Agronomic characteristics of forage sorghum genotypes

https://doi.org/10.56238/sevened2024.012-009

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ABSTRACT

The objective of this study was to evaluate the agronomic performance of 19 sorghum genotypes in three Brazilian cities. The sorghum genotypes evaluated were planted in three Brazilian municipalities: Goiânia, Nova Porteirinha and Sete Lagoas. A total of 19 sorghum genotypes were evaluated. The hybrids tested were: 15F27012, 15F27006, 15F27013, 14F20019, 15F26006, 14F21021, 14F20005, 13F26006, 15F26005, 15F27005, 15F30006, 15F30005, 15F270011, 15F26019, 13F26005, 13F03034, VOLUMAX, BRS658, BRS655. The genotypes planted in the three municipalities were evaluated for their agronomic characteristics. When evaluating the genotypes in each cultivation site, there was a variation among them ($p<0.05$) regarding the number of days to flowering in all municipalities evaluated. The genotype 15F27005 stood out among all the municipalities, obtaining its averages in lower flowering days than the other genotypes tested. Among the municipalities, there was variation in the value of plant height for most of the genotypes studied ($p>0.05$). The genotypes 15F30006, 15F30005 and 13F0334 showed higher mean heights in the three municipalities evaluated and both were influenced by the place of cultivation. The yields of MV and DM were influenced by the cultivation site for most of the genotypes evaluated ($p<0.05$). As for PMV, the genotype 15F3005 stood out among the others, because, despite having production influenced by the place of cultivation, it obtained a higher average in all the municipalities evaluated. Dry matter production between genotypes and municipality ranged from 7.0 t/ha-1 to 14.9 t ha-1 for genotypes 15F26006 and 15F30005, in Sete Lagoas and Goiânia, respectively. The genotypes 15F30006, 15F30005, 15F270011, VOLUMAX, BRS658, BRS655 stood out among the others, as they presented higher averages of dry matter production in at least two of the municipalities evaluated, demonstrating their adaptation to different cultivation sites.

Keywords: Sorghum, Height, Flowering, Dry matter.

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INTRODUCTION

The sorghum crop stands out for its rusticity, high biomass production and great tolerance to water deficit. These characteristics, associated with its great energy efficiency, allow the cultivation of sorghum in arid and semi-arid zones, with production in different seasons and regions, ensuring continuity in the supply of raw material, which has favored the expansion of the planted area in Brazil, mainly as an alternative for agricultural diversification in regions with low rainfall.

Sorghum (*Sorghum bicolor* L. Moench) is a crop intended for animal feed, cultivated in several regions of the world. In semi-arid areas, its cultivation is especially advantageous as a source of fodder, due to its characteristics adapted to water scarcity. With high dry matter (DM) yield, high concentration of soluble carbohydrates, reduced buffering capacity, and satisfactory nutritional value, sorghum stands out as a favorable option for silage production (Perazzo, 2017).

Its cultivation can be done in different densities of plants according to the type used and the climatic variation of the region, these characteristics combined with other factors such as spacing, sowing time, depth, genetics, fertilization and nutrition, which can directly or indirectly influence the productivity of the crop.

According to Parrella et al. (2014), in Brazil, there are few specialized sorghum cultivars aimed at animal feed, especially the BRS658 and Volumax varieties. In addition to these, the BRS716 and AGRI002E commercial hybrids are also considered promising sources of forage, due to their high levels of productivity and biomass quality (May, 2013; Monção et al., 2020).

In the northern region of Minas Gerais, forage scarcity is exacerbated, especially during the dry season, when forage has low nutritional value. This compromises the growth and development of the animals, resulting in a drop in productivity and, consequently, lower milk and meat production. The cultivation of plants that are more resilient to water stress helps to mitigate the effects of seasonality on forage production, thus ensuring the maintenance of animal production throughout the year.

Based on the above, the objective of this study was to evaluate the agronomic performance of 19 sorghum genotypes in three Brazilian cities.

MATERIAL AND METHODS

The sorghum genotypes evaluated were planted in three Brazilian municipalities: Goiânia, Nova Porteirinha and Sete Lagoas. Goiânia is the capital of the state of Goiás and is located at 16° 40' S and 49° 15' W. The climate in the place, as defined by Köppen, is classified as tropical rainy, Aw savannah, having a subsumed character, with two well-defined seasons: a dry one, lasting four to five months; and another rainy season, occurring from late September to April (RATKE *et al*., 2013).

Nova Porteirinha belongs to the northern region of Minas Gerais, with latitude 15°45' S and longitude 43°17' W. According to the Köppen classification, the typical climate is the Aw, that is, savannah with dry winter (ALBUQUERQUE *et al*., 2005). Sete Lagoas is located in the north-central portion of the State of Minas Gerais at 19° 28' S and 44° 15' W. The climate of the place is classified, according to Köeppen, as Cw, of savannah with dry winter (PANOSO *et al*., 2002).

The genotypes were planted in the three municipalities in November and December 2019, as soon as the first rains occurred in each region. The planting was carried out in three blocks, consisting of 24 plots, each with six rows of six meters in length and 70 centimeters of spacing between rows. As a function of the soil analysis, in each municipality, fertilization was adjusted in such a way as to provide the same amounts of nutrients to all genotypes.

A total of 19 sorghum genotypes were evaluated. The hybrids tested were: 15F27012, 15F27006, 15F27013, 14F20019, 15F26006, 14F21021, 14F20005, 13F26006, 15F26005, 15F27005, 15F30006, 15F30005, 15F270011, 15F26019, 13F26005, 13F03034, VOLUMAX, BRS658, BRS655.

The genotypes planted in the three municipalities were evaluated for their agronomic characteristics, in which the two central rows of each plot were used to determine the flowering age: days for the sorghum plant to emit the inflorescence after planting; plant height: by measuring the soil level at the upper end of the plant, in 20% of the plants in each plot; Green matter production: obtained from the weighing of all plants in the useful area of the plot, carried out after cutting at 15 cm from the soil and dry matter production: calculated from the green matter production and DM content of each genotype at the time of cutting.

To determine the agronomic characteristics, after data collection, individual analyses were performed for all variables, once the necessary requirement for its execution was met, as recommended by Banzatto and Kronka (2008), i.e., the ratio between the largest and the smallest residual mean square should not exceed 7:1, a joint analysis was carried out (SAS System, 2004) with the objective of analyzing the interactions between the regions and the sorghum hybrids. When the "F" test was significant, the hybrids and regions and the interaction between these factors were compared by the "Scott-Knott" test at the level of 5% probability, using the SISVAR software (FERREIRA, 2011).

The bromatological data obtained were submitted to analysis of variance using the SISVAR program and when it presented significance for the "F" test for the main factors and interaction between them, the mean of the genotype factor was compared by the Scott-Knott test at the level of 5% probability, according to the following statistical model:

$$\mathbf{Yik = \mu + Gi + Bk + eik}$$

Where:

Y_{ik} = Observation referring to genotype i, in repetition k;

μ = Overall average;

G_i = Effect of genotype i, with i = 1, 2, 3... 19;

B_j = block effect k, where k = 1, 2 and 3;

e_{ik}= The experimental error associated with the observed values (Y_{ik}) which, by hypothesis, has a normal distribution, with a mean of zero and variance σ^2.

RESULTS AND DISCUSSION

When evaluating the genotypes in each cultivation site, there was a variation among them ($p<0.05$) regarding the number of days to flowering in all municipalities evaluated. The genotypes 15F27013, 15F27005, 15F27001 took fewer days to flower in all three cities. The genotype 15F27005 stood out among all the municipalities, obtaining its averages in lower flowering days than the other genotypes tested.

When observing the results within each municipality, the genotypes 15F26005, 15F26019, 13F03034 in the municipality of Goiânia; genotypes 14F20019 and 15F26019 in the municipality of Nova Porteirinha; only the genotype 15F26019, respectively, was the latest in the flowering of the plant in all municipalities and both suffered the effect of the location on this trait (Table 1). The plants' ability to flower early allows for multiple annual growing cycles, offering greater flexibility in management and faster payback. In addition, it meets the demand of producers (DE OLIVEIRA et al., 2021).

TABLE 1: Mean values of days for flowering of 19 sorghum genotypes cultivated in Goiânia (GO), Nova Porteirinha (MG), Sete Lagoas (MG)

	Cities		
Genotypes	Goiânia	Nova Porteirinha	Sete Lagoas
15F27012	60,0 Fc	66,0 Ea	63,0 Cb
15F27006	69,0 Da	69,0 Da	64,3 Cb
15F27013	60,0 Fa	61,0 Ga	62,3 Ca
14F20019	81,0 Bb	87,0 Aa	68,0 Bc
15F26006	81,0 Ba	80,0 Ba	64,3 Cc
14F21021	81,0 Ba	79,0 Ba	64,3 Cb
14F20005	81,0 Ba	81,0 Ba	63,0 Cb
13F26006	69,0 Da	66,0 Eb	60,3 Dc
15F26005	83,0 Aa	71,0 Cb	63,7 Cc
15F27005	57,0 Ga	57,0 Há	57,0 Ea
15F30006	81,0 Ba	81,0 Ba	64,3 Cb
15F30005	81,0 Ba	81,0 Ba	63,0 Cb
15F270011	60,0 Fa	60,0 Ga	61,7 Da
15F26019	84,0 Aa	87,0 Aa	70,0 Ab
13F26005	74,0 Ca	71,0 Cb	57,0 Ec
13F03034	83,0 Aa	81,0 Bb	67,0 Bc
VOLUMAX	81,0 Ba	63,0 Fb	67,0 Bb
BRS658	74,0 Cb	81,0 Ba	57,0 Ec
BRS655	67,0 Eb	71,0 Ca	60,3 Dc

Averages followed by different uppercase letters in the columns and lowercase letters in the row differ by the Skott-Knott test at 5% probability. (P<0.05).

Standard error of mean: 0.6734

The average days to flowering ranged from 57 to 87 days. The 15F26019 genotype is among the later genotypes, except for Nova Porteirinha, where the 14F20019 had an average equal to the 15F26019 genotype. Paula et al. (2017) observed the presence of inducing photoperiods in second crop crops in 25 forage sorghum varieties grown both in the main crop (from November to March) and in the second crop (from March to June) in Uberlândia. A longer vegetative period was found in the main crop compared to the second crop for 23 of the varieties analyzed.

Table 2 shows that the 19 sorghum genotypes differed from each other in terms of plant height in all cities evaluated ($p<0.05$). Among the municipalities, there was variation in the value of plant height for most of the genotypes studied ($p>0.05$).

TABLE 2: Mean values of plant height in meters of 19 sorghum genotypes cultivated in Goiânia (GO), Nova Porteirinha (MG), Sete Lagoas (MG)

	Cities		
Genotypes	Goiânia	Nova Porteirinha	Sete Lagoas
15F27012	2,33 Ba	2,48 Ba	2,02 Ba
15F27006	2,67 Ba	2,62 Ba	1,79 Bb
15F27013	2,53 Ba	2,57 Ba	2,05 Ba
14F20019	2,67 Ba	2,63 Ba	2,02 Bb
15F26006	2,77 Ba	2,68 Ba	2,32 Aa
14F21021	2,70 Ba	2,65 Ba	2,25 Aa
14F20005	2,57 Ba	2,57 Ba	1,91 Bb
13F26006	2,57 Ba	2,55 Ba	2,11 Ba
15F26005	2,57 Ba	2,40 Ba	1,86 Bb
15F27005	2,20 Ba	2,30 Ba	1,89 Ba
15F30006	4,00 Aa	3,52 Aa	2,72 Ab
15F30005	3,76 Aa	3,65 Aa	2,42 Ab
15F270011	2,33 Ba	1,69 Ca	2,03 Ba
15F26019	2,40 Ba	2,47 Ba	1,88 Ba
13F26005	2,57 Ba	2,57 Ba	1,86 Bb
13F03034	4,06 Aa	3,65 Aa	2,47 Ab
VOLUMAX	2,87 Ba	2,78 Ba	1,88 Bb
BRS658	3,10 Ba	2,92 Ba	2,13 Bb
BRS655	2,27 Ba	2,42 Ba	2,00 Ba

Averages followed by different uppercase letters in the columns and lowercase letters in the row differ by the Skott-Knott test at 5% probability. ($P<0.05$).

Standard error of mean: 18.179

The genotypes 15F30006, 15F30005 and 13F0334 showed higher mean heights in the three municipalities evaluated and both were influenced by the place of cultivation. The genotypes 15F26006 and 14F21021 were higher only in the municipality of Sete Lagoas. Among the municipalities there was variation in plant height only in the municipality of Sete Lagoas for the genotypes 15F27006, 1420019, 14F2005, 15F26005, 15F30006, 15F30005, 13F26006, 13F03034, VOLUMAX, BRS658 respectively, obtained lower heights in relation to the other genotypes evaluated. Plant height ranged from 1.69 m to 4.06 m for genotypes 15F270011 in Nova Porteirinha and 13F03034 in Goiânia. In a study involving hybrids, Paula (2016) found that height averages were higher in the main crop (sown in November) compared to the winter crop (sown in March).

The genotypes 15F27012, 15F27013, 15F26006, 14F21021, 13F26006, 15F27005, 15F270011, 15F26019, BRS655 maintained their productions in the three municipalities. Analyzing the green matter (PMV) and dry matter (PMS) yields between the genotypes, shown in tables 3 and 4, respectively, it was observed that they differed from each other in all the municipalities evaluated ($p<0.05$). The yields of MV and DM were influenced by the cultivation site for most of the genotypes evaluated ($p<0.05$).

In the comparison of the genotypes of each municipality, 15F3005 was the one that presented the highest production of MV in the municipality of Goiânia, while in the municipality of Nova Porteirinha the genotypes 15F26005, 15F27005, 15F30006, 15F30005, 15F270011, 15F26019, 13F26005, 13F03034, VOLUMAX, BRS658, BRS655 presented the highest production of MV.

When the results were observed in the municipality of Sete Lagoas, the genotypes 15F27012, 14F20019, 14F2000F, 15F30006, 15F30005, 15F270011, 13F26005, VOLUMAX, BRS658, BRS655; showed higher MV production within the municipality, respectively, differing to (<0.05). However, all of these had production influenced by the cultivation site, with 15F3005 being the most affected, with higher production in Goiânia.

For genotypes 15F26006, 15F27005 there was variation in PMV among the municipalities ($p<0.05$), demonstrating that these materials obtained their lower MV production in at least two municipalities, and their production was influenced by the place of cultivation. Comparing between the municipalities, the genotypes 15F27012, 15F27006, 15F27013, 14F20019, 14F21021, 14F20005, 15F26005, 15F270011, 13F26005, VOLUMAX, BRS658, BRS655 showed higher production in the three municipalities observed.

Julio et al. (2019) observed a higher green mass yield in Sinop (45 Mg.ha-1) and Sete Lagoas (43.76 Mg.ha-1), when evaluating the performance of forage sorghum genotypes during the harvest in six localities. These also included Santo Antônio do Goiás (30.80 Mg.ha-1), Cocos (30.47 Mg.ha-1), Nova Porteirinha (26.07 Mg.ha-1) and Porto dos Gaúchos (20.85 Mg.ha-1).

As for PMV, the genotype 15F3005 stood out among the others, because, despite having production influenced by the place of cultivation, it obtained a higher average in all the municipalities evaluated. Some materials, despite having maintained their yields, when analyzed the different cultivation sites, presented MV yields lower than 15F3005 in the comparison between genotypes in at least one of the municipalities. The mean MVP ranged from 49.97 to 33.97 t $^{ha-1}$ for hybrids 15F30005 and 13F26005 in the municipalities of Goiás and Nova Porteirinha, respectively.

TABLE 3: Average values of green matter production in tons per hectare of 19 sorghum genotypes cultivated in Goiânia (GO), Nova Porteirinha (MG), Sete Lagoas (MG)

	Cities		
Genotypes	Goiânia	Nova Porteirinha	Sete Lagoas
15F27012	23,83 Ca	25,97 Ba	30,90 Aa
15F27006	24,20 Ca	26,67 Ba	21,63 Ba
15F27013	24,87 Ca	28,37 Ba	27,20 Ba
14F20019	24,87 Ca	25,86 Ba	28,57 Aa
15F26006	25,07 Cb	30,43 Ba	23,33 Bb
14F21021	26,33 Ca	29,01 Ba	24,73 Ba
14F20005	26,50 Ca	31,77 Ba	29,77 Aa
13F26006	28,53 Ca	30,43 Ba	22,13 Bb
15F26005	28,77 Ca	33,97 Aa	26,37 Ba
15F27005	28,83 Cb	34,93 Aa	25,90 Bb
15F30006	39,83 Ba	40,90 Aa	30,83 Ab
15F30005	49,70 Aa	43,30 Aa	28,27 Ab
15F270011	34,53 Ba	36,53 Aa	30,73 Aa
15F26019	35,93 Ba	38,07 Aa	25,77 Bb
13F26005	30,01 Ca	33,97 Aa	32,53 Aa
13F03034	38,83 Ba	35,50 Ab	26,43 Ba
VOLUMAX	34,53 Ba	36,27 Aa	34,53 Aa
BRS658	35,97 Ba	38,43 Aa	35,97 Aa
BRS655	29,97 Ba	34,87 Aa	32,47 Aa

Averages followed by different uppercase letters in the columns and lowercase letters in the row differ by the Skott-Knott test at 5% probability. ($P<0.05$).

Standard error of mean: 2.4350

Differences in PMS were observed between the genotypes evaluated for all cultivation sites ($p<0.05$) (Table 4). Comparing the genotypes within each municipality, 15F30005 showed a higher mean in Goiânia. The genotypes 15F27005, 15F30006, 15F30005, 15F270011, 15F26019, 13F26005, 13F26005, 13F03034, VOLUMAX, BRS658 and BRS655 obtained a higher average in relation to the other genotypes tested in Nova Porteirinha.

TABLE 4: Average values of dry matter production in tons per hectare of 19 sorghum genotypes cultivated in Goiânia (GO), Nova Porteirinha (MG), Sete Lagoas (MG)

	Cities		
Genotypes	Goiânia	Nova Porteirinha	Sete Lagoas
15F27012	7,15 Ca	7,79 Ba	9,27 Aa
15F27006	7,26 Ca	8,00 Ba	6,49 Ba
15F27013	7,46 Ca	8,51 Ba	8,16 Ba
14F20019	7,46 Ca	7,76 Ba	8,53 Ba
15F26006	7,52 Ca	9,60 Ba	7,00 Bb
14F21021	7,90 Ca	8,72 Ba	7,42 Ba
14F20005	7,95 Ca	9,53 Ba	8,93 Aa
13F26006	8,56 Ca	9,13 Ba	6,64 Bb
15F26005	8,63 Ca	8,65 Ba	7,91 Ba
15F27005	8,65 Cb	10,48 Aa	7,77 Bb
15F30006	11,95 Ba	12,27 Aa	9,25 Ab
15F30005	14,91 Aa	12,99 Aa	8,48 Bb
15F270011	10,36 Ba	10,96 Aa	9,22 Aa
15F26019	10,78 Ba	11,42 Aa	7,73 Bb
13F26005	9,02 Ca	10,19 Aa	7,91 Ba
13F03034	11,65 Ba	10,83 Ab	7,93 Ba
VOLUMAX	10,36 Ba	10,88 Aa	10,40 Aa
BRS658	10,79 Ba	11,53 Aa	10,62 Aa
BRS655	8,99 Ca	10,46 Aa	9,74 Aa

Averages followed by different uppercase letters in the columns and lowercase letters in the row differ by the Skott-Knott test at 5% probability. ($P<0.05$).

Mean Standard Error: 0.7351

In Sete Lagoas, the genotypes 15F27012, 14F20005, 15F30006, 15F270011, VOLUMAX, BRS658, BRS655 obtained higher averages in relation to the other genotypes tested in this municipality. The genotypes 15F30006, 15F30005, 15F270011, VOLUMAX, BRS658 and BRS655 were superior in at least two municipalities, however, these materials were affected by the cultivation site, temperature and climatic conditions. Magalhães *et al*. (2010), observed variations from 7.47 to 16.08 t $^{ha-1}$ when working with 25 dual-purpose sorghum genotypes

Dry matter production between genotypes and municipality ranged from 7.0 t/$^{ha-1}$ to 14.9 t $^{ha-1}$ for genotypes 15F26006 and 15F30005, in Sete Lagoas and Goiânia, respectively. As indicated by Resende et al. (2016), the dry matter productivity of forage sorghum increases as plant height increases.

CONCLUSION

The genotypes 15F30006, 15F30005, 15F270011, VOLUMAX, BRS658, BRS655 stood out among the others, as they presented higher averages of dry matter production in at least two of the municipalities evaluated, demonstrating their adaptation to different cultivation sites.

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