Cropping System and Upland Rice in Latin America [1]

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1 Introduction

Although Latin America represents only a small percentage (5 1%) of the total area planted with rice in the world and of the total rice production (3 7%), rice is becoming a very important staple in the Latin America diet as per capita consumption is increasing, mainly as a result of increases in production in almost every country (Posada, 1982)

Rice is grown in Latin America by people living in various ecosystem with distinct soil types, climatic conditions, and production constraints, these people also follow distinct cropping systems

Todays the predominant rice production system is upland rice (72%), whereas in 1978, upland rice provided only 49% of the total production This indicates that the upland rice sector in Latin America is increasing in importance, in sharp contrast to the situation in Asia where upland rice is of relatively minor importance (CIAT,1979)

Upland rice constitutes the major proportion (>50%) of national Rice production in countries such as Bolivia, Costa Rica, Guatemala, Honduras, Panama, and el Salvador

This paper discusses the distinct upland cropping systems found across Latin America, excluding Brazil

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2 Production systems and constraints

Definitions of upland rice and production systems in Latin America are given elsewhere (Laing el al 1982)

In Latin America rice is grown prodominantly on medium to large farms, but a great diversity in types of production systems exists, ranging from intensive irrigated to extensive upland systems Average yields in the different systems vary markedly The principal factor determining the type of production system include rainfall pattern, cost of irrigation, soil type, topography, and availability of infrastructure (CIAT, 1982)

Often rice production in Latin America is divided, somewhat misleadingly, into two main systems--irrigated and upland (Fig 1) The area upland in the different production systems, by country is presented in Table 1 In the period 1979-1980, irrigated and rainfed lowland rice comprised an estimated 2 3 million has, or about 27% of the total area Average yield of irrigated rice was 3 5 t/ha, average yield of less favored rice was 1 0 t/ha (Table 2) Upland rice covered 6 0 million has, about 73% of the area, with the great bulk (3 2 million has) in the unfavored areas of Brazil

Table 1 indicates that hardly any country relies on a single production system, most countries have a mix of farming systems, perhaps because this mixture provides a more stable total rice production

CIAT work with agroecosystem analysis has begun to identify and describe Latin American rice production areas However, very little information is now available It is incorrect to view upland rice in Latin America as a uniform farming system in which cropping practices and yield constraints are similar (Figs 2 and 3), upland rice comprises a broad continuum of ecosystems ranging from extremely low (Cerrados, in Brazil) to high levels of productivity (Eastern Plains of Colombia) It is difficult to subdivide further the continuum into discrete subsystems, neverthelesss, the classification that follows is a crucial exercise to analyze each ecosystem in terms of yield constraints, potential productivity, breeding objectives, priorities,and economic profitability (Jennings et al 1981)

Six rice production systems have been identified in Latin America irrigated,rainfed lowland,highly favored upland, moderately favored upland ,unfavored upland and traditional manual upland (CIAT,1982) In this paper we are concerned with the production systems found in the sector, and some case studies will be used to describe the cropping system, cultural practices,and yield constraints prevailing in the highly favored upland (Eastern Plains of Colombia), moderately favored upland (Guanacaste Province in Costa Rica), and traditional manual upland (Yurimaguas in Peru areas)

3 Cropping system, cultural practices, and yield constraints

1 Highly favored upland rice

The area of the savanna foothills near Villavicencio in the Eastern Plains of Colombia will be used to describe this mechanized cropping system This area is around 400-450 m above sea level Approximately 40,000 has are planted to rice under highly favored upland conditions in this area, which comprises alluvial soils of the rivers Ariari, Negro, and Guatequía Soil analysis is shown in Table 3

Table 3 Soil analysis of three alluvial sites in the Eastern Plains of Colombia

Site	pH	O M (%)	P (ppm)	Al	Ca	Mg	K	Na	CEC	Base Saturation (%)
				(meq/100 g soil)						
Ariari	5 8	5 0	16	0 3	9 9	1 6	0 71	0 8	13 31	98 1
Negro	4 9	3 8	22	1 8	4 4	1 5	0 24	0 12	8 06	77 7
Guatequía	6 0	1 7	27	-	2 0	0 3	0 28	0 14	2 72	100 0

Source Sánchez and Owen (1981)

These soils vary in their physical and chemical characteristics, but all have a good water-holding capacity (Sánchez and Owen, 1982) Most of the rice is concentrated on the deeper clay-loam soils with a pH of 4 9 to 6 0 and a medium fertility level The most pronounced nutritional problems are lack of nitrogen and, to a lesser extent, zinc deficiencies

Climate is typically characterized by a rainy season that usually starts in mid-March and ends in mid-November December, January, and February are extremely dry Total rainfall averages 2789 mm(12 years data), usually there are no marked dry perio's during the rainy season Table 4 shows monthly average data for rainfall, temperature, and relative humidity

Table 4 Climatic data characteristic of the Eastern Plains of Colombia ICA, La Libertad Experiment Station, Villavicencio

Month	Average rainfall[a] (mm)	Average Temperature[b] (C°)	Average Relative humidity (%)
January	26 9	26 8	68 5
February	42 3	28 0	65 5
March	167 0	26 9	72 2
April	318 4	25 4	81 2
May	438 3	24 8	83 2
June	369 6	24 0	85 0
July	328 9	23 9	82 5
August	274 3	24 2	82 8
September	254 0	24 9	81 5
October	304 9	25 0	81 5
November	186 1	24 3	81 0
December	78 7	25 6	78 0
Total	2789 4		

a 12 years data

b 4 years data

Land preparation is started before the onset of the rainy season when sorghum, corn, or cotton stubble is plowed in using a disk plow, depending on soil and weather conditions, two or three harrowings are made using an offset disk harrow

Crop establihment is done by broadcasting dry seed by means of a tractor and a portable seed spreader at a rate of 150 to 180 kg/ha of seed Often three is either too much or too little rain at planting time, resulting in problems in seed germination, fertilizer applications, and weed control

Short dry spells 20 to 40 days after seed germination provoke severe leaf blast attacks on high portions of field of susceptible varieties

Fertilizer is broadcasting and incorporated with the last harrowing using either a 10-30-10 or a 14-14 formulation The total amount applied depends on soil analysis Table 5 provides some fertilizer recommendations for these soils

Table 5 Some recommendations for P and K fertilization for upland rice in alluvial soils of the Eastern Plains of Colombia

Phosphorus		Phosphorus	
P in soil (ppm, Bray II)	Recommended dosage P_2O_5 (kg/ha)	K in soil (meq/100g)	Recommended dosage K_2O (kg/ha)
< 10	100	< 0 10	75
10–15	50–75	0 10–0 15	50–75
16–30	25–50	0 16–0 30	25–50
>30	0–25	>0 30	0–25

Source Sánchez and Owen (1982)

Nitrogen fertilization plays a very important role in this ecosystem since environmental conditions are often very conducive to epidemics of rice blast disease On susceptible varieties and without chemical control of blast, no more than 30 kg/ha of N are recommended, but with good chemical control up to 60 kg/ha of N can be applied, when blast-resistant varieties are planted, then up to 70 kg/ha of N can be used Split applications of N are recommended at 30, 50, and 70 days after germination, urea is the most widely used nitrogen form

Grassy weeds are a serious problem across the region The most important weeds are Ischaemum rugosum, Echinochloa colonum, Cyperus diffusus, Rottboellia exaltata, Digitaria sanguinalis, Tripogranda multiflora, red rice, Cenchrus echinatus, Ipomea sp , Chenopodium sp , Cynodon dactylon, Amaranthus dubius, Portulaca oleracea, Cyperus ferax and Fimbristilis annua (Vargas and Jaramillo, 1980, Fedearroz, 1982) Weed control is effected with single or split applications of a herbicide (using airplanes or spray booms) 12 to 15 days after seed germination when weeds are at the 2-4 leaf stage Some common treatments include (a) propanil (360 g/liter) at 2 to 2 5 gal of commercial product/ha and (b) propanil (480 g/liter) at 2 0 gal of commercial product/ha In some cases, a mixture of propanil and a preemergent herbicide is used when weed infestation is high Examples include propanil + benthiocarb (8 + 10 liters/ha) and propanil + butachlor (8 + 4 liters/ha)

The effect of herbicide applications on CICA-8 upland yields are shown in Table 6

Table 6 Effect of herbicide applications on CICA-8 yields under upland conditions, Villavicencio, Colombia, 1980

Treatment	Dosage (kg/a i /ha)	Time of application DA germination	Yield (kg/ha)	Comparative yield (%)
Bentiocarbo/propanil	4 0/2 0	13	7025	296
Propanil + piperofox/ dimetametrina	3 0 + 0 8	13	5917	249
Propanil + bifenox	3 0 + 1 3	13	5408	227
Propanil + butaclor	3 0 + 2 4	13	6958	293
Propanil/phenothil	2 2/2 2	13/21	6833	280
Bifenox	2 5	PREEMERG	7158	302
Propanil + 2-4-D BE	4 0 + 0 12	13	6700	282
CONTROL	0	0	2372	100

Source Vargas and Jaramillo (1980)

Sogatodes oryzicola, Eutheola sp , and Hydrellia sp are the most important insect pests in this area Spodoptera frugiperda, Panoquina sp , Rupella albinela, Elasmopalpus lignosellus, Blissus leucopterus, Tibraca sp and Mormidea ypsilon are of lesser importance (Fedearroz, 1982) According to Jimenez (1979) there are several predators and parasites that are effective in checking damage caused by insect pests The most important ones include Polistes canadiensis, Polybia sp , Colomegilla maculata Doldina bicarinata, Calosoma granulatum, Trichogramma fasciatum, and Telenomus sp

Insecticides most commonly used are Azodrin/Nuvacron (1 liter/ha), Methyl Parathon (1 liter/ha), Dipterex 80 (1 liter/ha), Carbofuran (1 5 liter/ha), Basudin (1 liter/ha), Dimecron-100 (1 liter/ha), and Sevin 80 (2 g/ha) (Fedearroz, 1982)

Hoja blanca virus disease and rice blast disease (Pyricularia oryzae) are the most important diseases, but grain discoloration (or dirty panicles) is also becoming a serious problem Leaf scald (Rynchosporium oryzae) and brown spot (Helminthosporium oryzae) are common, while

(1 line missing?)

tremely variable over years and areas and is the major cause of yield variances Furthermore, all years typically have a pronounced low-rainfall period of about 3 weeks, which occurs some time between mid-June to mid-August, normally when the rice is in the active-tillering stage This results in drought stress and occurrence of rice blast and other foliar diseases, which complicates weed control Some farmers prepare land during this dry period and plant when rains begin anew, they thus run the risk of an early cessation of rain at the end of the growing season Land preparation is started at the onset of the rainy season when volunteer rice and weeds are plowed in using a disk plow, depending on soil and weather conditions, two or three harrowings are made using an offset disk harrow, during the last harrowing, a board is attached to the back of the harrow to level the land surface

Crop establishment is done by direct seeding, either by broadcasting dry seed or by drilling it at a row spacing of 34 (occasionally 17) cm Drilling is most often used (90%), and planting density is 80-100 kg/ha Broadcasting can be done manually or by means of a tractor or airplane, in this case, 130-140 kg/ha of seed is used Often there is too much rain or lack of it planting time, which causes some problems in seed germination and interferes with fertilizer applications and weed control

Soils are disuniform in physical and chemical characteristics Most of the rice is concentrated on the deeper alluvial clay-loam soils with a pH of 5 5 to 7 0 The sandier soils are difficult for upland rice because of their low water holding capacity, which results in pronounced drought stress, greater fungal disease pressure, and loss of native fertility in heavy rainfall areas The most pronounced nutrient problems on the rice soils are nitrogen and phosphorus deficiencies, the latter particularly on vertisols Deficiencies of K, Zn, Mn, and Fe are common but less widespread

According to soil analysis, 60 kg/ha of P_2O_5 and 40 kg/ha of K_2O are applied at planting time, 75-90 kg/ha of N are applied to the crop in three split applications--at planting, at the medium-tillering stem rot (Leptosphaeria salvinii) and sheath blight (Thanatephorus cucumeris) are also found Nematodes (Aphelenchoides besseyi and Meloidogyne sp) have been reported in some areas (Villarraga, 1979) The following fungicides are regularly used for leaf and neck blast (3 to 4 applications) Hinosan (1 liter/ha), Kasumin (1-1 5 liter/ha), Bla-S (1 2 liter/ha), Kitasin (1 5 liter/ha), and Bim (300 g/ha), Antracol (2 kg/ha), Duter (2 kg/ha) and Benlate (300 g/ha) are recommended for leaf scald (Fedearroz, 1982)

Rice fields are combined and the harvest is transported in sacks to commercial mills for drying and processing Heavy rains at harvest cause some problems

Dwarf rice varieties such as CICA-8 and Metica 1, are planted in this area Farm yields in this highly favored area average about 4 5 t/ha, but better farmers get about 5 5 t/ha Production costs for CICA-8 are about US$900 per ha These extremely high yields are the consequence of fertile soils and excellent rainfall distribution The yields are approximately equal to those obtained in irrigated rice sown on the acid, infertile soils which predominate in the region Since the costs of production for upland rice are roughly $300 lower than those for irrigated rice, the upland sector is expanding rapidly Large areas of underutilized alluvial soils for upland rice cultivation are available for future expansion Continued growth in this highly favored upland ecosystem will depend largely on the development of stable resistance to the blast disease, the most serious biological constraint to productivity

2 Moderately favored upland rice

The province of Guanacaste in Costa Rica will be used to describe the prodominant mechanized cropping system in Central America (González and Murillo, 1981) Climate is typically characterized by a rainy season beginning in May and lasting 6 months, the ramaining 6 months are extremely dry Yearly rainfall averages 1800 mm, with the greatest amount falling in June, September, and October Total rainfall is exstage, and at primordia initiation In some cases, 10-15 kg/ha of ZnSO4 and 10-15 kg of manganese are used to prevent zinc or manganese deficiencies

Grassy weeds are a serious problem across the region, the most important weeds are Echinocloa colonum, Leptochloa filiformis, Rottboellia exaltata, Cynodon dactylon, Cyperus rotundus, red rice, Ischaemum rugosum, Eleusine indica, Stenotaphrum secundatien, and, among the broadleaves, Amaranthus spenosus, Commelina diffusa, Cucumis melo, Crotalaria striata, Mimosa pudica, and Portulaca oleracea Weed control is effected with one or with split applications In this first case, one application of 4 8-5 4 kg a i of propanil are applied approximately 15-20 days after germination when weeds are at the 2-4 leaf stage, in the split-application system, 2 7 kg a i of propanil are used when weeds are at the 2-leaf stage and same treatment is repeated later Some farmers combine propanil and a preemergent herbicide, such as 1 kg a i of Pendimethalin + 3 5 kg a i of propanil Airplanes or spray booms are used for these applications

Spodoptera frugiperda, Eutheola sp , Elasmopalpus lignosellus, Rupella albinella, Blisus leucopterus, Mormidea sp , and Sogatodes oryzicola are the most important insect pests in this system, when applied, the insecticides used are Bux (1 liter/ha), Nuvacron (750 cc to 1 liter/ha), Lannate (5 liter/ha), Lorsban (1liter/ha), Azodrin 50E (1 liter/ha), and Sevin 750 (1 5 kg/ha)

Rice blast (Pyriculary oryzae) is the most important disease, but leaf scald (Rynchosporium oryzae), brown spot (Helminthosporium oryzae), eye spot (Dreschlera gigantea), and sheath rot (Acrocylindrium oryzae) are also common Hinosan (1 5 liter/ha), Kasumin (1 5 liter/ha), Kitazin (1 5 liter/ha) and Bim (0 2 kg/ha) are used to control neck blast in epidemic years

Rice fields are combined and the harvest is transported in bulk to commercial mills for drying and processing

Dwarf rice varieties (including CR 1113, CR 201, CR 5272, CICA-7, CICA-8, Tikal 2, Eloni, ICTA Virginia, and ICTA Tempisque) are planted in this system throughout Central America Small areas of moderately tall varieties from the United States are also grown

Farm yields in this moderately favored upland system average about 2 t/ha Yield in years of better than average rainfall distribution or in more favored ecological areas may approach 5 t/ha Yields in years or areas of less than average precipitation decline to 2 or fewer t/ha

3 Subsistence upland rice

The subsistence (traditional manual) upland production system is found from Mexico through Central America to all of the tropical countries of South America In some areas it has neglible importance (Central America, except Panama), while in others it makes a modest contribution to local production Only in Bolivia and the Amazon Basin (Colombia, Ecuador, Peru, and Brazil) does it achieve more importance than the other production systems

Subsistence upland rice production is found only at the agricultural frontier in areas of tropical rainforest It involves the felling and burning of forest during the dry season Rice is planted in hills separated by roughly 50 x 50 cm with several seeds dropped into holes opened with a pointed stick Soils vary from extremely acid and infertile (Chocó in Colombia and the Amazon Basin) to fertile (Bolivia) Ash from the burn is the only source of added nutrients Rainfall in rainforest environments is abundant and well distributed

The system produces one crop a year, normally for 1 or 2 years, after which the farmer shifts to a new piece of forest to begin the process again When human pressure on land is low, the farmer rotates back to previously planted patches about every 20 years More recently, the rotation has been reduced to 8 to 10 years in most areas Broadleaf weeds may become a problem in the second year of planting

Weeds are controlled by hand with machetes

The system is totally one of hand labor Land is never plowed and no purchased inputs are hold Improved seed is not available since the varieties used are never found in other rice systems Varieties are unimproved native types--tall, leafy, low-tillering,and of medium maturity Their distinguishing feature is large panicles, an essential trait since the harvest is panicle by panicle Panicles are dried by placing them individually on tree trunks or by forming bunches hung shelter The difficulty of drying threshed seed in the rainforest prevents harvest by the cutting of plants with subsequent threshing by beating

Each farm family manages about 1 ha per season The rice harvest may be followed by a cash crop of maize,tomato,or other at the end of the rainy season The rice harvest averages about 1 ton/ha and is rarely marketed Rather,it is stored as panicles and threshed and consumed as required Seed is retained for the following season Rice consumption by producer-families is high since rice is one of the few staples that can be safely stored for a period of time

Insects and diseases are normally of minor impact because of varietal tolerance acquired through years of farmer selection in the ecosystem and because of the wide spacing,low density,and lack of applied fertilizer

Farm problems,apart from the low yields,are not readily apparent Nevertheless, the system is extremely difficult to improve Partial mechanization of small holdings is out of the question Simple farm technology for rice drying is not available If it were, farmers theoretically could plant shorter,high-tillering varieties at closer spacing and harvest and thresh plants Modern varietal types at closer spacing,however,undoubtelly would result in elevating presently minor pathogens and pests to serious yield constraints Because of these technical reasons,coupled with the minor contribution of the system to total rice production,CIAT has determined to do no research on subsistence upland rice systems

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Table 1 Area planted in different rice production systems in Latin America ('000 ha), 1979-1980 [a]

Country	System (100 ha)							
	Irrigated	Rainfed lowland	Highly favored upland	Moderately favored upland	Un-favored upland	Traditional manual upland	Total area	Total area planted with improved varieties (%)[c]
Brazil	779	125	623	810	3178	716	6231	8
Mexico	73	0	11	26	16	7	133	55
Tropical South America								
Bolivia	0	1	2	14	0	38	55	3
Colombia	308	0	21	0	0	93	422	70
Ecuador	51	20	10	23	0	0	104	32
Paraguay[b]	21	0	0	11	0	0	32	6
Peru	72	12	0	11	0	5	100	47
Venezuela	125	9	0	97	0	0	231	87
Central America								
Costa Rica	2	0	42	35	0	3	82	96
El Salvador	4	0	0	10	0	0	14	94
Guatemala	0	1	5	3	2	1	12	60
Honduras	1	2	1	2	1	12	19	86
Nicaragua	22	0	5	0	0	0	27	77
Panama	2	5	8	20	10	54	99	53
Caribbean								
Guayana[b]	86	0	0	35	0	0	121	20
Cuba	151	0	0	0	0	0	151	100
Dominican Republic	99	5	0	0	0	0	104	34
Haiti	38	3	2	2	10	3	43	30
Jamaica	1	0	0	0	0	0	1	50
Surinam	34	0	0	0	0	2	36	100
Belize	3	0	1	0	0	2	6	50
Temperate South America								
Argentina	100	0	0	0	0	0	100	12
Chile	41	0	0	0	0	0	41	0
Uruguay	62	0	0	0	0	0	62	0
TOTAL LATIN AMERICA	2069	183	731	1099	3208	950	8240	
(%)	25	2	9	13	39	12	100	

a Unofficial CIAT preliminary estimates based on information from qualified sources

b 1977/78 harvest (CIAT, 1982)

c Dwarf varieties only, mostly CIAT and CIAT-derived materials (CIAT, 1979, 1982)

Source Posada and Nores, 1982

Table 2 Summary of area and yield in major Latin America rice production systems, 1978

System	Area (million has)	(%)	Average yield (ton/ha)	Production (million ton)	(%)
Irrigated	1 9[a]	0 23	3 5	6 6	0 46
Rainfed lowland	0 6[b]	0 07	2 5	1 6	0 11
Upland					
Favored (highly and moderately)	1 3[c]	0 16	2 0	2 5	0 17
Less favored	3 4[d]	0 42	1 0[d]	3 3	0 23
Manual	0 9	0 12	0 6	0 5	0 03
TOTAL	8 1	1 00	1 9	14 5	1 00

a IRTP, Report of the Third Conference, CIAT-IRRI, May 1979

b Dominican Republic, Haiti FAO Production Yearbook, Ecuador 20,000 has, Pozas System, Programa Nacional de Pesquisa-Arroz Brazil 520,000 has, Varzeas, EMBRAPA, and Centro Nacional de Pesquisa-arroz Feijao, annual reports several issues

c Mexico, Costa Rica, Guatemala, Venezuela, Colombia, Ecuador, Peru, FAO Production Yearkbook, Brazil, 1 million has noncerrados upland rice

d Estimated as residual

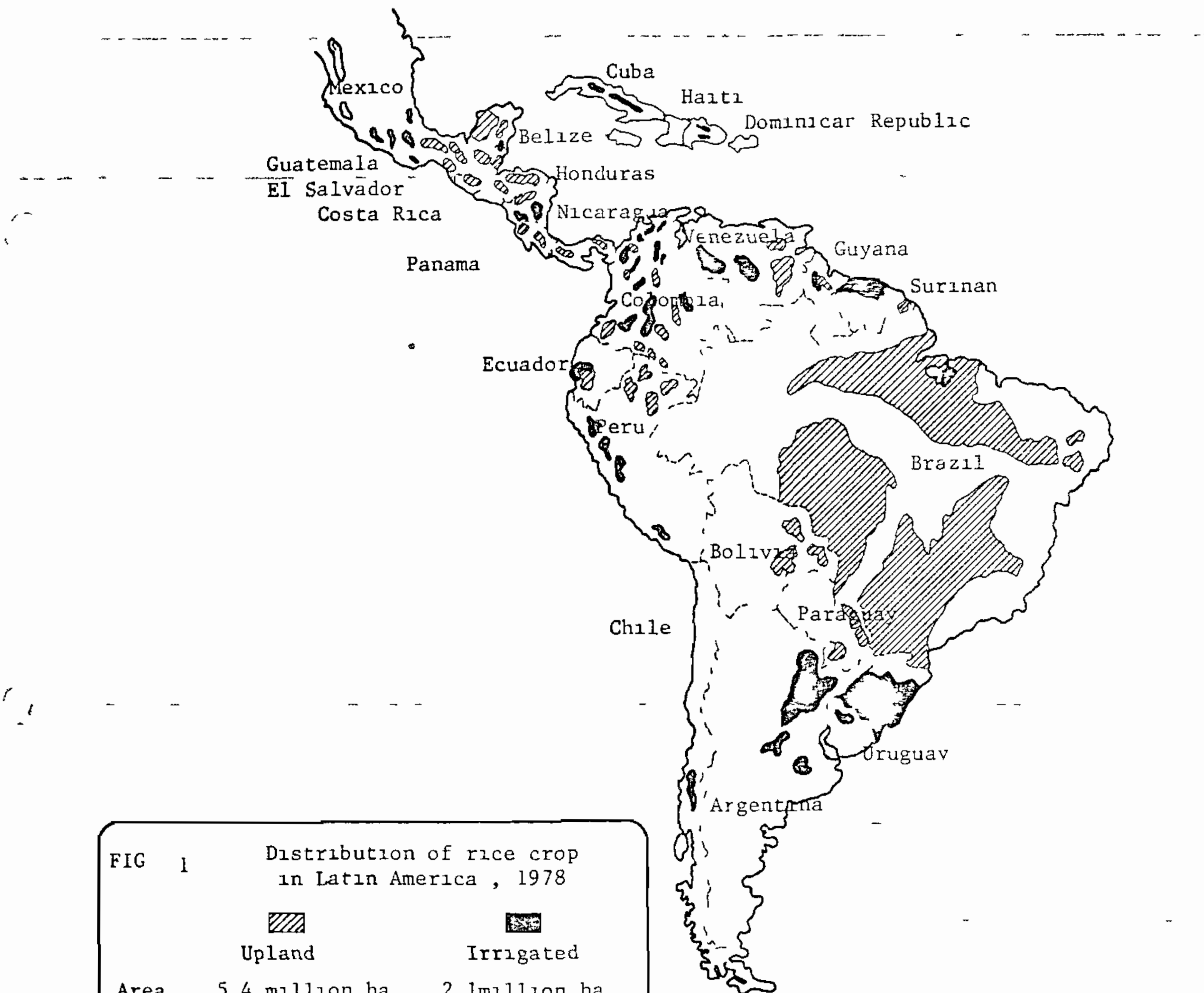


FIG 1 Distribution of rice crop in Latin America , 1978

	Upland	Irrigated
Area	5 4 million ha	2 1million ha
Prod	6 1 million tons	7 4 million tons
Yield	1 1 t/ha	3 6 t/ha

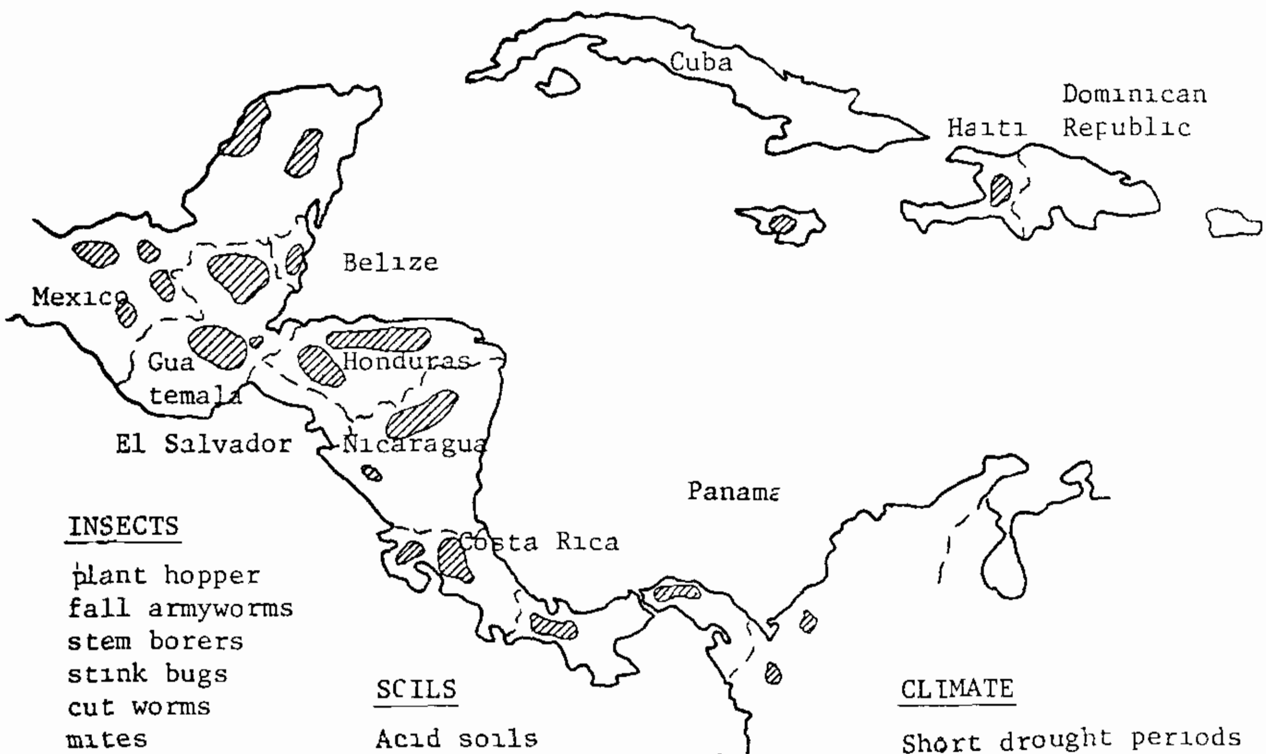
FIG 2 CONSTRAINTS TO UPLAND RICE PRODUCTION IN MEXICO AND CENTRAL AMERICA

DISEASES

Blast
Leaf scald
Brown spot
Sheath blight

VARIETIES

Lack of HYV tolerant to blast, drought, and acid soil problems



INSECTS

plant hopper
fall armyworms
stem borers
stink bugs
cut worms
mites

SOILS

Acid soils
P, Mn, Fe deficiencies, Al, Fe toxicity

CLIMATE

Short drought periods at seedling and flowering stages

WEEDS

Echinochloa
Digitaria
Rottboellia
Amaranthus

The cross-hatched patches indicates the upland rice areas in each country

FIG 3 CONSTRAINTS TO UPLAND RICE PRODUCTION IN SOUTH AMERICA

DISEASES

Blast
Hoja blanca
Grain discoloration
Leaf scald

VARIETIES

Lack of HYV having stable resistance to blast and tolerance to grain discoloration and acid soil conditions

INSECTS

Sogatodes
Stem borers
Fall armyworms
Eutheola sp
Stink bugs

SOILS

Acid soils
P, Mn , Zn, Fe deficiencies
Al toxicity

CLIMATE

Drought stress in Central Brazil

WEEDS

Echinochloa
Digitaria
Rottboellia
Cyperus
Broad leaves