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ARTICLE

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Nutritional and fermentative profile of forage sorghum irrigated with saline water

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ABSTRACT

This study aimed to evaluate the nutritional and fermentative potential of silage of the forage sorghum Ponta Negra irrigated with saline water. The bromatological characteristics, losses and fermentative profile of sorghum silages were observed. For the bromatological characteristics of the sorghum plant, a decreasing linear behavior was observed for the contents of dry matter and organic matter while a positive linear effect was verified for crude protein and mineral matter as the leaching fractions were increased ($P < 0.05$). A quadratic behavior was observed for non-fibrous carbohydrates, neutral detergent fiber, acid detergent fiber, and cellulose ($P < 0.05$). The pH values showed a quadratic effect ($P < 0.05$) with lower pH values observed at 15 days of silo opening for water depths of 10 and 15%. Regarding the silages, the leaching fractions provided differences ($P < 0.05$) for dry matter recovery, gas loss and effluent loss. A negative linear behavior for the contents of dry matter and organic matter and an increasing linear effect for mineral matter ($P < 0.05$). The highest concentrations of ammoniacal nitrogen were observed when irrigation was performed with a 10% saline water depth ($P < 0.05$).

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1. Introduction

The Brazilian Northeast region has about 1.56 million km^2, accounting for 18.2% of the country, housing almost entirely the Semiarid region. It is strongly influenced by a negative water balance coming from low annual mean precipitations of around 800 mm and annual mean temperatures from 23 to 27 °C, with an evaporation of 2000 mm/year, mean relative air humidity around 50%, and mean insolation of 2800 hour/year. Because of these characteristics and a regime of irregular and scarce precipitations, water sources are considered insufficient in the region (Andrade et al. 2018; Lima et al. 2018a).

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In addition to this scarcity, the Brazilian Semiarid region still faces a high content of salts in most of its groundwater sources, such as wells, and surface waters, such as dams and ponds of small and medium sizes. Due to the high concentrations of salts, these waters are often considered unfit for human and animal consumption, being necessary to adopt alternative measures for their use, such as the irrigation of plants more tolerant to salinity (Cosgrove and Loucks 2015).

Forage sorghum [*Sorghum bicolor* (L.) Moench] has been identified as a crop with high potential for use in salinized areas of the semiarid due to its high-energy value for animal feed and adaptation to dry, saline, and warm environments, which are limiting for the cultivation of other forage species. In addition to being a crop with great potential and tolerance to areas with saline soils, sorghum is highly adapted to the silage process in the semiarid region due to its high content of soluble carbohydrates, low buffering capacity, considerable dry matter production (DMP), adaptability to low precipitation conditions, and quality of silage produced (Hefny et al. 2013; Perazzo et al. 2017).

In addition to the use of salinity-tolerant crops, techniques that mitigate the effects of salts on plants are essential to ensure the sustainability of cultivations irrigated with saline waters. Water fraction applications above crop requirements (leaching fractions) that guarantee the leaching of part of soil salts is an essential technique to reduce the salinity of the plant root zone and ensure crop productivity (Aragüésa et al. 2014). Guimarães et al. (2016) evaluated the nutritional status of forage sorghum varieties irrigated with saline fish effluent and observed that the use of leaching fractions up to 15% changed Cu, Zn, Fe, and Mn leaf contents, reducing iron, manganese, and zinc, and increasing copper.

Therefore, studies on the use of saline water for the irrigation of forage sorghum and its salt absorption are required aiming at changes in the physicochemical conditions inside silos, allowing the mitigation of fermentative losses and those related to the aerobic exposure of silages, resulting in well-preserved silages with a high nutritional value.

This study aimed to evaluate the nutritional and fermentative potential of silage of the forage sorghum Ponta Negra irrigated with saline water.

2. Material and methods

2.1 Experimental site

The experiment was carried out at the Experimental Field of Caatinga, belonging to Embrapa Semiarid, Petrolina, PE, Brazil, in the sub-middle region of São Francisco Valley (09°08′8.9″ S and 40°18′33.6″ W, with an altitude of 373 m). The regional climate is classified as a semi-arid BSwh′ type according to Köppen classification, with a well-defined period of precipitations from November to April (Lopes et al. 2017). During the experimental period, the relative air humidity and mean air temperature were 55.75% and 26.17°C, respectively. The maximum evapotranspiration was 6.72 mm/day, with a mean of 4.58 mm/day. Precipitation events totaled 42.9 mm at the end of the experiment.

2.2 Sowing

Sorghum of the Ponta Negra variety was shown in an experimental area formed by five rows of five meters in length spaced at 0.5 m, totaling 12.5 m^2. The useful plot was composed of the three central rows without the initial and final meters of each row, totaling 4.5 m^2.

The soil of the area is classified as Red Yellow Argisol (Embrapa, 2013). Soil samples were collected for analysis of their chemical characteristics (Table 1). The experimental area was managed according to crop requirements, with liming at 90 days before sowing due to the low pH values.

2.3 Experimental design

The experiment was carried out in two steps. In the first step, a randomized block design composed of the sorghum variety Ponta Negra irrigated with saline water with four leaching fractions (0, 5, 10 and 15%) and four replications was adopted.

In the second step, the completely randomized design was used for mini-silos, using a day of opening (90 days) with four leaching fractions (0, 5, 10 and 15%) and three replications, totaling 60 mini-silos.

2.4 Irrigation

Irrigation was performed with saline water from wells. Water application was carried out based on crop evapotranspiration (ETc), providing 0, 5, 10 and 15% of ETc, which was obtained by reference evapotranspiration (ETo) and crop coefficient. Irrigation was performed by surface drip irrigation with emitters with a flow of 1.6 L/h, nominal diameter of 16 mm, and a spacing of 0.30 m from each other.

Irrigation management started after all plots were under field capacity, which comprises the maximum water retention capacity of the soil. From this moment on, irrigation water depths were calculated according to the crop evapotranspiration measured in the period between irrigations, using the method proposed by FAO 56 (Allen et al. 2006). For this, the methodology of dual Kc was used with basal Kc values of 0.15, 0.95 and 0.35

Table 1. Chemical composition of the soil of the experimental area.

	pH	K^+	Na^{2+}	Ca^{2+}	Mg^{2+}	Al^{3+}	CEC	SB	H+ Al
Layer (cm)	–cmol/dm^3–								
0–20	4.6	0.23	0.27	1.6	0.60	0.05	4.2	2.7	1.5
20–40	5.7	0.16	0.68	1.4	0.60	0.00	5.6	2.8	2.7
40–60	5.0	0.15	1.12	2.4	1.50	0.20	7.7	5.2	2.5
60–80	4.5	0.11	1.40	2.8	2.20	015	8.8	6.5	2.3
80–100	4.5	0.08	1.18	3.2	2.00	0.05	8.7	6.5	2.3
Layer (cm)	P	Cu	Fe	Mn	Zn	EC	V	Total C	
	–mg/dm^3–					m/Scm	%	g/kg	
0–20	6.14	1.07	21.4	18.2	4.54	1.33	64.0	4.6	
20–40	1.22	1.65	23.0	14.6	3.13	2.20	50.9	4.1	
40–60	0.55	1.49	8.5	12.9	2.07	2.41	67.4	3.7	
60–80	1.69	1.37	6.0	7.0	2.05	2.50	74.3	2.3	
80–100	0.21	1.18	9.5	8.1	2.82	2.60	74.2	2.1	

pH = Hydrogenionic potential; K^+ = Exchangeable potassium; Na^+ = Exchangeable sodium; Ca^{2+} = Exchangeable calcium; Mg^{2+} = Exchangeable magnesium; Al^{+3} = Exchangeable aluminum; CEC = cation exchange capacity; SB = Sum of bases; H+ Al = Potential acidity; P = Available phosphorus extracted by Mehlich-1; Cu = Copper available; Fe = Iron available; Mn = Manganese available; Zn = Zinc available; EC = Electrical conductivity; V = base saturation; Total C = Total carbon.

applied, respectively, for the initial, intermediate and end-of-cycle phenological stages, according to the water application efficiency and tested leaching fractions, as:

$$Di = [((ETo \times Kc \times Kl) - P)/Ef] \times (1 + FL)$$

where Di is the irrigation water depth (mm), ETo is the evapotranspiration measured in the period (mm), Kc is the crop coefficient, Kl is the coefficient of localized irrigation, P is the precipitation measured in the period (mm), Ef is the irrigation system efficiency (0.9), and FL is the applied leaching fraction.

Irrigation water samples were collected weekly during the experimental period to analyze their chemical characteristics (Table 2). Water was identified as C4S1, according to Richards (1954) classification.

2.5 Crop management

Manual weeding was conducted at 30 DAS (days after sowing), followed by a preventive application of insecticide against fall armyworm (*Spodoptera frugiperda*) at 40 and 60 DAS.

2.6 Sorghum harvest and preparation of silage

Sorghum was harvested at 101 DAS when grains were at the early to soft dough stage. Cutting was carried out manually at 10 cm above the ground, and this cut material was chopped in a forage machine, obtaining particles whose sizes ranged from 2 to 4 cm.

The chopped material was homogenized and sampled as a non-ensiled material (original material) and ensiled in experimental silos made of polyvinyl chloride (PVC) tubes with 10 cm of diameter and 50 cm of height and equipped with a Bunsen valve for the exhaust of gases. Sand was placed at the bottom of the experimental mini-silos, being protected by cotton fabric to avoid that forage were exposed to the sand, allowing the drainage of the effluent.

Sixty experimental silos were prepared for the storage of the chopped forages. The silos were weighed before and after forage deposition to determine the density of ensiled mass and volume and weight of silos. Silos were opened on different days (1, 15, 30, 60 and 90 days) and the silage in up to 10 cm from their ends was discarded. At the last opening (at 90 days), samples were collected to determine the bromatological composition and fermentation profile of silage.

Table 2. Chemical composition of water used in irrigation.

	EC	Ca^{2+}	Na^{+}	Mg^{2+}	K^{+}	Cl^{-}	SO_4^{2}	CO_3^{2}	HCO_3	SAR	TH
pH	ds/m	– – – – – – – – – – – – – – – –	– –	-mmol/L	– – – – – – – –	– – – – – –	– – – – – –				mg/L
7.37	4.19	15.83	14.8	14.49	0.52	55.79	4.26	4.3	4.25	3.8	140.65

pH = Hydrogenionic potential; EC = Electrical conductivity; Ca^{2+} = Ca^{2+} = Exchangeable calcium; Na^{+} = Exchangeable sodium; Mg^{2+} = Exchangeable magnesium; K^{+} = Exchangeable potassium; Cl^{-} = Chlorides; SO_4^{2-} = Sulfates; CO_3^{2} =-Carbonates; HCO_3 = Bicarbonate; SAR = Sodium adsorption ratio; TH = Total Hardness.

2.7 pH and ammoniacal nitrogen (NH_3–N)

Samples of 25 g were taken at the time after cutting and during mini-silo openings, placed in containers with 100 mL of distilled water, and mixed. These samples were left to stand for one hour, and the pH values were read using a potentiometer (Bolsen et al. 1992).

Ammoniacal N (NH_3–N) content was determined according to the technique proposed by Fenner (1965) and adapted by Vieira (1980). NH_3–N content in relation to the total N (TN) was calculated by the equation NH_3–N = (ammoniacal N × 100)/TN, where TN is obtained by dividing CP values by the factor 6.25 (Silva and Queiroz 2002).

2.8 Bromatological composition

Samples from in natura and silage material after silo opening were pre-dried in a forced air ventilation oven at 55 °C for 72 hours, processed in mills with sieves of 1-mm diameter openings, and conditioned in polyethylene bottles to determine the contents of dry matter (DM, method 967.03), mineral matter (MM, method 942.05), crude protein (CP, method 981.10), and ethereal extract (EE, method 920.29), according to the methods described by Association of official analytical chemists (Aoac 2016).

The contents of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined as described by Van Soest et al. (1991). Lignin was determined by treating the acid detergent fiber residue with 72% sulfuric acid (Silva and Queiroz 2002).

Total carbohydrates (TC) were calculated using the equation proposed by Sniffen et al. (1992): TC (%DM) = 100 − (CP + EE + ashes). Non-fibrous carbohydrate (NFC) contents were calculated as proposed by Hall (2003): NFC = %TC − %NDF.

2.9 Statistical analyses

The data were submitted to analyses of variance and regression. For pH evaluation as a function of the fermentation period, the data were adjusted to the nonlinear model Yt = A + B e-ct, as proposed by Hristov and McAllister (2002).

The data were analyzed by GLM procedure from SAS University (2015), considering as significant probability values lower than 5%.

3. Results

For the chemical-bromatological characteristics of the sorghum plant (Table 3), a decreasing linear behavior was observed for the contents of dry matter ($p < 0.001$) and organic matter ($p < 0.001$), while a positive linear effect was verified for crude protein ($p < 0.001$) and mineral matter ($p < 0.001$) as the leaching fractions were increased.

A quadratic behavior was observed for non-fibrous carbohydrates ($P < 0.001$), neutral detergent fiber ($P < 0.001$), acid detergent fiber ($P < 0.02$), and cellulose ($P < 0.001$), in which the 10% water depth of saline water application provided higher values for NDF, ADF, and cellulose and a lower mean for NFC (Table 3).

No effect of different leaching fractions was observed for ethereal extract, total carbohydrates, hemicellulose, and lignin ($P > 0.05$) (Table 3).

Table 3. Bromatological composition of sorghum of the Ponta Negra variety irrigated under different leaching fractions with saline water.

Variables	Leaching fractions				CV (%)	P Value
	0	5	10	15		
Dry matter (% fresh matter)[1]	35.94	32.87	32.38	32.27	0.54	<0.001
Crude protein (%DM)[2]	6.51	7.11	7.38	7.42	4.04	<0.001
Organic matter (%DM)[3]	94.03	93.99	93.80	92.92	0.21	<0.001
Mineral matter (%DM)[4]	5.97	6.01	6.21	7.08	3.02	<0.001
Ether extract (%DM)	1.85	1.78	2.05	1.87	15.42	0.72
Total carbohydrates (%DM)	84.32	85.53	84.73	83.69	1.15	0.21
Non-fibrous carbohydrates (%DM)[5]	32.25	34.18	27.87	28.35	5.07	<0.001
Neutral detergent fiber (%DM)[6]	52.07	51.35	56.86	55.34	2.12	<0.001
Acid detergent fiber (%DM)[7]	23.85	24.35	26.69	26.19	3.90	0.02
Cellulose (%DM)[8]	21.93	21.73	24.19	22.25	2.76	<0.001
Hemicellulose (%DM)	24.62	25.13	27.34	28.13	7.31	0.15
Lignin (%DM)	5.50	4.48	5.32	4.95	9.71	0.13

Leaching fractions of saline water: 0; 5; 10 and 15%; CV = Coefficient of variation; P value = probability value; Equations: $y^1 = 36.24–1.15x$, $R^2 = 0.73$; $y^2 = 6.35 + 0.3x$, $R^2 = 0.85$; $y^3 = 94.56–0.352x$, $R^2 = 0.76$; $y^4 = 5.435 + 0.353x$, $R^2 = 0.77$; $y^5 = 33.36 + 0.0115x - 0.3625x^2$, $R^2 = 0.60$; $y^6 = 49.075 + 2.532x - 0.2x^2$, $R^2 = 0.57$; $y^7 = 21.68 + 2.186x - 0.25x^2$, $R^2 = 0.81$; $y^8 = 19.49 + 2.517x - 0.435x^2$, $R^2 = 0.35$.

The pH values verified during the days of silo openings showed a quadratic effect ($P < 0.05$) for leaching fractions, with lower pH values observed at 15 days of silo opening for water depths of 10 and 15%, with mean values of 3.45 and 3.51, respectively (Table 4).

The different leaching fractions provided significant differences for dry matter recovery ($P = 0.001$), gas loss ($P = 0.009$), and effluent loss ($P = 0.004$) in silages of sorghum Ponta Negra. Silage density did not show a significant effect ($P > 0.05$) as irrigation water depths increased, with a mean value of 534 kg/m (Table 5).

Regarding the silages, the different leaching fractions with saline water promoted a negative linear behavior for the contents of dry matter ($P < 0.001$) and organic matter ($P < 0.001$) and an increasing linear effect for mineral matter ($P < 0.001$). Leaching fractions ($P > 0.05$) had no effect on crude protein, ethereal extract, total carbohydrates, non-fibrous carbohydrates, neutral detergent fiber, acid detergent fiber, cellulose, hemicellulose, and lignin (Table 6).

The maximum value found for NH_3–N/TN was 2.92%. The highest concentrations of ammoniacal nitrogen were observed when irrigation was performed with a 10% saline water depth ($P < 0.05$) (Figure 1).

Table 4. pH of sorghum silage of the Ponta Negra variety irrigated under different leaching fractions with saline water due to the time (days) of the silos opening.

	Opening	Leaching fractions 0	5	10[1]	15[2]	Average
pH	Plant	4.99	5.18	5.20	5.18	5.13
	1	3.77	3.63	3.69	3.61	3.67
	15	3.44	3.39	3.45	3.51	3.44
	30	3.54	3.54	3.53	3.53	3.53
	60	3.94	3.57	3.69	3.66	3.71
	90	3.74	3.63	3.70	3.77	3.71
	P value	0.11	0.08	0.05	<0.001	

Leaching fractions of saline water: 0; 5; 10 and 15%; P value = Probability value; Equations: $y^1 = 6.152–1.362x + 0.1643x^2$, $R^2 = 0.83$; $y^2 = 6.118–1.3616x + 0.1664x^2$, $R^2 = 0.82$.

Table 5. Average contents of dry matter recovery, gas losses, effluent losses and density of Ponta Negra sorghum silage irrigated under different leaching fractions with saline water.

Variables	Leaching fractions				CV (%)	P value
	0	5	10	15		
Dry matter recovery (g/kg)[1]	97.85	88.32	95.21	93.02	1.16	0.001
Gas losses (g/kg)[2]	0.214	0.227	0.242	0.260	8.60	0.009
Effluent losses (kg/t natural matter)[3]	6.589	7.105	7.193	7.219	6.59	0.004
Density (kg/m^3)	532	520	528	558	3.21	0.11

Leaching fractions of saline water: 0; 5; 10 and 15%; CV = Coefficient of variation; P value = probability value; Equations: $y^1 = 90.93 - 37x + 0.195x^2$, $R^2 = 0.77$; $y^2 = 0.213 + 0.003x$, $R^2 = 0.51$; $y^3 = 6.532 + 0.1978x$, $R^2 = 0.74$

Table 6. Bromatological composition of sorghum silage of Ponta Negra with 90 days, irrigated under different leaching fractions with saline water.

Variables	Leaching fractions				CV (%)	P Value
	0	5	10	15		
Dry matter (% fresh matter)[1]	35.17	30.83	30.80	30.67	0.48	<0.001
Crude protein (%DM)	7.44	7.48	7.19	7.85	4.83	0.24
Organic matter (%DM)[2]	92.89	92.79	92.51	92.47	0.05	<0.001
Mineral matter (%DM)[3]	7.11	7.21	7.49	7.53	0.62	<0.001
Ether extract (%DM)	1.47	1.56	1.27	1.75	26.50	0.57
Total carbohydrates (%DM)	84.36	84.32	84.37	83.42	1.12	0.56
Non fibrous carbohydrates (%DM)	28.64	26.60	27.05	25.05	6.28	0.15
Neutral detergente fiber (%DM)	55.72	57.72	57.32	57.32	0.52	0.08
Acid detergent fiber (%DM)	25.72	26.26	27.48	27.54	1.78	0.12
Cellulose (%DM)	25.04	24.90	25.52	25.60	2.11	0.34
Hemicellulose (%DM)	24.81	27.96	26.11	27.63	5.79	0.12
Lignin (%DM)	5.85	4.86	5.66	5.11	11.32	0.23

Leaching fractions of saline water: 0; 5; 10 and 15%; CV = Coefficient of variation; P value = probability value; Equations: $y^1 = 35.25–1.353x$, $R^2 = 0.63$; $y^2 = 93.05–0.154x$, $R^2 = 0.92$; $y^3 = 25.75 + 0.133x$, $R^2 = 0.73$

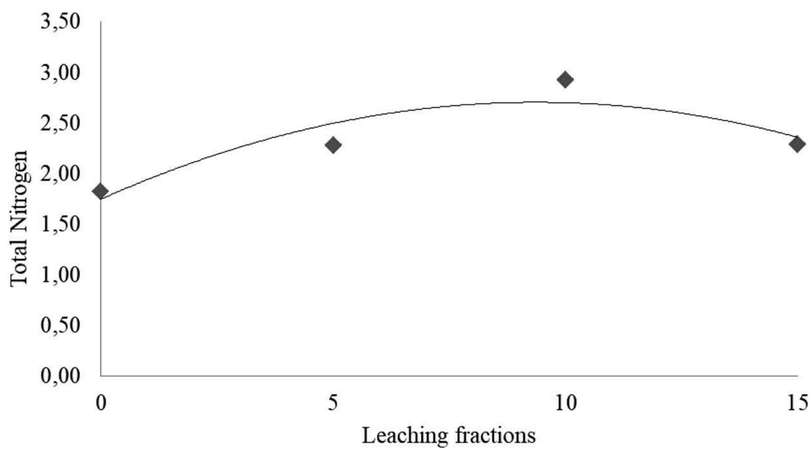

Figure 1. Ammoniacal nitrogen production curve in relation to total nitrogen (NH_3-N/NT) of sorghum silage at 90 days of opening. (Leaching fractions of saline water: 0; 5; 10 and 15%; Equation: $y = 1.7464 + 0.2046x - 0.0109 x^2$, $R^2 = 0.82$).

4. Discussion

The decreased dry matter is related to the toxic effect of ions such as Na^+ and Cl^- on the net carbon fixation and hence photoassimilate production (Acosta-Motos et al. 2017). This decrease in the dry matter as a function of salinity level differs from values found by Guimarães et al. (2018), who evaluated genotypes of irrigated forage sorghum under different leaching fractions and observed a positive linear effect, with means ranging from 41.44 to 44.62% of dry matter.

Dry matter values found are similar to those recommended by McDonald et al. (1991), who justifies a variation in dry matter content from 30 to 35%, as ideal for the preparation of good quality silages.

Soluble protein concentration in leaf tissue of forage sorghum was proportional to the salt content in the cultivation medium. It is possibly due to the occurrence of stress since some plants respond to the expression of certain genes that present proteins as the final product, i.e. the higher protein content may be an indicator for greater resistance of plants to saline water levels (Abdel-Hamid 2014).

Crude protein values were above the minimum required to guarantee an adequate ruminal fermentation, which is 7% according to Van Soest (1994), proving the proper nutritional value of sorghum.

The decreased organic matter is related to a continuous increase of mineral matter due to the higher absorption and accumulation of minerals by plants according to the amount of salts in the used water depths. The lowest values of non-fibrous carbohydrates found in plants submitted to an L10 fraction water depth are justified by the higher level of ADF provided to the plants. It is due to the higher proportions of fibrous compounds and is probably related to an increase in mineral matter content.

The increased non-fibrous carbohydrate content may be related to photosynthetic activity, which is less sensitive to saline stress when compared to the growth. It promotes the production of photoassimilates not used by plants, accumulating compatible solutes that can induce the break of macromolecules such as starch according to the enhancement of amylase activity in leaf cells, causing the release of sugars (Truernit 2017; Yasseen et al. 2018).

Higher percentages of neutral detergent fiber observed in higher leaching fractions are due to a greater allocation and absorption of nutrients and minerals by plants since they are cofactors of growth and differentiation of plant cells (Lima et al. 2018b).

In silages with a DM content higher than 20%, a pH equivalent to 4.0 is acceptable to obtain conservation within the standards (Possenti et al. 2016). In the present study, the evaluated silages presented pH values close to 4.0 regardless of the opening days, with a considerable difference in the plant pH in relation to that of silages. Possibly, it may have occurred because there was not enough time for transformations that occur in the ensiled mass, such as pH drop, lactic and acetic acid synthesis, temperature increase, and multiplication of fermentative bacteria.

The relatively high values of dry matter recovery obtained in this study may be correlated with the low gas loss, which may represent up to 98.4% of the dry matter loss, mainly due to the undesirable fermentation, in which CO_2 is formed (Gomes-Rocha et al. 2018).

The increasing effluent loss may indicate that the stabilization of the fermentation process was not achieved in the evaluated period. Borreani et al. (2018) observed that the effluent volume produced in a silo is mainly influenced by the dry matter content of the ensiled forage species, and the more similar the dry matter contents, the lower the effluent loss values.

Because dry matter content is directly related to the final silage quality, it becomes a fundamental prerequisite in the ensiling process. During silage preparation, dry matter content should be around 30–35% because values above or below this percentage can generate losses inside the silo resulting from an undesired fermentation (McDonald et al. 1991).

Organic matter values found in sorghum silages were inversely proportional to that of mineral material, i.e. there was a higher salt absorption by plants, leading to an OM decrease to the detriment of MM increase. However, this increase in MM can also be an indication of the occurrence of a poor-quality fermentation, with a higher organic matter mobilization, thus showing an increase in ash content, which would result in the decrease of organic matter (Oliveira et al. 2018) with increased leaching fraction.

Because there was no significant difference in silage protein contents between water depths, NH_3–N/TN is probably associated with the fermentative quality of silage because a slow decrease in pH leads to protein degradation, reducing CP concentrations and increasing NH_3–N concentrations (McDonald et al. 1991).

According to Costa et al. (2016), ammoniacal N contents in sorghum silages vary from 0.5 to 7.8% total N, which is in accordance with the results obtained in this study. Values lower than 10% of ammoniacal nitrogen in relation to total nitrogen indicate that the fermentation process did not result in an excessive protein breakdown into ammonia (Tolentino et al. 2016).

Most of the non-protein nitrogen (NPN) in low-quality silages is represented by ammonia and nitrates, whereas good quality silages present most of the NPN as amino acids. Excessive proteolysis is undesirable because ammonia does not meet the nitrogen requirements of all ruminal microorganisms. Diets with most of the N in this form require a supplementary source of protein to avoid impairments in animal performance. Still, this compound is volatile, being lost during silo opening and silage use (Yitbarek and Tamir 2014; Fijałkowska et al. 2015). McDonald et al. (1991) and Van Soest (1994) considered values below 10% of NH_3-N/TN as an indication of adequate fermentation. Values above 15% indicate excessive proteolysis.

5. Conclusions

Saline water application reduced dry matter content in plant and silage, but their values remained within the established standards for an adequate fermentation profile. The use of irrigation with a leaching fraction of up to 15% changed ADF, MM, and NFC contents, not influencing the silage quality of sorghum Ponta Negra.

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