

Timing of nitrogen application and cover crops on upland rice economic viability

Abstract – The objective of this work was to evaluate the economic viability and competitiveness of upland rice (*Oryza sativa*), compared with flooded rice, in a system with different nitrogen fertilization timing and cover crops in Southeastern Brazil. The treatments consisted of upland rice grown under *Urochloa brizantha* or *Urochloa ruziziensis* straw, with the following fertilization: T, 30 kg ha⁻¹ N at rice sowing + no extra N supply (0 kg ha⁻¹); C, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N at rice tillering; A2, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N one day before rice sowing; and A1, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N in the living cover crops. Total operating cost, gross revenue, operating profit, profitability index, and equilibrium price were determined. Upland rice results in a monetary gain for the farmer similar to that of flooded rice when nitrogen is added, regardless of fertilization timing. Under rainfall deficit conditions, upland rice sown on *U. brizantha* straw shows higher profitability rates than when sown on *U. ruziziensis*. When there is a possibility of rainfall deficit, *U. brizantha*, as a cover plant, results in a greater economic security for upland rice producers.

Index terms: *Oryza sativa*, *Urochloa brizantha*, *Urochloa ruziziensis*, paddy rice, rainfed rice.

Épocas de aplicação de nitrogênio e plantas de cobertura na viabilidade econômica do arroz de terras altas

Resumo – O objetivo deste trabalho foi avaliar a viabilidade econômica e a competitividade do arroz (*Oryza sativa*) de terras altas, em comparação ao arroz inundado, em sistema com diferentes épocas de fertilização nitrogenada e plantas de cobertura, no Sudeste do Brasil. Os tratamentos consistiram de arroz de terras altas cultivado sob palha de *Urochloa brizantha* ou *Urochloa ruziziensis*, com a seguinte fertilização: T, 30 kg ha⁻¹ de N na semeadura do arroz + sem N extra (0 kg ha⁻¹); C, 30 kg ha⁻¹ de N na semeadura do arroz + 90 kg ha⁻¹ de N no perfilhamento do arroz; A2, 30 kg ha⁻¹ de N na semeadura do arroz + 90 kg ha⁻¹ de N um dia antes da semeadura do arroz; e A1, 30 kg ha⁻¹ de N na semeadura do arroz + 90 kg ha⁻¹ de N nos plantios das plantas de cobertura. Foram determinados custo operacional total, receita bruta, lucro operacional, índice de lucratividade e preço de equilíbrio. O arroz de terras altas resulta em ganho monetário para o produtor similar ao do arroz inundado quando se adiciona nitrogênio, independentemente da época de adubação. Em condições de déficit hídrico, o arroz semeado na palhada de *U. brizantha* apresenta maior índice de lucratividade que o semeado na de *U. ruziziensis*. Quando há a possibilidade de déficit hídrico, *U. brizantha*, como planta de cobertura, resulta em maior segurança econômica para os produtores de arroz de terras altas.

Termos para indexação: *Oryza sativa*, *Urochloa brizantha*, *Urochloa ruziziensis*, arroz de sequeiro, arroz de várzea.

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Received
April 17, 2020

Accepted
November 23, 2020

How to cite
PASCOALOTO, I.M.; CRUSCIOL, C.A.C.; NASCIMENTO, C.A.C. do; FERREIRA, C.M.; SILVA, M.A.S. da; SOUZA, L.G.M. de; ESPERANCINI, M.S.T. Timing of nitrogen application and cover crops on upland rice economic viability. *Pesquisa Agropecuária Brasileira*, v.56, e01924, 2020. DOI: <https://doi.org/10.1590/S1678-3921.pab2020.v56.01924>.

Introduction

One of the greatest challenges faced worldwide by agricultural research is developing sustainable agriculture systems that produce more while requiring fewer inputs and less water (Mohanty et al., 2019). The increase in the average global temperature due to climate change has led to the increase in the frequency of prolonged drought periods, with changes in the dynamics of precipitation, which may affect water availability in the future (Boonwichai et al., 2018).

This scenario calls attention to the sustainability of the production of rice (*Oryza sativa* L.), the most consumed cereal in the world, which requires large amounts of water (Mohanty et al., 2019). In Brazil, rice is mostly grown in flooded soil (Peron et al., 2019), accounting for 81% of all rice production over 1.4 million hectares (Conab, 2019).

In 2017, three trillion cubic meters of water were used for global flooded rice production (FAO, 2020), with an average water demand of 15,000 m³ ha⁻¹ (Suárez & Sánchez-Román, 2016). Twenty-two billion cubic meters of water were consumed in the 2017/2018 harvest only in Brazil (Conab, 2019). Since part of the water used in irrigation does not return to its original course, which reduces the effective availability of the source (Back & Just, 2018), alternatives are being sought. Upland rice production is one of them due to its capacity of producing grains while conserving water (Portugal et al., 2015).

Besides using less water, upland rice causes lower greenhouse gas emissions, compared with flooded rice. Flooded rice is grown in an anaerobic environment, where methane (CH₄) and nitrous oxide (N₂O) are formed and emitted (Weller et al., 2015), whereas upland rice is cultivated in non-flooded areas; however, there may still be nitrogen losses due to leaching, volatilization, and erosion, which are important contributors to environmental pollution. According to Signor & Cerri (2013), a high amount of N₂O is produced through soil nitrification and denitrification, which are processes associated with nitrogen availability and management.

Nitrogen losses due to volatilization and leaching can be reduced by applying the fertilizer at a time when the nutrient is better absorbed and immobilized by plant tissues, both in growing rice and also in advance in growing cover crops. Several works on no-tillage systems have shown that, when there is

straw over the soil, N fertilization before upland rice sowing is possible and equally as practical as split fertilization in guaranteeing upland rice yield (Lopes et al., 2013; Arf et al., 2015; Nascente & Lanna, 2016; Pinheiro et al., 2016). However, none of these studies have analyzed the economic aspect of N fertilization applied in advance.

Decision making regarding fertilization must be based not only on technical aspects but also on a financial analysis, as the farmer always expects profit, regardless of which production system will be used (Araújo et al., 2012). In this context, scientific research has to find the balance between monetary profit and environmental protection, which is necessary to preserve the health of the planet, ensuring, at the same time, that the developed technologies are widely adopted by farmers and result in a sustainable food production.

The objective of this work was to evaluate the economic viability and competitiveness of upland rice, compared with flooded rice, in a system with different nitrogen fertilization timing and cover crops in Southern Brazil.

Materials and Methods

The experiment was installed in an upland area at Lageado experimental farm, which belongs to Faculdade de Ciências Agronômicas of Universidade Estadual Paulista, located in the municipality of Botucatu, in the state of São Paulo, Brazil (22°53'09"S, 48°26'42"W, at 840 m altitude), in the 2017/2018 and 2018/2019 growing seasons.

According to the Köppen-Geiger classification, the climatic type of the area is Cwa, which is characterized as high-altitude tropical with rainy summers and dry winters. During the two years of the experiment, climatic data were collected at the weather station of Lageado experimental farm (Figure 1).

During the 2017/2018 growing season, the total rainfall between October 2017 and April 2018 was 762 mm. Throughout the stages of rice growing and tillering (between December and February), flowering (between February and March), and maturation (March and April), accumulated rainfall was 324, 54, and 32 mm, respectively. In the 2018/2019 growing season, total precipitation was 970 mm, and accumulated rainfall was 436, 87, and 127 mm in the growth, flowering, and maturation stages, respectively.

The soil of the area is classified as a Latossolo Vermelho Distrófico (Santos et al., 2018), i.e., a Ferralsol (IUSS, 2015). The following soil chemical

properties were determined in the 0.0–0.40 m layer in the first and second years, respectively: 21 and 29 g dm⁻³ soil organic matter, pH (CaCl₂) 4.6 and 4.7, 11

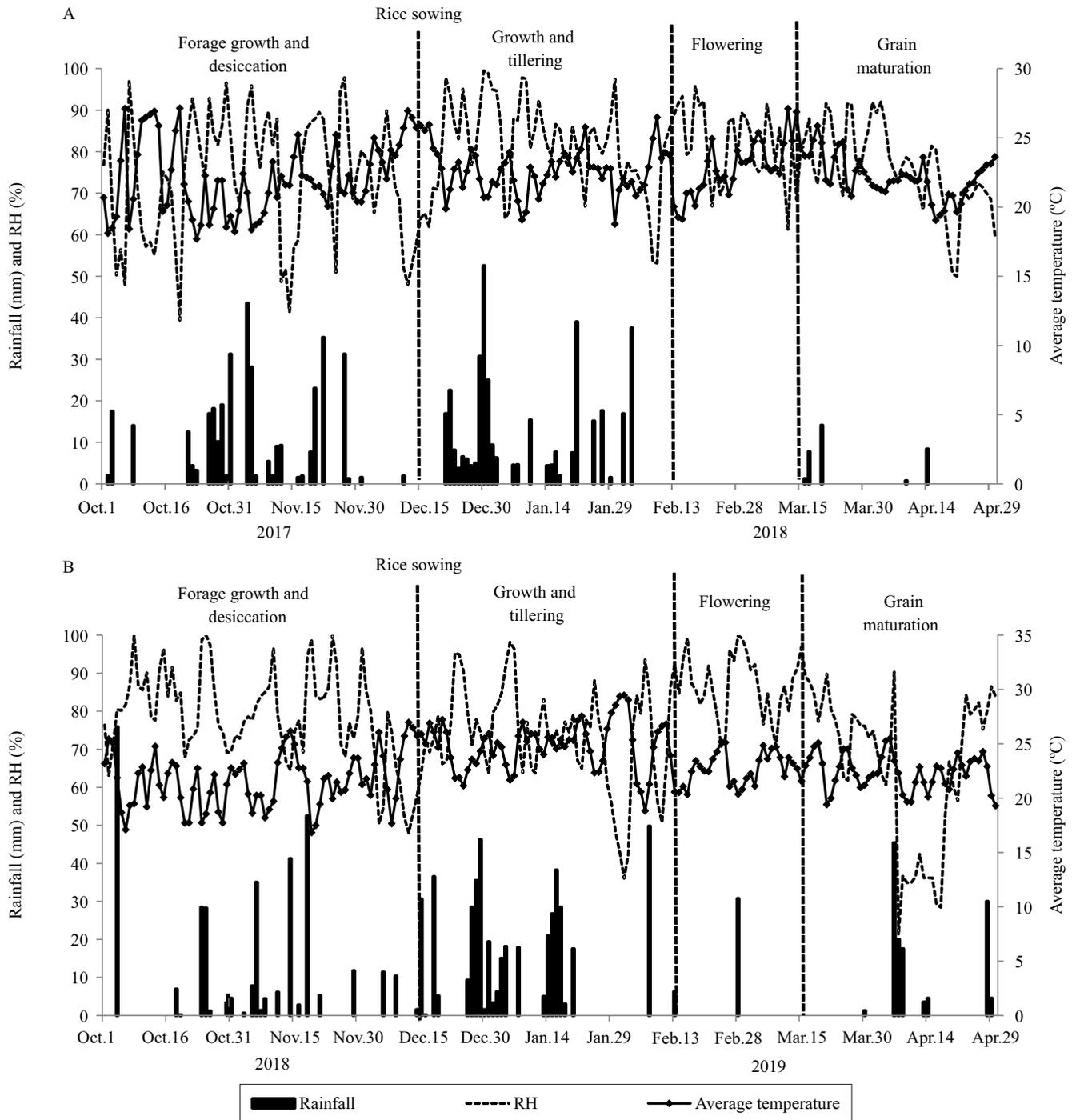


Figure 1. Rainfall, air relative humidity (RH), and average temperature for the 2017/2018 (A) and 2018/2019 (B) growing seasons of upland rice (*Oryza sativa*). The data were obtained at the weather station of the Lageado experimental farm of Universidade Estadual Paulista, located in the municipality of Botucatu, in the state of São Paulo, Brazil.

and 12 g dm⁻³ P (resin), 4 and 2 mmol_c dm⁻³ K⁺, 22 and 21 mmol_c dm⁻³ Ca²⁺, 16 and 10 mmol_c dm⁻³ Mg²⁺, cation exchange capacity of 88 and 104 mmol_c dm⁻³, and base saturation of 47 and 32%.

The experiment consisted of the management of nitrogen fertilization in upland rice grown over 'Marandu' *Urochloa brizantha* (A.Rich.) R.D.Webster or *Urochloa ruziziensis* (R.Germ. & C.M.Evrard) Morrone & Zuloaga straw after the cover crops had been established for two years in the experimental area. A randomized complete block design was used, with four replicates, in a 4×2 factorial arrangement (four N fertilization timing and two cover crops). The treatments were upland rice grown over *U. brizantha* or *U. ruziziensis* straw, with the following fertilization: T, 30 kg ha⁻¹ N at rice sowing + no extra N supply (0 kg ha⁻¹); C, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N at rice tillering, as recommended by Alvarez et al. (2005); A2, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N one day before rice sowing; and A1, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N in the living cover crop.

At the beginning of November 2017, the cover crops were terminated to produce straw for sowing rice under the no-tillage system. Rice was sown mechanically with a seeder-fertilizer for direct planting, with 0.34 m spacing between rows and a seed density appropriate for obtaining 150 plants per square meter. In all treatments, seeding fertilization was carried out according to the recommendation for the crop (Raij et al., 1997), using 100 kg ha⁻¹ triple superphosphate (41% P₂O₅), 35 kg ha⁻¹ potassium chloride (60% K₂O), and 140 kg ha⁻¹ ammonium sulfate (21% N). Chemical control with herbicides and fungicides was carried out simulating operations performed in commercial crops. Rice was harvested mechanically in April 2018 and 2019, when the top 2/3 panicle grains were hard and the bottom third were semi-hard. Grain yield was measured by weighing the husk grains harvested from the useful area of the plot and adjusted to 13% moisture.

The economic analysis was performed according to the methodology proposed by Martin et al. (1998), using the concepts of operational cost developed by Matsunaga et al. (1976). The total operating cost (TOC) was derived from the sum of the effective operating cost (EOC), that is, of the expenses resulting from mechanized operations, manual operations, inputs, and other operating costs (depreciation

and other operating expenses). Depreciation was calculated using the straight-line method, by dividing the difference between the initial value and the final value by the useful life of the equipment. The interest cost was calculated as 5.5 over 50% of the EOC, while the other expenses represented 5% of the EOC.

The gross revenue (GR) was obtained by multiplying yield by the selling price per unit. The operating profit (OP) was calculated as the difference between the GR and TOC, while the profitability index was considered the percentage of the OP over the GR. The equilibrium price was obtained by dividing the TOC by yield.

The input and operation values were obtained by consulting both with farmers, whose technological level was similar to that used in the present study, and with establishments that sold agricultural products in the region. As rice is priced based on the quantity and quality of grains, grain quality was established, and then the data were sent to a rice mill, also in the region, to determine the exact market value of the harvested grain batch. A 50 kg bag was valued at R\$41.85 and 42.45 in 2018 and 2019, respectively.

To determine the competitiveness of upland rice compared with flooded rice, data on the cost of flooded rice production in 2018 were obtained from the Brazilian yearbook on agriculture (Agrianual, 2019), and the values were corrected by the accumulated inflation of 5.84% from April 2018 to April 2019 (IBGE, 2019), in order to calculate the production cost in 2019. The average yield values were obtained from the crop monitoring report of Companhia Nacional de Abastecimento (Conab, 2019). The purchase values of a 50 kg bag of flooded rice were R\$34.50 and 37.55, respectively, in April 2018 and 2019, in the same rice mill where the upland rice prices were quoted.

Results and Discussion

The economic indicators to produce 1 ha of upland rice are shown in Table 1. The input costs contributed the most to the overall production cost of R\$1,406.65 and 1,423.80, respectively, in 2017/2018 and 2018/2019, accounting for about 57.5% of the TOC in both years. Fertilizers accounted for 74% of the input costs, which were of R\$1,034.15 and 1,049.60 in 2017/2018 and 2018/2019, respectively.

Among the used fertilizers, N was the costliest in both years (Table 1) and also the most demanded

nutrient, as it is the most limiting both for rice growth and yield (Santos et al., 2017; Niang et al., 2018). Since N is so costly, the farmer must pay attention not only to the used rate but also to the time in which it is applied. Considering that N is better absorbed at tillering (Alvarez et al., 2005), the usual recommendation is to apply N fertilizer during this stage (Tadesse & Tadesse, 2019). However, several studies have reported an absence of yield losses in upland rice grown under a no-tillage system in which N fertilization was applied in advance (Lopes et al., 2013; Arf et al., 2015; Nascente & Lanna, 2016; Pinheiro et al., 2016). When straw is

present on a soil surface and has a high C/N ratio, as in areas under a no-tillage system, the N fertilizer remains immobilized in the system in organic form, in the microbial biomass of the soil (Nascente & Lanna, 2016; Assmann et al., 2017), being gradually released during the crop cycle, which can help plants to better use this nutrient.

Operations accounted, on average, for only 25% of the TOC in both years (Table 1). Given that rice was sown in a no-tillage system, there was no expense involved in preparing the soil, which resulted in reduced operating costs. In the first year, the greatest

Table 1. Total operating cost (TOC) of producing 1 ha of upland rice (*Oryza sativa*), fertilized with nitrogen at different times, in the 2017/2018 and 2018/2019 harvest in the municipality of Botucatu, in the state of São Paulo, Brazil⁽¹⁾.

Operation and inputs	Unit	Quantity (unit ha ⁻¹)	2017/2018		2018/2019	
			UV (R\$ unit ⁻¹)	Total (R\$ ha ⁻¹)	UV (R\$ unit ⁻¹)	Total (R\$ ha ⁻¹)
Operation						
Desiccation	MH	0.50	122.80	61.40	122.80	61.40
Pulverization (2017/2018)	MH	1.00	122.80	122.80	-	-
Pulverization (2018/2019)	MH	1.50	-	-	122.80	184.20
Seed treatment	MH	0.10	16.11	1.61	16.11	1.61
Seeding	MH	0.55	281.41	154.78	281.41	154.78
Seeding fertilization	MH	0.50	117.06	58.53	117.06	58.53
Cover fertilization	MH	0.30	121.17	36.35	121.17	36.35
Harvest	HM	0.50	295.43	147.72	295.43	147.72
Subtotal A				583.18		644.58
Input						
Triple superphosphate	kg ha ⁻¹	100	2.84	284.00	2.82	282.00
Potassium chloride	kg ha ⁻¹	35	1.89	66.15	1.90	66.50
Ammonium sulfate	kg ha ⁻¹	570	1.20	684.00	1.23	701.10
Rice seeds	kg ha ⁻¹	50	84.00	84.00	84.00	84.00
Glyphosate	L ha ⁻¹	5	25.00	125.00	27.00	135.00
2,4-D (2017/2018)	L ha ⁻¹	1.5	16.60	24.90	-	-
2,4-D (2018/2019)	L ha ⁻¹	1	-	-	16.60	16.60
Thiram	L ha ⁻¹	0.3	32.00	9.60	32.00	9.60
Thiamethoxam	L ha ⁻¹	0.3	310.00	93.00	310.00	93.00
Tricyclazole	g ha ⁻¹	300	0.12	36.00	0.12	36.00
Subtotal B				1,406.65		1,423.80
EOC				1,989.83		2,068.38
Other expenses				99.49		103.42
Interest cost				54.72		56.88
Linear depreciation				269.05		269.05
TOC				2,413.09		2,497.73

⁽¹⁾UV, unitary value; MH, machine hours; and EOC, effective operating cost.

expense was of R\$154.78 with the sowing operation, representing 26.5% of the total operations; in the second, it was of R\$184.20 with spraying operations, representing 28.5% (Table 1). This extra spraying was necessary because the higher air relative humidity during the grain ripening stage (Figure 1) made rice more susceptible to blast (*Pyricularia grisea*), the main fungal disease of the crop.

The data corresponding to the profitability indicators is shown in Table 2. In the first agronomic year, the lowest yields were obtained in the T treatment, without the addition of extra N, both in the area previously occupied by *U. brizantha* and in the one previously occupied by *U. ruziziensis*.

Besides a lower yield, the T treatment also resulted in lower gross revenues and higher equilibrium prices (Table 2). For this treatment to be profitable in the first year, sale prices of R\$54.91 and 59.14 would be necessary for the areas cultivated with *U. brizantha* and *U. ruziziensis*, respectively; these prices are R\$13.00 and 17.30 higher, respectively, than the estimated sales value of R\$41.85 in April 2018.

The other treatments (C, A1, and A2), in which 90 kg ha⁻¹ N were added at different times, with the exception of A2 in an area previously occupied by *U. ruziziensis*, resulted in higher yields than the national average for upland rice (Table 2), which was of 2,409 kg ha⁻¹ in the first year (Conab, 2019). However, all *U. brizantha* straw treatments resulted in higher yields

Table 2. Grain productivity, gross revenue, total operating cost (TOC), operating profit, and equilibrium price both of a 50 kg bag of upland rice (*Oryza sativa*), fertilized with nitrogen at different times in an area previously occupied by two cover crops, and of flooded rice in the 2017/2018 and 2018/2019 harvest in the municipality of Botucatu, in the state of São Paulo, Brazil.

Treatment ⁽¹⁾	Grain productivity (kg ha ⁻¹)	Gross revenue (R\$ ha ⁻¹)	TOC (R\$ ha ⁻¹)	Operating profit (R\$ ha ⁻¹)	Equilibrium price (R\$)
2017/2018 – <i>Urochloa brizantha</i>					
A1	2,873	2,405.28	2,373.93	31.35	41.31
A2	3,379	2,828.90	2,373.93	454.97	35.13
C	3,005	2,515.79	2,350.03	165.76	39.10
T	1,691	1,415.71	1,857.10	-441.39	54.91
2017/2018 – <i>Urochloa ruziziensis</i>					
A1	2,505	2,097.19	2,373.93	-276.74	47.38
A2	2,191	1,834.31	2,373.93	-539.62	54.17
C	2,625	2,197.65	2,350.03	-152.38	44.76
T	1,570	1,314.40	1,857.10	-542.70	59.14
Flooded rice	7,513	5,188.48	5,336.00	-147.52	35.51
2018/2019 – <i>Urochloa brizantha</i>					
A1	3,035	2,576.11	2,458.56	117.55	40.50
A2	2,718	2,307.04	2,458.56	-151.52	45.23
C	3,007	2,552.34	2,434.67	117.67	40.48
T	2,964	2,515.84	1,927.84	588.00	32.52
2018/2019 – <i>Urochloa ruziziensis</i>					
A1	3,184	2,702.58	2,458.56	244.02	38.61
A2	3,040	2,580.35	2,458.56	121.79	40.44
C	3,538	3,303.05	2,434.67	568.38	34.41
T	2,408	2,043.91	1,927.84	116.07	40.03
Flooded rice	7,172	5,386.17	5,481.49	-95.32	38.21

⁽¹⁾A1, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N in the living cover crop; A2, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N one day before rice sowing; C, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N at rice tillering; and T, 30 kg ha⁻¹ N at rice sowing + no extra N supply (0 kg ha⁻¹).

than those with *U. ruziziensis* straw, irrespective of the N fertilization timing adopted.

Considering that the TOC was the same for each treatment in both areas occupied by the two cover crops and that yield was lower in all treatments under *U. ruziziensis* straw (Table 2), the gross revenue obtained using this cover crop was lower, as well as the operating profit. In the *U. brizantha* area, only the T treatment without the addition of N resulted in negative operating profit values.

The rice produced in the flooded system also resulted in negative operating profit values. Although the yield of this system was more than 5,000 kg ha⁻¹, compared with that of all upland rice treatments, the TOC was higher due to the greater mechanization and manual requirements for flooded rice production (Table 2). In this case, upland rice would be more competitive than flooded rice when sown in the *U. brizantha* area with the addition of N topdressing, regardless of application time. Therefore, in an area occupied by *U. ruziziensis*, flooded rice would be more competitive in the market.

In the second agronomic year, the yields of upland rice, irrespective of the treatment, and of the cover crops were higher than those of the first year (Table 2). This difference can be explained by climatic conditions (Figure 1). In the second year, precipitation during the rice growing and tillering stages was 436 mm, which was higher than the 324 mm recorded in the first year; this difference of more than 100 mm positively influenced final rice yield. Similarly, rainfall during the flowering stage was about 60% higher than in the first year, also resulting in a higher yield.

According to Niang et al. (2018), the productive capacity of upland rice is mainly influenced by the occurrence, duration, and intensity of rainfall in the production region. This happens because rice is a very demanding crop in terms of water availability during its development and responds negatively to water stress (Portugal et al., 2015). It should be noted that even in regions with high precipitation levels, it is common for drought periods or precipitation levels below those required for the full development of the crop to occur during the rainy season (Heinemann & Stone, 2009), which can lead to low yields (Niang et al., 2018) and to losses of up to 32% in plant total N uptake and N use efficiency (Teronpi & Bharali, 2018).

The impact of water deficiency on grain yield varies within the life cycle of the plant and depends on its

growth stages (Heinemann & Stone, 2009). The onset of water stress in field conditions without irrigation, for example, usually occurs in the second half of the growing season and reaches its maximum peak during the flowering stage (Heinemann & Stone, 2009).

As environmental conditions were favorable in the second year, the grain yields of the areas occupied by *U. brizantha* and *U. ruziziensis* were similar (Table 2). This result shows the potential of *U. brizantha* to create favorable conditions for the development of the successive crop, especially under water stress conditions. One possible explanation for this is the increase in the population of microorganisms in the soil and in the activity of the microbiota in the decomposition of organic matter in areas with the presence of this cover crop species, as reported by Freitas et al. (2018) and Rocha et al. (2020). Plants can alter soil microbiology differently by sending signals that affect specific microbial communities (Haichar et al., 2014; Baptistella et al., 2020).

During a water deficit period, there can be substantial reductions in soil microbial activity and biomass due to a reduction in the number of soluble nutrients and in water-dependent activities (Blackwell et al., 2010). When water was not a limiting factor, all treatments in both areas, except A2 under *U. brizantha*, resulted in a positive operating profit, indicating that the farmer had a monetary gain. This result was attributed to the greater increase in yield than in the TOC between the evaluated years.

Although there was a reduction in flooded rice yield in the second year, there was also an increase in the marketing cost of the rice bags, which resulted in a less negative operating profit compared with that of the first year. In this case, when rainfall conditions were favorable, upland rice was more competitive than flooded rice.

These same results are confirmed by the profitability indices from all treatments applied to upland and flooded rice (Figure 2). However, in the first year, when water deficit limited the productive potential of upland rice, only treatments sown on *U. brizantha* straw and with the addition of N were profitable.

As *U. brizantha* has a higher dry matter output than *U. ruziziensis* under free growth conditions (Machado & Assis, 2010), the straw over the soil after cover crop termination and during rice growth was thicker, reducing the heating of the soil and, consequently, the

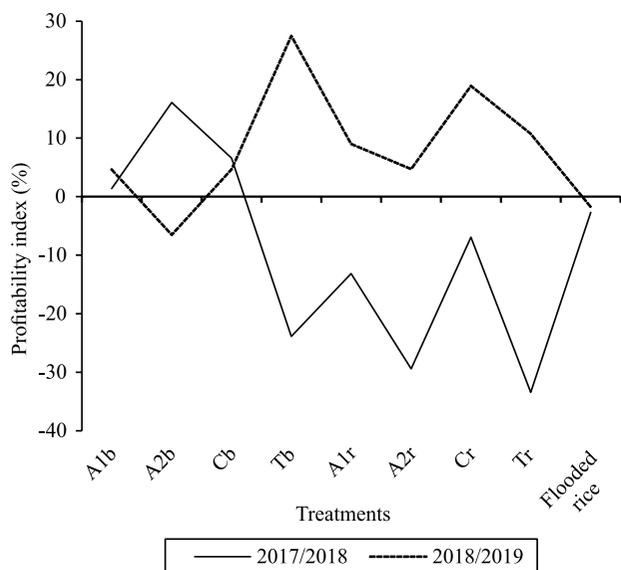


Figure 2. Profitability index both of upland rice (*Oryza sativa*), fertilized with nitrogen at different times in an area previously occupied by two cover crops (b, *Urochloa brizantha*; and r, *Urochloa ruziziensis*), and of flooded rice in the 2017/2018 and 2018/2019 growing seasons in the municipality of Botucatu, in the state of São Paulo, Brazil. A1, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N in the living cover crop; A2, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N one day before rice sowing; C, 30 kg ha⁻¹ N at rice sowing + 90 kg ha⁻¹ N at rice tillering; and T, 30 kg ha⁻¹ N at rice sowing + no extra N supply (0 kg ha⁻¹).

loss of water by evaporation. Moreover, the addition of plant material in the form of straw increases the specific surface area of the soil, improving its water holding capacity (Libohova et al., 2018). According to Mohanty et al. (2019), since soil water retention capacity represents the amount of water that a given soil can retain to be used by the crop during its development, an increase in this capacity significantly improves water use efficiency.

In the second agronomic year, almost all treatments resulted in positive profitability indices (Figure 2), highlighting the competitive capacity of upland rice, compared with that of flooded rice, when water is not a limiting factor.

Conclusions

1. Upland rice (*Oryza sativa*) can result in a monetary gain for the farmer similar to that of flooded

rice when there is no rainfall deficit and when nitrogen is added, regardless of fertilization timing and the type of cover crop used.

2. Under rainfall deficit conditions, upland rice shows higher profitability rates when sown on *Urochloa brizantha* straw than when sown on *Urochloa ruziziensis* straw.

3. When there is a possibility of a rainfall deficit, using *U. brizantha* as a cover plant could result in a greater economic security for upland rice producers.

Acknowledgments

To Nucleus: a virtual joint center to deliver enhanced nitrogen use efficiency via an integrated soil-plant systems approach for the UK and Brazil, for support; to Fundação de Amparo à Pesquisa do Estado de São Paulo (Fapesp), for grant (numbers 2015/50305-8, 2016/12317-17, and 2017/10226-7); to Fundação de Amparo à Pesquisa do Estado de Goiás (Fapeg), for grant (number 2015-10267001479); to Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão (Fapema), for grant (number RCUK-02771/16); and to Biotechnology and Biological Sciences Research Council, for grant (number BB/N013201/1).

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