English Version

Dry matter composition of the sorghum forage in different arranging of plants in semiarid of the Minas Gerais state

Carlos Juliano Brant Albuquerque[1]; Renzo Garcia Von Pinho[2]; Renata da Silva Brant[3]; Marcelo Cruz Mendes[4]; Pedro Milanez de Rezende[5]

Abstract

The work was performed during 2006/07 and 2007/08 agricultural years on North of Minas Gerais state, Brazil, with the objective of evaluate three plant densities and three rows spacing of sorghum cultivars in semiarid climatic conditions. In each year it was made experiments on contiguous area, using the row spacing of 50 cm, 70 cm and 90 cm. For each experiment it was evaluated three sowing densities - 100 thousand, 140 thousand and 180 thousand plants ha^{-1} – plus sorghum cultivars. The experiments were conducted in completely randomized block design in factorial 4x3, with three replications, with four cultivars and three sowing density. Initially it was made analysis of variance with the data obtained. After, it was made a joint analysis of variance with three experiments in each year and other considering all data obtained in experiments. The row spacing reduction and the sowing density increase propitiates higher plants height. The increase of the density in the 50 and 70 cm row spacing provides higher lodging. The alterations in the structural components of sorghum cultivars are influenced by the prevalent climatic conditions in agricultural year. The stems, leaves and panicles percentages in dry matter are affected by cultivars, row spacing and densities.

Keywords: *Sorghum bicolor*; silage; dry matter; densities; row spacing.

Introduction

The restriction and irregularity in the rainfall on the North of Minas Gerais are hallmarks, which makes it the region with higher degree of aridity of the State. Regarding to the agriculture, this has great influence on the economy of this region which has, approximately, 2.9 millions heads of cattle (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2009). The climate condition limits the potential yield of rainfed corn, proportioning an increase in cultivated area with sorghum for feeding cattle, sheep and goat.

Sorghum is highly tolerant to veranicos[6] and high temperatures, and can substitute corn in the form of concentrated feed, multiple protein mixture or forage stored in silos.

Some studies conducted in the decade of 1970 already demonstrated the technical viability of the sorghum cultivation for the production of grains and silage in the North region of the state of Minas Gerais (MOREIRA et al., 1977a; BORGONOVE et al., 1979; MOREIRA et al., 1977b; AZEVEDO et al., 1977). Although, recent researches involving the crop management and treatment with the new genetic material available in the market are scarce. One must seek, many times, support in results of researches in regions with high precipitation, and even with other crops, as corn.

Among the crop practices used to obtain higher yield, the choice of the ideal planting density is one of the major (ALMEIDA et al., 2000). Results of researches concluded that the sorghum crop is highly influenced by environmental conditions, plant population and spacing between rows (JONES and JOHNSON, 1997; BAUMHARDT and HOWELL, 2006).

The varieties of sorghum produce more ensilable dry matter than corn, however, with significant variation on the chemical composition

1 Pesquisador da EPAMIG, Nova Porterinha, MG, Rodovia MGT 122, Km 155 Caixa Postal: 12, CEP: 39525-000 e-mail: carlosjuliano@epamig.br.
2 Professor associado do Departamento de Agricultura, Universidade Federal de Lavras, Lavras-MG, CEP 37200-000, e-mail: renzo@ufla.br
3 Pesquisadora DTI1/CNPq/Unimontes. Janaúba, MG. e-mail: renataplantasmedicinais@yahoo.com.br
4 Professor colaborador do Departamento de Agronomia, Universidade Estadual do Centro-Oeste do Paraná / UNICENTRO, Guarapuava, PR, CEP 85.040-080. email: mcmendes@unicentro.br
5 Professor associado do Departamento de Agricultura, Universidade Federal de Lavras, Lavras-MG, e-mail: pmrezend@ufla.br
6 'Veranico' is a Brazilian word to define dry periods during the wet season.

of the silage – fact attributed to the high number of varieties and/or hybrids existent in the market, associated to factors as planting place and period, plant arrangement, period of cut, among others (PEREIRA et al., 1993).

The ideal plant arrangement is determined by the space between rows and by the total amount of plants in the row capable to explore in the most efficient way the natural resources and inputs provided by the farmer.

Studies reveal that it is possible to characterize the different hybrids of sorghum to silage, thought the percentage participation and the bromatologic of the main anatomic structures of the plant, defining an average profile of the sorghum plant to silage (NEUMANN et al., 2003; NEUMANN et al., 2002 e ZAGO, 1992). However, work relating different spacing between rows and plant population with the physic composition of sorghum cultivars are scarce.

This way, the objective of this work was to evaluate the composition of the dry matter of sorghum hybrids to silage in different plant arrangements.

Material and methods

The experiments were conducted in two agricultural years, in an experimental area of the Empresa de Pesquisa Agropecuária de Minas Gerais (Epamig), in the agricultural years 2006/07 and 2007/08. The area is located 12km from the city of Jaíba, MG, in the coordinates 15º16'20" S and 43º40'23"W, with an altitude of 456 m, in a Latossolo Vermelho Eutrófico. The soils are derived from rocks with high levels of calcium and potassium, which gives them high sum of bases (SB) and base saturation (V%). The climate is tropical, alternately dry and wet, according to the classification of Köppen.

Two crops were evaluated in the years 2006/2007 and 2007/2008, which, according to the rainfall data, were characterized as "rainy year" and "dry year", respectively. Both experiments were installed in the second fortnight of December, under the conventional cultivation system.

In each year three experiments were installed in contiguous areas, adopting, respectively, the spaces between rows of 50 cm, 70 cm and 90 cm. For each experiment it was evaluated three seeding rates – 100 thousand, 140 thousand and 180 thousand plants ha^{-1} - besides four cultivars of forage sorghum.

Each experiment was conducted in the experimental design of random blocks, in factorial scheme 4 x 3, with three replications, which were four cultivars and three seeding rates. The experimental plot constituted of 4 rows of 5 m length and the useful area was formed by the two center lines.

For all the experiments it was used 350 kg ha^{-1} of the formula 4(N): 30(P_2O_5): 10(K_2O) plus 0.5% de Zn, based on the analysis of the soil. It was performed only one cover fertilization with 60 kg ha^{-1} of K_2O and 80 kg ha^{-1} of N. To control weeds, it was used, in the first emergence, the herbicide Gezaprim 500 (atrazine), in the dosage of 3 L ha^{-1} of the commercial product.

The seeds were placed manually, uniformly in furrows, based on twice as many plants as necessary to obtain the densities sought. Later, it was performed thinning, with plants presenting five leaves, to achieve the desired population per linear meter, considering each space between rows (Table 1).

The plants were harvested 15 cm from the soil with the grains of the center of the panicle in the stage pasty to farinaceous. In the occasion of the harvest, it was taken, from each experimental plot, two plant samples. The first sample, of eight plants randomly collected in the useful area of each plot was grouped, identified and conducted to the laboratory,

Table 1. Number of plants per linear meter before the thinning in the different spacing and rates

Seeding rate	Spacing		
	50 cm	70 cm	90 cm
100.000 plants ha^{-1}	5	7	9
140.000 plants ha^{-1}	7	10	13
180.000 plants ha^{-1}	9	13	16

where it was crushed (particles of 2.5 cm) in forage chopper and homogenized. Later, it was removed a sample of 300 g, which was dried in an oven with forced aeration, at the temperature of 65 °C for 72 hours. Then, the samples were crushed in a Wiley mill, with screen with 1 mm sieves, to determine the dry matter at 105 °C (AACC, 1976) and perform the bromatological analysis.

The second sample, composed by five plants selected randomly in the useful area of each plot was group, identified and conducted to the laboratory, where it was separated in fractions of the stem, leaves and panicles. The three fractions were weighted separetely and dried in oven with forced aeration, at 65 °C, for 72 hours. It was then determined the dry matter of the plant fractions and, consequently, the participation of these fractions (stem, leaves or panicles) in the total dry matter of the plant.

The data obtained were submitted, initially, to the analysis of individual variance per experiment. Previously it was performed the tests of data additivity, normality of errors and homogeneity of variances. As there was no restriction to the presuppositions of the analysis of variance, it was performed joint analysis of variance involving the three experiments in each years and another considering simultaneously all the experiments conducted in the two years.

All the analysis, including the study of regression in function of the different spacing and seeding rate were performed using the statistic program SISVAR® (Ferreira, 2000). Data referent to the percentage of lodged and broken plants were submitted to normality test (normal distribution of Poisson) and later data transformation [$\sqrt{x+1}$]. The averages were grouped by the Scott and Knott (1974) test, at 5% of significance.

Results and discussion

Independent on the spacing between rows and seeding rate used, the experiments conducted in the crop 2006/2007 provided higher plant height (Table 2). The average plant height in 2006/2007 was 3.34 m, and, in the next year, 2.19 m.

The reduction of 34% observed in plant height, in these two years, is mainly due to the small amount of rainfall occurred in 2007/2008. The lower cell expansion caused by water stress inhibits the growth of sorghum plants (GRIMA and KRIEG, 1992; TAIZ and ZEIGER, 2004).

Evaluating agronomical characters of forage sorghum in regions with higher precipitations, Chiese et al. (2008) and Pinho et al. (2007) verified lower values of forage sorghum plant height than those obtained in the present work. In these works, the authors report range in the plant height from 1.7 to 3 m. Experiments performed in the municipality of Goiânia, GO, with the cultivar BRS 610, showed lower plant height. In this case, it was found 2.4 m (OLIVEIRA et al., 2005).

These results evidence the tolerance to drought and the yield capacity of forage sorghum under the conditions of the semiarid of Minas Gerais, since plant height has a direct correlation with dry matter yield of the forage (ZAGO, 1992; ROCHA JUNIOR et al., 2000; PINHO et al., 2007).

Comparing the genotypes in each agricultural year it was verified that BRS 610 and BRS 655 presented lower height and SHS 500 were larger in 2006/2007. In the following year, only cultivar BRS 610 was shorter, while SHS 500 continued superior to this characteristic (Table 2).

It is important to emphasize that SHS 500

Table 2. Average results obtained in the evaluation of plant height (m) of the cultivars in the two agricultural years.

Cultivars	2006/07	2007/08
BRS 655	3.14 cA	2.16 bB
BRS 610	3.09 cA	1.90 cB
1 F305	3.41 bA	2.21 bB
SHS 500	3.73 aA	2.50 aB

Means with the same lowercase vertically letter belong to the same group, according to Scott-Knott test. Horizontally, means with the same uppercase letter do not differ, by the F test at 5% probability.

presented higher plant height, independent on the spacing and population used in the years of evaluation. This difference of height between the materials evaluated is associated to the genetic of hybrids.

By the graphic representation of the equation of regression to plant height in function of the spacing, considering both agricultural years, it was observed a linear increase in the sorghum size with the reduction of the spacing (Figure 1).

Due to the lower intraspecific competition for water and nutrients, the smaller spacing provided higher plants. The reduction of the spacing provided better distribution of plants in the area. In this case, the lower concentration of plants per linear meter favored higher interception of light by leaves and higher individual area of soil exploitation, increasing the use of water and nutrients.

To seeding rate, it was verified, by the equation of regression, that the increase in the plant population provided highest plants (Figure 2). In this case, the highest populations promoted higher intraspecific competition for light, stimulating apical dominance and growth of plants.

The increase in the seeding rate in the spacing 50 and 70 cm provided more plant lodging (Figure

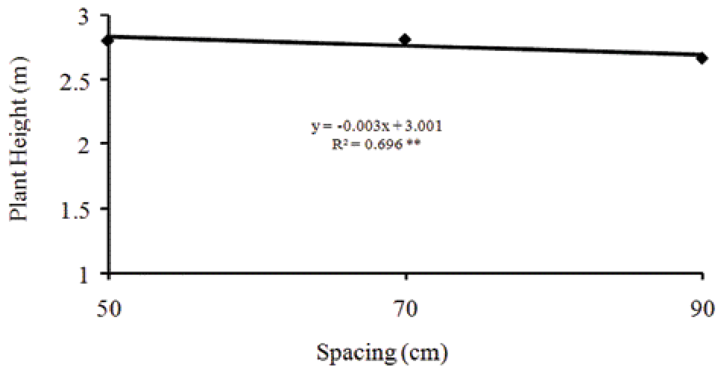

Figure 1. Graphic representation of the regression equation to plant height, regarding the spacing between rows, in two years of experiment.

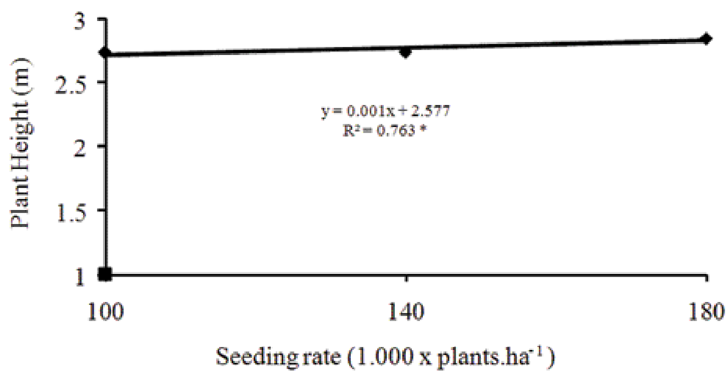

Figure 2. Graphic representation of the equation of regression to plant height, concerning densities, in the years of experiment.

3). As it was previously exposed, the higher seeding rates provided higher plant heights. With this in mind, it can be affirmed that larger populations provided higher intraspecific competition for light, and the consequent elongation of internodes, due to the apical dominance, leaving plants higher and more susceptible to tipping.

These results confirm those obtained by Zago (1992), Rocha Junior et al. (2000) and Pinho et al. (2007), which repot that higher plants presented higher loss by lodging and tipping. This condition may be harmful for the process of sorghum harvest for the production of silage, which makes its crop impracticable. In this case, the appropriate regulation and the management of the sorghum seeder are essential characteristics to reduce losses in the field.

Cultivar SHS 500 presented highest percentage of lodged and tipped plants in all spacing and seeding rate adopted. This pointed great effect of the genotype used in the percentage of lodged and tipped plants.

The graphic representation of the equation of regression to lodged and tipped plants in relation to the agricultural years and rates are presented in Figure 4. The increase in the seeding rate presented linear relation to lodging and tipping of the cultivars BRS 655 and SHS, in the experiment years and to the cultivar BRS610, in 2006/2007, with values of R^2 always superior to 90%. This indicates that most of the variation observed was explained by the linear regression.

According to Martins (2000), the ideal density to forage sorghum is between 100 thousand and 150 thousand plants per hectare, having as objective to reduce the lodging which, normally, occurs in larger populations.

There was no significant effect of seeding rate increase in lodging and tipping of the cultivar 1 F305, in the year of evaluation and in BRS 610, in 2007/2008 (Figure 4). This can be justified by the smaller height of plants of these cultivars. Rocha Junior et al. (2000) verified positive correlation highly significant to plant height and percentage of lodging in sorghum cultivars.

The interaction years x cultivars had significant effect to the components of the total dry matter of stem, leaves and panicles (Table 3). It can be verified, in this study, that SHS 500 has higher percentage of stem and BRS 655 was among the cultivars of lowest fraction stem in the composition of the total dry matter of the plant, independent on the agricultural year (Table 3).

Most of the cultivars presented higher percentage of stem in 2007/2008 (Table 3). The exception was SHS 500, which had lower participation of stem in this period.

The previous years showed that SHS 500 presented higher height of plants, higher percentage

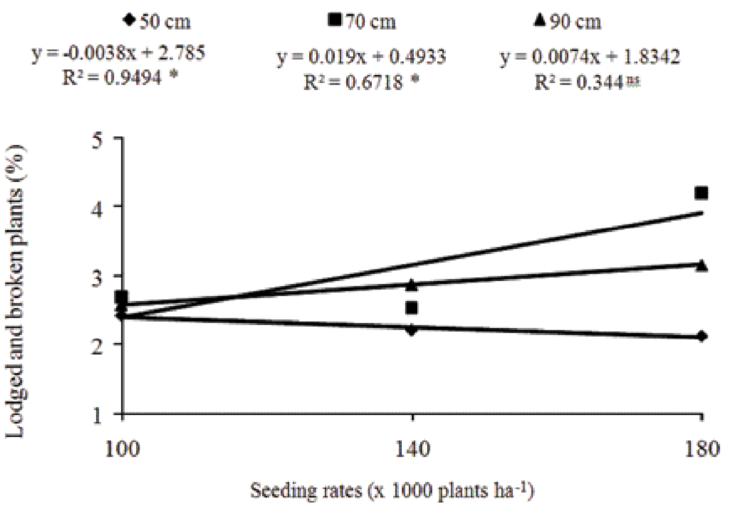

Figure 3. Graphic representation of the equation of regression to lodged and broken plants, in relation to spacing and seeding rates (data transformed √x+1).

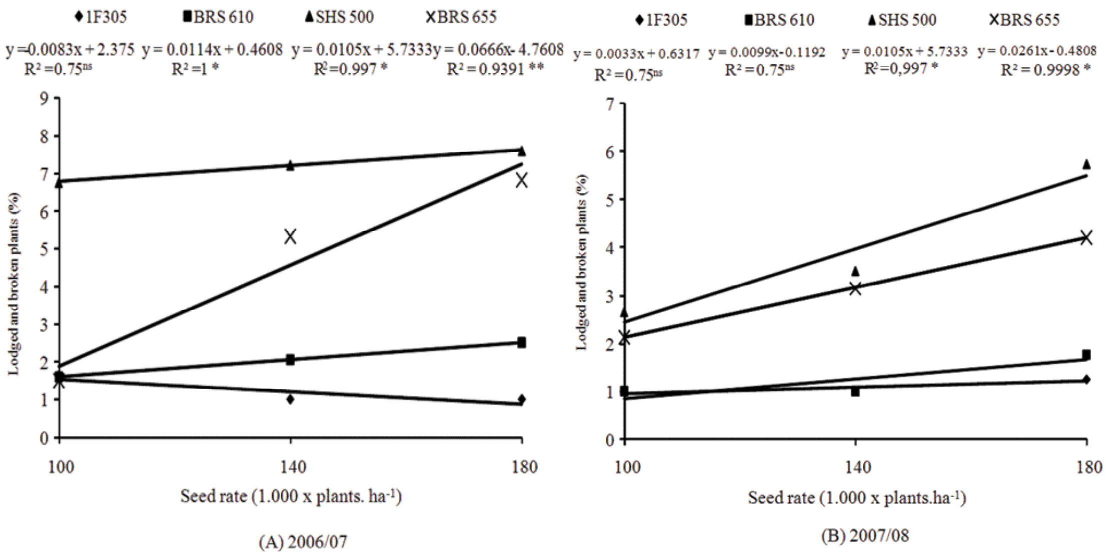

Figure 4. Graphic representation of the equation of regression for lodged and tipped plants, in function of the seeding rates and cultivars in the year 2006/2007 (A) and 2007/2008 (B) (data transformed √x+1).

Table 3. Percentage of stem, leaf and panicle in the total dry matter of sorghum cultivars in relation to the agricultural years.

Component	Cultivars	Means	
		2006/07	2007/08
Stem	1F305	47.86 bB	59.70 cA
	BRS 610	46.50 bB	54.07 bA
	SHS 500	71.33 aA	65.84 aB
	BRS 655	44.82 bB	39.23 dA
Leaf	1F305	21.51 aB	24.90 aA
	BRS 610	20.87 aB	24.40 aA
	SHS 500	13.20 cB	16.27 bA
	BRS 655	18.34 bA	17.30 bA
Panicle	1F305	30.64 bA	13.31 cB
	BRS 610	32.64 bA	21.53 bB
	SHS 500	16.46 cA	17.89 cA
	BRS 655	36.84 aB	43.47 aA

Means with the same lowercase vertically letter belong to the same group, according to Scott-Knott test. Horizontally, means with the same uppercase letter do not differ, by the F test at 5% probability.

of lodged plants and higher percentage of stem. The height of the plant can be positively correlated to the production of natural material and dry matter. Although, generally, it also presented positive correlation with the percentage of lodging, characteristics not desirable to the efficient production of forage (CORRÊA et al., 1996).

When analyzing the effect of the years and cultivars in the percentage of leaf in the total dry matter of plants, cultivars 1 F305 and BRS 610 presented higher values, independent on the years of experiments (Table 3).

In the second agricultural year, the interaction year x cultivar showed that there was no significant difference between cultivars SHS 500 and BRS 655 to leaf percentage, on the contrary to what happened in 2006/2007, when SHS 500 presented lower percentages (Table 3).

In 2007/2008, it was verified higher percentage of leaves to most of the cultivars. Only cultivar BRS 655 did not have percentage of leaves affected by the agricultural years (Table 3).

It was observed higher level of panicles in the total dry matter of plants to the cultivar BRS 655, in both agricultural years (Table 3). By contrast, cultivar SHS 500 had lower participation of panicles in the total dry matter, in two years of experiment.

In cultivars BRS 610 and 1 F305, it was verified expressive reduction in the percentage of panicle in the dry matter in 2007/2008. This characteristic is related to the grain yield. The choice of cultivars of higher grain yield has been a criterion widely used in the choice of corn or sorghum cultivars to the production of silage (HUNTER, 1978; PENATI, 1995).

The alteration of the structural components of the plant, in both agricultural years, was already expected. This difference may be justified by the environmental conditions to which the cultivars were exposed during the experiments. Oliveira et al. (2005) reported results different from the present work, in which cultivar BRS 610 presented 58.17% of panicles, 27.37% of leaves and 14.06% of stem in the total dry matter.

Evaluating the physic plant composition of different sorghum hybrids, Neumann et al. (2003) verified values for the components from 28.2 to 48.1% of stem, 25.2 to 32.7% of leaves and 22.6 to 45.6% of panicles.

It was obtained significant linear relation to the percentage of stem in the total plant dry matter, in relation to seeding rate in the spacing 50 and 90 cm. In both situations, R^2 was superior to 96%; however, the relation was inverse for each spacing. From 100 thousand plants ha^{-1}, it was found an increase of 0.053% to each increase of a thousand plants in the spacing 50 cm. In the spacing 90 cm, it was verified a decrease of 0.077% of stem in the total dry matter with an increase of thousand plants per hectares (Figure 5).

Dourado Neto et al. (2003), when evaluated different plant arrangements in the corn crop, verified that, with large populations, independent on the genotype, the stem diameter increased with the reduction of the spacing, but, with smaller populations, it was observed a reduction on the

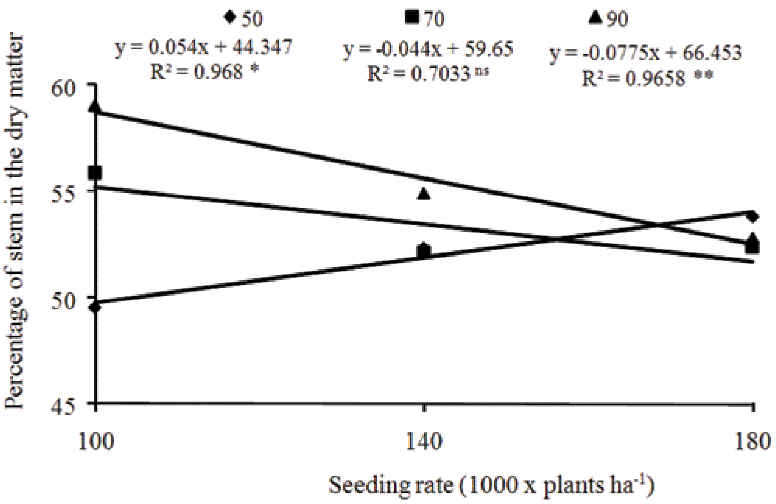

Figure 5. Graphic representation of the equation of regression for the percentage of stem, in relation to the seeding rates in different spacing.

stem diameter under reductions of the spacing. Still in this work, the reduction of the plant population, independent on the genotype and spacing used, resulted in increase of the stem diameter.

Possibly, alterations in the diameter or in the length of stem were the main morphologic characteristics affected by plant arrangement.

To the percentage of stem in plant dry matter, in relation to the space between plants adopted, it was found that cultivars SHS 500 and BRS 601 presented significant linear relations (Figure 6). The coefficient of determination (R^2) found were 99% and 100%, i.e., it may be concluded that the adopted plant spacing explain most of the variations in the percentage of stem in these genotypes.

It was verified, for each increase of one centimeter in the spacing between rows, an increase of 0.014% of percentage of stem in total dry matter of the cultivar SHS 500 (Figure 6). However, to the cultivar BRS 610, it was observed a different behavior, i.e., to each increase of one centimeter in the spacing between rows, there was a decrease of 0.20% of percentage of stem in the total dry matter.

It was obtained significant quadratic relation to the percentage of leaves in the dry matter of the forage sorghum cultivars, in relation to the seeding rate in the year 2006/2007 and linear significant relation in 2007/2008, with coefficient of determination of 100% and 97.4%, respectively (Figure 7).

In the first year, there was a decrease in the percentage of leaves to the density of 162 thousand plants ha^{-1}, achieving 24.90%. From this, with the increase in the density, there was a reduction of leaves in the dry matter. In the second year of experiment, it was verified a decrease of 0.0333% in the proportion of leaves in the DM, for each increase of a thousand plants for hectare (Figure 7).

It was obtained a significant linear relation to the percentage of panicles in the total dry matter of plants relating to the spacing only to cultivar BRS 610 (Figure 8). It was verified, to each one centimeter in spacing between rows, increase of 0.235% of percentage of panicles in the dry matter of this cultivar (Figure 8).

Among the cultivars studied, BRS 610 and BRS 655 were those which presented highest percentage of panicles (>30%) in plant dry matter independent on the plant spacing and density evaluated, which was a strong indicative of the forage quality.

According to Neumann et al. (2002), higher nutritive values are observed in sorghum double purpose when compared to forage sorghum due to higher amount of panicles in the total dry matter. Due to the fact that producers try to maximize the

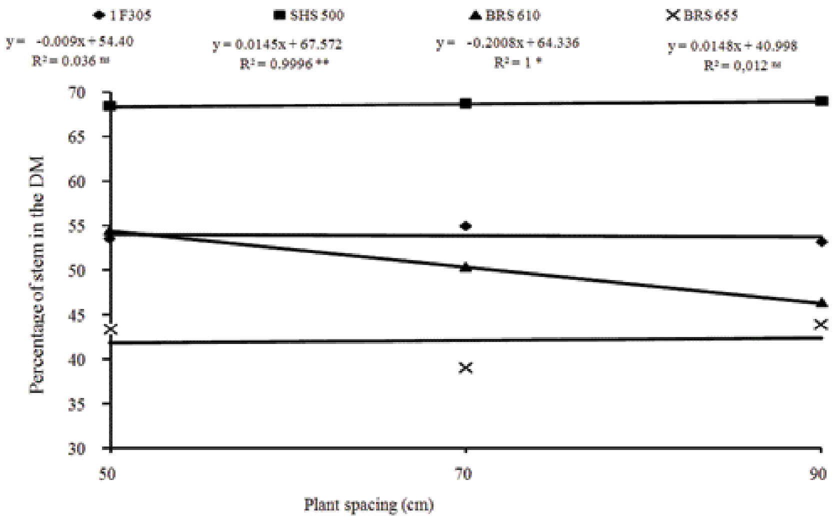

Figure 6. Graphic representation of the equation of regression for the percentage of stem, in relation to the cultivars.

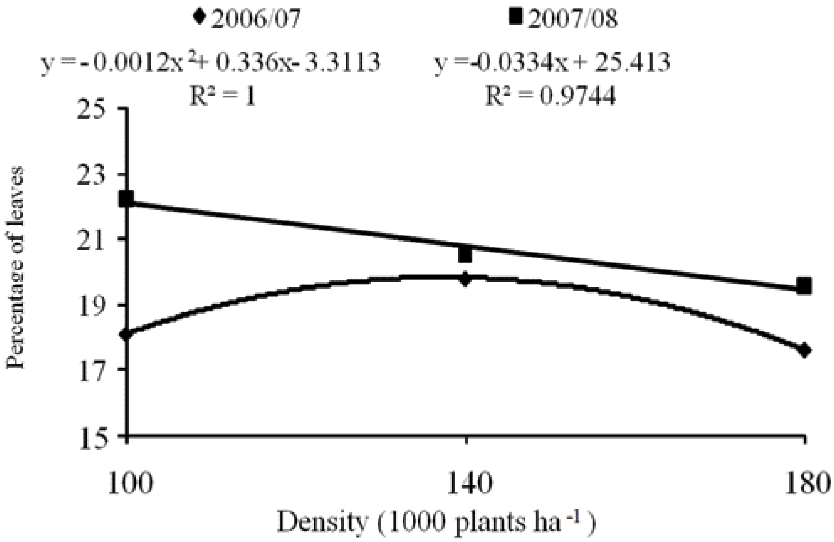

Figure 7. Graphic representation of the equation of regression to the percentage of leaves, in relation to the density, in two years of evaluation.

weight gain or the milk yield during the feedlot, the market tend to launch sorghum hybrids which present biological value (lower concentration of FDN and amount of grains present in dry matter higher than 30%) superior to those present in the market (CHIESA et al., 2008).

The increase in the seeding rate in cultivar BRS 610 had effect in the reduction of the percentage of panicles. To each increase of a thousand plants per hectare, it was noted a decrease of 0.09% of percentage of panicles in the dry matter of this cultivar (Figure 9).

The same trend of decrease of percentage of corn ears in relation to the total dry matter of plants with the increase of the population was reported by Dourado Neto et al. (2003).

The various factors and processes that act for the grain and panicle yield in sorghum are related

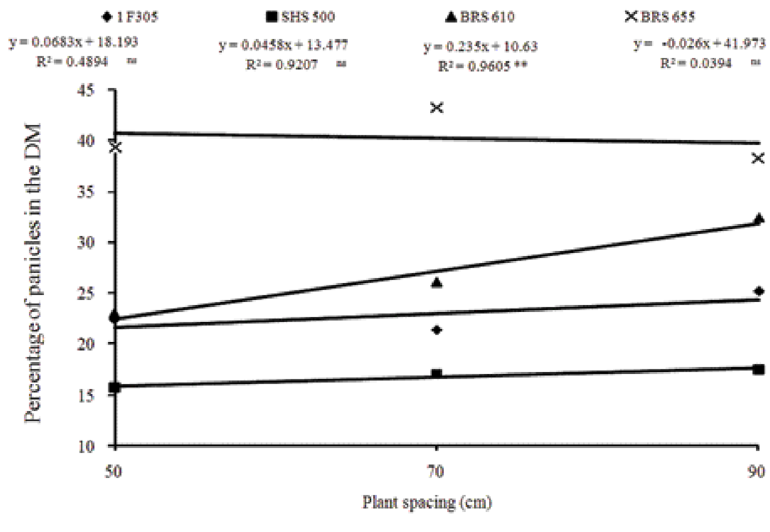

Figure 8. Graphic representation of the equation of regression to the percentage of panicle, in relation to the plant spacing and cultivars evaluated.

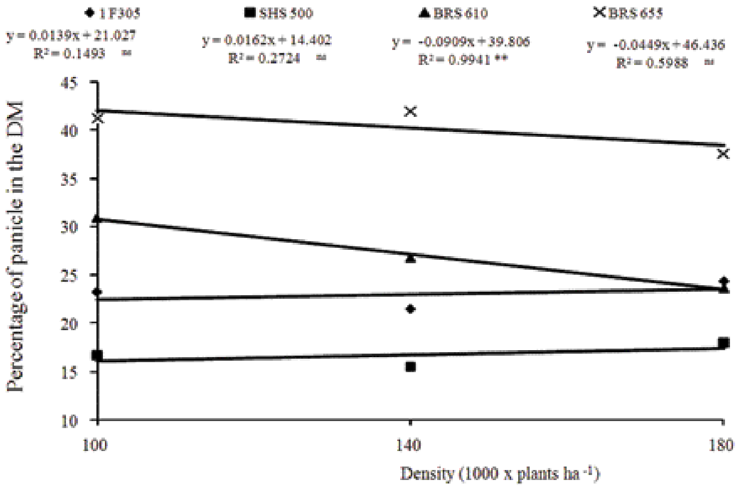

Figure 9. Graphic representation of the equation of regression to the percentage of panicle, in relation to the density and cultivar evaluated.

to the interception of light by the leaves, metabolic efficiency of plants, efficiency of photosynthates translocation from leaves and stems to the growing grains, and capacity of drainage (TAIZ e ZEIGER, 2004). The excess of plants in the seeding row increases the competition for water and light in plants damaging the translocation of photoassimilates to grains, decreasing, thus, the percentage of panicles in the total dry matter of sorghum.

Conclusion

a) The reduction of the spacing between rows and the increase in seeding rate provided higher plants.

b) The increase in plant density in the spacing 50 and 70 cm provided higher plant lodging.

c) The alteration in the structural components of the sorghum cultivars are influenced by the climate conditions which prevail in the agricultural year.

d) The percentage of stem, leaves and panicles in the dry matter of forage sorghum cultivars are affected by cultivar, spacing and density used.

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