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Introduction

Brazil produces rice in commercial scale in two ecosystems: lowland and upland. Because of its inherent characteristics, the rice plant grows better and, consequently, presents a higher productive potential in systems where the soil remains humid. Thus, in addition to its recent history of high yield potential, lowland rice produces grains with improved commercial attributes and better suited to most consumers. Today, rice produced in uplands presents similar grain characteristics to that from the lowlands. Consequently, the price of both became similar. Therefore, new improved cultivars associated with modern technologies made possible expressive yield increases, with positive impacts upon the entire rice production chain and the Brazilian society as well. This reality has also been beneficial to food safety including the possibility of exporting rice surplus. Farming infrastructure in addition to soil and climate conditions in the states of Mato Grosso and Rondônia make possible to achieve expressive rice grain production in upland conditions. The Rice Technical Committee from those states CTA MT-RO has been involved with the enhancement of grain quality attributes and plant characteristics as well. The 3rd meeting of this Committee took place in 2009, from August 4 to 5, in Rondonópolis, under the coordination of the Rondonópolis and Southern Mato Grosso Food Industry Association (SIAR-SUL) with the support of many local institutions: Brazilian Supporting Service for Small Business (SEABRE, MT); Mato Grosso Research, Assistance and Rural Extension Association (EMPAER, MT); Mato Grosso Research Foundation (FAPEMAT), Paranatinga Mayor´s Office; Mato Grosso Rice Industry Association (SINDARROZ, MT); Department of Trade, Mining and Power (SICME); Caceres Food Industry Association (SIA); Mato Grosso Food Industry Inter-County Association (SIAMT). In addition, there was financial support from Rice Tec, farming support from Cabeça Branca Sementes de Arroz, Produtos Rei, Agroleste and Famato.

Two important documents resulted from this meeting: the proceedings and a technical bulletin aggregating updated technical information for upland rice production in both states in the 2009/10 and 2010/11 cropping seasons.

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Head, Embrapa Rice and Beans

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Technical Information on Highland Rice in the States of Mato Grosso and Rondônia for the 2009-10 and 2010-11 Crops Seasons

Economic Importance

Rice is among the worlds most important cereals as demonstrated during the 2006 rice market crisis. Approximately 90% of its production comes from Asia, followed by the Americas (4.5%), Africa (4.5%) with Europe and Oceania responding for the remaining 1%. Since its consumption follows closely the production, there is not much room left for international trade. Only 6% of the total world rice production is traded.

According to FAO (2009) a 70% increase in food production will be needed to feed the nine billion inhabitants expected in 2050. However, while struggling to end hunger and poverty the world needs to use its natural resources in a more rational way.

According to FAO, the effects of climatic changes such as floods and droughts may reduce the agricultural production for up to 30% in Africa and 21% in Asia. This forecast is somber to rice since the most affected regions will be the largest producers but the poorest as well. In this context Brazil rice production might be an alternative to supply the international marketplace.

Irrigated rice produced in southern Brazil has been sufficient to keep a good offer in the domestic market, both in quality and in quantity. However, the upland rice plays an important role in complementing the demand not totally covered by irrigated rice. So, besides its role in domestic supply the Brazilian upland rice may have an international market potential.

Little by little the stigma that the upland rice is cropped in disagreement with sustainable development recommended practices is being overcome. According to Ferreira (2008), since 2006 the state of Mato Grosso has been developing a whole set of studies under the leadership of the Rondonópolis and Southern Mato Grosso Food Industry Association (SIAR-SUL) in partnership with institutions such as the Mato Grosso Research, Assistance and Rural Extension Association (EMPAER, MT), the Mato Grosso Research Foundation (FAPEMAT), Embrapa and Sebrae, MT, the Department of Trade, Mining and Power (SICME), and the city of Paranatinga, besides other organizations involved in different phases of the rice production chain.

The objective of this document is to contribute with information to help farmers to overcome these challenges taking in consideration the current and further importance of the upland rice crop in the states of Mato Grosso and Rondônia.

Data from the Geography and Statistics Brazilian Institute, IBGE (2009b) show that Mato Grosso and Rondônia produced 974 and 281 thousand metric tons of rice, respectively, corresponding to 7.5% of the Brazilian total rice grain production. Figure 1 presents the distribution of the production on those states and yield ranges obtained in the 2007/08 cropping season. Figure 2 shows yield values in the various micro-regions. There is a wide variation around the average with the lowest yield in Porto Velho micro regions (1,090kg below average) and the highest in Colíder (840kg above average). Close analysis of both figures demonstrates the expansion potential of rice, the different cropping technologies used and yields.

On the other side, actors of the rice production chain in Mato Grosso and Rondônia know that financial gain is a key factor in competitiveness based on grain quality, the environment, and social achievements. Another important factor involved is the partnership between public and private institutions towards sustainability.

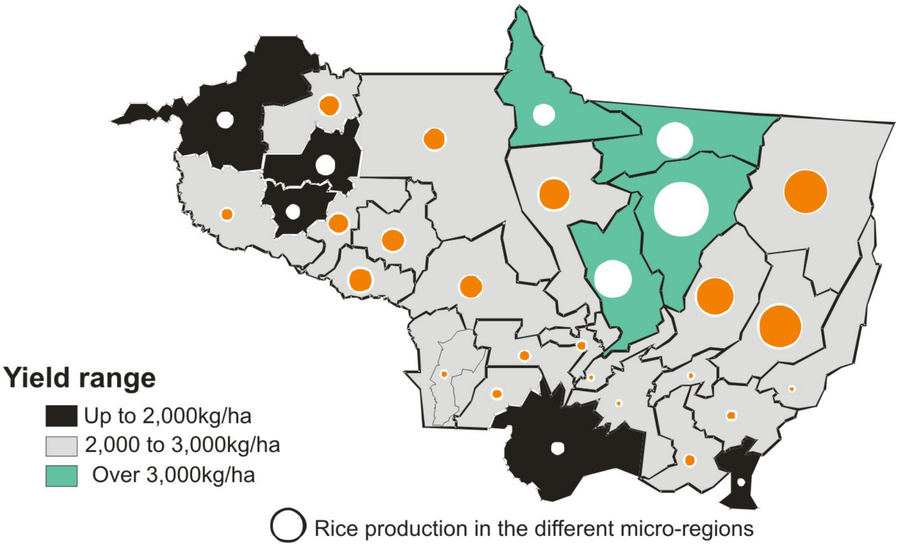

Fig. 1. Relative participation and yield ranges in the rice micro-regions in the states of Mato Grosso and Rondônia in the 2007/08 season.
Source: IBGE data (2009b).

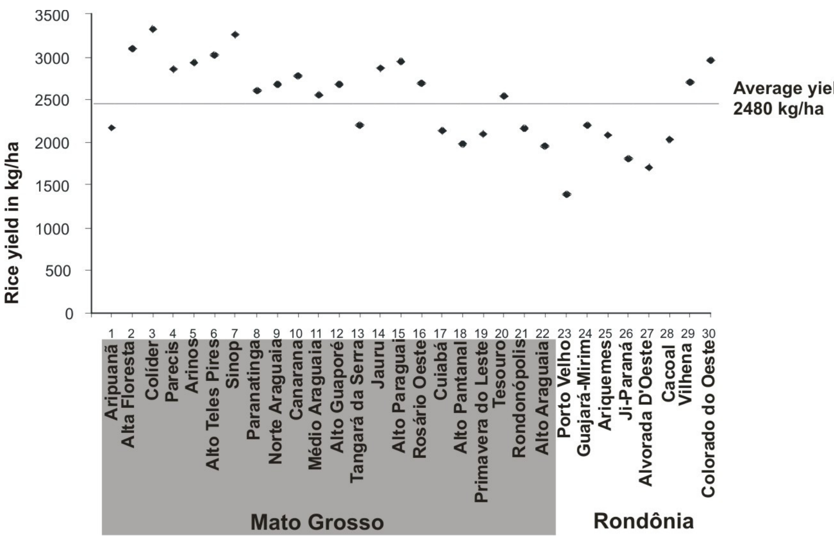

Fig. 2. Rice yield in the micro-regions of Mato Grosso and Rondônia in the 2007/08 cropping season.
Source: IBGE data (2009b).

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Climate

The states of Mato Grosso and Rondônia have a tropical climate with dry and wet seasons. Approximately 95% of the rain falls from October to April, with the dry season going from May to September. The annual rainfall can reach very high averages, sometimes up to 2,750mm. The state of Rondônia is practically free of sea and altitude influences. Its yearlong climate is hot wet tropical with very little annual changes, but important daily changes especially during the rainy season.

55% of Mato Grosso is slightly flat (30% plain, 10% hilly and 5% mountainous). Its altitude varies from 105 to 850 meters above sea level, while Rondônia presents a plain to mountainous topography with an altitude ranging from 60 to 1,000 meters.

Climatic Risk and Sowing Season

Mato Grosso

Climatic risk, that is characterized by the amount of soil water, is higher when the rainfall is irregular. This is often translated as drought spells, lasting up to

35 days in the Brazilian Cerrado region. The result can be a reduction in grain production. However, it is believed that the negative effect of water deficits can be minimized when one knows the rainfall pattern of each region and the crop water requirements at different phenological phases.

It is important to have in mind that Mato Grosso is a major upland rice producer. Data from several assessment studies indicate low climatic risk for rice in most of the state since the amount of rain, as well as rainfall distribution, are among the best in the country.

Rain shortage is very harmful to upland rice yields. To minimize its negative effects it is necessary to adjust sowing time in order to synchronize plant flowering and grain filling stages with the raining season. Further studies related to soil water balance will certainly bring a better characterization of higher or lower rain intensity periods, and their use to support the mapping climatic risk in the region.

Water balance simulation studies by Embrapa Arroz e Feijão (*Embrapa Rice and Beans*), associated to geo-processing techniques made possible to identify the best sowing season for upland rice in Mato Grosso with 80% of success probability (two years lost in ten), avoiding drought spells during the grain filling stage. The study variables were: daily rainfall potential evaporation and transpiration; crop coefficient; water storage soil capacity; and crop phenological phases. The higher the soil water retention capacity (associated to short plant cycles), the lower the losses. On the other hand, independently of soil and crop cycle the later the sowing time, the higher the risk of loss.

Except in regions where rainfall is quite regular; the climatic risk is higher when the sowing date exceeds December 20. So, it is possible to sow between November 1st and January 20th using short cycle cultivars in the following localities with a clay content over 300g/kg of soil: Alta Floresta; Alto da Boa Vista; Alto Paraguai; Apiacás; Araputanga; Aripuanã; Barra do Bugres; Bom Jesus do Araguaia; Campo Novo do Parecis; Campo Verde; Campos de Júlio; Canabrava do Norte; Carlinda; Castanheira; Chapada dos Guimarães; Cláudia; Colider; Comodoro; Cotriguaçu; Cuiabá; Denise; Diamantino; Feliz Natal; Figueirópolis d'Oeste; Guarantã do Norte; Indiavaí; Itaúba; Jauru; Juara; Jurema; Lucas do Rio Verde; Marcelândia; Matupá; Nobres; Nortelândia; Nova Bandeirantes; Nova Brasilândia; Nova Canãa do Norte; Nova Guarita, Nova

Lacerda, Nova Marilândia, Nova Maringá, Nova Monte Verde, Nova Mutum, Nova Olímpia; Nova Santa Helena; Nova Ubiratã; Novo Horizonte do Norte; Novo Mundo; Paranaíta; Paranatinga; Peixoto de Azevedo; Planalto da Serra; Pontes e Lacerda; Porto dos Gaúchos; Querência; Reserva do Cabaçal; Rosário Oeste; Santa Carmen; Santa Cruz do Xingu; Santa Rita do Trivelato; Santo Afonso; São Félix do Araguaia; São José do Rio Claro; São José do Xingu; Sapezal; Sinop; Sorriso; Tabaporã; Tangará da Serra; Tapura; Terra Nova do Norte; União do Sul; Vera; and Vila Rica.

Rondônia

Similarly to Mato Grosso, climatic risk for upland rice in Rondônia is very low. Therefore the amount of rainfall and, most important, the water distribution presents no negative effect for upland rice cropping.

As in Mato Grosso, in Rondônia it was possible to identify the best sowing dates for upland rice within the same range of possible losses up to 80%, avoiding drought spells during grain filling stage. Also, sowing time delays increase the risk of losses. depending on soil characteristics and crop cycle.

Sowing in Rondônia can be performed from October 1st of January 31 using early cycle cultivars. The best soils are those with clay content over 300g/kg of soil, and the localities are: Alta Floresta d'Oeste; Alto Alegre dos Parecis; Alto Paraíso; Alvorada d'Oeste; Ariquemes; Buritis; Cabixi; Cacaulândia; Cacoal; Campo Novo de Rondônia; Candeias do Jamari; Castanheiras; Cerejeiras; Chupinguaia; Colorado do Oeste; Ministro Andreazza; Mirante da Serra; Monte Negro; Nova Brasilândia do Oeste; Nova Mamoré; Nova União; Novo Horizonte do Oeste; Ouro Preto do Oeste; Parecis; Pimenta Bueno; Pimenteiras do Oeste; Porto Velho; Presidente Médici; Primavera de Rondônia; Rio Crespo; Rolim de Moura; Santa Luiza do Oeste; São Felipe d'Oeste; São Francisco do Guaporé; São Miguel do Guaporé; Seringueiras; Teixerópolis; Theobroma; Urupá; Vale do Anari; Vale do Paraíso; and Vilhena.

Soils

The objective of this chapter is to discuss the diversity of soils in a specific region. However it is also important for farmers and professionals in the field of technical assistance and consultancy to identify soil types in the productive farms and to be able to know the influence of the environment concerning soil for agricultural production and its limitations.

Mato Grosso

Studies by Embrapa, Radambrasil and, more recently, by the Mato Grosso State Department of Planning and General Coordination (Seplan-MT), show a wide diversification of soils. Maps with scales ranging from 1: 1 million (Radambrasil); 1:1.5 million (Economic Ecological Zoning – ZEE/MT), and up to 1: five million (Brazil's soil map – IBGE/Embrapa Solos) are suggested for regional planning.

This chapter also presents succinct descriptions of soil classes predominant in Mato Grosso suitable for rice cultivation based on ZEE/MT. Descriptive material is available at www.seplan.mt.gov.br and supplemented by the Brazilian Soil Classification System (*Sistema Brasileiro de Classificação de Solos – SiBCS*).

Soil classes: characteristics, limitations, potential and occurrences

Spatial distribution of the main soil classes in Mato Grosso shows a wide variety of pedological coverage even on a regional scale as the one presented here.

Soils most appropriate to upland rice in Mato Grosso are: Latosols, Argisols, Nitosols and clayey or very clayey Chernosols, with good water retention capacity.

Other soils present in Mato Grosso are: Plinthosols, Gleysols, Fluvic and Quartzarenic Neosols, Planosols and Vertisols, present in low sedimentary areas of wetland or terraces where irrigated rice yields better.

Cambisols and Luvisols are less indicated due to their occurrence in rough surfaces and the presence of stones and gravel.

Bellow are the main soil classes with their best agriculture aptitude in the state of Mato Grosso.

Red-Yellow Latosols (LVA)

These are the most common soils in Mato Grosso occupying an area of approximately 262 thousand square kilometers. They are present mainly in the Central Northern region of the state – in the Parecis Plateau from Brasnorte to the west to São Félix do Araguaia and Cocalinho to the east and from Peixoto de Azevedo to the north to Nova Mutum and Diamantino to the south. They are also found in the Guimarães Plateau and in the regions of Campo Verde, Primavera do Leste, Novo São Joaquim and General Carneiro, extending toward the east up to Barra do Garça and Araguaiana. The soils appear as patches on the extreme Norwest of the state, in the Chapada dos Dardanelos between Juína and Aripuanã; in the Norwest of Aripuanã and in Apiacás, between the rivers Juruena and Teles Pires besides scattered patches throughout the Pantanal region as well as in Cáceres and Poconé.

These soils have 11% or less ferrous oxide, but normally over 7% when clayey or very clayey and non concretionaries. Their nomenclature is from the classification performed before 1999.

Latosols are deep (>100 to 200 cm) to very deep (>200 cm), well drained with texture varying from clayey to very clayey. Soils with clayey to very clayey texture and with a more oxidic constitution have an apparent low bulk density from 0.86g to 1.21g/cm3 and their total porosity ranges from high to very high. They are acid to very acid with low base saturation (dystrophic) and aluminum content surpassing 50%.

Their physical conditions are good and along with a plain or slightly undulated surface they very much favor their use for agriculture with crops adapted to the climate and the region.

Their major limiting factors are high acidity and low fertility. They require a good management with pH correction, additional fertilization and erosion control. Erosion can be controlled by terracing, especially on those soils of medium texture, the poorest and prone to erosion. The medium-texture soils are also those where deficiency in micronutrients can occur.

Red-Yellow Claysols (PVA)

These soils are found throughout an area of 208 thousand square kilometers mainly in the north of the state from Aripuanã and Juína, where they are very common to Santa Teresinha to the east. They are also present in Agua Boa, Campinapolis and Paranatinga, going towards southwest; in the Baixada

Cuiabana up to Cáceres and to the south, in the Pantanal region and close to the Paraguay River banks, the edges of the Parecis Plateau and on the far southwest, between Vila Bela da Santissima Trindade and Caceres.

They present a textural gradient with clear separation between horizons concerning color, structure and texture. Their ferrous oxide content is usually below 11%.

Argisols are deep to shallow (>50 to 100 cm); moderately to well drained with variable texture, mostly medium texture on the surface and clayey texture on the undersurface, also with or without gravel on the surface. Their total porosity goes from low to medium and the bulk density from 1.32g to 1.63g/cm^3.

Concerning base saturation, there is a wide variation with eutrophic soils (V>50%), dystrophic soils (V<50%) and also alic soils whose exchangeable aluminum saturation surpasses 50%.

The great diversity of characteristics interfering in the agricultural use associated to the presence of these soils in different places and surfaces makes it difficult to generalize their ability and limitations for agricultural use. As a whole the Argisols are very susceptible to erosion, in special when the texture gradient has gravel and where the surface is rough with slopes. In this case these soils are not recommended for agriculture and are better used for pasture and forestation or even for preservation of the native flora and fauna.

On plain or slightly undulated surfaces, Argisols can be used for different crops, providing the necessary acidity correction and fertilization are performed, especially when the soils are dystrophic or alic.

Dystrophic Red Latosols (LVd)

Latosols are found in an area of approximately 53 thousand square kilometers, mostly on the Chapada dos Parecis. They also occur in the south of the state, over the Itiquira and Guimaraes plateaus and as scattered patches throughout the Araguaia plains.

They are mineral soils with 8% to 18% of ferrous oxide in the clayey or very clayey soils to less than 8% in the medium texture ones. These soils were classified as Dark Red Latosols, previously.

They are very deep, well drained, and friable to very friable soils of clayey, very clayey or medium texture. The clayey or very clayey more oxidic soils have a bulk density from 0.84g to 1.03g/cm3 and high to very high porosity.

Their physical conditions are very good and when on a flat to slightly undulated surface they are suitable to various different crops, since climatically adapted to the region.

Because of their acidity and dystrophic nature these soils require acidity correction and fertilization.

The clayey and very clayey soils are better suited for cropping than the medium texture ones. The latter are very poor soils and easily degradable by compaction and erosion when farming equipment is inadequately used, such as frequent plowing with very heavy equipment like disc plowing or harrowing up slope.

Yellow Latosols (LA)

They are found in the southwest of the state (Guapore depression) occupying an area of 7,100 square kilometers, approximately. Their content in ferrous oxide seldom goes above 7%.

They are well drained deep and very deep soils with predominance of medium texture, low textural ratio and little differentiation between horizons. Their saturation is low and their content in bases and aluminum saturation give them an alic nature.

One of their most important features is their cohesion – when dried they are classified as hard or very hard.

Their major drawbacks are the strong acidity, high extractable aluminum saturation and low natural chemical fertility. Consequently they are very poor in soil nutrients, requiring high initial investments and intensive use of fertilizers. Liming aims at neutralizing the toxic effect of the aluminum and to supply calcium and magnesium to the plants.

They differentiate from other Latosols for their low permeability due to their natural cohesion favoring erosion.

Argilluvic Chernosols (MT)

Their presence is scattered, going from northwest to southeast in 1,700 square kilometers along the edges of the Parecis Plateau in the southwest of the state.

They present high activity clay and saturation by high bases over 50%. Before 1999 they were called Reddish Brunizens.

They are moderately deep to shallow (<50cm) with clear differentiation between horizons, with medium texture on the superficial horizons and clayey on the subsurface. They exhibit moderate permeability on the superficial horizon and low permeability on the B horizon, and are very susceptible to erosion.

Their chemical characteristics make them excellent for agriculture because of their high nutritional potential, high base saturation and cation exchange capacity (CEC) besides having very low acidity.

Their occurrence in places with rough surface confers them high risk of erosion being better suited for pastures.

Dystroferric Red Latosols (LVdf)

They are present in the Parecis Plateau extending for approximately 1,700 square kilometers in the municipalities of Tangará da Serra, Santo Afonso, Arenápolis and Nortelândia.

They are well drained soils derived from basic rocks with high content of ferrous oxide, manganese oxide and titanium oxide with strong magnetic force. Before 1999 they were called Dusky Red Latosols.

They are very deep, friable or very friable when humid, and clayey of very clayey. Their bulk density is low (0.92 to 1.15 g/cm^3) and their porosity is high to very high (60 to 69%), indicating good physical characteristics.

Their main limitation is a low natural fertility since they are dystrophic soils with low base saturation. Differently from most Latosols, they have a good content of micronutrients.

When in natural condition or when well managed these soils are quite resistant to laminar erosion. Submitted to intensive farming by plowing or successive harrowing they suffer superficial compaction – plow or harrow foot – favoring superficial encrusting that considerably increases the risk of erosion, and consequently, decreasing their yield. Under inappropriate management conditions these soils may suffer deeply from erosion, resulting in ravines and depressions formation.

Red nitrosols (NV)

The most expressive areas are located on the north and southwest regions of Mato Grosso with approximately 1,200 square kilometers.

They are low activity clayey soils, derived from basic rocks with relatively high content of ferrous oxide (over 15%). Before 1999 they were called "Terra Roxa Estruturada" (Ultisol).

They are deep to medium deep well drained soils with clayey to very clayey texture along their profile and reduced textural gradient. Being predominantly dystrophic, their base saturation is low. Some of them are eutrophic and alic soils.

Their physical condition is in general good.

Their main limitations are a low base saturation and when under undulated surfaces are prone to erosion.

Rondônia

In Rondônia Latosols are found in approximately 58% of the total state area, with suborders Yellow, Red-Yellow and Red. The information in here is from the Rondônia Geo-Environmental Atlas produced by ZEE/RO and available at www.sedam.ro.gov.br

Red-Yellow Latosols cover approximately 26% while Yellow and Red Latosols represent 16% of the state area. Usually individually found on predominantly flat and slightly undulated lands.

Its natural fertility is low to very low and being their main restriction for agriculture, requiring liming and fertilization, except for the Red Latosol whose average fertility is high.

The soils of the Argisol class occur on slightly wavy and wavy surfaces with predominantly low fertility even though in many places their natural fertility is medium to high.

Soils of the Alisol and Luvisol classes differ from Argisol for their high clay activity, indicating mineral differentiation between classes. Alisol and Luvisol classes differ in natural fertility; Alisol has a very low natural fertility while Luvisols have medium to high.

The Neosol class, including the classes previously known as Litholic, Quartzpsamment Soils, Regosols and Aluvial Soils, is found in approximately 11% of the state area. This soil class is subdivided in the following suborders: Fluvic Neosol, Regolithic Neosol, Quartzarenic Neosol and Litholic Neosol. Only the soils of the suborder Fluvic Neosol and part of the Quartzarenic Neosol are absent on firm lands, showing drainage problems and probability of flooding. Soils of these suborders are frequently found on flat surfaces like wetlands. Fulvic Neosols include those soils formed by organic material deposition carried by water on river banks, where their natural fertility depends on the nutrient content of the deposited material.

The soil of suborders Regolithic Neosol and Quartzarenic Neosol has similar features such as sandy texture, little development (less susceptible to weather and biological degrading processes) and with excessive drainage. They are different because the Regolithic Neosol contains primary minerals that are easily degraded. These suborders present soils deeper than those in the same class. They are usually found on flat to slightly undulated locations with very low natural fertility even though the medium to high fertile Regolithic Neosol may be present in small areas.

The soils of the Litholic Neosol order are equally little developed, presenting shallow soils on rough surfaces. In Rondônia these soils occur on undulated to rough surfaces, close to rocks. Their natural fertility varies according to the rock of origin, with medium to high natural fertility prevailing.

Usually they present a granulometry with significant amount of rock fragments (stones or pebbles) on their surface or undersurface.

Cambisols are another important soil class in Rondônia, covering approximately 10% of its area. The soils of this class are found on well-founded lands. Their natural fertility is very low; they are stony, shallow and found in undulated surfaces.

Gleysols occupy little more than 9% of the Rondônia area. When clayey they are known as *tabatinga* and used as raw material for ceramics. Their natural fertility is low; are poorly drained and present on flat surfaces. Gleysols are predominantly found in the Guaporé Valley and in areas neighboring major rivers.

The less important soil classes found in Rondônia are Planosol, Plinthosol and Organosol. They are usually found on flat to slightly undulated surfaces with the exception of Planosols; they are hydromorphic, i.e. they are flooded during the rainy season and have low natural fertility. Organosol corresponds to organic soils and Plinthosol to hydromorphic laterites. The Planosol kept its name from the old Brazilian classification system.

Tillage and Sowing

Types of Tillage

Rice has been cropped in the states of Mato Grosso and Rondônia under the conventional tillage system (SPC in Portuguese). Conventional tillage aims weed control and satisfactory sowing conditions for good seed germination, seedling emergence and crop development. Usually conventional tillage consists of one to three plowings with disc plow followed by one to two superficial harrowing for leveling. Regardless of the number of plowings the soil must remain non-pulverized.

In the no-tillage system (SPD in Portuguese), on the other hand, soil revolving practices and harrowing are not used. This system requires weeds dissection by herbicides and use of special sowing equipment to cut the crop residues and to open furrows for sowing. Both in Mato Grosso and Rondônia the practice of no-tillage in the upland rice crop has been successful in some cases as after grazing, but still needs adjustments for crop rotation with other crops such as soybean and corn, as well as winter crops such as millet and others.

It is important to study the region history to better assess the tillage systems to be used.

Sowing

Sowing time and density – In Mato Grosso and Rondônia rice sowing is performed at the beginning of the rainy season, which lasts from November to January (see chapter on Climate), with delays presenting yield losses. The seed density must make possible a good seed distribution in the row. A good low sowing density will depend on the accuracy and good adjustment of the sowing machines. If this is not the case seed density must be increased. The recommended density varies from 60 to 80 seeds per meter.

In the specific case of hybrids the sowing density must be 40kg/ha or 30 to 35 seeds per meter with 25cm between rows.

Spacing and depth – Row spacing influences many agronomic aspects. Narrow spacing gives higher yield but increases susceptibility to pests, lodging, and to stress by drought spells. Upland rice can be uniformly sowed from 17 to 40cm apart and 3 to 5cm depth, with fertilizer placed at 5cm bellow seed bed.

Fertilizer + sowing

In order to obtain a good sowing performance, the planter must be able to: adjust the sowing mechanisms in different spacing and density; be able to adjust seed and fertilizer flow, and to be easy to adjust the feeders; damage the seeds the minimum possible; place seeds and fertilizer uniformly into the furrow in even depth with little removal of soil; have good soil penetration even in no-tillage system; sow and fertilize adequately in the presence of crop residues and possess good autonomy and working capability.

Sowing devices: seed feeders may be equipped with devices of the following types: channeled rotor, horizontal perforated disc, inclined perforated disc or pneumatic disc. The channeled rotor with re-entry on its periphery rotates within a cylinder taking the seeds to the conveying tube and from there to the soil. The seed flow is adjusted by laterally displacing the rotor or by adjusting the gear to change the rotating speed. This kind of feeder is better indicated for small seeds distributed in high density as in rice. The perforated disks work within the seed deposit on a horizontal or inclined position. The disk on the horizontal position is mostly used in planters and its advantage is to be of simple construction and operation. However, this mechanism is poor in terms of sowing consistency when the speed surpasses 6km/hour. The inclined disk is different from the horizontal one for the lack of scrapers and seed expeller from the disk holes.

For low density sowing, the simple exchange of the gear in charge of the seed distribution may guarantee a good performance in this kind of machine. The use of graphite in the seed box may also help a good seed distribution.

Some machine dealers offer specific kits for that: ex: channeled rotor.

Fertilizer feeder – Rice planters can be equipped with rosette type mechanisms, rotor and worm screw. The indented disk shaped rosette operates at the bottom of the fertilizer bin and is activated by a set of crown and pinion. The rotor typed mechanism is formed by an axe and vane in its external surface that when turning around a horizontal axe at the bottom of the deposit takes the fertilizer to an adjustable-opening lock. The worm screw thread rotates and pushes a certain amount of fertilizer out of the deposit and into the furrow. Contrary to what happens with the rosette and the rotor, the fertilizer feeder is not significantly influenced by speed variations of the fertilizer mechanism. To regulate the flow of fertilizer the opening of the lock gate should be altered – rosette and rotor feeder or to modify the rotation speed by changing the gear of the worm screw thread feeder.

Crop residues cutting disk – In no-tillage the machine must have a 16 to 20″ diameter simple disk placed in front of the fertilizer-furrower to cut the crop residues. According to the soil movement, single disks are classified as corrugated or plain. They open furrows of approximately 9, 5 and 3cm respectively. The corrugated disk tends to blister on clayey soils, mainly when wet while the smooth presents fewer problems in clayey soils. The best for wet clayey soils is the plain disc. When the amount of crop residues on the soil is small the presence of a double unparallel disk may replace the plain cutting disk on the fertilizer-sowing device; performing efficient no-tillage sowing.

Furrower and compactor – In general the fertilizer-sowing device has a furrowing device equipped with double disks for sowing and an extirpator chisel for fertilizing or two sets of double disks; one for sowing and another for fertilizing. Even though less efficient, this setting is commonly used for rice farming.

The furrower-compactor is a device placed on the back of the sowing device. Its task is to improve the contact of the seed to the soil. The best compactors for rice are the convex type ones. The adjustment is performed by modifying the pressure of the springs and so changing the compacting weight of the soil on the seeds and/or by changing the angle of the wheels.

Sowing Adaptation

-Depth limiting disk

It is a disk to be coupled to the double disk sowing-fertilizer distributor to limit the sowing dept.

-Compacting wheels

Compacting wheels enhance the contact of the seeds to the soil improving seed germination.

Fundamentals of Plant Mineral Nutrition

The processes of mineral nutrition are those related to the supply and absorption of chemical elements from the environment and their role in the plant metabolism and growth.

Nutrient function

Each nutrient plays a unique role within the plant. Even though each of them has a specific task, they must act together for better results. Then, the effectiveness of each nutrient – especially when related to plant growth – depends on the amount of other essential elements stored (Liebig's Law of the Minimum). Plants need the following minerals for their full development: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S), Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn). The first six (N, P, K, Mg and S) are called macronutrients because of their higher demand from the plant. The other six (B, Cu, Fe, Mn, Mo and Zn) are the micronutrients. It remains clear, however, that by the criterion of essentiality, all nutrients – macro and micro – are equally important. As an example; the deficiency or lack of molybdenum is as detrimental to plant development as that of nitrogen.

Nutrient absorption

Absorption is the uptake of nutrients by the plant. It usually happens through ions in any part of the cell or vegetal tissue.

Transport and redistribution

After absorption nutrients are carried to the interior of the plant by a process known as translocation. The transport can be carried out in the same form as it was absorbed or not. It goes from one plant organ (or region) to another, usually from the root to the leaves. This movement along the respiratory current via xylem occurs in a way that all nutrients are considered mobile in terms of translocation.

The redistribution is the transfer of an element from one organ (or region) to another under the same or in a different form it was absorbed and after being metabolized. The redistribution occurs through the phloem. The nutrient is taken from the synthesis sites (leaves) to the storage/growth sites (fruits). It is during redistribution that mobility differences between nutrients take place (Table 1).

Table 1. Compared mobility of nutrients applied on the leaves. Elements in each group are listed in descending order.

Higly mobile	*Mobile*	*Partially immobile*	*Immobile*
Nitrogen	Phosphorus	Zinc	Boron
Potassium	Magnesium	Copper	Calcium
		Manganese	
		Iron	
		Molybdenum	
		Sulfur	.

This higher or lower mobility in the phloem has practical importance.

a) If there is supply shortage (transfer soil > soil solution or soil solution > root) then deficiency symptoms will appear:
- mobile elements – older leaves;
- low mobility elements – usually older leaves;
- immobile elements – leaves and younger organs.

The nutritional deficiencies based on these concepts can be diagnosed visually.

Symptoms of mobile nutrient deficiency in rice

The older the leaf, the more intense the symptoms (Fig. 3 to 6).

Fig. 3. Phosphorus deficiency.
Source: Barbosa Filho (1987)

Fig. 4. Nitrogen deficiency.
Source: Barbosa Filho (1987)

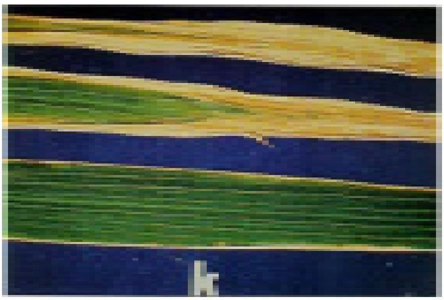

Fig. 5. Potassium deficiency.
Source: Barbosa Filho (1987)

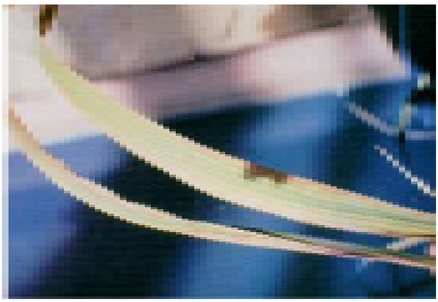

Fig. 6. Magnesium deficiency.
Source: Barbosa Filho (1987)

Symptoms of immobile and partially immobile nutrient deficiency in rice

The younger the leaves the more accentuated the symptoms. (Fig. 7 to 14).

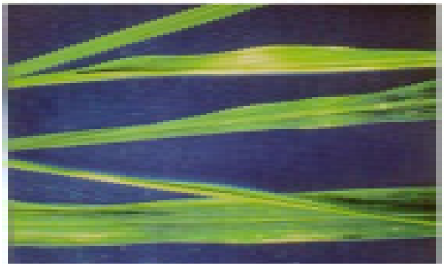

Fig. 7. Boron deficiency.
Source: Barbosa Filho (1987)

Fig. 8. Calcium deficiency.
Source: Barbosa Filho (1987)

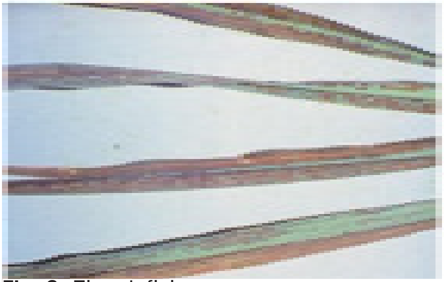

Fig. 9. Zinc deficiency.
Source: Barbosa Filho (1987)

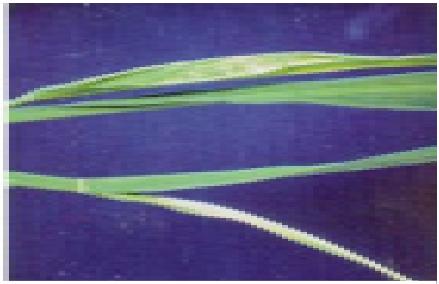

Fig. 10. Copper deficiency.
Source: Barbosa Filho (1987)

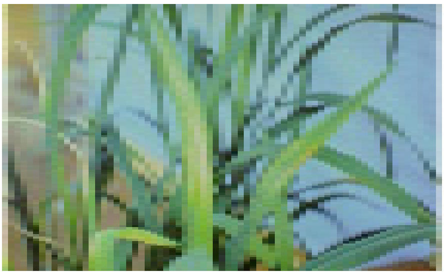

Fig. 11. Manganese deficiency.
Source: Barbosa Filho (1987)

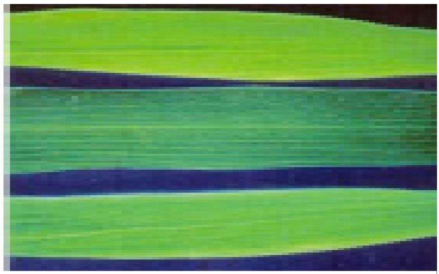

Fig. 12. Molybdenum deficiency.
Source: Barbosa Filho (1987)

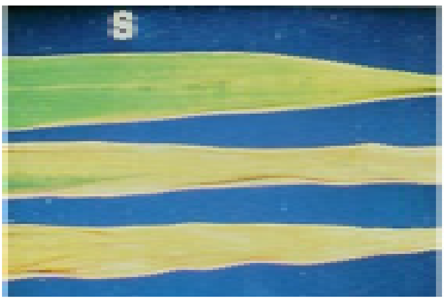

Fig. 13. Sulfur deficiency.
Source: Barbosa Filho (1987)

Fig. 14. Iron toxicity.
Source: Barbosa Filho (1987)

Plant chemical analysis

Assessment of the nutritional status

To assess the nutritional status of a plant it is necessary to compare sample to a pattern.

The sample is one plant or a group of plants (an entire crop or a part of it).

Pattern is a plant or a group of plants considered to be “normal” from the nutritional viewpoint.

A plant is considered to be normal when all the elements in its tissues are in adequate amount and proportion; the plant is capable of yielding good production and its appearance is similar to a highly productive crop.

Foliar diagnose

Foliar diagnosis is a method used to evaluate the nutritional condition of plants. It is accomplished by examining certain leaves in determined periods of the plant cycle. The reason for the leaves to be examined is because they are the organs that best reflect the nutritional status of a plant, i.e. they respond better to the nutrients supplied either by the soil or by fertilizers.

Sampling

As indicated, leaves are the external organs better reflecting the plant nutritional status. However, there is a adequate growing period for sampling. Also, certain leaves are better indicated for sampling than others, and there is a certain amount of leaves to be sampled. Table 2 gives the available information for the rice crop and Table 3 the reference values for interpretation of a foliar tissue analysis.

Table 2. Site of the plant, time and amount of tissue necessary for the chemical analysis of rice.

Crop	*Sampled site*	*Time*	*Amount/homogeneous plot*
Rice	Aereal part	30 days after germination	20 plants
	Newly mature leaves	Maturity	50 leaves

Source: Ribeiro et al. (1999).

Table 3. Reference values to interpret results from foliar tissue analysis.

Crop/ Methodology Rice	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Mo	Zn
	g/kg						mg/kg					
30 days after germination	30	1.2	20.0	6.0	3.0	-	30	15	-	-	-	20
Maturity	22.6-26.2	1.4-1.6	11.8	6.6-85	4.0-4.1	4.9-7.0	78	23	260	90	0.30	33

Source: Ribeiro et al. (1999)

References

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RIBEIRO, A. C.; GUIMARÃES, P. T.; ALVAREZ, V. H. **Recomendações para o uso de corretivos e fertilizantes em Minas Gerais** – 5ª aproximação. Viçosa, MG: Comissão de Fertilidade do Solo do Estado de Minas Gerais, 1999. 359 p.

Acidity Correction and Soil Fertilization

Rice cropping systems in Mato Grosso and Rondônia have always been associated with new settlements in low fertility acid soils. Even though rice is considered to be acidity tolerant since it can be cropped on soils whose average pH varies from 5 to 5.5 and liming is used to supply nutrients, we should consider upland rice within a crop rotation system. Usually, in the Brazilian Cerrado rice is cropped to clean the land for pasture or soybean, beans, corn and other crops. However, in this situation farmers use insufficient inputs to increase soil fertility and crop yield.

On the other hand the intense use of soils for pastures or grain production reduces the level of the soil nutrients taken by the plants. So, these nutrients must be replaced by liming and balanced fertilizations. The principal nutrients to be replaced are nitrogen (N), phosphorus (P), potassium (K) and micronutrients. Of the latter the most important is zinc (Zn). Its deficiency is very common in the Brazilian Cerrado soils.

Adequate fertilization includes a good knowledge of the crop nutritional needs, the chemical and physical characteristics of soils and the kind of fertilizers to be used as well as the factors affecting the availability of nutrients in the soil.

Liming and Fertilization

When is liming recommended?

Several factors are to be taken in consideration when recommending liming. Some of them are soil related, such as the exchangeable or potential acidity, soil texture and organic matter content. Other factors are inherent to liming itself, such as lime granulometry and lime neutralizing power besides plant factors as its degree of tolerance to acidity. Then, soil analysis is vital to determine the amount of lime to be applied on the soil.

Besides acidity, another condition recommending liming is soil low content of calcium (Ca) and magnesium (Mg) or when the replacement of these nutrients becomes necessary due to plants uptake. It is important to point out that lime still is the lowest cost source of Ca and Mg. Usually liming has two goals: correcting acidity and supply Ca and Mg to plants.

When to apply lime?

The time for liming depends on its solubility. Lime dissolves slowly in the soil and requires incorporation to increase its contact to the soil particles. Lime should be applied two to three months before sowing, for the soil to be ready at the moment of the first sowing. However, a successful liming depends on the soil water content. If after lime incorporation there is not enough water to start its reaction with the soil, its efficiency will be minimal even if applied well before sowing.

On the other hand there are cases when the soil is intensely used for more than one crop per year, using irrigation during the dry season, resulting almost impossible to lime in advance. Then the best time for liming is when the farming machinery is not being used elsewhere. The effect may not be the best in the first harvest but it is better than nothing.

How much to apply?

Three methods to calculate the amount are used in Brazil: (1) exchangeable Al neutralization and content of Ca and Mg increase; (2) base-saturation increase and (3) SMP buffer solution. This third method is used in the states of Rio Grande do Sul and Santa Catarina only, since in these two states are the only ones the method was calibrated.

The methods used for the Brazilian Cerrado soils analyses are the interchangeable Al neutralization and the base-saturation increase. The exchangeable aluminum neutralization method is used according to soil CEC, and clay Ca and Mg contents. The detailing of this method aims higher results accuracy.

Recommendation of liming by interchangeable aluminum neutralization

1. For soils whose cation exchange capacity (CEC or T value) is higher than 4.0 cmolc/dm^3; their clay content over 15% and Ca + Mg over 2.0 cmolc/dm^3 the formula to use is:

   NC (t/ha) = (2 x Al) x f

2. When soils are Quartzpsamment Soils or Neosols (whose clay content is less than 15%) the amount of lime to use (N.C.) is given by the highest value found in one of the two formulas below:

   NC (t/ha) = (2 x Al) x f
   NC (t/ha) = 2 - (Ca + Mg) x f

3. Soils which cation exchangeable capacity (CEC or T) is higher than 4.0 cmolc/dm^3 use the following formula:

   NC (t/ha) = {(2xAl) + [2-(Ca + Mg)]} x f

   Note:
   - The values of Al, Ca and Mg are given in cmolc/dm^3 or mmolc/dm^3
   - f is the lime corrective factor (f = 100/(lime PRNT)

The calculation above is to correct 20cm soil layers, raising the pH to 5.7 when all the interchangeable aluminum will be neutralized.

The obtained values should be divided by two in the no-tillage cropping system. In this case the corrected soil layer will be 10 cm.

Recommendation of liming using the base-saturation method (V %)

This method takes in account the relationship between pH and the saturation by bases. For that the amount of interchangeable bases (total sum of bases) and potential acidity should be considered. The method is more accurate than the previous one. It is recommended for soils with CEC (effective), base saturation and low content of organic matter ($\leq$ 2.3 cmol/dm^3, $\leq$ 40% and $\leq$20 g/kg). The amount of lime must be sufficient to neutralize the toxic aluminum of non-tolerant crops by raising their base saturation (V %) to a predetermined level from 35% to 60% and, from 40%. Pay attention to micronutrient needs.

If the crops require saturation percentage values (V %) so different, what will be the V% for an agricultural system involving rice, beans, corn or soybean? Strictly speaking it would be practically impossible to satisfy all those species while they are part of a given agricultural system. In those cases the best to do would be to use an average value of 60 – within satisfactory limits – the requirements of these crops.

To calculate the amount of lime by the base-saturation method the following formula is to be applied:

$$NC = \frac{(V2 - V1) \times T \times f}{100}$$

Where:

NC = lime needed given in metric tons per hectare (t/ha)
V2 = base-saturation for the cropping system – 60%
V1 = present soil base-saturation
T = soil CTC (cmolc/dm^3)
F= 100 (lime PRNT)

As it was said above, the aluminum neutralization method uses these calculations for liming to correct a 20cm soil layer. If the calculations are for a no-tillage system, these values can be divided by two to correct the 10cm layer used in that system.

The soil acidity can be divided in active and potential. Potential acidity, on its turn, can be further divided in exchangeable and non exchangeable.

The active acidity is given by the ions H+ and Al3 that are retained on the surface of the mineral or organic colloids by electrostatic. The amount of exchangeable hydrogen under natural conditions seems to be small.

The nom exchangeable acidity is given by the covalent linking hydrogen (more difficult to break down) associated to the colloids with variable negative charge and to the aluminum compounds.

The potential acidity is the total sum of the soil exchangeable acidity plus the non exchangeable.

Within the mentioned concepts a major farmer concern must be correcting the potential acidity which is the most deleterious to plant growth. However, an acid soil (active acidity expressed in pH values) may not contain aluminum. In this case the pH value and the base saturation must be considered to carry on liming.

It is important to remember that some soils may be subjected to very high environmental variations, with relatively low pH; Ca, Mg and K deficiencies plus high aluminum saturation, but not enough aluminum to produce acidity even to the less tolerant crops. Since in those conditions there is not toxic aluminum to be neutralized, the need for liming is that to keep an appropriate Ca Mg ratio with aluminum. The objective in that case is not to correct acidity but to increase mineral content.

How to apply?

Lime must be applied in a way it can react rapidly with the soil, producing the wanted effects in the most efficient possible way. Liming efficiency is associated to its solubility, usually low. However, a measure adopted to increase liming efficiency in conventional soil preparation through plowing has been to increase the contact of the lime particles with the soil. For that the recommendation is to make a uniform distribution of the product on the soil surface and to incorporate those particles deep into the soil; a procedure not always easy with conventional agricultural machines.

Under dry soil conditions, where the probability of drought spells is high, an incorporation as deep as possible is particularly important, since it allows a larger growth of the plant roots, giving the plants a higher water stress resistance capability during the dry season. The dept lime should be incorporated into the plowable layer is around 20 cm.

What kind of lime to apply

There is a variety of limes available. They are usually assembled in three groups:

1. Calcitic limes – Up to 5% of MgO;
2. Magnesian limes – Between 5.1 and 12% of MgO; and
3. Dolomitic limes – Over 12% of MgO.

When choosing a lime one must consider its characteristics through the chemical and physical analyses supplied by the supplier. The major points to consider in assessing those characteristics are the sum of CaO and MgO contents (38% minimum) and its Total Neutralization Relative Power (PRNT in Portuguese) value. This index is the sum of the Neutralizing Value (VN) plus the granulometry (fineness level) of the lime. So it is not enough to have a high content of CaO or MgO for a good acidity correction, it is also necessary the lime to dissolve well in the soil. So, the higher the PRNT the better the lime.

Another point as important as the lime quality is the on farm cost. For high levels of MgO content dolomite lime has been recommended by many agronomists to balance the deficiency in MgO. Depending on the distance from lime mining sites to the farm, its transportation cost might be so high as to discourage its use unless the soil is so poor in MgO that the choice is justified.

The Brazilian legislation sets at 67% the VN minimum value to commercialize lime. The higher the VN the faster and more complete will be its reaction with the soil.

Effects on the soil

The effect of liming is not permanent. The acidification keeps going on even after liming. Several factors are behind this continuous acidification including the crop itself. The plants release weak acids into the rhizosphere, exporting considerable amount of bases from the soil (Ca and Mg), besides leaving organic waste on the soil surface. Another important point in soil acidification is the frequent fertilizations with nitrogen fertilizer compounds, in special the ammoniacals, that generate residual acidity; lowering soil pH.

To keep soil pH within desired range, new liming should be performed after three to five years.

Finally, farmers and agronomists should also be aware of excessive liming. If, for one side, liming corrects soil acidity, supplying Ca and Mg to the plants, on the other side when lime is applied in excessive amounts it can bring in micronutrients deficiency such as zinc, iron and manganese deficiencies. Another problem is the reduction in growth and grain yield due to deficiency in micronutrients uptake, minimizing the response of plants to NPK fertilizers, with considerable economic losses.

Nitrogen fertilization

How much, when and how to apply

Rice absorbs nitrogen during its whole cycle. However, there are two critical physiological moments: tillering and flowering. It is recommended to apply 10 to 30kg/ha when sowing, at the base, and 20 to 70kg/ha before tillering.

Sources of nitrogen

In the state of Mato Grosso, the most commonly used nitrogen fertilizers are found in one of the following forms: ammonia or amidic (Table 4). For upland rice the oxidant nature of the soil accepts well the nitric forms, but the most used is ammonia; probably because it is the most commonly found fertilizer. Urea top dressing may result in huge nitrogen losses due to ammonia volatilization. However, if urea is incorporated into the soil, losses will be minimized and top dressing fertilization successful.

Table 4. Chemical properties of the major nitrogenous fertilizer sources.

Fertilizer	*Formula*	*%N*	*Note*
Ammonium sulphate	$(NH_4)2SO_4$	20	(1)
Urea	$CO(NH_2)_2$	45	(2)

(1) Supplies sulfur plant macronutrient.
(2) Contains high amount of nitrogen. Absorbs air moisture faster (highly hygroscopic).Its grains are coated with protective material do lower hygroscopicity.

Phosphorous fertilization

Classification of the available P contents in the soil

The classification of available P in the soil depends of the extractor, the soil texture and the crop. To classify available phosphorus content one has to have in mind several variables such as the kind of soil to fertilize (specially its texture), the crop and the extractor to be used.

Table 5 shows the interpretation of a chemical analysis of a soil sampled between 0 and 20cm dept for upland rice. The elements analyzed are extractable P (Mehlich-1 method, also known as double acid or North Carolina) and clay. The critical contents of P (minimum appropriate levels) are 4, 8, 15 and 18mg/dm3 for soils of clayey, very clayey, medium and sandy texture respectively and enough to obtain 80% of grain yield without using phosphorus fertilizer.

Table 5. Interpretation of a soil analysis for P, extracted by the Mehlich 1 method according to clay content for recommended P fertilization in upland systems and annual crops in the Brazilian Cerrado.

Clay in g/kg of soil	P in the soil				
	Very low	Low	Medium	Adequate	High
	mg/dm³				
≤ 150	0 a 6.0	6.1 a 12.0	12.1 a 18.0	18.1 a 25.0	> 25.0
160 a 350	0 a 5.0	5.1 a 10.0	10.1 a 15.0	15.1 a 20.0	> 20.0
360 a 600	0 a 3.0	3.1 a 5.0	5.1 a 8.0	8.1 a 12.0	> 12.0
> 600	0 a 2.0	2.1 a 3.0	3.1 a 4.0	4.1 a 6.0	> 6.0

Source: Sousa et al. (2004).

Fertilization recommendation

Corrective fertilization for annual crops

The objective of corrective fertilization is to turn a low fertility soil into a fertile one. To determine the fertility level to be reached one has to bear in mind the amount of phosphorus required to fertilize a given area.

Annual cropping soils can be amended with phosphate in a single or in several applications. For soils already amended with adequate P, only maintenance fertilization is required.

The recommendation for a single application of corrective fertilization is to use the necessary amount of fertilizer (see Table 6), and to incorporate it to provide a high volume of amended soil, so the roots can easily absorb the phosphorus. However, amounts less than 100kg/ha of P_2O_5 must be applied on the sowing furrow similarly to the gradual corrective fertilization described below.

Table 6. Corrective phosphorous fertilization recommended for annual cropping systems in the Brazilian Cerrado region, according to the availability of phosphorus and the amount of clay in the soil.

Clay in g/kg of soil	*P in the soil*		
	Very low	*Low*	*Medium*
	kg/ha of P_2O_5		
≤ 150	60	30	15
160 a 350	100	50	25
360 a 600	200	100	50
> 600	280	140	70

Source: Sousa et al. (2004).

Maintenance fertilization in amounts shown below is to follow the application of corrective P when its availability is adequate.

Gradual corrective fertilization (Table 7) can be performed when it is not possible to make the correction in a single operation; a common situation for clayey and very clayey soils whose required amounts or fertilizer are often high. To do so, apply into the furrow an amount of P higher than that indicated for the maintenance fertilization until getting – usually after some years – the targeted P availability. The application of phosphorous fertilizers for a maximum of five years and in the amounts recommended on Table 7 should raise P to an adequate level.

Table 7. Five-year gradual corrective phosphorous fertilization recommended for annual cropping systems in the Brazilian Cerrado region, according to phosphorus soil availability and clay content.

Clay in g/kg of soil	*P in the Soil*		
	Very Low	*Low*	*Medium*
	kg/ha of P_2O_5		
≤ 150	70	65	63
160 a 350	80	70	65
360 a 600	100	80	70
> 600	120	90	75

Source: Sousa et al. (2004).

The progressive corrective fertilization consists in applying the amount of phosphorus defined in Table 6 but in a broken-up fashion, adding to the maintenance annual fertilization a portion of the total corrective fertilization.

As an example, lets say that the amount of corrective fertilizer needed is 200kg/ha (P_2O_5). This amount can be applied over a five year period added to the maintenance fertilization, Table 8, (60kg/ha of P_2O_5) the 40kg/ha of P_2O_5 corresponding to 1/5 of the 200kg. 100kg/ha of P_2O_5 furrow application over five years will do the corrective fertilization of 200kg/ha of P_2O_5 gradually.

Maintenance fertilization

Maintenance fertilization is used in rice when the level of soil P is adequate or high. P amounts are shown on Table 8.

Table 8. Maintenance fertilization recommended for rice in accordance with the availability of phosphorus in the soil and the yield expected .

Expected yield metric tons/ha	*Extractable P*	
	Adequate	*High*
	kg/ha of P_2O_5	
3	40	20
4	60	30
5	70	35

Source: Sousa et al. (2004).

Potassium fertilization

The chemical analysis of soil makes possible to precise the amount of potassic fertilizer needed to correct de deficiency of such nutrient.

Corrective fertilization for annual crops

Two systems are used for potassium deficiency correction in the Brazilian Cerrado region. The first is known as total corrective fertilization: the application of potassium fertilizer to eliminate its deficiency, followed by annual inputs to replace potassium uptake by plants. The other, called gradual corrective fertilization is the annually application of potassium a little above crop requirement.

The recommended amounts of potassium to apply, according to soil analysis results are shown on Table 9. The recommendation was divided in two CEC classes: a) soils with CEC at pH 7 less than 4.0cmolc/dm^3; b) soils with CEC at pH 7 over or equal to 4.0cmolc/dm^3. It is important to remind that the potential of potassium losses by erosion is high in the first group of soils (a). In this case the recommendation is to brake up doses over 40kg/ha of K_2O. Amounts over 100kg/ha of K_2O – independently of the soil CEC – must preferentially be broken up or applied by broadcasting.

Table 9. Corrective potassium fertilization recommended for the Brazilian Cerrado region annual crops according to the soil analysis and potassium availability.

Contents cmolc/dm^3		Interpretation mg/kg	Total Corrective kg of K_2O/ha	Gradual Corrective
		CTC at pH 7 less than 4 cmloc/dm^3		
< 0.038	< 15	Low	50	70
0.039 - 0.078	16 - 30	Medium	25	60
0.079 - 1.0	31 - 40	Adequate	0	0
> 0.10	> 40	High	0	0
		CTC at pH 7 equal or over 4 cmloc/dm^3		
< 0.064	< 25	Low	100	80
0.065 - 0.128	26 - 5	Medium	50	60
0.129 - 2.0	51 - 80	Adequate	0	0
> 0.20	> 80	High	0	0

Source: Vilela et al. (2004) adapted by Villar (2007).

Soil fertility maintenance

In upland rice, soil fertility maintenance is indicated when the levels of potassium are adequate or high. The amount of potassium recommended is shown on Table 10.

Table 10. Fertilization recommended for soil fertility maintenance in rice according to soil potassium availability and expected crop yield.

Expected yield metric tons/ha	Extractable K	
	Adequate	High
	kg/ha of K_2O	
3	40	20
4	50	30
5	60	40

Source: Vilela et al. (2004), adaptado por Villar (2007).

Fertilization with micronutrients

Causes of micronutrient deficiencies

It has been observed that the deficiency of micronutrients increases due to:

a) Increased micronutrients demand due to intense management systems and adaptation of high yielding and more micronutrients demanding cultivars;

b) High use of fertilizer formulations without adequate amounts of micronutrient;
c) Low use of animal manure and crop residues;
d) Cropped soils with low original micronutrient content.

Recommendations of fertilization with micronutrient

The soil analysis is the most important tool to diagnose micronutrient deficiency. On the other side Galrão (2002) reported that the recommendations based on that analysis is quite limited due to few calibrating studies conducted for those nutrients. As a trial, on Table 11 he presents the critical levels for the Cerrado region after extraction by the Mehlich 1 method.

Table 11. Interpretation of micronutrients for annual crops in the Brazilian Cerrado, based on the result of soil analysis.

Contents	B (hot water)	Cu	Mn	Zn
		Mehlich 1		
		mg/dm^3		
Low	0 a 0.2	0 a 4	0 a 1.2	0 a 0.5
Medium	0,3 a 0.8	5 a 12	1.3 a 5.0	0.6 a 1.2
High	>0.8	>12	>5.0	>1.2

Application on the soil - The deposition of micronutrients on the soil is the most commonly used method and can be performed placing the fertilizer in the sowing furrow or by broadcasting on the soil surface followed by incorporation. Broadcasting allows a better contact of the fertilizer particles with the soil particles but it can be less efficient, if the soil is clayey. To reduce this contact the fertilizer must be applied into the planting furrow. Dressing applications where deficiency symptoms are present probably will not give good results due to the low mobility of micronutrients – especially zinc. Higher amounts of fertilizer are needed when it is placed on the soil surface than in the furrow.

Recommendations on Table 12 can be used on annual crops in the Brazilian Cerrado region, with expected residual results in five years.

Table 12. Micronutrient recommended for annual crops with fertilizer broadcasted on the soil surface in Central Brazil with five years residual effects.

Contents	B	Cu	Mn	Zn
		(kg/ha)		
Low	1.5	2.5	6.0	6.0
Medium	1.0	1.5	4.0	5.0
High	0.5	0.5	2.0	4.0

Source: Galrão (2002).

Foliar application - Recommended in case of plant deficiency correction (Table 13).

Table 13. Suggestions to correct micronutrient deficiencies in upland rice.

Micronutrient	Source	Soil (kg/ha)	Foliar (200 L/ha de H_2O)
Boron	*Borax*	*1.0 – 2.0*	*0.1 – 0.25% (Borax)*
Copper	*Copper sulphate*	*1.0 – 2.0*	*0.1 – 0.2%*
Iron	*Iron sulphate*	*?*	*2% ($FeSO_4$)*
	Iron chelates		*0.02 – 0.05% (chelate)*
Manganese	*Manganese sulphate*	*10.0 – 30.0*	*0.1 %*
Molybdenum	*Sodium molybdate*	*0.5 – 2.0*	*0.7 – 0.1%*
	Ammonium molybdate		
Zinc	*Zinc sulphate*	*3.0 – 5.0*	*0.1 – 0.5% ($ZnSO_4$)*

Seed treatment – Seeds can be treated with low amounts of micronutrients. Seed treatment is used to correct zinc deficiencies in rice in Asia, where seeds are pelleted with 1% ZnO. Seed treatment is not recommended where farmers use rice and pasture in succession. Zinc is an important element in grazing, and it is commonly applied on the soil for further use by livestock.

Application with fertilizer – The levels range of certain micronutrients causing deficiency and or toxicity is very narrow. So their application must be performed in the most uniform way possible; notwithstanding the difficulty to do so due to the small recommended amounts, usually less than 10kg/ha. Adding small amounts of nutrients to a granulated mixture of an NPK fertilizer is a quite uniform and adequate way to apply micronutrients to the soil. The method may seem expensive but it eliminates unevenness that often occurs when fertilizer mixtures are handled. Besides, there is a reduction application costs, since both macro and micronutrients are applied in a single operation using conventional equipment.

Table 13 suggests corrective measures that may not be applicable to all cases. They must be used only after diagnosing the eventual actual as well as possible future deficiency.

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Cultivars

Breeding and development of improved cultivars for upland production systems have contributed to raise the supply of rice to the Brazilian population. Today, traditional varieties are of little importance, remaining only in the most traditional communities. Embrapa and the Mato Grosso Research, Assistance and Rural Extension Association (EMPAER-MT) have been working together to obtain new lines for the upland rice cropping systems. Breeding populations' variability was developed under the environmental conditions of Mato Grosso and the best individuals selected to start new lines tested in observation trials. The process resulted in two cultivars: *Carajás*, selected in the Jaciara, MT, Empaer Experimental Station and *BRSMT Vencedora* selected in Lucas do Rio Verde, MT. Agronorte and RiceTec also contributed in the development of those rice cultivars.

Recommended cultivars - main features

Tables 14 and 15 list and discuss the cultivars recommended for Mato Grosso and Rondônia. They have different heights and varied levels of resistance to disease. It is up to the farmer to pick up the one he thinks is the best performing in his cropping system.

Table 14. Upland rice cultivars recommended for the states of Mato Grosso and Rondônia

Cultivar	*Year*	*Seed availability*	*Cycle*	*Grain*
BRS Primavera	1997	Seed companies	Precocious	Long-thinned
BRS Bonanza	1999	Licensed seed companies	Semi-precocious	Mixed*
BRSMG Curinga	2005	Licensed seed companies	Semi-precocious	Long-thinned
BRS Sertaneja	2006	Licensed seed companies	Precocious	Long-thinned
BRS Pepita	2007	Licensed seed companies	Precocious	Long-thinned
BRS Monarca	2007	Licensed seed companies	Semi-precocious	Long-thinned
Cirad 141	1994	Agronorte	Medium	Long
Best 2000	2000	Agronorte	Medium	Long-thinned
AN Jatobá	2000	Agronorte	Medium	Long-thinned
AN Cambará	2000	Agronorte	Precocious	Long-thinned
Ecco	2007	RiceTec	Medium	Long-thinned*

*BRS Bonanza classification may vary according to the lot.

Table 15. Agronomic characteristics and reaction to diseases of upland rice cultivars recommended for the states of Mato Grosso and Rondônia*.

Cultivar	Flo** (days)	Alt (cm)	Aca	BP	ESC	MP	MG
			Concept***				
BRS Primavera	72	107	MS	S	MR	MR	MR
BRS Bonança	80	96	R	MS	MS	MR	MR
BRSMG Curinga	83	99	R	MS	MR	MR	MS
BRS Sertaneja	76	100	MR	MS	MR	MR	MR
BRS Pepita	72	102	MR	MR	MR	MR	R
BRS Monarca	82	107	MR	MR	MR	MR	MR
Cirad 141	87	122	R	MR	MR	MR	MR
Best 2000	88	64	R	S	MS	MS	MS
AN Jatobá	92	93	R	MS	MS	MS	MS
AN Cambará	75	94	R	MS	MR	MR	MR
Ecco	89	90	R	MR	R	MR	MR

*Important: cultivar behavior may vary depending on local conditions.
**Flo: number of days from sowing to average flowering;
Alt – plant height
Aca – lodging
BP – rice blast on the panicle neck
MP – leaf brown spot
ESC – leaf scald
MG – chalkiness
***Concepts based on the average behavior during trials conducted in Mato Grosso: R: resistant; MR: moderately resistant; S: susceptible.

BRS Primavera: early cycle long-slender grain cultivar – Recommended for low or moderately fertile areas due to its tendency to lodging under high fertility conditions. It can also be cropped in fertile soils with moderate fertilization. It has excellent cooking quality, and yields satisfactory under varied cropping conditions except when rice blast is present. To reduce blast risk this cultivar must be sown at the beginning of the wet season and preventively treated with pre-flowering fungicides. It is moderately resistant to other rice common diseases.

BRS Bonanza: medium to long-slender intermediate grain semi-early cycle cultivar – Short plant, resistant to lodging and widely adapted to different management systems and types of soil, including center pivot. Its grains are of dimensions close to the limit between the two classes with 30 to 40% classified as medium in some lots resulting in a “mixed” marketing classification. It presents excellent whole grains yield, even in delayed harvest. Grains have good appearance and satisfactory cooking quality. It is moderately susceptible to rice blast with good resistance to brown-spot and chalkiness. The incidence of foliar leaf scald is common but with moderate impact on yield.

BRSMG Curinga: long-slender grain early cycle cultivar – Short erect and highly tillered plant, quite resistant to lodging. Well adapted with high yield potential to both upland and wet lowland cropping systems. It is moderately resistant to brown-spot and leaf scald, and moderately susceptible to chalkiness and rice blast. In late sowing (December) preventive use of fungicides against neck blast is recommended. Its grains are long-slender with high yield of whole-grains, and good cooking quality, but it can present white belly resulting in less translucency. Under different farming conditions it gives more confidence to farmers.

BRS Sertaneja: long-slender grain early cycle cultivar – It features average sized vigorous plants, moderately tillered and moderately resistant to lodging. Its cycle is four to seven days longer than BRS Primavera. It is easily adaptable and can be cropped in all regions of the states of Mato Grosso and Rondônia. Its resistance to brown-spot, leaf scald and chalkiness is moderate. It is moderately susceptible to rice blast, mainly in late season crops. The panicles are long with many grains. Whole-grain yield is high and stable with translucent grains. After cooking they get loose, dry and soft.

BRS Pepita: long-slender grain early cycle cultivar – It is a medium sized rustic cultivar with vigorous plants, moderately tillered and moderately resistant to lodging. Early cycle; two to three days shorter than BRS Primavera, and moderately resistant to blast, brown-spot and leaf scald, also resistant to chalkiness. Its panicles are long with many grains. The presence of white center is low and the yield of whole-grains during processing is high and stable, with translucent grains. After cooking, grains get loose, dry and soft pleasing Brazilian consumers. Its yield potential is high and it can be indicated for crop rotation and for degraded pastures recovery.

BRS Monarca: long-slender grain medium cycle cultivar – It features high initial vigor with excellent rows closing, making this cultivar highly competitive with weeds. It is moderately resistant to rice blast, brown-spot, leaf scald and chalkiness. The excellent quality of its grains is given by low incidence of white center, translucency, good cooking quality, stability, softness, dryness and good appearance. Its after-harvest maturation period is not as long like BRS Privavera. Its industrial yield is high as well as the reproductive capability, which indicates the cultivar as an option for crop rotation, indicated for agriculture-livestock integration programs and degraded pastures recovery.

Cirad 141: long grain medium cycle cultivar – It is a rustic widely adaptable cultivar, with high reproductive potential, tolerant to drought and lodging with good tolerance to diseases. Its cycle is 120 days and adapts easily to different technologies and crop systems which allow its use to open bushy areas, to recover degraded pastures and to soils with long history of soybean rotation. Its whole grain yield is good and it can be harvested with 18% moisture. It is productive and of high rusticity. The grains need approximately four months storage before cooking.

Best 2000: long-slender grain medium cycle cultivar - This high-technology cultivar is good for both upland and irrigated systems, yielding over six thousand kg/ha with good yield of whole-grains when harvested on the right time (22% moisture). It is short 120-day cycle and resistant to lodging cultivar. It is moderately tolerant to blast but susceptible to chalkiness. Requiring good fertility level and good fertilizing management.

AN: Jatoba: long-slender grain medium cycle cultivar – It is a high-technology double aptitude cultivar for both uplands and lowlands. Its yield potential is high and it can produce over six thousand kg/ha.

Characteristics: modern plant architecture, short, good resistance to lodging, 120 day cycle, high whole translucent grain yield producing excellent mass with looseness after cooking. Good tolerance to blast, but susceptible to chalkiness. Recommended for low altitude (less than 450 meters), but requires fertile soils and regular rain fall.

AN Cambara – long-slender grain early cycle cultivar – Highly adaptable cultivar that responds well to technology. It has a modern plant architecture, medium height; is resistant to lodging, 105-day cycle, high whole-grain yield, translucent grains that become loose and soft soon after cooking. Have good tolerance to foliar rice blast; leaf scald; leaf spot and chalkiness. It can be cropped in open bushy zones, and used for pastures recovery or crop rotation.

ECCO: long-slender grain medium cycle hybrid – This is a medium cycle (average 115 days) rice hybrid developed for uplands. It features: high yielding potential (7,680kg/ha in Tabaporã, MT, 2008/09 cropping season); high tillering capability, allowing low sowing density (40kg/ha); good tolerance to rice blast, leaf spot and environmental stresses. It is easily adapted to tropical zones and indicated for crop rotation and pasture recovery.

Relevant aspects when choosing a cultivar

Cycle

Cycle differences among cultivars are given by the vegetative length phase up to panicle differentiation. From that moment on cycle length depends on environmental conditions mainly.

Cycle length has several practical implications. For example, early cycle cultivars sowed “early” in October and early November are marketed before the usual harvesting season starts, which usually results in higher prices. Also, for late sowings in the second half of December, early cultivars should be preferred because they will depend on rain fall for a shorter period of time with less risk of losses. The combination of cultivars of different cycles optimizes the use of the machinery and of drying and storage facilities.

Under ideal conditions and low climate risk, the medium cycle cultivars tend to produce more than the early ones, since they reach a more vigorous vegetative development. In addition, medium cycle cultivars have more time to recover in case of drought spells or from defoliant caterpillars, during the vegetative phase; they also offer more time to correct nutritional deficiencies by top dressing fertilization.

Plant height and lodging

The height is the distance in centimeters from the soil surface to the tip of the first panicle during the grain maturation phase. Lodging depends not only on plant height but also on the diameter and resistance of the stem, on the level of adhesion of the sheaths to the inter-knots, on the yield and environmental factors such as wind speed as well as water supply.

When cropping rice in adequate environment components, such as soil, climate and technology, the best is to use short cultivars with straight leaves that are more efficient in trapping sun light and more resistant to lodging. Lodging decreases yield and increases harvest costs with yield losses and reduction in grain quality, besides becoming dark due to fungal infection. Maturation is uneven and, when processing, the amount of whole translucent grains is reduced.

On the other side a taller plant has some advantages, such as a higher competitiveness with weeds which facilitates the use of herbicides. When sowed together with forages, tall cultivars should be preferred because short cultivars suffer higher competition with reduction in yield. Tall plants are the choice of subsistence farmers for – among other things - easy hand harvesting.

Resistance to diseases

Resistance to diseases is one of the major goals of genetic improvement. Blast is the most destructive disease, therefore a reasonable degree of resistance to it becomes essential to recommend any cultivar. However, the rice blast agent changes quickly, breaking down the resistance of most cultivars within time. Susceptible cultivars (like BRS Primavera) should be avoided when blast is present in a specific region. Additional measures include sowing at the beginning of the rainy season and the use of preventive control practices.

In 2002 Embrapa released the very productive and excellent grain yielding cultivar BRS Colosso. The release was based on 187 field trials along several years. The breeding line was moderately resistant to rice blast. However, such resistance was totally broken down on commercial scale in the 2003/04 cropping season. From then on, BRS Colosso has been extremely susceptible to the disease and Embrapa no longer recommends it.

Grain quality

The grain quality is where upland rice has presented its major advances through genetic improvement. Grain quality is mainly classified based on whole-grain yield; grain dimension class (long, long slender, medium, short), chalky and cooking quality. The latter includes softness, stickiness, and taste, among others.

In Brazil the consumer preference is for long-slender type 1 rice (milled grain), which presents good cooking characteristics with the grains becoming loose after cooking. This characteristic is very much appreciated and breeders work hard to obtain it in new cultivars. Today's reference cultivar is BRS Primavera for upland rice.

The higher the variability in grain moisture the worst will be the whole-grain yield during processing. Cultivars differentiate very much in terms of the ideal harvesting time with the BRS Primavera being the most sensible to that factor. It must be harvested when grain moisture contents is above 20%, otherwise the yield will be reduced. Harvesting is recommended to take place 30 to 40 days after average flowering.

The grain translucence i.e. the absence of white center or white belly is another important factor in rice grain quality. It very much depends on the cultivar, time of harvest and cropping environment.

Grain class and cooking quality are primarily determined by the cultivar while whole-grain yield and grain type depend on cultivar and management. Management includes keeping the crop free from weeds and insects, harvest at the right time and drying and storing the grains under adequate conditions.

Irrigation

Most of the Brazilian rice cropped area is under the upland ecosystem, without irrigation even the crop being highly susceptible to water stress. In 2005, 64% of the total rice cropped area was occupied by upland rice cultivars. However the upland rice responded for 37% of the total rice grain output only. The reason was the low average yield of that cropping system (1,965kg/ha).Three times less than that obtained for irrigated rice. The main reason is that most of the upland rice is located in the Brazilian Cerrado region where dominated Latosols with low available water capacity. During the rainy season from October to April the rainfall distribution is irregular with two to three-week dry periods (drought spells) on areas classified as high climatic risk. The high transpiration demand associated to the soil nature lower rice yield, resulting in oscillations in the national production. In Mato Grosso, notwithstanding the rain distribution being more favorable to higher yields (2,651kg/ha in average) the problem of water stress must not be disregarded. So, it is not only important to know the benefits of irrigation, but also to know how and when to do it.

When to irrigate

An important consideration in sprinkle irrigation is the interval between applications. The frequency of irrigation can be based on the consumption of a certain amount of available soil water (30 to 40%), or on a limit value of the soil water matric potential. In the latter case, considering yield and economy, the sprinkle irrigation must be performed so as to the soil water potential at 15cm deep may remain higher than -25kPa.

How much to irrigate

It is difficult to exactly quantify the total volume of water necessary for supplemental irrigation since this volume depends on the amount and distribution of rain fall.

Class A Pan Method

Water requirement for rice sprinkling can be estimated using evaporation pans, based on the ratio between the evaporation in a Class A USWB pan (ECA) and the crop evapotranspiration (ETc). The ratio is obtained using the pan coefficient (Kp) and that of the crop (Kc), so:

$$ETc = ECA \times Kp \times Kc$$

Table 16 gives different pan coefficient values according to climate and environment. Coefficient values for rice rows spaced 50cm are 0.70, 0.90, 1.24 and 0.90 respectively during sowing, vegetative, final vegetative-reproductive and grain filling. Table 17 gives the coefficient values for rice sown with 20cm between rows using the no-tillage system and conventional soil tillage (disc plowing followed by leveling). Crop and soil management affects crop coefficient values. As table 17 shows, the maximum value for rice sown with 20cm between rows is higher that for rice sown with 50cm between rows. Likewise the Kc values for rice cropped in conventionally tilled soils are higher than those in no-tillage.

Table 16. Class A pan corrective coefficient (Kp).

	Exposure A				Exposure B			
	Pan surrounded by grass				Pan surrounded by naked soil			
		UR% (average)				UR% (average)		
Wind (m/s)	*Pan position R*(m)*	*Low <40%*	*Medium 40-70%*	*High >70%*	*Pan position R*(m)*	*Low <40%*	*Medium 40-70%*	*High >70%*
	1	0.55	0.65	0.75	1	0.70	0.80	0.85
Slight	10	0.65	0.75	0.85	10	0.60	0.70	0.80
< 2	100	0.70	0.80	0.85	100	0.55	0.65	0.75
	1000	0.75	0.85	0.85	1000	0.50	0.60	0.70
	1	0.50	0.60	0.65	1	0.65	0.75	0.80
Moderate	10	0.60	0.70	0.75	10	0.55	0.65	0.70
2-5	100	0.65	0.75	0.80	100	0.50	0.60	0.65
	1000	0.70	0.80	0.80	1000	0.45	0.55	0.60
	1	0.45	0.50	0.60	1	0.60	0.65	0.70
Strong	10	0.65	0.60	0.65	10	0.50	0.55	0.75
5-8	100	0.60	0.65	0.75	100	0.45	0.50	0.60
	1000	0.65	0.70	0.75	1000	0.40	0.45	0.55

*R: shorter distance between the center of the pan and the border limit

Note: for wide surfaces of naked soil, reduce the Kp values in 20% when temperature is high and heavy wind and in 5 to 10% when temperature, wind and humidity are moderated.

Source: adapted from Doorenbos and Kassan (1979).

Simulation of rice sowing in uplands in early November in Primavera do Oeste, MT, using the crop coefficients (Table 17) with the rice being sowed at 20cm between rows under conventional soil tillage and in no-tillage system showed that the evapotranspiration in no-tillage is 417mm or 17% less than under conventional soil tillage (487mm). This results in a lower supplemental irrigation with an average of 45mm in no- tillage, against 73mm in conventional soil tillage.

Table 17. Crop coefficients for upland rice, 20 cm between rows.

Phase	*Duration (day)*	*Crop Coefficient*	
		Conventional soil tillage	*No-tillage*
Emergence – early tillering	20	0.58	0.18
Early tillering-panicle emission	45	0.72	0.67
Early panicle –dough grain	55	1.34	1.28
Dough grain – maturation	15	0.67	0.53

Tensiometer method

Another way to calculating the amount of water to apply to the soil is using a tensiometer and soil water retention curve. Tensiometers are devices to measure the soil water matric potential. The retention curve is the ratio between the soil water contents and the force this soil exerts to retain this same water. It is a physic-chemical soil propriety that can be calculated in laboratory.

When the irrigation is by center pivot, the tensiometers must be installed 15 and 30cm deep into the soil on at least three sites of the crop surface. The sites correspond to 4/10, 7/10 9/10 of the pivot radius on a straight line from the base. The 15cm-tensiometer is called “decision” tensiometer because it indicates the moment to irrigate; the 30cm-tensiometer is called “control” tensiometer because it indicates the way the irrigation is to be carried out without excess or shortage of water. The irrigation must be carried out when the tensiometer readings average turns around – 25kPa.

The amount of water to apply is calculated as follows: knowing the soil water retention curve, calculate how much correspond -25kPa in soil water contents. Then calculate the difference between the moisture contents at -10kPa (field capacity) and at -25kPa. The difference multiplied by 30cm depth will indicate the irrigation depth. This is justified by the fact that the 0-30cm soil depth includes almost all roots of a rice field irrigated by sprinkle irrigation and also because the reading of the decision tensiometer will represent the average potential of soil water in that layer.

Reference

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Weed Control Management

Since long, upland rice is cropped on new lands free of weeds. The consequence was a lack of technologies and products for controlling weeds in rice in rotation with commercial crops like soybean and corn and with cover crops like millet and Brachiaria. That, added to the low rice competing capability with weeds is one of the main barriers to the introduction of this crop in agricultural systems already existing for several seasons in amended soils.

Weed control is about reducing weed content rather than completely eliminating them. The goal is threefold: to avoid yield losses due to competition by water and minerals; to improve harvest conditions and to minimize weed presence in the field.

The association of different weed control methods is recommended whenever possible adapting them to the local infrastructure; to the availability of manpower and implements, and to cost analysis.

The methods for controlling weeds are: cultural, preventive, mechanic and chemical. Recently the chemical controls with herbicides became the most commonly used practice to lower cost and raise the efficiency when compared to other weed control methods. But to get the best results, use the chemicals at the right time (Table 18).

Table 18. Recommended* herbicides to control weeds in upland rice crop.

Weed	Herbicide	Amount (L/ha or g/ha)	Application
Narrow leaves	Pendimenthalin	2.0-3.0 L	Pre-emergence (after planting). If there are narrow leaves use post-emergence
	Trifularin	2.0-3.0 L	
	Oxadiazon	2.0-4.0 L	
	Cyhalofop-butyl	1.0-1.5 L	In post-emergence 30 days after rice germination. The use of only post-emergence for narrow leaves is indicated only for low-infested areas.
	Profodixium	0.4-0.6 L	
	Fenoxaprop p-etil	0.4-0.6 L	
	If a post-emergence herbicide is not used, combine pre and post-emergence early 10 to 15 days after rice germination. It is recommendable to use Cyhalofop-butyl (1L/ha) + Pendimenthalin (2L/ha) or Profoxydium (0.35L/ha) + Pendimenthalin (2L/ha).		
Wide	Metsulforon-metil	4.0g	Weeds with up to four leaves usually 10-25 after rice germination.
	2.4D	0.6-1.0L	After rice offshoot usually 30 days after germination

*The possible absence of an herbicide does not mean it is not recommendad, providing it is licensed by the Ministry of Agriculture and Food Supply.

Disease Control Methods

During all its cycle rice can be affected by diseases that reduce grain yield and quality. The intensity of the disease depends on the type of pathogen, the environment and the cultivar susceptibility. The control of rice diseases aims the reduction of the infection rate to acceptable levels. In upland rice integrated control management system, the increase in yield takes in account production costs and the relationship between the adopted measures and the environmental impact.

The most important diseases of upland rice in Mato Grosso resulting in significant losses in grain yield and quality are (from the most important down): rice blast (Magnaporthe oryzae); brown spot (Bipolaris oryzae); grain discoloration syndrome (several pathogens) and leaf scald (Monographella albescens Thumen). For each disease mentioned here the following subjects will be discussed: symptoms, casual agent, favoring factors and control measures.

It is understood that the aspects here mentioned are indispensable for the right implementation of preventive measures whose components are: genetic resistance, cultural practices and chemical control (Table 19). The correct cultivar election for each region and the most indicated cultural practices will maximize the effect of the chemical control which must be adopted as a preventive measure.

Table 19. Products licensed by the Ministry of Agriculture, Livestock and Food Supply to control rice diseases.

Active principle	Formulation[1]	Dose	Toxicology class	Environmental classification	Indication
azoxistrobine	SC	0.4 L ha^{-1}	III	III	rice blast, brown spot
carbendazim + tiram	SC	0.2 - 0.3 L 100kg $seeds^{-1}$	III	II	rice blast, brown spot, grain spot
carboxyne	WP	0.15 - 0.25kg 100kg $seed^{-1}$	II	*	rice blast
carboxyne + thiram	WP	0.25 - 0,3kg 100kg $seed^{-1}$	III	II	rice blast, brown spot, scalding, grain spot
carboxyne + tiram	SC	0.25 - 0.30 L 100kg $seed^{-1}$	IV	II	rice blast, brown spot, scalding, grain spot
casugamycine	SL	1 – 1.5 L ha^{-1}	III	III	rice blast
chloratolonyl	WP	1.7 - 2.4kg ha^{-1}	II	*	brown spot
chloratolonyl	SC	2.5 - 3.0 L ha^{-1}	I	*	brown spot
chloratolonyl	SC	2.5 - 3.0 L ha^{-1}	I	II	brown spot
chloratolonyl	SE	2.5 - 3,0 L ha^{-1}	I	II	brown spot
chloratolonyl	SC	2.5 L ha^{-1}	I	II	brown spot
dypheconazole	EC	0.3 L ha^{-1}	I	II	brown spot
phtalide	SC	1 - 1,5 L ha^{-1}	IV	III	rice blast
mancozebe	WP	2 kg ha^{-1}	III	*	rice blast, brown spot, narrow spot
mancozebe	WP	4.5 kg ha^{-1}	III	II	rice blast, brown spot
mancozebe	WP	2 kg ha^{-1}	III	*	rice blast, brown spot, narrow spot
mancozebe	SC	8 L ha^{-1}	III	III	rice blast
mancozebe	WG	2 - 3 kg ha^{-1}	IV	III	rice blast
mancozebe	WP	2 – 3.5 kg ha^{-1}	IV	III	rice blast
mancozebe + methylic tyophanet	WP	2 - 2,5 kg ha^{-1}	III	II	rice blast
propychonazol	WP	0.4 L ha^{-1}	III	II	brown spot
propychonazol + trifloxistrobyne	EC	.75 - 0,5 L ha^{-1}	I	II	rice blast, brown spot
tebuconazole	EC	0.75 L ha^{-1}	III	II	rice blast, brown spot
tebuconazole	EC	0.75 - 1,0 L ha^{-1}	III	II	rice blast, brown spot
tebuconazole	EC	0.75 L ha^{-1}	III	II	rice blast, brown spot
tebuconazole + trifloxistrobyne	EC	0,6 a 0,75 L ha^{-1}	III	II	rice blast, brown spot
tetraconazole	EW	0.3 - 0,5 L ha^{-1}	II	III	rice blast, brown spot, scalding, sheath spot
thyabendazole	DP	0.2 – 0.3 kg 100 kg $seed^{-1}$	IV	*	rice blast, narrow spot
thyam	DP	0.2 – 0.3 kg 100 kg $seed^{-1}$	III	*	rice blast, brown spot, grain spot, sheath burn
thrycyclazole	WP	0.2 – 0.3 kg ha^{-1}	III	II	rice blast
thryfloxistrobyne	WG	0.2 – 0.25 kg ha^{-1}	III	II	rice blast
thryphenyltine + hydroxide	SC	0.75 L ha^{-1}	I	II	brown spot

Rice blast

Symptoms

That disease occurs from panicle emergence to crop maturation. The first symptoms are little brownish necrotic lesions on the leaves. With time the lesions enlarge becoming elliptical with brown borders and gray to whitish center (Fig. 15-A). Under favorable conditions the lesions coalesce resulting in the death of leaves and eventually of the plant. The symptoms on the knots and inter-knots usually appear in the maturation phase. The infection on the first knot bellow the panicle is called neck rice blast. Different parts of the panicle as the rachis, the primary and secondary ramifications and the pedicels may also be affected becoming straw-yellow (Fig. 15-B). Late panicle infection results in losses on the infected parts only.

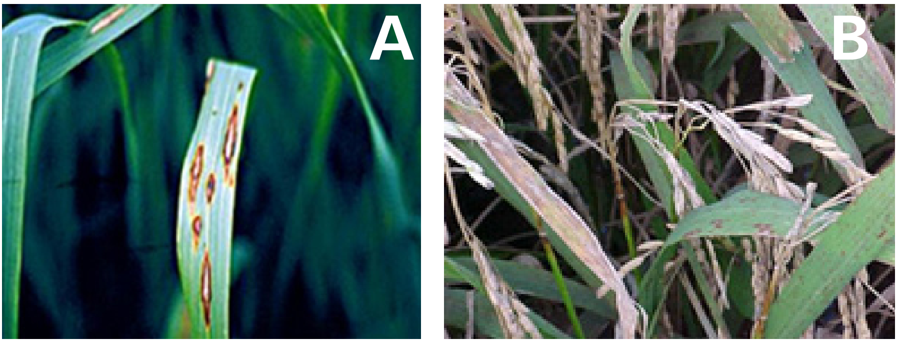

Fig. 15. Rice blast symptoms; leaves (A), panicle (B).

That disease is transmitted by infected seeds considered as a primary source of inoculum; but these seeds do not cause epidemics in well managed crops. Other sources of contamination are the debris and spores carried by wind from one farm to another.

Control

Damage caused by rice blast can be reduced using resistant cultivars, adequate cropping practices and fungicides in an integrated crop management system encompassing good soil tillage, balanced fertilization, use of healthy and good physiological quality seeds, as well as sowing at uniform depth at the beginning of the rainy season to prevent infection outbreaks. Protection against rice blast in the panicle is made by spraying systemic fungicides with one application at the end of the flowering and the second at panicle formation with at 1 to 5% concentration.

Brown spot

Symptoms

Brown spot attacks the coleoptiles, leaves, sheath, panicle branches, glumes and grains. Symptoms usually appear on the leaves, immediately after flowering and, later, in glumes and grains. On leaves the symptoms are pale brown circular or oval spots with gray or whitish centers and brown to reddish margins (Fig. 16). Lesions in the sheaths are similar to those found on leaves. In grains, the spots are dark brown and often coalesce, covering the whole grain. If the disease occurs soon after booting, the spikelet may become sterile.

Infected seeds and crop residues are sources of contamination. The fungus is

Fig. 16. Brown spot symptoms.

lodged inside the seed, causing its discoloration and wrinkling. The disease is favored by temperatures between 20 and 30° C and relative humidity above 89%. Stresses brought by excess or shortage of water supply, low soil fertility (mainly potassium) and too much or too little nitrogen increase the plant susceptibility to brown spot.

Control

Treating seeds with fungicides reduces initial contamination and helps to control primary seedling infections. The foliar fungicide protective action has been effective, but the use of systemic fungicides at the beginning of booting protects the grains and improves its quality. Crops for seed production require two applications; the first before booting and the second seven to ten days after the first application. The use of fertilizers with inorganic calcium may reduce disease incidence.

Grain Spot

Symptoms

The discoloration appear from early booting up to ripening. Symptoms vary widely, depending on the predominant pathogen, stage of infection and weather conditions. Burning of glumes may be seen when the panicles appear, with reddish-brown spots on the spikelet. Oval spots with white center and brown edges appear when the infection occurs at the milky and dough phases after panicle emission (Fig. 17).

Fig. 17. Grain discoloration symptoms.

Agents of grain spot are Bipolaris oryzae and Phoma sorghina, and among the bacteria causing grain discoloration, are Pseudomonas fuscovagina and erwinia sp. Just by looking at the symptoms it is difficult to identify which micro-organisms are involved. A laboratory analysis is necessary to identify the pathogen(s).

During grain filling the disease is favored by rain fall and high humidity. Also by plant lodging, which facilitates the contact of the panicles with the soil; also by the presence of the rice stink bug (*Oeabalus poecilus*) which promotes the entry of grain staining micro-organisms.

Control

Use of healthy seeds. Seeds treated with fungicides increase their vigor, preventing initial inoculation. Chemical control should be performed preventively with one or more applications using systemic fungicides. The first application should be carried out at late booting or early panicle emission, and the second, ten days later.

Leaf Scald

Symptoms

Typical symptoms start at the leaf apex or edge. The spots have no well-defined margins, and are initially olive green (Figure 18). Furthermore, the affected areas present sequences of concentric bands. The lesions coalesce, causing necrosis and death of infected leaves. The affected crop presents a generalized yellowish discoloration and leaf tips death. When environmental conditions do not favor the development of the disease, leaves show small pale-brown spots, usually resembling other diseases. Similar symptoms can appear in the sheaths. In grains, the symptoms are small pin head size spots. In severe cases, glumes brown-reddish discoloration is present.

Fig. 18. Rice leaf scald symptoms.

The main sources of primary contamination are infected seeds and crop residues. The disease is favored by wetted leaves, either by rainfall or dew during tillering and booting periods as well as by high-density sowings and excessive nitrogen fertilization.

Control

Control measures include the use of good physiological and sanitary quality seeds. Crop rotation and good irrigation management (when appropriate) help reducing the disease incidence. As for chemical control, there is no information on its economical viability.

General considerations

Cultural practices combined with resistant cultivars reduce the use of chemicals and, consequently, environmental damage and production costs. It is a procedure to protect crops with effective disease management. The result is higher yield and product quality at lower cost.

Pests Control Methods

The main pests attacking upland rice in the Mato Grosso are: neck bit, termites, spittlebug meadow, black bit, cabbage-root, defoliating caterpillars, stem bit, bug-stem and grain-bug. Table 20 lists the registered chemicals to control these pests.

Early pests

The initial growth phase of upland rice goes from seedling emergence to the beginning of the tillering. In this stage, the crop is subjected to attacks from several arthropods like neck-bit, termites and pasture leafhopper.

Stem-bit or plant caterpillar (Fig. 19a). It is a pest with preference for sandy soils, little rain and high temperature. Its presence can be sporadic and localized, but it may devastate large crop areas.

Termites – They contribute to reduction in plant emergence and to partial or total destruction of roots; weakening the plants and favoring weeds growth.

Pasture Spittlebug - Among the species attacking rice, the most common is Deois flavopicta (Fig. 19b). When feeding they introduce toxins that turn leaves yellow with white stripes and wilted tips. A severe infestation resulting in leaves and plants death.

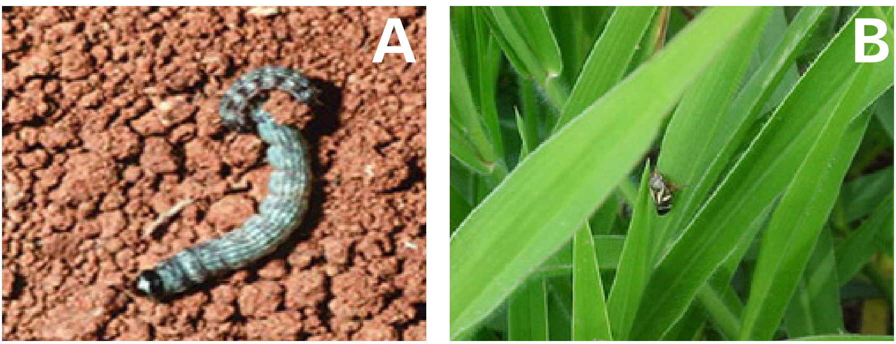

Fig. 19. Early rice pests - Larva of the stem-bit (A) and pasture spittlebug (B).

Table 20. Chemicals registered to control upland rice pests.

Trade Name	Technical Name	Chemical Group	CT[1]	Environmental Classification	Indication	Dose	Registered to
Actara 250 WG	Tiamethoxane	Neonicotinoid	III	III	Stem bug	100-150g/ha*	Syngenta
Karate Zeon 50 CS	Lanbda cyhalothrine	Pyrethroid	III	II	Gralssland leaf worm	100-150g/ha	
					Stem bug	150ml/ha	Syngenta
Mustang 350 EC	Zeta-cypermethrine	Pyrethroid	II	II	Cartridge lizard	60ml/ha	FMC
Bulldock 125SC	Beta-cyfluthrine	Pyrethroid	II	II	Cartridge lizard	30ml/ha	Bayer
Decis 25 EC	Deltamethrine	Pyrethroid	III	I	Grassland leaf worm	200ml/ha	
					Cartridge lizard	100ml/ha	Bayer
Klap	Fipronile	Pyrazole	III	II	Rapa-rapa ant	20ml/ha	Basf
Talcord	Permethryne	Pyrethroid	III	II	Cartridge lizard	80ml/ha	Basf
Arrivo 200 EC	Cypermethrine	Pyrethroid	III	II	Cartridge lizard	50-75ml/ha	FMC
Galgoper	Permethrine	Pyrethroid	I	II	Cartridge lizard	65ml/ha	Milenia
Valon 384 EC	Permethrine	Pyrethroid	II	**	Spodoptera eridania	65ml/ha	Dow AgroSciences
Malathion 500 CE	Malathion	Chlorophosphate	III	**	Cartridge lizard	2.6 l/ha	
					Grassland leaf worm	2.6 l/ha	
					Grain bug	1.3-2.0 l/ha	
					Stem bug	1.3-2.0 l/ha	Action
Dipel WP	Bacillus thuringiensis	Biological agent	IV	IV	Grassland leaf worm	400-600g	Sumitomo
					Cartridge lizard		
Bac-Control WP	Bacillus thuringiensis	Biological agent	IV	IV	Cartridge lizard		
					Grassland leaf worm	400-600g/ha	Vectorcontrol
Carbaryl Fersol 850	Carbaryl	Methyl-carbamate	II	**	Cartridge lizard		
					Borer		
					Grassland leaf worm		
					Grain bug		
					Stem bug	1.2-1.5kg/ha	Fersol

[1]Toxicology classes: I - Extremely toxic; II - Highly toxic; III - Moderately toxic; IV - Slightly toxic

* A small doses should be used when there are early signs of pest infestation. If the pest is already present in high number including in adjacent crops, or in cultivars susceptible to virus, use the largest doses, both in foliar and spray or through soil dripping.

** According to law 7802/89.

Management - The monitoring and management of pests in the initial phases of crops are essential for obtaining adequate stand mainly in short-cycle varieties with little tillers. The loss of primary stems reduces the stand and affects the uniformity and crop yield. As a preventive measure the seeds must be chemically treated in places where at the beginning of the season pests such as termites, flat caterpillars and pasture spittlebugs often damage the young plants.

Seed Treatment

Benefits

- When weather conditions hamper the access of machines and equipment to the field, seed treatment may be advantageous.
- Farmers who crop large surfaces and cannot inspect the fields regularly to assess the impact of pests should spray insecticides in the post-emergence period. Considering the level of the pest population this can be a difficult task.
- Seed treatment (Table 21) reduces the need to monitor the crop in the early weeks, allowing the use of workers and equipment elsewhere.
- The protection of the crop from arthropods attacking the plants in their early stage ensures the survival of rice plants, providing high uniformity panicle maturation.
- Insecticides used in seed treatment are little affected by rain or irrigation.

Limitations

- The decision to invest in seed treatment to control early pests should be taken before the problem is detected.
- The economic return on the investment is uncertain.
- If a drought spell affects germination, resowing will be necessary and in this case, the treatment will also be lost and a new treatment will be necessary.
- Unfavorable conditions for seedling emergence such as low-quality seeds or high temperature may require seed treatment to avoid stand reduction.

Black beetle

Several species can attack rice with *Euetheola humilis* being the most common (Fig. 20). Its presence tends to be more intense in areas of no-tillage. In places where this pest is highly present, plowing the soil may be an alternative to expose the larvae to its natural enemies and to direct sunlight, which desiccates them. However, this practice violates the principles of no-tillage. Another measure is to use light traps to attract the adults, concentrating them at some points where they can be destroyed. The pest must be monitored by sampling the field before sowing. Chemical control is recommended when two adults per square meter are found.

Table 21. Licensed products to protect upland rice seeds against the pests affecting its early development.

Technical Name	Trade Name	Chemical Group	CT[1]	Class	Indication	Dose/100 kg of seeds	Registered to
Cruiser 350 FS	Thiamethoxan	Neonycothynoides	III	III	Termites Pasture spittlebug Borer	200-400ml 200-400ml 300-400ml	Syngenta
Cruiser 700 WS	Thiamethoxan	Neonycothynoides	III	III	Mound termites Pasture spittlebug Borer	100-200g 100-200g 150-200ml	Syngenta
Furazin 310 FS	Carbofurane	Methyl-carbamate	I	II	Termites Pasture spittlebug Borer	1.7 liters	FMC
Furadan 350 FS	Carbofurane	Methyl-carbamate	I	II	Termites Pasture spittlebug Borer	1.5 liters	FMC
Fenix	Carbofurane	Methyl-carbamate	I	II	Termites Pasture spittlebug Borer	2.0 liters 2.0 L	FMC
Futur 300	Thyodicarb	Methyl-carbamate	III	III	Pasture spittlebug Borer	1.5 liters	Bayer
Gaucho	Imidachlopryde	Neonecotinoyde	III	III	Termites	200g	Bayer
Gaucho FS	Imidachlopryde	Neonecotinoíde	III	III	Termites	250ml	Bayer
Semevin 350	Thyodicarb	Methylcarbamate	III	III	Borer Pasture spittlebug Mound termite Scarabs	1.5 liters	Bayer
Standak	Pyrazole	Phypronyl	III	II	Termites	200-250ml	Basf
Laser 400 SC	Benfuracarb	Methyl-carbamate	II	II	Borer	2.5 liters	Iharabras
Ralzer 350 TS	Carbofurane	Methyl-carbamate	I	II	Termites Passture spittlebug Borer	1.5 liters	Fersol

[1]Toxicology classes: I - Extremely toxic; II - Highly toxic; III - Moderately toxic; IV - Slightly toxic.

Root flea

It is a rare pest, but becoming important mainly in no-tillage. They are small odorless soft-bodied sucking insects whose main species is Rhopalosiphum rufiabdominalis Sasaki (Fig. 21). When present in high numbers they affect the development of roots, turning the leaves yellowish and stopping plant growth.

Fig. 20. Cake bug larva (*Euetheola humilis*).

Fig. 21. Root flea (*Rhopalosiphum rufiabdominalis*).

Defoliating Caterpillars

The leaf caterpillar *Spodoptora frugiperda* and the grass caterpillar *Mocis latipes* are the most important rice defoliants. The infestation critical time is the beginning of the vegetative phase when the caterpillars may totally destroy the crop. *M. latipes* usually appears when the plants are already advanced in the vegetative phase or even in the reproductive phase. Bugs must be monitored weekly right after plant emergence. The monitoring tool is a 0.5x0.5m metal square frame placed along the crop rows. At the early vegetative phase a 3rd stage caterpillar (sized 1cm long in average) per square meter can cause up to 1% drop in rice grain production. Later in the vegetative stage, plants are more tolerant to plague attack. In addition to monitoring, it is recommended to pay attention to rice crops near corn and sorghum. Soil fertility must be taken care of to promote fast plant growth reducing the period of the highest susceptibility to the insect. Insecticides must be applied only when the level of control is reached to preserve the insect natural enemies.

Diatraea saccharalis

The stem bit *Diatraea saccharalis* has high potential for economic damage. Almost every year it occurs in low densities in most of the rice fields in Brazil. This bug survives even after rice harvest, in alternative hosts such as maize and sorghum. In fields where the harvest is mechanized, a considerable mortality of larvae and pupae is caused by the mechanical action of the combine. However, many bugs survive, especially those in the stem base, close to the ground, where the combine cannot reach them. In areas under no-tillage, where crop residues are not destroyed, the survival of insects may be even greater. The use of cultivars resistant to the plague is the main option for controlling it. The cultivars less attacked by this plague are Primavera, Carisma and Bonanza. As there are many natural enemies, the natural biologic control is an alternative to be considered to maintain the bug population at acceptable levels. Natural enemies are greatly affected by the insecticides used to spray the crop. The monitoring of the crop in order to control *D. saccharalis* should be performed from the stages of stem elongation and beginning of panicle formation. Samples should be collected at random, going up the field diagonally, starting 10 to 15m from the edges. It is recommended to consider in each collecting point ten stalks at a distance of 1m or so. Each stem should be carefully analyzed and the number of eggs recorded. When the number of eggs per 100 stems is equal or above 5 and the level of egg parasitism is below 50% it is recommended to performe treatment. To assess the degree of parasitism the color of the eggs of *D. Saccharalis* should be observed. Th dark gray colored are paralyzed while those with pink spots will produce larvae in two to three days, and those who for two to three days remain white can be considered sterile.

Stem bug

The stem bug *Tibraca limbativentris* (Figure 22) is a very important pest of irrigated crops. Its importance in the upland environment has grown in recent years, especially in places favored by rain fall. Damage starts when the insects inject their toxic saliva causing the death of inner tissues named “dead heart” and, in the reproductive stage, the spikelets become empty. To manage tat bug it is recommended to reduce the number of host plants in and around the rice crop. The crop remains left in the field may serve as shelter to the bug during crop off-season must also be reduced. Fields should start being monitored 40 days after sowing through weekly sampling. For sampling, it is recommended to count the number of adults in one square meter in at least ten spots from the edges of the crop. Control is recommended when one bug per m^2 on the average is found. It is important to start the sampling period as recommended since if insecticide is required it must be applied before the insects start laying their eggs. As the insects are lodged at the base of the stems, it is difficult for the insecticide to reach bugs housed in the lower portion of the canopy.

Fig. 22. Adult *Tibraca limbativntris.*

Grain bug

There are several species of bugs that feed on the panicles of upland rice. *Oebalus ypsilongriseus* (Fig. 23) is the most commonly found in this environment in all Brazil rice producing regions. Other species such as *O. poecilus* and *Mormidea* spp. can also be found. The bug populations grow outside rice crops and invade the fields moving rapidly. The infestation begins in the flowering plants, but the bugs prefer to get food from the spikelets in the milky stage, causing qualitative and quantitative losses. Severe attacks result in seeds with spots in the endosperm, low grain mass and low germination. The affected grains have a "chalky" appearance, irregular size and usually breakdown during processing. In addition to the direct damage, the grain bugs, while feeding from the spikelets, can also spread fungi that cause stains on grains. Monitoring of bugs in upland rice fields should be conducted from flowering to panicles ripening. Sampling must be performed in the morning until 10 AM, starting on the borders of the crop and where parts of the plant are stronger. Using an entomologic net, the sampler has to walk at random on the field, take a sample of ten handfuls of plants at each point and count the bugs caught in the net. Chemical control is recommended when an average of five adult bugs per sampling in milky stage grain or ten at the dough stage are found.

Fig. 23. Adult grain bug *Oebalus ypsilongriseus.*

Harvest

Factors affecting harvest

When sowing is carried out at the appropriate time as recommended for the cultivar and the region, it provides good yield and efficient harvest. In wide areas, sowing should be planned to prevent crop development concentration in only one period to avoide losses due to lack of combines and dryers.

The occurrence of weeds affects the crop yield not only by competition (of plants) for water, light and nutrients, but also by interfering with harvesting by frequently obstructing the trail and mixing up with the cereal which results in depreciation of the product. The crop should be kept free of weeds.

Combines

Rice combines pick up and thresh the plants in a single operation.

The conventional mechanism that cuts and collects the plants is called cutting platform. For cutting the stems below the panicle and away from the ground, the best platform for rice is the rigid, without flexion movements at the cutting bar.

The relationship between the speeds of the reel and the displacement of the machine must be less than 1.25 to minimize grain losses on the platform. Approximately 70% of the losses occur in the cutting deck.

An alternate to the cutting platform to produce less straw is a grain picker platform whose main component is a picker drum with threshing fingers made of polypropylene. The speed and hence the feeding rate of the machine can be increased without overloading its mechanism.

The components responsible for threshing are the shattering and the hollow drums which must have teeth when used for rice. The use of cylinder bars, commonly used for soybeans, increases grain losses due to imperfect shattering. The peripheral cylinder speed varies with grains moisture content. Under normal conditions it varies from 20 to 25m/s with a rotating speed around 600rpm.

To facilitate the next crop the sowing, rice combines must be operated with chopper and straw spreader. This helps a better soil straw coverage and lowers the population of stem caterpillars.

Harvesting time

The ideal harvesting time is when the cereal reaches maturity. The number of whole grains is higher in processing and the losses in the field smaller.

The industrial yield of whole grains is a characteristic related to the product quality, the seed, and the cultivar and crop management. However, even a cultivar of high yield potential for producing whole grains may not manifest this characteristic due to the environment, harvest procedures and post-harvest management. When left on the field, rice grains may suffer re-hydration and when this happens and moisture gets below a critical threshold (around 15%), there is an internal differential tension which can crack it. The result is the presence of broken grains in processing. This phenomenon may be caused by dew, high relative humidity and, especially, by rain. Thus, at harvest, the lower the proportion of grains below this critical threshold, the less cracked grains will appear.

The grain moisture must preferably be measured using a grain moisture meter. Generally, to obtain higher yields of whole grains it is recommended to harvest the rice with moisture contents still high (18 to 22%). However, one must be attentive to the peculiarities of each cultivar as some may be more demanding in terms of harvesting time.

Cultivars differ concerning ideal harvesting time. If picked up over 35 days after flowering, BRS Primavera cultivar will drastically reduce its yield. BRS Sertaneja, in turn, has high percentage of whole grains in harvested crops up to 45 days after flowering. Notwithstanding the fact that cultivars are different in terms of the best time for harvest, it is advisable to avoid harvesting too early when grain moisture is high (above 25%), or too late when moisture is very low, because the longer the rice stays in the field, the greater the risk of lodging, bird and insect attacks and loss of quality, especially in terms of whole grain yield.

Grain losses

In mechanized harvest, losses are due to outside and inside the combine factors. The outside factors are due to the mechanical functioning of the cutting deck and reel, while the inside ones are related to the threshing and separation mechanisms, and to the action of the drum beater, straw bag, and sieves.

When the rice is being harvested, the impact of the plants on the collecting unit causes a series of damages, depending on the cultivar's threshing capability, grain moisture, and presence of weeds and operation of the combine as well as its conservation condition. Speeds above 5km/h are incompatible with the rotating speed of the reel and results in premature threshing and failures in harvesting, thus greatly increasing the losses.

Losses also occur in the threshing unit, being higher when the opening of the threshing cylinder and the concave are not properly adjusted. Poor adjustments cause inadequate threshing with many grains getting stuck in the panicles, hindering the separating operation in the screens or cracking the grains. The result is a reduction in the percentage of whole grains processed.

It is also worth noticing the occurrence of losses due to bad air flow regulation in the screens and their wrong positioning. In the straw disposer, losses may result from obstruction, poor adjustment and excessive machine speed or even from the conditions of the crop such as high content of weeds or grains with high moisture content or immature.

A survey by Embrapa Rice and Beans of grain losses in upland rice found that the average loss in grain combines amounted to 13% of its yield. The cutting unit was responsible for 73.2% of losses, the straw disposer for 12.9%, and the sieves for 9.9% and natural threshing for 4%.

Procedures to determine grain losses

Determination of total loss

(a) After harvesting, choose at random an area of one square meter and delimitate it so that his largest side includes the combine path width;
(b) Collect each grain in the delimitated area including those trapped in the panicle;
(c) Calculate the grain mass and turn the losses into kg/ha by equation 1:

Loss (kg/ha) = grain weight (g) x 10 / demarcated area (m^2) (1)

The loss can also be calculated as shown in Table 22. Another alternative is the use of a plastic volumetric meter glass with specific scale for rice. It is a simple, practical and precise method of measuring losses without needing counting or weighing grains;

Table 22. Minimum and maximum rice losses (number of grains per m^2 after harvest).

Grains (total/m²)	*Rice losses (kg/ha)*	*Grains (total/m²)*	*Rice losses (kg/ha)*
50	12.9	550	141.9
100	25.8	600	154.8
150	38.7	650	167.7
200	51.6	700	180.6
250	64.5	750	193.5
300	77.4	800	206.4
350	90.3	850	219.3
400	103.2	900	232.2
450	116.1	950	245.1
500	129.0	1000	258.0

*Weight of 100 seeds of rice equals to 2.58 g.

(d) Losses must be evaluated in at least four sites of the harvesting crop.

Determination of fractional losses - The broken grain determination makes possible to know whether the loss is from the cutting deck, the straw disposer or from the combines screens.

How to verify losses in the cutting deck

(a) During normal harvesting operation, stop the combine and turn off the cutting deck;

(b) Raise the platform and step back the combine to a distance equal to its length (4 to 5 meters);

(c) Delimit an area of one square meter in front of the marks left by the tires;

(d) Pick up all grains fallen on the delimited area;

(e) Determine grain mass and calculate the loss in kg/ha using equation 1 (see pg. 69);

(f) Repeat this procedure in four sites.

Losses in the straw disposer and screens must be calculated in at least four sites in the crop surface.

Technical recommendations

To avoid unnecessary losses, before the harvest, care should be taken to day time harvest, grains moisture content and combine adjustments and maintenance.

Harvest time - Avoid harvesting when the grains are still moistened by dew. In case of rain wait until the rice is completely dry, otherwise the combine may get jammed.

Grain moisture content - For most rice cultivars the ideal grain moisture should be between 18 and 22% at harvest.

Adjustment and maintenance of the combine - Higher yields at reduced cost can be obtained by following all the instructions in the combine's operator manual, and making appropriate adjustments in the internal and external mechanisms. Attention should be paid mainly to its conservation status and maintenance; checking for faulty blades, lack of parts and other irregularities in the mechanisms of trashing and ventilation. Most of the combines in use have a reel speed adjusted to pull the plants into the machine which should be up to 25% higher than the combine speed. Operating the combine at excessive speed overloads the machine and predisposes it to premature wear and numerous risks of accidents. In more recently built combines, there is no need to worry about this adjustment, they already have it automatically.

When the rice is lodged, the speed of the combine must be reduced and the reel regulated shorter and more advanced than in its normal positioning, always aligned parallel to the blades. The harvest made along the lodging is more efficient and, therefore, sometimes it is necessary to harvest following a single direction, even though there may be a reduction in the efficiency of the daily operation.

Post harvest

Post-harvest involves a number of important steps such as transportation, reception, processing, packaging and storage. To reduce losses and to obtain a product of high commercial value from transport to storage, some measures should be considered.

Processing

Processing includes a number of operations rice is subject to, from its entry into the processing plant to its packaging and distribution. The goal is to improve the appearance of the cereal while protecting from pests and diseases. Processing has the following steps: pre-cleaning and drying, cleaning and classification.

Pre-cleaning and drying

Depending on the assessment by the receptionist, before drying the harvested rice has to go through pre-cleaning for getting rid of some large size impurities. These larger than the rice grain impurities are soil, stones, insects, leaves, straw and weed seeds or other plant parts that hinder subsequent operations. It is recommended to choose with discretion the appropriate set of screens and adjust the air and grains flow in the pre-cleaning machine. Thus, when well done, this operation provides better further drying, reducing costs, providing better grain classification, and higher capacity of the air screen machine.

Rice drying, for obtaining seeds or grains is an important step in keeping the quality of the harvested product. Whenever rice is harvested with moisture above 14%, drying immediately becomes necessary in order to prevent fermentation in the mass of grains and seeds which reduces their commercial value and may turn them unsuitable for human consumption or for planting due to low vigor and germination.

Special attention should be given to the moisture content, the temperature in the mass of grains during the drying, to avoid damage regarding the percentage of whole grains during processing - peeling and polishing. When drying for seeds, the temperature must not exceeding 45°C until reaching 13 to 14% of moisture. Rice for commercial grains, on the other hand, if admitted with high moisture content drying should start with air temperature below 70 °C. As the grain moisture decreases, the dryer temperature can be increased gradually. A recommended drying method is the intermittent, which passes the product two to three times through the hot air to reach the adequate storage moisture. It is important to remember that drying should be carried out immediately after harvest or at most within 24 hours.

Cleaning

Cleaning is performed by an air screen machine whose operation is similar to the pre-cleaning machine, but with more features to separate impurities not eliminated in pre-cleaning. This operation has a great number of screen options and a better control of ventilation to aspirates or to blow impurities lighter than the grains or seeds.

Classification

After cleaning, when necessary, rice should be taken to grading machines for finishing and improvement, and also to eliminate impurities left by the pre-cleaning and air screen machines. In the classification, as alternative, the separator cylinders or *trieurs*, are recommended since they pull apart the broken and peeled grains and seeds that were not previously separated. In addition to the cylinders, the gravity or densimetric table that classifies by specific weight has been very useful equipment in grading rice. One reason is that upland rice is more subject to environmental stresses (drought), with occurrence of low weight grains. Thus, the gravity table eliminates lighter seeds which, although not different in shape or size from the heavier ones, were not removed by the cleaning equipment and cylinders. The gravity table must be positioned at the end of the processing line, i.e. after the cleaning and classification machines and before the scale.

Storage

For a safe storage, it is recommended the product to be with moisture content around 13%. To maintain this moisture content – the water balance between grain and environment - rice should be stored under a relative humidity around 60% and temperature of 27 ºC.

In the State of Mato Grosso it is common for the rice to enter the warehouse with a moisture content of 13% and about six months later have this moisture lowered to around 9%. In that region the temperature in warehouses can easily reach 30 ºC or higher and the relative humidity 40% or less. In those conditions (30 ºC and 40% of relative humidity), rice grains reach their water balance at 9.0% to 9.6% of moisture.

Bulk storage can be carried out in bins or silos. When in silos rice should be taken in after they grains are cooled or partially cold and keep them at temperatures as low as possible. Aeration is also recommended to remove or distribute moisture and heat.

Conventional storage in bags should be done in good ventilated warehouse to allow air circulation between stacks. The bags must be placed on wooden pallets 12 cm tall. Whenever possible, the stacks should limit their height to 4.5 m. Regardless of the system used, the storage of rice for a period of one year does not alter the taste or odor of the product; however, when kept in uncontrolled environments, especially under high relative humidity (above 65%), the respiratory rate of the grains may increase, resulting in the occurrence of fermentation, appearance of insects and fungi development. All these events reflect negatively on the product quality and may change the taste, making it unsuitable for human consumption. Therefore, to preserve the quality of rice and prevent unnecessary losses, it is important that the storage conditions meet safe storage requirements, taking in account grain moisture and environmental conditions. A digital hygrotermograph is recommended to check the relative humidity and temperature inside the warehouse.

Purge or fumigation

Rice must be protected against pests such as weevils and moths by purging or fumigation. The aim is to eliminate insects both in their adult, pupae, larvae or egg forms. The method may result low quality grains and seed low germination, besides the presence of dead insects, eggs and rat excrement. Fumigation must be performed according to the fumigating product prescription and under the guidance and supervision of an agronomist.

Most commonly used products for purge and fumigation are those based on phosphyne (aluminum or magnesium phosphides) in tablets (0.6 g) or pellets (3 g).

For rice in bags, the recommended dosage is one tablet for three to four 60kg bags or a pellet for every 15 to 20 sixty kg bag pile. For larger amounts, fumigation should be performed when loading the warehouse, placing tablets according to the number of bags and with all upper openings in the building closed. If the storage facility is already full, it is recommended the introduction of tablets through a tube. Two thirds of the fumigant must be applied on top of the piles and the remaining at the bottom. Use 1 to 3 tablets or 3 to 6 pellets per metric ton of grain, according to prescription. When the operation is completed, grains must be covered with plastic to seal the place for a better chemical action. Humans should not remain in the interior of then warehouse.

Rice should be left at least five days under the action of the fumigating gases. The chemical product should be handled by people trained and equipped with masks and gloves because the phosphyne is highly toxic and can lead to death. In case of new infestations, repeat the operation.

Storage pest control can be supplemented with powder or liquid insecticides for disinfecting the store, aiming to exterminate the insects sheltering in crevices and depressions. The application can be carried out when the silo is already full or when it is being loaded. For such the best chemicals are fenitrothion, deltamethrine, byphenthrine, and pyrimiphos-ethyl, among others. All must comply with the technical recommendations.

All insecticide applications must follow the agronomic prescription observing their toxicity waiting period and dosages. Special care must be taken in application, reading the label and following the recommended instructions. Remember that the operator should never work alone. Besides the application of poison around the warehouse to eliminate rats, close all holes between tiles and cracks in the walls.

ATTACHMENTS

GENERAL STANDARDS FOR AGRICULTURAL CHEMICAL PRODUCTS

Legislation

According to the federal law Nº. 7802 of July 11, 1989, pesticides are chemical products and physical or biological agents used in production, storage and processing of agricultural products, and in the protection of crops, native or cropped grassland, forests and other ecosystems as well as in urban, water and industrial environments. Pesticides are used to alter the composition of the flora and fauna in order to preserve them from the harmful action of living creatures considered harmful.
Each country has its own laws and rules to regulate the activities carried out with pesticides into the country either from its own production or from imports up to the final destination of their waste and or packaging. In this sense Brazil published the complementary decree Nº. 4074 of January 4, 2002. Other aspects of the legal use of pesticides include: agricultural chemical classification, certification of service providers, transportation, application, workers safety and the final destination of its waste and already used containers. In 2005, the Ministry of Labor approved its norm # 31 regulating the safety and labors health in agriculture, livestock, forestry, logging and aquaculture. The norm establishes rules to be observed in the organizations and in the working environment of any agricultural activity including the industrial activities in the agricultural environment. The norm 31 sets the procedures and requirements to be met with regarding the use of pesticides by both the employer and employees. The main pesticides used in upland rice crops are the insecticides, herbicides and fungicides. It is important to point out is that the improper use of pesticides is subjected to fine or even imprisonment.

Classification

The toxicity of most pesticides is expressed in oral lethal averaged doses (LD50) expressed in milligrams of the active product ingredient per kilogram of body weight necessary to kill 50% of a population of rats or other test animals. The LD50 is used to establish safety measures to be followed in order to reduce risks to humans.

Pesticides are grouped into classes according to their toxicity (Table 23).

Tabela 23. DL_{50} based pesticides toxicology.

Class	*Classification*	*Label color band*
I	Extremely toxic (DL_{50} < 50mg/kg of body weight)	Bright red
II	Highly toxic (DL_{50} 50 - 500mg/kg of body weight)	Deep yellow
III	Mildly toxic (DL_{50} 500 – 5,000mg/kg of body weight)	Deep blue
IV	Little toxic (DL_{50} > 5,000mg/kg of body weight)	Deep green

Label

The label is the main form of communication between the manufacturer and the users. The information on the label are the result of years of research and tests before receiving registration and authorization from the Ministry of Agriculture, Livestock and Food Supply (MAPA) to be marketed. Therefore, before handling any pesticide, read carefully its label, which must contain the following information:

- Pests controlled by the pesticide;
- Crops where the pesticides may be applied;
- Recommended dosages for each situation;
- Toxicological classification;
- Way in which the pesticide may be used;
- Place where the pesticide can be applied;
- Time to apply the pesticide: pre-planting, pre-emergence or post-emergence;
- Toxicity waiting period, i.e. the time interval in days to observe between the application of the pesticide and harvesting. The observance of that waiting period is therefore essential so the cereal harvested won't have pesticide residue levels above the maximum allowed by the Ministry of Health. The marketing of agricultural products containing pesticide residues at levels above the ceiling set by the Ministry of Health is unlawful;
- If the pesticide can be mixed with other frequently used in similar situations; and
- If the pesticide may cause injury to crops for which it is recommended.

Application

The effectiveness of pesticides in controlling pests, diseases and weeds depends much on its application. Besides generating waste, the misuse of pesticides can contaminate people and the environment. Thus, the equipment used for applying pesticides is as important as the pesticide itself. Many problems resulting from pesticides application such as drift, uneven coverage and failure in reaching its target are due to the kind of equipment used and its handling, mostly.

When choosing a device to apply the pesticide, one must be aware of its efficiency, cost and how ease is to use and to clean it. Most pesticides are applied via spray liquid solutions or suspensions.

Before loading the equipment with the pesticide one must calibrate it, i.e. adjust it so that it applies the right amount of pesticide at the wanted site. This must be done whenever another pesticide is used or when there is a change in the dose to be applied. There are several ways to calibrate the equipment and it is important to choose a reliable and easy one.

Before use it, it is necessary to calibrate the equipment because: (1) the several equipments are not identical. Small differences can result in large variations in the actual dose to be applied, generate inefficient control and damage the environment, and (2) the wear of the sprinkler nozzles increases the flow and changes the pattern of pesticide distribution, increasing the risk of the pesticide to damage the crop.

Another caution to be taken regularly refers to the maintenance and cleaning the equipment for pesticide application. This measure is important for two reasons:

- Economy - the proper maintenance of the equipment reduces the need of replacing parts and facilitates the application of pesticides. To well calibrate the equipment it must be in good operating conditions.
- Health – the equipment may retain product residue in its parts (tank, hoses and nozzles) and surface. Such waste can contaminate people and animals. The correct cleaning of the equipment reduces the risk of contamination and poisoning.

Use precautions

All pesticides must be registered for the specific crop and the targeted pest. Its misuse can cause con be harmful to humans, wild animals, fish and other organisms that inhabit or visit the rice fields looking for food. To reduce the risk of contamination and the impact on the environment, in addition to the information printed on its label, the following measures are recommended:

- Choose the right pesticide to the target organism, taking into account the level of infestation and where the product will be applied;
- Use the pesticide at the recommended dose;
- Observe restrictions on the use of pesticides and the area;
- If the pesticide presents restrictions to its use, one must obtain a special permission with the competent government agency, whether the Brazilian Institute for environment and Natural Resources (IBAMA in Portuguese) or the State Agency for Environment Protection;
- Apply pesticides only when the weather conditions are favorable (light or inexistent winds) to prevent the drift of pesticides contaminating areas around the field and canals; and
- Observe the toxicity waiting period.

Waste and containers disposal

The disposal of waste and empty pesticide containers must be carried out according to legislation. The improper disposal of pesticide residues can result in serious harm to humans, animals and the environment. Waste includes rests of pesticides, empty containers and products contaminated with pesticides.

Empty pesticide containers must be sent to a central receiving station. Before being sent to this station all used equipment and containers are to be washed three times. The same procedure must be followed for cleaning the equipment used to apply pesticides. The triple washing of pesticide containers is conducted as follows:

- Empty the container completely, leaving the liquid to drain from the spray tank;
- Add water to 25% of the container capacity;
- Close and shake the container for 30 seconds;
- Make the water in the container to pass through the spray tank;
- Repeat the procedure at least two more times; and
- Pierce the container to ensure that it will not be reused for other purposes.

Good management practices

Good pest management control practices (GMP include procedures preventing the potential risk of pesticides being carried by water reaching underground reservoirs and potentially contaminate the drinking water of cities and rural communities.

When incorporated into farming regular operations the GMPs listed below can reduce the potential adverse impact of pesticides regarding the environment and human health.

. **Integrated pest management** – The integrated pest management (IPM) is the consistent use of all means of control, chemical or not, to reduce crop losses caused by insects, diseases and weeds. The pesticides are a resource for controlling pests and are to be used only when economically feasible. In other words, the value of the expected loss due to pest should be higher than the cost of its control. Therefore, monitoring and sampling pest agents must be a regular farming practice to check if the level of infestation justifies the pest control, whether it is by using insecticides or other measures like traps.

. **Protected areas between the crop and the most sensitive areas** – Underground water may be contaminated by pesticides carried away by soil water. To avoid it, farmers can create a buffer zone of natural or planted forests between the crop fields and the natural water reservoirs as a barrier to contamination.

. Alternative methods of pest control - Usually,pests control requires less effort than it is actually done to reduce the level of losses. Often the combination of agricultural practices to slow down the advancement of pests and to preserve their natural enemies is used as preventive measure or as a more efficient tool than the pesticides themselves. Moreover, consumers and industries are increasingly asking for farm products free or with a minimal amount of pesticides.

TECHNICAL COEFFICIENTS, COSTS AND YIELD

These coefficients were generated in the 2004-2005 season by a panel of specialists. The price factors were later updated for the 2006/2007 crop costs.

Production costs

The survey of production costs is of great value to assess the efficiency of the productive process, management tool and economic evaluation of the agricultural activity. Thus, the monitoring of costs should not be used only as a historical account of the business finances, but also as a valuable tool in decision-making.

Below are the fixed, variable and total estimated production costs of upland rice based on the average of production systems used by different sized farms in the state of Mato Grosso.

The production cost is the return on capital plus expenses with inputs, farming and other operations used in a production process. The total production cost is the sum of fixed and variable costs.

The fixed cost is that of the production factors whose quantities do not vary in short term, even if the market indicates to change the production scale. This text considers as fixed cost the depreciation and interests over the value of machinery and equipment as well as the remuneration of the capital invested in land or the estimated cost for rent or lease.

The variable cost includes the payment for production factors whose quantities can be altered according to the level of production desired. Production factors are seeds, fertilizers, agricultural operations, transport and the like.

Each farm has its own topography, physical condition, soil fertility, type of machinery, surface cropped, technological and even management aspects. These features differentiate the farm in terms of structure and production costs. Therefore, costs may be different and the balance point and coverage yield may vary due to changes in the production cost or in the final product price, resulting in higher or lower profitability. The coverage yield indicates the amount of money necessary to cover all costs.

Two production systems were considered: one was upland rice in no previously cropped land and the other was rice after pasture or soybean. Table 24 shows the cost of upland rice crop in new areas while Table 25 shows the same after pasture or soybean in Mato Grosso. Table 27 has the costs of Rondônia.

Table 24. Fixed, variable and total cost per hectare of upland rice in new areas of Mato Grosso (2006/07)*.

Cost component		Unit	Amount	Unit Price (R$)	Value (R$)	Share (%)
A –	**Fixed cost**				**328.17**	**26.20**
	Depreciation and interest	R$			193.07	15.40
	Remuneration of land	R$			135.10	10.80
B -	**Variable cost**				**923.84**	**73.80**
B.1 -	**Supplies**				**545.63**	**43.60**
	Rice seed	kg	75.00	1.10	82.50	6.60
	Fungicide 1 (seed treatment)	kg	0.14	144.00	20.16	1.60
	Fungicide 2 (seed treatment)	l	0.14	35.00	4.90	0.40
	Insecticide (seed treatment)	l	1.40	31.50	44.10	3.50
	Fertilizer (maintenance)	t	0.40	676.00	270.40	21.60
	Fertilizer (cover)	t	0.10	644.00	64.40	5.10
	Insecticide 1	l	0.05	24.20	1.21	0.10
	Insecticide 2	l	0.06	61.00	3.66	0.30
	Insecticide 3	l	0.50	14.00	7.00	0.60
	Fungicide	l	0.30	136.00	40.80	3.34
	Ant poison	l	0.10	6.50	6.50	0.50
B.2 -	**Agricultural operations**				**242.00**	**19.30**
	Harrow	hm	1.60	54.23	86.77	6.90
	Leveling harrow	hm	0.65	54.00	35.10	2.80
	Sowing / fertilization	hm	0.50	55.06	27.53	2.20
	Internal transport	hm	0.50	38.73	19.37	1.50
	Topdressing	hm	0.30	36.01	10.80	0.90
	Application of insecticides (two app.)	hm	0.50	36.36	18.18	1.50
	Application of fungicides	hm	0.25	36.36	9.09	0.70
	Application of ant poison	dh	0.04	35.00	1.40	0.10
	Harvest	hm	0.50	67.51	33.76	2.70
B.3 -	**Other costs**				**136.21**	**10.90**
	External transport	sc	65.00	0.90	58.50	4.70
	Technical assistance	sc	0.30	21.00	6.30	0.50
	Interest	%	8.75		34.55	2.80
	Rural Social Security (CESSR)	%	2.70		36.86	2.90
Total cost (A + B)				**1,252.01**	**100.00**	

* Expected productivity: 65 sacks/ha.

Table 25. Fixed, variable and total cost per hectare of upland rice in new areas of Mato Grosso (2006/07)*.

Cost component	*Unit*	*Amount*	*Unit Price (R$)*	*Value (R$)*	*Share (%)*
A – Fixed cost				**386.15**	**18.30**
Depreciation and interest	R$			214.65	10.10
Remuneration of land	R$			171.50	8.20
B - Variable cost				**1.710.37**	**81.70**
B.1 - Supplies				**1,120.06**	**53.50**
Lime	t	1.00	82.00	82.00	3.90
Rice seed	kg	75.00	1.15	86.25	4.10
Fungicide 1 (seed treatment)	kg	0.14	27.00	3.78	0.20
Insecticide (seed treatment)	l	1.40	45.00	63.00	3.00
Fertilizer (maintenance)	t	0.40	1,630.00	652.00	31.10
Fertilizer (cover)	t	0.10	1.235.00	123.50	5.90
Herbicide 1	l	3.00	15.30	45.90	2.20
Herbicide 2	l	3.30	1.10	3.63	0.20
Insecticide 1	l	0.10	19.50	1.95	0.10
Insecticide 2	l	0.06	67.50	4.05	0.20
Insecticide 3	l	0.50	15.00	7.50	0.40
Fungicide	l	0.30	155.00	46.50	2.20
B.2 - Agricultural operations				**350.71**	**16.80**
Liming	hm	0.20	58.21	11.64	0.60
Harrowing	hm	1.60	69.12	110.58	5.30
Leveling harrow	hm	0.65	66.62	43.30	2.10
Sowing	hm	0.50	70.80	35.40	1.70
Internal transport	hm	0.50	53.71	26.85	1.30
Topdressing	hm	0.30	45.05	13.51	0.60
Application of herbicides	hm	0.25	48.21	12.05	0.60
Application of insecticides (two app.)	hm	0.50	48.21	24.10	1.10
Application of fungicides	hm	0.25	48.21	12.05	0.60
Harvest	hm	0.50	122.46	61.23	2.90
B.3 - Other costs				**239.60**	**11.40**
External transport	sc	65.00	1.16	75.40	3.60
Technical assistance	sc	0.30	35.00	10.50	0.50
Interests	%	6.75	46.31	2.20	
Rural Social Security (CESSR)	%	2.70	61.43	2.20	
Proagro	%	6.70	45.98	2.20	
Total cost (A + B)				**2,096.52**	**100.00**

* Expected productivity: 65 sacks/ha.

Supplies

It is important to note that supplies are the highest production costs for new crops (43.60%) and for areas in rotation (53.50%).

Fertilizer (maintenance and coverage) is the main production cost. It is 26.70% in new areas and 37.00% in pasture or soybean.

Income

Based on the two production systems, upland rice in new areas and in previous pasture or soybean fields, farmers can obtain revenue equal or above the production costs, providing they use the technology expressed by the system reflected on the cost items.

For upland rice in new areas, get rid of the existent vegetation and in the following year burn the slash, cut out any bushes or roots found so the soil can be prepared.

Considering an expected yield of 3,900kg/ha which can be obtained by both systems, the average total cost per 60kg bag is 19,26 reals for rice from new areas and 32.25 reals for rice cropped after pasture or soybeans (Table 26). However, while the yield needed to face the production costs in new areas is 3,130kg/ha that from pasture or soybean areas will be 3,594 kg/ha.

Table 26. Economic indicators for upland rice in Mato Grosso in 2006/07 (new area) and 2008/09 (rotation).

Economic indicator	*Unit*	*New area*	*Area with soybean or pasture*
Fixed cost	R$	328.17	386.15
Variable cost	R$	923.84	1,710.37
Total cost	R$	1,252.01	2,096.52
Average variable cost	R$	14.21	26.31
Average Total Cost	R$	19.26	32.25
Price paid to producers	R$	24.00	35.00
Revenue	R$	1,560.00	2,275.00
Gross margin	R$	636.16	564.63
Net margin	R$	307.99	178.48
Production of coverage	sc ha^{-1}	52.2	59.90
Expected productivity	sc ha^{-1}	65.0	65.00
Cost / benefit ratio	1.25	1.09	

Table 27. Fixed, variable and total cost per hectare of upland rice per hectare in Rondônia (2009/10)*.

Cost component	*Unit*	*Amount*	*Unit Price (R$)*	*Value (R$)*	*Share (%)*
A - Fixed cost				**540.00**	**32.61**
Depreciation and interest	R$	260.00		260.00	15.70
Remuneration of land	R$	280.00		280.00	16.91
B - Variable cost					
B.1 - Supplies				747.97	45.16
Seeds	kg	65	1.65	107.25	6.48
Lime	t	1	82.00	82.00	4.95
Fertilizer (sowing)	kg	300	0.82	246.00	14.85
Fertilizer (coverage)	kg	100	0.95	95.00	5.74
Fungicide 1 (seed treatment)	l	0.175	28.90	5.06	0.31
Fungicide 2	l	0.3	115.60	34.68	2.09
Insecticide 1 (seed treatment)	l	1.1	28.90	31.79	1.92
Insecticide 2	l	0.5	15.30	7.65	0.46
Herbicide 1	l	2.5	9.50	23.75	1.43
Herbicide 2	l	2.5	17.00	42.50	2.57
Herbicide 3	l	0.8	57.80	46.24	2.79
Herbicide 4	l	0.5	39.10	19.55	1.18
Ant poison	l	0.10	6.50	6.50	0.50
B.2 - Agricultural operations				**189.59**	**11.45**
Liming	hm	0.2	30.86	6.17	0.37
Harrowing	hm	1	44.63	44.63	2.69
Leveling harrow (2)	hm	1	30.86	30.86	1.86
Sowing / fertilization	hm	1	39.37	39.37	2.38
Labor d/h	0.6	12.00	7.20	0.43	
Application of insecticides	hm	0.3	31.43	9.43	0.57
Application of fungicides	hm	0.3	31.43	9.43	0.57
Harvest	hm	0.50	67.51	33.76	2.70
B.3 - Other costs				**178.61**	**10.78**
External transport	sack	72	1.00	572.00	4.3
Funrural	2.70%	0.027	1,500.00	40.50	2.45
Interest on turnover capital (6 months)	10.75%	0.05375	1,229.89	66.11	3.99
Total cost (A + B)				**1,656.10**	**100.00**

* Expected productivity: 65 sacks/ha.