AN OVERVIEW OF UPLAND RICE RESEARCH

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UPLAND RICE IMPROVEMENT AT EMBRAPA, BRAZIL

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Rice is an important crop in Brazil, covering a cultivated area of 5.4 million ha and yielding 7.6 million t. It is the basic energy food for Brazilians who consume an annual 45 kg rice/person (IBGE 1980).

Although farmers grow rice in all parts of Brazil, the most important regions are the west central, southeast, and southern areas, which give 78% of production.

Brazilians cultivate rice using four different systems:

- System I - lowland rice under controlled irrigation,
- System II - lowland rice without controlled irrigation,
- System III - lowland rice without irrigation (varzea), and
- System IV - upland rice totally dependent on rainfall for water requirement.

Upland rice is the most important and covers about 77% of the total cultivated area, about 4.2 million ha, and yields 4.4 million t.

Brazil has different climatic and soil conditions for upland rice. Although those regions have not been clearly defined, climatic data show regions where upland rice suffers from water deficits during the rainy season. Because it is a risky crop to grow, farmers use poor technology and harvest low yields. These regions are unfavorable for upland rice cultivation.

Most System IV areas are in south central Brazil and include the southern states of Goias, Mato Grosso do Sul, São Paulo, and Parana and, which contribute about 53% of upland rice production (Table 1). However, farmer and extension agent information and preliminary climatic analysis show that some upland areas in the north central region have good rain distribution during the wet season. The strongly reduced probability of drought will encourage farmers to use more technology. Best rice yields may come from these areas considered more favorable for upland rice cultivation.

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Table 1. Rice area (A, in ha) and production (P, in t) per cultivation system, 1978-79 (IBGE).

State		Upland (IV)	Lowland (I)	Lowland (Varzea) (III)	Others (I, II, III, IV)	Total
Goias	A	927,000	–	–	–	931,110
	P	1,140,210	–	–	–	1,155,080
Maranhão	A	853,779	–	–	–	853,779
	P	1,070,190	–	–	–	1,070,190
M. Grosso	A	741,130	–	–	–	741,130
	P	975,476	–	–	–	975,476
M. Gerais	A	371,836	77,528	60,000	–	509,364
	P	178,070	181,340	300,000	–	659,370
M. Grosso S.	A	584,719	–	–	–	584,719
	P	457,131	–	–	–	457,131
S. Paulo	A	300,400	–	–	–	300,400
	P	307,800	–	–	–	307,800
Parana	A	323,916	–	–	–	323,916
	P	286,676	–	–	–	286,676
R. G. Sul	A	31,500	493,500	–	–	525,000
	P	13,400	1,661,600	–	–	1,675,000
Sta. Catarina	A	75,877	80,197	–	–	156,074
	P	20,323	239,471	–	–	259,794
Others	A				514,430	514,430
	P				745,391	745,391
Total	A	4,210,157 (77.4%)	655,335 (12.0%)	60,000 (1.1%)	514,430 (9.5%)	5,439,922 (100%)
	P	4,449,276 (58.6%)	2,097,281 (27.6%)	300,000 (4.0%)	745,391 (9.8%)	7,591,948 (100%)

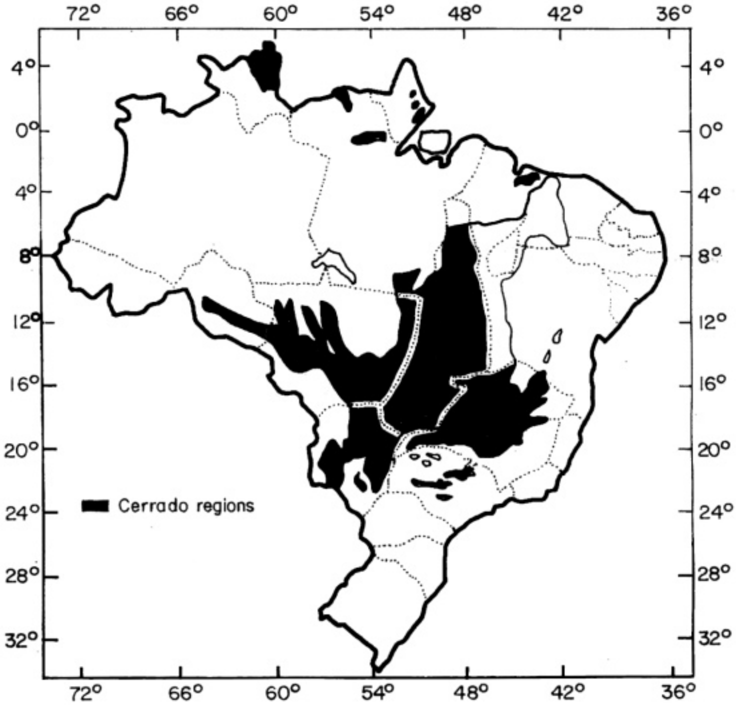
CHARACTERISTICS OF UNFAVORED AREAS

More than 60% of upland rice production in Brazil comes from low-yielding unfavored areas. The most important constraints are water deficits, diseases, and low fertility or toxic soil.

In unfavored areas, farmers plant rice in deep cerrado soils (Fig. 1). They have high permeability, low water retention capacity, and low organic matter. They also have low fertility, phosphorus deficiency, and aluminum toxicity (Table 2). Soil water deficits are frequent and occur during all stages of rice growth. Drought may vary from a few days to more than 3 wk, causing a marked yield decrease or even total crop Loss.

Besides causing soil and plant water deficits, drought also favors blast, which significantly reduces yield.

The law phosphorus content and high aluminum toxicity of cerrado soils prevent the normal rice plant development. Short tillers and inadequate root systems make the plant more sensitive to soil water deficits (Fageria and Zimmermann 1979, Fageria and Barbosa Filho 1980).



1. Distribution of cerrado soils in Brazil.

Table 2. Soil property means for each type cerrado vegetation[a] (Lopes and Cox 1977).

Soil property[b]	Campo limpo (64)[+]	Campo cerrado (148)[+]	Cerrado (245)[+]	Cerrado (45)[+]
pH (H_2O)	4.87	4.94	5.00	5.14
Organic matter (%)	2.21	2.33	2.35	2.32
Exch. Ca (meq/100 ml)	0.20	0.33	0.45	0.69
Exch. Mg (meq/100 ml)	0.06	0.13	0.21	0.38
Exch. K (meq/100 ml)	0.08	0.10	0.11	0.13
Exch. Al (meq/100 ml)	0.74	0.63	0.66	0.61
Eff. CEC (meq/100 ml)	1.08	1.19	1.43	1.81
Al saturation (%)	66	58	54	44
Extr. P (ppm)	0.5	0.5	0.9	2.1
Extr. Zn (ppm)	0.58	0.61	0.66	0.67
Extr. Cu (ppm)	0.60	0.79	0.94	1.32
Extr. Mn (ppm)	5.4	10.3	15.9	22.9
Extr. Fe (ppm)	35.7	33.9	33.0	27.1
Clay (%)	33	36	34	32
Silt (%)	20	16	15	16
Sand (%)	46	48	51	53

[a]Figures in parentheses are number of samples analyzed. [b]Exchangeable Al, Ca, and Mg were extracted with 1 NKC 1. P, K, Zn, Cu, Mn, and Fe were extracted with 0.05 + 0.025 H_2SO_4. These soils are deficient in Ca, Mg, P, and Zn. They are acidic in reaction, organic matter and CEC level are low, and Fe and Al saturation is high.

CHARACTERISTICS OF FAVORED AREAS

Although intensive studies of rice cultivation in favored areas are not available, preliminary yield trials at different favored sites show that grain yield is higher than in other areas. Yields can be more than 4 t/ha, and in large areas yield is 2.5—3 t/ha. This may be due to good rain distribution during the growth period. The temperature is also higher than in the unfavored areas and blast is not an important disease.

Currently, favored upland areas have less rice production than unfavored areas, but they are becoming an important rice production region because of increasing numbers of big farms and better yield stability.

BREEDING UPLAND RICE FOR UNFAVORED AREAS

The main objective of the upland rice breeding program for unfavored areas is yield stabilization. In the last 25 years upland rice yields decreased as rice expanded onto less fertile cerrado soils and farmers used the more fertile soils for crops such as soybean and maize. Besides soil problems, drought is the main cause of production changes. Additional problems are the strong relationships between drought and blast and drought and insect (the Lesser cornstalk borer, *Elasmopalpus Lignosellus* Zeler) attack.

New varieties for unfavored areas should be:

- drought tolerant,
- blast resistant,
- tolerant of low soil phosphorus and high aluminum toxicity, and
- insect resistant.

Drought tolerance

Rice varieties actually grown by Brazilian farmers have good drought tolerance. However, experiments show that this characteristic could be increased by modifying plant morphology. Increased root length and reduced leaf size allowed traditional varieties experiencing drought to show yield increases. Growth duration is also important. Short—duration varieties will escape flowering during the drought period. By using such varieties, farmers can choose the most convenient time for sowing during any month of the rainy season, even after the most important drought period between January and February. We are also selecting medium—duration varieties for farmers using supplementary irrigation.

Blast resistance

Blast is the most important disease affecting upland rice in unfavored areas. Experimental results show that blast control may increase upland rice yield about 40%.

EMBRAPA is attacking the blast problem by:

- diversifying resistant varieties with vertical resistance genes from different sources,
- developing multilines from these sources,
- developing varieties with many genes for vertical resistance, and
- breeding for horizontal resistance.

Tolerance for soil phosphorus deficiency

Phosphorus is the most important nutrient for upland rice in cerrado soils. It favors root development, which helps rice tolerate drought. With low phosphorus levels and high fertilizer prices, farmers use a minimum and consequently have poor yields.

In breeding upland rice for phosphorus deficient soils we are

- screening for tolerance to low phosphorus content in the soil (We evaluated more than 200 varieties and found some with good tolerance to the low phosphorus content.);
- doing basic studies on tolerance to phosphorus deficiency; and
- incorporating low phosphorus tolerance into upland rice varieties.

Tolerance for high aluminum toxicity

Aluminum toxicity is another important factor that decreases yield in cerrado soils. It affects the normal root development and interferes in important biochemical reactions including absorption, transport, and use of nutrients such as phosphorus, calcium, and magnesium. It limits root absorption of nutrients and water essential for upland rice. To deal with aluminum toxicity, we are:

- screening for tolerance. (Research using a nutrient solution showed that high aluminum concentration markedly reduced plant weight and height and root length. Based on the results, we classified the varieties into high, medium, and low aluminum toxicity tolerance.);
- doing basic studies on the nature of aluminum tolerance in rice. (Data analysis of plant height, root length, weight of aerial part of the plant, and dry root weight showed that aluminum tolerance was quantitative.); and
- incorporating aluminum toxicity tolerance in upland varieties.

Insect resistance

Many insects attack upland rice but the most important in Brazil is the lesser cornstalk borer *Elasmopalpus lignosellus* Zeler. Infestation accompanies drought, mainly at the seedling stage. Selected tolerant plants from severely attacked varieties were 60% more tolerant than the original population.

BREEDING UPLAND RICE FOR FAVORED AREAS

Although most upland rice research has been on unfavored areas, preliminary experimental results show that rice varieties for favored conditions need different characteristics from those for unfavored areas. Favored areas with more and better rainfall distribution and higher temperatores encourage rice growth. Varieties currently grown in favored uplands are more than 1.5 m high and lodge easily.

Without a drought period during harvest time, farmers often must harvest in the rain, which causes serious grain quality problems.

Varieties developed for favored regions should yield higher with better technology, and have lodging resistance; resistance to diseases, mainly leaf scald (Rynchosporium oryzae) and brown spot (Helminthosporium oryzae); seed dormancy; adequate growth duration; and drought tolerance.

Grain yield capacity and lodging resistance

Varieties currently grown in favored areas are tall with large leaves. With good technology, they lodge, which decreases yield and grain quality.

Physiological disturbance causes large leaves when well-developed plants shade each other.

Because there is little drought risk in the favored areas, we encourage farmers to use more technology and we need better varieties to support that. In the upland rice breeding program for favored areas, we select plants that have erect leaves and are no more than 1.2 m high.

Disease resistance

Leaf scald is the prevalent disease in favored areas in Para and Amazonas and is increasing in Maranhao. We have not found varieties resistant to leaf scald, perhaps because a good screening method does not exist.

Although brown spot leaf lesions do not significantly reduce yield, even under epidemic conditions, the grain infection causes substantial yield reduction. We have identified brown spot resistant varieties and used thein to incorporate resistance in new material for favored uplands.

Seed dormancy

In favored uplands, farmers frequently must harvest rice in the rain, which decreases grain quality. Heavy rain and wind may also cause lodging before harvest. Some seed dormancy is necessary to avoid this problem.

Adequate growth duration

Suitable growth duration is important in breeding for favored areas. Small farmers usually prefer long-duration varieties harvested at the end of the wet season because they have no way to dry the rice after harvest. Large scale farmers, however, prefer short- to medium-duration varieties because they have dryers and can harvest even on rainy days.

Drought tolerance

Although long drought periods in favored areas are extremely improbable, short periods (1 wk or less) may occur and severely damage rice on sandy soils. If drought occurs at early growth stages, before roots are well developed, plants can die. Drought during flowering stage may decrease yield. Thus, some drought tolerance is necessary for varieties developed for favored uplands.

REFERENCES CITED

Fageria, N. K., and M. P. Barbosa Filho. 1980. Avaliacão de cultivares de arroz para maior eficiência na absorcão de fósforo. CNPAF. II Reunião Nacional de Pesquisa de Arroz.

Fageria, N. K., and F. J. P. Zimmermann. 1979. Selecão de cultivares de arroz para tolerancia a toxidez de alumínio em solucão nutritiva. Pesy. Agropec. Bras. 14(2):141-147.

IBGE (Instituto Brasileiro de Geografia e Estatistica). 1980. Anuario estatistico do Brasil-1980. 837 p.

Lopes, A. S., and F. R. Cox. 1977. Cerrado vegetation in Brazil: an edaphic gradient. Agron. J. 69: 328-381.