AN OVERVIEW OF UPLAND RICE RESEARCH

INTERNATIONAL
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UPLAND RICE IN BRAZIL

EMBRAPA

Rice is a staple food for the Brazilian people and an important source of income for large, medium, and small producers. Production must continually increase to meet the demands of a growing population, but annual production varies substantially because nearly 70% of it is from upland rice.

Upland rice in Brazil is cultivated under diverse climatic conditions and land characteristics. Producers are inclined to spend less on high technology and more for production stability, and to emphasize cultivation in areas where there is less risk of natural disaster and greater potential for yield increases.

DEFINITION

Many classification systems are used to describe rice cropping. All are based on water availability.

According to a 1976 classification proposed by Centro Nacional de Pesyuisa de Arroz e Feijao (CNPAF) research teams, Brazil has four basic rice cropping systems: 1) rice cropped in lower elevation floodplains using controlled irrigation and high technology, 2) rice cropped in low elevation floodplains with no controlled irrigation that depends on river water levels, 3) rice cropped without irrigation on low elevation floodplains that depend on rainfall or groundwater levels near the soil surface, and 4) upland rice grown on soils with good drainage and low water retention capacity unaffected by groundwater levels, and dependent on rainfall as the sole water source. This latter system is defined as upland rice.

Upland rice represents 77% of the rice area in Brazil and accounts for about 66% of national rice production. It is cultivated during the rainy period mainly in the central region of the country, which has a monomodal rainfall regime with a May-September dry season and October-April wet season. Rainfall is high (1,200 mm annually), but short dry periods during the growing season determine the success or failure of the rice crop. Climatic variations within the upland region have prompted scientists to divide upland culture into favorable and unfavorable systems.

PRODUCTION SYSTEMS

Upland rice production systems in Brazil vary because of climate, regional infrastructure, and farmers' goals for future land use.

When upland areas were first opened for agricultural development, rice was the crop of choice. As frontier areas are developed, rice is still the first crop cultivated because it easily adapts to new land, performs better than other crops in poor soils, and improves soil fertility. After several years rice begins to be replaced by pasture, maize, and soybean. For example, the states of Minas Gerais, Sao Paulo, and Parana planted from 5.4 to 9.6% less upland rice in 1980 than in 1970 (Table 1). Frontier states Rondonia, Maranhao, Mato Grosso do Sul, and Mato Grosso expanded upland rice cultivation by 1.9 to 13.4%.

In the central-west region and parts of the southeast, where production is frequently affected by veranicos (dry periods), rice is cropped for 1 to 3 years to minimize the cost of establishing pasture. Some farmers interplant rice with grass as early as the first year.

Upland rice farmers use minimum inputs and technology. Inadequate rainfall reduces fertilizer efficiency and low fertilizer application rates, usually 100-200 kg of 6-30-16 NPK + Zn/ha, do not meet plant nutrient requirements. Farmers often apply natural rock phosphate to reduce soil acidity and provide phosphorus.

In much of Brazil, especially in the Amazon region of the north and northeast, farmers seek to produce only enough rice to feed their families. Very little surplus is marketed. Upland rice is intercropped with maize, kidney bean, cassava, watermelon, melon, pumpkin, gourd, fava bean, okra, cotton, and other crops. About 70% of production is grown on 4- to 10-ha farms. In Rondonia, the major rice growing state of the north,

Table 1. Changing upland rice production areas in Brazil.

State	Percent total area planted to upland rice		Change (%)
	1970	1980	
Rondonia	0.3	2.2	1.9
Maranhao	14.5	19.9	5.4
Minas Gerais	21.5	11.9	–9.6
Sao Paulo	13.5	6.0	–7.5
Parana	13.3	7.9	–5.4
Mato Grosso do Sul	5.4	10.1	4.7
Mato Grosso	4.6	18.0	13.4
Goias	27.0	24.1	–2.9

and in Acre, Para, Piaui, and Roraima, low income farmers practice shifting cultivation in forested areas where soil is easily exhausted and weeds are a major constraint. Both traditional and mechanized upland rice systems are used in Roraima.

In most of south and southeastern Brazil, upland rice is cultivated using relatively high technology levels. A substantial amount of rice is grown with controlled irrigation in some states, but upland rice is the major source of production. Although there are some areas of traditional farming in the south, most farms are large, mechanization is used in all phases of production, and areas are usually planted to wheat or soybean after the second year rice crop is harvested. Rio Grande do Sul and Santa Catarina are major upland rice producers in the south.

CLIMATIC CHARACTERISTICS

Upland rice is grown in almost every Brazilian state and in many different climatic regions. In the Cerrados region, where the greatest concentration of upland rice is located, the predominant climate types, according to the hopper classification system, are Aw (rainy tropics) in the lowlands, and Cwh_1 (rainy temperate with dry winter) in the central plateau.

Tables 2 and 3 show data on rainfall, temperature, solar radiation, and potential evapotranspiration during the rainy season for 26 sites that are representative of climatic conditions in Brazil. Figure 1 shows their geographic location.

Rainfall

Annual rainfall in Brazil varies from less than 500 to more than 3,000 mm, Figure 2 shows annual rainfall distribution for the different regions and identifies the representative upland rice growing areas listed in Table 2. Using the rainfall data for the selected sites the following observations can be made:

1. Rainfall regimes are monomodal and most locations have a distinct rainy and dry season. In the central-west region (Goiania, Porto Nacional, and Diamantino) the season lasts from October/Novenber through March/April. In the north (Grajau, Caxias, and Altamira), the rainy period begins in December/January. Boa Vista has a May-June rainy period which differs from other locations. Xanxere and Guarpuava receive more rain during the winter seasons and the dry period is not so distinct as in most locations.
2. The rainy season, defined as the months when rainfall exceeds 200 mm, varies among locations. Rains usually last 4-5 months, although some areas (Porto Velho and Porto Nacional)

Table 2. Rainfall characteristics in some producing areas of upland rice of Brazil.

Station	Location				Rainfall (mm)												Number rainy months (P> 200 m)	Number dry months (P< 100m)	Growing period[d]		
	State	Lati-tude (N)	Longi-tude (W)	Alti-tude (m)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun			Number months	Total rain-fall (mm)	MAI[c]
Imperatriz	MA	05°32'	47°30'	123	10	7	40	92	152	198	241	256	309	219	89	19	4	6	6	1.375	1.3
Grajau	MA	05°48'	46°27'	154	8	4	28	70	142	154	170	212	281	163	69	16	2	6	5	985	1.1
Caxias	MA	04°52'	43°21'	77	8	3	13	29	66	96	169	243	288	283	72	19	3	8	4	983	1.4
Carolina	MA	07°20'	47°28'	183	10	5	40	119	190	217	243	226	294	167	47	8	4	5	6	1.337	1.2
Goiania	GO	16°41'	49°17'	729	10	3	36	143	237	271	234	210	198	110	30	5	4	5	6	1.293	1.0
Porto Nacional	GO	10°43'	48°25'	237	2	3	35	142	233	284	274	229	273	150	36	1	6	5	7	1.443	1.2
Parana	GO	12°33'	47°47'	275	2	2	29	108	227	261	218	214	184	84	8	1	4	6	5	1.104	1.0
Catalao	GC	18°10'	47°58'	857	2	4	37	143	240	341	315	234	229	82	28	9	5	6	6	1.502	-
Diamantino	MT	14°25'	56°27'	258	7	9	52	146	224	297	320	295	299	142	47	12	5	5	6	3.581	-
Caceres	MT	16°04'	57°41'	118	11	7	36	94	157	197	215	206	171	78	48	20	2	7	5	946	0.9
Cuiaba	MT	15°36'	56°06'	172	6	12	40	130	165	194	216	198	232	116	52	14	2	5	5	1.005	1.2
Gen. Car-neiro	MT	15°43'	52°45'	478	4	5	49	129	210	268	300	240	214	94	30	8	5	6	5	1.232	-
Uberaba	MG	19°44'	47°55'	743	13	10	70	130	218	292	274	240	202	107	38	30	5	5	5	1.226	1.2
Guarapuava	PR	25°24'	51°28'	1108	102	112	157	163	157[b]	153[b]	188	141	134	113	119	136	0	0	5	613	0.8
Londrina	PR	23°21'	51°09'	610	58	46	89	150	131	165	208	190	143	94	88	80	1	6	5	644	-
Campo Grande	MS	20°27'	54°37'	566	36	29	62	162	164	191	229	199	140	101	81	50	1	5	5	945	0.8
Aquidauana	MS	20°28'	55°48'	207	44	30	71	139	138	198	234	193	150	116	98	57	1	5	4	775	0.8
Ponta Pora	MS	22°32'	55°43'	650	59	50	112	197	164	177[b]	189	173[a]	162	131	122	107	0	2	6	1.062	-
Franca	SP	20°33'	47°26'	1036	16	11	65	131	206	270	250	220	187	81	40	22	4	6	5	1.133	1.0
Porte Velho	RO	08°46'	63°55'	128	13	33	120	188	205	285	389	303	320	233	106	36	6	3	7	1.923	2.0
Altamira	PA	03°12'	52°45'	80	51	23	30	41	66	108	220	272	334	276	178	73	4	6	5	1.280	-
Conceicao de Ara-guaia	PA	08°15'	49°12'	150	7	15	64	163	196	227	253	252	263	163	60	8	4	5	7	1.517	1.2
Teresina	PI	05°05'	42°44'	79	8	6	10	28	60	105	175	236	311	254	91	15	3	7	4	976	1.3
Xanxere	SC	26°51'	52°24'	541	172	191	274	250	163	180	233	207	194	193	194	235	5	0	5	977	0.9
Boa Vista	RR	02°48'	60°42'	99	378	236	107	63	62	44	31	38	54	129	298	382	4	6	4	1.294	-
Sena Madu-reira	AC	09°08'	68°40'	135	36	45	126	173	193	274	316	285	266	231	125	66	5	3	7	1.739	1.6

[a] The growing season was defined using the following criteria: 1) Rainfall (R) of 1st month > 150mm; 2) R 2nd month > 150mm; 3) R of 3rd, 4th ... > 200 mm; 4) The last month only is considered to belong to the growing season if 150 mm < R < 200 mm; 5) A tolerance of 5% on the monthly rainfall was observed to establish the growing period. [b] Months in which the rainfall does not reach the values established to define the growing season.

[c] $\text{MAI} = \dfrac{\text{75\% probability of rainfall}}{\text{Potential evapotranspiration}}$

[d] The growing period was defined based mainly on the air temperature.

Table 3. Temperature, solar radiation, and potential evapotranspiration during the growing season in some upland rice producing areas of Brazil (Azevedo 1974, Brazil Ministry of Agriculture 1969, Hancock et al 1979).

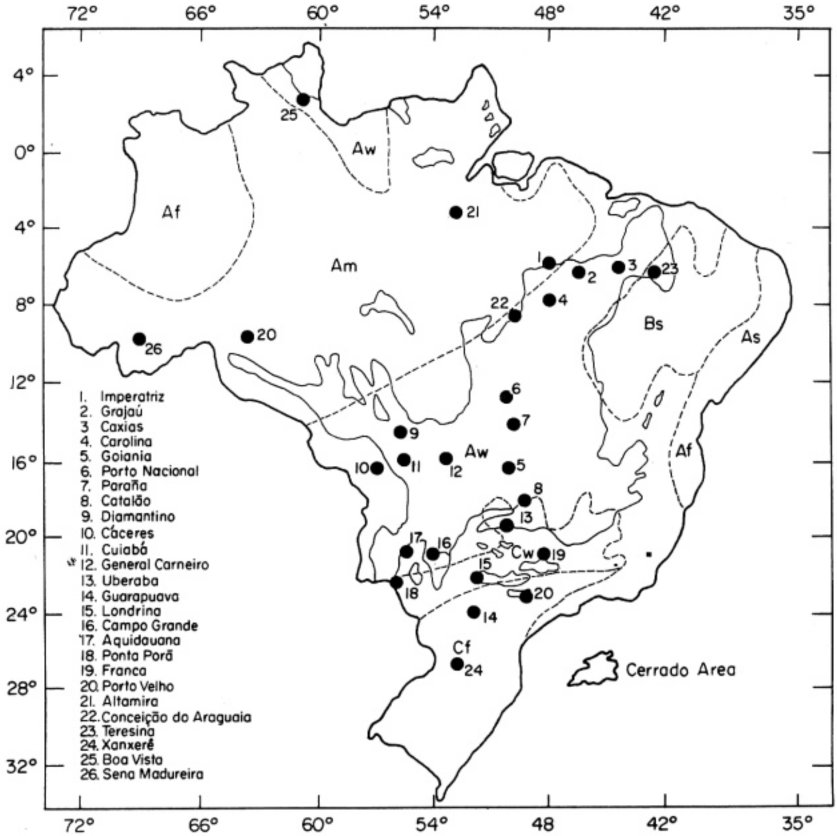
Station	State[a]	Air temperature (°C)			Solar radiation (cal/cm^2 per day)	Potential evapo-transpiration (mm/mo)
		Mean	Max	Min		
Imperatriz	MA	25.4	31.6	24.9	453	146
Grajau	MA	25.5	31.0	21.0	459	140
Caxias	MA	26.3	32.3	22.5	453	139
Carolina	MA	25.9	32.0	21.6	450	138
Goiana	GO	23.0	29.2	17.9	495	142
Porto Nacional	GO	25.6	31.5	21.5	463	143
Parana	GO	25.6	–	–	496	151
Catalao	GO	22.5	27.7	18.5	501	163
Diamantino	MT	–	–		–	–
Caceres	MT	26.4	32.4	22.5	479	149
Cuiaba	MT	26.5	32.7	22.5	476	148
General Caneiro	MT	–	–	–	–	–
Uberaba	MG	22.9	–	–	520	148
Cuarapuava	PR	18.1	24.2	13.2	510	130
Londrina	PR	–	–	–	–	–
Campo Grande	MS	24.1	30.1	39.2	516	151
Aquidauna	MS	26.3	32.5	21.9	516	160
Ponta Pora	MS	–		–	–	–
Franca	SP	21.3	27.0	16.8	490	134
Porto Velho	RO	26.4		–	397	123
Altamira	PA	–	–	–	–	–
Conseiçao do Ardguaia	PA	25.3	–	–	447	136
Teresina	PI	26.5	32.1	22.6	455	141
Xanxere	SC	19.6	27.2	13.6	538	140
Boa Vista	RR	–	–	–	–	–
Sena Madureira	AC	25.1	–		395	119

[a]See footnote a of Table 2.

have a 6—month season, and some have 2 rainy months (Grajau, Guiaba, and Caceres). Some areas (Guarapuava and Ponta Pora) never receive more than 200 mm during one month.

3. The upland rice growing season usually ranges from 5 to 6 months, but Teresina, Aquidauana, and Boa Vista have 4—month seasons, and Porto Velho, Conceicao de Araguaia, and Sena Madurei—ra have a 6—month growing season.
4. Total rainfall during the growing season ranges from 775 mm at Aquidauana to 1,923 mm at Porto Velho.
5. Moisture availability index (MAI), which is defined as

$$\text{the ratio } \frac{\text{25\% probability of rainfall}}{\text{Potential evapotranspiration}}$$



1. General climatic types in Brazil (by Koppen) and representative upland rice producing areas discussed in Tables 1 and 2.

during the growing season is highest (2.0) in Porto Velho and lowest (0.8) in Guarapuava, Aquidauana, and Campo Grande.

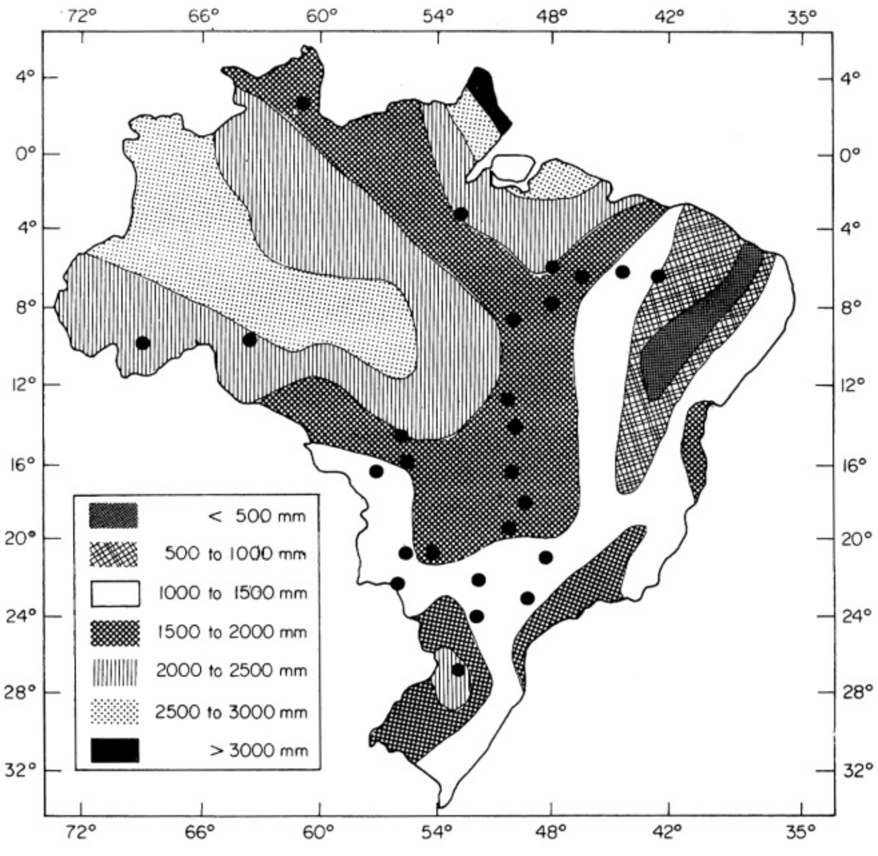
Although the cerrado (savannah) region receives adequate total precipitation for successful upland rice cultivation, there are often veranicos (dry spells) that last from 1 to 3 or more weeks. Studies at EMBRAPA /CNPAF show that a 10—day water deficit during the reproductive phase of rice reduces yield by as much as 40%. Frequent losses are caused by veranicos in Goias, Mato Grosso do Sul, Mato Grosso, and in parts of Minas Gerais and Maranhao. High evapotranspiration, low soil moisture holding capacity, and aluminum toxicity compound the effect of veranicos and increase crop losses.

Little research has been conducted on rainfall patterns in the cerrado area, but preliminary studies at EMBRAPA have divided upland areas into favorable and unfavorable regions, depending upon the probability of veranico during rice production (EMBRAPA 1981). More research needs to be conducted to locate and document upland areas by rainfall frequency so that technologies compatible with climatic risk can be developed and recommended. More detailed rainfall information is discussed in Favorable rainfall periods of upland rice production regions in Brazil, presented at the Workshop on Upland Rice, Bouaké, Ivory Coast.

Temperature, solar radiation, and potential evapotranspiration

Air temperature data (Table 3) show that all locations except Guarapuava and Xanxere have average temperatures above 20°C and average minimum temperatures above 15°C. Temperature does not limit rice cropping.

Sena Madureira and Porto Velho receive the lowest amounts of solar radiation (395 and 397 cal/cm^2 per day) during the growing season, and Xanxere (538 cal/cm^2 per day) receives the highest levels. Solar



2. Annual rainfall in Brazil and location of selected representative upland rice growing areas discussed in Table 2.

radiation for other sites ranges from 450 to 520 cal/cm^2 per day.

Spikelet number increases as solar radiation increases up to 500 cal/cm^2 per day (Yoshida and Parao 1976). Although the lower radiation values recorded at Porto Velho and Sena Madureira probably do not limit rice production at current yield levels, solar radiation levels must be considered when attempting to increase productivity by using higher technology.

Potential evapotranspiration values range from 140 to 150 mm/month during the growing season in most locations. Lowest evapotranspiration values are recorded in Sena Madureira (119 mm/month) and Porto Velho (123 mm/month). Highest evapotranspiration is in Catalao (163 mm/month) and Aquidauana (160 mm/month).

SOILS

Most rice production in Brazil is in the central region, in areas dominated by cerrado. Cerrado makes up 22% of Brazil's area (Fig. 3).

Oxisols predominate. Fifty-two percent are Dark-Red and Yellow-Red Latosols. There also are substantial areas of Hydromorphic Laterite and Yellow-Red Podzol soils.

Soil mineralogy

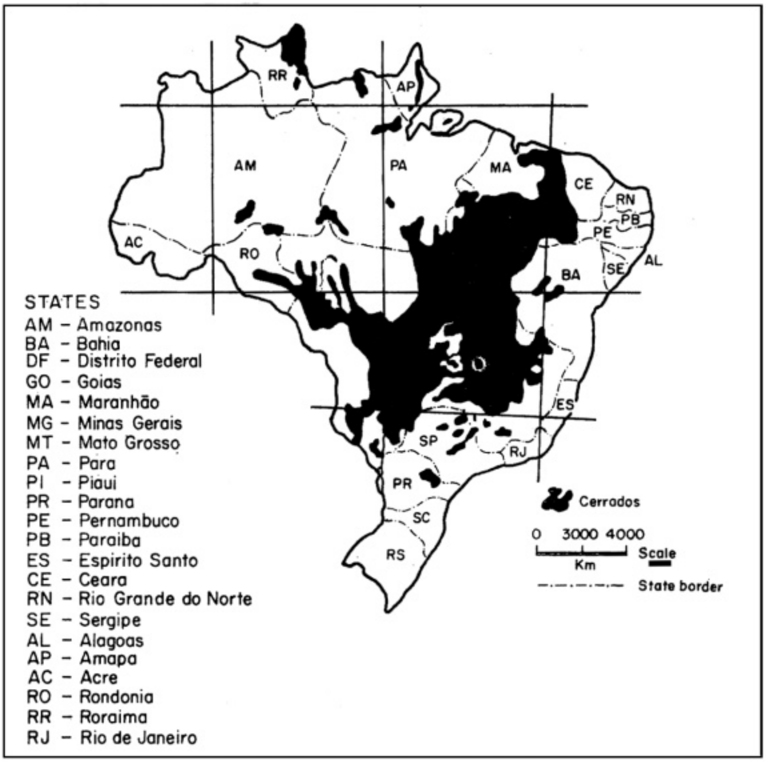
Although Brazilian soil mineralogy studies are scarce, they indicate that the mineralogical composition of the soil clays in central Brazil is mainly lattice 1:1 clays such as kaolinite and halloysite; oxides of iron, aluminum, and titanium; and insoluble minerals such as quartz. Gibbsite, hematite, and goethite are found at some sites. Advanced weathering firmed resistant microaggregates gathered by aluminum and iron oxides that cause the clay soils to have permeability equal to that of medium-textured soils, which encourages root development.

Soil physical conditions

Brazilian soils usually have good physical characteristics, in terms of friability, porosity, permeability, and depth, all of which facilitate root growth. Soil texture ranges from extremely clayey (83%) to extremely sandy. Even the clay soils have low water-holding capacity (Lopes 1977). Studies show that water availability can be reduced by 2/3 or more by tensions of 1/10 to 1 bar, independent of soil texture.

Soil chemistry

Brazilian soils, in general, and cerrado soils, in particular, have the following characteristics: N, P,



3. Brazilian cerrado region.

K, S, and Zn deficiency; Ca and Mg deficiency and low soil Ca and Mg retention capacity when they are applied as fertilizer; high exchangeable aluminum levels that are toxic to rice plants and cause phosphorus to be immobilized; low cation exchange capacity (CEC) and low total bases; high phosphorus fixation capacity; and medium organic matter content with reduced activity caused by low pH, high iron and aluminum oxide content, and low microorganism activity.

Liming and fertilization are difficult because of high phosphorus fixation, low CEC, and easily unbalanced soil nutrient content. High phosphorus fixation capacity linked with an extremely low Level of available phosphorus is one of the most limiting factors to crop development in Brazilian soils.

DISEASES

Fourteen fungal diseases and two nematodes attack upland rice in Brazil. Virus and bacterial diseases are not found. Leaf blast (*Pyricularia oryzae*), brown spot (BS) (*Helminthosporium oryzae*), leaf scald (*Rhynchos*-

porium oryzae), narrow brown leaf spot (NBLS) (Cercospora oryzae) and glume discoloration (Gld) (Phoma Ghina) are the most common and serious of diseases. Other diseases of less economic importance are secondary basal node rot (Fusarium oxysporium), white-tip nematode (Aphelenchoides besseyi), root-knot nematode (Meloidogyne javanica), false smut (Ustilaginoidea virens), kernel smut (Tilletia barclayana), leaf smut (Entyloma oryzae), and stackburn (Alternaria padwickii).

Blast is endemic and occurs every year with varying intensities. It is one of the most serious rice diseases, particularly in central west Brazil. Brown spot attacks rice grown in poor soils in the northern states. Leaf scald is found throughout Brazil. It is the most serious upland rice disease in Para, Amazonas, Acre, Rondonia, and Amapa and causes substantial damage in Maranhao. It is common in northern Brazil in areas with Dark Red Latosol soils. Leaf scald is the most serious disease during the first year of rice cultivation on newly opened lands in central Brazil, but there is little yield loss information for the disease.

NBLS usually occurs after booting, is sporadic, and does not affect production substantially. In 1981, however, it caused significant yield losses in Rorarima.

Gld reduced grain yield and quality significantly in Goias, Mato Grosso do Sul, and Mato Grosso during 1979-80. Continuous rainfall at panicle emergence increases disease incidence.

Secondary basal node rot is becoming more important in cerrado soils. Other diseases occur sporadically and cause little harm.

INSECTS

Upland rice is affected by insect pests, predators, and parasites. Common insects in the central-west region that sometimes reduce grain production are subterraneous termite (Syntermes spp. Isoptera-Termitidae), thrips (Frankliniella rodeos Thysanoptera-Tripidae), rice stink bugs (Oebalus ypsilongriseus, O. poecilus, Tibraca limbativentris Hemiptera-Pentatomidae), leafhoppers (Exitianus obscurinerves, Balclutha sp., Hortensia sp, Graphocephala sp. Homoptera-Cicadellidae), planthopper (Sogatodes oryzicola Homoptera-Delphacidae), spittlebugs (Deois flavopicta, Deois spp. Homoptera-Cercopidae), armyworms (Mocis latipes, Spodoptera frugiperda Lepidoptera-Noctuidae), lesser cornstalk-borer (Elasmopalpus lignosellus. Lepidoptera-Pyralidae), stem borer (Diatraea spp. Lepidoptera-Pyralidae), rice beetles (Diabrotica spciosa, Chaetocnema sp. Coleoptera-Chrysomelidae), and cutting ant (Acromyrmes spp., Atta spp. Hymenoptera-Formicidae).

The beetles Oediopaquerini and O. sternalis (Coleoptera—Chrysomelidae) have caused damage in Maranhao and Para, and panicle borer Neobaridia amplitarsis (Coleoptera—Curculionidae) recently damaged rice in Mato Grosso.

Insect damage often causes yield losses of as much as 29% in the central—west region. Lesser cornstalk borer and spittlebug sometimes damage seedlings and cause large areas to be replanted. Lesser cornstalk borer is most active in dry periods and spittlebug damages upland rice during rainy periods.

WEEDS

Although weeds are one of the most serious upland rice constraints in Brazil, they are not a problem during the first 2 years new lands are cropped. After the second crop year weed competition is a continual production barrier and, without adequate control, can reduce yields by 50% in years with good rainfall and by 70% if dry periods occur. High weed control costs and low rental demand for upland ricelands after the second year cause farmers to replace rice with pasture or other more economically viable crops.

The most common weed species in upland rice areas are the grasses Digitaria sanguinalis, Setaria geniculata, Cenchrus echinatus, Cynodon dactylon, Eleusine indica, Brachiaria plantaginea, and Imperata brasiliensis; sedges Cyperus rotundus and Cyperus spp.; and broadleaf weeds Sida rhombifolia, Cassia tora, Cassia occidentalis, Bidens pilosa, Amaranthus spinosus, Ipomoea spp., Portulaca oleracea, Ageratum conyzoides, Commelina spp., Galinsoga purviflora, Acanthospermum australe, Acanthospermum hispidum, Solanum sp., Borreria spp., Emilia sonchifolia, Euphorbia hirta, Alternanthera ficoidea, Amaranthus spp., and Sonchus oleraceus.

Weeds reduce rice grain yield through competition for water, nutrients, and light and also reduce the quality of the harvested product. If not controlled early in the production cycle, weed populations increase to harmful levels.

Although weeds are usually controlled by manual or mechanical weeding, chemical control is used in some areas. Because weed competition is most severe during the early development of the upland rice crop, efficient weed control is necessary to avoid or minimize yield reduction. Frequent rains early in the crop cycle enhance weed growth and limit manual and mechanical controls, making chemical methods necessary. Integrated weed control techniques are best for upland rice grown in unfavorable conditions and rational utilization of chemical weed control is best in favorable conditions.

BRAZILIAN UPLAND RICE VARIETIES

The active germplasm bank of the National Rice and Bean Research Center (EMBRAPA/CNPAF) has already documented more than 800 traditional varieties of upland rice in Brazil. Small producers, especially subsistence farmers, who use traditional farming methods, are the predominant users of these varieties. However, a few improved modern varieties have been developed for upland areas, and most of these are adapted to unfavorable conditions, although they are extensively planted in favorable regions.

Preferred maturity period for rice varies by upland region in Brazil. In unfavorable uplands medium-duration (120-140 days) and short-duration (100-120 days) varieties are planted. In favored uplands with long rainy seasons, longer-duration varieties, although unavailable, would be selected to mature after the rainy season ends to simplify harvest. Producers currently utilize medium-duration varieties that were developed for unfavorable uplands.

Most Brazilian upland rice varieties are tall, especially when planted in favorable conditions. Height varies between 1.2 m in unfavorable areas and 1.8 m in favorable ones. Varieties have low tillering capacity and are planted at low density to minimize yield losses under limited rainfall.

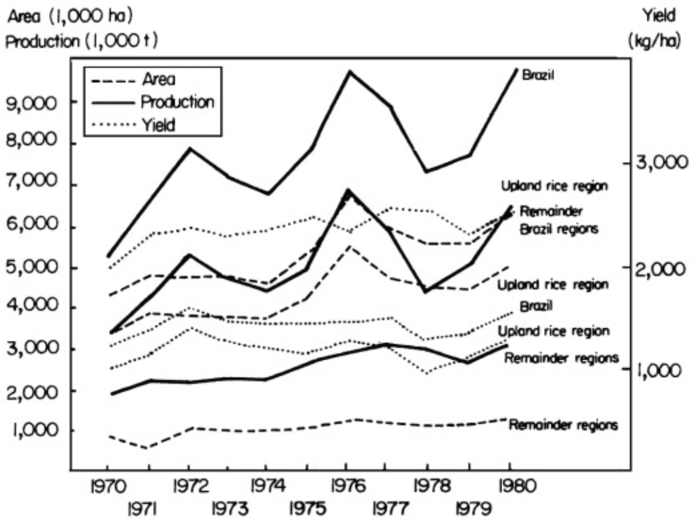
Most varieties have long, broad leaves and substantial foliar area. Leaves are decumbent and glabrous. In favorable conditions foliage causes shade that promotes the spread of pathogens. Plants have long panicles with many glabrous spikelets without aristae and with long, hyaline grains.

Some varieties have blast resistance, but no variety with multiple pest resistance has been developed.

UPLAND RICE YIELD AND PRODUCTION

Although there is no separate information available on upland and irrigated rice yields and production, approximate levels can be estimated by using statistics from states within the primary upland and irrigated areas. Production statistics from Maranhao, Minas Gerais, Sao Paulo, Parana, Mato Grosso do Sul, Mato Grosso, Goias, and Rondonia, where upland rice is the primary system, are used to represent Brazilian upland production in this paper. Other states were selected to represent irrigated production, although all states have some upland producing areas.

Figure 4 shows the fluctuation of relationships between upland rice area, production, and yield from 1970 to 1980. Upland area and production tend to fluctuate more sharply than irrigated areas; however, both areas show a gradual increase at all three levels.



4. Crop area, yield, and production of rice in Brazil.

Table 4. Growth of upland rice area and yield in Brazil 1970-80.

Production region	Area increase (%)	Yield increase (%)
Brazil	44.8	28.3
Uplands	49.8	27.6
Others	21.1	33.5

The growth of area and yield for major upland rice producers in Brazil for 1970-80 is shown in Table 4. Upland rice area increased substantially above other areas, but irrigated yields increased slightly more than upland yield.

Table 5 shows 10-year average upland rice yields in major Brazilian upland rice producing states.

OBJECTIVES OF UPLAND RICE IMPROVEMENT

The current upland rice breeding program in Brazil seeks to develop modern varieties for favorable and unfavorable conditions. Major goals for favorable uplands are to develop high yield potential; lodging resistance; 130- to 150-day maturity, brown spot (Helminthosporium oryzae) resistance; good tillering ability; phosphorus utilization efficiency; long, slender, translucent grains; 1 m height; high vegetative vigor; and resistance to pasture spittlebug (Deois sp.). For unfavorable upland conditions, goals are

Table 5. Average rice yield for major upland rice growing states in Brazil, 1970-80.

State	Average yield 1970-80 (t/ha)
Rondonia	1.6
Maranhao	1.3
Minas Gerais	1.1
Sao Paulo	1.1
Parana	1.3
Mato Grosso do Sul	1.2
Mato Grosso	1.5
Goais	1.0
State average	1.2
Irrigated areas	2.4
Brazil	1.4

drought resistance, blast resistance, high yield, 100- to 120-day maturity, tolerance for soil stresses (aluminum toxicity, low phosphorus), 100-120 cm height, lodging resistance, and resistance to lesser cornstalk borer (Elasmopalpus lignosellus) and stem borer (Diatraea saccharalis).

REFERENCES CITED

Azevedo, D. da C. 1974. Chuvas no Brazil, regime, variabilidade e probabilidades du alturas mensais e anuais. Brasilia, UFRGS. 41 p. Tese Mestrado. Hidrologia Aplicada.

Brazil, Ministerio da Agricultura, Escritorio de Meteorologica. 1969. Normais climatologicas. 5v. Rio de Janeiro.

Hancock, J. K., R. W. Hill, and G. H. Bargreaves. 1979. Potential evapotranspiration and precipitation deficits for tropical America. Cali, CIAT. 108 p.

Lopes, A. S. 1977. Available water, phosphorus fixation, and zinc levels in Brazilian cerrado soils in relation to their physical, chemical, and mineralogical prpperties. Ph D thesis, Raleigh, North Carolina State University. 189 p.

Yoshida, S., and F. T. Parao. 1976. Climatic influence on yield and components of lowland rice in the tropics. Pages 471-494 in Climate and rice. International Rice Research Institute. Los Baños, Philippines.