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Organic and mineral fertilizer application in upland rice irrigated by sprinkler irrigation: economic analysis

Aplicação de fertilizante orgânico e mineral em arroz de terras altas irrigado por aspersão: análise econômica

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Abstract

Organic fertilizers produced by agro-industrial waste are sources of nutrients for plants, making it relevant to study their technical and economic efficiency in several crops as well as in upland rice irrigated by sprinkler irrigation. Thus, this study aimed to conduct an economic analysis of the application of organic fertilizer made from fridge waste and mineral fertilizer in two upland rice cultivars irrigated by sprinkler irrigation. The experiment was conducted in the agricultural years 2009/2010 and 2010/2011, in Selvíria - MS. Treatments consisted of two rice cultivars with different characteristics (BRS Primavera - intermediate type and IAC 202 - modern type) and six combinations of mineral and organic fertilizer at sowing (100% mineral fertilizer, 80% mineral fertilizer + 20% organic fertilizer, 60% mineral fertilizer + 40% organic fertilizer, 40% mineral fertilizer + 60% organic fertilizer, 20% mineral fertilizer + 80% organic fertilizer and 100% organic fertilizer). Total Operating Cost, Gross Revenue, Operating Profit, Profitability Index, Equilibrium Yield and Equilibrium Price have been estimated. It was concluded that, in the year without excessive rainfall (2009/2010), BRS Primavera cultivar in association with 40% mineral fertilizer + 60% organic fertilizer has obtained higher yield. However, the highest profit was obtained with IAC 202 with 80% mineral fertilizer + 20% organic fertilizer. In the year with heavy rainfall in sowing and harvesting season (2010/2011), IAC 202 cultivar with 100% organic fertilizer has obtained higher yield and profitability.

Additional keywords: agro-industrial waste; *Oryza sativa* L.; profitability; total operating cost.

Resumo

Os adubos orgânicos produzidos pelos resíduos da agroindústria são fontes de nutrientes para as plantas, tornando relevante estudar sua eficiência técnica e econômica, sob diversas culturas, assim como no arroz de terras altas irrigado por aspersão. Sendo assim, o objetivo deste trabalho foi realizar a análise econômica da aplicação de adubo orgânico à base de resíduo de frigorífico e adubo mineral, em duas cultivares de arroz de terras altas irrigado por aspersão. O experimento foi realizado nos anos agrícolas de 2009/2010 e 2010/2011, em Selvíria – MS. Os tratamentos foram constituídos por duas cultivares de arroz com características diferentes (BRS Primavera - tipo intermediário e IAC 202 - tipo moderno) e seis combinações de adubo mineral e orgânico na semeadura (100% de adubo mineral, 80% de adubo mineral + 20% de adubo orgânico, 60% de adubo mineral + 40% de adubo orgânico, 40% de adubo mineral + 60% de adubo orgânico, 20% de adubo mineral + 80% de adubo orgânico e 100% de adubo orgânico). Estimou-se: Custo Operacional Total, Receita Bruta, Lucro Operacional, Índice de Lucratividade, Produtividade e Preço de Equilíbrio. Concluiu-se que, no ano sem excesso de precipitação (2009/2010), a cultivar BRS Primavera, em associação com adubo 40% mineral + 60% orgânico, obteve maior produtividade, porém o maior lucro foi obtido com IAC 202 com 80% de adubo mineral + 20% de adubo orgânico. No ano com intensa precipitação no período de semeadura e colheita (2010/2011), a cultivar IAC 202, com 100% de adubo orgânico, obteve maior produtividade e lucratividade.

Palavras-chave adicionais: custo operacional total; lucratividade; *Oryza sativa* L.; resíduo agroindustrial.

Introduction

Rice is a staple food for the Brazilian population and for populations of several countries. It provides 21% of calorie requirements and 14% of protein requirements for about six billion people worldwide (Ferreira et al., 2006). Brazil is the 9th largest producer of rice, being the largest producer in the Americas, and its production is only surpassed by Asian countries (USDA, 2015).

Upland rice, which is grown mainly in the Midwest, is among rice production systems. In this region, Latosols predominate, which have low natural fertility (Guimarães et al., 2006). This system represented 21% of Brazil's total output in 2010 (Ferreira & Santiago, 2012) and is essential for increasing rice production, since the area available for advancement of flooded rice is limited, generates high impact on the environment and competition for water demand by industry and domestic use (Heinemann & Stone, 2009).

As in all crops, the adequate supply of nutrients to upland rice is important in order to obtain good yields, which in most cases is done by the application of mineral fertilizers. However, as there are currently available on the market organic fertilizers produced from agro-industrial waste, it is relevant to study their efficiency in different crops.

According to Steiner et al. (2011) and Costa et al. (2011), organic fertilization or its association with mineral fertilization promotes the improvement of chemical, physical and biological soil characteristics and is also an economically viable alternative for most producers. Further, Ahmad et al. (2006) report that the combined use of organic and inorganic sources of plant nutrients can reduce the exclusive reliance on mineral fertilizers, in order to assist in the conservation of natural sources of nutrients. There is a strong demand for alternative fertilizers, both because of the high cost of mineral fertilizers and the increasing demand for organic products (Roscoe et al., 2006).

It is necessary to emphasize the importance of the use of organic fertilizers in agriculture that goes beyond the agronomic aspect, because the generation of waste is a serious problem to be solved in several activities of production and processing of agricultural products (Roscoe et al., 2006). Wastes from agricultural activities such as slaughter of animals, when deposited in water springs, cause the degradation of existing biome and damage on water quality, especially when water is used for domestic consumption (Edvan & Carneiro, 2011). In addition to polluting water springs, the disposal of waste in environment without prior treatment pollutes soil and contributes to disease transmission, making it relevant to search for such waste treatment alternatives (Olinto et al, 2012). Thus, the final destination of waste represents a major challenge/problem for humanity (Edvan & Carneiro, 2011). Therefore, the practice of turning waste, potential source of pollution, into new inputs can generate ecological and economic gains (Roscoe et al., 2006), being the agricultural use an alternative for the disposal of solid waste (Mangieri & Tavares Filho, 2015).

Among organic fertilizers, the organic fertilizer made from fridge waste is available in the market. This fertilizer is made from rumen grass, blood and leather of beef cattle (Pereira et al., 2015). Fridge wastes are transformed by composting, which is an efficient system in the treatment of such waste, wherein the stabilizing material happens in a satisfactory time, allows nutrient cycling and has been established as a viable, low cost and sanitarily efficient alternative in the elimination of pathogens (Costa et al., 2009). Wastes from fridges, slaughterhouses, fish processing plants, etc., are rich in calcium, phosphorus, nitrogen, and other nutrients. Therefore, they have great potential for agricultural use (Silva, 2008). According to several authors, the main advantage in the use of organic fertilizers is their low cost. According to Roy et al. (2015) the use of fridge waste for agriculture can provide economic and environmental benefits. Myint et al. (2010) mention that an advantage of agricultural application of organic waste is the nutrient supply for crops with little additional cost. Rocha et al. (2013) also state that wastes can reduce fertilization costs on crops.

Another important aspect when evaluating the effect of fertilization is the use of cultivars, since it is known that producers use various upland rice cultivars, which differ as to the type of growth, especially intermediate and modern, and that nutrient absorption varies among cultivars, making it important to evaluate the influence of fertilizer types on yield.

Therefore, it is relevant to study the use of organic fertilizer on the yield of upland rice cultivation, since there are few studies about it. And, above all, it is relevant to evaluate the economic feasibility of using this alternative input through cost analysis and whether its application provides greater profit to the producer, compared to mineral fertilizer.

The determination of production costs aims to analyze profitability and economic feasibility, determine parameters for decision-making, such as varieties, technologies used, fertilizers, among others. In addition, production costs allow us to assess the efficiency of the production system adopted by the producer or rural entrepreneur (Bulegon et al., 2012).

Thus, this study aimed to conduct an economic analysis of the application of organic fertilizer made from fridge waste and mineral fertilizer in two upland rice cultivars irrigated by sprinkler irrigation.

Material and methods

The experiment was conducted in the agricultural years 2009/2010 and 2010/2011, in an experimental area belonging to the Faculty of Engineering - UNESP, Campus Ilha Solteira, in the city of Selvíria - MS, located approximately at 51º 22’ longitude West and 20º 22’ latitude South, with an altitude of 335 meters. Soil of the experimental area, according to Santos et al. (2013), is a typical clayey Dystrophic RED LATOSOL. The average annual rainfall is 1330 mm, with an average annual temperature of about 25 °C and average annual relative humidity of the air of 66% (Centurion, 1982).

Climatic data of rainfall (mm), maximum and minimum temperatures during the implementation period of the experiment are shown in Figure 1.

Soil analysis of the area was conducted before the experiment, and values are shown in Table 1.

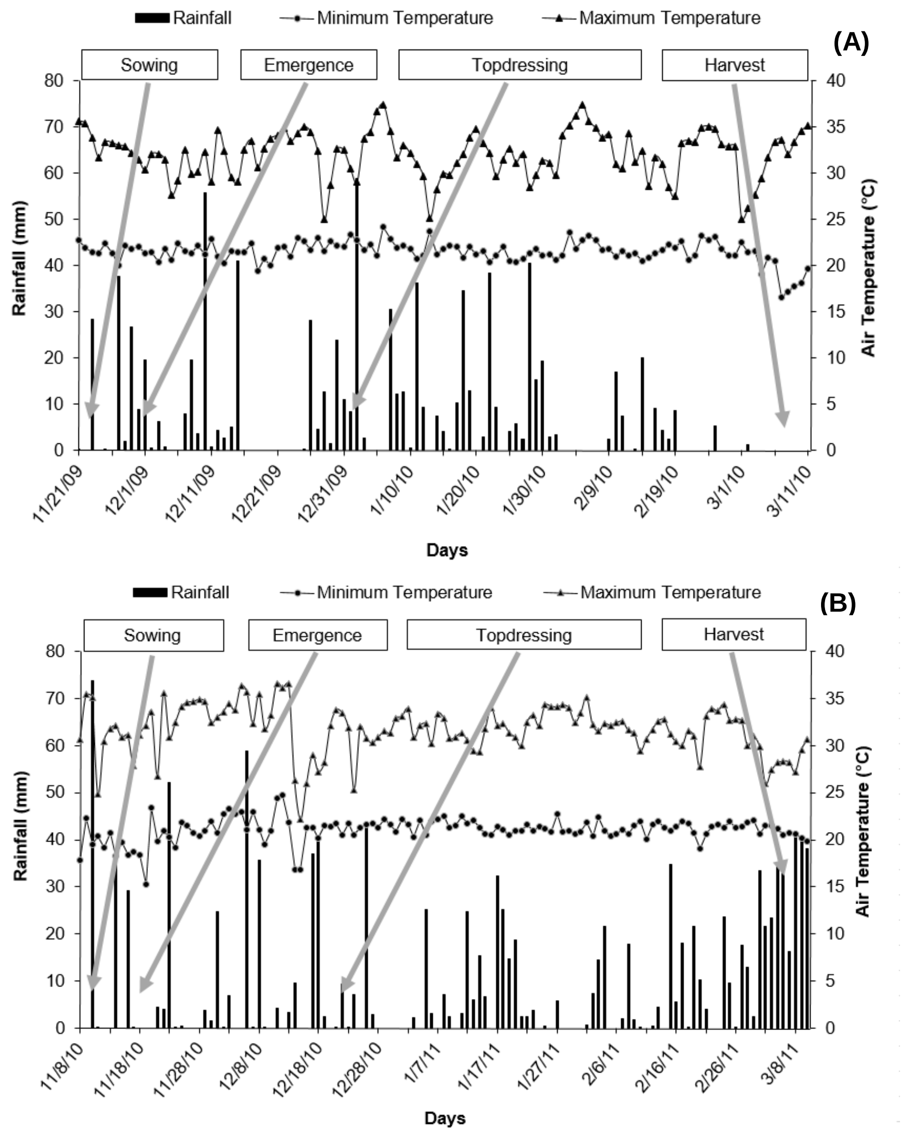

Figure 1 - Rainfall (mm), maximum and minimum temperature (ºC) for ten days recorded during the development period of the rice crop. A) Agricultural year 2009/2010 and B) Agricultural year 2010/2011. Selvíria - MS.

Table 1 - Chemical characteristics of the soil of experimental area, evaluated at layer 0.0 to 0.20 m. Selvíria – MS, 2009/2010.

Year	P resin	M.O.	pH	K	Ca	Mg	H+Al	Al	CEC	V
	(mg dm^{-3})	(g dm^{-3})	$CaCl_2$	------------------- ($mmol_c$ dm^{-3}) ---------------------						(%)
2009/2010	17	13	5.2	2.9	33	14	27	0	77	65

The experimental design was in randomized blocks, arranged in factorial scheme 6 x 2, with four repetitions. Treatments consisted of two rice cultivars with different types of plants (BRS Primavera - intermediate type and IAC 202 - modern type) and six combinations of mineral and organic fertilizer at sowing (100% mineral fertilizer, 80% mineral fertilizer + 20% organic fertilizer, 60% mineral fertilizer +

40% organic fertilizer, 40% mineral fertilizer + 60% organic fertilizer, 20% mineral fertilizer + 80% organic fertilizer and 100% organic fertilizer).

Plots consisted of five rows of 4.5 m length, spaced 0.35 m. Useful area consisted of the three central rows, disregarding 0.50 m at both ends of the rows.

BRS Primavera has medium size (100--120 cm), short cycle (112 days), period between emergence and flowering of 80 days, long and thin grain (Agulhinha) and is moderately susceptible to blast and plant lodging (Breseghello et al., 1998). IAC 202 has small size (87 cm), short cycle (120 days), period between emergence and flowering of 87 days, long and thin grain and is resistant to plant lodging (Bastos, 2000).

Sowing fertilizer applied in furrows for both years was 180 kg ha^{-1} 08-28-16 formulation (mineral fertilizer). In turn, for organic fertilizer from fridge waste, the amount used was 1.2 t ha^{-1}, whose analysis shows about 50% organic matter, 2% to 4% phosphorus (P), 3% to 5% nitrogen (N), 0.7% to 1.5% potassium (K) and carbon/nitrogen ratio equal to 10/1. The organic fertilizer used has granule format, similar to mineral fertilizer, being easy to handle. In accordance with the nutrient percentage present in its constitution, the average percentage of each nutrient was used to calculate the used dose of the organic fertilizer.

Soil preparation was performed using scarifier and two harrowings for harrowing and leveling the soil, the last one being performed on sowing eve, for both crop years. Scarification was made using a scarifier with 7 stems, at 30 cm deep, pulled by a 150 hp 4x2 AFWD (auxiliary front-wheel drive) tractor. Level harrowing was performed with a 32x20” harrow, using an 86 hp 4x2 AFWD tractor.

Sowing was mechanically performed on 11/21/2009 and 11/08/2010, with a five-row disk distribution sower pulled by 86 hp 4x2 AFWD tractor with 70 kg ha^{-1} seeds. According to Arf et al. (2000), this is the most appropriate month for sowing rice irrigated by sprinkler irrigation in the region, providing higher yield. In both years, seeds were treated with imidacloprid (105 g i.a.) + thiodicarb (315 g i.a.) per 100 kg of seed, aiming to control soil pests.

Immediately after sowing, the application of the herbicide pendimethalin (1,400g ha^{-1} i.a.) was performed in pre-emergence. In both years, two herbicide applications were performed in post--emergence, the first one with the herbicide Bentazon (720 g ha^{-1}) and the second application with the herbicide 2,4-D (1,005 g ha^{-1}). All sprayings were made using a sprayer with a 12-meter bar and tank with capacity for 600 liters of syrup, using an 86 hp tractor.

Topdressing was performed at 32 and 35 days after emergence (DAE) for the first and second year of cultivation, respectively, with 70 kg ha^{-1} N as broadcasted urea, using hydraulic distributor with capacity for 600 kg attached to a 86 hp tractor. After topdressing, a water depth of approximately 10 mm was applied to incorporate the fertilizer.

Water supply, when needed, was performed by sprinkler irrigation by the central pivot system. In water management, three crop coefficients (Kc), divided into four periods between emergence and harvest, were used. Value 0.4 was used for growing period. For reproductive stage, two crop coefficients (Kc) were used, the initial was 0.70 and the final was 1.00 and, for maturation stage, these values were reversed, i.e., the initial was 1.00 and the final was 0.70 (Rodrigues et al., 2004). During the crop of 2009/2010, there was less rainfall, therefore, we needed to apply 100 mm throughout the cycle. In turn, during the crop of 2010/2011, there was less need for irrigation, being the application of 70 mm in the whole cycle.

Harvest was performed at 100 and 114 DAE in 2010 and 2011, respectively. Grain yield of each plot was determined by weighing paddy grains from the useful area of the plot, correcting humidity to 13% and converting into kg ha^{-1}.

In order to perform the economic analysis, we first calculated the total operating cost (TOC) (Matsunaga et al., 1976). The effective operating cost (EOC) was estimated considering the cost of mechanized operations, manual operations and inputs. Values of depreciation, other expenses and the cost interest were added to the EOC to obtain the TOC. Costs with CESSR were not considered. This methodology has been already used in several studies on economic evaluation in crops such as Kaneko et al. (2010), Garcia et al. (2012), Leal et al. (2013), Kappes et al. (2015), Oliveira et al. (2015).

Costs were obtained based on the following items: a) for mechanized operations, a survey of technical coefficient was carried out to implement them, then, it was multiplied by its value obtained in Agrianual (2014) updated to April 2014, except for irrigation, whose value was obtained in the survey conducted in 2013 by Gerlach (2014) and readjusted to April 2014. All costs with tractor, implement and tractor driver are already included in the costs of mechanized operations obtained in Agrianual (2014); b) for manual operations, a survey of labor needs in the upland rice cycle, the number of men/day (MD) to perform it was conducted. Then, the technical coefficient of labor was multiplied by its value obtained in Agrianual (2014) updated to April 2014; c) the costs of inputs were obtained by multiplying the amount of materials used by their respective prices in April 2014, according to the Institute of Agricultural Economics (IEA, 2014), except for the price of seeds and organic fertilizer, which were obtained directly from the local market; d) depreciation; e) for other expenses, the rate of 5% of the total costs with the EOC was considered; f) cost interest expense was obtained considering the annual interest rate of 6.0% over 50% of the EOC.

To determine the profitability of the treatments, following the methodology of Martin et al. (1998), the following indicators were calculated: a) Gross revenue (GR), obtained by multiplying the amount obtained (in 60-kg bags) by the average price of five years (June 2009 to June 2014) of the paddy rice bag received by the producer (IEA, 2014) monthly deflated by the General Price Index - Internal Availability from Fundação Getúlio Vargas (IGP-DI/FGV) to June 2014 (R$42.66 bag^{-1}); b) Operating profit (OP), calculated by the difference between gross revenue and total operating cost; c) and profitability index (PI) is the ratio of operating profit and gross revenue expressed as a percentage; d) equilibrium price (EP), understood as the minimum required price to cover the TOC, considering the average yield achieved by the producer: EP = TOC/average yield achieved by the producer; e) equilibrium yield (EYield) determines the minimum yield required to cover the TOC, considering the average price received by the producer: EYiled = TOC/average price received by the producer. This methodology was also used by several authors to estimate the profitability indicators in crops (Kaneko et al., 2010; Garcia et al., 2012; Leal et al., 2013).

Results and discussions

A detailed model of TOC structure used in all treatments is shown in Table 2, using as an example the IAC 202/BRS Primavera cultivar, using sowing fertilizer with 60% mineral fertilizer + 40% organic fertilizer in the crop of 2009/10. It is seen that urea is the item with the highest cost, accounting for 16.8% of total operating cost. When comparing mechanized operations, manual operations and inputs, inputs correspond to 55.6% of the total operating cost (TOC), followed by 29.5% of mechanized operations and 0.1% for manual operations. Similarly, Oi (2008) also obtained a higher cost with inputs in upland rice irrigated by sprinkler irrigation. Embrapa (2009) reports that the highest cost in upland rice in succession to pasture in Mato Grosso was with inputs. In addition, the cost of the fertilizers applied at sowing (R$304.41) were responsible for the largest share of total input costs in this treatment. However, in the treatment using only mineral fertilizer (180 kg ha^{-1}) the cost was R$235.35, i.e., organic fertilizer with granule fridge waste resulted in higher cost. It is important to highlight that we used the technical coefficient for sowing of 0.7 HM when organic fertilizer was applied and 0.5 HM when only mineral fertilizer was applied.

The total operating cost (TOC) of all treatments is shown in Table 3. It is observed that the cost with cultivars in the same treatments were the same, since the price of seeds for both was R$75.00 per bag of 40 kg. Regarding sowing fertilization, there was a cost increase as the proportion of organic fertilizer was increased. This happened because the dose used in treatment using 100% mineral fertilizer (R$235.35 ha^{-1}) resulted in lower cost than the dose using 100% organic fertilizer (R$408.00 ha^{-1}). However, the value per ton of mineral fertilizer is R$1,307.50 while for organic fertilizer it is R$340.00, due to the concentration of nutrients in each source of fertilizer. Also in this table, it can be seen that TOC in the crop of 2010/2011 was lower than in the crop of 2009/2010. This is due to higher rainfall this year and, therefore, less water was used for irrigation (30 mm less).

The average yield and gross revenue of each treatment are shown in Table 4. In the crop of 2009/10, higher rice yield was obtained for all treatments when compared to the crop of 2010/2011. In 2009/2010, rainfall was consistent with the needs of each stage of the crop. There was good rainfall during the emergence of seedlings and growing period. However, during grain filling stage, rainfall was lower and plant need was supplemented by sprinkler irrigation. On the other hand, in the agricultural year 2010/2011, there was heavy rainfall after sowing, causing silting of the sowing furrow, unevenness in seedling emergence and occurrence of failures. There was also heavy rainfall during maturation and harvesting, delaying the harvest and providing the beginning of grain germination on panicle, which was observed in BRS Primavera cultivar.

Regarding sowing fertilization in each evaluated cultivar, higher yield and, therefore, higher gross revenue were obtained in the crop of 2009/2010, with IAC 202 associated with the combination of 80% mineral fertilizer + 20% organic fertilizer and with BRS Primavera combined with 40% mineral fertilizer + 60% organic fertilizer. Ferreira et al. (2010), when studying the impact of using waste from poultry and pig slaughtering process as biofertilizer on bean yield in the region of Campos Gerais, found a higher value with the proportion of 50% mineral fertilizer + 50% organic fertilizer. According to Ahmad et al. (2006), recycling organic waste and aggregating their value by nutrient mixture or enrichment could not only help in achieving high crop yields but also in maintaining a sustainable environment.

In turn, in the crop of 2010/2011, both cultivars had higher yield and gross revenue value when using 100% organic fertilizer, which may have happened because the greater rainfall during this year leads to a greater leaching of soil nutrients from mineral fertilizers. Therefore, since organic fertilizer has organic matter, it can increase soil CEC (cation exchange capacity) and hence retain higher amounts of nutrients, enabling less leaching. Furthermore, the organic fertilizer provides nutrients gradually. Falleiro et al. (2003) reported that the increase in organic matter increases soil CEC, due to the increase of the balance of negative charges or decrease of the activity of H^+, in which cations present in soil solution also participate. Therefore, the use of organic fertilizers is a key tool in agricultural production, providing benefits on chemical, physical, physico-chemical and biological properties of the soil (Costa et al., 2011 Ourives et al., 2010, Rocha et al., 2013, Pereira et al, 2015).

Aziz et al. (2010) when verifying the addition of organic matter by organic fertilizers, observed improvement in the properties of the soil and growth of maize. Briedis et al. (2011) when evaluating the wheat crop productive response to the application in the previous crop (residual effect) of organic waste from poultry and pig slaughterhouse in the region of Campos Gerais-PR, reported that treatments that received the highest doses of organic waste (100 and 75%) in the bean crop tend to have the highest yields. On the other hand, Borges et al. (2015) found no effect on corn yield when comparing the base fertilization with mineral fertilizer and organic fertilizer from fridge waste.

Table 2 - Estimate of Effective Operating Cost and Total Operating Cost obtained with the cultivation of upland rice irrigated by sprinkler irrigation for treatment with IAC 202/BRS Primavera cultivar and sowing fertilization with 60% mineral fertilizer and 40% fertilizer organic in the crop of 2009/2010 in one hectare. In R$ of 2014. Selvíria-MS.

Description	Specification	number of times	Amount	Unit value (R$)	Total (R$)
Mechanized operations					
Scarification	HM	1	1.6	76.00	121.60
Level harrowing	HM	2	0.5	48.00	48.00
Sowing and Fertilization	HM	1	0.7	104.00	72.80
Spraying	HM	3	0.15	60.00	27.00
Irrigation	R$/mm	1	100	1.76	176.00
Topdressing	HM	1	0.21	54.40	11.42
Harvest	HM	1	0.5	144.00	72.00
Subtotal					528.82
Manual operations					
Pre-sowing	MD	1	0.1	14.00	1.40
Subtotal					1.40
Inputs					
Seeds	sc	1	1.75	75.00	131.25
Imidacloprid+Thiodicarb	L	1	0.49	235.67	115.48
8-28-16	t	1	0.108	1,307.50	141.21
Organic fertilizer	t	1	0.48	340.00	163.20
Pendimethalin	L	1	2.8	27.89	78.09
Bentazon	L	1	1.2	41.54	49.85
2,4-D	L	1	1.25	13.11	16.39
Urea	t	1	0.16	1,879.30	300.69
Subtotal					996.15
Effective operating cost (EOC)					1,526.37
Depreciation					132.21
Other expenses					82.93
Cost Interests					49.76
Total operating cost (TOC)					1,791.27

Table 3 - Operating cost (TOC) obtained with the cultivation of upland rice irrigated by sprinkler irrigation according to cultivars and sowing fertilization. Selvíria (MS), 2009/2010 and 2010/2011. Base price of April 2014.

Cultivar	Sowing Fertilization	TOC (R$)	
		2009/2010	2010/2011
IAC 202/BRS Primavera	100% Mineral	1,688.60	1,617.32
	80% Mineral + 20% Organic	1,753.98	1,682.70
	60% Mineral + 40% Organic	1,791.27	1,719.99
	40% Mineral + 60% Organic	1,828.56	1,757.28
	20% Mineral + 80% Organic	1,865.85	1,794.57
	100% Organic	1,903.15	1,831.87

Table 4 - Yield and gross revenue per hectare, obtained with the cultivation of upland rice, according to cultivars and sowing fertilization. Selvíria- MS, crops of 2009/2010 and 2010/2011.

Cultivar	Sowing Fertilization	Yield (kg ha^{-1})		*Gross Revenue (R$ ha^{-1})	
		2009/2010	2010/2011	2009/2010	2010/2011
IAC 202	100% Mineral	5,277	2,915	3,751.77	2,072.84
	80% Mineral + 20% Organic	5,442	3,162	3,869.26	2,247.96
	60% Mineral + 40% Organic	5,153	3,216	3,663.96	2,286.86
	40% Mineral + 60% Organic	5,316	3,485	3,779.32	2,477.61
	20% Mineral + 80% Organic	5,145	3,437	3,657.74	2,443.39
	100% Organic	4,638	3,647	3,297.62	2,592.70
BRS Primavera	100% Mineral	5,154	2,283	3,664.67	1,623.09
	80% Mineral + 20% Organic	5,087	2,340	3,617.03	1,663.52
	60% Mineral + 40% Organic	4,961	2,146	3,526.92	1,525.76
	40% Mineral + 60% Organic	5,536	2,095	3,935.74	1,489.21
	20% Mineral + 80% Organic	4,749	2,214	3,376.72	1,574.06
	100% Organic	4,373	2,702	3,108.85	1,921.45

* We used the average price of five years (June 2009 to June 2014) of the 60-kg bag of paddy rice monthly deflated to June 2014 according to IEA (2014), which was R$42.66, therefore it was R$0.71 kg^{-1}.

When comparing cultivars in both crops, IAC 202 showed an average yield higher than BRS Primavera (185 kg ha^{-1} in 2009/2010 and 1014 kg ha^{-1} in 2010/2011). This may have happened because of its modern growth habit, which has better efficiency in trapping solar radiation, resulting in higher availability of photoassimilates to the plant, higher tillering and higher yield potential. It was observed that BRS Primavera had greater loss of yield with excessive rainfall for germinating on panicle, a characteristic of the cultivar that increased the yield gap with the other cultivar.

Operating profit (OP) is shown in Table 5. The highest operating profit in the crop of 2009/2010 was obtained with IAC 202 associated with 80% mineral fertilizer + 20% organic fertilizer, followed by BRS Primavera associated with 40% mineral fertilizer + 60% organic fertilizer. In the crop of 2010/2011, IAC 202 cultivar combined with 100% organic fertilizer provided the highest OP value, and this cultivar combined with all sorts of sowing fertilization provided positive values. However, for that same crop, negative OP values were obtained for BRS Primavera with most types of sowing fertilization, except for 100% mineral and 100% organic fertilization, which is due to lower yield this year due to the rainfall at harvesting.

Profitability index is seen as a profitability measure of the activity, which shows the available percentage of gross revenue, i.e., the proportion of available resources after the payment of all operating costs (TOC) (Kaneko et al., 2010). The highest profitability (Table 5) in the crop of 2009/2010 was obtained with IAC 202 cultivar combined with 100% mineral fertilizer, followed by the same cultivar with 80% mineral fertilizer + 20% organic fertilizer and by BRS Primavera associated with 100% mineral fertilizer. In the crop of 2010/2011, the highest profitability was shown by IAC 202 associated with 100% organic fertilizer, followed by the same cultivar with 40% mineral fertilizer + 60% organic fertilizer. However, BRS Primavera had negative value for most proportions of mineral and organic fertilizer. This factor is related to lower yield, which was not able to cover the costs. Even proportions that achieved positive profitability for BRS Primavera have very low values.

Equilibrium yield is the minimum amount that must be produced per hectare to cover costs. In Table 6, it is observed that, in both cultivars, the equilibrium yield increases when increasing the proportion of organic fertilizer, since the increment of organic fertilizer increases the total operating cost.

Equilibrium price (EP) is the minimum price required in each treatment to cover TOC. The equilibrium price ranged from R$19.20 to R$50.34 (Table 6). IAC 202 with 100% mineral fertilizer had the lowest equilibrium price in the crop of 2009/2010, followed by the same cultivar in association with 80% mineral fertilizer + 20% organic fertilizer and BRS Primavera with 100% organic fertilizer. In the crop of 2010/2011, the lowest value was obtained with IAC 202 with 100% organic fertilizer, followed by the same cultivar with the combination of 40% mineral fertilizer + 60% organic fertilizer.

Table 5 - Operating profit (OP) per hectare and profitability index (PI) obtained with the cultivation of upland rice, according to cultivars and sowing fertilizer. Selvíria - MS, crops of 2009/2010 and 2010/2011.

Cultivar	Sowing Fertilization	OP (R$ ha^{-1})		PI (%)	
		2009/2010	2010/2011	2009/2010	2010/2011
IAC 202	100% Mineral	2,063.17	455.51	54.99	21.98
	80% Mineral + 20% Organic	2,115.29	565.27	54.67	25.15
	60% Mineral + 40% Organic	1,872.69	566.87	51.11	24.79
	40% Mineral + 60% Organic	1,950.76	720.33	51.62	29.07
	20% Mineral + 80% Organic	1,791.89	648.82	48.99	26.55
	100% Organic	1,394.47	760.84	42.29	29.35
BRS Primavera	100% Mineral	1,976.07	5.77	53.92	0.36
	80% Mineral + 20% Organic	1,863.06	-19.17	51.51	-1.15
	60% Mineral + 40% Organic	1,735.65	-194.23	49.21	-12.73
	40% Mineral + 60% Organic	2,107.18	-268.07	53.54	-18.00
	20% Mineral + 80% Organic	1,510.86	-220.51	44.74	-14.01
	100% Organic	1,205.70	89.58	38.78	4.66

Table 6 - Equilibrium yield (EYield) per hectare and equilibrium price (EP), obtained with the cultivation of upland rice, according to cultivars and sowing fertilizer. Selvíria - MS, crops of 2009/2010 and 2010/2011.

Cultivar	Sowing Fertilization	EYield (kg ha^{-1})		EP (R$ sc^{-1})	
		2009/2010	2010/2011	2009/2010	2010/2011
IAC 202	100% Mineral	2,378	2,278	19.20	33.29
	80% Mineral + 20% Organic	2,470	2,370	19.34	31.93
	60% Mineral + 40% Organic	2,523	2,423	20.86	32.09
	40% Mineral + 60% Organic	2,575	2,475	20.64	30.26
	20% Mineral + 80% Organic	2,628	2,528	21.76	31.33
	100% Organic	2,680	2,580	24.62	30.14
BRS Primavera	100% Mineral	2,378	2,278	19.66	42.51
	80% M + 20% Organic	2,470	2,370	20.69	43.15
	60% Mineral + 40% Organic	2,523	2,423	21.67	48.09
	40% Mineral + 60% Organic	2,575	2,475	19.82	50.34
	20% Mineral + 80% Organic	2,628	2,528	23.57	48.64
	100% Organic	2,680	2,580	26.12	40.67

Therefore, it is found that the profitability of growing upland rice in conventional cultivation system is greatly influenced by the cultivar and climate conditions, given the fact that in the year with heavy rainfall in the sowing period, there might be failures in germination, and a low tillering cultivar ends up obtaining lower yield. In addition, excessive rainfall in harvesting also reduces yield, especially in a cultivar that is more sensitive to this climatic element.

Conclusions

Costs increase as a higher proportion of organic fertilizer is used.

In years without heavy rainfall in the period of sowing and harvesting, yield and, therefore, gross revenue are higher with BRS Primavera in association with 40% mineral fertilizer + 60% organic fertilizer, followed by IAC 202 with 80% mineral fertilizer + 20% organic fertilizer. However, the highest profit is obtained with IAC 202 with 80% mineral fertilizer + 20% organic fertilizer.

In years with excess rainfall at sowing and harvesting, yield, gross revenue and operating profit are higher with the IAC 202 cultivar with 100% organic fertilizer.

The use of organic fertilizer in the cultivation of upland rice irrigated by sprinkler irrigation is recommended for its benefit to plants and soil. Furthermore, its use contributes to the reduction of environmental pollution.

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