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Sorgo sacarino submetido a aplicação de fósforo e ethephon

Saccharin sorghum submitted to application of phosphorus and ethephon

Saccharin sorghum presentado a la aplicación de fósforo y ethephon

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Resumo

O sorgo sacarino (*Sorghum bicolor* L. Moench) é uma cultura energética promissora, devido ao armazenamento de açúcares fermentescíveis nos colmos, sendo estes facilmente convertidos em etanol. Assim, objetivou-se avaliar a aplicação de doses de fósforo (P) e de Ethephon no desenvolvimento, produtividade e qualidade tecnológica do sorgo sacarino. O experimento foi conduzido na Fazenda de Ensino e Pesquisa-FEPE, localizada no Município de Selviria-MS. O delineamento experimental foi em blocos ao acaso, em esquema fatorial 5x4, sendo cinco doses de fósforo (0, 40, 80, 120 e 160 kg ha^{-1} de P_2O_5), utilizando como fonte o superfosfato simples e quatro doses do Ethephon (0, 330, 660 e 1.320 mL ha^{-1}), com quatro repetições. As variáveis analisadas foram: altura de plantas, diâmetro do colmo, número de folhas, stand aos 15 e 60 dias após a aplicação (D.A.A) de Ethephon, volume de biomassa fresca e seca e produtividade. Além dessas, foram avaliadas as variáveis tecnológicas: teor de sólidos solúveis (BRIX %); teor de sacarose (%); açúcares redutores (AR%); açúcares redutores totais (ART%); fibra (%); pureza (%) e umidade. As doses de P_2O_5 não influenciaram a produtividade, porém aumentaram o diâmetro do colmo. As doses de Ethephon não influenciaram a produtividade do sorgo sacarino, porém melhorou a qualidade tecnológica do caldo extraído.

Palavras-chave: *Sorghum bicolor L. Moench*; Adubação fosfatada; Fitorregulador; Qualidade da matéria prima.

Abstract

Saccharin sorghum (*Sorghum bicolor* L. Moench) is a promising energy crop due to the storage of fermentable sugars in the stems, which are easily converted into ethanol. The objective of this study was to evaluate the influence of the application of phosphorus and Ethephon on the development, productivity of sorghum and technological quality of saccharin sorghum. The experiment was conducted at Teaching and Research Farm, located in Selviria-MS. The experimental design was a randomized complete block design with a 5x4 double factorial design, with five doses of phosphorus (0, 40, 80, 120, 160 kg ha^{-1} P_2O_5) and four doses of Ethephon (0, 330, 660, 1,320 mL ha^{-1}) with four replicates. The variables analyzed were: plant height, stem diameter, leaf number, stand at 15 and 60 days after Ethephon application (D.A.A), fresh and dry biomass volume and yield. In addition, the following technological variables were evaluated: soluble solids content (BRIX%); sucrose content (POL%); reducing sugars (RS%); total reducing sugars (TRS%); fiber (%); purity (%) and humidity. The doses of P_2O_5 did not influence the productivity, but increased the stem diameter. Ethephon doses did not influence the yield of sorghum, but improved the technological quality of the extracted juice.

Keywords: *Sorghum bicolor* L. Moench; Fertilizing; Phosphate; Phytogulator; Quality of raw material.

Resumen

El sorgo dulce (*Sorghum bicolor* L. Moench) es un cultivo energético prometedor, debido al almacenamiento de azúcares fermentables en los tallos, que se convierten fácilmente en etanol. Por lo tanto, el objetivo fue evaluar la aplicación de dosis de fósforo (P) y Ethephon en el desarrollo, la productividad y la calidad tecnológica del sorgo dulce. El experimento se llevó a cabo en la Granja de Enseñanza e Investigación - FEPE, ubicada en Selviria-MS. El diseño experimental fue en bloques al azar, en un esquema factorial 5x4, con cinco dosis de fósforo (0, 40, 80, 120 y 160 kg ha^{-1} de P2O5), utilizando el superfosfato simple y cuatro dosis de Ethephon (0, 330, 660 y 1.320 ml ha^{-1}), con cuatro repeticiones. Las variables analizadas fueron: altura de la planta, diámetro del tallo, número de hojas, soporte a los 15 y 60 días después de la aplicación (D.A.A) de Ethephon, volumen de biomasa fresca y seca y productividad. Además de estos, se evaluaron las variables tecnológicas: contenido de sólidos solubles (BRIX%); contenido de sacarosa (%); azúcares reductores (% AR); azúcares reductores totales (ART%); fibra (%); pureza (%) y humedad. Las dosis de P_2O_5 no influyeron en la productividad, pero sí aumentaron el diámetro del tallo. Las dosis de etefón no influyeron en el rendimiento del sorgo dulce, pero sí mejoraron la calidad tecnológica del jugo extraído.

Palabras clave: *Sorghum bicolor* L. Moench; Fertilización con fosfato; Fitoregulador; Calidad de la materia prima.

1. Introduction

Sorghum (*Sorghum bicolor* L. Moench) originates from the African continent, belonging to the Poaceae family and is the fifth most important cereal in the world (Food agriculture organization of the United Nations [Faostat], 2016). In Brazil, its cultivation reaches 782.2 thousand hectares and an average production of 2,136 million tons, with an average yield of 2,731 kg ha^{-1} (Companhia Nacional de Abastecimento [Conab], 2018).

Although sugar cane is a higher-yielding raw material per acreage for ethanol production, such as searches for crops that serve as renewable raw materials and have a shorter development cycle (Batista et al., 2018). Among these crops, sorghum is a promising economic crop due to the storage of fermentable sugars (sucrose, glucose and fructose) in stalks, similar to sugarcane, which are easily converted into ethanol (Khalil et al., 2015).

A sorghum crop that is enabled by broad soil and climate adaptation, high water use efficiency and the use of the same infrastructure and machinery as the sugarcane industry, from extraction to the use of commercial yeast for ethanol fermentation (Masson, 2013).

Although rustic, sorghum is considered demanding in phosphorus (P), and studies have shown a positive effect of phosphate fertilization on its dry matter and grain yield (Cruz et al., 2009). P is an important macronutrient for the development of agricultural crops, being involved in cell division, photosynthesis, participation as a structural element of sugar and starches. Also, it influences the absorption and metabolism of several other nutrients, especially nitrogen (N) (Sá et al., 2017).

Phosphate fertilization in serum culture is performed with soluble sowing sources. However, combined use with natural phosphates, due to the gradual release of P over time, can balance P supply during cycles. In this context, he selected the agronomic and economic importance of the use of natural phosphates, which contributes to the better use of P by plants and the cultivation time (Souza et al., 2014).

Another critical input for sorghum cultivation is the chemical ripener that facilitates crop planning and increases agro-industrial activity. In Brazil, maturators classified as growth regulators, such as Ethephon (Viana et al., 2016), also known as 2-chloroethylphosphonic acid, were used.

Ethephon is a component used as a growth regulator with systemic action in vegetables, which brings benefits to the cultivation of sorghum and sugar cane. The product is applied in order to accelerate the maturation process, enable improvements in the quality of raw materials, improve agro-industrial and economic results and aid in crop programming, activate or require crop management in its modern production system (Benedini & Ricci, 2009).

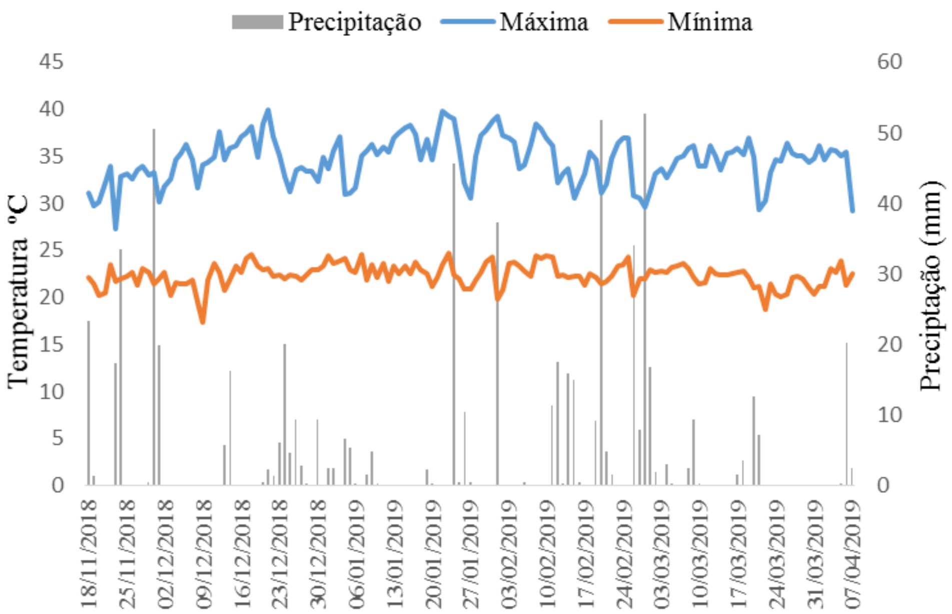
These plant regulators can modify plant morphology and physiology, can lead to qualitative and quantitative changes in agricultural production, use increases in sucrose content, early maturation and increased evaluation (Caputo et al., 2007).

Thus, we aimed to evaluate the application of phosphorus and Ethephon in the development, productivity and technological quality of saccharin sorghum.

2. Methodology

The experiment was conducted in 2018/2019 at the São Paulo State University Farm, located in Selvíria (MS), with geographic coordinates 20º 22 '02 "S and 51º 25 '08" W. The climate of the region is Aw, according to the Köppen classification, with an average annual temperature of 23°C, an average annual rainfall of 1,322 mm and an average annual relative humidity of 66% (Alvares et al., 2013). Precipitation data and maximum and minimum daily temperatures that occurred in the experimental area were obtained during the experiment (Figure 1).

Figure 1 - Rainfall data and average air temperatures for the period from 18 November 2018 to 7 April 2019.



Source: Author.

The soil of the experimental area is classified as dystrophic red Latosol, clay texture (Empresa Brasileira de Pesquisa Agropecuária [Embrapa], 2018). The study was quantitative as stated by Pereira et al (2018). Before the implementation of the experiment, chemical analysis of the soil was performed, according to Raij et al (2001) (Table 1), which allowed, using the fertilization and liming recommendations for the State of São Paulo, to perform the correction and fertilization of the soil from the experimental area (Raij et al., 1997).

Table 1 - Chemical analysis of the soil in the experimental areas located at the Education and Research and Extension Farm (FEPE), belonging to the Faculty of Engineering of the Ilha Solteira Campus. Selviría, (MS), 2018.

P	MO	pH	Ca	Mg	K	H+Al	Al	SB	CTC	V%	Ca/CTC	Mg/CTC	M
(mg dm^{-3})	(g dm^{-3})	($CaCl_2$)			(mmol$_c$ dm^{-3})							(%)	
16	23	4,7	17	13	4,5	34	3	34,5	68,5	50	25	19	8

Source: Author.

The sorghum cultivar BRS 508 was sowed on 18th December of 2018, and harvest on 9th April, 2019. Phytosanitary treatments of sorghum plants occurred according to the technical recommendations of the crop (Embrapa, 2011).

The experimental design was randomized blocks in a 5x4 factorial scheme, with five phosphorus doses (0, 40, 80, 120 and 160 kg ha^{-1} of P_2O_5), based on simple superphosphate (18% P_2O_5, 16% Ca, 8% S), with the fertilizer placed in the sowing furrow and four doses of the Ethephon phytoregulator (0, 330, 660 and 1,320 mL ha^{-1}), with four replications, totaling 80 plots. The experimental plots consisted of 6 rows, spaced 0.45 m long and 5 m long. The two lateral lines were taken as the border, and the samples were taken in the two central lines with a density of 10 to 12 plants per linear meter.

Ethephon was applied 60 days after sowing, at the time of floral induction. A 3 m long T-bar pressurized CO_2 sprayer with 6 tips AXI 11002 with flat jets spaced 0.5 m apart was used. The bar was placed horizontally on two other vertical bars, which kept the spray bar at ± 0.50 m above the culture level with a volume of 150 L ha^{-1}. The application was performed during the period from 07:00 to 10:00, where there was a little occurrence of winds, with the temperature around 25 to 30ºC and the relative humidity between 60-80%.

In the field, the following evaluations were carried out: average plant height, with a ruler graduated in centimeters, measuring the distance between the neck and panicle, basal diameter of the stem with caliper, at 15, 30.45 and 60 days after application (DAA) of Ethephon in which three plants were randomly evaluated in the useful area of each experimental plot. Plants were counted at 15 and 60 days after Ethephon application, and at harvest, the number of plants per meter was counted in each experimental plot.

At harvest, three whole plants per plot were cut and weighed, thus obtaining fresh biomass. After weighing the plants were sent to the greenhouse at 65ºC and weighed after 72 hours, obtaining dry biomass and productivity (Chioderoli, 2010). The material was processed

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and the technological variables evaluated were: soluble solids content (Brix%); reducing sugars (RS%); sucrose content (SC%); total reducing sugars (TRS%); fiber (%); purity (%) and humidity (Conselho dos Produtores de Cana de Açúcar, Açúcar e Etanol do Estado de São Paulo [Consecana], 2006).

Data were subjected to analysis of variance by the F test. Quantitative variables (doses) were evaluated by regression analysis at 5% significance.

3. Results and Discussion

Table 2 shows the results of the analysis of variance and regression of plants stand at 15 and 60 D.A.A of Ethephon. For both cases there were no significant interactions between the two factors.

Table 2 - Analysis of variance and regression of saccharin sorghum stand of plants. Selvíria (MS), 2019.

Treatments	Plant Stand (plants m^{-1})	
	15	60
PD ($kg.ha^{-1}$)		
0	7,98	9,93
40	7,73	10,00
80	7,06	8,75
120	6,25	8,93
160	6,72	9,00
ED ($ml.ha^{-1}$)		
0	7,42	8,55
330	7,42	9,90
660	7,18	9,55
1320	6,58	9,20
F Test		
DP	5,45**	1,03 ^{ns}
DE	2,08 ^{ns}	1,03 ^{ns}
PD x ED	0,94 ^{ns}	0,70 ^{ns}
Mean	7,15	9,32
CV (%)	7,64	11,65
Linear Regression (PD)	17,10**	2,50 ^{ns}
Quadratic Regression (PD)	1,33 ^{ns}	0,43 ^{ns}
Linear Regression (ED)	5,75 ^{ns}	0,11 ^{ns}
Quadratic Regression (ED)	0,46 ^{ns}	0,87 ^{ns}

Source: Author.

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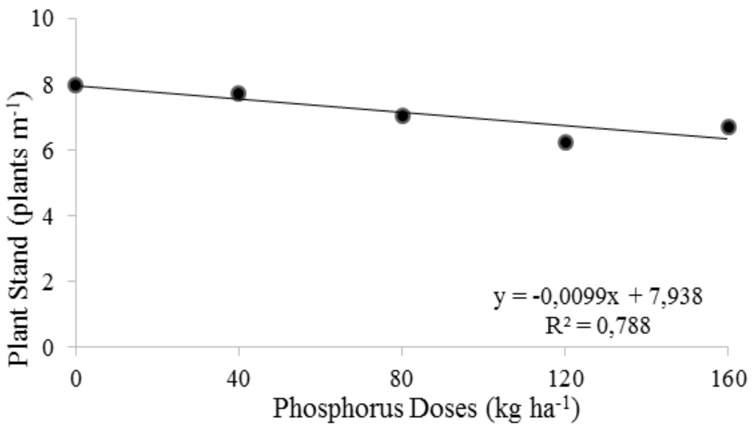
The stand of saccharin sorghum plants was significant for the isolated factor of phosphorus doses at 15 days (Table 2), adjusting for a decreasing linear function (Figure 2). That is, plant stand decreased as P_2O_5 doses increased. Such negative effects of localized P fertilization have been attributed to salinity or toxicity, resulting from the high concentrations of sulfo-phosphate fertilizers, such as the simple superphosphate used in the present study, which would affect the germination of seeds reflecting directly in the initial stand on root growth (Conus et al., 2009; Bernardes et al., 2015).

Figure 2 - Stand of plants per meter as a function of phosphorus doses.



Source: Author.

The plant height was not significantly different at doses of P_2O_5 in any of the periods evaluated (Table 3).

Table 3 - Analysis of variance for plant height (AP), stem diameter (DC), of saccharin sorghum. Selvíria (MS), 2019.

Treatments	Plant Height (m)				Stem Diameter (mm)			
	D.A.A of Ethephon							
PD ($kg.ha^{-1}$)	15	30	45	60	15	30	45	60
0	2,12	2,61	2,55	2,60	5,14	6,09	4,22	3,74
40	2,15	2,68	3,59	2,73	4,90	8,06	4,47	5,08
80	2,17	2.65	2,61	2,74	5,40	6,50	4,63	4,67
120	2,21	2,66	2,59	2,62	5,49	6,67	4,79	4,86
160	2,16	2,69	2,67	2,68	5,37	7,97	4,82	4,93
ED ($ml.ha^{-1}$)								
0	2,39	2,71	2,65	2,75	5,07	7,67	4,33	3,74
330	2,15	2,66	3,00	2,78	5,19	7,68	4,47	4,66
660	2,05	2,63	2,97	2,63	5,38	6,45	4,94	4,51
1320	2,09	2,63	2,53	2,55	5,40	6,43	4,61	4,93
F Test								
PD	0,72 ^{ns}	0,82^{ns}	2,25^{ns}	0,88 ^{ns}	1,56 ^{ns}	0,93 ^{ns}	1,71 ^{ns}	6,75**
ED	24,33**	1,58 ^{ns}	0,80 ^{ns}	3,28*	0,85 ^{ns}	0,72 ^{ns}	2,37 ^{ns}	1,11 ^{ns}
PD x ED	0,76 ^{ns}	1,10 ^{ns}	0,73 ^{ns}	0,75^{ns}	0,90 ^{ns}	0,99 ^{ns}	0,85 ^{ns}	0,85 ^{ns}
Mean	2,164	2,66	2,808	2,681	5,26	7,06	4,591	4,661
CV (%)	6,76	5,31	13,13	9,889	14,53	17,16	16,48	17,563
Linear Regression (PD)	1,12 ^{ns}	1,89 ^{ns}	0,67 ^{ns}	0,06 ^{ns}	3,06 ^{ns}	0,64 ^{ns}	6,44 ^{ns}	11,40**
Quadratic Regression (PD)	0,99 ^{ns}	0,07 ^{ns}	0,77 ^{ns}	1,09 ^{ns}	0,05 ^{ns}	0,01 ^{ns}	0,39 ^{ns}	6,27*
Linear Regression (ED)	46,78**	3,51 ^{ns}	0,44 ^{ns}	8,43*	2,05 ^{ns}	1,56 ^{ns}	1,85 ^{ns}	2,10 ^{ns}
Quadratic Regression (ED)	25,81**	1,21 ^{ns}	1,87 ^{ns}	0,03 ^{ns}	0,39 ^{ns}	0,11 ^{ns}	3,69 ^{ns}	0,55 ^{ns}

Source: Author.

Increasing doses of Ethephon promoted decrease in height sorghum plants (Figures 3A and 3B). This is because the ethylene present in the growth regulator acts as inhibitor of cell division and expansion and auxin transport, providing significant effect in reducing stem growth in length, however, promotes its radial expansion and diameter (Coll et al., 2001). Besides, Khosravi and Anderson (1991) state that the Ethephon application reduced plant height and improves resistance of the same to lodging, thus, the highest concentration of ethylene in the plant promotes decreased internode lengthening (Li & Solomon, 2003).

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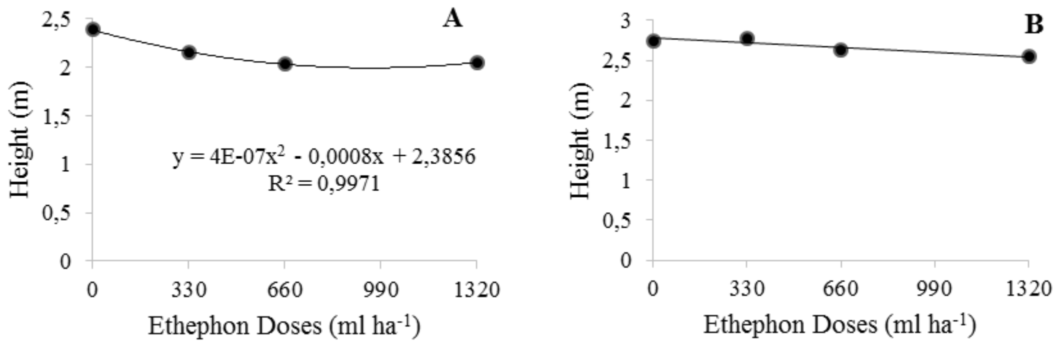
However, for Ethephon doses, significance was verified at 15 and 60 DAA, adjusting to a quadratic and linear regression model, respectively (Figure 3.A and B).

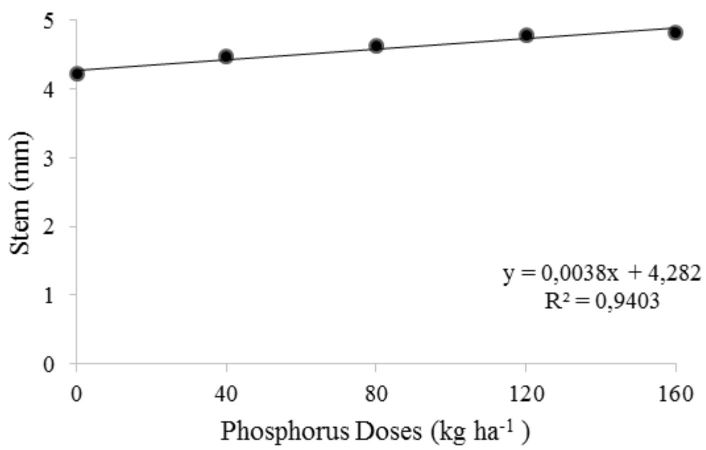
Figure 3 - Plant height as a function of Ethephon doses. A:15 D.A.A from Ethephon, B: 60 D.A.A from Ethephon.



Source: Author.

The diameter of the stem, was significant at doses of P_2O_5 at 60 DAA Ethephon, allowing an adjustment of increasing linear regression (Figure 4).

Figure 4 - Plant diameter as a function of phosphorus doses.



Source: Author.

For the stem diameter (Figure 4), there was a positive linear response as a function of P_2O_5 doses. This shows that phosphate fertilization brings benefits to the growth of sorghum plants because it participates in numerous structural substances in plants, such as proteins,

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lipids, sugars and others that can also act on energy input and osmotic adjustment (Taiz et al., 2017).

It is important that the diameter of the sorghum stem presents good results, because, according to Carneiro (1995), plants with larger stem diameter can have a better balance in the growth of the shoot, which will lead to better crop development, ensuring plant conditions achieve satisfactory yields.

The components dry mass, fresh mass and productivity (Table 4) were not influenced by the increase of P_2O_5 and Ethephon doses.

Table 4 - Analysis of variance for dry mass (DM), fresh mass (MF) and productivity (P) of saccharin sorghum. Selvíria (MS), 2019.

Treatments	Fresh Mass (kg ha^{-1})	Dry Mass (kg ha^{-1})		Productivity (mg ha^{-1})
	D.A.A of Ethephon			
PD (kg.ha^{-1})	60	15	60	60
0	0,407	0,287	0,139	48,09
40	0,382	0,287	0,133	45,67
80	0,474	0,271	0,155	48,85
120	0,429	0,306	0,144	45,70
160	0,441	0,281	0,145	49,24
ED (ml.ha^{-1})				
0	0,405	0,325	0,136	40,61
330	0,444	0,255	0,152	55,00
660	0,419	0,309	0,139	46,62
1320	0,439	0,258	0,146	47,81
F Test				
PD	1,85^{ns}	0,22^{ns}	0,64^{ns}	0,17^{ns}
ED	0,63^{ns}	2,21^{ns}	0,58^{ns}	2,58^{ns}
PD x ED	1,90^{ns}	0,56^{ns}	1,29^{ns}	1,03^{ns}
Mean	0,427	0,286	0,143	47,51
CV (%)	5,48	18,81	3,13	17,12
Linear Regression (PD)	2,05^{ns}	0,01^{ns}	0,54^{ns}	0,03^{ns}
Quadratic Regression (PD)	0,48^{ns}	0,00^{ns}	0,22^{ns}	0,13^{ns}
Linear Regression (ED)	0,56^{ns}	2,07^{ns}	0,16^{ns}	0,40^{ns}
Quadratic Regression (ED)	0,14^{ns}	0,06^{ns}	0,09^{ns}	2,34^{ns}

Source: Author.

No regression fit the data presented. This fact is probably due to average levels of available soil phosphorus (Table 1). This behavior is a consequence of the consecutive addition of fertilizers in the surface layer, and decrease of erosion rates, which could lead to the loss of this nutrient (Rheinheimer & Anghinoni, 2001).

The technological variables fiber and humidity were influenced by doses of Ethephon. Nonetheless, there was no significant effect on any other technological characteristics assessed (Table 5).

Table 5 - Analysis of variance for technological variables. Selvíria (MS), 2019.

Treatments	Brix	Pol broth	Purity	RS broth	Fiber	TRS	Humidity
	(%)	(%)	(%)	(%)	(%)	(kg tc^{-1})	(%)
PD (kg.ha^{-1})							
0	20,13	15,66	77,95	0,96	19,98	117,11	59,88
40	20,00	15,72	78,81	0,93	19,35	118,82	60,64
80	19,83	15,61	78,79	0,93	19,78	117,02	60,38
120	20,18	15,94	79,06	0,92	20,37	117,92	59,44
160	20,66	15,61	75,80	1,04	20,03	117,14	59,30
ED (kg.ha^{-1})							
0	20,55	15,62	76,16	1,02	20,38	116,34	59,06
330	20,01	15,85	79,22	0,92	19,79	118,55	60,18
660	19,95	15,71	78,94	0,93	20,04	117,13	60,00
1320	20,12	15,65	78,00	0,96	19,39	118,39	60,47
F Test							
PD	1,31 ^{ns}	0,45 ^{ns}	1,49 ^{ns}	1,53 ^{ns}	2,21 ^{ns}	0,30 ^{ns}	2,25 ^{ns}
ED	1,24 ^{ns}	0,32 ^{ns}	1,98 ^{ns}	1,97 ^{ns}	3,40*	0,70 ^{ns}	3,11*
PD x ED	0,72 ^{ns}	1,07 ^{ns}	0,92 ^{ns}	0,91 ^{ns}	1,07 ^{ns}	0,89 ^{ns}	0,85 ^{ns}
Mean	20,16	15,71 ^{ns}	78,08	0,96	19,90	117,60	59,93
CV (%)	5,40	5,16 ^{ns}	5,65	15,72	5,06	4,80	2,58
Linear Regression (PD)	2,08 ^{ns}	0,03 ^{ns}	1,37 ^{ns}	1,44 ^{ns}	1,95 ^{ns}	0,03 ^{ns}	3,68 ^{ns}
Quadratic Regression (PD)	2,97 ^{ns}	0,20 ^{ns}	3,73 ^{ns}	3,74 ^{ns}	0,63 ^{ns}	0,19 ^{ns}	2,96 ^{ns}
Linear Regression (ED)	0,98 ^{ns}	0,02 ^{ns}	0,77 ^{ns}	0,72 ^{ns}	7,81*	0,72 ^{ns}	6,29*
Quadratic Regression (ED)	2,55 ^{ns}	0,43 ^{ns}	4,29*	4,28 *	0,00 ^{ns}	0,10 ^{ns}	1,32 ^{ns}

Source: Author.

The concentration of soluble solids (Brix), which is considered to be the main parameter for estimating the concentration of sugar in the broth, were down, but next of what is expected from the variety range, which is 22.9% (Embrapa, 2011).

A quadratic function was adjusted for broth purity when Ethephon was applied up to the dose of 810 mL ha^{-1} (Figure 5), obtaining a maximum purity of 80%. The results

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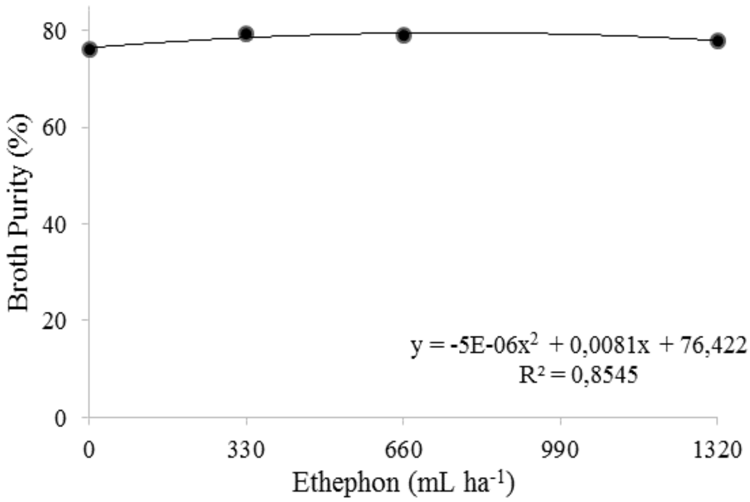
corroborate with Caputo et al. (2008), who also found higher purity values after the application of chemical ripeners. It is known that the juice purity correlates with the sugarcane maturation process, recommending minimum levels of 80% for the beginning and 85% during the harvest (Fernandes, 2011). Since purity is a positive factor for sugarcane, it is expected to be similar for sorghum.

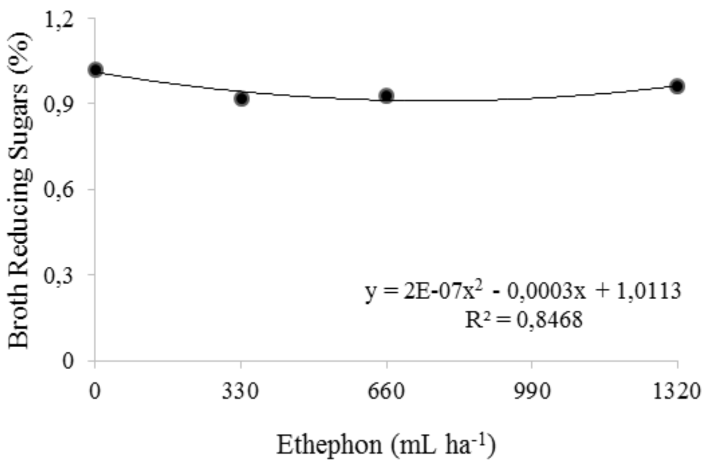
Figure 5 - Broth purity as a function of Ethephon doses.



Source: Author.

Reducing sugars values (RS) showed negative quadratic effect, in which the smallest value was obtained at a dose 660 ml h^{-1} of Ethephon (Figure 6).

Figure 6 - Broth reducing sugars as a function of Ethephon doses.



Source: Author.

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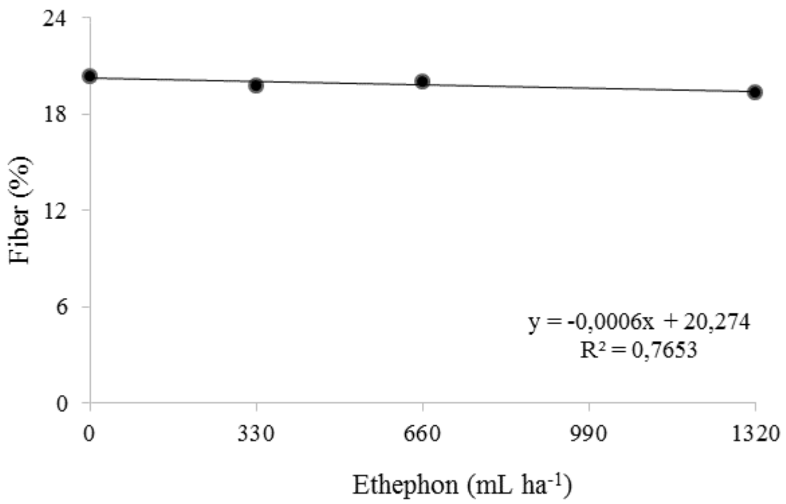
Reducing sugars consist of glucose and fructose, which are synthesized in the leaves and translocated to other parts of the plant as sucrose through the phloem. According to Gomide et al. (2008), this fact may have occurred due to the use of the maturer, as they help in the maintenance and anticipation of sucrose gain, with consequent reduction of reducing sugars.

For fiber content, a negative linear adjustment was observed. As the Ethephon dose increased, the percentage of fiber was lower (Figure 7).

Figure 7- Fiber as a function of Ethephon doses.

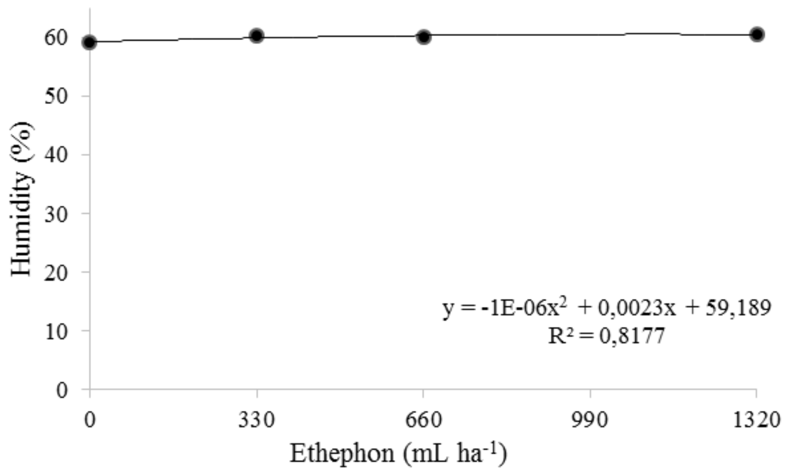


Source: Author.

The lower fiber values favor agro-industrial processing of the raw material. According to Barbosa et al. (2007), there is a negative association between fiber content and sugar, especially in early varieties, which are richer in sucrose and generally have lower fiber content, so that the ideal amount of fiber varies between 12% and 13%.

For the humidity variable, there was an increase up to the dose of 1150 mL ha^{-1} of Ethephon, reaching a maximum value of 61% in saccharin sorghum (Figure 8).

Figure 8 - Humidity as a function of Ethephon doses.



Source: Author.

There is an inverse relationship between broth and fiber, the higher percentage of fiber in a plant, the lower the broth (Table 5).

4. Final Considerations

The phosphorus levels did not significantly affect productivity but increased the diameter of the stem providing increased resistance of plants. Increasing doses did not affect the technological parameters of the sorghum plants.

The doses of Ethephon did not influence the yield of sorghum but provided improvements in the technological quality of the extracted juice, such as a reduction in reducing sugar content, an increase in humidity and reduction of fiber content.

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