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Evaluating biomass sorghum genotypes for ensiling purposes: agronomic traits, silage fermentation, and nutritive value

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Abstract. Biomass sorghum (*Sorghum bicolor* L.) genotypes, although typically selected for bioenergy production, are increasingly considered suitable for producing high-quality silage, and supporting more sustainable forage systems in semiarid regions. This study compared seven genotypes (7500, 7101, B015, 7100, 7502, AGRI002E, and BRS 716) to identify the most optimal for ensiling using a randomised complete block design with three replicates. Genotypes 7500 and

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7502 had the lowest dry matter yield (DMY) (14.34 and 11.35 t/ha, respectively), but their silages reached the highest *in vitro* digestible dry matter (IVDDM) values (506.9 and 528.3 g/kg). The lactic-to-acetic (LA) acid ratios ranged from 1.9 to 3.5, suggesting differences in the relative contribution of homolactic and heterolactic fermentation pathways. While genotype 7500 silage showed the highest ratio (3.5), indicating predominant homolactic fermentation, all silages had suitable pH and ammonia nitrogen levels. Genotype BRS 716 produced the highest DMY (24.50 t/ha) and silage digestible dry matter yield (DDMY) (9.24 t/ha). The first two principal components (PC1 and PC2) accounted for 54.29% of the total variation. BRS 716 was positioned in the upper-right quadrant of the scatter plot, consistent with its superior agronomic performance, with the highest values for fresh matter yield (FMY), DMY, and DDMY. Genotypes 7502 and 7500 were positioned on the left side of the plot and were associated with high silage digestibility, while 7502 was also associated with high silage temperature, and 7500 with high ethanol production. BRS 716 is recommended for ensiling due to its high yield of digestible nutrients per area, suitable fermentation, and potential for large-scale silage production.

Keywords: digestible dry matter yield, ensilability, semiarid regions, *Sorghum bicolor*

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Introduction

Sorghum (*Sorghum bicolor* L.) is an important crop in semiarid regions because of its adaptability and stability under water deficit conditions and warm climate (Souza et al., 2021). The versatility of sorghum enables various uses, ranging from bioenergy generation to the production of alcohol, sugar, artisanal brooms, and forage for animal feed. Sorghum is the fifth most grown grain crop worldwide with high genetic diversity (Mendes et al., 2025).

Among sorghum types, forage sorghum is frequently grown for silage production because of desirable traits such as high dry matter (DM) digestibility, soluble carbohydrate content, and a suitable DM concentration when harvested at the pasty or floury grain stages. These characteristics

support lactic acid fermentation by lactic acid bacteria (LAB), resulting in a silage with good nutritive value and acceptability by ruminants (Carvalho et al., 2021).

Conversely, biomass sorghum genotypes are primarily developed for bioenergy applications, including biogas production through anaerobic digestion and the generation of heat and/or electricity through direct combustion. As a result, they are taller and show higher dry matter yield (DMY) than forage sorghum genotypes and can reach 45 t/ha DM per harvest, and 6 m in height. Thus, their cultivation may a viable alternative for increasing forage productivity on farms (Guerra et al., 2024). However, biomass sorghum genotypes have a high vegetative growth rate and undergo rapid lignification due to the accumulation of fibre components in cell wall. Such characteristics are important for bioenergy production but can considerably reduce silage digestibility (Moore et al., 2020).

However, recent studies have reported adequate pH values, ammonia nitrogen, and organic acid concentrations in silages from biomass sorghum genotypes, despite their high fibre contents. The biomass sorghum genotype BRS 716 has shown suitable ensilability characteristics, as well as other biomass sorghum genotypes from different breeding programmes. Therefore, selecting new biomass sorghum genotypes with good characteristics for ensiling may increase silage production, including digestible dry matter yield (DDMY) per hectare, potentially improving the sustainability of forage production systems in semiarid regions. DDMY has been little used as a selection criterion in sorghum genotypes for ensiling, including recent studies.

Based on this background, we hypothesised that biomass sorghum genotypes would differ in DDMY and that genotypes with higher DDMY would maintain acceptable silage fermentation and nutritional quality. To this end, we compared seven biomass sorghum genotypes to identify the most promising lines for ensiling by assessing agronomic traits, fermentation parameters, chemical composition characteristics, and silage digestibility.

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Methods

Compliance with ethical standards

The Unimontes Ethics Committee for Experimentation and Animal Welfare approved the procedures related to animal welfare, health care, and animal management (protocol CEBEA-008/2023).

Study site

The field trial was conducted from 11 November 2022 to 30 April 2023, and the silage assessments were carried out from 1 May to 30 October 2023. The experiment was conducted at Embrapa Maize and Sorghum in Nova Porteirinha, Brazil (15°45′26″ S, 43°16′53″ W), at an altitude of 533 m.

The soil is classified as Red-Yellow Latosol or Ferralsol (Santos et al., 2018; IUSS Working Group WRB 2015). The regional climate is classified as Aw (dry tropical climate), with rainy summers and dry winters (Alvares et a., 2013). Meteorological data, including monthly rainfall and temperatures, were obtained from the automatic weather station of the National Institute of Meteorology (INMET, Station ID: A563) located at the Gorutuba Experimental Station, Nova Porteirinha, MG, Brazil. Monthly rainfall and temperature data are shown in Figure 1, including the low precipitation recorded in February and March 2023.

Experimental design, cropping and management of sorghum genotypes

Two commercial biomass sorghum genotypes (AGRI002E and BRS 716) and five experimental genotypes from the Active Germplasm Bank of Embrapa (7500, 7101, B015, 7100, and 7502) were assessed for ensiling in this study. The experiment was conducted using a complete randomised block design with three independent replicates (three 7 m² plots per genotype). Sorghum was sown on 11 November 2022 under rainfed conditions. The seeding rate ranged from 200,000 to 250,000 seeds ha^{-1}. Manual thinning was performed at the the V5 phenological stage to remove excess

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seedlings after germination, resulting in an average planting density of 157,000 plants/ha, within the recommended range of 140,000–170,000 plants/ha (Mendes et al., 2025). Basal fertilization consisted of applying 300 kg/ha of a commercial fertilizer (8-28-16 of NPK). Topdressing was performed with 150 kg/ha of urea 35 days after sowing.

Agronomic traits

Flowering time (days), plant height, number of plants/ha, fresh matter yield (FMY), and dry matter yield (DMY) were evaluated as agronomic traits. Flowering time was recorded when 50% of the plants in each plot had flowered, with the time calculated from the sowing date. Plant height was measured from the ground to the panicle apex using a ruler immediately before the sorghum harvest in each plot. The number of plants was counted manually in each plot and then converted into plants/ha.

FMY and DMY was estimated by harvesting the forage from the useful plot area. Sorghum was harvested 175 days after sowing, after flowering, to estimate FMY and DMY. The plants were weighed using a digital scale with 1-g precision, and the values were converted to t/ha. The harvested forage was chopped using a stationary forage machine (JF 50 MAXXIUM®, São Paulo, Brazil) to a particle size of 2 cm and then dried in a forced-air oven at 55 °C for 72 h to determine DM concentration and calculate DMY according to the INCT-CA G-001/1 method (Detmann et al., 2025).

Silage fermentation, deterioration and nutritive value parameters

Chopped forage from each experimental plot was transferred to an experimental silo, totalling 21 silos (7 genotypes × 3 blocks). The silos consisted of polyvinyl chloride (PVC) tubes with a diameter of 100 mm, a height of 50 cm, and a volume of 4 l. Laboratory determinations were performed in technical duplicates and averaged for each experimental unit (silo) prior to statistical

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analysis. The lid of each silo was equipped with a Bunsen valve, and the forage was compacted to achieve a density of 550 kg/m^3. The silos were stored for 120 days at room temperature before analysis at the Laboratory of Animal Feeding and Nutrition from Unimontes.

A 500-g aliquot was collected from each silo at opening, then dried in a forced-air oven at 55 °C for 72 h, and ground to pass through a 1-mm sieve using a Willey-type mill for further analyses of chemical composition and digestibility. Another aliquot of silage from each silo was pressed using a 20-t hydraulic press to extract silage juice for determination of pH (Kung Jr. et al., 2018), ammonia nitrogen (N-NH_3) (Bolsen et al., 1992), and organic acids. Lactic, acetic, propionic, and butyric acids, as well as ethanol concentrations, were determined using a liquid chromatograph (Shimadzu™ Prominence System model 20A, Kyoto, Japan) according to the method proposed by Pryce (19**Błąd! Nie można odnaleźć źródła odwołania.**69). The lactic-to-acetic ratio was calculated by dividing the lactic acid concentration by the acetic acid concentration.

A third aliquot of silage, weighing 2 kg, was placed in labelled buckets containing Datalogger devices to record minimum, average, and maximum temperatures over time and determine aerobic stability after silo opening. Aerobic stability was defined as the period until the silage temperature exceeded room temperature by 2 °C (Moran et al., 1996).

Chemical composition variables were determined using methods of the National Institute of Animal Science and Technology (INCT-CA) (Detmann et al., 2025). The contents of dry matter (DM, G-001/1), ash (M-001/1), crude protein (CP, N-001/1), neutral detergent fibre (NDF, F-001/2), and acid detergent fibre (ADF, F-003/2) were determined. *In vitro* digestible dry matter concentration (IVDDM) was determined according to the method proposed by Detmann et al. (2025) using 1-g samples placed in non-woven fabric bags measuring 7 × 7 cm with a basis weight of 100 g/m^2. The samples were subjected to digestion in an artificial *in vitro* incubator (TE-150, Tecnal, São Paulo, Brazil) using rumen fluid collected from adult lambs with an oesophageal probe. The collection was performed by a trained technician to ensure animal comfort and minimise stress. Approximately

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500 ml of rumen fluid was collected from each animal before morning feeding. Following the procedure, the animals were monitored for 48 h for signs of respiratory distress, oesophageal injury, or abnormal behaviour; no adverse effects or complications related to the collection were observed.

The DDMY of silage was calculated using the following equation:

DDMY (t/ha) = [DMY (t/ha) × 0.85] × [IVDDM (g/kg DM) / 1000],

where DMY is forage dry matter yield and IVDDM is *in vitro* digestible dry matter concentration. The factor 0.85 represents an assumed 15% dry matter loss (standardised loss) during the ensiling process (Wilkinson, 2015), as these losses were not measured individually for each genotype.

Principal component analysis

Data on the agronomic traits of the genotypes (flowering, plant height, number of plants/ha, FMY, and DMY), as well as the fermentation parameters and nutritive value of the silages (pH, ammonia nitrogen, aerobic stability and organic acids), were subjected to multivariate analysis using principal component analysis (PCA). The PCA was conducted using 21 individual plot-level observations rather than genotype means. Before analysis, all variables were centred and standardised to unit variance using the correlation matrix to account for differences in measurement scales. The PCA was performed using PROC PRINCOMP, and graphs were produced using PROC SGPLOT in SAS® OnDemand for Academics.

Statistical analysis

The data set, comprising 21 independent observations (n = 3 per genotype), was subjected to analysis of variance (ANOVA) and a normality test of the residuals (Shapiro-Wilk, $P \geq 0.05$) using Genes v1900.2023.93 software. When the F-test was significant, means were grouped using the Scott–Knott test at a 5% significance level ($P < 0.05$). The mathematical model was:

$$Y_{ij} = \mu + G_i + B_j + e_{ij},$$

where: Y_{ij} – observed value, μ is the overall mean, G_i – biomass sorghum genotype effect

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(1 to 7), B_j – block effect (1 to 3), and e_{ij} – error associated with each observation.

Results

Agronomic traits

Genotype affected the agronomic traits of biomass sorghum, except for flowering time, which averaged 151 days. Genotypes 7101, B015, 7100, AGRI002E, and BRS 716 were taller than 7500 and 7502, which had mean plant heights of 3.95 and 4.05 m, respectively (Table 1).

Silage fermentation, deterioration and nutritive value parameters

Genotype significantly affected pH and N-NH_3 concentration in the silages, but not aerobic stability, which averaged 164 h (Table 2). Silages from genotypes B015, 7100, and AGRI002E had higher pH values, whereas the lowest values were found in silages from genotypes 7500 and 7502.

The highest N-NH_3 concentration was recorded in silage from genotype 7500, while the lowest concentrations were found in silages from genotypes 7100 and 7502. Significant differences between genotypes were observed in the concentrations of almost all organic acids, except acetic acid (Table 2). Silage from genotype 7500 had the highest lactic acid concentration and lactic-to-acetic (LA) ratio, as well as the lowest butyric acid concentration. In contrast, silage from genotype 7502 had the lowest lactic acid concentration and LA ratio, as well as the highest butyric acid concentration. Silages from genotypes 7500 and AGRI002E had lower propionic acid concentrations than those from the other genotypes. The highest ethanol concentration was recorded in silage from genotype 7500, whereas the lowest was found in silage from genotype 7502 (Table 2). The LA ratio ranged from 1.9 to 3.5, reflecting differences in the relative proportions of lactic and acetic acids during fermentation.

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There were no significant differences in silage aerobic stability between genotypes, and on average, it took 164 h for the silage temperature to rise 2 °C above room temperature. Silage genotype 7502 produced more heat than the other silages directly after silo opening (Table 2).

Regarding silage chemical composition, genotype affected the contents of DM, ash, CP, NDF, and ADF (Table 3). Silage from BRS 716 had the lowest DM content, whereas the other genotypes showed higher values, with no differences among them. Silage from B015 had the highest ash content, whereas lower values were recorded for the other genotypes, with no differences between them. Silages from genotypes 7500 and BRS 716 had higher CP content than those from genotypes 7101, B015, 7100, AGRI002E, and 7502.

Genotype affected IVDDM concentration and DDMY of the silages ($P < 0.05$). Silages from genotypes 7500 and 7502 had the highest IVDDM concentrations, while the highest DDMY was recorded in the BRS 716 silage (Table 3).

Principal component analysis

Principal components 1 and 2 (PC1 and PC2) accounted for 54.29% of the total variation in the agronomic and silage traits (Figure 2A). NDF, ADF, plant height and pH showed high loadings on PC1, together with IVDDM and silage temperature. PC2 was strongly influenced by butyric acid, DM, ethanol, lactic acid, ammonia nitrogen, the LA ratio, number of plants, and flowering time (Figure 2A).

BRS 716 was located in the upper-right quadrant of the scatter plot, close to the agronomic traits, FMY, DMY, and DDMY, consistent with its favourable agronomic performance (Figure 2B). Genotype 7502 was positioned in the upper-left quadrant, aligning with silage temperature and IVDDM, but was associated with the lowest DMY and DDMY values. Genotype 7500 was located in the lower-left quadrant, near IVDDM and the LA ratio, and was also characterised by high ammonia nitrogen and ethanol concentrations. The remaining genotypes were located closer to the centre of the plot, reflecting more intermediate

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values for the variables assessed.

Discussion

Selecting biomass sorghum genotypes is often based on agronomic traits associated with DMY, such as plant height (Figueiredo et al., 2024). This trait is genetically determined, and recessive alleles at the *Dw1* and *Dw4* loci are associated with dwarf genotypes, whereas recessive alleles at only one of these loci are associated with tall plants such as BRS 716 (Diatta-Hogate et al., 2024). However, the superior performance of BRS 716 cannot be attributed solely to plant height, as it was numerically shorter than lines 7100 and 7101, which had significantly lower DMY (Table 1). The higher DMY of BRS 716 was likely related to its higher final plant density (144.67×10^3 plants/ha) and longer vegetative cycle, with flowering occurring after 173 days. The prolonged vegetative phase and late flowering observed for BRS 716 are consistent with previous reports on this genotype describing it as possibly photoperiod-sensitive (Lombardi et al., 2024a), which may have allowed greater biomass accumulation over time. Additionally, other factors not measured in this study, such as tillering capacity, stem diameter, and leaf-to-stem ratio, may also have contributed to the observed differences in yields.

Tall-growing sorghum genotypes show morphological traits and chemical composition that are favourable for bioenergy production, including longer and thicker stems with higher cellulose and lignin concentrations than dwarf genotypes (Silva et al., 2021; Yang et al., 2023). BRS 716 was selected based on such characteristics and released by Embrapa in 2014. Since then, it has shown high DMY and good tolerance to water deficit, particularly in semiarid lands (Souza et al., 2021). Other field studies have also reported good agronomic performance of BRS 716. Castro et al. (2015) assessed 16 biomass sorghum genotypes and found higher FMY for the BRS 716 (61.77 t/ha) than for CMSXS7012 (48.60 t/ha) and CMSXS7023 (47.38 t/ha). Rosa et al. (2022) evaluated the DMY of 15 biomass sorghum cultivars and reported higher productivity for BRS 716 and AGRI002E (28.77 t/ha, on average) than for the other lines.

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The low rainfall recorded in February and March (Figure 1) indicates a period of water restriction (mid-summer dry spell or 'veranico') during the final growth stages of the genotypes. Sorghum is known for its high adaptability and stability under water deficit conditions (Souza et al., 2021). This environmental stress likely contributed to the high DM concentrations observed at harvest, which exceeded 315 g/kg for most genotypes (Table 3). The higher DM content at the end of the vegetative cycle resulted in all silages exceeding the 250 g/kg threshold considered suitable for fermentation (Anjos et al., 2022). Despite this period of restricted precipitation, BRS 716 demonstrated high resilience, maintaining the largest DMY (24.50 t/ha) of the tested materials (Table 1).

The pH levels and ammonia nitrogen concentrations of silages from all genotypes remained within ranges assumed adequate for fermentation (Anjos et al., 2022). In addition to plant height and phenology, DM concentration at ensiling is an important factor affecting silage fermentation. All silages had DM contents above 250 g/kg (Table 3), which likely limited clostridial proteolysis (Silva et al., 2025). The higher NDF and ADF contents measured in genotypes such as BRS 716 and 7100 may also affect silage quality. High fibre concentrations and greater lignification provide greater resistance to lodging (Lombardi et al., 2024b) but may reduce the availability of soluble carbohydrates.

The LA ratio ranged from 1.9 to 3.5 (Table 2), indicating differences in the relative proportions of lactic and acetic acids produced during fermentation. According to Muck et al. (2020), a higher LA ratio suggests a greater proportion of lactic acid relative to acetic acid. The highest ratio was observed in genotype 7500 (3.5), whereas the lowest was found in genotype 7502 (1.9). These differences were accompanied by differences in the concentrations of other fermentation products, including ethanol and butyric acid (Table 2). Despite these differences in fermentation profiles, all genotypes showed suitable preservation, with aerobic stability averaging 164 h. Thus, the lower LA ratios did not result in poorer aerobic stability under the conditions of this study (Anjos et al., 2022).

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Nevertheless, aerobic stability remained high after silo opening, regardless of genotype. Loss of aerobic stability occurs when the silage temperature rises 2 °C above room temperature and indicates increased activity of aerobic microorganisms, mainly yeasts and moulds, which degrade residual soluble carbohydrates (Kung Jr. et al., 2018). In the present study, the silage temperature increased by 2 °C above room temperature after 164 h.

The lower DM content of silage from BRS 716 was related to its higher moisture content compared to other genotypes. The prolonged vegetative phase of BRS 716 may have maintained higher tissue moisture and physiological activity for longer, thereby delaying flowering (Queiroz et al., 2021). Nevertheless, all silages had DM contents above 250 g/kg, which is considered sufficient to achieve suitable fermentation (Anjos et al., 2022).

The higher ash contents in silages from BRS 716 and B015 may indicate greater accumulation of mineral nutrients in the forage. Biomass sorghum cultivars are known to extract substantial amounts of nutrients from the soil, and some of the absorbed minerals accumulate in plant tissues (Souza et al., 2023).

Silages from genotypes 7500 and 7502 had lower NDF and ADF contents and higher IVDDM concentrations. Lower fibre contents translates to a lower proportion of structural components in the cell wall responsible for plant rigidity. a lower fibre content in forage is generally associated with a greater proportion of DM degraded by rumen microbiota (Sales-Silva et al., 2023).

Conversely, silage from BRS 716 had the highest DDMY per hectare, largely because of its higher DMY compared to the other assessed genotypes. In recent decades, the selection of sorghum genotypes for ensiling has increasingly focused on nutritive value at the expense of forage DMY. This approach has contributed to a reduction in sorghum productivity over time in tropical countries (Guerra et al., 2024). The use of biomass sorghum genotypes for ensiling may help reverse this trend, as DDMY combines forage productivity with nutritive value. Souza et al. (2023) also reported higher DDMY in the BRS 716 silage (21.89 t/ha) than in other

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genotypes, including 201814B (17.54 t/ha), 201813b (18.38 t/ha), and Volumax (10.69 t/ha). The PCA results indicate that the morphological traits of BRS 716, particularly its tall plant stature and late flowering, contributed to its high forage production and digestible forage yield. In contrast, genotypes 7500 and 7502 were associated with greater silage digestibility but lower forage production, likely due to morphological characteristics such as shorter plant stature compared with the other biomass sorghum genotypes.

However, it is important to consider the differences between agronomic traits and silage parameters when evaluating sorghum genotypes. Agronomic characteristics are typically assessed directly in the field, whereas silage parameters are determined by laboratory analyses after silo opening. Therefore, strong relationships between agronomic performance and silage quality may not always be observed.

Conclusions

Silage produced from all biomass sorghum genotypes showed adequate fermentation parameters and high aerobic stability, indicating their suitability for forage production systems in semiarid regions.

Among the assessed genotypes, BRS 716 can be recommended for ensiling due to its high yield of digestible nutrients per area, suitable fermentation, and potential for large-scale silage production. Genotypes 7500 and 7502 may be used as alternatives when the aim is to improve the nutritive value of roughage using a biomass sorghum genotype. However, some fermentation and aerobic deterioration characteristics should be considered. Further studies are needed to evaluate silages from these genotypes in animal performance trials.

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Conflict of interest

The Authors declare that there is no conflict of interest.

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Table 1. Agronomic traits of biomass sorghum genotypes (*Sorghum bicolor* L.) harvested for ensilage in the 2022/23 harvest season, Nova Porteirinha, Minas Gerais, Brazil

Genotype	Flowering, days	Plant height, m	NP, thousand ha^{-1}	FMY, t/ha	DMY, t/ha
7500	158	3.95 ^{B}	129.67 ^{A}	40.98 ^{D}	14.34 ^{D}
7101	134	4.80 ^{A}	91.00 ^{B}	48.45 ^{C}	16.96 ^{C}
B015	138	4.53 ^{A}	122.00 ^{A}	50.38 ^{C}	17.63 ^{C}
7100	155	4.92 ^{A}	115.33 ^{A}	54.07 ^{B}	18.93 ^{B}
AGRI002E	153	4.72 ^{A}	127.33^{A}	54.30 ^{B}	19.00 ^{B}
7502	146	4.05 ^{B}	126.00 ^{A}	32.43 ^{E}	11.35 ^{E}
BRS 716	173	4.67 ^{A}	144.67 ^{A}	70.00 ^{A}	24.50 ^{A}
P-value	N/A	0.003	0.010	<0.001	<0.001
SEM	N/A	0.154	7.312	1.758	0.615

NP – number of plants; FMY – fresh matter yield; DMY – dry matter yield; SEM – Standard error of mean, values are presented as mean ± standard error of the mean (SEM), means followed by the same letter within columns do not differ by the Scott-Knott grouping test at 5% of error probability ($P < 0.05$), $^{A-D}$ – means within a column with different superscripts are significantly different at $P < 0.05$

Table 2. Fermentation traits and aerobic stability of silages made of biomass sorghum genotypes (*Sorghum bicolor* L.) harvested in the 2022/23 harvest season, Nova Porteirinha, Minas Gerais, Brazil

Variable	Genotype							*P*-value	SEM
	7500	7101	B015	7100	AGRI002E	7502	BRS 716		
pH	3.52 ^{C}	3.70 ^{B}	3.75 ^{A}	3.76 ^{A}	3.80 ^{A}	3.54 ^{C}	3.70 ^{B}	<0.001	0.02
N-NH_3, g/kg TN	42.5 ^{A}	37.6 ^{B}	34.8 ^{B}	24.5 ^{D}	29.6 ^{C}	27.7 ^{D}	32.2 ^{C}	<0.001	0.13
Lactic acid, g/kg DM)	13.2 ^{A}	12.5 ^{A}	11.7 ^{B}	9.2 ^{C}	9.4 ^{C}	7.6 ^{D}	11.1 ^{B}	<0.001	0.49
Acetic acid (g/kg DM)	3.7	3.9	3.4	3.8	3.7	3.9	4.2	0.263	0.23
Propionic acid (g/kg DM)	0.19 ^{B}	0.37 ^{A}	0.52 ^{A}	0.35 ^{A}	0.20 ^{B}	0.40 ^{A}	0.42 ^{A}	0.003	0.55
Butyric acid (g/kg DM)	1.3 ^{E}	1.7 ^{D}	1.4 ^{E}	2.4 ^{C}	3.0 ^{B}	3.6 ^{A}	3.6 ^{A}	<0.001	0.07
Ethanol (g/kg DM)	6.9 ^{A}	5.8 ^{B}	4.0 ^{C}	2.4 ^{D}	2.7 ^{D}	1.4 ^{E}	3.8 ^{C}	<0.001	0.32
L/A ratio	3.5 ^{A}	3.2 ^{A}	3.5 ^{A}	2.4 ^{B}	2.5 ^{B}	1.9 ^{C}	2.6 ^{B}	0.001	0.17
Aerobic stability	168	168	168	160	168	149	168	0.985	0.45
Top temperature	28.8 ^{B}	28.1 ^{B}	27.4 ^{B}	27.5 ^{B}	27.1 ^{B}	31.2 ^{A}	27.0 ^{B}	0.001	0.67

pH – hydrogen potential; N-NH_3 – ammonia nitrogen; TN – total nitrogen; DM – dry matter content, L/A – lactic-to-acetic acid ratio; SEM – Standard error of mean, means followed by the same letter within rows do not differ by the Scott-Knott grouping test at 5% of error probability, $^{A-E}$ – means within a column with different superscripts are significantly different at $P < 0.05$

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Table 3. Chemical composition, digestible dry matter yield, and digestibility of silages made of biomass sorghum genotypes (*Sorghum bicolor* L.) harvested in the 2022/23 harvest season, Nova Porteirinha, Minas Gerais, Brazil

Genotype	DM	Ash	CP	NDF	ADF	IVDDM	DDMY
	(g/kg DM)						(t/ha)
7500	329.9 ^{A}	49.1^{B}	53.9 ^{A}	576.9 ^{B}	332.0 ^{B}	506.9 ^{A}	6.19 ^{B}
7101	338.0 ^{A}	57.0 ^{B}	43.7 ^{B}	692.9 ^{A}	421.6 ^{A}	384.5 ^{B}	5.50 ^{B}
B015	327.5 ^{A}	62.6 ^{A}	45.7 ^{B}	672.6 ^{A}	404.6 ^{A}	438.0 ^{B}	6.58 ^{B}
7100	324.0 ^{A}	56.6 ^{B}	43.1 ^{B}	697.1 ^{A}	425.5 ^{A}	393.0 ^{B}	6.36 ^{B}
AGRI002E	325.1 ^{A}	55.8 ^{B}	42.6 ^{B}	688.4 ^{A}	416.4 ^{A}	390.8 ^{B}	6.32 ^{B}
7502	315.2 ^{A}	58.1 ^{B}	46.8 ^{B}	543.3 ^{B}	331.0 ^{B}	528.3 ^{A}	5.12 ^{B}
BRS 716	278.4 ^{B}	69.4 ^{A}	56.1 ^{A}	662.2 ^{A}	383.5 ^{A}	443.7 ^{B}	9.24 ^{A}
P-value	0.001	0.002	0.018	<0.001	<0.001	0.002	0.001
SEM	6.33	2.27	2.74	15.30	11.57	22.58	0.52

DM – dry matter; CP – crude protein; NDF – neutral detergent fiber; ADF – acid detergent fiber; IVDDM – *in vitro* digestible dry matter; DDMY – digestible dry matter yield; SEM – Standard error of mean, means followed by the same letter within columns do not differ by the Scott-Knott grouping test at 5% of error probability ($P < 0.05$), ^{A,B} – means within a column with different superscripts are significantly different at $P < 0.05$

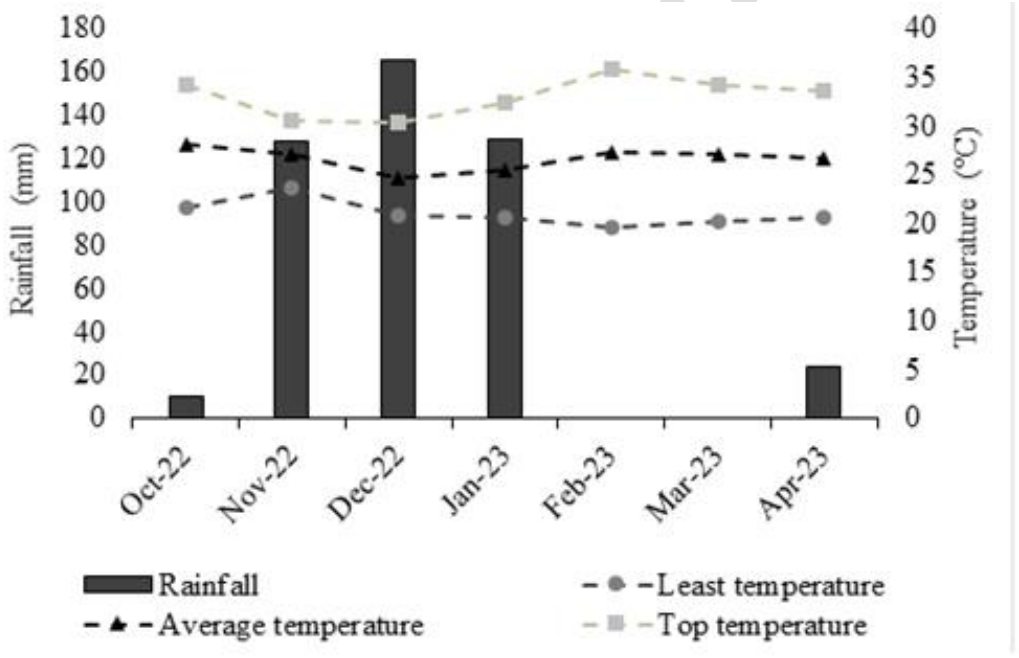


Figure 1 Monthly rainfall (mm) and minimum, average, and maximum air temperatures (°C) recorded from November 2022 to April 2023 at the Gorutuba Experimental Station (INMET station A563), Nova Porteirinha, MG, Brazil

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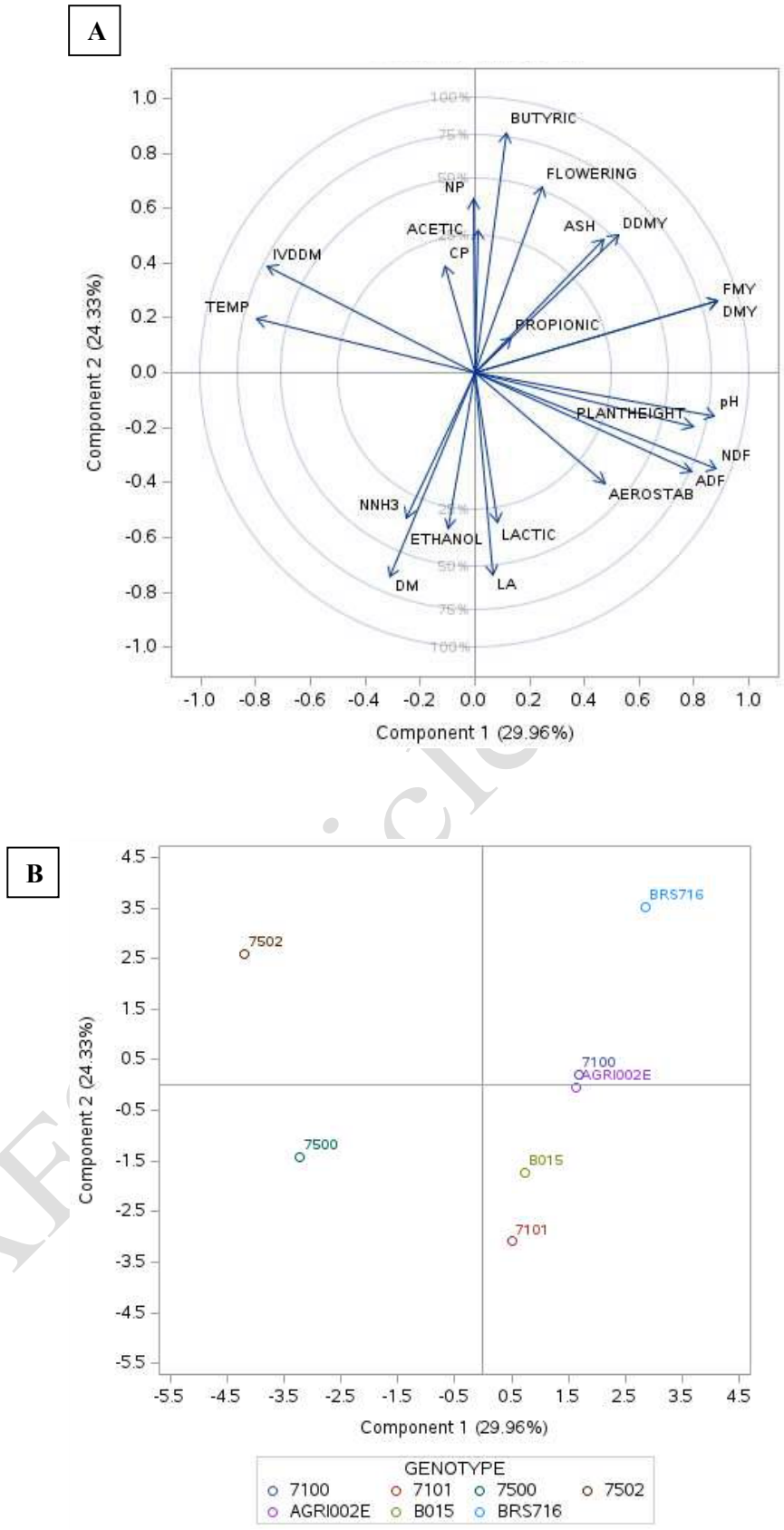


Figure 2. A: Distribution of agronomic traits of biomass sorghum genotypes (*Sorghum bicolor* L.), and their respective silage fermentation and nutritive value parameters, in the coordinate and eigenvector systems of principal components 1 and 2. Abbreviations: PLANTHEIGHT – plant height, NP – number of plants per hectare, FMY – fresh matter yield, DMY – dry matter yield, pH – silage pH, NNH3 – silage ammonia nitrogen content, DM – silage dry matter content, ASH – silage ash content,

CP – silage crude protein content, NDF – silage neutral detergent fiber content, ADF – silage acid detergent fiber content, IVDDM – *in vitro* digestible dry matter concentration, DDMY – digestible dry matter yield of silage, AEROSTAB – silage aerobic stability, TEMP – silage temperature, LACTIC – lactic acid concentration, ACETIC – acetic acid concentration, PROPIONIC – propionic acid concentration, BUTYRIC – butyric acid concentration, ETHANOL – ethanol concentration, LA – lactic-to-acetic acid ratio

Figure 2. B. Scatter plot of the biomass sorghum genotypes (n = 21 observations), where each point represents an individual experimental plot (3 plots per genotype), and considering the principal components 1 and 2

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