UPLAND RICE RESEARCH FOR LATIN AMERICA

(A REPORT TO THE TAC SUB-COMMITTEE ON UPLAND RICE)

Centro Internacional de Agricultura Tropical
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UPLAND RICE IN LATIN AMERICA

Production, Constraints and Research Proposals Designed to Improve Productivity in the Upland Sector in the Latin American Region

A paper prepared by CIAT at the request of the TAC Subcommittee on Upland Rice

CIAT-Cali, Colombia
December 23, 1979

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CORRECTIONS TO TABLE QUOTATIONS ON UPLAND RICE RESEARCH

TABLE 2, Page 8

CIAT. Trend Highlights on Beans, Cassava, Beef, Corn, Rice, Swine and Fertilizers. Internal Document Econ. 1.3 April 1978.

*CIAT. Latin America: Trend Highlights for CIAT Commodities. Internal Document Econ. 1.4 May 1979.

TABLE 4, Page 10

CIAT. Latin America: Trend Highlights for CIAT Commodities. Internal Document Econ. 1.4 May 1979.

TABLE 5, Page 12

CIAT. Latin America: Trend Highlights for CIAT Commodities. Interanl Document Econ. 1.4 May 1979.

TABLE 6, Page 13

CIAT. Latin America: Trend Highlights for CIAT Commodities. Internal Document Econ. 1.4 May 1979.

APPENDIX 3, Page 49

CIAT. Trend Highlights on Beans, Cassava, Beef, Corn, Rice, Swine and fertilizers. Internal Document Econ. 1.3 April 1978.

APPENDIX 4, Page 50

CIAT. Trend Highlights on Beans, Cassava, Beef, Corn, Rice, Swine and fertilizers. Internal Document Econ. 1.3 April 1978.

*CIAT. Latin America: Trend Highlights for CIAT Commodities. Internal Document Econ. 1.4 May 1979.

CONTENTS

PREAMBLE

The TAC Subcommittee on Upland Rice has requested that CIAT prepare a base paper on upland rice in the context of the Latin American region. The outline of the base paper as provided by the Subcommittee was addressed to the following issues:

1. Present and potential importance of upland rice in the diet and economy of Latin America.

2. Major constraints to increase production, achievements and present allocation of resources, priorities and plans.

3. Support required from IARCs to complement national research and training programs.

4. Need for additional information and fact finding.

5. Coordination of efforts to ensure that suitable cooperation takes place between IARCs and national programs.

A definition of upland rice was agreed to at the Subcommittee meeting (October, 1979) by representatives of the IARCs involved (i.e. WARDA, IITA, IRRI and CIAT). Upland rice is defined as rice production systems where all of the following characteristics prevail:

(i) no control or addition of water beyond rainfall or changes in water table height.

(ii) soil water levels not normally above the soil surface except during occasional flooding.

(iii) topography flat or undulating and where bunding may or may not be present.

In the context of Latin America there are only two broad production systems for rice which are recognised namely irrigated rice (arroz de riego) and upland rice (arroz de secano). The upland or dryland rice areas of Latin America largely fit within the above definition. Areas of flooded rice do occur in Colombia, Ecuador and Guyana but the proportion is very small. CIAT considers that no major error of omission will be made if we accept the prevailing and traditional nomenclature which is used throughout Latin America as describing upland rice in a world context. The areas of non-irrigated and non-upland rice production are very limited. Latin America does not have rainfed rice as strictly defined for Asia.

CIAT AND RICE RESEARCH IN LATIN AMERICA

CIAT collaborates closely with IRRI in rice research in Latin America. A liaison scientist has been appointed by IRRI to CIAT since 1976 to coordinate the International Rice Testing Program for Latin America. The CIAT rice unit commenced operations in 1967 through a collaborative program with the Instituto Colombiano Agropecuario (ICA). The research gradually took on an international focus in Latin America as the demands placed on CIAT by national programs increased. The IRTP was an essential vehicle in this evolution.

Rice research at CIAT has concentrated exclusively on the irrigated sector. Constraints of particular importance in Latin America have received attention by the CIAT group including Pyricularia and Sogatodes. Particular emphasis has been placed on grain quality, yield and stability of yield in tropical, mainly irrigated, environments in the region.

The rice program at CIAT has trained a total of 171 rice research and extension scientists from the region, over the period 1969-1979. Training was concentrated in rice production technology with less emphasis on breeding per se. This was in line with national program requirements. The vast majority of rice researchers in the region are in direct contact with CIAT on a regular basis through the regular meetings of the IRTP, through the monitoring tours of the IRTP group, through special conferences, seminars and workshops and through day to day germplasm exchange.

New varieties derived from the CIAT/IRRI program have been provided to national programs through the IRTP and directly as a result of scientific visits to CIAT by national program scientists. Table 1 shows the 'international' material now under commercial, mainly irrigated, production in the region. Material directly from IRRI has had less success in terms of release within national programs but in all cases the varieties derived from CIAT and from most national programs were heavily dependent on IRRI germplasm. Fine tuning of IRRI based irrigated rice technology has proved necessary to meet local constraints of particular importance.

The success of the new irrigated technology when applied in Colombia has been elegantly documented by Scobie and Posada (1977). Rice production in Colombia has grown at an average rate of 8.0% per annum over the period from 1963 to 1977 while average yields have increased at a rate of 6.7%. Only a very small increase in rice area was recorded. The distribution of net benefits of the new technology was heavily weighted towards the poor urban and rural consumers. The relative price of rice in the Colombian food basket is now approximately 1/3

Table 1. CIAT/IRRI Breeding lines released for commercial production in Latin America.

Breeding Lines	Source	Guatemala	Ecuador	Dominican Rep.	Venezuela	Colombia	Honduras	Paraguay	Bolivia	Brazil	Cuba
4	CIAT	●	●	●	●	●	●			●	
4422	CIAT	●									
4461	CIAT					●					
4444	CIAT		●	●							
P723-6-3	CIAT					●	●				
4421	CIAT				●	●	●				
4440	CIAT					●		●			
IR 1529-430-3	IRRI								●		●
IR 665	IRRI									●	
IR 841	IRRI									●	
IR 22	IRRI					●					

compared to 10 years ago (i.e. relative to prices of other commodities). Over the same period a marked decrease in upland rice production took place. In this case the price decreases occasioned by increased productivity made the more marginal upland producers uncompetitive.

The success which has been achieved in the Colombian irrigated rice sector is now being exported to other countries in the region. Table 2 shows changes in national production and yields of a number of countries in the region where the new irrigated rice technology is being applied. However, as will be described later in this report, there are serious limitations to the expansion of irrigated rice production in some countries in the region. These limitations derive from both environmental and economic considerations.

In this report information will be provided on the question of upland rice in the Latin American region. The interrelationship of the two production sectors, however, should always be considered. This derives from the vast areas available for increased production in both sectors in some countries in the region or from the possibility of conversion from upland to irrigated production in others. Economic questions will eventually decide the exact balance of the two production systems country by country.

CIAT had requested an increase in the size of the rice program for the 1980-81 biennial budget period. The increase amounted to three scientists and necessary support to mount a complementary program in upland rice and to provide a socio-economic input into the program as a whole. A breeder and a physiologist (soil-plant relations specialist) and an economist were to have come on stream in 1980.

The TAC Subcommittee was appointed in 1979 to consider the whole question of upland rice research on a global basis. The CIAT application was deferred by the CGIAR until a reading from TAC could be obtained. In this report CIAT will present a case for the inclusion of a modest program on upland rice research within the core budget.

The cornerstone of the case will remain our close collaboration with IRRI (a) through the IRTP program, (b) through germplasm flow to the CIAT breeders and (c) through basic research and technology development activities which are only possible at IRRI given the obvious critical mass that it has now achieved.

Table 2. Average of rice yields for selected countries in Latin America. Averages 1963/65, 1973/75 and 1975/77

Country	1963/65	1973/75	1975/77
	----------------	kg/ha	----------------
Colombia	1964	4229	4169
Peru	3965	4152	4425
Dominican Rep.	2238	3444	3970
Venezuela	1841	2774	3246
Ecuador	1501	2698	2787
Costa Rica	1374	1182	2065
Nicaragua	1314	2976	2954

Source: Estimated from FAO

RICE PRODUCTION IN LATIN AMERICA

Table 3 gives the total Latin American regional production in rice by sector for the latest provisional figures available for 1978.

Table 3. Latin American rice production statistics in the two production sectors for 1978.

	Area Million ha	Production Million tons	Yield t/ha
Irrigated Rice	2.1	7.1	3.4
Upland Rice	5.3	6.9	1.3
Total	7.4	14.0	
Upland % of Total	72 %	49 %	

Source: Provisional data provided by participants at 3rd IRTP meeting held at CIAT, May-June, 1979. Data incomplete in some smaller countries.

Upland rice production provided 49% of total production in 1978 and was grown on 72% of the total area devoted to rice in the region. The upland sector is thus a large proportion of total production. The yields are much lower in the upland sector which is to be expected from the different production conditions involved. The relative importance of the upland sector in Latin America is in sharp contrast to the situation in Asia where upland rice is of relatively minor importance.

Data in Table 4 shows the production, imports and exports and resulting apparent per capita consumption of rice by country for the region for 1975/76. Latin America was a net importer of rice with six countries (Cuba, Peru, Dominican Republic, Trinidad and Tobago, Venezuela and Chile) showing significant imports. Colombia, Uruguay, Argentina, Guyana and Surinam were significant exporters. Apparent per capita consumption amounted to 45kg/annum in 1975-76. This is an apparent increase from 41 kg in 1973-75.

Guyana and Surinam are the heaviest consumers per capita followed in order by Panama, Costa Rica, Brazil. Rice is a commodity which is of increasing importance in the region. The growth rate of demand for rice in the region is outstripping the growth rate of production

Table 4. Production, trade and apparent consumption of rice in Latin America by countries. Average 1975/76.

Country	Production	1975/76 Imports Exports	1975/76 Apparent consumption	Apparent per capita consumption
	------------	'000 ton	------------	kg/year
Exporting				
Colombia	1587	-189	1398	57
Uruguay	203	-104	99	36
Argentina	330	- 82	248	10
Guyana	260	- 81	179	225
Surinam	176	- 58	118	276
Brazil	8549	- 17	8532	79
Nicaragua	75	- 4	71	32
Costa Rica	173	- 2	171	86
Ecuador	373	- 2	371	54
Panama	165	-	165	97
Paraguay	51	-	51	19
Importing				
Cuba	434	+208	642	67
Peru	554	+ 74	628	40
Dominican Rep.	225	+ 41	296	61
Trinidad & Tobago	20	+ 29	49	45
Venezuela	320	+ 28	348	27
Chile	86	+ 20	106	10
Haiti	120	+ 8	128	25
El Salvador	49	+ 8	57	14
Honduras	28	+ 6	34	10
Guatemala	29	+ 5	34	6
Belize	6	+ 2	8	54
Bolivia	120	1	121	21
Mexico	590	-	590	10
Latin America	14523	-109	14414	45

Source: Estimated from FAO

in the following countries, i.e. Honduras, Chile, El Salvador, Brazil, Guyana, Dominican Republic, Ecuador, Peru, Panama. Data in Table 5 shows these growth rates over the period from 1963 to 1975 by country.

The overall growth of demand for the region was 3.6% for 1963-75 while the growth rate of production was 2.8%. The growth rate of human population over the same period was also approximately 2.8%. Production increased from 1963-75 at a faster rate than population in most countries except Brazil, Honduras, El Salvador, Panama and Chile. Since Brazil participation in total production of the region is high (69%) its slow production growth (1.2% per annum) dominates the overall trend of higher growth rates in some countries.

In general only one third of the increases in production could be attributed to yield (Table 6). The remaining two thirds are attributed to area increases. This, however, varies from country to country. In Colombia, Ecuador, Panama, Belice, Haiti and Trinidad and Tobago most of the increases were due to yield increases. In contrast the increases in production of Brazil, Cuba, Argentina, Bolivia, Paraguay and Guatemala were mostly due to area increases. For Brazil, Paraguay, Bolivia and Guatemala most of the production increase over the period apparently relied upon expansion of area in the upland sector.

Accurate data by production sector for some of countries in the region was not available at the time of writing. The data has been requested from all national programs but only a few have replied. Under these circumstances it has not proved possible to calculate separate growth trends for the two sectors. Analysis of this type will be made available to the Subcommittee when and if the data becomes available.

The general conclusion reached from the data now available strongly suggests a stagnant or negative yield trend in upland rice in almost all countries in the region. Over the same period there has been a marked increase in irrigated rice yields in Colombia, Venezuela, Costa Rica, Panama, Surinam, Guyana, Cuba.

While it is impossible to quantify the reasons for this situation it is clear that the lack of a research network in upland rice in Latin America has contributed to this lack of progress in the sector.

Table 5. Growth rates of demand and production of rice in Latin America by countries. 1963/75

Region and Country	Growth rate of: Per Capita GNP [a/] $\dot{y}$	Growth rate of: Human population [a/] $\dot{p}$	Income elasticity of demand for rice [b/] $E\dot{y}$	Growth rate of: Demand $\dot{d}$ [1/]	Growth rate of: Production [c/]
	------ % ------			------ % ------	
Tropical Latin America				3.90	
Ecuador	4.0	3.34	0.5	5.40	4.13
Venezuela	4.0	3.16	0.3	4.40	5.18
Colombia	2.6	2.72	0.5	4.05	8.47
Mexico	3.3	2.90	0.3	3.92	4.92
Peru	2.0	3.30	0.3	3.92	3.99
Brazil	4.0	2.89	0.2	3.71	1.18
Bolivia	2.5	2.43	0.5	3.71	7.32
Paraguay	2.0	2.54	0.3	3.15	10.59
Central America				4.40 [2/]	
Guatemala	3.3	2.91	0.6	4.95	6.70
El Salvador	1.8	3.29	0.6	4.40	0.65
Nicaragua	3.0	3.09	0.4	4.33	9.07
Honduras	1.6	3.28	0.6	4.27	-4.36
Costa Rica	2.9	3.13	0.3	4.03	4.12
Panama	4.1	2.95	0.2	3.79	2.16
Caribbean				3.50 [2/]	
Dominican Rep.	3.1	3.27	0.6	5.19	4.57
Jamaica	3.6	1.47	0.4	2.93	n.a.
Guyana	1.5	2.32	0.2	2.62	-1.13
Haiti	1.5	1.52	0.7	2.58	11.52
Trinidad & Tobago	4.0	1.19	0.1	1.59	4.44
Temperate Latin America				1.83 [2/]	
Chile	1.7	2.01	0.2	2.36	-4.17
Argentina	2.8	1.39	0.1	1.67	5.02
Uruguay	1.5	1.13	0.2	1.43	8.19
Latin America				3.60	2.80

1/ $\dot{d} = \dot{p} + E\dot{y}\ \dot{y} + \dot{p}\ \dot{y}$ 2/ Average, weighted by population

Source: a/ IFPRI, b/ FAO c/ Estimated from FAO

Table 6. Annual growth rates of production, area and yields for rice in Latin America by countries 1963/1977.

Country	Production	Area	Yields
	percentage		
Brazil	2.25***	2.40***	-0.15
Colombia	8.00***	1.30	6.70***
Mexico	4.07***	2.05***	2.02***
Peru	4.25***	3.43***	0.82***
Cuba	12.56***	9.97***	2.59**
Dominican Rep.	4.97***	-0.36	5.33***
Venezuela	6.06***	1.66	4.40***
Argentina	4.07***	4.09***	-0.02
Ecuador	4.97***	0.42	4.55***
Guyana	0.36	-0.12	0.48
Panama	2.05**	-0.72	2.77***
Surinam	5.64***	4.08***	1.56**
Uruguay	8.53***	5.88***	2.65***
Costa Rica	4.58***	2.82*	1.76
Haiti	10.78***	3.63***	7.15
Bolivia	7.21***	6.32***	0.89
Nicaragua	4.90**	-1.06	5.96***
Chile	-0.70	-2.44	1.74**
Paraguay	10.98***	6.36	4.62
El Salvador	-0.43	-1.34	0.91
Guatemala	5.24**	3.92***	1.32
Honduras	-1.60	0.54	-2.16**
Trinidad & Tobago	5.45***	1.04	4.41***
Belize	14.21***	6.89***	7.32***
Latin America	3.43***	2.43**	1.00***

* Significance level 10%
** Significance level 5%
*** Significance level 1%

Source: Estimated from FAO

PRODUCTION OF UPLAND RICE IN LATIN AMERICA

Production statistics for the countries of Latin America broken down by production sector are given in Table 7 for 1978. The relative importance of upland rice in terms of production and area sown is given in Table 8, in rank order of upland production contribution to total Latin American rice production.

The predominance of Brazil in these data is obvious. However, upland rice constitutes the major proportion (>50%) of the national production for other countries i.e. Bolivia, Costa Rica, Guatemala, Honduras, Panama and El Salvador. While Mexican production is concentrated mainly in irrigated areas, the situation is changing rapidly due to economic circumstances in that country and it is expected that upland production will increase significantly over the next few years due mainly to increases in area sown(at least in the first few years).

In general terms yields in the upland sector have remained stagnant over the past ten years in most countries. Data for Brazil in Figure 1 shows the production statistics for the upland sector in contrast to the irrigated sector. The lack of improvement in productivity reflects the more limiting production conditions in that sector and the lack of an appropriate and effective research effort for the crop in the region.

Data on the areas sown in the two sectors is shown in Table 9 for three years 1969, 1975, and 1978. Brazil has shown a continuous increase in upland area sown with an apparent decline in area in the irrigated sector compared to 1969. Other countries showing significant increases in upland area where Bolivia, Panama, Honduras. Countries showing a significant decrease in area over the period were Colombia, Venezuela and Nicaragua. In the latter three countries there has been an increase in irrigated area and production. With this increased productivity has come a more competitive price structure and resulting pressure on the more marginal upland producers. Differential cost of production increases in the irrigated sector is now changing this situation.

In general the conclusion can be reached that there has been a marked increase in total production from the upland sector in Latin America in the past ten years. All of this increase was probably due to increased area sown while yields have remained stagnant or declined. In the latter case where declines are indicated this was probably due to the movement of upland rice production into less favored areas of production where the environmental and biological constraints were more severe.

PRODUCTION STATISTICS FOR BRAZIL 1969-78

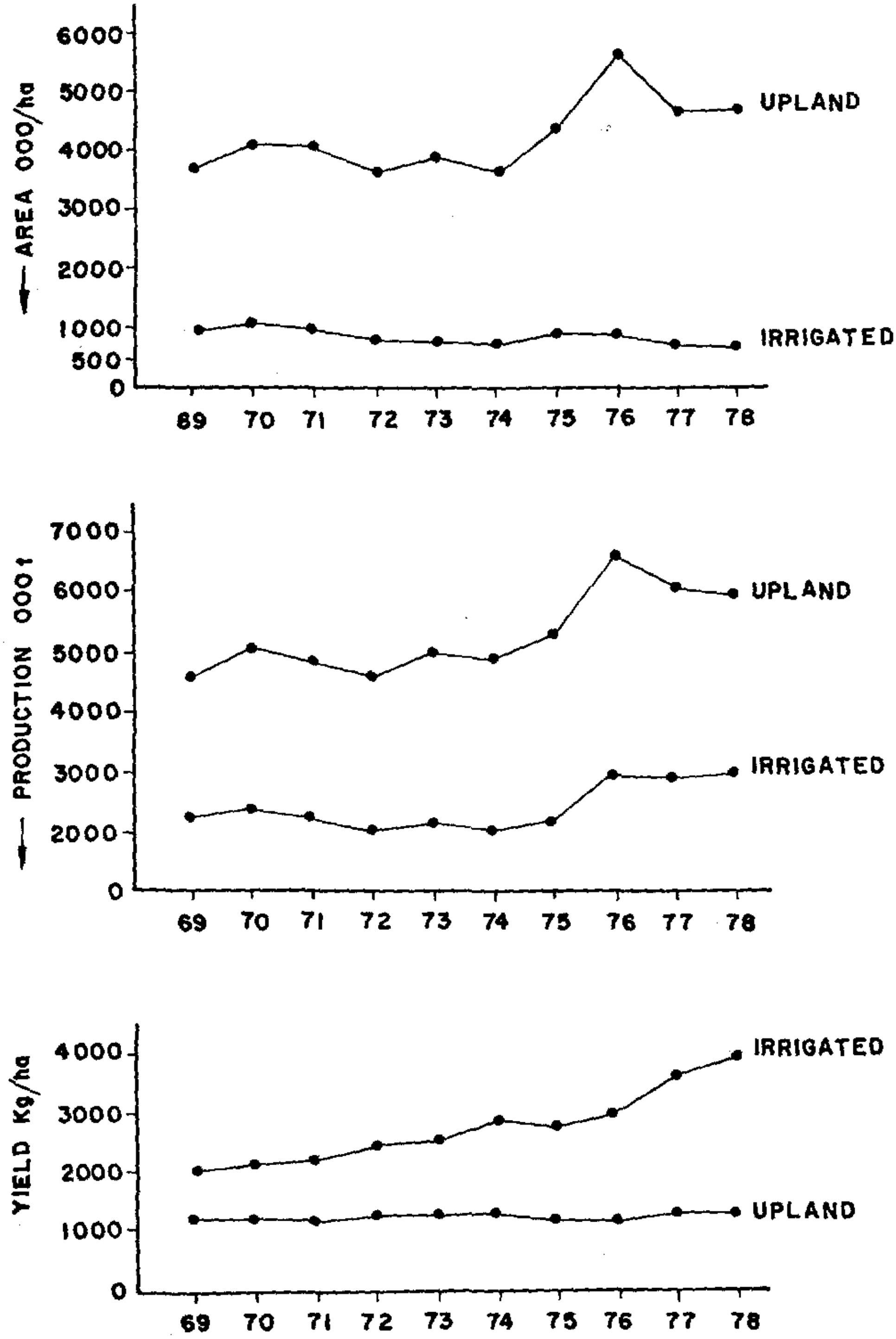

FIGURE 1

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Table 7 Production statistics for rice by sector for Latin America in 1978.

Country	Area '000 ha		Production '000 ton		Yield ton/ha	
	Irrigated	Upland	Irrigated	Upland	Irrigated	Upland
Argentina	91.0	0	320	0	3.50	–
Belice	4.0	0	7	0	1.75	–
Bolivia	0.0	83.0	0	101	–	1.22
Brazil	756.0	4644.0	2995	5946	3.96	1.28
Colombia	261.2	79.8	1219	110	4.66	1.38
Costa Rica	3.3	59.7	11	119	3.24	2.00
Cuba	200.0	0.0	420	0	2.10	–
Chile	35.0	0.0	n	0	n	–
Ecuador	56.1	58.9	167	148	2.98	2.56
El Salvador	4.5	8.5	n	n	n	n
Guatemala	0.0	11.5	0	26	–	2.26
Guyana	95.8	39.2	249	51	2.60	1.29
Haiti	36.0	12.0	83	17	2.31	1.39
Honduras	4.8	19.2	9	21	1.98	1.12
Mexico	99.3	73.7	344	137	3.47	1.85
Nicaragua	11.6	3.4	41	4	3.56	1.09
Panama	3.4	111.6	4	186	3.64	1.63
Paraguay	19.5	10.5	56	19	2.87	1.81
Peru	93.5	28.5	454	49	4.85	1.71
Dominican Rep.	61.7	3.3	197	6	3.20	1.90
Surinam	49.0	1.0	n	n	n	n
Uruguay	58.3	0.0	228	0	3.91	–
Venezuela	111.3	36.7	442	65	3.97	1.78
Totals	2055.3	5284.5	7246	6999.4		

n = not available

Source: Data provided by participants at 3rd IRTP Conference

Table 8. Area and production in upland rice as a percentage of total for each country in Latin America, 1978 estimates.

Country	Upland Area as % of total	Upland Production
Brasil	86.0	66.5
Colombia	23.4	8.3
Venezuela	24.8	12.9
Perú	23.4	9.7
Mexico	42.6	28.4
Cuba	0	0
Argentina	0	0
Ecuador	51.2	47.0
Guyana	29.0	16.9
Uruguay	0	0
Panama	97.0	97.9
Costa Rica	94.7	91.8
Haiti	25.0	16.7
Bolivia	100.00	100.0
Paraguay	34.9	25.4
Nicaragua	22.6	8.1
Honduras	80.0	69.4
Guatemala	100.0	100.0
Belice	0	0
Chile	0	0
El Salvador	65.0	n
Dominican Rep.	5.0	n
Surinam	0	0

Source: Data provided by participants at 3rd IRTP Conference at CIAT May, June 1979.

Table 9. Area sown in the two rice sectors for the years 1969, 1975 and 1978 by country in Latin America.

Country	Area ('000/ha)					
	1969		1975		1978	
	Irrigated	Upland	Irrigated	Upland	Irrigated	Upland
Argentina	89.0	0.0	93.0	0.0	91.0	0.0
Belice	2.0	0.0	4.0	0.0	4.0	0.0
Bolivia	0.0	54.0	0.0	74.0	0.0	83.0
Brasil	1101.2	3686.8	791.8	4487.2	756.0	4644.0
Colombia	91.0	169.0	279.0	93.0	261.2	79.8
Costa Rica	2.2	41.8	2.9	84.1	3.3	59.7
Cuba	164.0	0.0	200.0	0.0	200.0	0.0
Chile	23.0	0.0	23.0	0.0	35.0	0.0
Ecuador	27.3	50.7	46.2	85.8	56.1	58.9
El Salvador	1.2	10.8	5.9	11.1	4.5	8.5
Guatemala	0.0	13.8	0.0	31.4	0.0	11.5
Guyana	–	–	120.0	14.0	95.8	39.2
Haiti	25.0	13.0	32.0	16.0	36.0	12.0
Honduras	0.9	8.1	2.2	15.8	4.8	19.2
Mexico	114.0	38.0	128.5	128.5	99.3	73.7
Nicaragua	5.2	20.8	15.0	15.0	11.6	3.4
Panama	0.8	104.2	1.1	113.9	3.4	111.6
Paraguay	–	–	–	–	19.5	10.5
Peru	110.0	30.4	100.3	22.2	93.5	28.5
Dominican Rep.	72.0	8.0	62.7	3.3	61.7	3.3
Surinam	–	–	–	–	49.0	1.0
Uruguay	34.3	0.0	46.9	0.0	58.3	0.0
Venezuela	24.0	96.0	43.5	70.5	111.3	36.7
Totals	1887.1	4345.4	1998.0	5265.8	2055.3	5284.5

Source: Gross data from FAO for area sown with estimates of the proportion in the two sectors obtained from participants at 3rd IRTP Conference at CIAT May–June, 1979.

PRODUCTION CONSTRAINTS FOR UPLAND RICE IN LATIN AMERICA

The distribution of production areas of the two rice sectors is shown in **Map 1** for the Latin American region. The areas have been defined on the basis of collected information. A full target area survey of rice production in Latin America will be mounted in 1980 and 1981 by CIAT. This survey will accurately define the existing situation. With only three research scientist in CIAT core and one IRRI liaison scientist the resources of the rice program are quite limited and it has not proved possible to provide the vital survey and socio-economic input into the program.

The map shows a clear demarkation of upland and irrigated production in Brazil between the southern irrigated areas and the vast areas in the north and central west where upland rice is grown. There is also a fairly clear demarkation in Central America from southern Mexico to Panama with the exception of Nicaragua. The area in Bolivia is contiguous to the area in the Matto Grosso of Brazil and has therefore quite similar problems. For the purposes of this report the discussion of upland rice production will be divided into subregions as follows:

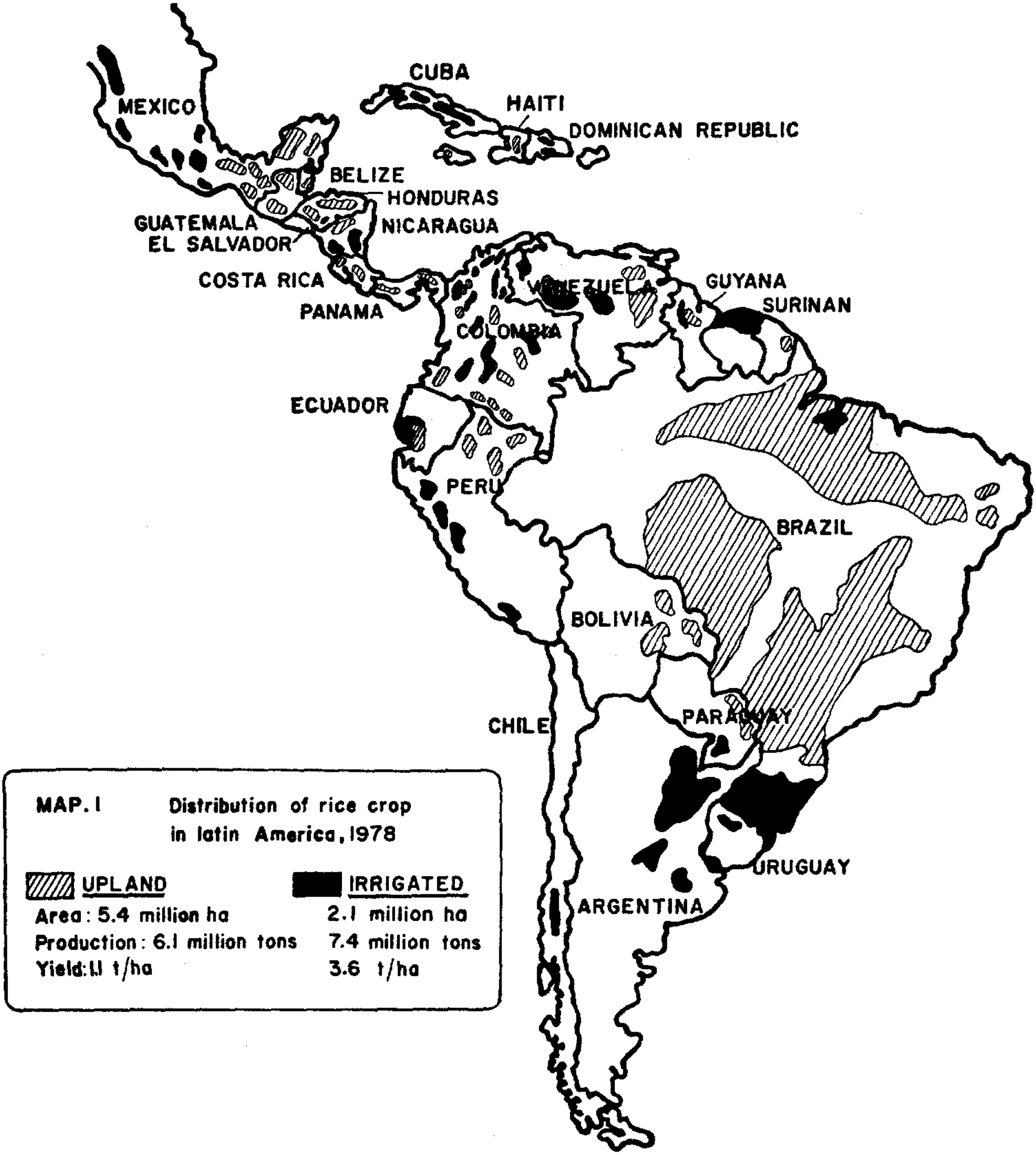
1. Brazil
2. Central America Region: Mexico, Guatemala, Costa Rica, Nicaragua, El Salvador, Honduras, Panama, Belice and the Caribbean
3. Northern South American Region: Colombia, Venezuela, Ecuador Surinam, Guyana
4. Southern South American Region: Peru, Bolivia, Chile, Argentina, Paraguay, Uruguay

The collected production statistics for those regions is shown in Table 10 for 1978.

Table 10 . Production area and yield of upland rice by subregion in Latin America for 1978: Preliminary data

Region	Production '000 tons	Area '000ha	Yield t/ha
1 Brazil	5945.8	4644.0	1.28
2 Central American Region	509.8	303.9	1.68
3 North S. America Region	375.0	214.6	1.74
4 Southern Andean Region	168.8	122.0	1.38

Source: Data provided by participants at 3rd IRTP Conference



MAP. I Distribution of rice crop in latin America, 1978

Sub Region 1: Brazil

Brazil is the dominant country in the region for upland production. Data in Figure2 gives the actual area sown, production and yield for 1978 by states superimposed on the actual areas in which upland rice is sown (estimated data as of December, 1979). The cerrado region of Brazil (Figure 3) coincides with the majority of production in the states of Matto Grosso, Minas Gerais, Goias and Maranhão. These states are also those with the majority of production in the upland sector. Thus the problems of the Cerrado are the main problems of upland rice production as well.

An excellent account on the ecology of the cerrado has been published by Goodland and Feri (1979). This report will not attempt to do an in-depth analysis of these conditions.

The basic problem in the Cerrado is concerned with the soil type. The rainfall environment under more normal soil conditions would offer no particular problem beyond that suffered by other favored dryland areas of crop production in the world. However, the combination of the particular set of soil conditions with rainfall patterns produces a serious constraint to increased production with existing genotypes.

These acid soils (pH 4-5) are well drained latosolic soils red or yellow in color. The level of aluminium saturation in the exchange complex lies between 50-80% and usually increases with depth in the soil horizons. The high level of aluminium saturation restricts root growth in the subsoil even though 'available' water may be present. Thus in a soil with a rather narrow range of water holding capacity a quantity of water is made unavailable due to poor root growth. Liming allows excellent growth of roots in the topsoil but does not solve the problem. These factors combine to bring about water stresses in the growing crop when rainless periods of more than 6-8 days are experienced (veranicos). The degree of severity of these conditions depends largely on the Al saturation condition in the subsoil. Some areas of the Cerrado are definitely more favored and are being exploited. The need then is for germplasm which is able to produce reasonable root growth in aluminium saturated conditions.

The non-Cerrado upland areas in Sao Paulo and Parana are more favored from a rainfall point of view but also suffer in large part from the same problems of Al toxicity particularly in the subsoil. It is clear that many areas of Brazil which are classified as more favored areas of production, do suffer from the same basic soil constraints. Any attempt to improve productivity must clearly address this basic problem. A more accurate definition of favored and unfavored rice areas in Brazil

REGIONAL PRODUCTION STATISTICS OF UPLAND RICE IN BRAZIL

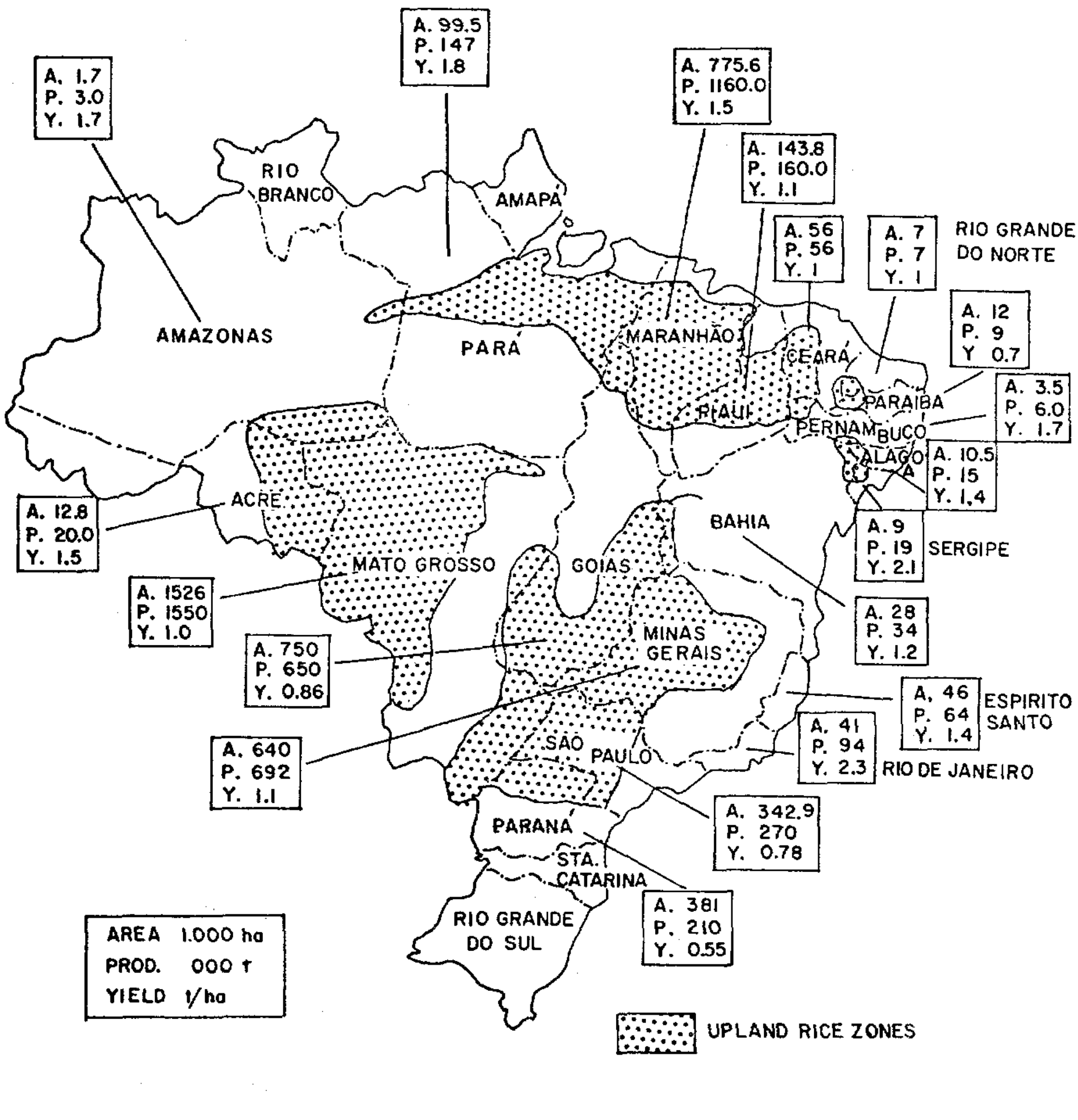


FIGURE 2

CONSTRAINTS TO UPLAND RICE PRODUCTION IN BRAZIL

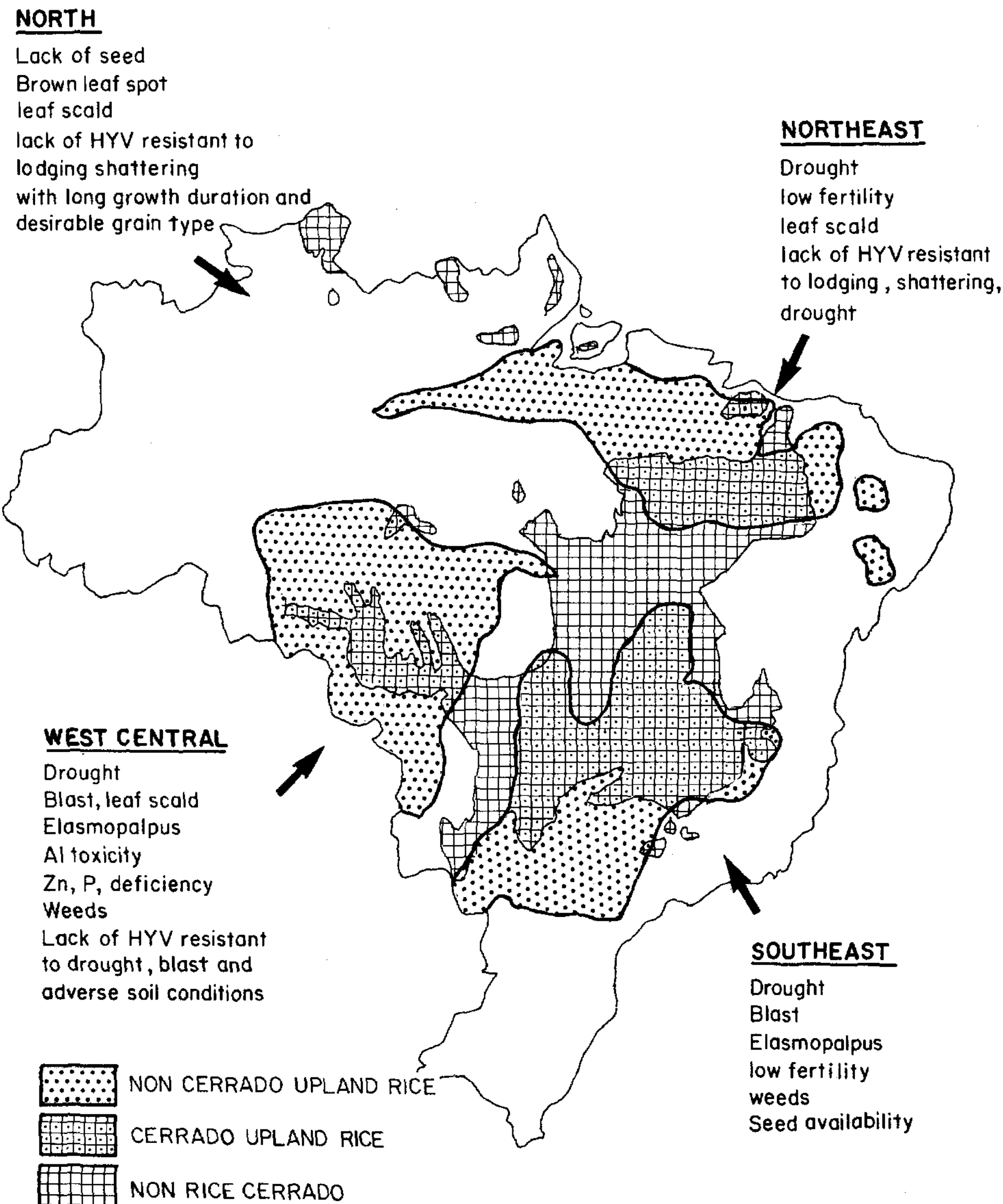


FIGURE 3

will be available in 1980-81 when the target area survey begins to concentrate on rice. The soil and landscape analysis has already been done for the region. Accurate information on exactly where the upland rice is being grown within the zones in Figure 2 has yet to be obtained. Until this information is available the discussion as to the classification of favored and infavored areas will have to be delayed.

The non Cerrado areas in the north of Brazil do not have the same problem of Al toxicity but do suffer from low soil fertility particularly with respect to P deficiency.

The main constraints to upland rice production in Brazil are summarised in Figure 3 . These constraints are those agreed on within the Brazilian program. Further discussion of these constraints appears in the section on country research.

Sub Region 2: Central America Region

The main constraints to production of upland rice in this region as a whole are shown in Figure 4 . In general the picture is little different from Brazil except that the important areas in the region are far more favored for upland production. New areas of former jungle in Mexico and Guatemala suffer very similar problems as those experienced in the non-Cerrado areas of northern Brazil. These are certain differences in the minor disease and insect pressures but it is clear that blast represents the most serious limitation among the biological constraints. Aluminium toxicity is also present in the region over large areas but its net effect is probably somewhat less due to a more favored rainfall situation in most areas. Weeds are a very serious constraint in the regions and strong competitive ability of new varieties is critical.

Sub Region 3: Northern South American Region

Of the constraints already mentioned for the other two regions the only one of a more serious nature in the region is that of "hoja blanca" (white leaf) virus which is transmitted by Sogatodes species. Leaf yellowing due to iron toxicity is quite severe in the Colombian and Venezuelan areas. If development of upland rice takes place in the acid infertile soils of the Llanos of these countries then the conditions faced will be very similar to areas in Brazil with respect to aluminium toxicity and blast. Weeds are also a serious problem in upland areas in the area.

CONSTRAINTS TO UPLAND RICE PRODUCTION IN MEXICO AND CENTRAL AMERICA

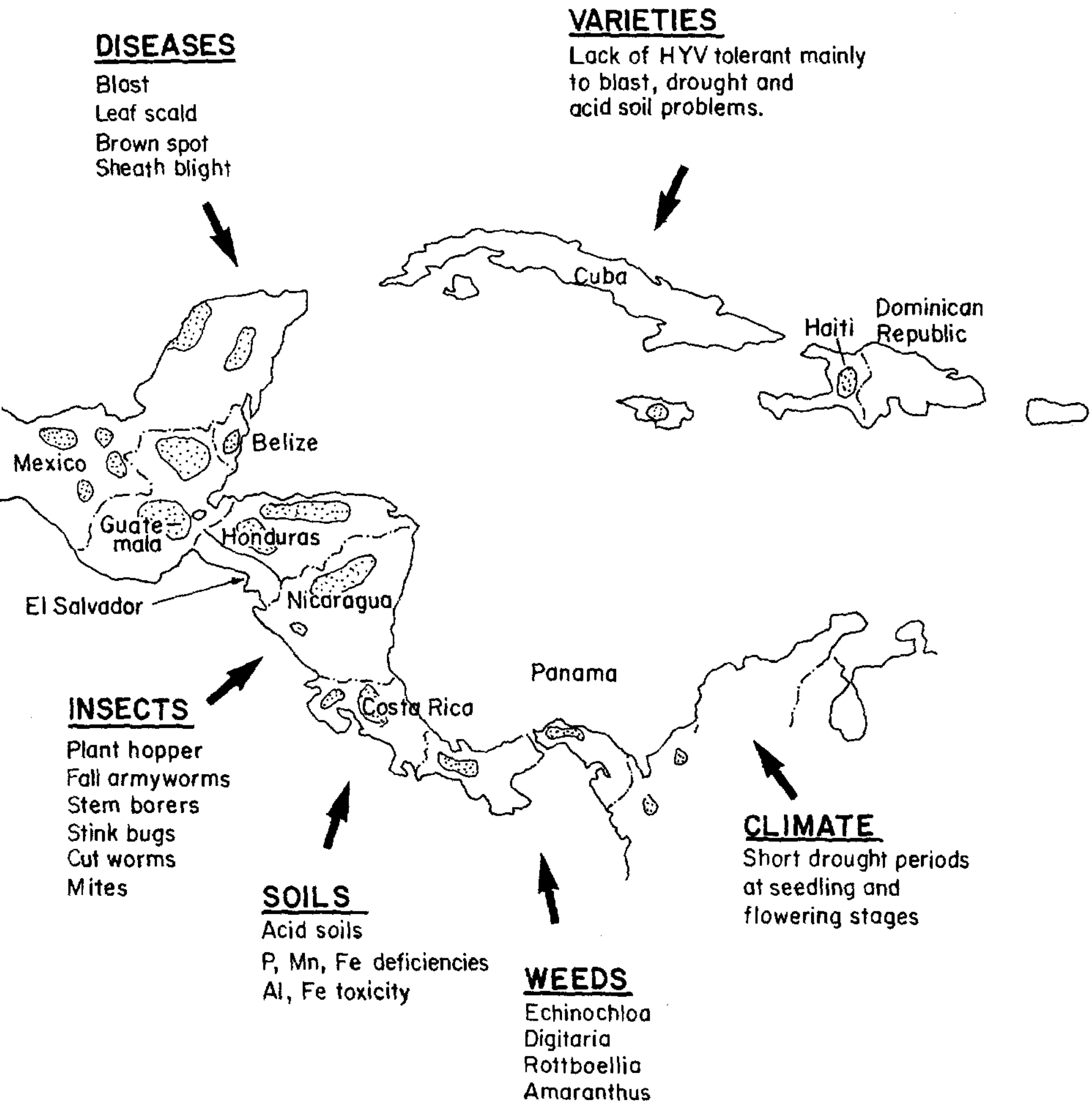


FIGURE 4

Subregion 4: Southern Andean Region

The upland problems in Bolivia are very similar to those of Brazil; Peru and Paraguay have some location specific problems but drought is by far the most critical followed by blast and "hoja blanca". Location specific problems such as zinc deficiency are also encountered. Manganese and iron deficiencies are suffered by crops in the region.

The principle constraint in South America other than Brazil remain basically the same as for that country: namely the lack of higher yielding varieties with resistance to acid soil conditions and to blast.

A copy of the proceedings of the CIAT workshop on strategies for improving rice production in Latin America has been forwarded to the consultant panel engaged by TAC. This report covers the constraints in detail and outlines the appropriate strategy to meet these problems. The data was collected from country representatives and a process of rating by relative importance completed. That document should be read in conjunction with this base paper.

COUNTRY TRENDS AND POLICIES IN UPLAND RICE

The Latin American region as a whole does not have a large research effort in upland rice. This is a similar situation that is encountered for most crops grown by small farmers in the region. Except for the mechanised areas in the parts of the Cerrado of Brazil the crop is largely grown by small farmers using traditional low input technology. The crop, however, produces a significant quantity of total production in the region.

Future trends in the production of upland rice are very difficult to gauge given the present inflationary times and the mounting costs of production in the irrigated sector in each country. This combined with the human migration to areas with upland potential in countries such as Mexico, Guatemala, Ecuador, Peru, Bolivia and Brazil, places the situation in a considerable state of flux a the present time.

Table 11 shows some conclusions which have been drawn by CIAT with respect to possible trends in the future. Mexico has definitely made a policy decision to expand the area of upland rice in the south and south east in both jungle and savanna areas. The present areas of irrigated rice are under strong competition from high value, mainly export, horticultural and vegetable crops. The increasing costs of production combined with this competition is placing the irrigated sector at a strong disadvantage. The expansion of upland rice is closely correlated with the migration of people to these new areas and the opening up of government sponsored land development schemes. It is expected that Mexico will be a major producer of upland rice in the coming years. Problems in maize production and the rapidly increasing population of that country is making these developments necessary.

Central America with the exception of Nicaragua is expected to maintain the existing areas of upland rice with possible expansion in Guatemala due also to migration into the Peten. The lack of an irrigated rice infrastructure in Central America is limiting progress in the irrigated sector. Competition for the water supply is also a factor in this situation. A slow increase in the irrigated area is expected to occur but this will not be at the expense of the upland sector. The traditional small farmers in upland rice derive significant income from the crop and no obvious replacement is apparent at the present time.

Venezuela is suffering from the inflation caused by oil price increases. Venezuelan participants at the recent IRTP meeting at CIAT mentioned the problem of high production costs in the irrigated sector (increases in fertilizer, chemicals, pumping and cultivation costs) and

Table 11 General and expected trends in rice production in the irrigated and upland sectors by country.

Country	Irrigated Sector	Upland Sector
Mexico	Decreased emphasis due to HPC and vegetable crop competition	Increased emphasis due to LPC and excellent potential
Central America	Slow increase in area but severe lack of infrastructure	Maintain actual area due to LPC
Venezuela and Guyana	Slight increase but limited by infrastructure cost	Expected increase in emphasis in Orinoco due to LPC
Colombia and Ecuador	Slow increase in irrigated rice in lowland areas subject to flooding, long term expectations but costly infrastructure required	Less emphasis due to lack of stable higher yielding varieties
Surinam	Increase in area expected	No upland rice
Brazil	Increased area expected to improve stability of supply, costs of production high, trade off for stability of supply	Increased area expected due to LPC, but production suffers from instability of supply. New areas developing in Amazon basin and Cerrado
Bolivia	Slight increase expected	Increased emphasis with opening of new areas
Paraguay	Slight increase expected	Areas decreasing due to drought problems
Peru	Maintain actual area and develop new infrastructure, further development limited by overall water supply	Maintain actual traditional area; new areas in Amazon expected due to human migration

HPC= high production cost/ton
LPC= low production cost/ton

the need for that country to expand into upland rice in the Orinoco delta where good potential land for 'upland' rice is available.

Colombia expects a slow increase in irrigated rice conditioned by the availability of funds to provide costly water control infrastructure in the north coast seasonally flooded areas. While this is a long term plan it is not expected to bear immediate fruit. Less emphasis is expected in the upland sector due to the overriding success of the existing irrigated sector. The situation in Ecuador is similar, however, the present irrigated areas have not got the type of infrastructure as is found in the higher irrigated areas in Colombia. Continuing emphasis on present upland areas in Ecuador may be a natural result of the poorer infrastructure in the coastal irrigated areas of that country.

An increase in both the irrigated sector and the upland sector is expected in Brazil. The problem of production instability in the upland sector is forcing the planners to consider expansion of the irrigated sector. However, the continuous migration and development of new areas in Brazil will proceed and upland rice will follow as the pioneer crop for these areas. Based on recent conversations of the Director General of CIAT with the authorities at CNPAF it was learned that they project an increase in production of the irrigated sector to a production ratio of 1:1 for the two systems. This projection, however, does not imply a decrease in the upland sector but rather an expansion of the present limited areas of irrigated rice in the country. Brazil had an average demand growth for rice of 3.71% per annum over the period 1963-75 while production growth in rice stood at 1.18% per annum. An increase in total rice production in Brazil is an essential part of the national plan.

Production costs per ton in Brazil in the upland sector were stated to be from 1/3 to 1/2 of that in the irrigated sector. An improvement in the stability of supply would place less emphasis on the need to move towards expanding the irrigated rice sector. An active research program at both the international and national level would be expected to improve the stability of supply through improved disease and insect resistance and through better adaptation to the conditions in the various regions.

In Bolivia an increased emphasis on upland production is expected as new areas are developed in the north east of the country bordering Brazil. Only a slight increase in the irrigated area is expected. Paraguay has suffered problems of drought in the upland areas in recent years and the country is expected to place more emphasis on irrigated rice in the future.

Peru will probably maintain the existing traditional areas of upland rice although rustic production of upland rice is expanding in the Selva region. A severe limitation on water supply may place a limit on the very successful irrigated sector in that country although new infrastructure is under development in the northern provinces.

COUNTRY RESEARCH IN UPLAND RICE

Recent data on the number of active research workers in the two rice sectors in the Latin American region are shown in Table 12. According to these data 133 scientists are actively working in rice in national programs in Latin America. The vast majority of these researchers have either been trained at CIAT for various periods of time as post graduate interns or have attended conferences and seminars. Active contact is maintained with them through the IRTP program and the monitoring tours which are an essential aspect of that program.

With respect to upland rice 72 scientists are engaged in research. However, 49 of those are in crop management with very limited numbers in the other disciplines. Except for the teams at CNPAF, Goiânia and at IAC, Sao Paulo there is really no strong crop improvement research component for the upland crop in Latin America as a whole. The present resources available suggest that, unless CIAT does provide some back up support in the area of upland rice research, upland research progress in the region will be limited.

National programs in all commodities are suffering from lack of support from hard pressed governments struggling with inflationary pressure.

The research group in Brazil at CNPAF will direct research on problems of national importance and coordinate research on problems of regional importance. Upland rice problems vary from region to region. CNPAF considers the following constraints of priority importance in upland rice on a national basis:

North: Brown leaf spot, leaf scald and lodging

North East: Drought, low soil fertility, leaf scald and lodging

West Central: Drought, blast, leaf scald, lesser corn stalk boser, phosphorus deficiency and aluminium toxicity

South: Drought, blast, lesser corn stalk borer and weeds

Table 12. Number of rice research personnel for some countries in Latin America: data are estimated for December, 1979.

Country	Upland Rice Research					Irrigated Rice Research	Total
	Crop Management	Breeding	Pathology	Soils/Physiology	Sub Total	Sub Total	
Mexio	7	2	1	0	10	10	20
Guatemala	2	1	0	0	3	0	3
Belize	1	0	0	0	1	0	1
El Salvador	2	0	0	0	2	0	2
Honduras	4	0	0	0	4	1	5
Nicaragua	1	0	0	0	1	2	3
Costa Rica	2	1	1	0	4	0	4
Panama	4	1	0	0	5	1	6
Haiti	1	0	0	0	1	0	1
Ecuador	1	0	1	1	3	7	10
Colombia	1	0	0	0	1	7	8
Venezuela	1	0	0	0	1	3	4
Guyana	1	1	1	1	4	6	10
Brazil	17	3	3	3	26	11	37
Peru	1	1	1	0	3	13	16
Bolivia	2	0	0	0	2	0	2
Paraguay	1	0	0	0	1	0	1
Total	49	10	8	5	72	61	133

Source: Information obtained at 3rd IRTP Conferences, CIAT, 1979. Some estimates could be inaccurate due to changes in personnel not accounted for. Data for Argentina, Chile and Uruguay not included since they are strictly irrigated rice producers.

Consequently the CNPAF program will concentrate on those national problems of greatest importance as follows:

1. Drought
2. Diseases (blast, leaf scald, and helminthosporium)
3. Soil fertility (P, Zn deficiency, Al toxicity)
4. Insects: Lesser corn stalk borer
5. Others: Lodging, growth cycle length and shattering

The research group at IAC has been quite successful at producing varieties for the upland sector in terms of area sown. At the present time IAC varieties predominate in all upland areas. In terms of the effort required in the upland sector the magnitude of the research effort in Brazil is quite limited. The staff at CNPAF particularly are all recent graduates. A strong back up from CIAT through training will continue. A back up from CIAT in the research field will also be necessary if real progress is to be expected. In this sense CIAT would provide a research component which would compliment the existing research in Brazil. CIAT has no intention of releasing finished varieties as such but would assist in the provision of segregating and advanced lines for screening under Brazilian conditions. Aspects of this collaborati will be discussed in the following section with respect to the projected role of CIAT in upland research for the region as a whole.

Research programs in upland rice in countries other than Brazil are very limited in scope except for Mexico. In the general the researchers are mainly involved in varietal selection at the advanced germplasm stage and in solving country specific agronomic and soil problems. A strong dependence on CIAT is obvious in all national programs. CIAT continues to try and develop stronger national program through training and direct contacts. To this end one outreach scientist (Dr. P. Jennings) has been placed in the Central American region under a UNDP special project. In-country courses have been held in the Dominican Republic in collaboration with CIAT and this has developed into further courses presented by the national program staff of that country. The multiplier effect appears to be working very well. In country courses have also been held in Panama (20 participants), Ecuador (25) and Honduras(36). Requests are in for courses in Haiti, Peru, El Salvador and Guatemala in 1980. These courses contribute greatly to CIAT's aim of strengthening national program capacity in the smaller countries in the region.

CIAT RESEARCH IN UPLAND RICE

The Quinquennial Review panel on behalf of TAC recommended increased emphasis on upland rice at CIAT. This recommendation was made in the light of the observations made by the panel with respect to the prevailing situation in upland rice areas in the region. As a result of these concerns the CIAT Board of Trustees minuted as follows at its May 1977 meeting. "The Program Committee of the CIAT Board of Trustees noted concern with respect to rice improvement strategy in Latin America". They specifically recommended the following:

(1) CIAT define a strategy for Latin America ascertaining the importance of the major rice types included irrigated deepwater, floating and several upland rice categories.

(2) CIAT identify and access national capacities to carry out the objectives of the overall rice improvement program.

(3) CIAT organize a workshop with appropriate consultations which would result in a report to the program committee in Feburary 1978. Pursuant to those instructions CIAT organized an international workshop of leading rice specialists in the region and involving both CIAT and IRRI staff. A copy of the proceedings of this workshop is attached to this report.

The workshop served as the basis for the identification of the major areas of production constraints to increased rice production in Latin America. Foremost are agronomic factors such as water control, land preparation, seeding methods, weed control and fertilization. For irrigated rice, research on cultural practices that are of a non-specific nature is rather complete; today, the priorities in cultural practices are in the areas of technology transfer and location-specific agronomic research. The latter, of course, is primarily within the domain of national research institution responsibilities.

A second constraint to increased production is varietal improvement. Much has already been achieved in yield capacity of modern varieties; the challenges in varietal improvement are to close the gap between potential and actual yields (largely through improved farming practices with modern varieties) and to stabilize acceptable high actual yields. This is basically a problem of creating stable resistance to *Pyricularia* (rice blast disease), the only pathogen presently causing widespread or epidemic infections on a regional basis. Losses from *Pyricularia* are substantial in some areas. Added to this are costs for chemical control, reduced prices for damaged grain and foregone yields wherever producers refrain from aiming at maximum productivity because of the threat of blast attacks. Failure to obtain stable resistance forces the release of new varieties every one or two years.

A third major production constraint includes the other pathogens and pests that are not so widespread as blast but, nevertheless, can be devasting in specific areas. Of most importance are the fungal diseases *Rhyncosporium* (leaf scald), *Helminthosporium* (brown leaf spot) and *Corticum* (sheath blight); a bacterial disease, *Xanthomonas* (leaf blight); and a range of insect pests (including *Sogatodes oryzicola*, the vector of the "hoja blanca" virus).

Upland rice production has an additional group of constraints that result from environmental stresses. Plant types developed to be grown under the favorable irrigated conditions are not necessarily suitable for upland culture. Moreover, upland rice is often cultivated on marginal soils which are frequently characterized by low pH levels and high levels of aluminum, manganese and iron. The relatively low water-holding capacity of the soil in the root zone of the rice plant creates severe drought stresses, even during relatively short dry periods. All of these stresses make the plant less tolerant to attacks from the pests and diseases mentioned earlier.

RECOMMENDED ACTION

During the workshop a Task Force was appointed to make recommendations to CIAT regarding the future role of the CIAT/IRRI activities in the region. The conclusions of that Task Force are presented as Section IV, pages 41-46, in the Proceedings. These conclusions may be summarized as follows:

(1) CIAT rice work should concentrate on broadly based problems and leave location specific problems (such as those related to fertilization, soil management and land preparation) to national programs.

(2) Basic varietal work should be maintained: there is a continued need for improved breeding materials for irrigated rice; moreover, as new diseases emerge and new strains of existing diseases arise, CIAT must have a breeding capability to respond.

(3) There is a clear need for CIAT rice work to be expanded to include research on upland rice. The establishment of carefully delimited ecological boundaries for upland rice research is necessary to assure that only the more favored rice growing areas are included where

there is a prospect for significant improvement through rice research.

(4) CIAT work in favored upland rice should address itself to three overriding problems: (a) low tolerance of present, improved varieties to short periods of drought stress; (b) low adaptability of presently available improved varieties to acid soil conditions; and (c) rice blast (Piricularia).

(5) A basic lack of systematized edaphic, climatic, and socio-economic information relating to rice production in Latin America impedes the selection of appropriate research strategies. Hence, CIAT should engage in the collection and analysis of such information for the important rice growing areas in Latin America.

CIAT, in general, endorses these recommendations and hereby is proposing a course of action that the Center should take on the basis of these findings.

A. Current Staff and Activities

In recommending the modification of a program which involves the addition of new staff positions, it is always important to review current staffing to determine which, if any, of these positions or activities can be phased out in order to provide resources for the new activities. The currently budgeted CIAT-based Rice Unit contains four senior staff positions: a Breeder, and Agronomist and a Plant Pathologist, funded by CIAT, and an IRRI Liaison Scientist funded by IRRI. The Breeder dedicates most of his efforts to generating and testing new rice lines in a search of more stable resistance to the ever-changing rice blast organism, as well as resistance to other diseases and insects; and development of highly-yielding, segregating materials and advanced breeding lines to be made available to national programs for rice production under irrigated conditions. The Agronomist does research on cultural practices of a non-location specific nature for irrigated rice, such as weed control, and devotes a major part of his time to training on rice research and production specialists. The Pathologist is concerned with rice disease problems for both irrigated and upland conditions. The IRRI Liaison Scientist concentrates on the coordination of the Latin America component of the International Rice Testing Program. A review of the recommendations and expectations summarized in the workshop proceedings makes clear that the above activities still have highest priority. Therefore, any expansion into work for upland conditions would need to be additive rather than substitutionary.

B. Roles of CIAT and IRRI

Activities in the collaborative CIAT/IRRI program in Latin America must always be considered as a relay activity of the much larger, global activities of IRRI with the goal of adapting IRRI and other rice technology to Latin American conditions and insuring that the specific problems of this region are adequately dealt with. Such fundamental rice research as can best be handled on a global basis from a central location should always be done by IRRI. This includes such research as studies on the genetics of the rice plant, (including studies of heterosis in the F_1 and on sterility in the F_2 of certain crosses suggested for CIAT at the workshop), basic physiological studies on root development and plant nutrition and biochemical studies on nutritional quality of rice. The large IRRI effort currently devoted to upland rice and drought resistance represents an important resource base for the Latin America relay needs.

The activities described below are the minimum requirements of what must be done in Latin America to develop new rice technology for the more favored upland areas. It is hoped that IRRI will be able to enlarge its contribution to this joint effort in Latin America and that it will be possible to achieve the same high level of complementarity between the upland rice work at the two Centers as has been achieved with respect to irrigated rice.

C. New Activities and Positions

We recommend that the CIAT-based Rice Unit activities be expanded to include work for the more favored upland rice growing regions, and socio-economic studies.

Work on upland rice is clearly indicated for a number of reasons, including the following:

(1) The large proportion of rice production in Latin America which is currently grown under upland conditions. Strong evidence for this is given in the workshop proceedings.

(2) The large amount of land available for expansion of rice production on upland conditions.

(3) The large amount of capital investment required for expansion of irrigated rice production, even though large areas suitable for this type of rice culture are available in the region.

(4) The fact that most of the small farmers producing rice do so under upland conditions.

(5) The fact that rice technology developed for irrigated conditions has not proven very useful for upland rice culture.

(6) The fact that national programs have not yet developed their research work on favored upland rice (including their human and physical resources) to the point where they can produce the appropriate technology for upland rice production by themselves.

It had been assumed that the new varieties developed in the joint program between CIAT and the Colombian Institute for Agriculture (ICA) especially the more vigorous varieties CICA 7, 8 and 9, would be highly useful for the more favored upland conditions. However, Dr. P. Jennings, since his assignment, under the aegis of a UNDP/CIAT special project on International Cooperation, to the Central America and Caribbean region, has reported that these varieties are less useful for the upland conditions in that region than had previously been anticipated.

While there seems to be overwhelming evidence of the importance of upland rice in Latin America, and while national programs have expressed a strong desire that CIAT become actively involved in developing technology for these conditions, the chief question pertains to which set of ecological conditions CIAT should consider its chief target area in expanded work for upland rice. CIAT agrees with the recommendation that the emphasis should be on the more favored regions where the Center could make a significant contribution to increased rice production for the favored upland conditions. Nevertheless, it must be recognized that the "favorable" and "unfavorable" conditions are the two extremes on a continuum. Favorable upland rice may be defined as the dry-land rice grown on unbunded fields that are flat or gently sloping with annual rainfall of 1,500 mm or more with at least 250 mm of monthly average rainfall in each of the growing months, and not more than 10 rainless-day periods during reproductive and ripening stages. In these areas, water-holding capacity of soil is good to excellent with no severe soil fertility problems that cannot be corrected by fertilizer application. Unfavorable upland rice, on the other hand, may be defined as rice grown on unbunded fields with varying slopes and with annual rainfall of less than 1,500 mm and monthly average rainfall of less than 250 mm in each of the growing months, and more than 10 rainless- day periods during reproductive and ripening stages. In those areas, water-holding capacity of soil is poor to very poor with varying degrees of soil problems (some problems can be corrected with fertilizers; others, such as highly, acid soils with high aluminum saturation, cannot be easily amended). The expanded CIAT Rice Unit would concentrate its activities in developing upland rice technology for the more favored end of the continuum of which the above two definitions constitute the extremes. By doing so, the Rice Unit would develop certain components of technology (e.g., better tolerance to water stress, more vigor for competing with weeds) which will be useful in the unfavored regions. It is expected that both CIAT-based efforts as well as the national programs in upland rice will derive considerable benefits from the materials gathered on a worldwide basis for the upland nurseries of the International Rice Testing Program. All of these are supported by the large and growing research program for upland rice at IRRI. Thus, the activities described below are not an isolated effort but merely a modest but important component of a collaborative network in the task of developing what is essentially a new crop: upland rice.

To achieve the objectives described above, it is proposed that the CIAT-based Rice Unit becomes a "major program" within the CIAT structure (the other such programs being the Bean Program, the Cassava Program and the Tropical Pastures Program) and that upland rice work be backed by senior staff positions in Physiology, Pathology, Breeding, Agronomy and Agricultural Economics. Given that the Pathology and the Agronomy inputs are to be provided by already existing senior staff positions, a net increase of three senior staff positions is proposed.

1. Physiologist. The soil-plant-climate relations of upland rice are very different to those of lowland rice. However, most studies have been made on the latter. It is highly probable that a different plant type is needed for upland rice conditions, specifically with respect to tolerance to adverse soil conditions and with shading out of weeds. Given that the specific problems of soil acidity and high aluminum content as prevalent in Latin America are not commonly dealt with in Asia, IRRI- generated work in upland rice physiology must be complemented by Latin American-based, fundamental studies in physiology, with special emphasis on root development. The proposed physiologist is to describe the soil-plant-climate relations, and define the genetic variability available for use by the breeder so as to overcome the soil-climate stresses.

2. Breeder. The second breeder in the Rice Program would concentrate on the development of adapted high yielding strains with the desired grain qualities and with tolerance to low pH, low fertility (especially P) aluminum toxicity and limited levels of water stress. Incorporation of disease resistance is essential, especially for blast which is exceptionally severe under upland conditions.

3. Pathologist. The already existing senior staff position in Plant Pathology is devoted both to irrigated and upland rice. The responsibilities of the Pathologist include the determination of the distribution of various diseases prevalent under upland rice conditions and to assess the losses caused by the respective diseases. Those that are economically important will be studied in an effort to develop control methods. It is envisaged that control will normally be by varietal resistance. Hence, major emphasis will be placed on finding resistance sources and on developing rapid screening methods.

4. Agronomist. The already existing Agronomy position is to serve both the upland and lowland rice endeavors of the Rice Program. Up to the present, little agronomic work has been done on upland rice. Upland rice requires distinctly different management practices from those which have been developed for irrigated rice, particularly with respect to crop associations, seeding methods, timing and rates, fertilization, weed and pest control, and harvesting. It will also be necessary to determine how these factors interact with genotypes under the range of upland conditions in the target areas of Latin America. The agronomist would be responsible for developing non-location specific farming practices. As new upland varieties are developed their response to agronomic inputs will be evaluated under varied conditions in representative locations. The agronomist would also assist national programs through consultation, collaborative research and training, to convert upland to irrigated rice production in areas where this can be done easily and economically.

5. Economist. The Economist's principal activities would be to continue to survey upland rice growing areas in climatic, edaphic and economic terms. Also, he would characterize the Latin American rice production potential, determine the constraints to more rapid adoption of improved technology at different levels of production, assist his biological colleagues in technology design and assess the impact of adoption of such technology. He would keep abreast of market trends and prices in relation to production costs in various parts of the region in order to advise CIAT management and Rice Program scientists regarding priorities for rice research and outreach as well as make available information to client governments which might help them to establish appropriate government policies.

PROPOSED NETWORK FOR UPLAND RICE IN LATIN AMERICA

A flow chart has been prepared in Figure 6 which outlines the collaboration by CIAT with IRRI, IITA, WARDA and the national programs in the proposed network for Latin America.

Source of Germplasm

The germplasm resources of all organisations involved in upland rice research will be exploited in the program. The essential role in IRRI needs to be emphasized with respect to plant type, drought tolerance and sources of disease and insect resistance. In particular the screening of germplasm and the breeding of materials with drought tolerance at IRRI is considered by CIAT to be the essential link necessary if drought tolerance is to be obtained. The superior material coming from IRRI and other sources will be screened in different locations in Latin America to evaluate material with better adaptation to the specific soil conditions of low soil fertility and aluminium toxicity which are widespread in the region.

Preliminary Evaluation

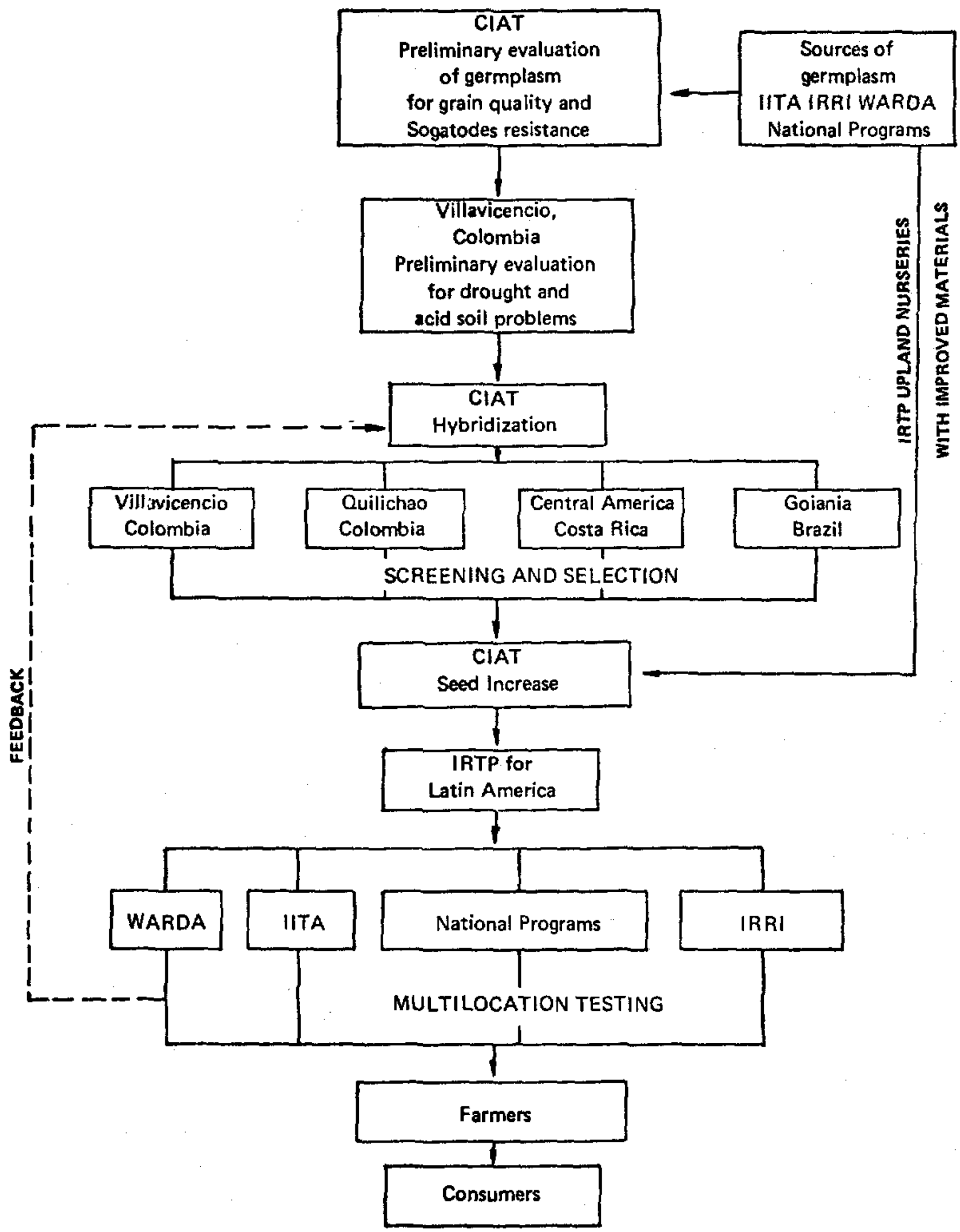
The first evaluation would take place at CIAT for grain quality and Sogatodes resistance. All material would then be evaluated at Villavicencio under typical conditions of the Amazon basin of both disease pressure and the soil constraints. Drought screenings will also be undertaken near CIAT at Santander de Quilichao where the acid soil conditions provide a useful first pass. The proposed physiologist would undertake screening work both at CIAT and at CIAT-Quilichao. New glasshouse techniques becoming available for aluminium toxicity tolerance will be evaluated as rapid screening techniques. It is clear that an improvement in this character should lead directly to improved drought tolerance in material already promising in the latter under more normal soil conditions.

Hybridization

The crossing program would be mounted at CIAT with an intensive program receiving inputs from the pathologist and the physiologist and feedback from the IRTP program. Parent selection being based on the performance of parental materials under the actual conditions in upland areas. The development of a large number of segregating populations appears essential to the process of improvement.

FIGURE 6

PROPOSED SCHEME FOR UPLAND RICE RESEARCH IN LATIN AMERICA



Screening, Selection and International Testing

The segregating populations will be screened by CIAT at two and possibly three locations in Colombia (Villavicencio with ICA and at Quilichao and possibly Carimagua) as well as by other national programs specifically CNPAF at Goiania in Brazil and at one location in Central America or possibly Mexico. The screening research in the populations will be a collaborate effort involving national program scientists directly in the research process. In the case of Brazil the CIAT screennings would be closely coordinated with the on-going work of the team at that location. Selections showing high promise in those screenings would be returned to CIAT for purification and for seed increase prior to submission to the IRTP program for Latin America. The upland international nursery would develop as a combined testing program including materials selected through the above process, materials showing promise received directly from IRRI and national programs as well as other international sources. Essentially only materials would be included which have real promise in the region.

Some Specific Concerns in Breeding

The question of Pyricularia or rice blast is a central issue and a serious limitation to rice production in the region. Progress at CIAT towards the pyrimiding of resistance genes and in the use of multilines looks very promising at the present. The difficulty with respect to rice blast can be seen from the data in Table 13. In the first International Pyricularia Nursery in Latin America grown at seven location in 1978 a wide range of responses to the race structure of the disease was observed. Some line ranging from complete resistance to susceptibility across the different ecosystems represented. A comparison of the line IR 665 for the Costa Rica locations points up the magnitude of the problem faced in breeding for blast resistance. Some of the newer CIAT lines under test i.e P1369 and P 1387 have shown excellent resistance across a wide range of locations. Parental material of this type will be invaluable in the blast resistance strategy.

Another significant question for the breeders is the aspect of grain quality. Many of the international materials suffer from an inadequate grain quality for the Latin American market. Special emphasis will need to be placed in screenings for these characters.

The question of weed competitiveness in new lines is also a very basic issue which is limiting the use of certain materials. Weed growth in the wide spacings normally used in upland rice is quite severe. The problems of weed control in extensive areas of production are sometimes very difficult . A big improvement in competitive ability against weeds is of critical need in new upland varieties for the region.

Table 13 Reaction of selected rice germplasm to *Pyricularia* in the 1st International *Pyricularia* Nursery (VIPAL-78) at seven locations in Latin America: data in body of table shows disease reaction on international 1-9 scale[1]

Selection Number	Identification	Locations[2]							Response Range
		COL	COL	CRI	CRI	ELS	GUA	RDO	
2003	IR 665/ F_1 (IR 841-65/C46-15)	7	5	1	6	1	1	1	1-7
2035	IR 930-2/IR 822-432 (74070)	5	2	4	4	7	7	1	1-7
2048	IR 22/F_1 (IR 930-147-8 x Col. 1)	4	3	1	6	4	6	5	1-6
2057	IR 1544-238-2-3	2	1	1	1	4	7	4	1-7
2135	P 1369	1	1	1	1	1	1	1	1
2145	P 1377	1	4	1	1	1	1	3	1-4
2149	P 1379	4	2	1	1	5	5	4	1-5
2152	P 1360	3	2	1	2	5	9	4	1-9
2175	P 1391	4	2	1	1	4	2	1	1-4
2177	P 1397	1	1	1	1	2	1	1	1-2
Mean Location		3.2	2.4	1.3	2.4	3.3	4.0	2.5	

1 1= resistant, 9= completely susceptible

2 COL: Colombia (Palmira, Villavicencio); CRI: Costa Rica (Cañas, Jicaral); ELS: El Salvador (San Andres); GUA: Guatemala (Los Amantes); RDO: Dominican Republic (Bonas).

INTERNATIONAL RICE TESTING PROGRAM FOR LATIN AMERICA

The IRTP in Latin America was initially coordinated directly from IRRI through direct contact with the national programs. Several yield observation and blast nurseries with broad genetic diversity were dispatched in 1975 to various countries. Although the material included was of great genetic value much of it was inappropriate for Latin American conditions. This was primarily due to consumer preferences and cultural systems different from the rest of the world. Secondly the national programs in most instances do not have the resources or the trained personnel to utilize the germplasm in a hybridization and selection program.

With this background CIAT and IRRI in 1976 formalized the IRTP for Latin America. Basically this program evaluates at CIAT the nurseries which have been formed from promising material selected from IRRI and other countries. From these nurseries appropriate material is distributed to Latin America.

The First IRTP Conference was held at CIAT in August of 1976 to define the objectives of the IRTP for Latin America, to establish channels of communication and to coordinate and classify the nurseries. Both CIAT and IRRI strongly believe in full consultation with potential collaborators in the design of all international nurseries. Thirty five delegates in this conference included the leaders of 14 national programs. Each of these participants contributed information on their prospective countries and suggested the most appropriate means by which the IRTP could serve their needs. Further IRTP meetings were held in 1977 (42 participants) and in 1979 (75 participants).

The program has continued since 1977 with the IRRI liaison scientist in charge. The program has become very significant, with considerable growth since 1977. In 1979 a total of 13 different types of nurseries where dispatched from CIAT which included 497 different genotypes in a total of 254 sets. Table 14 shows the full range and definition of the nurseries dispatched in 1979. A further series of IRRI nurseries for specific conditions were dispatched to several countries at the request of these programs. Data now available from the 1977 VIRAL nurseries has shown that every line in the program has received further testing by country researchers in one or more of the collaborating institutions.

Table 14. IRTP nurseries for Latin America distributed in 1979

Nursery 1/	Number of entries	Number of sets	Yield range 2/ (t/ha)
VIRAL-P	23	39	4.3 - 6.7
VIRAL-T	23	28	3.6 - 8.5
VIRAL-Tar	19	9	5.9 - 7.9
VIRAL-S	24	30	4.8 - 8.9
VERAL	14	22	4.7 - 7.0
VIOAL	97	14	4.1 - 9.1
VIOAL-S	52	25	3.9 - 8.7
VIOAL-R	61	18	4.3 - 8.3
VIPAL	120	31	-
VIAVAL	16	12	5.5 - 8.9
VIOSAL	10	8	4.7 - 8.6
VITBAL	23	10	2.9 - 8.1
VIRAL-F	15	8	4.6 - 8.1
TOTAL	497	254	

1/ VIRAL-P = International Rice Yield Nursery- Early
VIRAL-T = International Rice Yield Nursery- Medium
VIRAL-Tar = International Rice Yield Nursery-Late
VIRAL-S = International Rice Yield Nursery-Upland
VERAL = International Specific Rice Yield Nursery
VIOAL = International Rice Observational Nursery
VIOAL-S = International Rice Observational Nursery-Upland
VIOAL-R = International Rice Observational Nursery-Leaf Scald
VIPAL = International Rice Blast Nursery
VIAVAL = International Rice Sheath Blight Nursery
VIOSAL = International Rice Salinity and Alkalinity Observational Nursery
VITBAL = International Rice Low Temperature Nursery
VIRAL-F = International Rice Yield Nursery-Deep Water

2/ Range yield of two seasons at CIAT under irrigated-transplanted conditions.

APPENDICES

APPENDIX 1

Biological Index of Constraints

Diseases	Blast	*Pyricularia oryzae*
	Leaf Scald	*Rhynchosporium oryzae*
	Brown Spot	*Helminthosporium oryzae*
	Sheath Blight	*Thanatephorus cucumeris*
	"Hoja Blanca"	White leaf virus of rice
Insects	Plant hopper	*Sogatodes oryzicola*
	Fall armyworm	*Spodoptera frugiperda*
	Stem borer	*Rupella* and *Diatraea* species
	Stink bug	*Mormidea sp*, *Oebalus sp*, *Blissus sp*.
	Cutworms	*Elasmopalpus sp*, *Phyllophaga sp*.
	Mites	Several species
Weeds	Grasses	*Echinochloa cruzgalli*, and others
		Digitaria sp.
		Rottboelliea sp.
		Ischaemum sp.
		Leptochloa sp.
		Cynodon sp.
	Broad leaved	*Amaranthus sp*. and others

APPENDIX 2

Rice: production, trade and apparent consumption of Latin America, by countries. Averages 1963/65 and 1973/75

Country	Average for 1963/65				Average for 1973/75			
	Production	+Imports -Exports	Apparent consumption	Apparent per capita consumption	Production	+Imports -Exports	Apparent consumption	Apparent per capita consumption
	'000 ton			kg/year	'000 ton			kg/year
<u>Exporting:</u>	1617	-137	1480	26	3025	-330	2695	36
Uruguay	71	- 19	52	19	161	- 67	94	31
Colombia	590	- 1	589	33	1435	- 63	1372	55
Guyana	239	- 82	157	253	214	- 61	153	193
Surinam	88	- 19	69	214	167	- 47	120	292
Argentina	212	- 22	190	9	309	- 36	273	11
Venezuela	166	- 6	160	18	323	- 35	288	24
Nicaragua	31	+ 7	38	23	83	- 9	74	34
Costa Rica	71	+ 2	73	51	117	- 7	110	57
Panama	130	+ 3	133	111	173	- 4	169	104
Paraguay	19	+ 0	19	10	43	- 1	42	17
<u>Importing:</u>	7862	+289	8151	46	9434	+472	9906	42
Cuba	138	+252	390	52	398	+249	647	71
Peru	304	+ 47	351	31	437	+ 59	496	33
Dominican Rep.	144	+ 25	169	48	341	+ 48	389	81
Chile	86	+ 11	97	12	55	+ 33	88	9
Mexico	301	+ 6	307	7	522	+ 31	553	10
Trinidad & Tobago	10	+ 29	39	43	17	+ 28	45	47
Ecuador	172	+ 2	174	35	277	+ 15	292	42
Guatemala	17	- 1	16	4	29	+ 2	31	5
Haiti	37	+ 1	38	10	102	+ 2	104	21
Brazil	6555	- 83	6472	81	7108	+ 1	7109	67
Belize	2	+ 2	4	35	8	+ 1	9	68
Honduras	24	+ 1	25	11	17	+ 1	18	6
Bolivia	42	+ 0	42	10	88	+ 1	89	17
El Salvador	30	- 3	27	9	35	+ 0	35	9
Latin America	9479	+152	9631	41	12459	+142	12601	41

Source: Production, trade data from FAO

Population data from USDA

APPENDIX 3

Rice: Index of apparent intake of energy, and indices of yields, per capita production, apparent per capita availability and of net exports of rice in Latin America, by countries. Averages 1975/77.

Country	Apparent intake of energy as percentage of requirement[1]	Index of Average yields[2]	Index of Per capita production[2]	Index of Apparent per capita availability[3]	Net exports as percentage of total production[3]	Net imports as percentage of total availability[3]
					---------- percentage	----------
Surinam	n.a.	200	911	613	33	-
Guyana	112	122	755	500	31	-
Panama	111	78	224	215	0	-
Dominican Republic	92	209	118	136	-	14
Brazil	115	80	178	175	0	-
Costa Rica	114	109	176	191	1	-
Belize	n.a.	79	113	120	-	25
Colombia	94	220	135	127	12	-
Uruguay	115	214	169	80	51	-
Cuba	108	112	98	149	-	32
Ecuador	84	147	113	120	0	-
Nicaragua	110	156	64	71	5	-
Peru	101	233	78	89	-	12
Venezuela	99	171	64	60	-	8
Haiti	79	122	49	56	-	6
Trinidad & Tobago	99	132	40	100	-	59
Paraguay	108	115	49	42	0	-
Bolivia	85	86	44	47	-	0
Argentina	122	192	29	22	25	-
Mexico	115	149	20	22	-	0
El Salvador	83	151	22	31	-	14
Chile	114	176	20	22	-	19
Honduras	93	80	20	22	-	18
Guatemala	93	96	111	13	-	15
Latin America	112	100	100	100	4	3

1/ Period 1973/75 2/ Period 1975/77 3/ Period 1975/76

Source: Estimated from FAO and USDA n.a.= not available

APPENDIX 4

Rice: production in Latin America, by countries. 1963/65, 1973/75 and 1975/77

Country	1963/65		1973/75		1975/77*	
	Average	Percentage of total	Average	Percentage of total	Average	Percentage of total
	'000 ton	%	'000 ton	%	'000 ton	%
Brazil	6555	69.2	7108	57.1	8680	59.4
Colombia	590	6.2	1435	11.6	1501	10.3
Peru	304	3.2	437	3.5	562	3.8
Mexico	301	3.2	522	4.2	554	3.8
Cuba	138	1.5	398	3.2	429	2.9
Venezuela	166	1.8	323	2.6	383	2.6
Ecuador	172	1.8	277	2.3	354	2.4
Argentina	212	2.2	309	2.5	327	2.2
Guyana	232	2.6	214	1.7	273	1.9
Dominican Rep.	144	1.5	341	2.8	262	1.8
Uruguay	71	0.7	161	1.3	211	1.4
Surinam	88	0.9	167	1.3	178	1.2
Panama	130	1.4	173	1.4	173	1.2
Costa Rica	71	0.7	117	0.9	159	1.1
Bolivia	42	0.4	88	0.7	114	0.8
Haiti	37	0.4	102	0.8	113	0.8
Chile	86	0.9	56	0.4	97	0.7
Nicaragua	31	0.3	83	0.7	65	0.5
Paraguay	19	0.2	43	0.3	59	0.4
El Salvador	30	0.3	35	0.3	43	0.3
Guatemala	17	0.2	29	0.2	31	0.2
Honduras	24	0.3	17	0.1	29	0.2
Trinidad & Tobago	10	0.1	17	0.1	20	0.1
Belize	2	0.0	8	0.0	6	0.0
Latin America	9479	100.0	12459	100.0	14623	100.0

Source: Estimated from FAO

APPENDIX 5

Consumption of rice (kg/person/annum) in selected South American cities by income strata.

City	Income Strata				
	I	II	III	IV	V
Bogotá	15.8	20.0	22.7	25.6	25.6
Barranquilla	39.8	44.0	46.2	50.7	56.2
Cali	29.6	33.3	37.1	36.4	45.6
Medellin	17.7	29.8	16.9	19.0	20.6
Santiago	15.7	14.8	15.2	15.7	14.8
Quito	41.3	63.3	68.0	90.0	95.3
Guayaquil	115.3	143.3	151.3	166.3	156.0
Caracas	21.7	17.7	16.0	16.0	17.0
Maracaibo	18.0	19.7	19.1	19.7	19.1
Lima	38.1	42.6	42.9	44.8	44.2
Rio de Janeiro	43.2	44.9	43.8	50.8	26.2
Recife	14.7	25.2	22.2	17.4	28.0
Porto Alegre	39.0	41.6	45.6	47.1	44.3
Mean of all cities	32.9	38.6	38.8	40.8	45.6

Data Source: Per capita expenditure in rice by income strata was estimated from ECIEL (Joint Studies on Latin America Economic Integration) tapes of Household Budget Surveys, average prices taken from DANE statistics (Colombia), America en Cifras (OEA) and Pesquisa sobre orcamentos familiares (Fundacao Getulio Vargas) for all Brazil data.

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