Upland Rice Production in Brazil

By M.P. Barbosa Filho and T. Yamada

Most of the upland rice produced in Brazil is on Oxisols with low water-holding capacity and often with low fertility. This article outlines some of the management practices being studied for sustainable rice production systems.

Upland rice occupied 2.4 million ha or 64 percent of the total rice area in Brazil in 1999 (Table 1). However, due to lower productivity as compared with flooded rice, it contributes only about 38 percent of Brazil’s total rice production.

The lower productivity of upland rice is attributed to dry spells during the crop season and low soil fertility. Higher risk due to dependence on rainfall discourages farmer investment in soil fertility. As a result, low soil fertility increases crop susceptibility to water stress and disease. Moreover, the Oxisols where upland rice is cultivated have low water holding capacity, with two-thirds or more of the available water being removed by suction of 0.1 to 1.0 atmospheres, regardless of soil texture (Lopes, 1977). Studies done at the national Rice and Bean Research Center in Brazil show that normal water deficits during the reproductive stage can reduce yield by 40 percent.

Upland rice producing areas can be separated into two regions according to rainfall. The less risky area produces yields of 3 to 5 t/ha because of favorable rainfall and a medium/high technological level among farmers (comprising the states of Mato Grosso do Sul and Mato Grosso and the southern part of Pará and Maranhão states). The more risky area (comprising the states of São Paulo, Minas Gerais, Goiás and Tocantins, and the Federal District) produces yields of 1.5 to 1.8 t/ha and suffers one to two dry spells (veranicos) during the rainy season. Primary upland rice growing states are shown in Figure 1.

In the past, upland rice was grown mainly to prepare the land for pasture establishment. Continuous monocrop rice production and the

<table>
<thead>
<tr>
<th>Systems</th>
<th>Area '000 ha</th>
<th>%</th>
<th>Production '000 t</th>
<th>%</th>
<th>Yield kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland</td>
<td>2,430</td>
<td>63.8</td>
<td>4,450</td>
<td>37.8</td>
<td>1,830</td>
</tr>
<tr>
<td>Flooded</td>
<td>1,310</td>
<td>34.2</td>
<td>7,180</td>
<td>61.0</td>
<td>5,500</td>
</tr>
<tr>
<td>Várzea</td>
<td>75</td>
<td>2.0</td>
<td>144</td>
<td>1.2</td>
<td>1,920</td>
</tr>
<tr>
<td>Brazil</td>
<td>3,810</td>
<td>100.0</td>
<td>11,800</td>
<td>100.0</td>
<td>3,090</td>
</tr>
</tbody>
</table>


1 Várzea: low lands adjacent to rivers

Figure 1. States growing mainly upland rice in Brazil (yellow area).
associated excessive tillage, inadequate erosion control measures, and insufficient application of lime and fertilizer resulted in significant environmental damage and a non-sustainable crop production system.

Presently, upland rice is grown for about two years after clearing the cerrado vegetation, because the root residues do not permit mechanical harvest of soybeans. Therefore, upland rice is considered as a crop to “tame” cerrado soils before planting crops which are currently more profitable, such as soybeans and corn.

Most of the upland rice production area occurs on two Oxisol groups, Dark-Red Latosol and Yellow-Red Latosol, representing about 52 percent of the cerrado region. Characteristically, these soils are deficient in nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), copper (Cu), manganese (Mn), and zinc (Zn). They are high in aluminum (Al), low in cation exchange capacity (CEC), and have a high P fixation capacity. Although these soils have a medium organic matter content, they are low in microbial activity due to low pH and high contents of iron (Fe) and Al oxides. (Lopes, 1977).

In general, these Oxisols have very good physical characteristics for plant growth: soil friability, porosity, permeability, and depth, all of which facilitate good root development. Topography varies from greatly to slightly undulated. Texture ranges from extremely clayey to extremely sandy. A characteristic of these soils is their low water holding capacity.

### Liming

Residual effects of liming to either correct pH to 5.5 or for Al neutralization last for at least five years following application. Care must be taken to avoid excessive liming which causes deficiencies of all micronutrients, except molybdenum (Mo). Liming above pH 6.0 has been considered the primary cause of Zn and Fe deficiency in upland rice grown after a leguminous crop (Barbosa Filho et al., 1994).

According to Souza et al. (1986), the liming recommendation for central Brazilian soils with more than 20 percent clay content is calculated by the following formula:

\[
\text{Lime (t/ha)} = \text{Al}^{3+} \times 2 + [2 - (\text{Ca}^{2+} + \text{Mg}^{2+})]
\]

For soils with less than 20 percent clay content, the higher value obtained by either of the two formulas shown below is used.

1. Lime (t/ha) = \text{Al}^{3+} \times 2,
2. Lime (t/ha) = 2 - (\text{Ca}^{2+} + \text{Mg}^{2+})

The above calculations are based on lime with a relative neutralizing value of 100 percent and where \text{Al}^{3+}, \text{Ca}^{2+} and \text{Mg}^{2+} are expressed as cmol/dm³ soil.
NPK Fertilization

The yield response of upland rice to high rates of fertilization depends on favorable rainfall conditions or supplemental irrigation (Figure 2a, 2b and 2c). Application of N significantly increased the grain yield of four cultivars of upland rice in three consecutive crop seasons under supplemental irrigation. As shown in Figure 2a, the maximum grain yield of 5.5 t/ha was obtained with 113 kg N/ha (Stone et al., 1999).

For upland rice production in Brazil, P is the most important yield-limiting plant nutrient, due to the inherently low soil P levels and high P fixation capacities. Application of both P and K increases grain yield, but the effect is more pronounced under favorable rainfall conditions. In one study, P fertilization increased yield nearly five-fold with application of 150 kg P₂O₅/ha compared to the unfertilized control when moisture was sufficient (Figure 2b). Where drought severely limits yield response, similar non-responsive results are obtained with both P and K fertilization (Figure 2c).

Corrective P fertilization recommendations range from 50 to 240 kg P₂O₅/ha (broadcast and incorporated), depending on the P level and clay content of the soil (Table 2). Corrective K fertilization recommended by the Brazilian Agricultural Research Corporation (EMBRAPA) Cerrados, based on soil K level and soil clay contents greater than 20 percent, is presented in Table 3. It is recommended that K be broadcast to avoid leaching losses due to the low cation exchange capacity (CEC) of cerrado soils.

Maintenance fertilization varies with the production system, the amount of residue left by the preceding crop and the expected yield. In general, maintenance applications recommended are: 60 to 120 kg N/ha for one (clay soils) or two (sandy soils) applications, 60 to

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**Table 2.** Soil P level and clay content affect corrective P fertilization.

<table>
<thead>
<tr>
<th>Clay content, %</th>
<th>Soil P level, Mehlich I, mg/dm³</th>
<th>Corrective fertilization, P₂O₅ kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>61-80</td>
<td>0-1</td>
<td>1.1-2.0</td>
</tr>
<tr>
<td>41-60</td>
<td>0-3</td>
<td>3.1-6.0</td>
</tr>
<tr>
<td>21-40</td>
<td>0-5</td>
<td>5.1-10.0</td>
</tr>
<tr>
<td>&lt;20</td>
<td>0-6</td>
<td>6.1-12.0</td>
</tr>
</tbody>
</table>

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**Table 3.** Corrective K fertilization as determined by soil K level and clay content greater than 20 percent.

<table>
<thead>
<tr>
<th>Exchangeable K, mg/dm³</th>
<th>K₂O rate, kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>100</td>
</tr>
<tr>
<td>26-50</td>
<td>50</td>
</tr>
</tbody>
</table>
120 kg $P_2O_5$/ha, and 30 to 90 kg $K_2O$/ha.

**Micronutrients**

Micronutrient deficiencies are widespread in central Brazil. Corrective rates for soil and foliar applications are recommended for B, Cu, Fe, Mn, Zn, and molybdenum (Mo).

**Sustainable Production**

The objective of EMBRAPA Rice and Bean Research Center efforts is to develop technologies for sustainable rice production systems that have the least negative impact on the environment. Technologies being tested include: no-tillage, crop rotation, nutrient management, integrated pests, diseases and weed control, efficient water use, and development of improved cultivars.

Farmland under no-till is increasing and already covers about 14 million ha. It is proving to be one of the most efficient ways to control soil erosion and to rebuild the fertility of degraded soils. However, many of the management practices adapted from conventional tillage systems, such as lime requirement and N fertilizer timing, need to be studied in no-till systems. **BCI**

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**References**


