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Production of Irrigated Rice in the Second Stage of the River Formoso Project in the Brazilian Savanna Region

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The information survey was carried out in the second stage of the Formoso River Project in Formoso do Araguaia - TO, in the COPERJAVA area - Mixed Cooperative Rural Valley of Javaés Ltda, located in the Brazilian savanna region. During the research period, some practices related to the production of irrigated rice were monitored, such as straw burning, soil preparation, sowing, nitrogen fertilization cover, and phytosanitary treatments to control weeds, insect pests, and diseases. Monitoring was made in the cultivated areas to observe the development of irrigated rice, and to regulate the height of the water depth in the plots and its uniformities of the water depth. Activities were developed to regulate equipment and facilities involved in rice production. These provided an increase in the knowledge acquired about the irrigated rice crop, emphasizing the need and importance of the association between the theoretical basis acquired during the course and the practice in the field.

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Keywords: Riziculture; monitoring; handling.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is among the three most consumed and produced cereals in the world, is an annual grass originating in Asia, belonging to the Poaceae family, having a photosynthetic system C3. It is a specie adapted to the aquatic environment due to the presence of aerenchyma in the stem and roots, thus allowing the passage of oxygen from the air to the rhizosphere layer [1].

This cereal is considered one of the most economically important products in many developing countries, constituting basic food for about 2.4 billion people. The increasing consumption in the world imposes on the productive sectors the search for new techniques and technologies that can increase production. Being a means of combating hunger in the world [2].

In Brazil, rice is cultivated in two different environments: in lowland conditions and as dry land in the highlands, and due to the edaphoclimatic peculiarities of each of the environments, they have different production systems. Most of the rice production in Brazil is the result of a lowland ecosystem, where irrigated rice cultivation accounts for 69% of the national production, being considered a stabilizer of the national crop, not as dependent on climatic conditions as in the case of land-water crops. In Brazil, there are 33 million hectares of floodplains, with topography and availability of water conducive to food production. However, only 3.7% of this area is used for oriziculture [2].

The Araguaia River lowland soil is 500,000 hectares long and is considered the largest continuous flood irrigation area in the world [3]. Thus, this region has a great potential for the cultivation of flooded rice in the rainy season, being explored since the mid-1970s.

The development of the rice plant is usually expressed by chronological age, in the number of days after emergence, and not by physiological stage. The specific time intervals between the stages and the total numbers of developed leaves may vary between cultivars, sowing period, soil fertility, and growing regions [4].

The occurrence of shading in the reproductive phase and grain filling harms productivity. In these phases, the demand for photoassimilates is high due to the greater amount of organs of drains (panicles) compared to the vegetative phase (leaves), which makes the energy balance of negative photosynthesis, consequently compromising productivity.

Among the climatic factors, the photoperiod, temperature, and solar radiation mostly affect the growth, development, and, consequently, the productivity of the cultivated rice crop under irrigated conditions. The main problems caused by these factors are: cycle shortening in photoperiod-sensitive plants [5], increased sterility of spikes due to temperatures below 15 ºC or above 35 ºC in the flowering period [6,7], and a fall in grain yield at the time of low radiation accumulation in the grain filling period [8,9].

Red rice is one of the weeds that cause damage to the rice crop responsible for causing reduced productivity, presenting difficulty in controlling, increasing the cost of production, and depreciation of the commercial value of the final product, making it possible to achieve losses of 20% of production. The use of herbicide-resistant cultivars of the chemical group of imidazolinones, identified by the suffix ¨CL" (*Clearfield®*) or IR (Imidazolinones Resistant), has been a great ally in the management of areas with high red rice infestation.

In the Tocantins, irrigated rice areas showed a delay in planting due to low levels of reservoirs, rivers, and rainfall. The rice growers had to wait for the return of the rains to carry out the planting safely. The areas had average productivity of 5.907 kg ha^{-1} [10].

One of the limiting factors for the expansion of irrigated rice from the Tocantins in recent years is the need for new rice cultivars resistant to blast through genetic improvement techniques and with satisfactory quality of the final product [11]. The production of irrigated rice in the rainy season has become a great challenge to rice growers due to the breakdown of resistance of cultivars due to the *Magnaporthe grisea* in the period of two to three consecutively cultivated crops.

2. METHODOLOGY

2.1 Characterization of the Physical and Socio-economic Environment of the Araguaia Formoso Region - to

2.1.1 Location

Formoso do Araguaia is the largest municipality in the territorial extension of the State of Tocantins, with a territorial area of 13.423,38km². It has the geographic coordinates 11º 47' 48" south latitude and 49º 31' 44" of west longitude, with an altitude of 240m, with an estimated population of 18,773 inhabitants, of which 13,258 reside in urban areas [12]. The research was carried out in the second stage of the Formoso River Project in Formoso do Araguaia - TO, in the area of COPERJAVA - Mixed Cooperative Rural Valley of Javaés Ltda.

2.1.2 Climate and Rainfall Aspects

The climate of the Formoso does Araguaia region is defined as tropical dry and humid, with two well-defined seasons: a dry season and a rainy season that correspond to the climatic classification Aw Köppen (1948). The average annual precipitation varies between 1,400 to 2,200mm year^{-1}, more than 70% of the total precipitation occurs between November to March. The average annual temperature increases in the north direction of the region, ranging from 22ºC to 26ºC reaching a maximum of 38ºC in August and September [13].

2.1.3 Main soils of the region

The predominant soils in the Araguaia Plain are the Plinthssolos and Gleissolos. Plinthosols are soils with a plinthic B diagnostic horizon, having as characteristic soils formed on land with high groundwater or presenting temporary restriction to water percolation.

Plintite is agglomerated of reddish and reddish-colored iron and aluminum oxides. They are soft and plastic when damp, and hard and indeformable when dry. They have soils of sandy frank texture, moderately acidic, and with low activity clay, presenting reduced colors due to the oscillation of the water table [2].

Gleissolos are characterized by iron reduction and the prevalence of reduced state or reduced part, mainly due to still water, evidenced by neutral or close to neutral colors in the horizon matrix, with or without more vivid color muskets. It is a horizon strongly influenced by the water table, possibly free of dissolved oxygen due to year-round water saturation, or at least for the year [2].

2.1.4 Socioeconomic aspects

Formoso do Araguaia is the largest municipality in the territorial extension of the state of Tocantins and has the largest irrigated rice project in the continuous area in the world, totaling 27,787 ha of the floodplain. The intensifications and occupations of land in these places, were mainly by people coming from other regions increasing the number of settlements in the region. The municipality has five settlement projects with an area of 53,813,271 hectares of land and 575 families settled in the settlements Gameleira, Caracol, Pirarucu, Três Poderes, and Lagoa da Onça.

These settlement projects have contributed greatly to the expansion of the local economy. The main crops of the settlements are irrigated rice, with a planted area of 2496 hectares; Maize (*Zea mays*), with an area of 684 ha and *Manihot esculenta*, with 200 ha. The production of family farming is consumed and commercialized in the municipality, while the large producers are aimed only at exporting.

3. ACTIVITIES WERE CARRIED OUT

During the research period, intense participation in activities related to irrigated rice cultivation was opportunistic, especially soil preparation, sowing, nitrogen fertilization, weed control, pest control, fungal disease control, water depth regulation in plots, facilities used for rice production, calibration and regulation of agricultural equipment and harvesting. All these practices were associated with periodic inspections and monitoring of cultivated areas.

3.1 Desiccation and Soil Preparation

The total desiccation of the area to be cultivated with the conditional selective herbicide of systemic action of the chemical group was carried out in advance: glycine replaced, formulation: Soluble Concentrate (SC) trademark Syngenta Zapp QI 620 (4 L ha^{-1} of the p.c.). After desiccation, the vegetation cover was burned and soil preparation was carried out in the conventional system. The preparation consisted of the use of a plow gradation and two leveling gradations. Some plots were carried out only with the leveling grid because there was no need to make a crate. After leveling, the compactor roller was scrolled to standardize the soil before sowing.

3.2 Choice of Cultivars

The choices of cultivars for harvest were based on genotypes with different cycles for the scaling of the area and facilitate the harvest, disease tolerant, like the *Magnaporthe grisea* being the main fungal disease and also taking into account weed control, in specific red rice with the technology (*Clearfield®*). The cultivars used IRGA 426, Epagri SCS 121 CL, BRS 701 CL, BRS Catiane, and BRS Tropical.

3.3 Rice Sowing

The treatment of seeds was carried out with VITAVAX THIRAM 200 SC 0,250 L p.c. 100 kg^{-1} of seeds, systemic fungicide, and chemical group contact Carboxanilida (Carboxina). Dimethyldithiocarbamate (Tiram) and FIPRONIL NORTOX 0,250 L p.c. 100 kg^{-1} of seeds, contact insecticide, and intake of the chemical group Pyrazole. The treatment of seeds ensures the sanity of rice seedlings to diseases and pests. Sowing was carried out with a trademark sower Semeato model TDNG 420 from 26 lines, with the spacing of 0.17 meters between lines and a population on average of 50 to 60 seedlings per linear meter, with an average spend of 115 kg ha^{-1} the 120 kg ha^{-1} of seeds. It was used in sowing 350 Kg ha^{-1} of the formulated fertilizer 5-30-20 + micronutrients. After sowing, the compactor roller was scrolled to improve and standardize the emergence of rice seedlings and increase the efficiency of the pre-emergent herbicide. The herbicide used was the Goal BR common name oxyfluorfen (0,3 L h^{-1} of the p.c.).

3.4 Nitrogen Management in Rice

Nitrogen favors plant development and increased productivity components. Its requirements are high because it is one of the nutrients that accumulate the most in the plant. It is responsible for encouraging the leaf area index of the plant, increasing the efficiency of interception of solar radiation, increasing photosynthetic rate, and, consequently, grain yield. N deficiency is one of the factors that most limit the productivity of irrigated rice. The efficiency of N recovery by irrigated rice is less than 50% in lowland soils. The low efficiency of N recovery by plants is associated with volatilization, leaching, and denitrification [14].

Under field conditions, the recommendation of nitrogen fertilization is based on soil analysis and crop response depending on the genotype. Three years of work carried out by [15], concluded that the adequate nitrogen cover dosage for irrigated rice is among the ranges of 90 the 120 kg ha^{-1} from N, serving the main rice-producing regions in Brazil.

Nitrogen fertilization performed at the research site was programmed in four applications with an average interval of 10 days between applications, starting at 15 DAE and ending at 45 DAE, where the dosages used were 100 kg ammonium sulfate, 100 kg of 30-00-20, 70 kg of urea and 70 kg of urea, totaling 113 kg of cover N.

3.5 Phytosanitary Management

Phytosanitary treatments performed in rice culture started 15 days after emergence, due to the initial phase being a very critical period. The rice plant begins to determine its productive potential and there can be no competition or damage caused by pests, applications of herbicides, insecticides, and fungicides were carried out by land and aerial spraying, with the use of agricultural aircraft, where aviation the used doses of each product were calculated, insecticide applications were carried out simultaneously with fungicides or herbicides according to the phenological stage of the crop prepared based on observations and periodic monitoring of cultivated plots.

3.5.1 Weed control

During the research, weed species that occurred most frequently in rice cultivation were, rice grass (*Echinochloa spp.*), Angiquinho (*Aeschynomene spp.*) *Cyperus ferax*, *Cyperus iria*, and *Cyperus difformis*, popularly called by Junquinho, Juncão. In the initial phase of the crop, they are quite competitive and aggressive, competitiveness decreases when the rice plant starts shading the lines [2].

4. RESULTS AND DISCUSSION

There are herbicide-resistant cultivars of irrigated rice on the market of the chemical group of imidazolinones. Identified by suffix “CL” (*Clearfield®*) or “IR” (Imidazolinones Resistant).

In Brazil, it was launched in 2002, the first cultivar with this characteristic was the cultivar (IRGA 422 CL). The use of non-selective herbicides, in association with resistant cultivars, should occur when there is a high infestation of red rice (*Oryza ssp*) in the area to be cultivated and may compromise 20% of the production [16].

Weed control was performed in cultivated areas with the use of herbicides, and chemicals are one of the most used methods for weed control in rice crops, due to practicality and efficiency. For weed control, herbicide choices were made according to the diagnosis made in each of the plots, incidence level, species present with higher pressure, and stage of development of weeds and crops.

4.1 Pest Insect Management

The bedbug *Tibraca limbativentris*, known as rice stem bedbug is an important pest in irrigated rice crops, causing damage throughout the crop cycle, the insect bite occurs at the base of the plants, in the vegetative phase, causes the appearance of symptoms known as “dead heart” and, in the reproductive phase, known as “white panicle” [17]. A study conducted by [2], with the cultivar BR IRGA 409, about different male populations of *T. limbativentris*, observed that infestations in the reproductive phase increase the number of broken and gnawed grains and that 1 bedbug m², in the vegetative phase, causes a reduction of 58.7 kg ha^{-1} grain production.

Bedbugs of panicles *Oebalus poecilus* [18], and *Oebalus ypsilongriseus* [19], affect the quantity and quality of the grain, feeding on the spikelets in the maturation phase. According to [2], the permanence of an adult from *O. poecilus* panicle, from the beginning of the milky phase of the spikelets to their complete maturation can cause a reduction of 10.4% in the mass and 12.3% in the germination power of the spikelets, the samplings should be carried out preferably in the early morning or late afternoon, avoiding the hottest period of the day, when mean number equal to or greater than 0.3 bedbugs per fall of 0.38 x 0.80 m is collected, starts the control for both insects. The management adopted in the cultivated plots was preventive for both the stem and panicle bedbugs, ensuring the clean site of pests and ensuring the health of the crop.

4.2 Disease Management

Rice, throughout its cycle, is affected by diseases that can drastically limit grain yield and quality. The main disease that occurs in irrigated rice crops in the Formoso region of Araguaia is the *Magnaporthe grisea*, caused by the fungus *Pyricularia grisea*, which causes productivity to drop by 20 to 50% [20]. The severity of this disease is influenced by favorable environmental conditions and cultural practices, being favored by the high temperature and humidity in the flowering period, which provides favorable conditions for infection and the spread of the pathogen [21]. The management of diseases adopted in cultivated areas was preventive starting at 30 DAE and ending in the reproductive phase of the bunch emission.

4.3 Water Slide Control and Water Pump Installations

The management of the water depth in irrigated rice helps in the reduction of water waste, prevents the removal of nutrients that are transported in suspension in the water, assists in the control of weeds, and influences the components of productivity and grain production. It was carried out to pump installations in the plots where the rice was in the phase of differentiation of the floral onset, at the beginning of the reproductive phase, and in the emission of panics, due to historical water deficit occurred reducing the level of the waterway of the plot.

4.4 Implement Regulation and Calibration

The regulation and calibration of the hydraulic drag bar spray were performed for each chemical used in pre and post-sowing, and the seed distribution was adjusted where only the current in the gear system was moved both seed and fertilizer. The regulation for seed distribution was made following the recommendations for each cultivar totaling an average expenditure of 115 kg ha^{-1} the 120 kg ha^{-1} of seeds. The flow and vane scans of the solid fertilizer hydraulic distributor of the trademark were regulated Stara model TWISTER 1500 APS, for each nitrogen source used in coverage with an applied range of 24 meters.

4.5 Harvest

Harvesting at the right humidity is important to obtain a grain of better quality and with a higher yield. Rice reaches the appropriate ripening point when two-thirds of the panicle grains are ripe. Although this phase is easy to be determined visually, one can also take as a basis the moisture content of the grains, which should be

Table 1. Trade name, active ingredients of post-emergent herbicides, chemical group, mechanism of action, and dosages applied in cultivars for weed management

Trade name	Active Ingredient	Chemical Group	Mechanism of Action	Dose (L h^{-1} or Kg h^{-1} do p.c.)	Volume of air syrup L h^{-1}
2,4-D Nortox	2,4-D	Aryloxyalcanoic acid	Auxin's Mimetizer	0,150	20 L h^{-1}
Basagram	Bentazone	Benzothiadiazine	Inibição da fotossíntese no fotossistema II	2,0	20 L h^{-1}
Clincher	Butyl cialofope	Aryloxyphenoxypropionic Acid	Inhibition of the enzyme Acetyl CoA carboxylase	2,0	20 L h^{-1}
Gamit Star	Clomazone	Isoxazolidinona	Carotene synthesis inhibitor	0,200	20 L h^{-1}
Kifix	Imazapir + Imazapique	Imidazolinone	Inhibition of the enzyme Aceto Lactate Synthase (ALS)	0,120	20 L h^{-1}
Stam	Propanil	Anilidas	Inhibition of photosynthesis in photosystem II	3,7	20 L h^{-1}

Source: (Author Himself)

Table 2. Trade name, active ingredients of insecticides, chemical group, mechanism of action, and dosages applied in cultivars for the management of insect pests

Trade name	Active Ingredient	Chemical Group	Mechanism of Action	Dose (L ha^{-1} or Kg ha^{-1} of the p.c.)	The volume of air syrup L ha^{-1}
Urge 750 SP	Acephate	Organophosphate	Acetylcholinesterase Inhibitor	0.600	20 L ha^{-1}
Fastac® 100 SC	Alpha-Cypermethrin	Pyrethroid	Inhibitor of transmission of nerve impulses	0.200	20 L ha^{-1}

Source: (Author Himself)

Table 3. Trade name, fungicide active ingredients, chemical group, mechanism of action, and dosages applied in cultivars for disease management

Trade name	Active Ingredient	Chemical Group	Mechanism of Action	Dose (L h^{-1} or Kg h^{-1} of the p.c.)	The volume of air syrup L h^{-1}
Alterne	Tebuconazole	Triazole	Inhibition of Biosynthesis sterol	0.750	20 L h^{-1}
Bim	Triciclazole	Benzotriazole	Inhibition of biosynthesis From melanin (MBI's)	0.400	20 L h^{-1}
Propiconazole Nortox	Propiconazole	Triazole	Inhibition of Biosynthesis Sterol	0.600	20 L h^{-1}
Native	Trifloxistrobin + tebuconazole	Strobilurine + triazole	Inhibitor of Breathing and Inhibition of Biosynthesis sterol	0.750	20 L h^{-1}

Source: (Author Himself)

between 20 and 23%, depending on the cultivar. Early harvesting, with high humidity, increases the proportion of malformed and gessated grains. The rice harvested late, with very low humidity, affects the production by the degree at harvest, occurring the cracking of the grains and the reduction of the yield of a whole in the processing [2].

5. CONCLUSION

During the field research, it was possible to monitor the activities of irrigated rice production. And how is the production process of the crop from planting to harvesting, being an opportunity to acquire experience and greater knowledge about rice crops. Thus, the research provided the opportunity to be more prepared to conduct irrigated rice.

Monitoring the entire production process is of great importance, not only for professional growth but also for personal growth. The dynamics of working as a team experienced during the research period contributed greatly to obtaining information about irrigated rice.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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