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Morpho-anatomical aspects and technological quality of saccharine sorghum submitted to plant regulators[1]

Aspectos morfoanatômicos e qualidade tecnológica do sorgo sacarino submetido à reguladores vegetais

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Abstract - With the increase in the demand for renewable fuels, the sugarcane industry must seek a way of increasing agro-industrial productivity while reducing production costs. Currently, there are few reports on the use of plant growth regulators in saccharine sorghum crops. The objective of this study was to evaluate the effects of the application of chemical ripening agents on the technological quality and the morphological and anatomical aspects of saccharine sorghum. The experiment was conducted at the Cerradinho Mill in Catanduva, São Paulo state. Plant growth regulators applied were etephon at 1.32, 0.66 and 0.33 L ha^{-1}, sulfometuron-methyl at 20.0, 10.0 and 5.0 g ha^{-1}, thiadizuron at 0.150, 0.100 and 0.50 L ha^{-1}, ethyl-trinexapac at 0.80, 0.40 and 0.20 L ha^{-1} and a control treatment. The experiment was conducted in randomized blocks with a subplot design with four replications. The following technological parameters were evaluated: juice purity, reduced sugars, total recoverable sugars, juice brix, juice pol, theoretical recoverable sugars and fiber (%). The thickness of the upper face or adaxial epidermis (AdE), the thickness of the lower face or abaxial epidermis (AbE), sclerenchyma diameter (SD), mesophyll thickness (MT), diameter of xilematic vessels (DX) and diameter of phloematic vessels (DP) were evaluated. It is concluded that saccharine sorghum showed a significant increase in technological quality when etephon was used at dose of 0.33 L ha^{-1}, and at 0.66 L ha^{-1} between 37 and 44 days after the application of chemical ripening agents. For the technical characteristics, the chemical ripening agent sulfometuron-methyl and etephon in doses of 5 g. ha^{-1} and 0.33 L ha^{-1}, respectively, promoted the best results from the 37 days after application. For anatomic characteristics of saccharide sorghum plants, the chemical ripener agent thiadizuron in dose of 0.100 L ha^{-1} showed the best results at 44 days after application.
Keywords: hormonal phytoregulators; stress phytoregulators; raw material quality; chemical ripening agents

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tem tido como desafio o aumento da produtividade agroindustrial, além da redução dos custos de produção. Atualmente, são escassos os relatos da utilização de reguladores vegetais na cultura do sorgo sacarino. O objetivo deste trabalho foi avaliar aplicação dos reguladores vegetais na qualidade tecnológica e aspectos morfoanatômicos do sorgo sacarino. O ensaio foi realizado na usina Cerradinho em Catanduva SP. As aplicações dos reguladores vegetais foram: etephon nas dosagens de 1,32, 0,66, 0,33 L ha^{-1}, sulfometeuron-methyl nas dosagens de 20, 10, 5 g ha^{-1}, thiadizuron nas dosagens de 0,150, 0,100, 0,50 L ha^{-1}, ethyl-trinexapac nas dosagens de 0,80, 0,40, 0,20 L ha^{-1} e controle. O experimento foi conduzido em Blocos Casualizados, no esquema de parcelas subdivididas com quatro repetições. Foram avaliadas as variáveis tecnológicas: pureza do caldo, açúcares redutores, açúcares totais recuperáveis, brix do caldo, pol do caldo, açúcares teóricos recuperáveis, fibra (%) e mensurados: espessura da epiderme da face adaxial (EAD); espessura da epiderme da face abaxial (EAB); diâmetro do esclerênquima (DE); espessura do mesofilo (MF); diâmetro dos vasos xilemáticos (DX) e diâmetro dos vasos floemáticos (DF). Para as características tecnológicas, os maturadores químicos sulfometeuron-methyl e etephon nas doses 5 g ha^{-1} e 0,33 L ha^{-1}, respectivamente, promoveram os melhores resultados a partir dos 37 dias após a aplicação. Para as características morfonatômicas, o maturador químico thiadizuron na dose 0,100 L ha^{-1} apresentou os melhores resultados aos 44 dias após a aplicação.
Palavras-chaves: fitorreguladores hormonais; fitorreguladores estressantes; qualidade da matéria prima; maturadores químicos

Introduction

Currently, there is a worldwide growing concern regarding environmental conditions. This grows awareness on the use of fossil fuels observing a proper amount of greenhouse gas emissions into the atmosphere. Several countries are seeking to minimize the use of such fuels, whether by its replacement or by mixing it with other fuels in order to reduce pollution load. Among crops used for the industrial production of ethanol, sugar cane and saccharine sorghum are highly regarded in the international scene due to their high photosynthetic efficiency and high productivity in tropical environments. This assures a competitive superiority. Corn ethanol is an example thereof (Bermann, 2008).

Saccharine sorghum (*Sorghum bicolor* L.) can be cultivated during the renovation of crops or between harvests because of its fast growth and because its growing season is approximately 120 days. This crop reduces the industry’s off-season, during which distilleries remain considerably idle (Durães, 2011). It is also worth mentioning that saccharine sorghum uses a lesser amount of fertilizers and stores sugar in its stalks at different times of the year. The sugar production cost is similar to that of sugarcane. Because it is a rustic plant, sorghum can be cultivated in areas where sugarcane does not adapt very well (Echer et al., 2006).

Plant growth regulators are products used to anticipate the ripening process and to improve the quality of raw materials, including saccharine sorghum. In addition, their use is intended to facilitate the planning of the harvest of raw materials for the sugarcane industry, as well as increasing agro-industrial productivity.

Growth regulators are synthetic compounds acting as chemical signaling agents in the control of plant development. They normally bind to receptors in the plant triggering a series of cellular changes, which may affect the beginning of or may modify the development of tissues or plant organs (Taiz and Zeiger, 2008). Among phytoregulator classes, there are growth regulators, which are compounds capable of affecting several plant characteristics such as reducing plant size and leaf area and increasing chlorophyll content, thickness of leaves and growth of the root system.

For Caputo et al. (2008), ripening agents are defined as growth regulators. They act by altering the morphology and the physiology of the plant, considering quantitative and qualitative changes that may occur during cultivation. They also may promote a decrease in plant growth, thus increasing the sucrose content, as well as early ripening plants and increasing sucrose productivity in stems. The application of ripening agents in the sugarcane production system has provided a greater flexibility for managing crops. This is highly relevant to the planning of crop productivity. They also promote an industrialization of raw materials with a better quality. Therefore, the use of ripening agents and flowering inhibitors in the culture of sugarcane aims to increase productivity and anticipate the cutting, allowing a more adequate crop management in the modern production system.

This study hypothesized that the use of plant growth regulators in the cultivation of saccharine sorghum improves its technological characteristics and the agro-industrial yield of its raw material destined to the industry. In this sense, the objective of this study was to evaluate the effect of the application of chemical ripening agents on the technological quality and the morphological and anatomical parameters of saccharine sorghum.

Material and Methods

The experiment was conducted at the Cerradinho Mill S/A in the municipality of Catanduva, São Paulo state, in a canebrake area. The sowing took place between December 15, 2011, and January 15, 2012.

The experimental design was randomized blocks in a subplot design. Treatments were different doses of plant growth regulators and sub-treatments were different times of collection. The experiment had four replications, totaling 52 plots. In each plot, four collections of material for technological analysis were performed. Each plot contained 5 rows 10 m long. The cultivar of saccharine sorghum used was Cv.80007.

The treatments consisted of ripening agents. In the sub-treatments, collections of saccharine sorghum samples at different times were performed. Collection times were restricted to February to April. The treatments with the applications of chemical ripening agents were performed following the dosage suggested by the manufacturers.

The applications of plant growth regulators were etephon (Ethrel 720 SC, 480 g of a.i., or 660 ml c.p./ha, SC, Bayer) at 1.32, 0.66 and 0.33 L ha^{-1}, sulfometuron-methyl (Curavial, 750 g/kg of a.i., GD, Du pont) at 20, 10 and 5 g ha^{-1}, thiadizuron (Dropp ultra SC, 0.5 L of c.p. equivalent to 60 g of a.i. Tiadizurom and 30 g of a.i. Diuron, SC, Bayer) at 0.150, 0.100 and 0.50 L ha^{-1}, ethyl-trinexapac (Moddus, 250 g/L of a.i., EC, Syngenta) at 0 80, 0.40 and 0.20 L ha^{-1} and a control application.

After 60 days of sowing, the applications of chemical ripening agents were performed following the recommended application period for each product used. A spray with pressurized CO_2, with a T-shaped 6 m bar with six AXI 11002 nozzles with a flat jet, was used, enabling the simultaneous application in two rows. The bar was placed horizontally and supported on two other vertical bars that held the spray bar at approximately 50 cm above the culture level. The constant pressure used was 40 pounds/inch^2 with a volume of 200 L ha^{-1}. The applications were performed during from 07:00 to 11:00, a period in which there is little occurrence of winds. The temperature was 25-30°C and the relative air humidity was 60-80%.

For sub-treatments, a technology assessment was conducted in the saccharine sorghum Cv. 80007 sampled at four different times: 15, 22, 37 and 44 days after application (DAA) of the ripening agent. Ten plants in sequence were manually collected in a planting row intended for measurements. All plants were topped and cut at apical bud height (break point) and taken to the Payment Laboratory of Cerradinho Mill in the municipality of

Catanduva, São Paulo state. The processing was performed according to the methodology of the sucrose payment system. After the disintegration and homogenization of the stems, a 500 g aliquot was subjected to a hydraulic press. The extracted juice was sent to the laboratory to determine Brix (% juice), Pol (% juice), Theoretical Recoverable Sugars (TRS), Fiber (%), Purity (% juice), Reducing Sugars (% RS) and Total Reducing Sugars (%) using chemical-technological determination according to Consecana (2006).

The evaluation of leaf morphological and anatomical characteristics of saccharine sorghum in each plot was performed at 44 days after application of ripening agents. A leaf fragment was removed from three randomly chosen plants to prepare histological slides for analysis of morphological and anatomical characteristics. Each fragment contained approximately five cm. It was taken from the middle portion of the first fully expanded leaf showing a visible ligule on the sorghum apex. Leaf pieces were fixed in a FAA 70 solution (37% formaldehyde, glacial acetic acid and 70% ethanol in the proportion of 1.0, 1.0 and 18.0 v/v). After 24 hours, they were washed and stored in 70% ethanol until analyses according to Lisboa et al. (2013). All leaf fragments underwent the relevant procedures to dehydration and diaphanization, inclusion and embedment.

Using a Leica table microtome containing a steel blade, 8 µm cross sections were performed on leaf fragments containing the midrib. All sections underwent a staining process with 1% safranin and were mounted on slides and coverslip with an Entellan adhesive. The slides were observed with an Olympus optical microscope with a camera attached to take photographs of the cuts. The photos were used to measure anatomical parameters using the image analysis software Olympus DP2-BSW calibrated with a microscopic ruler at the same magnification of the photographs according to the methodology described by Pereira et al. (2008).

Regarding leaf morphological and anatomical characteristics of the saccharine sorghum, the following quantitative parameters of tissues were measured: thickness of the upper face or adaxial epidermis (AdE), thickness of the lower side or abaxial epidermis (AbE), sclerenchyma diameter (SD), leaf mesophyll thickness (MT), diameter of xilematic vessels (DX) and diameter of phloematic vessels (DP) according to Queiroz-voltan et al. (2011).

The variables were subjected to analysis of variance by F test ($p<0.05$) and compared by Tukey test at 5% probability. The Assistat 7.6 Beta software was used.

Results and Discussion

The treatments with plant growth regulators ethephon at 0.33 L ha^{-1} and sulfometuron-methyl at 5 g ha^{-1}, as shown in Table 1, stand out when applied to the Cv. 80007 for the technological variables juice Brix (%), juice Pol (%) and theoretical recoverable sugar (%) at 37 and 44 days after application (DAA). According to Leite et al. (2009), who studied the technological quality and the margin of productivity and agricultural contribution of sugarcane according to the application of plant growth regulators at the beginning of the harvest, ripening agents generally provided an improvement in technological quality of raw materials with a positive impact on sugar productivity and the margin of agricultural contribution. The ripening agents KNO_3 + Boron, ethephon and ethyl-trinexapac, under weather conditions unfavorable to the natural maturation process, allowed anticipating the harvest at 5, 8 and 25 days, respectively, in relation to the control treatment.

It is noteworthy that the concentration of soluble solids (brix) has been widely used to the production of sugar and alcohol by the industry as a main parameter to estimate the concentration of sugars in the juice. The production of juice is directly related to the amount of green matter produced along the sorghum plant cycle, evidencing a greater amount in saccharin plants throughout the reproductive stage until its physiological maturation (Leite et al., 2011).

By analyzing the quality of sugarcane subjected to the application of ripening agents in the last harvest, it was found that ripening agents used usually did not affect the technological characteristics of the raw material. However, after 45 days of application, mixed ripening agents (ethyl-trinexapac + glyphosate, ethyl-trinexapac + sulfometuron methyl and sulfometuron methyl + glyphosate) resulted in a tendency towards a better quality than the control treatment (Viana et al., 2015).

Table 1. Average values for juice Brix (%), juice Pol (%), theoretical recoverable sugars (%) and fiber (%) in the treatments with ripening agents at different sampling times for saccharine sorghum. Catanduva (SP), 2013.

Ripeners (A)	Doses L or g ha^{-1}	Juice Brix	Pol (%)	TRS	Fiber
etephon	1.32	12.52 de	5.41 bcd	63.46 cde	11.98 fg
etephon	0.66	12.93 d	6.16 b	69.95 cd	11.83 fg
etephon	0.33	15.94 b	8.00 a	85.82 ab	11.58 g
sulfometuron-methyl	20	14.06 bcd	6.32 b	71.55 c	12.65 cd
sulfometuron-methyl	10	13.49 cd	5.86 bc	68.24 cde	12.78 cd
sulfometuron-methyl	5	18.26 a	7.98 a	87.24 a	12.34 ef
thiadizuron	0.150	15.28 bc	6.44 ab	73.77 bc	13.68 bc
thiadizuron	0.100	13.76 cd	4.23 de	56.02 efg	14.80 a
thiadizuron	0.50	15.35 bc	5.72 bcd	68.35 cde	12.57 de
ethyl-trinexapac	0.80	13.63 cd	4.43 cde	57.58 def	13.50 cd
ethyl-trinexapac	0.40	9.66 f	2.88 e	43.87 g	14.68 ab
ethyl-trinexapac	0.20	10.77 ef	3.43 e	48.49 fg	13.19 cd
Control	-	10.52 f	3.19 e	46.47 fg	13.45 cd
MSD		1.90	1.59	13.26	1.04
Times (B)					
(15 DAA)		12.73 b	4.89 b	60.53 b	12.69 c
(22 DAA)		12.90 b	4.83 b	59.91 b	12.82 bc
(37 DAA)		14.32 a	5.85 a	68.65 a	13.10 ab
(44 DAA)		14.26 a	5.98 a	69.63 a	13.39 a
MSD		0.76	0.60	5.08	0.37969
Factor A		38.85**	27.47**	27.02**	23.29**
Factor B		17.30**	13.91**	14.03**	9.28**
Factor A x B		3.37**	3.61**	3.34**	4.03**
CV% Plot		11.27	23.68	16.44	6.44
CV% Subplot		10.96	21.87	15.37	5.70

Same letters do not differ by Tukey test within the same factor (P=0.05); $^{*}P<0.05$; $^{**}P<0.01$; $^{ns}P\geq0.05$; (DAA) days after application.

The mean values, as shown in Table 2, for the technological characteristics of juice purity and total reducing sugars showed higher averages when plants were treated with the plant growth regulators etephon at 0.33 and 0.66 L ha^{-1} and sulfometuron-methyl at 5 g ha^{-1}, at 37 and 44 days after application of chemical ripening agents. Knowing the composition of the juice extracted from the stems of saccharine sorghum genotypes allows evaluating the feasibility of using this species as a raw material for the production of ethanol, including as a crop complementary to sugarcane, increasing the sustainability of the activity.

This contributes to an increased production of ethanol due to a prolongation of the harvest using another culture in sugarcane's off-season, thus reducing the idleness of production and industrializing the structure due to a more rational and efficient use of production resources (Bermann, 2008).

Table 2. Average values for juice purity (%), reducing sugars (%) and total reducing sugars (%) for the treatments with ripening agents at different sampling times of saccharine sorghum. Catanduva (SP), 2013.

Ripeners (A)	Doses L or g ha^{-1}	Juice Purity	Reducer sugars	Total reducer sugars
			%	
etephon	1.32	50.07 bc	1.58 cd	7.28 cde
etephon	0.66	53.84 ab	1.49 de	7.98 cd
etephon	0.33	58.82 a	1.31 e	9.73 ab
sulfometuron-methyl	20	52.94 ab	1.50 de	8.16 c
sulfometuron-methyl	10	49.40 bc	1.63 cd	7.80 cde
sulfometuron-methyl	5	50.77 abc	1.53 de	9.93 a
thiadizuron	0.150	47.87 bc	1.65 cd	8.43 bc
thiadizuron	0.100	34.77 d	2.06 ab	6.51 efg
thiadizuron	0.50	42.24 cd	1.83 bc	7.85 cde
ethyl-trinexapac	0.80	35.99 d	2.01 ab	6.68 def
ethyl-trinexapac	0.40	33.57 d	2.12 a	5.15 g
ethyl-trinexapac	0.20	35.92 d	2.04 ab	5.66 fg
Control	-	34.27 d	2.08 ab	5.45 fg
MSD		9.04	0.27	1.44
Times (B)				
(15 DAA)		42.52 c	1.83 a	6.98 b
(22 DAA)		42.66 bc	1.82 a	6.91 b
(37 DAA)		46.32 ab	1.70 b	7.87 a
(44 DAA)		47.10 a	1.68 b	7.97 a
MSD		3.67	0.10	0.55
Factor A		23.81**	26.35**	27.32**
Factor B		5.81**	7.01**	14.35**
Factor A x B		3.64**	3.97**	3.36**
CV% Plot		17.10	0.50	15.53
CV% Subplot		13.24	0.38	14.48

Same letters do not differ by Tukey test within the same factor (P=0.05); *P<0.05; **P<0.01; $^{ns}P \geq 0.05$; (DAA) days after application.

The mean values, as shown in Table 3, for the morphological and anatomical characteristics of the upper face or adaxial epidermis (AdE) evidenced that there was an expansion in the AdE when plants were treated with different growth regulators, highlighting the application of sulfometuron-methyl ripening agent at 10.0 g ha^{-1}, followed by the treatments with thiadizuron at 0.50 L ha^{-1}, thiadizuron at 0.10 L ha^{-1} and ethyl-trinexapac at 0.80 L h^{-1}, when compared to the control treatment 44 days after application. The epidermis is a specialized protection tissue of the mesophyll and plays a vital role for plants. It is covered by a cuticle composed of cutin and waxes, whose special functions are to prevent water loss on the leaf surface and to act as a barrier to the entry of pathogens (Stangarlin et al., 2011). It was found that stresses of any nature, whether biotic or abiotic (such as water deficiency, use of herbicides and different production environments) may affect epidermis thickness (Gardoni et al., 2007).

The morphological changes were accompanied by changes in the development and the physiology of plants (Gardoni et al., 2007). Further studies generating information on the implications of using growth regulators in saccharine sorghum are thus necessary.

As for the average values of the morphological and anatomical variable thickness of the lower face or abaxial epidermis (AbE), it was found that the treatments that had higher mean values for AbE were thiadizuron at 0.10 L ha^{-1} followed by thiadizuron at 0.50 L h^{-1} and ethyl-trinexapac at 0.80 L h^{-1} 44 days after application, as shown in Table 3. The thickness of the epidermis, as well as its composition, may either facilitate or hinder the action of pathogens and insects, as well as influence the effective action of defensive products.

Table 3. Average values for thickness of the upper face or adaxial epidermis (AdE), thickness of the lower face or abaxial epidermis (AbE) and sclerenchyma diameter (SD) for treatments with different ripening agents at 44 days after application in saccharine sorghum. Catanduva (SP), 2013.

Ripeners	Doses L or g ha^{-1}	AdE	AbE	SD
etephon	1.32	27.55 ab	16.46 abc	3.78 cde
etephon	0.66	25.43 bcd	15.33 cd	3.63 de
etephon	0.33	26.62 abc	15.14 d	4.16 bcd
sulfometuron-methyl	20	26.80 abc	16.43 abc	3.81 cde
sulfometuron-methyl	10	28.97 a	15.57 bcd	3.79 cde
sulfometuron-methyl	5	22.38 de	16.46 abc	3.56 e
thiadizuron	0.150	25.16 bcd	16.75 ab	4.23 abc
thiadizuron	0.100	27.94 ab	17.50 a	4.61 ab
thiadizuron	0.50	28.09 ab	16.52 abc	3.65 de
ethyl-trinexapac	0.80	25.94 abc	16.58 abc	4.70 a
ethyl-trinexapac	0.40	24.12 cd	15.10 d	3.96 cde
ethyl-trinexapac	0.20	22.24 de	16.30 abcd	3.42 e
Control	-	19.09 e	15.81 bcd	4.30 abc
MSD		3.37	1.26	0.53
CV%		35.77	21.11	36.60
F		15.40**	6.92**	12.19**

Same letters do not differ by Tukey test within the same factor (P=0.05); *P<0.05; **P<0.01; ^{ns}P≥0.05.

Another important function of the epidermis is to avoid predation by insects and other animals. This function may be more pronounced due to the incorporation of silica crystals into the plant cell wall, which provides it with a greater resistance to abrasion, thus hindering its ingestion by animals. As the main functions of this tissue are protection of plant surface and control of gas exchange, including water vapor, plants with a thicker epidermis can better protect the mesophyll against several injuries (Stangarlin et al., 2011). In addition, there is the ability to reflect light radiation that falls over plants, especially tropical plants, due to the presence of the cuticle, which provides a shiny aspect for leaves, preventing the overheating caused by infrared radiation.

The results in Table 3 show that the treatments with the plant growth regulators ethyl-trinexapac at 0.80 L ha^{-1} and thiadizuron at 0.100 L ha^{-1} had the highest mean values for sclerenchyma diameter (SD) when compared with other treatments. Sclerenchyma diameter, within acceptable limits, provides a greater resistance to the plant regarding biotic and abiotic factors, preserving the cellular structure due to the presence of fibers and lignified cells (Lisboa et al., 2013).

Table 4 shows that the highest averages were in treatments with the plant growth regulators thiadizuron at 0.10 L ha^{-1} and ethyl-trinexapac at 0.80 L h^{-1} for morphological and anatomical characteristics of the diameter of xilomatic vessels (DX), diameter of phloematic vessels (DP) and leaf mesophyll thickness (MT). The lowest average values were observed for the treatments with etephon at 0.33 L ha^{-1} and ethyl-trinexapac at 0.20 L ha^{-1}. Xilematic vessels have as a main function the upward transport of nutrients and water. This movement occurs according to perspiration. Therefore, the variation on their diameter may interfere with a better supply for plant parts. In addition to water, the phloem transports carbohydrates, amino acids, organic acids, proteins and nutrients to various destinations in the plant.

Hence, increasing their anatomical dimensions is essential for contributing to a greater transport of assimilates to specific sites (Taiz and Zeiger, 2008).

Table 4. Average values for diameter of phloematic vessels (DP), diameter of xilematic vessels (DX), and leaf mesophyll thickness (MT) when subjected to treatments with different ripening agents at 44 days after application in saccharine sorghum. Catanduva (SP), 2013.

Ripeners	Doses L or g ha^{-1}	DP	DX	MT
etephon	1.32	10.36 def	49.11 def	10.36 def
etephon	0.66	9.93 fg	50.58 def	9.93 fg
etephon	0.33	9.62 g	43.85 g	9.62 g
sulfometuron-methyl	20	10.42 def	47.14 efg	10.42 def
sulfometuron-methyl	10	10.94 abcd	51.31 cde	10.94 abcd
sulfometuron-methyl	5	10.58 cdef	48.06 defg	10.58 cdef
thiadizuron	0.150	10.68 bcde	52.09 bcd	10.68 bcde
thiadizuron	0.100	11.55 a	57.60 a	11.55 a
thiadizuron	0.50	11.16 abc	55.94 abc	11.16 abc
ethyl-trinexapac	0.80	11.32 ab	56.37 ab	11.32 ab
ethyl-trinexapac	0.40	10.06 efg	50.77 de	10.06 efg
ethyl-trinexapac	0.20	9.43 g	47.48 defg	9.43 g
Control	-	10.50 cdef	46.07 fg	10.50 cdef
MSD		0.72	4.69	0.72
CV%		18.56	25.08	18.56
F		17.18**	17.44**	17.18 **

Same letters do not differ by Tukey test within the same factor (P=0.05); $^{*}P<0.05$; $^{**}P<0.01$; $^{ns}P\geq0.05$.

Among the tissues that compose the mesophyll, the spongy parenchyma, which contains cells with a large quantity of chloroplasts and intercellular spaces, is responsible for performing photosynthesis. With the presence of nutritive substances, it allows the vital metabolism of plants. Changes in the thickness of the mesophyll may influence the quantity or quality of the substances produced, directly interfering with crop yields (Stangarlin et al., 2011).

Queiroz-Voltan et al. (2011) found that variations in the mesophyll might potentially interfere with the photosynthetic capacity and with the productivity of vine fruits. Ferreira (2009) found that micro-morphologic factors should be considered together with the physiological characteristics of the plant.

Conclusions

For the technical characteristics, the chemical ripening agents sulfometuron-methyl and etephon in doses of 5 g ha^{-1} and 0.33 L ha^{-1}, respectively, promoted the best results from the 37 days after application. For anatomic characteristics of saccharide sorghum plants, the chemical ripener agent thiadizuron in dose of 0.100 L ha^{-1} showed the best results at 44 days after application.

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