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Economic viability of production of Nellore heifers on *Urochloa brizantha* cv. Marandu pastures deferred and fertilized with nitrogen

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ABSTRACT. The objective of this study was to evaluate the effect of different levels of nitrogen on deferred pastures of *Urochloa brizantha* cv. Marandu, and the implications on the economic viability of production of Nellore heifers. This was a completely randomized design with four treatments (T1 = deferred pasture without nitrogen fertilization; T2 = deferred pasture fertilized with 50 kg N ha^{-1}, T3 = deferred pasture with 100 kg N ha^{-1}, T4 = deferred pasture with 150 kg N ha^{-1}) and four replications (16 fertilized paddocks). First, there were used 48 Nellore heifers, average eight months of age and initial body weight of 178.69 ± 26.67 kg, with three heifers in each paddock, in all treatments, in a continuous grazing system, with variable stocking rate. Only the treatment the without nitrogen fertilization showed negative monetary values of R$ -181.96, R$ ha^{-1} -72.79 and R$ @$^{-1}$ -32.11. The treatment with 50 kg N ha^{-1} achieved the highest positive monetary values of R$ 756.02, R$ ha^{-1} 302.40 and R$ @$^{-1}$ 50.52. Economic viability data in beef heifer production demonstrate that the treatment with 50 kg N ha^{-1} is the most financially viable under the conditions of this study.

Keywords: economic analysis, deferment, nitrogen fertilization, profitability, urea.

Viabilidade econômica da produção de novilhas Nelore em pastos de Urochloa *brizantha* cv. Marandu diferidos e adubados com nitrogênio

RESUMO. O objetivo deste estudo foi avaliar o efeito de diferentes doses de nitrogênio em pastos de *Urochloa brizantha* cv. Marandu diferidos, e suas implicações sobre a viabilidade econômica da produção de novilhas da raça Nelore. Utilizou-se o delineamento inteiramente ao acaso, com quatro tratamentos (T1 = pasto diferido sem adubação nitrogenada; T2 = pasto diferido com 50 kg de N ha^{-1}; T3 = pasto diferido com 100 kg de N ha^{-1}; T4 = pasto diferido com 150 kg de N ha^{-1}) e quatro repetições (16 piquetes adubados). Foram utilizadas, inicialmente, 48 novilhas da raça Nelore, com média de oito meses de idade e com peso corporal inicial de 178,69 ± 26,67 kg, sendo distribuídas três novilhas por piquete em todos os tratamentos em um sistema de pastejo sob lotação contínua, com taxa de lotação variável. Apenas o tratamento sem adubação nitrogenada apresentou valores monetários negativos de R$ -181,96; R$ ha^{-1} -72,79 e R$ @$^{-1}$ -32,11. No entanto, o tratamento com 50 kg de N ha^{-1} apresentou os maiores valores monetários positivos com R$ 756,02; R$ ha^{-1} 302,40 e R$ @$^{-1}$ 50,52. Os dados da viabilidade econômica na produção de novilhas de corte demonstram que o tratamento com 50 kg de N ha^{-1} é o mais viável financeiramente, nas condições de realização desta pesquisa.

Palavras-chave: adubação nitrogenada, análise econômica, diferimento, lucratividade, ureia.

Introduction

Among the alternatives to mitigate the seasonality of forage production, the deferment has shown promise for being inexpensive and easily implemented (Euclides, Flores, Medeiros & Oliveira, 2007b). Grazing deferment is a management strategy that consists in selecting a particular area of the property and fencing against grazing, usually in late summer, in order to ensure forage accumulation to be used, under grazing during the forage shortage period (Santos et al., 2009b). The most suitable forage for this practice are those with low accumulation of stems and good retention of green leaves, which result in minor reductions in nutritional value over time, in this case, the genus Brachiaria (Urochloa) have been highlighted (Euclides, Flores, Medeiros & Oliveira, 2007b), especially Urochloa brizantha cv. Marandu.

Nitrogen fertilization can allow greater flexibility in the pasture deferment period, since nitrogen increases the growth rate of the grass and thus the amount of forage produced per unit time (Santos, Fonseca, Balbino, Monnerat & Silva, 2009a). Nitrogen also has an important role on nutritional value thereof, and consequently on the stocking rate and gain per hectare, maximizing animal performance (Vitor et al., 2009). Nitrogen fertilization is the technological tool most questioned by farmers because of its economic viability; therefore, making calculations of production costs to determine the profitability of results become necessary mainly due to changes in fertilizer prices over the growing season, among other variables.

The use of pastures cultivated with nitrogen fertilization can be an economically viable alternative for ruminant production; and it is extremely important to evaluate the forage intake by animals (Euclides, Costa & Macedo, 2007a).

Economic assessment in cattle production aims to analyze the performance of properties and can be accomplished through the use of economic indicators obtained through the production costs. The cost measurement provides a range of possibilities of economic efficiency analysis, including the evaluation of rate of return and profitability (Viana & Silveira, 2008).

In this context, the goal of the present study was to investigate the effect of different nitrogen levels on deferred pastures of *Urochloa brizantha* cv. Marandu and their implications on the economic viability of Nellore heifer production.

Material and methods

The experiment was conducted at the Boa Vista Farm, municipality of Macarani, central southern Bahia State, at 15° 33’ 46” South latitude and 40° 25’ 38” West longitude, at an altitude of 315 m, from March 18 to November 07, 2013. The climate in the region is type Aw, tropical, with a dry season, according to the Köppen classification. Data of temperature and rainfall were collected using a thermometer and rain gauge placed in the experimental area (Table 1).

The soil of the experimental area is classified as Podzolic Red Yellow Eutrophic Equivalent. Collection of soil samples was performed before nitrogen fertilization and chemical analysis showed the following properties in the layer 0-20 cm (Table 2).

The values of base saturation of the soil (Table 2) indicated no need for amendment of acidity or application of potassium (Ribeiro, Guimarães & Alvarez, 1999). Despite the low content of phosphorus, no phosphate fertilization was done, considering that the deferment practice is typically used in low-tech systems.

The used experimental area was 10 hectares (ha) consisting of *Urochloa brizantha* cv. Marandu, planted about 10 years ago, which was divided into 16 paddocks with approximately 0.6 ha each.

The experiment consisted of a completely randomized design (CRD) with four treatments (nitrogen levels) and four repetitions (number of fertilized paddocks), as follows: T1 = deferred pasture without nitrogen fertilization; T2 = deferred pasture fertilized with 50 kg N ha^{-1}, T3 = deferred pasture with 100 kg N ha^{-1} and T4 = deferred pasture with 150 kg N ha^{-1}.

Urea (45% N) was used as a source of nitrogen (N), applied by throw, according to the amounts set out in treatments (111, 222 and 333 kg ha^{-1}) related to the levels of 50, 100 and 150 kg N ha^{-1}, respectively. The doses were divided into two applications, the first on April 17, 2013 and the second on June 6, 2013, both during rainy periods.

The experiment lasted 230 days, with 107 deferment days, 15 days for adaptation of animals to the experimental diet and 108 days of grazing and data collection.

Table 1. Monthly mean values of maximum, minimum and average temperature (°C) and rainfall (mm) during the study period.

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Deferment period				Period of use				
Maximum temperature	30.1	26.2	25.6	24.0	26.8	30.0	29.6	32.4	30.8
Minimum temperature	16.7	16.2	15.2	14.5	16.5	17.6	17.9	18.9	20.2
Average temperature	23.4	21.2	20.4	19.3	21.7	23.8	23.7	25.6	25.5
Rainfall index	19.0	67.6	28.0	33.0	25.0	30.0	64.0	22.0	30.0

Table 2. Chemical analysis of the experimental area.

	pH mg DM^{-3}	cmol$_c$ DM^{-3} soil									%		mg DM^{-3}
Level	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	S.B.	t	T	V	m	O.M.
0	5.7	1.0	0.3	1.6	1.3	0.3	2.4	3.2	3.4	5.8	54.3	7.5	3.58
50 N	5.8	1.0	0.4	1.7	1.3	0.3	2.6	3.4	3.7	6.2	54.3	7.8	3.91
100 N	5.8	1.0	0.5	1.5	1.3	0.2	2.2	3.3	3.5	5.7	57.0	6.8	3.75
150 N	5.6	1.0	0.3	1.4	1.2	0.2	2.6	3.0	3.2	5.8	51.0	7.3	4.12

From March 18 to April 3, 2013, regulator animals were allowed in the experimental area for grazing standardization, the recommended residue height was between 15 and 20 cm. Next, the structure of the experiment was implemented, whose division of paddocks was made with fences of two electrified wire strands, and placed collective plastic drinkers and troughs with a distance of approximately 5 m, with one drinker for each paddock, and the number of troughs according to the number of animals.

Paddocks were closed at the entrance of the animals for 107 days and used from July 21 to November 7, 2013, a dry period, suitable for the start of use of deferred pastures in the region in an attempt to adjust a leaf blade supply to 3.6% body weight, considering the amount of accumulated leaf blade during the deferment period.

Forage evaluations were made every 27 days for 3 grazing periods. To characterize the beginning of grazing, the values of the 1st forage collection (0 days of grazing) and the 2nd forage collection (27 days of grazing) were used; and for the final grazing period, the values of the 3rd forage collection (54 days grazing) and 4th forage collection (81 days of grazing) were used.

For forage production estimation, 5 samples were randomly taken from each paddock, 5 cm from the ground, using pruning shears and a square of 0.70 x 0.70 m, totaling 0.49 m^2 area. All samples were weighed, homogenized and divided into two representative sub-samples: one was separated into leaf blade, stem (stem+pseudostem) and dead material, considering that the proportion of each morphological component was expressed as a percentage of total weight, being packed in labeled paper bags and dried in a forced ventilation oven at 60°C for 72 hours.

The use efficiency of nitrogen by the forage was obtained by subtracting the production of the treatment without nitrogen fertilizer from the total DM production (kg DM ha^{-1}) of each treatment with nitrogen. The difference in production was divided by the total dose of nitrogen, used in the respective period and treatment. The ratio kg DM kg N^{-1} represented how many kg DM were produced per 1 kg nitrogen applied on the pasture, demonstrating the nutrient use efficiency (Castagnara et al., 2011).

For the evaluation of animal performance, 48 Nellore heifers, averaging eight months of age and initial body weight of 178.69 ± 26.67 kg, were distributed into 16 paddocks three animals in all treatments. The grazing method was the continuous grazing system with variable stocking rate, using regulatory animals, according to the put and take technique, each treatment received two test animals and a variable number of regulators, according to forage availability. The grazing period began on July 21, 2013 and ended on November 07, 2013. All heifers were identified with ear tag containing the registration number and dewormed before the start of the experiment.

The heifers were given balanced supplement for 0.2% body weight in order to achieve an average daily gain of 0.400 kg, according National Research Council (NRC, 1996). The supplementation was provided daily at 10 am, in plastic, collective and uncovered troughs to minimize the interference of substitutive effect of supplement intake on forage intake behavior (Adams, 1985).

Heifers were weighed at the beginning and end of the experimental period, after fasting for approximately 12 hours. Two intermediate weighings were made to adjust the stocking rate, the amount of supplement provided and to evaluate animal performance. The proportion of ingredients and chemical composition of the supplement are shown in Table 3.

With the sum of total weight gain divided by the paddock area, we calculated weight gain per area (WG ha^{-1}) and dividing the value of WG ha^{-1} by grazing period, we calculated WG ha^{-1} day^{-1}.

Table 3. Proportion of ingredients and chemical composition of the supplement.

			Supplement				
Ingredients						% DM	
Ground corn grain						58.3	
Soybean meal						25.4	
Mineral salt[1]						8.3	
Urea + Ammonium sulphate[2]						8.0	
	Chemical composition[3] (% DM)						
DM	CP	NDFcp	ADF	LIG	EE	MM	NFC
89.9	32.9	28.0	8.9	0.5	2.8	9.2	50.0

[1]Composition = calcium 195 g (max.), calcium 175 g (min.), phosphorus 60 g (min.), sodium 107 g (min.), sulfur 12 g (min.), magnesium 5.000 mg (min.), cobalt 107 mg (min.), copper 1.300 mg (min.), iodine 70 mg (min.), manganese 1.000 mg (min.), selenium 18 mg (min.), zinc 4.000 mg (min.), iron 1.400 mg (min.), fluoride 600 mg (max.). [2]Mixture composed of nine parts of urea and one part of ammonium sulfate (9:1). [3]DM = dry matter; CP = crude protein; NDFcp = neutral detergent fiber corrected for ash and protein; ADF = acid detergent fiber, LIG = lignin, EE = ether extract, MM = mineral matter, NFC = non-fiber carbohydrates.

The average daily weight gain (ADG) was partially calculated by animal weight difference between two consecutive weighings, divided by the number of days between weighings, resulting in initial and final ADG. To determine the total ADG, we divided the total weight gain per animal per 108 grazing days.

The stocking rate (SR) was calculated considering the animal unit (AU) as 450 kg BW, using the following formula: SR = TAU/area, where: SR = stocking rate in AU ha^{-1}; TAU = total animal unit; Area = total experimental area, in ha.

To evaluate the economic viability of the experiment, we used the cost calculation methodology based on the operating cost methods (Matsunaga et al., 1976). The indicators of economic results were: effective operational cost - EOC, total operating cost - TOC, depreciation - Da, remuneration on capital invested - RCI and remuneration on capital invested in land - RCIL, total cost - TC, gross revenue – GB in reais (R$), in hectare (R$ ha^{-1}) and in arroba (R$ $@^{-1}$), gross margin - GM and net margin – NM in reais (R$), in hectare (R$ ha^{-1}) and in arroba (R$ $@^{-1}$) and result (profit or loss) - RES in reais (R$), in hectare (R$ ha^{-1}) and in arroba (R$ $@^{-1}$). Indicators of economic performance evaluated were profitability - L (%) and rate of return - RR (%).

The effective operational cost was composed of hired labor, supplement (intake per animal/day multiplied by 59 animals and by 108 days of the supplementation period), urea used for pasture fertilization, vaccinations and dewormers. Depreciation was estimated by linear method of fixed quotas: where: Da = (Iv - Fv)/n; where: Da = value of annual depreciation; Iv = initial value of the asset; Fv = final value of the asset (scrap value) and n = useful life of the asset (Noronha, 1987). The total operational cost (TOC) was calculated as follows, TOC = total operational cost + depreciation.

The remuneration on invested capital was calculated with a net rate of 6.00% per year (capital invested in R$ ha^{-1} 108 $days^{-1}$ multiplied by 3.00% for the item land) (Gottschall, Flores, Ries & Antunes, 2002; Nogueira 2007). The total cost is the sum (TOC + RCI + RCIL).

Gross revenue was calculated using the amount of @ produced in each treatment, multiplied by the price of the @, which was R$ 126.00, according to the average of 2014 of Center for Advanced Studies in Applied Economics (Cepea, 2014), gross revenue was calculated in ha, by the equation: GR (R$ ha^{-1}) = (@ produced in each treatment 2.5 ha^{-1}) and in @, where: GR (R$ $@^{-1}$) = (GR$@^{-1}$ produced in each treatment).

Gross margin is gross income minus the effective operational cost. Gross margin was calculated in ha using the equation: GM (R$ ha^{-1}) = (GM 2.5 ha^{-1}) and in @, where GM (R$ $@^{-1}$) = (GM $@^{-1}$ produced in each treatment).

Net margin is gross income minus total operating cost. Net margin was calculated in ha with the equation: NM (R$ ha^{-1}) = (NM 2.5 ha^{-1}) and in @, where: NM (R$ $@^{-1}$) = (NM $@^{-1}$ produced in each treatment). The result (RES) (profit or loss) is the gross revenue minus total cost. The result (profit or loss) was calculated in ha using the equation: RES (R$ ha^{-1}) = (RES 2.5 ha^{-1}) and in @, where: RES (R$ $@^{-1}$) = (RES $@^{-1}$ produced in each treatment).

The profitability was calculated using the following equation: (P = GR -TC*100)/GR); total gross income minus total cost multiplied by 100, divided by the total gross income, according to Antunes and Ries (2001). For calculation of rate of return, we used the equation: Rate of return (RR = RES/IC), where: IC is invested capital.

Table 4 lists data on prices of inputs and services used in the experiment.

Table 5 lists the data on the lifetime and value of improvements, equipment, animals and land used in the experiment.

Table 4. Prices of inputs and services used in the experiment.

Discrimination	Unit	Unit price (R$)
Supplement	kg DM	0.77
Urea	50 kg bag	70.00
Meat	Arroba	126.00
Vermifuge	6 mL	0.90
Fever aphthous vaccine	Dose	1.25
Manpower	Value per day	28.82

Table 5. Lifetime and value of improvements, equipment, animals and land used in the experiment.

Discrimination	Lifetime (years)	Unit value (R$)	Unit	Total value (R$)	Depreciation (R$)
Heifers	-	750.50	59	44,279.50	-
Scale of the pen 1,500 kg	20	8,000.00	1	8,000.00	120.00
Pen for 59 animals	20	11,200.00	1	11,200.00	168.00
Building the structure *	10	3,670.20	1	3,670.20	110.10
Bare soil	-	5,000.00	10 ha	50,000.00	-
Fixed capital investment				117,149.70	398.10

*Paddocks and drinkers.

Analyses of variance were run using a statistical significance level of 5%, regression models of variables were tested according to nitrogen levels applied, considering the coefficients of determination. For statistical analysis, it was used the Statistical Analysis System and Genetics - Saeg. The indices of economic viability were compared using descriptive analysis using the application MS Excel®.

Results and discussion

There was an increasing linear effect ($p < 0.05$) according to nitrogen levels for the availability of total dry matter (ATDM), leaf blade (ADMLB) and stem (ADMS), with increases of 11.89, 6.16, and 6.97 kg DM ha^{-1} for each 1 kg of N applied, respectively, in the initial grazing period (Table 6).

The increase in availability of total dry matter (ATDM) was probably caused by the positive effects of nitrogen, combined with weather conditions favorable for the growth and development of the plant during the deferment period (Table 1). Weather conditions at the time of fertilization were ideal for minimizing the loss of nitrogen, which usually occurs through volatilization, and consequently increased its incorporation into the soil.

The availability of dry matter of leaf blade (ADMLB) and stem (ADMS) may also be attributed to the positive effects of nitrogen and good weather conditions (Table 1). Nitrogen has a positive effect on tiller population and is a key nutrient in the photosynthetic process, and consequently in the higher production and supply of photoassimilates to the growth tissues, causing an increase in the number of leaf blades and stems, generating greater availability of these components.

At the end of the grazing period, there was no effect ($p > 0.05$) of nitrogen levels for ATDM, ADMLB and ADMS with mean values of 2,943, 611 and 785 kg DM ha^{-1}, respectively (Table 6). Probably, the increased stocking rate promoted the similarity of these results in this period (Table 7).

For the use efficiency of nitrogen (Nef), there was a quadratic effect ($p < 0.05$), with minimum point at 114 kg N ha^{-1}, with estimated value of 11.82 kg DM kg^{-1} N^{-1} (Table 6). The volatilization of ammonia and/or the leaching of nitrate may have caused this quadratic effect, because as it increases the nitrogen levels, these losses become inevitable, even with all the management measures taken to minimize these processes.

There was no effect ($p > 0.05$) of nitrogen levels on the final body weight, with an average of 202.7 kg (Table 7). This result can be explained by the similarity in availability of leaves and stems (Table 6) and the adjustment of the stocking rate.

Table 6. Availability of structural components, in kg DM. ha^{-1}, use efficiency of nitrogen in kg DM^{-1} kg N^{-1}, of deferred pastures of *Brachiaria* (Syn. Urochloa) *brizantha* cv. Marandu fertilized with nitrogen.

	Grazing	Nitrogen level (kg ha^{-1}) 0	50	100	150	CV%[1]	P[2]	ER[3]	$R^{2,4}$
ATDM	Initial	3680	4412	4854	5587	12.4	0.003	$\hat{Y} = 3630.62 + 11.895x$	1
	Final	2769	3162	2867	2975	18.3	0.761	$\hat{Y} = 2943$	-
ADMLB	Initial	1006	1337	1668	1924	9.6	0.000	$\hat{Y} = 1021.48 + 6.167x$	2
	Final	485	703	688	567	31.8	0.374	$\hat{Y} = 611$	-
ADMS	Initial	873	1307	1765	1882	11.5	0.001	$\hat{Y} = 934.059 + 6.970x$	3
	Final	539	1026	771	803	45.2	0.332	$\hat{Y} = 785$	-
Nef	Total	0.00	22.23	12.74	15.97	37.3	0.035	$\hat{Y} = 44.42-0.571x +0.0025x^2$	4

[1]Coefficient of variation, in percentage. [2]Error probability. [3]Regression equation. [4]Coefficient of determination. ATDM = availability of total dry matter; ADMLB = availability of dry matter of leaf blade; ADMS = availability of dry matter of stem; Nef = nitrogen use efficiency.[1]R^2 = 0.93, [2]R^2 = 1.00, [3]R^2 = 0.95, [4]R^2 = 1.00.

Table 7. Performance of Nellore heifers and stocking rate on deferred pastures of *Brachiaria* (Syn. Urochloa) *brizantha* cv. Marandu fertilized with nitrogen.

Performance	Nitrogen level (kg ha^{-1}) 0	50	100	150	CV%[1]	P[2]	ER[3]	$R^{2,4}$
IBW (kg)	175.3	179.7	189.1	170.3	-	-	-	-
FBW (kg)	197.6	205.3	214.8	193.1	15.7	0.246	$\hat{Y} = 202.7$	-
ADG Inicial	0.314	0.573	0.515	0.600	22.8	0.005	$\hat{Y} = 0.381 + 0.0016x$	0.64
ADG Final	0.176	0.319	0.305	0.298	39.0	0.168	$\hat{Y} = 0.275$	-
WGA (kg ha^{-1})	70.8	180.0	175.4	168.9	13.2	0.001	$\hat{Y} = 76.375 + 2.3233x - 0.0117x^2$	0.92
WGAD (kg ha^{-1})	0.656	1.667	1.624	1.555	13.2	0.001	$\hat{Y} = 0.7072 + 0.0215x - 0.000108x^2$	0.92
SR initial	1.5	2.7	2.8	2.8	17.5	0.002	$\hat{Y} = 1.800 + 0.00853x$	0.70
SR final	1.6	3.0	3.2	3.2	16.1	0.001	$\hat{Y} = 2.043 + 0.0097x$	0.69

[1]Coefficient of variation, in percentage. [2]Error probability. [3]Regression equation. [4]Coefficient of determination. IBW = initial body weight; FBW = final body weight; ADG = average daily gain (kg day^{-1}); WGA = weight gain per area; WGAD = weight gain per area per day; SR = stocking rate.

There was an increasing linear effect ($p < 0.05$) for average daily gain (ADG), in the initial grazing period (Table 7). The increase in ADG was certainly caused by the positive effects of nitrogen fertilization, hence there was a greater availability of leaf blade and stem (Table 6), which may have caused a greater selectivity of the ingested material, allowing the forage intake with better nutritional value in this period.

At the end of the grazing period, the nitrogen levels had no influence ($p > 0.05$) on ADG, with average of 0.275 kg day^{-1} (Table 7). This result can be explained by increased stocking rate, certainly this has caused the reduction in selective grazing and consequently led to a lower utilization of available nutrients in the forage, affecting animal performance.

For weight gain per area (WGA) and weight gain per area per day (WGAD), the N levels promoted a quadratic effect ($p < 0.05$), with maximum point at 99 kg N ha^{-1} for both gains, with estimated values at 192 and 1.8 kg ha^{-1} day^{-1} (Table 7). These results can be explained by the increase in stocking rate, which, in turn, was justified by high forage availability. The decrease in weight gain was definitely influenced by the quality of the fodder, possibly impairing the intake and, as a consequence, these animals did not show a satisfactory performance. Moreover, the first adjustment in the stocking rate occurred on the grazing day 51, and new regulatory animals failed to show a positive performance, which may have affected the treatment with 150 kg N ha^{-1}, since this treatment received the largest number of animals.

There was an increasing linear effect ($p < 0.05$) depending on nitrogen levels for the initial stocking rate (SRI) and the final stocking rate (SRF) (Table 7). The increase in stocking rate was due to the high amount of available forage quantified before the entry of animals into the paddocks, and after forage collections during the experimental period, due to the positive effects of nitrogen on forage production.

For economic viability, it was observed that the total effective operational cost, the total operational cost and the total cost were higher for treatment with 150 kg N ha^{-1}, with values of R$ 902.63, R$ 1,002.16 and R$ 1,371.95, respectively (Table 8). These values were influenced by the greater amount of urea used in this treatment, increasing costs, since the other items had the same or had similar values. Depreciation was similar for all treatments, with value of R$ 99.53, due to the use of the same structure and equipment during the experimental period (Table 8).

Gross revenue was higher for the treatment with 50 kg of N ha^{-1}, with values of R$ 1.814,40 and R$ ha^{-1} 725.76. These results can be explained by the increase in initial average daily weight gain of animals, which was higher in this treatment (Table 7). As to the gross revenue in R$ @$^{-1}$, there was no difference between treatments, as it was used the price of arroba at R$ 126.00, according to Cepea 2014 (Table 8).

Gross margin and net margin showed positive values for all treatments. However, the treatment with 50 kg N ha^{-1} had the highest results, with values of R$ 1,225.34, R$ ha^{-1} 490.14 and R$ @$^{-1}$ 85.09 for gross margin; and R$ 1,125.81, R$ ha^{-1} 450.32 and R$ @$^{-1}$ 31.27 for net margin (Table 8). In this work, gross margin and net margin were all positive, and this means that all the treatments covered all costs of the experiment: effective operational costs, total operational costs and total cost, and even the opportunity cost.

Gross margin is gross income minus the effective operational costs; according to Antunes and Ries (2001), it is the index that represents how much of the income generated by the sale of each unit is committed to cover the costs for its production. When the gross margin is positive, it means the operation pays off and will survive at least in the short term, when it is negative, it means that the activity is uneconomic. Thus, purchases and consumption are greater than production.

To analyze the outcome indicator in the medium term, the net margin is calculated. When the net margin is positive, it means that revenues cover the total costs of the activity, indicating that the activity can survive, at least in the medium term, as it also covers the depreciation costs.

For the result (profit or loss), only the treatment without nitrogen fertilization had negative values of R$ -181.96, R$ ha^{-1} -72.79 and R$ @$^{-1}$ -32.11 (Table 7). These results demonstrate that only the implementation of this treatment was not feasible, and the remaining treatments covered all costs and still generate profits. These results indicate the importance of nitrogen fertilizer to increase the profit of the production system, and the costs were offset by higher profits in activity compared to treatment without fertilization.

Nevertheless, the treatment with 50 kg N ha^{-1} exhibited the highest values of the result (profit), with R$ 756.02; R$ ha^{-1} 302.40 and R$ @$^{-1}$ 50.52. Furthermore, this treatment presented the highest use efficiency of nitrogen (Table 6), making it an important feature for maintaining the viability of the system.

Table 8. Economic viability of Nellore heifer production on deferred pastures of *Urochloa brizantha* cv. Marandu fertilized with nitrogen.

Especification	Unit[1]	Nitrogen level (kg ha^{-1})			
		0	50	100	150
1 - Effective operational cost					
1.2 - Manpower	R$	389.15	389.15	389.15	389.15
1.3 - Supplement	R$	29.39	30.11	31.57	31.08
1.4 - Urea	R$	0.00	155.40	310.80	466.20
1.5 - Vaccines and dewormers	R$	8.10	14.40	14.40	16.20
1.6 - Total effective operational cost	R$	426.64	589.06	745.92	902.63
2 - Other costs					
2.1 - Depreciation	R$	99.53	99.53	99.53	99.53
3 - Total operational cost	R$	526.17	688.59	845.45	1,002.16
4 - Opportunity cost					
4.2 - Remuneration on capital invested	R$	257.29	257.29	257.29	257.29
4.3 - Remuneration on capital invested in land	R$	112.50	112.50	112.50	112.50
5 - Total cost	R$	895.96	1,058.38	1,215.24	1,371.95
6 - Revenue					
6.1 - Gross revenue	R$	714.00	1,814.40	1,768.20	1,692.60
6.2 - Gross revenue	R$ ha^{-1}	285.60	725.76	707.28	677.04
6.3 - Gross revenue	R$ @$^{-1}$	126.00	126.00	126.00	126.00
7- Outcome indicators					
7.1.1 - Gross margin	R$	287.36	1,225.34	1,022.28	789.97
7.1.2 - Gross margin	R$ ha^{-1}	114.94	490.14	408.91	315.99
7.1.3 - Gross margin	R$ @$^{-1}$	50.71	85.09	72.85	58.81
7.2.1 - Net margin	R$	187.73	1.125.81	922.75	690.44
7.2.2 - Net margin	R$ ha^{-1}	75.13	450.32	369.10	276.18
7.2.3 - Net margin	R$ @$^{-1}$	13.26	31.27	26.30	20.56
7.3.1 - Result (Profit or Loss)	R$	-181.96	756.02	552.96	320.65
7.3.2 - Result (Profit or Loss)	R$ ha^{-1}	-72.79	302.41	221.18	128.26
7.3.3 - Result (Profit or Loss)	R$ @$^{-1}$	-32.11	50.52	39.40	23.87
8 - Economic performance indicators					
8.1 - Profitability	%	-25.49	41.67	31.27	18.94
8.2 - Rate of return[2]	%	-0.27	1.13	0.82	0.48
8.3 - Rate of return[3]	%	-0.06	0.26	0.19	0.11

[1]R$ = reais; @ = arroba; R$ ha^{-1} = reais per hectare; R$ @$^{-1}$= reais per arroba; % = percentage. [2]Capital invested without land; [3]Capital invested with land.

When profit is positive, it can be said that the activity is stable and has growth potential. When negative, it can be said that farmers may continue producing for a certain period, though with a growing problem of undercapitalization, making the activity financially unviable.

The profitability and the rates of return were negative only for the treatment without nitrogen fertilization, with values of -25.49, -0.27 and -0.06%, respectively (Table 8). Profitability and rate of return were better for the treatment with 50 kg N ha^{-1} because this treatment showed the highest values for profitability and for rates of return of 41.67, 1.13 and 0.26%, respectively. The rate of return on capital invested without land of the treatment with 50 kg N ha^{-1} reached 0.4% per month, compared to an interest rate of 0.5% per month from savings accounts (6% per year). The rate of return on capital invested in land explores the item land and should increase productivity per area, as the land cost is considered high.

Rate of return is one way to assess the profit in a productive activity in relation to invested capital for the development of this activity. It should be noted that, to reach the profit an activity has generated, it first should return all the capital invested to its investors (farmer), that is, it shows the farmer how much worth or not worth investing and run business risks proposed (Antunes & Ries, 2001).

Santos, Carvalho, Nabinger, Carassaii and Gomes (2008) evaluated the economic response of pasture fertilization consisting primarily of *Paspalum notatum,* with levels of 0, 100 and 200 kg N ha^{-1}, and found that the total cost was R$ 175.00, R$ 357.22 and R$ 539.44, the gross revenue was R$ 545.18, R$ 616.20 and R$ 1,045.20 and a gross margin of R$ 370.18, R$ 258.98 and R$ 505.76, respectively, and concluded that investment in pasture fertilization is economically feasible, regardless of the nitrogen level up to 200 kg ha^{-1}.

Conclusion

Data on economic viability of production of beef heifers demonstrate that the treatment with 50 kg N ha^{-1} is the most financially viable under the conditions of this study.

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