

# Yield, Agronomic Characteristics and Chemical Composition of Silage Fodder (*Sorghum bicolor* L.) With and Without Fertilization

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## ABSTRACT

**Objective:** To evaluate the yield and structural characteristics of sorghum fodder, as well as the chemical quality of the fodder and the silage with and without fertilization.

**Design/Methodology/Approach:** The evaluated variables were, in the fodder: dry matter yield (DMY, kg ha<sup>-1</sup>), leaf:stalk ratio (L:S, g g<sup>-1</sup>), plant height (H, cm) and intercepted radiation (IR, %); and in the silage: dry matter (DM, %) crude protein (CP, %), neutral detergent fiber (NDF, %), acid detergent fiber (ADF, %), lactic acid (LA, %) and pH. There were two treatments, with fertilization and without fertilization.

**Results:** The agronomic characteristics L:S, H and IR improved with fertilization (P<0.05). The DMY with fertilization was 7060 kg DM ha<sup>-1</sup> and without fertilization, it was 5472 kg DM ha<sup>-1</sup>. The values of DM, CP, NDF, ADF and LA of the silage with fertilization were 33.60, 7.83, 51.06, 28.51 and 4.51%, respectively, and the pH was 4.3, and without fertilization these values were 47.67, 5.83, 43.36, 25.21 and 2.86%, respectively, and the pH was 4.66; all values were different when comparing with and without fertilization (P<0.05).

**Study Limitations/Implications:** These quality parameters should continue to be studied in sorghum silages and with different fertilization doses to expand the decision outlook.

**Findings/Conclusions:** According to the results obtained, it is concluded that the sorghum fodder crop should be fertilized for the ensilage, since higher dry matter yield, better agronomic, and nutritional characteristics are obtained.

**Keywords:** sorghum, sowing, fertilization, ensilage, bromatology analysis.

## INTRODUCTION

**Sorghum** fodder is very important in the elaboration of balanced feed for animals (Nichols *et al.*, 1997). It is of forage quality and requires less water than maize, so it adapts to rainfed management. In addition, it can be cultivated in the tropics with productive response and nutritional value similar to maize (Contreras *et al.*, 2011; Reborá *et al.*, 2018).

Sorghum fodder uses less water than maize in grain production, in addition to its dense and ramified roots, and the lower growth speed of the leaf area, making the use of nitrogen of the soil more efficient (Bolaños *et al.*, 2018) al emplear plantas con concentraciones promedio de 300 g kg<sup>-1</sup> de MS. Se estudiaron tres variedades de grano (Solarius, Aralba y Topsilo. Nitrogen is the most restrictive element for plant growth and therefore for production (Diez, 2015). In recent decades its use has increased to raise the productivity of the crops (Espinosa *et al.*, 2002).

It is important to understand the yield and nutritional composition of sorghum since it is an alternative in the Mexican tropics due to the irregularity of rainfall (Rojas *et al.*, 2018). This irregularity leads to times of scarcity and abundance of fodder. In times of abundance, the excess fodder must be turned into silage to be used in times of scarcity. Ensilage is a fodder conservation method with high moisture content (60-70%). This method consists in compaction of the fodder, air expulsion and fermentation, which allow bacterial acidification of the silage until obtaining pH values below 5 (Fernández *et al.*, 2017).

In Mexico, Ramírez *et al.* (2019) obtained in average 27.7% of dry matter and 11500 kg MS ha<sup>-1</sup> with different varieties of sorghum in the tropics, at the time of ensilage and in the silage pH values of 3.7 and raw protein of 8.4%. However, there are few studies about the effect of fertilization on the quality of sorghum silages in Mexico. Therefore, the objective of this study was to evaluate the yield and the chemical quality of the fodder and the silage, with and without fertilization.

## MATERIALS AND METHODS

### Location

The field research was carried out in 2018 in Rancho los Laureles, located on Km 7 of the

Cuajinicuilapa highway, Guerrero-Santo Domingo, Oaxaca, and the chemical studies were done in the Animal Nutrition Laboratory of the Veterinary and Zootechnics School No. 2 of the Universidad Autónoma de Guerrero, on Km 197 of the Acapulco-Pinotepa Nacional highway, in Cuajinicuilapa, Guerrero, Mexico; coordinates 16° 08' N and 98° 23' W 50 masl, average temperature 29 °C and accumulated rainfall of 1200 mm.

The climate is Aw, dry tropical according to the Köppen-Geiger classification (García, 2004). The climate data were obtained from CONAGUA's agro-meteorological station located in the municipality of Cuajinicuilapa, 10 km from the experimental plots. The maximum temperature, 36 °C, was reached on the month of November, while the minimum, 17 °C, in August and September; the accumulated rainfall was 950 mm (Table 1).

### Management of the Plots

Sowing was carried out in the rainy season, on August 1<sup>st</sup>, and the ensilage on November 1<sup>st</sup>, 2018, in Rancho los Laureles, using sorghum from the company DEKALB<sup>®</sup> variety BRS-72. Six hectares of sorghum were sown; three of them fertilized and three without fertilization. Sowing was carried out with an agricultural tractor (New Holland<sup>®</sup>, Mexico) in furrows of 80 centimeters of separation, placing the seed by continuous string and at a depth of 3 cm; at 14-16 seeds per linear meter, the sowing density was 8 kg ha<sup>-1</sup> of pure viable seed. The soil, of clay-sandy texture, pH 4.8 to 5.0, was deficient in organic matter.

At the time of sowing, 150 kg ha<sup>-1</sup> of DAP fertilizer (18-46-00) and 100 kg ha<sup>-1</sup> of ammonium sulfate (12-61-00) were applied for the treatment with fertilization, together with the seed with the sower's hopper. At 40 days after sowing (das), fertilization was carried out again with 150 kg ha<sup>-1</sup> of urea (46-00-00). Weed control was performed manually with a hoe.

**Table 1.** Maximum, minimum, mean (°C) temperature and precipitation (mm) during the study period in 2018.

Month	Maximum	Minimum	Average	Precipitation	Irrigation
August	33	17	25	269	No
September	33	17	25	290	No
October	35	18	26	282	No
November	36	18	27	109	No

At 90 das, fodder cutting was performed with an agricultural tractor (New Holland®, Mexico) and the ensilage with a silo (Twin 623600®, SWISSMEX). The fodder chopping was in 2 to 3 cm, depositing it directly in trailers to be transported to the silo (cake) that was uncovered after 90 days (180 das).

## Evaluated Variables

### Dry Matter Yield

At 90 days after sowing (das), the plants were ensilaged in the milky-pasty stage of panicle. One day later two squares of 1 m<sup>2</sup> per ha<sup>-1</sup> were harvested at 10 cm height from the ground. The harvested fodder was washed and placed in paper bags. The samples were dried in a forced-air stove at 55 °C until constant weight, and their weight was recorded.

### Plant Height

Twenty readings per repetition were taken randomly one day before harvesting the fodder for ensilage. For this purpose, a ruler measuring in cm was used, which was placed randomly in the plots so that the lower part of the ruler was at ground level and the posterior part was in contact with the flag leaf.

### Leaf:Stalk Ratio

After harvesting the fodder for ensilage, the weights of the leaves and stalks of the plants were recorded in dry base and with them the leaf:stalk ratio was estimated (g g<sup>-1</sup>). Drying was done at 55 °C until constant weight in a forced air stove.

### Intercepted Radiation

Five radiation readings per experimental plot were taken randomly the day prior to the harvest, with the method of wooden meter described by Rojas *et al.* (2016).

### Chemical Variables

In the plant components, when finalizing the ensilage process which lasted 90 days, the following variables were determined in the ensilage: dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lactic acid (LA), and pH (Van Soest *et al.*, 1991; AOAC, 2005). Three samples were taken randomly in the middle part of each ensilage.

## Statistical Analysis

The treatments were assigned to experimental units according to a design of random blocks with three repetitions, and each repetition was one ha<sup>-1</sup>. The data obtained were organized and analyzed with PROC GLM of SAS (SAS, 2011), the means were compared with Tukey's test (P<0.05).

The experimental unit for the yield was a sample taken from each one of the two squares, from each one of the three hectares with and without fertilization; in total, six experimental units with fertilization and six without fertilization.

## RESULTS AND DISCUSSION

The fodder yield with fertilization was 7060 kg MS ha<sup>-1</sup> and without fertilization 5472 kg MS ha<sup>-1</sup> (P<0.05). The plant height, leaf:stalk ratio, and intercepted radiation were also higher with fertilization (P<0.05) than without fertilization, 1.77 cm, 0.44 g g<sup>-1</sup> and 95 % vs. 1.62 cm, 0.37 g g<sup>-1</sup> and 89%, respectively.

**Table 2.** Yield of sorghum fodder and agronomic characteristics with and without fertilization.

Variable	With fertilization	No fertilization	SEM
DM kg ha <sup>-1</sup>	7060a	5472b	110
Height (cm)	1.77a	1.62b	0.42
Leaf: stem ratio (g g <sup>-1</sup> )	0.44a	0.37b	0.05
Intercepted radiation (%)	95a	89b	0.12

ab Means with different literals in the same row are statistically different (p<0.05), DM = dry matter yield; SEM = standard error of the mean.

Boschini and Elizondo (2005), when evaluating different cutting ages in sorghum fodder, obtained in average 6303 kg MS ha<sup>-1</sup> that are very similar to results in this study. On the other hand, Ibarguren *et al.* (2020) reported in sorghum hybrids a height that ranges from 1.54 to 2.81 by applying fertilization (18-46-00), similar to results in this study. Espinosa *et al.* (2002) reported in sorghum at different physiological ages that height and yield increase from nitrogenous fertilization. Diez (2015) reported a higher amount of leaf and panicle, up to 20%, when nitrogenous fertilization is carried out in sorghum crop destined to ensilage. The height and intercepted radiation are important for a good harvest in the milky-pasty stage of the panicle; in tropical fodders, 95% of intercepted radiation is considered optimal and it is reached with fertilization (Da Silva and Nascimento, 2007; Rojas *et al.*, 2018).

There was a difference in the DM obtaining a higher percentage from the sorghum plant fertilized with 37.66 % and a lower one in non-fertilized sorghum of 33.60 % (P<0.05). In the CP of the panicle, stalk and leaf

of the sorghum plant there were differences between the fertilized and non-fertilized sorghum, obtaining the highest percentage when fertilized with 2.49, 4.89 and 15.72% of protein ( $P < 0.05$ ). The neutral detergent and acid detergent fibers in the components of the sorghum plant are quite variable depending on whether it is fertilized or not.

For their part, Boschini and Elizondo (2005) obtained a similar behavior to this study's when evaluating different frequencies of black sorghum fodder in the structures of the plant obtained in average, harvesting sorghum at 133 days after sowing, dry matter of 23.3%, crude protein of 13.88%, and neutral and acid detergent fiber with 70.39 and 38.32%, respectively, in the leaf's component. In contrast, in the stalk the crude protein content was lower, with 4.79%, although higher in the neutral and acid detergent fibers with 80.91 and 53.28, respectively. However, in this study it was harvested 90 days after sowing since it is when the best conditions were found for ensilage with the panicle in milky-pasty stage; this depends on the variety and soil-climate elements of the region (Ibarguren *et al.*, 2019).

Compared to silage without fertilization, the sorghum silage with fertilization produced higher values ( $P < 0.05$ ) of CP, NDF, ADF and LA (7.83, 51.06, 28.51 and 4.51%, respectively) and lower value ( $P < 0.05$ ) of pH (4.3). The

**Table 3.** Nutritional analysis of the components of sorghum plants with and without fertilization for ensilage.

	With fertilization	No fertilization	SEM
DM	33.60b	37.66a	3.19
PCP	2.49a	1.68b	0.25
PCT	4.89a	3.11b	0.52
PCH	15.72a	14.48b	0.60
FDNP	85.01b	89.08a	1.87
FDNT	61.74b	71.31a	2.19
FDNH	61.55b	67.50a	1.39
FDAP	21.54b	24.55a	2.33
FDAT	39.19b	44.53a	1.30
FDAH	33.77a	33.76a	0.53

ab, means with different literals in the same row are statistically different ( $p < 0.05$ ); SEM = standard error of the mean; DM = dry matter of the plant; PCP = crude panicle protein; PCT = crude stem protein; PCH = crude leaf protein; FDNP = neutral detergent fiber of panicle; FDNT = stem neutral detergent fiber; FDNH = neutral detergent fiber of the leaf; FDAP = acid detergent fiber of the panicle; FDAT = acid detergent fiber from the stem; FDAH = neutral detergent fiber of the leaf.

**Table 4.** Chemical analysis of the sorghum silage with and without fertilization.

	With fertilization	No fertilization	SEM
DM	33.60b	47.67a	3.19
PC	7.83a	5.83b	0.64
FDN	51.06a	43.36b	1.87
FDA	28.51a	25.21b	0.84
AL	4.51a	2.86b	0.37
pH	4.3b	4.66a	0.08

ab Means with different literals in the same row are statistically different ( $p < 0.05$ ); DM = dry matter; PC = crude protein; NDF = neutral detergent fiber; FDA = acid detergent fiber; AL = lactic acid; pH = hydrogen potential; SEM = standard error of the mean.

advantage of the sorghum silage without fertilization was its higher DM (47.67%), which in the fertilized sorghum silage was 33.60%. These results were similar to those reported by Corral *et al.* (2011) who reported higher values of CP and LA from nitrogenous fertilization.

Dávila *et al.* (2016), when evaluating sorghum silages associated with *Tithonia diversifolia*, found similar values of DM (27%) to those of this study, and higher of CP (13.26%); this higher value of CP is probably due to the association of sorghum with *T. diversifolia*.

### CONCLUSIONS

The sorghum fodder crop should be fertilized to ensile since higher yield of dry matter, and better agronomic and chemical characteristics are obtained. It is suggested to perform studies with ensilages with more varieties of sorghum, other levels of fertilization, other frequencies of cutting, and associations with other species.

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