(DOI): 10.5777/PAeT.V4.N1.07

This article is presented in Portuguese and English with "resumen" in Spanish.

Brazilian Journal of Applied Technology for Agricultural Science, v. 4, n.1, p. 113-132, 2011.

Scientific paper

Sowing period of forage sorghum in two places of the state of Minas Gerais

Carlos Juliano Brant Albuquerque [1]

Marcelo Cruz Mendes [2]

Abstract

The objective of this work was to evaluate the effect of sowing of sorghum cultivars in two locations in the State of Minas Gerais in the severity of *Colletotrichum graminicola* and yield of dry matter. The experiments were conducted in a randomized block design in a factorial 5 x 5 x 2, with four replications and five cultivars, five sowing dates and two locations. The first plantings were made early in the second half of October, the second, third, fourth and fifth were 15, 30, 45 and 60 days after the first. The cultivars SHS500 and Volumax show greater tolerance to anthracnose regardless and city of Francisco Sá, MG and Jaíba, MG. The delay in sowing date increases the severity of *Colletotrichum graminicola* of sorghum, depending on the cultivar and location. The dry matter yield of sorghum is affected by sowing date and city of Francisco Sá, MG and Jaíba, MG.

Keywords: *Sorghum bicolor* (L.), *Colletotrichum graminicola*, dry matter, semiarid

Introduction

Considered one of the main alternatives for the animal fed in the semiarid regions of Minais Gerais, the culture of forage sorghum has been expanding in the municipalities of Francisco Sá and Jaíba. The small availability of forages in the period of draught is one of the main factors responsible for low index of productivity of cattle livestock of the referred regions, and the sorghum forage is a viable alternative in the productive process.

The seasonality in the forage production and the need to produce milk and meat during all the year has led farmers to adopt practices of conservation of forage, mainly as silage. Forage sorghum is a viable option to reach the demand of farmers due to its bromatological characteristics which, similar to maize, enable appropriate fermentation and consequent conservation of this food under the form of silage, trough the high contents of crude protein in some varieties (WHITE et al., 1991) and by the agronomic characteristics, as higher tolerance to draught (CUMMINS, 1981).

The climate conditions and other natural factors of regions of the semiarid limit the potential productivity of some cultures, fact that makes the production of maize unfeasible for high productions. The cultivation of sorghum is an alternative in these conditions and may substitute in nutritional terms the maize in the cattle fed either as silage or as concentrated ration.

Despite its tolerance to water stress, the productivity of sorghum is related to the amount of water in soil. Several works are related evidencing that the sorghum sowing should be programmed so that the periods of flowering and grain filling occur in the period of higher water availability in soils (VON PINHO et al., 2007; VIANA, 1997; RESENDE, 1988 and DOWNES, 1972).

Anthracnose, caused by fungus *Colletotrichum sublineolum*, is considered one of the main diseases of the sorghum crop in Brazil, and may cause significant damages to the production. The most efficient strategy for its control is the use of resistant cultivars. However, its use is hampered by the occurrence of high genetic variability in the pathogen population (COSTA et al., 2009; CASELA et al., 1996). This fact has intensified the search for alternatives of management to mitigate the effect of this fungus in the culture.

Due to the limited number or works evaluating the production of forage sorghum in the semiarid region of Minas Gerais, it was aimed with the work at evaluating the effect of the period of sowing in two places in the seasonality of *Colletotrichum graminicola*, as well as dry matter yield of the forage.

Recieved on: 08 /11/2010 Accepted for publication on: 02/04/2011

1 Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), Rodovia BR-050, km 63, S/N, CEP 38.402-019, Uberlândia, MG. E-mail: carlosjuliano@epamig.br.

2 Professor Adjunto A*, Department of Agronomy, Universidade Estadual do Centro-Oeste do Paraná, CEP 85040-080, Guarapuava, PR. E-mail: mcmendes@unicentro.br

* Brazilian Academic Degree

Material and methods

Simultaneous experiments were conducted in the Fazenda Experimental de Mocambinho and Fazenda Caititu in five different periods of sowing.

The first experiment was conducted in the Fazenda Experimental de Mocambinho, which is located in the Perímetro Irrigado de Jaíba, in the city of Jaíba, MG, whose latitude is -15.3383 and longitude is -43.6753. The area is in an altitude of 452 m, with average rainfall of 807 mm annually, concentrated in the months from October to March. The second area is located in the municipality of Francisco Sá, north of the state of Minas Gerais, the Fazenda Caititu, whose latitude is -16.4761 and longitude -43.4886, with average rainfall of 1080 mm annual and an altitude of 610 m.

The genetic material used was five cultivars of forage sorghum from different companies. The main characteristics are described in table 1.

The data about ranges in rainfall and averages each 10-day period during the conduction of the experiments in the different places of study are presented in figures 1 and 2.

The first sowings were performed in the second half of October/2007, the second, third, fourth and fifth were with the intervals of 15, 30, 45 and 60 days respectively.

The physical and chemical characteristics of the experimental areas of both places are presented in table 2.

The experiments were conducted under the experimental design with randomized blocks under the factorial 5 x 5 x 2, with four replications, and five cultivars, five sowing periods and two places. The experimental plot was constituted of 4 rows of 5 cm of depth and the useful area was formed by the two central rows, where it was collected all the experimental data, before and during the harvest.

Table 1. Characteristics of the five sorghum cultivars used in the experiments.

Cultivar	Genetic base	Cycle	Panicle	Company
SHS 500	Simple	Medium Early	Open	Santa Helena
1 F305	Simple	Early	Semi-open	Dow Agroscienses
BRS 610	Simple	Medium Early	Semi-open	Embrapa
BRS 601	Simple	Medium Early	Semi-open	Embrapa
Volumax	Simple	Medium Early	Semicompact	Agroceres

Source: Companies which produce the seeds

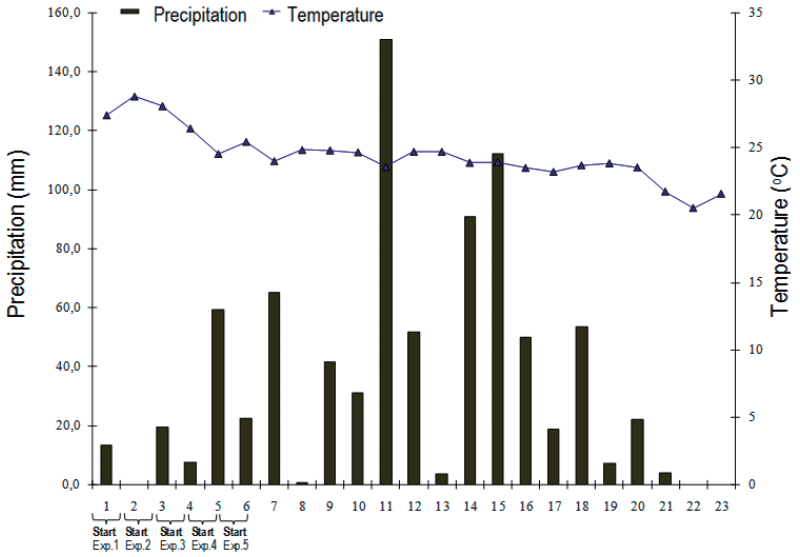

Figure 1. Average data of temperature and rainfall in a 10-day period, in Francisco Sá, MG, from 15/10/2007 to 30/05/2008.

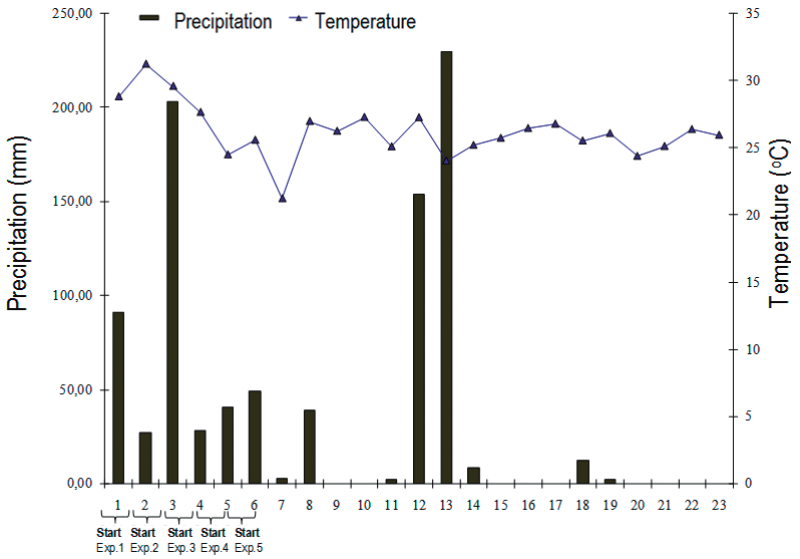

Figure 2. Mean data of temperature and rainfall per 10-day period, in Jaíba, MG, from 15/10/2007 to 30/05/2008

Table 2. Results of the analysis of soil samples (0-20 cm of depth) of the area in which it was conducted the experiments. Data obtained in the laboratory of soil fertility from Epamig in Nova Porteirinha, MG.

Chemical characteristics	Francisco Sá	Jaíba
pH in H_2O	6.1	4.9
H + Al (cmolc dm^{-3})	2.6	2.3
Al (cmolc dm^{-3})	0.0	0.1
Ca (cmolc dm^{-3})	7.2	1.4
Mg (cmolc dm^{-3})	1.5	0.5
K (mg dm^{-3})	224	63
P (mg dm^{-3})	4.1	3.6
Zn (mg dm^{-3})	4.3	0.9
Fe (mg dm^{-3})	44.4	17.0
Mn (mg dm^{-3})	92.5	39.7
Cu (mg dm^{-3})	2.4	0.4
B (mg dm^{-3})	0.5	0.3
Mat. org. (dag kg^{-1})	2.8	0.8
SB (cmolc dm^{-3})	9.4	2.1
T (cmolc dm^{-3})	12.0	4.5
t (cmolc dm^{-3})	9.4	2.2
V (%)	78	48
m (%)	0	4
Phisical characteristics		
Sand (dag kg^{-1})	29	83
Silt (dag kg^{-1})	40	10
Clay (dag kg^{-1})	31	7

The soil of the experimental area was conventionally prepared, using one ploughing and two harrowing. According to the results presented in the soil analysis and demand of the crop for medium technology according to the recommendation of the Comissão de Fertilidade do Solo do Estado de Minas Gerais (5ª Aproximação, 1999) it was used for the sowing fertilization the formula 08-28-16 + 0.5% of zinc. Furrows spaced in 70 cm were opened for later manual sowing using twice the number of seeds needed to obtain the stand. The cover fertilization was performed with the application of 300 kg ha^{-1} of the formula 20-00-20 when plants reached between four and six definitive leaves, and in the same day it was performed thinning leaving a stand of 100 thousand plants ha^{-1}.

The spraying for control of the armyworm (*Spodoptera frugiperda*) was performed with the product Decis 50 CE, in the dosage of 200 ml ha^{-1}, trough a backpack sprayer. The panicles of the useful area were protected with kraft paper bags of 10 kg for the protection of birds.

The plants were harvested 15 cm from the soil with the grains of the center of the panicles in the pasty to chalky stage for the evaluation of the weight of the green parcel. After obtaining the fresh matter of all the plants of the useful area of the plot, it was collected eight plants randomly selected to be ground

and homogenized in a forage cutter. Next, a sample of 300g was placed to dry in an oven with forced air, at the temperature of 65ºC, for 72 hours, for the determination of the percentage of dry matter of the forage. The productivity of dry matter was estimated trough the fresh matter of the plots multiplied by the percentage of dry matter.

The mean weight was transformed in t ha^{-1}. For the obtaining of the severity of anthracnose grades from 1 to 5 were attributed in the occasion of plant flowering. It was defined a priori grade 1 as 0% of the plant infested with the disease, while grades 2, 3, 4 and 5 would be 25, 50, 75 and 100% of the infected plant.

The data obtained were submitted, initially, to the individual analysis of variance per place. Previously it was performed the tests of additivity of dada, normality of errors and homogeneity of the variances. When there was no restriction to the presumptions of the analysis of variance, it was made joint analysis of variance involving both places.

The statistic analysis, including the study of regression for the different periods was performed with the statistic software SISVAR® (FERREIRA, 2000). The data referent to the severity of anthracnose was submitted to test of normality (*normal distribution of Poisson*) and later transformation [√x+1]. The averages were grouped by the Skott and Knott test at 5% of significance.

Results and Discussions

Considering the severity of anthracnose there were differences ($p < 0.01$) for the effect of the periods, cultivars and places, besides the interactions places x cultivars. For dry matter yield, there were differences ($p \square 0.01$) in all the sources of variation and interactions evaluated. The experimental accuracy evaluated by the transformed data (√x+1) presented 12.41% for severity of anthracnose and 8.36% for dry matter yields. The coefficients of variation are considered low, and it was reported similar values in works conducted by COSTA et al. (2008) and VON PINHO et al. (2007).

In the experiment conducted in Francisco Sá the cultivars Volumax, 1F305 and SHS500 presented higher severity to anthracnose (table 3). In Jaíba, it was noted lower values of severity for cultivars Volumax and SHS 500. It was still reported that the cultivar BRS601 was more susceptible to diseases in the municipality of Jaíba.

Table 3. Mean results for severity of anthracnose in the sorghum cultivars in both places. Data transformed √x+1.

Cultivars	Francisco Sá	Jaíba
Volumax	1.57 aA	1.55 aA
1F305	1.70 aA	1.74 bA
SHS500	1.66 aA	1.63 aA
BRS601	1.82 bA	1.97 bB
BRS610	1.83 bA	2.11 cA

Averages with the same lowercase latter in vertical, in each place belong to the same group, according to the Skott Knott test. In the horizontal feature, averages with the same uppercase letter do not differ by the F test, at 5% of probability.

Thus, it may be inferred that there are in marked hybrids with different levels of resistance to anthracnose. However, several works already showed the capacity of adaption of the pathogen to cultivars which are genetically resistant, which reduced the useful life of commercial hybrids, resulting in a great prejudice for the producers besides it demands effort from researchers in the aim at solutions to control the disease. Considering the average of both places, the hybrids SHS500 and Volumax may be considered more resistant than the others evaluated.

In Francisco Sá it was evidenced that the severity of the disease in hybrids 1F305 and BRS610 was affected by the different periods of sowing (figure 3).

For cultivar 1F305 it was verified increase of the severity of the disease in the sowings performed in the second half of October until the first half of November (figure 3). In this case, it was attributed grade until 2.37, i.e., 29.63% of severity in the plants sown in this period, and, from this, it was noted reduction of the pathogen. However, it was seen low magnitude due to the coefficient of determination (R^2) of 50.53%.

Still in this place, it was found significant linear relation between severity of the disease and period of sown for the cultivar BRS610, with R^2 equal to 87.67%. In this cultivar, for each day of delay in the sowing period, there was an increase of 0.33% of the severity of the disease.

For the experiment conducted in the municipality of Jaíba it was found a significant effect in the periods of sowing for cultivars BRS601, SHS500 and Volumax (Figure 4). It was observed significant quadratic relation for the three cultivars.

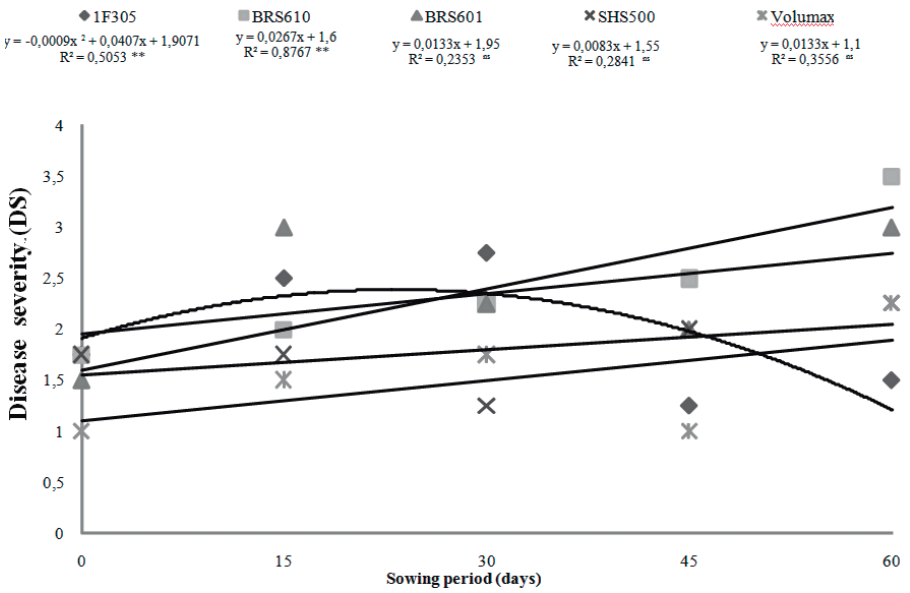

Figure 3. Graphic representation of the equations of regression for the severity of anthracnose (data transformed √x+1) in function of the periods of sowing and cultivar in Francisco Sá, MG. ** Significant at 1%; ns = non significant.

For BRS601 it was verified an increase of the severity of the disease in the sowings performed until the beginning of the second half of November (33 days after the first sowing) with the maximum levels of 39% (grade 3.14). In the sowings performed after this period, there was reduction of the severity.

Cultivar SHS500 accused increase of anthracnose in the plants of sowings performed

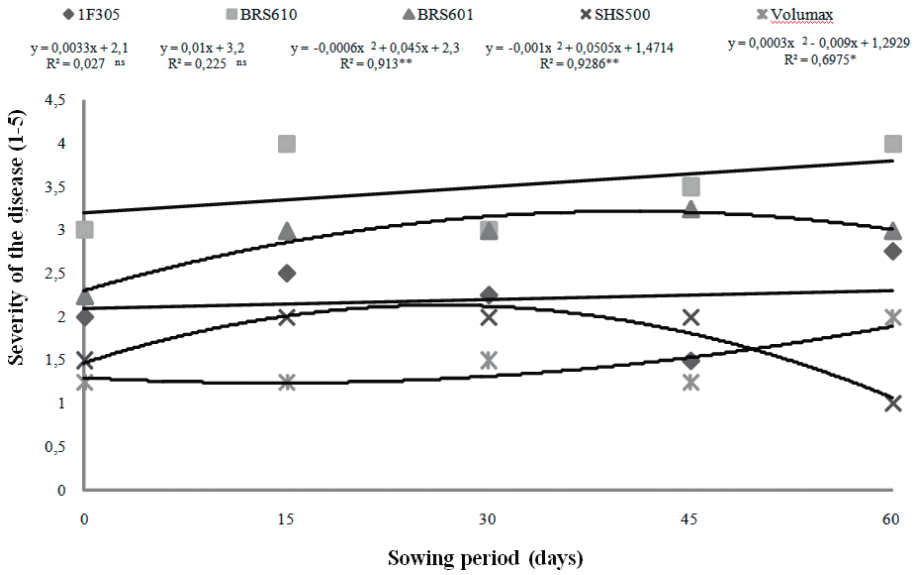

Figure 4. Graphic representation of equation of regression for severity of anthracnose (data transformed √x+1) in function of the periods of seeding and cultivar in Jaíba, MG. **;* Significant at 1%. ns Non significant.

until the end of the first half of November (23 days after the first sowing). The sowings performed from this period limited the development of the pathogen.

Differing from the two previous cultivars, the hybrid Volumax presented reduction in the severity of anthracnose in the earlier sowing, i.e., in the first and beginning of the second sowing period. In the next periods, it was verified increase in the severity of the disease. This fact may be explained by the different cycle of the three cultivars. According to the companies which produce the seeds, cultivar Volumax has late cycle, while BRS601 and SHS500 are early. According to CASELA et al. (1992), the foliar stage of the disease may occur in any stage of plant development, but it appears with more evidence from the beginning of the development of the panicle.

The flowering of Volumax occurred 80 days after sowing. Thus, it can be observed in figure 2 that the sowing in the second half of October conducted a lower exposition of anthracnose due to the low humidity in the period of evaluation. Looking at the obtained results, we may infer that the earlier sowing of this cultivar caused lower severity of the disease in the referred region in the crop 2007/08.

Considering the dry matter yield of the experiments individually for each place, it was verified yield equivalent to 11.33 t ha^{-1} of dry matter in Francisco Sá and 6.57 t ha^{-1} of dry matter in Jaíba.

The lowest production of dry matter in Jaíba is due to the worst distribution of rainfall along the crop cycle (figures 1 and 2), as well as the soil fertility of the experimental areas where the experiments were conducted (table 2).

In the main areas which produce sorghum in the world, the annual rainfall does not exceed 1000 mm. However, which is important is the amount of rainfall in the crop cycle. Considering the environmental features of the regions of the semiarid, the water deficiency caused by the low index of rainfall is the main liming factor for the cultivation of several species. The water stress is accentuated when the loss of water exceeds the absorption, due to the reduction of the content of water in the plant rhizosphere (TAIZ and ZEIGER, 2004).

The results obtained evidenced the potential for the cultivation of forage sorghum in both places, which would not happen with maize. For the obtaining of high yield in the maize crop, besides rainfall superior to 600 mm along its cycle, night temperatures should not exceed 22°C. High night temperatures of maize crop reduce the net photosynthetic rate, due to the increase of the respiration, interfering in the process of production (FANCELLI and DOURADO NETO, 2004). This characteristic makes the maize crop unfeasible for high yield in summer in the north region of Minas Gerais, since the daily average temperatures reported in both experiments were 25 °C and 30 °C (Figures 1 and 2) with night temperature superior to 24 ^{o}C. When compared to maize, sorghum is more tolerant to high temperatures, since its yield is not affected by mean temperatures of until 38 ^{o}C (MAGALHÃES and DURÃES, 2003).

In relation to the temperature, it is important to emphasize that it was not limiting for the sorghum crop, in both places during de execution of this work.

When evaluating best periods of sowing for the cultivation of forage sorghum, in the municipality of Francisco Sá, it was observed that period 2 (first half of November) favored the highest dry matter yield of Volumax, BRS610 and SHS500 (table 4). Still in this place, periods 4 and 5 favored the highest yield of cultivars 1F305 and BRS601, considering that for SHS500 the grain yield was still higher when the fifth period of sowing.

Comparing cultivars inside each sowing period in the experiment conducted in Francisco Sá, cultivar SHS 500 presented higher values of dry matter independent on the period. However, for period 4, cultivars BRS610, BRS 601 and Volumax were among the most productive. Considering the experiment conducted in Jaíba, cultivars SHS500, BRS601, BRS601 and Volumax presented highest yields. In periods 3 and 5, cultivar BRS610 was superior than the others, while in period 4 this cultivar was between the most promising, however, with values similar to cultivar BRS601 (table 4).

For the condition of the semiarid, the mean yield of dry matter was 8.95 ha $^{-1}$, considering the different periods of sowing in both places. This value can be considered good, due to the water limitations of these regions. Similar results for most of the cultivars evaluated were reported by ALBUQUERQUE et al. (2009).

The difference of yield between the cultivars evaluated in each period is associated to the genetics of the hybrids and interaction with the climatic condition which prevails in different periods of sowing, mainly, concerning the water regime.

The graphic representations of the equation of regression for the dry matter yield in function of the period of sowing and cultivar in the experiment

Table 4. Mean results for dry matter yield (t ha-1) of forage sorghum cultivars, in function of the places and periods of sowing in the agricultural crop 2007/08.

Cultivar	Francisco Sá					Jaíba				
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 1	Period 2	Period 3	Period 4	Period 5
1F305	5.57 Dc	7.28 eB	8.03 eB	8.56 Ba	8.88 dA	2.27 bC	5.76 bA	5.70 cA	5.26 bA	4.29 dB
BRS601	9.34 cB	9.44 dB	10.06 dB	11.88 aA	12.25 bA	5.75 aC	8.34 aA	8.46 bA	7.23 aB	5.32 cC
BRS610	8.82 cD	13.23 cA	12.16 cB	10.31 aC	9.63 cC	4.69 aC	7.89 aB	10.01 aA	7.96 aB	8.41 aB
Volumax	11.5 bC	14.78 bA	13.44 bB	12.75 aB	10.00 bD	5.28 aB	7.70 aA	7.56 bA	5.62 bB	5.73 cB
SHS500	12.6 aD	16.75 aA	15.34 aB	13.81 aC	16.75 aA	5.81 aB	7.70 aA	8.42 bA	5.99 bB	7.15 bA

Averages with the same lowercase letter in the vertical and uppercase in horizontal in each place belong to the same group, according to the Scott Knott test.

conducted in Francisco Sá may be seen in figure 5. For cultivars Volumax, SHS500 and BRS610, it was obtained significant quadratic equations. For BRS610 and Volumax the sowing until the first half of November provided higher yield of dry matter, while SHS500 had higher yield until the second half of November.

For cultivars BRS601 and 1F305 it was related linear and positive equations. For the cultivars 1F305 it was noticed an increase of 35.30 kg ha^{-1} of dry matter for each day of delay. For BRS601 it was noticed an increase of 36.66 kg ha^{-1} of dry matter for each day of delay.

In figure 6 it is represented the equations of regression for the dry matter yield in function of the sowing period and cultivar in the experiment conducted in Jaíba. For all the cultivars it was observed significant quadratic equations.

It was noticed increases in dry matter until the first half of November for cultivars Volumax, SHS500 and BRS601. For cultivars 1F305 and BRS610 this referred period expanded to the second half of November, approximately.

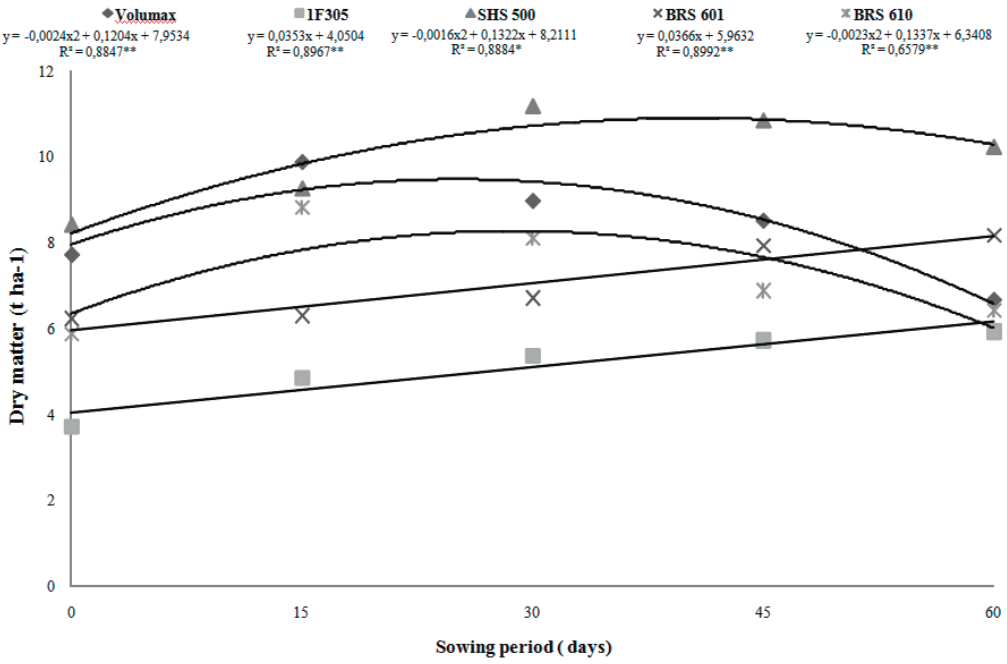

Figure 5. Graphic representation of the equations of regression for dry matter yield in function of the cultivars and sowing period in the municipality of Francisco Sá, MG. **,* Significant at 1% and 5% of probability.

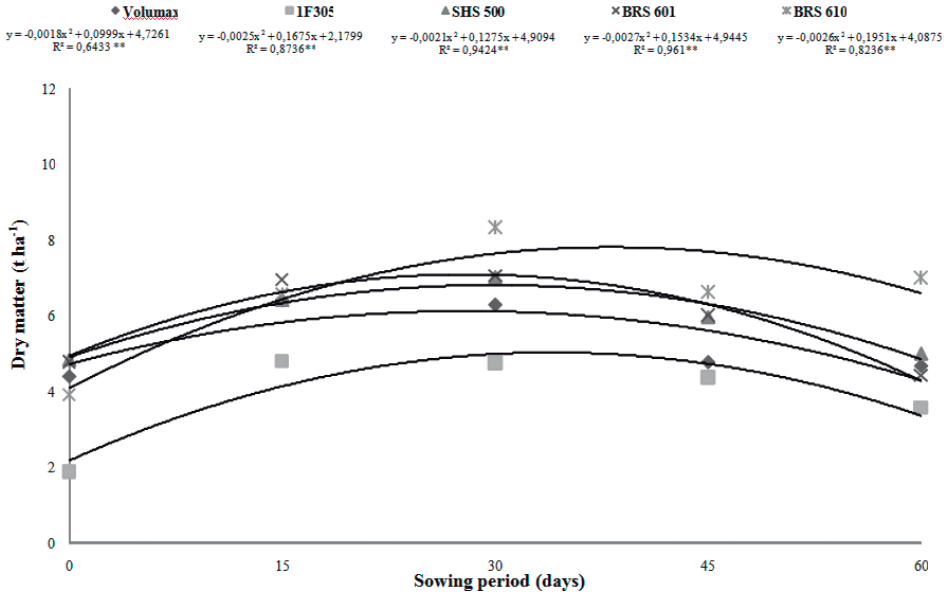

Figure 6. Graphic representation of the equations of regression for dry matter yield in function of cultivars and sowing periods in the municipality of Jaíba, MG. **;* Significant at 1%.

Conclusions

Cultivars SHS500 and Volumax present higher tolerance to anthracnose, independent on the cities of Francisco Sá and Jaíba, MG.

The delay in the sowing period increases the severity of anthracnose of sorghum, in function of the cultivar and place.

The dry matter yield of forage sorghum is affected by the sowing period in the municipalities of Francisco Sá and Jaíba, MG.

References

ALBUQUERQUE, C.J.B.; PINHO, R.G.V.; BRANT, R.S.; MENDES, M.C.; REZENDE, P.M. Composição da matéria seca do sorgo forrageiro em diferentes arranjos de plantas no semiárido de Minas Gerais. **Pesquisa Aplicada & Agrotecnologia**, v.2, p.105-118, 2009.

ALVAREZ,V.H.V.,DIAS,L.E.,RIBEIRO, A.C., SOUZA,R.B. Uso de Gesso Agrícola. **In:** RIBEIRO, A.C.; GUIMARÃES, P.T.G.; ALVAREZ, V.H. (Ed.). **Recomendação para o uso de corretivos e fertilizantes em Minas Gerais**: 5. Aproximação. Viçosa: Comissão de Fertilidade do Solo do Estado de Minas Gerais, 1999. P.67-78.

CASELA, C.R.; FERREIRA, A.S.; BRANCÃO, N. Variabilidade e estrutura de virulência em Colletotrichum graminicola em sorgo. **Fitopatologia Brasileira**, v.21, p.357–361, 1996.

CASELA, C.R.; FERREIRA, A.S.; SCHAFFERT, R.E. Sorghum diseases in Brasil. **In:** MILIANO, W.A.J.de; FREDERIKSEN, R.A.; BENGSTON, G.D. (Ed.). **Sorghum and millets diseases:** a second world review. Patancheru. ICRISAT, 1992. P.57 62.

COSTA, R.V., CASELA, C.R., FERREIRA, A.L., SANTOS, F.G. Manejo da antracnose do sorgo pela utilização de híbridos triplos. **Circular técnica 113**. Embrapa-CNPMS. Sete Lagoas, 2008.

COSTA, R.V.; COTA, L.V.; RODRIGUES, J.A.S.;TARDIN, F.D.; LANZA, F.B. **Controle químico da antracnose do sorgo**. Sete Lagoas: Embrapa Milho e Sorgo, 2009. 8p. (Embrapa Milho e Sorgo. Circular técnica, 177).

CUMMINS, D.G. Yield and quality changes with maturity of silage type sorghum fodder. **Agronomy Journal,** v.73, n.3, p.988-990, 1981.

DOWNES, R.W. Effect of temperature on the phenology and grain yield of sorghum bicolor. **Australian Journal of Agricultural research,** v.23, p.585-594, 1972.

FANCELLI, A.L.; DOURADO NETO, D. **Produção de Milho.** Guaíba; Porto Alegre: Agropecuária, 2000. 360p.

FERREIRA, D.F. S**istema de análises de variância para dados balanceados.** Lavras: UFLA, 2000. (SISVAR 4. 1. pacote computacional).

MAGALHÃES, P.C.; DURÃES, F.O.M. **Ecofisiologia da produção de sorgo**. Sete Lagoas: Embrapa, 2003. (Comunicado técnico, 87)

RESENDE, M.C. **Comportamento de cultivares de sorgo sacarino (***Sorghum bicolor* **(L.) Moench) em diferentes épocas de semeadura.** Dissertação (Mestrado em Fitotecnia)- Escola Superior de Agricultura, Lavras. 1988. 105f.

TAIZ, L.; ZEIGER, E. **Fisiologia vegetal**. *Tradução. de Santarém, E,R.* Porto Alegre: Artmed. 2009. 819p.

VIANA, C.A. Época de plantio. **In:** EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. **Manejo cultural do sorgo para forragem**. Sete Lagoas, MG: Embrapa Milho e Sorgo, 1997. P.29-30. (Circular Técnica, 17).

VON PINHO, R.G.; VASCONCELOS,R.C.; BORGES, I.D.; RESENDE, V.R. Produtividade e qualidade de silagem de milho e sorgo em função da época de semeadura. **Bragantia**, v.66, n.2, p.235-245, 2007.

WHITE, J.S.; BOLSEN, K.K.; POSLER, G. Forage sorghum dry matter disappearance as influenced by plant part proportion. **Animal Feed Science and Technology,** v.33, n.4, p.312-322, 1991.