 5. List of favourable upland rice varieties released in Guatemala in the 1996 to 2000 period where CIRAD's lines were involved in the combination, including the year of release and the crosses.

Variety name	Year of release	Origin	Cross and Parents	CIRAD parent
ICTA Izabal	1996	CIAT	CT 11615	IRAT 112
			[Tox 1780/IRAT 216//IAC47] /	IRAT 122
			[Tox 1010/ IRAT 216//IRAT 120/IRAT 112]//[Tox 1010/IRAT 216//Tox 1780]	IRAT 216
Masagua	2000	CIAT	CT9102	IRAT 122
			[CICA 8//BG90-2/K8]/[IRAT 122]//[P 3041/IR13240]	
Oásis	2000	CIAT	CT11008	IRAT 121
			[BR IRGA409/LEMONT//CT 7363]/[P 2217/IRAT121//P 3299]	

Valès, personal communication).

In Nicaragua, farmers of the central region for upland and rainfed-lowland ecosystems adopted CIRAD 301. This line is praised for its good adaptation to different stress, for its high yield potential and as well as grain quality (G. Trouche, personal communication). In Peru, CIRAD 409 - selected and released in Colombia (Table 3), is seen as an excellent alternative for the slash and burn rice system in the Pucallpa region (D. White, personal communication).

CONCLUSIONS

The analysis made leads to the following conclusions:

- A total of 61 CIRAD's lines were used for crossing in Latin America, and some of them were used in high frequency mainly in Brazil and Colombia, where CIRAD had direct international rice breeding collaboration;
- There were more than 2,000 crosses made in by four Latin American Countries where at least one

parent was from CIRAD;

- Fourteen different CIRAD's lines participated in the genetic background of the commercial varieties released;

- Twenty-five commercial varieties released in Brazil, Bolivia, Colombia and Guatemala had at least one CIRAD's line participating in the cross of origin;

- Five IRAT lines bred by CIRAD were directly

Table 6. List of CIRAD's lines used as parents of the commercial varieties released in Latin America.

CIRAD line	Country of selection	Year of registration by CIRAD	Parents
IRAT 2	Senegal	1963	560 /Variety from Zaire
IRAT 10	Côte d'Ivoire	1973	63-104/Lung Sheng 1
IRAT 13	Côte d'Ivoire	1973	Mutant of 63-83
IRAT 79	Côte d'Ivoire	1976	Mutant of IRAT 2
IRAT 112	Côte d'Ivoire	1978	IRAT 13/ Dourado Precoce
IRAT 120	Madagascar	1979	Makalioka/Chianan 8
IRAT 121	Madagascar	1979	Makalioka/Chianan 8
IRAT 122	Madagascar	1979	Makalioka/Chianan 8
IRAT 124	Madagascar	1979	Chianan 8/Makalioka
IRAT 146	Burkina Faso and Côte d'Ivoire	1979	IRAT 13/Dourado Precoce
IRAT 170	Côte d'Ivoire	1981	IRAT 13/Palawan
IRAT 177	French Guyana	1981	Mutant of IRAT 79
IRAT 257	Brazil	1983	Mutant of Makuta
IRAT 357	Côte d'Ivoire	1989	E 425/ IRAT 257

Table 7. List of promising upland rice varieties to be released in Colombia, Nicaragua and Peru.

Promising lines	Country	Origin and place where bred	Cross	CIRAD parent
CNA 8812	Brazil	CIAT/CIRAD (Colombia)/ Embrapa Rice and Beans (Brazil)	CT13226-11-1-M-BR1 [Tox 1780/IRAT 216//IAC 47]/ [Ngovie/Taipei 309//IRAT 216]/ [PDR 34/Tox 1858]/[P3084/Tox 891]/ [P5268/CampecheA80]/[IRAT13/Ceysvoni//IR8073]// [Carolino/Tox 1785//Colombia 1/Tox 1011]/ [Tox 1780/IRAT 216//IAC 47]/ [Camponi/IRAT 216//IAC 165]	IRAT 13 IRAT 124 IRAT 216
CIRAD 445	Colombia	CIAT/CIRAD (Colombia)	CT10069-27-3-1-4 [Ngovie/IRAT 124//IRAT 216]/{Ngovie/Taipei 309//Camponi}/[Camponi/IRAT 216]	IRAT 124 IRAT 216
CIRAD 446	Colombia	CIRAD (Madagascar)/ CIAT (Colombia)	IRAT 265/Jumli Marshi	IRAT 265
CIRAD 447	Colombia	CIRAD (Madagascar)/ CIAT (Colombia)	IRAT 265/Jumli Marshi	IRAT 265
CIRAD 301	Nicaragua	CIRAD (Côte d'Ivoire)	62-667/IRAT 104	IRAT 104
CIRAD 409	Peru	CIAT/CIRAD (Colombia)	CT11891 [IRAT 146/Oryzica Sabana 6//CT10035-43-4-M-3]	IRAT 124 IRAT 146 IRAT 216

released as commercial varieties in Brazil and Bolivia and;

- Six promising upland lines were identified for release in Brazil, Colombia, Nicaragua and Peru.

RESUMO

Cooperação internacional para o melhoramento do arroz na América Latina: CIRAD, um estudo de caso

Na América Latina e no Caribe (LAC) o arroz é um alimento básico da dieta. Significativo aumento na produção do arroz foi alcançado na região, principalmente devido ao lançamento e a adoção de variedades de alto potencial de rendimento. Durante os últimos 40 anos cerca de 300 variedades foram lançadas. Esses materiais foram desenvolvidos por intuições nacionais e internacionais de pesquisa em arroz. O “Centre de cooperation internationale en recherche agronomique pour le développement” (CIRAD), Montpellier, França, trabalhou em colaboração com a Embrapa Arroz e Feijão, Goiânia, Brasil, e o Centro Internacional de Agricultura Tropical (CIAT), Cali, Colômbia, no desenvolvimento de variedades para a LAC. Este estudo tem como objectivo analisar a contribuição do CIRAD no melhoramento genético do arroz, com ênfase na América Latina. A presença das linhas do CIRAD foi detectada nos programas de melhoramento do Brasil, Bolívia, Colômbia, México, Guatemala e Peru. Os resultados observados foram: a) o CIRAD forneceu 61 linhas diferentes, as quais foram utilizadas como genitores em mais de 2000 cruzamentos na região; b) cinco linhagens do CIRAD foram lançadas diretamente como variedades; c) 25 variedades lançadas possuem pelo menos uma linha do CIRAD em seu cruzamento; e d) existem seis linhagens próximas a serem lançadas no Brasil, Colômbia, Nicarágua e Peru.

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