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PASTURE AND FORAGE UTILIZATION

Nopalea cactus pear fertilized with nitrogen: morphometric, productive and nutritional characteristics

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ABSTRACT. This study aimed to evaluate the structural, productive and nutritional characteristics of cactus pear (*Nopalea cochenillifera* Salm Dyck. cv. Miúda/Doce) under five nitrogen doses and two planting orientations. A randomized block design in a 5 x 2 factorial scheme was used in the scheme: five nitrogen doses (0, 150, 300, 450 and 600 kg of N ha^{-1}), and two planting orientations (North/South and East/West), with three replicates. Except for the thickness of the secondary ($p = 0.04$) and tertiary cladodes ($p = 0.02$), the morphometric characteristics of the cactus pear were not influenced by the nitrogen doses ($p > 0.05$). The mean height was 120 cm, the areas of the primary, secondary and tertiary cladodium were 160.9; 208 and 158.4 cm^2, respectively. The application of nitrogen fertilizer, in the dry conditions and doses evaluated, did not affect the production of green matter (PGM, $p = 0.56$), dry matter (PDM, $p = 0.74$) and dry matter content (DM, $p = 0.72$), with averages of 276 t ha^{-1}, 43.2 t ha^{-1} and 15.7%, respectively. The increase of the nitrogen doses does not improve the majority of the morphometric characteristics or the dry matter yield of the cactus pear cv. Miúda at 730 days after planting.

Keywords: biomass; management; morphometry; semiarid; viability.

Palma forrageira *Nopalea* adubada com nitrogênio: características morfométricas, produtivas e nutricionais

RESUMO. Objetivou-se avaliar as características estruturais, produtivas e nutricionais da palma forrageira *(Nopalea cochenillifera* Salm Dyck. cv. Miúda/Doce) sob cinco doses de nitrogênio e duas orientações de plantio. Utilizou-se um delineamento em blocos casualizados em esquema fatorial de 5 x 2, sendo cinco doses de nitrogênio (0, 150, 300, 450 e 600 kg de N ha^{-1}), e duas orientações de plantio (Norte/Sul e Leste/Oeste), com três repetições. Com exceção das espessuras de cladódio secundário ($p = 0,04$) e terciário ($p = 0,02$), as características morfométricas da palma forrageira não foram influenciadas pelas doses de nitrogênio ($p > 0,05$), sendo a média da altura de 120 cm e área do cladódio primário, secundário e terciário de 160,9; 208,0 e 158,4 cm^2, respectivamente. A aplicação de adubo nitrogenado, nas condições de sequeiro e doses avaliadas não afetou a produtividade de massa verde (PMV; $p = 0,56$), de massa seca (PMS; $p = 0,74$) e o teor de matéria seca (MS; $p = 0,72$), sendo as médias de 276,0 t ha^{-1}, 43,2 t ha^{-1} e 15,7%, respectivamente. O incremento das doses de nitrogênio não melhora a maioria das características morfométricas e nem a PMS da palma forrageira Miúda aos 730 dias após o plantio.

Palavras-chave: biomassa; manejo; morfometria; semiárido; viabilidade.

Introduction

The production of ruminants in Brazil is mainly based on the use of forage crops as a source of nutrients for animals (Barbero et al., 2017). However, the forage supply is not constant throughout the year due to the effect of climatic seasonality, leading to a reduction in animal production (Detmann, Valente, Batista, & Huhtanen, 2014). Several strategies have been studied to address the nutritional deficits of animals during the dry season, such as supplementation with concentrate (Barbero et al., 2015; Sampaio et al., 2017), or bulky, especially in the semi-arid region (Barros et al., 2016; Donato, Pires, Donato, Bonomo et al., 2014), where this period lasts more than 200 days. The production of forage Cactus pear in these regions has grown considerably in the last 10 years, providing nutritional support for the animals (Marques, Paula Gomes, Mourthé, Santos, & Pires Neto, 2017), due to the adaptation of this culture to edaphoclimatic conditions. The varieties of the genus *Opuntia* stand out as the most researched between the cactus pear (Almeida, Campos, Ferreira, Correia, & Andrade, 2015; Barros et al., 2016; Donato, Pires, Donato, Silva, & Aquino, 2014).

In practice, the Cactus pearcultivation of the species *Nopalea cochenillifera* Salm Dyck. cv. Miúda/Doce has increased by several factors such as resistance to pests, diseases and drought, besides being easy to manage (Amorim, Martuscello, Araújo Filho, Cunha, & Jank, 2015). However, there are few researches with varieties of the genus *Nopalea*. In addition, research results have shown that the potential of the cactus pear production is still low (Padilha Junior, Donato, Silva, Donato, & Souza, 2016), which can be attributed to the absence of information related to the management and types of technologies available for this purpose.

One of the methods to improve the production and nutritional value of cactus pearis the use organic fertilizers in the variety *Opuntia ficus-indica* (L.) Mill. cv. Gigante (Barros et al., 2016; Donato, Pires, Donato, Silva et al., 2014). However, there are still few studies with nitrogen fertilization regarding the cultivar Miúda/Doce (Cunha et al., 2012; Silva, Santos, Dubeux Júnior, Cunha, & Ferraz, 2016). The productive and nutritional improvement of forage grasses with the use of nitrogen (N) is very widespread in the literature (Lobo et al., 2014; Sales, Reis, Rocha Júnior et al., 2014), but the results of its effects on cactus pear are still scarce and controversial. Furthermore, there are gaps regarding the management of planting, being the most used the East/West direction. However, in a rain fed system in the semi-arid region of northern Minas Gerais, this planting arrangement has been criticized by some producers, claiming greater exposure of the cladodium to sunlight, dryness, and consequently, poor performance of the palmal.

In this context, the objective of this study was to evaluate the structural characteristics, the accumulation of biomass and the nutritional value of the cactus pear (*Nopalea cochenillifera* Salm Dyck), under five nitrogen doses and two planting orientations in the semi-arid North of Minas Gerais.

Material and methods

The experiment was conducted at the Experimental Farm of Gorutuba, belonging to the Agricultural Research Company of Minas Gerais (EPAMIG), in the municipality of Nova Porteirinha, in Minas Gerais state. The climate according to Köppen and Geiger (1928) classification is Aw type (Caatinga hot climate), with summer rainfall and well defined dry periods in winter (Reboita, Rodrigues, Silva, & Alves, 2015). The average annual precipitation is around 877 mm, irregularly distributed between the months of November to April, with average annual temperature of 26ºC and maximum of up to 40ºC. The Figures 1 and 2 show the rainfall averages of the months in which the experiment was conducted.

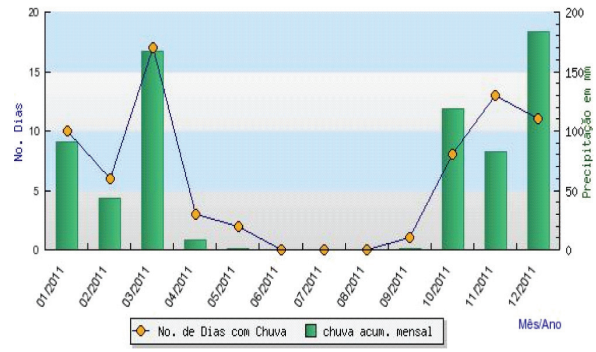

Figure 1. Rainfall indices and number of rainy days in the municipality of Janaúba – MG, in the year 2011. Source: Instituto Nacional de Metereologia (INMET, 2014).

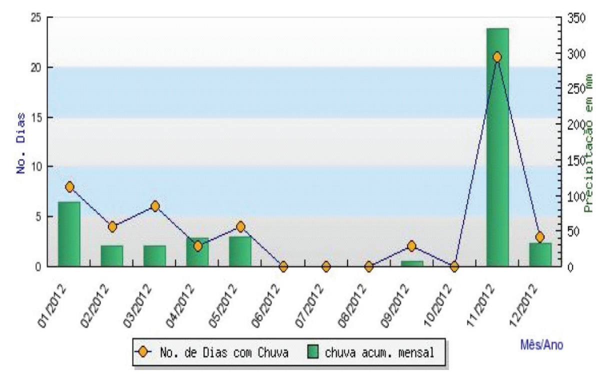

Figure 2. Rainfall indices and number of rainy days in the municipality of Janaúba, MG, in 2012. Source: INMET (2014).

According to the figures above, rainfall rates of 270 mm were recorded from December 2011 to February 2012, which comprehends the time that the fertilization was parceled out in three applications of equal proportions.

The soil of the experimental area was classified as eutrophic Red-Yellow Latosol with sandy texture (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2006), with the following chemical characteristics in the 0 to 20 cm layer: pH in H_2O: 6.0; phosphorus and potassium (Melich^{-1}) 65.7 and 207 mg dm^{-3}, respectively; calcium, magnesium and aluminum (extractor KCl 1 mol L^{-1}), 3.1; 1.6 and 1.6 $cmol_c$ dm^{-3}, respectively; organic matter, 1.3 dag kg^{-1}, base saturation, 77 % and Cation-exchange capacity (CEC), 6.8 $cmol_c$ dm^{-3}. Due to the chemical analysis of the soil, it was not necessary to perform the correction of the acidity and fertilization for implantation of palmal.

The seedlings (primary cladodium) of the cactus pear *Nopalea cochenillifera* Salm Dyck. cv. Miúda/Doce were obtained from a private property under satisfactory conditions of cultivation (free from diseases and pests), located in the municipality of Janaúba, in the State of Minas Gerais. After collection, the cladodes were stored in a covered shed for 15 days, for wound healing left by the cut.

A randomized complete block design in a 5 x 2 factorial scheme (five nitrogen doses - 0, 150, 300, 450 and 600 kg of N ha^{-1}) was used, with urea as the nitrogen source and two planting orientations (east/west and North/South), with three replicates.

The palmal was implanted in August 2010, and the planting was done manually. The cladodes were fixed to the ground in an upright position, with the cutting region facing downwards, and in a depth of soil sufficient to cover the half of the cladode. Each plot was composed of four lines of 4.0 m, establishing the two central lines as the useful area for data collection purposes, and the spacing used was 1.0 m between rows and 0.5 m between plants. The management of the palmal was conventional, using the rainfed system and maintaining the weed-free area through manual weeding. The fertilization was divided in 3 applications, carried out in quantity proportional to the doses and in equal intervals in the months of December, January and February.

The evaluations initiated in August 2012, the second year of harvest (730 days of planting). The following characteristics were evaluated: length (cm), width (cm), thickness (mm) and area of cladodium (cm^2) for primary, secondary and tertiary cladodes, and plant height (cm). For measurements of cladode length and width, a ruler graduated in cm was used. The thickness of the cladodium was determined through a digital caliper, and the plant height was measured from the base of the soil to the apex of the last cladode using a metric ruler.

The cladode area (CA) was determined according to the methodology used by Donato, Pires, Donato, Bonomo et al., 2014 by the following expression:

$\text{AC} = \text{Length x Width x } 0.693$, expressed in cm^2, with 0.693 being the correction factor as a function of the eclipse form of the cladode.

For green mass yield, four plants were cut in the useful area of each plot, weighed in a digital pendulum scale, and the estimated value corresponded to the number of 20,000 ha^{-1} plants.

For the sampling, 2 kg of cladodes per plot were randomly collected. The samples were chopped and pre-dried in a forced ventilation oven, with temperature of 55°C, until reaching constant weight. The pre-dried material was ground in a Willey mill with 1 mm sieves and analyzed for dry matter (DM), mineral matter (MM), ethereal extract (EE) and crude protein (CP), according to Association of Official Analytical Chemist (AOAC, 1997). The neutral detergent fiber and acid detergent fiber were calculated according to Van Soest and Robertson (1985). The total carbohydrate (TC) content was estimated by the equation: $\text{CT}\,(\%) = 100 - [\%\text{Moisture} + \text{PB}(\%) + \text{EE}(\%) + \text{ashes}(\%)]$ and the non-fibrous carbohydrate content by Sniffen, O'Connor, Van Soest, Fox, and Russell (1992). Total digestible nutrients (TDN) were estimated using the formula:

$\text{NDT} = 40.2625 + 0.1969\,\text{PB} + 0.4028\,\text{CNF} + 1.903\,\text{EE} - 0.1379\,\text{FDA}$ (Weiss, 1998).

For economic feasibility, the average value of the urea input practiced in Janaúba, Minas Gerais market in the 2$^{\text{nd}}$ semester of 2017 was considered, with the urea kilogram of R$ 1.56 or the kilogram of the N of R$ 3.46. The costs of transporting and applying urea were not considered. The additional cost with the acquisition of the fertilizer was calculated by multiplying the doses by R$ 3.46. The value obtained with the additional cost of acquisition divided by the additional dry mass productivity gives the additional cost per ton. Nitrogen use efficiency was obtained by dividing the dry mass yield at each N dose by the dry mass yield of the control treatment (without fertilization), as a percentage (adapted from Sales, Reis, Monção et al. (2014)).

The data were submitted to statistical analysis using SISVAR (Ferreira, 2014) and when the variables were significant by the F test, the nitrogen fertilization levels were submitted to regression analysis. The regression equations were selected based on the trend of the data and higher coefficient of determination (R^2). The probability was set at 5%.

Results and discussion

For the morphometric variables, no interaction ($p > 0.05$) was observed between the nitrogen doses (ND) and planting arrangement (North/South and East/West). Thus, the variables were discussed in isolation for ND and DP (Table 1).

Except for the thickness of the secondary (SCT; $p = 0.04$) and tertiary cladodes (EST $p = 0.02$), the other morphometric characteristics of the cactus pear were not affected by ND ($p > 0.05$), with values for mean height of 120 cm, and area of primary (APC), secondary (ASC) and tertiary cladodium (ATC) of 160.9; 208.0 and 158.4 cm^2, respectively. Positive modifications on the morphometric characteristics may occur due to N acting as a cell division and elongation stimulator, which would promote direct effects on the width and length of the cladodes, increasing the cladodium area. However, the irregular distribution of rainfall during the 730 days of cultivation, mainly on the days of application of the fertilization, may have contributed to the N absorption by the plant, consequently, not modifying the structural arrangement of the palm. According to Donato, Pires, Donato, Bonomo et al., 2014, the increase in the area of the cladodium is fundamental in determining the active photosynthetic area of the plant, because the greater area of the cladodium, the better the interception of the sunlight to transform it into dry mass yield. The nitrogen, when absorbed by the plant, participates in the composition of several organic molecules inside the plant, and is the main controller of the photosynthetic processes, generating photoassimilates, which consequently increases the cladodes area and mass production (Cunha et al., 2012).

For the SCT and TTC, the means adjusted to the quadratic regression model, with the greatest thicknesses being verified at the dose of 417 and 375 kg ha-1 of N, respectively. Planting palms in different PA did not modify the morphometric characteristics evaluated ($p > 0.05$). Therefore, it is possible to plant using the two PA suggestions.

Table 1. Morphometric characteristics of cactus pear at 730 days after planting, as a function of nitrogen doses (ND) and different planting arrangement (PA).

Item (cm)	PA	Nitrogen doses (kg ha^{-1}) 0	150	300	450	600	SEM	P-value ND	PA	ND x PA
Height	North/South	113	127	125	115	123	4.5	0.31	0.69	0.12
	East/West	121	126	119	127	102				
PCT, mm	North/South	35.4	40.2	50.2	46.1	41.9	3.2	0.21	0.46	0.60
	East/West	40.2	50.1	45.8	47.6	41.1				
SCT [1], mm	North/South	12.5	15.8	22.4	20.6	15.8	1.3	0.04	0.22	0.28
	East/West	12.3	23.5	17.5	24.7	21.0				
TTC [2], mm	North/South	9.6	10.2	14.8	12.8	9.5	1.3	0.02	0.14	0.06
	East/West	7.7	15.8	10.6	18.4	13.5				
PCW	North/South	10.0	9.8	10.0	9.7	10.5	0.5	0.75	0.26	0.85
	East/West	11.5	9.8	10.4	10.5	10.6				
SCW	North/South	10.0	12.1	10.2	9.9	10.9	0.7	0.53	0.15	0.16
	East/West	14.1	11.0	10.9	11.3	10.8				
TCW	North/South	9.7	10.2	10.2	9.7	9.6	0.3	0.83	0.33	0.24
	East/West	10.5	9.4	9.6	11.2	10.4				
PCL	North/South	23.8	27.5	25.5	25.4	24.7	0.8	0.96	0.18	0.39
	East/West	28.3	25.6	25.3	27.1	28.6				
SCL	North/South	28.0	29.2	28.3	33.2	29.2	1.2	0.53	0.97	0.62
	East/West	29.2	29.3	30.1	29.8	29.6				
LTC	North/South	21.5	25.1	26.6	23.5	24.5	0.8	0.34	0.09	0.11
	East/West	25.7	24.5	25.3	26.3	25.5				
PCA, cm^2	North/South	149	170	160	154	164	6.7	0.16	0.63	0.64
	East/West	148	157	167	159	181				
SCA, cm^2	North/South	179	224	182	207	202	17.4	0.85	0.25	0.32
	East/West	203	203	207	214	201				
TCA, cm^2	North/South	132	161	172	144	150	8.9	0.79	0.11	0.07
	East/West	171	146	154	186	168				

PCT - Primary cladode thickness; SCT - Secondary cladode thickness; TTC- Thickness of tertiary cladodium; PCW - Primary cladode width; SCW - Secondary cladode width; TCW - Tertiary cladode width; PCL - Primary cladode length; SCL - Secondary cladode length; LTC - Length of the tertiary cladode; PCA - Primary cladodium area; SCA - Secondary cladodeal area; TCA - Tertiary cladodeal area; SEM - Standard error of the mean; P - Probability. ND x PA - interaction. $^{1}\hat{Y} = -6E-05x2 + 0.05x + 12.7$; $R^2 = 0.91$; $p < 0.001$; $^{2}\hat{Y} = -4E-05x2 + 0.03x + 8.6$; $R^2 = 0.80$; $p < 0.001$

The application of nitrogen fertilizer in the rain fed conditions and evaluated doses did not affect the green mass yield (GMY, $p = 0.56$), dry matter yield (DMY, $p = 0.74$) and dry matter, (DM; $p = 0.72$), with averages of 276.0 t ha^{-1}, 43.2 t ha^{-1} and 15.7%, respectively. This response is justified because the cladode area was not altered with nitrogen fertilization or with PA (Table 2).

Table 2. Productive and nutritional characteristics of cactus pear at 730 days after planting, as a function of nitrogen fertilization (ND) and different planting arrangement (PA).

Item	DP	Doses de nitrogênio (kg ha^{-1}) 0	150	300	450	600	EPM	P-valor DN	DP	DN x DP
GMY	North/South	218	262	307	252	316	40.3	0.63	0.78	0.56
	East/West	227	362	260	309	247				
DMY	North/South	33.8	43.8	56.7	42.3	51.9	7.7	0.64	0.49	0.74
	East/West	33.6	46.0	44.4	48.3	31.8				
DM	North/South	15.5	17.0	18.5	16.1	17.1	0.7	0.41	0.03	0.72
	East/West	14.9	12.8	17.0	14.7	12.9				
CP	-	6.0	7.9	9.6	8.3	8.7	0.6	0.01	<0.01	0.05
NDF	-	47.2	47.0	54.9	44.2	36.0	1.1	<0.01	<0.01	<0.01
ADF	North/South	13.9	13.3	15.6	18.1	12.8	1.1	0.28	0.58	0.55
	East/West	14.9	15.5	16.0	15.5	14.4				
Hem	-	32.7	32.6	39.1	27.7	22.4	1	<0.01	<0.01	<0.01
TC	North/South	64.3	59.4	55.1	61.0	58.1	1.3	0.06	<0.01	0.23
	East/West	64.8	66.6	61.7	63.2	66.0				
NFC	North/South	35.7	40.6	44.9	39.0	41.9	1.3	0.06	<0.01	0.23
	East/West	35.2	33.5	38.3	36.8	34.0				
TDN	North/South	57.7	60.4	62.4	59.0	61.3	0.6	0.06	<0.01	0.13
	East/West	57.4	56.7	58.7	58.3	57.1				

GMY –Green mass yield; DMY – Dry matter yield; DM – Dry matter content; CP – Crude protein; NDF – Neutral detergent fiber; ADF – Acid Detergent Fiber; Hem – Hemicellulose; TC – Total Carbohydrates; NFC – Non-fibrous carbohydrates; TDN – Total digestible nutrients; SEM – Mean standard error; P – Probability. ND x PA – interaction.

According to Cunha et al. (2012), the characteristics of GMP are not considered important, as they are of little relevance in studies with other forage plants. However, the same authors argued that the PMV becomes important when used for the design and control of the flow of animals, and due to the amount of water from this biomass, which is high and very important for the animals in arid and semi-arid conditions. In practice, it may also be noted that the supply of cactus pear to the animals occurs during the dry season, where the pasture mass is dry and the average temperature is usually lower, which can affect the intake of water by the animals. Thus, the cactus pear in the diet has high importance both as water and nutrients supplier. The absence of a significant response to DMY may be related to the dynamics of the development of the cactus pear root system, in order to capture water and nutrients from the soil, as well as the nitrogen source used, as verified in studies by Cunha et al. (2012). In addition, the irregular distribution of rainfall (Figure 1 and 2) can generate short periods of complete growth of the root system, most of which disappears during the dry season (Zúñiga-Tarango et al., 2009), as a strategy for saving energy and humidity.

In studies evaluating the cactus pear of *Nopalea* gender under increasing levels of N (0, 100, 200 and 300 kg ha^{-1}), Cunha et al. (2012) also found no effect of the fertilizer on the DMP. The authors argued that the source of N used, in this case urea, presented losses by volatilization and leaching, not allowing the root system of the cactus pear to efficiently absorb the available N, most of which is lost to the environment. The studies from Gonzalez (1989) corroborate this statement. The author verified improvement in DMY of *Opuntia lindheimeri* Engelm. palm, fertilized with nitrogen and phosphorus, in long-term experiments, however, he did not observe effects of fertilization in the first two years after planting, a fact also verified in this research.

For the crude protein levels in the two PA, the means were adjusted to the quadratic regression model, where the maximum dose was 333.3 kg ha^{-1} of N (North/South) and 444.4 kg ha^{-1} of N (East/West; Figure 3). Among the PA, there was no difference in CP content within the control treatment (without fertilization) and with application of 450 kg ha^{-1} of N, with averages of 5.95% and 8.25%, respectively. Among the treatments with application of 150, 300 and 600 kg ha^{-1} of N, it was verified that the means in the North/South DP were 46.8%; 70.4% and 55.9% higher than East/West SD (6.4%, 7.1% and 6.8%), respectively.

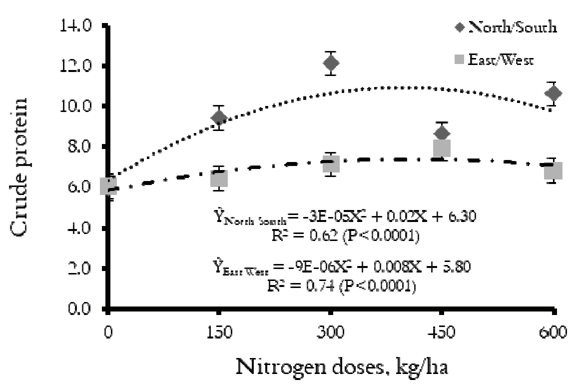

Figure 3. Crude protein contents (CP, % dry matter) of cactus pear in two planting orientations and under nitrogen doses.

For the NDF, the means were also adjusted to the quadratic regression model, with the highest levels observed at 250 kg ha^{-1} of N (North/South) and 540 kg ha^{-1} of N (East/West). The North/South PA impairs the exposure of the cladodium area to sunlight for, at least, the first 6 months, which may be an obstacle in the initial development of the plants under ideal edaphoclimatic conditions. Therefore, more N is required to stimulate the development of the plant, which explains the higher NDF mean at high N doses in the North/South DP. However, with the advancement of plant age, new tillers sprout in several directions, which mask the results of PD. In the Northern region of Minas Gerais state, the North/South plantation seems to be more interesting when considering light intensity and elevated temperature, especially at the beginning of the rainy season, a time recommended for planting the cactus pear in dry conditions. This DP prevents intense dehydration of the matrix paddle.

Within the ND, there was no difference between the PA in the control treatment (47.1%). However, the North/South PA presented higher NDF contents in the ND of 150, 300, 450 and 600 kg h^{-1}a of N in relation to the East/West PA in the order of 37.1; 25; 70 and 53.9%, respectively (Figure 4).

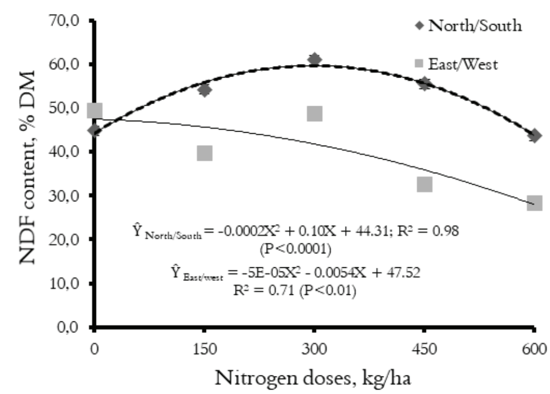

Figure 4. Neutral detergent fiber (NDF) contents of cactus pear in two planting orientations and under nitrogen doses.

The use of cactus pear as the only ingredient to fed ruminants is not recommended due to its nutritional characteristics. Its low CP content, as can be verified in the treatment without fertilization (5.95%), is below the value recommended (8%) for reproduction and growth of the fibrolytic bacteria present in the rumen (Van Soest, 1994), so it is necessary to correct the diet with protein ingredients. However, at doses above 150 kg ha^{-1} of N, the CP values were within the recommended. Although, the main purpose of palmal fertilization with N is to increase DMP and to allow a more intensive cutting management throughout the year. Another nutritional aspect of cactus pear that must be considered is its low NDF content (25.7%), according to studies by Almeida et al. (2015) in cactus pear of the genus Opuntia. The NDF level recommended in diets for ruminants is 28%, in order to avoid metabolic disorders. In the present study, in all treatments, NDF levels were above recommended levels (28%) (National Research Council [NRC], 2001), but attention should be paid to NDF levels that are effective and physically effective mainly due to the stimulation of rumination and salivation in ruminants, which avoids, in fact, the metabolic disorders (Van Soest, 1994). The content of NDF in the cactus pear is increased by several factors, such as the growth and effect of age, which allowed the increase of the components present in the cell wall, especially in the older cladodes. Nevertheless, the exclusive use of cactus pear as a source of bulky for ruminants is not recommended.

Concerning the hemicellulose (HEM) contents in the North/South PA, the ND that maximized the contents was 500 kg ha^{-1} of N (quadratic effect), which is justified by the higher NDF levels at this dose (Figure 5). For East/West DP, HEM levels reduced daily 0.03% for each unit of N applied, which may be associated with the dilution effect provided by N on the levels of ADF. The PA did not differ within the control treatment, with means of 32.7% of HEM, based on DM. Within each applied ND, the North/South PA had the highest HEM averages, in relation to the East/West PA.

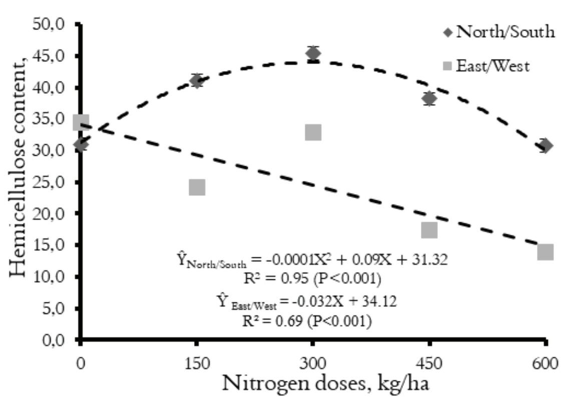

Figure 5. Hemicellulose contents (HEM, % dry matter) of cactus pear in two planting orientations and under nitrogen doses.

With respect to the total carbohydrate (TC), non-fibrous carbohydrate (NFC) and total digestible nutrients (TDN), no interactions were observed between the ND x PA and the isolated ND effect ($p > 0.05$). However, TC levels were higher in the East/West PD (64.5%) than in the North/South PA (59.6%). Contrary behavior was verified for the NFC, which was 13.7% higher in North/South PA than in East/West PA (mean 35.5%). The energy concentration, as TDN, was also higher, 4.4%, in the North/South PA in relation to the East/West PA (57.6%). In general, these results of TC, NFC and TDN highlight the great potential for use the cactus pear from Miúda cultivar in diets for ruminants, mainly due to its energy amount. This fact may imply in a readjustment in the inclusion of concentrated ingredients, which has a higher value of acquisition.

Regarding the additional production costs with the adoption of nitrogen fertilization technology, the largest differential of dry mass productivity and nitrogen use efficiency was verified at 300 kg ha^{-1} of N (17 t ha^{-1}) and 50%, respectively. However, the lowest cost per ton produced was R$ 47.2, at the dose of 150 kg ha^{-1} of N (Table 4).

Table 4. Cost of dry mass yield and nitrogen utilization efficiency in cactus pear Miúda in the Northern region of Minas Gerais.

Item[1]	Nitrogen doses (kg ha^{-1})				
	0	150	300	450	600
Additional cost, R$ ha^{-1}	-	519	1038	1557	2076
Differential PDM, t ha^{-1}	-	11	17	12	8
Additional cost per ton, R$	-	47.2	61.1	129.8	259.5
Efficiency of Use of N, %	-	32	50	35	24

DMY - Dry mass yield; N - nitrogen. [1] Values practiced in the Janaúba-MG market, 2nd half of 2017.

Conclusion

The increase of nitrogen doses up to 600 kg ha^{-1} does not improve most of the morphometric characteristics or the dry matter yield of cactus pear cv. Miúda/Doce at 730 days after planting, in a rain fed system. The nitrogen dose of 333.3 kg ha^{-1} associated with the North/South planting arrangement promotes better results for the crude protein contents. Cactus pear cultivated in the North/South arrangement present better non-fibrous carbohydrate contents and total digestible nutrients.

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