

**Use of rizostar in the production of sorghum silages**

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**Uso de rizostar en la producción de ensilajes de sorgo**

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## **Abstract**

This study aimed to evaluate the development of culture, mass production, and the silage nutritional value of sorghum under three nutrients fonts. The experiment was conducted as a block randomized design, with three treatments and six replications. The treatments consisted of fonts fertilizations in showing: Monoammonium Phosphate, with 90.0 kg ha<sup>-1</sup>, and Rizostar with 37.5 kg ha<sup>-1</sup> and 45.0 kg ha<sup>-1</sup> doses. The productive parameters of the plants were evaluated at 30 days and at the time of harvesting the plants for silage, in addition to the nutritional value of the silages. The materials presented expressive productions, with averages of 43846; 43346; 44002; and 35674 kg ha<sup>-1</sup> of green matter. The Maxisilo sorghum hybrid presented the highest levels of acid detergent fiber (ADF), with a mean of 471.42 g kg<sup>-1</sup> dry matter (DM). Crude protein (CP) contents in each hybrid remained constant over time, presenting mean values of 74.37; 65.26; 54.44; 78.43 g kg<sup>-1</sup>. The mean total digestible nutrients values found in the Dominator sorghum hybrid were 657.34 g kg<sup>-1</sup>, being higher than the others. After long storage periods, the nutritional parameters of the materials remained stable in their CP, DM, NDF, and ADF values. The aerobic exposure nutritionally deteriorated silages. Fertilization with Rizostar 45, does not influence the final level of plants, fresh raw materials, and dry raw materials, besides significantly increasing the use of samples.

**Keywords:** Crude protein; Neutral detergent fiber; *Sorghum bicolor*; Total digestible nutrients.

## **Resumo**

Este estudo teve como objetivo avaliar o desenvolvimento da cultura, produção em massa e o valor nutricional da silagem de sorgo sob três fontes de nutrientes. O experimento foi conduzido em delineamento de blocos ao acaso, com três tratamentos e seis repetições. Os tratamentos consistiram em adubações com fontes, mostrando: fosfato monoamônico, com 90,0 kg ha<sup>-1</sup>, e Rizostar com doses de 37,5 kg ha<sup>-1</sup> e 45,0 kg ha<sup>-1</sup>. Foram avaliados os parâmetros produtivos das plantas aos 30 dias e no momento da colheita das plantas para silagem, além do valor nutricional das silagens. Os materiais apresentaram produções expressivas, com médias de 43846; 43346; 44002; e 35674 kg ha<sup>-1</sup> de matéria verde. O híbrido Maxisilo sorgo apresentou os maiores níveis de fibra em detergente ácido (FDA), com média de 471,42 g kg<sup>-1</sup> de matéria

seca (MS). O conteúdo de proteína bruta (PB) em cada híbrido permaneceu constante ao longo do tempo, apresentando valores médios de 74,37; 65,26; 54,44; 78,43 g kg<sup>-1</sup>. Os valores médios de nutrientes digestíveis totais encontrados no híbrido de sorgo Dominator foram de 657,34 g kg<sup>-1</sup>, sendo superiores aos demais. Após longos períodos de armazenamento, os parâmetros nutricionais dos materiais permaneceram estáveis nos valores de PB, MS, FDN e FDA. A exposição aeróbica deteriorou nutricionalmente as silagens. A fertilização com Rizostar 45 não influencia o nível final de plantas, matérias-primas frescas e matérias-primas secas, além de aumentar significativamente o uso de amostras.

**Palavras-chave:** Proteína bruta; Fibra em detergente neutro; *Sorghum bicolor*; Nutrientes digestíveis totais.

### Resumen

Este estudio tuvo como objetivo evaluar el desarrollo del cultivo, la producción masiva y el valor nutricional del ensilado de sorgo bajo tres fuentes de nutrientes. El experimento se realizó en un diseño de bloques al azar, con tres tratamientos y seis repeticiones. Los tratamientos consistieron en fertilizaciones con fuentes, mostrando: fosfato monoamónico, con 90.0 kg ha<sup>-1</sup>, y Rizostar con dosis de 37.5 kg ha<sup>-1</sup> y 45.0 kg ha<sup>-1</sup>. Los parámetros productivos de las plantas se evaluaron a los 30 días y al momento de la cosecha de las plantas para ensilaje, además del valor nutricional de los ensilajes. Los materiales presentaron producciones expresivas, con promedios de 43846; 43346; 44002; y 35674 kg ha<sup>-1</sup> de materia verde. El híbrido de sorgo Maxisilo presentó los niveles más altos de fibra en detergente ácido (FDA), con un promedio de 471,42 g kg<sup>-1</sup> de materia seca (MS). El contenido de proteína cruda (PC) en cada híbrido se mantuvo constante en el tiempo, con valores promedio de 74,37; 65,26; 54,44; 78,43 g kg<sup>-1</sup>. Los valores promedio de nutrientes digeribles totales encontrados en el híbrido de sorgo Dominator fueron de 657.34 g kg<sup>-1</sup>, siendo más altos que los demás. Después de largos períodos de almacenamiento, los parámetros nutricionales de los materiales se mantuvieron estables en los valores de PB, MS, NDF y FDA. La exposición aeróbica deterioró nutricionalmente los ensilajes. La fertilización con Rizostar 45 no influye en el nivel final de plantas, materias primas frescas y materias primas secas, además de incrementar significativamente el uso de muestras.

**Palabras clave:** Proteína cruda; Fibra en detergente neutro; *Sorgo bicolor*; Nutrientes digeribles totales.

## 1. Introduction

The natural grasslands of the Pampa biome (PB) are maintained by moderate grazing of large ruminants, under low forage supply, with gains low animal weight and economic return (Moraes et al., 2019). Still, natural grasses fertilization is not used with declining soil fertility, and carrying capacity of pastures, while increasing soil erosion and pasture (Moraes et al., 2019). To increase income, farmers are replacing fields degraded by agriculture, reducing livestock and pastures areas biome Pampa (Oliveira et al., 2017).

However, the cattle raised in the region have the genetic potential for high gains that can be achieved with the introduction of production technologies. Beyond the addition to fertilization of pastures with increased forage production, supplementation of animals with concentrate or bulky with silage would contribute to increase the gains per area. In these conditions, the diversification of activities can contribute to sustainable intensification, increasing food production while maintaining or improving environmental quality and preserving natural biodiversity (Moraes et al., 2019).

As under the conditions of the Pampa the forage production is not constant in the year. This, the storage with silage of high forage production of the spring and summer could use during autumn and winter, when in pastures there is low production and a low nutritional quality (Vasconcelos et al., 2018).

The production of silages would contribute doubly to the conservation of Pampa. Initially by higher forage production per unit area compared to grazing pastures cultivated for grazing and later for softening the animal load in periods of low forage supply reducing the overgrazing of the fields. However, the crop production is dependent on climate and soil fertility. The yield is strongly controlled by weather and climate it is highly vulnerable to climate change (Rolla et al., 2018). In Pampa, the climate is subtropical, the thermal amplitude allows the occurrence of frosts outside winter, and a summer temperature of 35 degrees Celsius (Vasconcelos et al., 2018). Southeast South America (Argentina, Uruguay, and southern Brazil), is one of the regions of the world with major changes in climate in the last 30 years, that has the greatest annual variability (Rolla et al., 2018).

Thus, climate is one of the main risk factors involved in silage production (Rolla et al., 2018) hindering the Pampa corn silage production and suggesting the sorghum to cultivate. The sorghum is relatively more resistant to environmental stress conditions than the other C<sub>4</sub> plants, and has satisfactory yield and quality under stress conditions a certain extend (Kaplan et al., 2019). Tas high resistance to both drought and produce a notable yield as compared to many

other plants just because of a well-developed root system with efficient uses water and nutrients. However, the development root system is dependent on phosphorus, and this nutrient is determinant in plant growth (Garay, Amiotti & Zalba, 2018) and crop yield (Alvarez, Gangi, Caffaro, Molina & Berhongaray, 2019).

In soil, much of the total phosphorus is not available to crop plants (Suñer, García, Galantini, Forján & González, 2018). In the vast plain Pampa region (Alvarez et al., 2019), the parent material is constituted by a mantle of eolic loess of a loamy texture and calcareous nature, that cause generally low soil availability phosphorous (Suñer et al., 2018) and restricts crop yields (Alvarez et al., 2019). This phosphate fertilizers have been applied in grains and forage crops (Alvarez et al., 2019), however, still below the need for crops due to costs.

To optimize yields from the fertilizer used, alternative fertilizers could be adopted. Rizostar is a phosphate fertilizer whose phosphorus preservation technology protects nutrient adsorption to soil colloids, increasing the availability of phosphorus to plants. Also, it is produced in the form of microgranules that allows the use of low dosages and distribution next to the seed, increasing the availability of the nutrient to the root system from the beginning of its development (Arysta, 2014). Its use in sorghum cultivation areas for silage could supply low levels of phosphorus in the soil, provide good root development, and even greater tolerance of the crop to adverse climatic conditions with higher productivity.

This, aimed to study was to measure the productivity and quality of silages produced with Qualysilo sorghum under different phosphorus fonts in Pampa, Brazil.

## 2. Methodology

The work was conducted in the experimental areas of the school farm of the Federal University of Pampa and at the Animal Nutrition Lab of Unipampa - Uruguiana Campus, located at the Rio Grande do Sul, Pampa, Brazil (29°45'17"S and 57°05'18"W, 66 m above sea level). The experiment took place in the year 2016, with planting in January and harvests in April.

The design was block randomized, with three treatments and six replications (Pimentel-Gomes, 2009). The treatments consisted of fonts fertilizations in showing: Monoammonium Phosphate (MAP - N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 11:52:00), with 90.0 kg ha<sup>-1</sup>, and Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) with 37.5 kg ha<sup>-1</sup> and 45.0 kg ha<sup>-1</sup> doses. The K and N were equalized with potassium chloride and urea. In all treatments, the cover fertilizer, 100 kg ha<sup>-1</sup> of nitrogen was applied as

urea at four leaves the phenological state. The experimental plots consisted of 8 sowing lines with a length of 15 m.

In area preparation was applied Roundup® WG (2 kg ha<sup>-1</sup>), with syrup volume of 200 L ha<sup>-1</sup> and syrup conditioning Fulltec (Spraytec®) (0.060 L ha<sup>-1</sup>). Sorghum was implanted on 15 Nov. 2017, using a continuous flow seeder system with a spacing of 0.80 m, aiming 220000 ha plants population. At the time of sowing, the seeds were treated with CROPSTAR® (imidacloprid and thiodiocarb) insecticide and fungicide, and PackSeed (Spraytec®). To control insects (*Spodoptera frugiperda*, *Dichelops melacanthus* and *Dichelops furcatus*) during crop development, on 01 Jan. 2018, was applied Lorsban® 0.5 L ha<sup>-1</sup>. To identify weeds, on 22 Dec. 2018 a phytosociological survey was carried. Weed control was made whit Primoleo® (6.0 L ha<sup>-1</sup>) and Imantic (Spraytec®) (0.100 L ha<sup>-1</sup>).

The harvest was carried out on 26 Mar. 2017, when the panicle of the plants presented the grains with 70% of the pasty consistency and 30% with a milky consistency, obtaining a forage mass with an ideal dry matter content for silage around 35%. With the aid of a tractor, the green material was cut at 15 cm from the ground and the equipment knives adjusted for particle chopping between two and five cm in length.

The harvested material was transported to a sheltered location and accommodated on a tarpaulin where the required amount of material for ensiling, compaction, and analysis of the fresh material was separated. For silage were prepared experimental silos of PVC, with a height of 50 cm and 10 cm in diameter. The silos were capped with a Bunsen type valve to escape gases from the fermentation. At the bottom, 0.500 kg of clean sand was used to drain the effluents during the storage processes. For adequate compaction, the density of 600 kg m<sup>-3</sup> of material was used, using a manual metal press, then the silos were tape sealed.

Were evaluated the height of plants and production of dry matter content (DM) at 30 d and at the time of harvesting of the plants for silage. Also, plant height (PH), final stand (FS), accumulated fresh mass (ACFM), accumulated dry mass (ACDM) were evaluated. The plant height was determined before harvesting, five random plants per plot were evaluated and measured, with the aid of a graduated ruler, from the soil surface until the insertion of the flag leaf; the final stand was evaluated before harvest by counting plants in a linear meter; the accumulation of accumulated fresh matter was obtained from the production of five linear meters per plot, evaluated at random points of the useful area with correction for the area of one hectare. In the accumulated dry matter, the samples were dried in a forced-air circulation oven for 72 hours at a temperature of 55 °C to obtain the dry matter content, these values were later multiplied by the production of green matter, obtaining the dry matter production.

The nutritional value of silages was studied by determination of the pH (Silva & Queiroz, 2009), ammoniacal nitrogen (Bolsen et al., 1992). The bromatological profile was determined in the samples after obtaining the DM and milling in a mill of Willey type knives with stainless steel chamber and sieve, with 1mm mesh. It was determined the dry matter correction at 105 °C and the contents of mineral matter, crude protein, ether extract, lignin (AOAC, 2000). Was determined the neutral detergent fiber, acid detergent fiber, cellulose, and hemicellulose (Van Soest, Robertson & Lewis, 1991). Fractions of carbohydrates Were estimated according to the fractions of carbohydrates, total carbohydrates, non-fibrous carbohydrates, and fibrous carbohydrates (Sniffen, O'Connor, Van Soest, Fox & Russell, 1992), total digestible nutrients (Bolsen, 1996), and dry matter intake in the percentage of live weight (Mertens, 1997). Was determined the digestible dry matter (Rohweder, Barnes & Jorgensen, 1978). After ten days of aerobic exposure, the silages were again analyzed.

For statistical data analysis, they were submitted to variability analysis and when the meaningfulness was established, the rate was compared according to the Tukey test (5%). All the analyses were carried out on the Sisvar Statistic Program.

### 3. Results

The highest plant height, stand, fresh mass production, and dry mass production were obtained with the basic fertilization of 45 kg of Rizostar (Table 1). The dry matter contents of the forage at harvest were satisfactory (Table 2), with no differences between the fertilizations studied.

**Table 1.** Agronomic characteristics and mass production of Qualysilo sorghum with different sources of phosphate fertilization, Uruguaiiana-RS.

Variables	Treatments			Mean	CV (%)	<i>P value</i>
	MAP	RIZ45	RIZ37			
Plant height (cm)	104 <sup>b</sup>	107 <sup>a</sup>	102 <sup>c</sup>	104	1.22	0.0006
Stand (plants ha <sup>-1</sup> )	89583 <sup>b</sup>	97222 <sup>a</sup>	89814 <sup>b</sup>	92206	2.71	0.0028
ACFM (kg ha <sup>-1</sup> )	16937 <sup>b</sup>	20791 <sup>a</sup>	18018 <sup>ab</sup>	18582	9.36	0.0311
ACDM (kg ha <sup>-1</sup> )	4262 <sup>b</sup>	5328 <sup>a</sup>	4889 <sup>ab</sup>	4827	10.56	0.0460

Means followed by the same letter in the column do not differ significantly by the Tukey test (5%). CV, coefficient of variation. Treatments; MAP, Monoammonium Phosphate (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 11:52:00) with 90.0 kg ha<sup>-1</sup>; RIZ37, Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) with 37.5 kg ha<sup>-1</sup>; RIZ45, Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) 45.0 kg ha<sup>-1</sup> doses. ACFM, accumulated fresh mass; ACDM, accumulated dry mass. Source: Authors.

The chemical composition of the obtained forage was not altered by the fertilizations studied (Table 2). It was evaluated the production of silage effluent is obtained due to the DM content of the ensiled forage adopted due to compression.

**Table 2.** Bromatology of Qualysilo sorghum forage for ensiling, produced under different sources of phosphate fertilization, Uruguaiiana-RS.

Variables	Treatments			Mean	SEM	P value
	MAP	RIZ45	RIZ37			
DM (g kg <sup>-1</sup> ) <sup>ns</sup>	296.62	271.51	244.43	270.85	2.35	0.0741
MM (g kg <sup>-1</sup> ) <sup>ns</sup>	69.70	69.86	71.44	70.33	1.88	0.7761
CP (g kg <sup>-1</sup> ) <sup>ns</sup>	69.70	69.86	71.44	74.21	4.26	0.346
TC (g kg <sup>-1</sup> ) <sup>ns</sup>	824.95	821.89	829.51	825.45	4.69	0.5400
NFC (g kg <sup>-1</sup> ) <sup>ns</sup>	240.01	240.26	202.44	227.57	19.2	0.3284
FC (g kg <sup>-1</sup> ) <sup>ns</sup>	584.94	581.64	627.07	597.88	20.03	0.2604
NDF (g kg <sup>-1</sup> ) <sup>ns</sup>	607.94	604.64	650.07	620.88	20.01	0.2312
ADF (g kg <sup>-1</sup> ) <sup>ns</sup>	380.90	396.31	399.11	392.11	15.4	0.6799
LIG (g kg <sup>-1</sup> ) <sup>ns</sup>	69.13	70.55	75.03	71.57	3.05	0.4027
CEL (g kg <sup>-1</sup> ) <sup>ns</sup>	242.65	255.22	249.04	248.97	10.11	0.7408
HEM (g kg <sup>-1</sup> ) <sup>ns</sup>	227.04	208.32	250.96	228.77	16.38	0.2423
TDN (g kg <sup>-1</sup> ) <sup>ns</sup>	611.77	600.98	599.02	603.92	10.78	0.6799

Means followed by the same letter in the column do not differ significantly by the Tukey test (5%). SEM, standard error of the mean. Treatments; MAP, Monoammonium Phosphate (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 11:52:00) with 90.0 kg ha<sup>-1</sup>; RIZ37, Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) with 37.5 kg ha<sup>-1</sup>; RIZ45, Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) 45.0 kg ha<sup>-1</sup> doses. DM, dry matter; MM, mineral matter; CP, crude protein; TC, total carbohydrates; NFC, non-fibrous carbohydrates; FC, fibrous carbohydrates; NDF, neutral detergent fiber; ADF, acid detergent fiber; LIG, lignin; CEL, cellulose; HEM, hemicellulose; TDN, total digestible nutrients. Source: Authors.

As with fresh forage, in silages there was also a dry matter content close to 300 g kg<sup>-1</sup> and without significance for fertilization (Table 3). Despite the statistical difference between treatments, NH<sub>3</sub>-N was adequate for the preservation of forage, in none of the silages the levels exceeded 10% of the total nitrogen. The average pH obtained for the silages was 5.14, higher than the ideal range indicated for the silages. The OM was similar between treatments with an average of 917 g kg<sup>-1</sup>.

MAP fertilization made it possible to obtain silages with higher levels of neutral detergent insoluble nitrogen (NDIN) e acid-detergent insoluble nitrogen (ADIN) than



fertilization with 37 kg ha<sup>-1</sup> of Rizostar, however, similar to the fertilization with 45 kg of the same fertilizer (Table 3).

**Table 3.** Bromatology of Qualysilo sorghum silages grown under different sources of phosphate fertilizer, Uruguaiiana-RS.

Variables	Treatments			Mean	SEM	<i>P value</i>
	MAP	RIZ45	RIZ37			
DM (g kg <sup>-1</sup> )	299.2	292.4	298.8	296.8	0.63	0.7024
NH <sub>3</sub> -N (% N Total)	6.21 <sup>b</sup>	6.24 <sup>a</sup>	6.09 <sup>c</sup>	6.18	0.03	0.0000
pH	5.14	5.20	5.08	5.14	0.11	0.7253
OM (g kg <sup>-1</sup> )	920.81	914.86	917.70	917.79	2.39	0.2671
CP (g kg <sup>-1</sup> )	68.16 <sup>a</sup>	68.81 <sup>a</sup>	63.74 <sup>b</sup>	70.24	2.36	0.0074
NDIN (% N total)	6.51 <sup>a</sup>	5.73 <sup>ab</sup>	5.31 <sup>b</sup>	5.85	0.19	0.0078
ADIN (% N total)	4.34 <sup>a</sup>	3.82 <sup>ab</sup>	3.54 <sup>b</sup>	3.90	0.13	0.0071
EE (g kg <sup>-1</sup> )	31.47	31.21	31.90	31.53	0.86	0.8536
TC (g kg <sup>-1</sup> )	812.66	816.05	823.96	817.56	3.32	0.1034
NFC (g kg <sup>-1</sup> )	273.40	264.86	187.31	241.86	17.98	0.2680
FC (g kg <sup>-1</sup> )	539.26	551.20	636.65	575.70	14.55	0.1663
NDF (g kg <sup>-1</sup> )	562.26	574.20	659.65	598.70	17.45	0.1960
ADF (g kg <sup>-1</sup> )	342.39 <sup>a</sup>	308.19 <sup>b</sup>	344.89 <sup>a</sup>	345.16	14.59	0.0177
LIG (g kg <sup>-1</sup> )	66.55	70.49	73.16	70.07	11.25	0.7408
CEL (g kg <sup>-1</sup> )	242.62	255.19	239.02	248.94	0.92	0.3260
HEM (g kg <sup>-1</sup> )	219.87	266.01	254.75	253.54	14.68	0.5145
TDN (g kg <sup>-1</sup> )	638.73 <sup>ab</sup>	662.67 <sup>a</sup>	628.97 <sup>b</sup>	636.79	11.09	0.0166
CDM (% LW)	2.22	2.11	1.82	2.05	0.15	0.2177
DIGDM (g kg <sup>-1</sup> )	622.28 <sup>b</sup>	648.92 <sup>a</sup>	589.17 <sup>c</sup>	620.12	11.34	0.0177
RVF	107.21	106.70	83.14	99.02	8.18	0.1179

Means followed by the same letter in the column do not differ significantly by the Tukey test (5%). SEM, standard error of the mean. Treatments; MAP, Monoammonium Phosphate (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 11:52:00) with 90.0 kg ha<sup>-1</sup>; RIZ37, Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) with 37.5 kg ha<sup>-1</sup>; RIZ45, Rizostar (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O - 10:40:00) 45.0 kg ha<sup>-1</sup> doses. DM, dry matter; NH<sub>3</sub>-N, ammoniacal nitrogen; pH, potential hydrogen; OM, organic matter; CP, crude protein; NDIN, neutral detergent insoluble nitrogen; ADIN, acid-detergent insoluble nitrogen; EE, ether extract; TC, total carbohydrates; NFC, non-fibrous carbohydrates; FC, fibrous carbohydrates; NDF, neutral detergent fiber; ADF, acid detergent fiber; LIG, lignin; CEL, cellulose; HEM, hemicellulose; TDN, total digestible nutrients; CDM, consumption of dry matter in relation to live weight; DIGDM, digestible dry matter; RVF, relative value of forage. Source: Authors.

The contents of EE, NFC, and FC of the silages were similar. The levels of NDF, cellulose, and hemicellulose in silages were not affected by fertilization. The ADF was lower in the silage obtained with the sorghum fertilized with 45 kg ha<sup>-1</sup> of Rizostar (Table 3), however, it obtained greater TDN and DIGDM. The relative value of forage (RVF) was constant in the studied silages.

#### 4. Discussion

The fertilization with 45 kg of Rizostar obtained productive parameters superior to the others due to the nutrients made available since sowing, whose use was optimized after the covering fertilization. This result stems precisely from the benefits provided by the fertilizer, which aims to increase the availability of phosphorus for the plants. The Rizostar increasing the availability of the nutrient to the root system from the beginning of its development (Arysta, 2014). However, the yields were lower than those found in the literature for the crop tested due to the edaphoclimatic limitations of the 2018/2019 crop and the study region.

Although the DM indicated for obtaining silages is approximately 30% (Muck et al., 2018), in conditions where the forage to be ensiled has favorable characteristics such as the content of soluble carbohydrates, even with DM below 30% good quality silages can be obtained.

Monitoring DM in the forage to be ensiled is paramount because forage silage with low DM content causes loss of quality and DM (Borreani, Tabacco, Schmidt, Holmes & Muck, 2018) and favors the development of *Clostridium* (Driehuis, Wilkinson, Jiang, Ogunade & Adesogan, 2018). Thus, DM is one of the main parameters to be monitored in the production of silages for the rapid reduction of pH by the action of lactic acid bacteria (Muck et al., 2018) and inhibition of the development of undesirable microorganisms (Driehuis et al., 2018).

The DM contents were not altered by fertilization and remained close to 300 g kg<sup>-1</sup>. Forage ensilage with low DM content causes loss of quality and DM (Borreani et al., 2018) and promotes the development of *Clostridium* (Driehuis et al., 2018). However, if the forage is ensiled with adequate dry matter content, in the silo, there will be a rapid reduction in pH due to the action of lactic acid bacteria (Muck et al., 2018) and inhibition of the development of undesirable microorganisms (Driehuis et al., 2018), such as proteolytic.

As a consequence of forage silage with the indicated DM, NH<sub>3</sub>-N, which is the result of plant and microbial proteolysis (Kung Jr, Shaver, Grant & Schmidt, 2018). The NH<sub>3</sub>-N was adequate for the preservation of forage, in none of the silages the levels exceeded the border

values of 10 to 15% of the total nitrogen (Kung Jr et al., 2018). The NH<sub>3</sub>-N production in silos occurs through biochemical means called deamination, decarboxylation, oxidation, and reduction reactions. Its evolution is derived from the catabolism of amino acids and other products like, fatty acids and amines. As a result, there is an increase in ammonia production from proteolysis.

The pH obtained was higher than the indicated range for adequate silages, which is between 3.6 and 4.2 (Moura et al., 2016). At the beginning of the ensiling process, a reduction of pH to safe values for efficient fermentation by lactic acid bacteria such as *Lactobacillus*, that promote rapid pH reduction inside the silo (Muck et al., 2018). Therefore, in association with NH<sub>3</sub>-N, pH is a safe indicator of the fermentative quality of silages, since low values of both indicate rapid stabilization of the silage (Moura et al., 2016).

The monitoring of OM in animal feed is relevant because it contains nutrients that are potentially energy suppliers such as carbohydrates, lipids, and proteins. Of these, fertilization with MAP and 45 kg ha<sup>-1</sup> of Rizostar provided the minimum CP levels for a good rumen function and maintenance of the 70 g kg<sup>-1</sup> ruminal microbiota in DM. For animal performance, knowledge of the levels of CP of silages is essential in the formulation of diets of high-performance animals such as dairy cows or beef cattle in feedlots. For proper performance, ruminants depend on a balanced supply of nutrients, of which nitrogen is the most critical (Hristov et al., 2019).

In all treatments, ADIN levels were below 31% of the total nitrogen indicated for conserved forages (Gayer et al., 2009). These parameters indicate the nitrogen fractions linked to the plant cell wall and insoluble in acidic and neutral detergent, respectively. As they are expressed about total nitrogen, the higher the values, the lower the availability of nitrogen for use by animals, especially in the case of ADIN. Although ADIN can be partially digestible (Wang et al., 2015), this fraction is accepted as the nitrogen that is nutritionally unavailable to ruminants and its negative correlation with dietary nitrogen digestibility. These values can be influenced by the plant's physiological maturity stage during harvest and its lignification (Moura et al., 2016) and heat damage (Mahesh, Thakur, Kumar, Malik, Gami, 2017) during prolonged exposure to temperatures above 50 °C (Kung Jr et al., 2018). NFCs, as long as they are synchronized with the availability of nitrogenous compounds, is the most efficient in increasing milk and meat production as they are substrates for microbial protein synthesis. FCs correspond to the fractions of the slowest digestion at the rumen level.

The NDF contents of the silages can be considered high in the present study, since they represent the largest fraction of the diet in confined production systems and ruminants. NDF is

the main source of energy in ruminants (Krämer-Schmid, Lund & Weisbjerg, 2016), its evaluation allows to estimate the consumption of dry matter and, together with CP, it is essential to know the nutritional value of bulky foods. However, as NDF is directly related to dry matter consumption (Hristov et al., 2019) these parameters must be studied together, as they will determine the level of inclusion of silages in the diets depending on the animal category and its nutritional requirement.

As the ADF is related to digestibility, the values can still be considered high. Their knowledge, especially in bulky foods, is crucial in the nutrition of ruminants, since the NDF content does not affect the digestibility of the ADF, however, the reverse occurs. The ADF is used as a predictor of digestibility because there is an inverse relationship between them (Malaguez, Dinarte, Tadielo, Santos, Castagnara, 2017) due to the presence of lignin, which in this study was similar between silages. High levels of lignin in silages are not desirable because it is practically indigestible and chemically phenolic, it causes a physical and chemical barrier to fibrolytic microorganisms, compromising the digestibility of the fibrous fractions of the diet. Although NDF is the most widely used consumption predictor, feeds with a high ADF also have the potential for consumption depression due to their filling effect (Poczynek et al., 2020). Thus, the higher the lignin content, the greater the filling effect (Poczynek et al., 2020) and the lower the digestibility of the diet.

Both the depression in consumption and the digestibility of DM can be accentuated by the cellulose contents of bulky foods. Together with lignin, cellulose, and hemicellulose, they depress the consumption of dry matter (Poczynek et al., 2020) and bulky foods, the higher the content, the lower the nutritional value (Gayer et al., 2019).

TDN, together with DIGDM, are fundamental parameters for the inclusion of silages in dairy cow diets. TDN corresponds to the energy present in the feed, therefore, the higher its content, the greater the energy potential of the feed and the greater its potential for milk or meat production. In the present study, the TDN content was higher in silages with 45 kg ha<sup>-1</sup> of Rizostar.

The silage with application of 45 kg ha<sup>-1</sup> of Rizostar in the sowing had greater DIGDM, since this is directly affected by CP, NDF and lignin, in addition to being the result of the combination of both fractions, together with the other fractions of carbohydrates in feed (Du, Risu, Gentu, Jia & Cai, 2020). The greater the digestibility of FC, and the less encrusted they are by the lignin present in the feed, the greater the digestibility of their dry matter.

RVF is a quality indicator when referring to concentrations of constituents of the plant cell wall (Gayer et al., 2019). The results found are explained by the proportions of

carbohydrates in the silages, because the higher the cellulose, hemicellulose and lignin content, the lower the RVF of the feed, indicating lower or higher quality materials (Gayer et al., 2019). These fractions correspond to the fibrous carbohydrates of the feed, which, due to their slow digestion (Du et al., 2020) and give the fodder a low nutritional value, evidenced by the low RVF.

## 5. Conclusion

Fertilization with Rizostar 45, does not influence the final level of plants, fresh raw materials and dry raw materials, besides significantly increasing the use of samples.

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