TECHNOLOGICAL PROFILE OF SWEET SORGHUM JUICE cv. CMSXS-646 SUBMITTED TO CHEMICAL RIPENERS APPLICATION AND SAMPLING PERIODS

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ABSTRACT - There is a little information about sweet sorghum crop behavior under chemical ripeners spraying management. Therefore, the aim of this study was to assess the technological profile of sweet sorghum (cv. CMSXS-646) juice under spraying of plant growth regulators and sampling periods. A randomized complete block experimental factorial design was used, with an additional control treatment (arrangement 7x2), corresponding to chemical ripeners, glyphosate (0.2, 0.4, and 0.8 l c.p. ha^{-1}), methyl-sulfumeturon (10, 20, and 30 g c.p. ha^{-1}), and control treatment (water spraying) with two sampling periods (15 and 30-days after spraying - DAS).. After crop harvest, stalks were milled using a hydraulic press and the derived juice was assessed for total soluble solids (°Brix), apparent sucrose (POL), purity (PRT), reducing sugars (RS), total reducing sugars (TRS), fibers (FIB) and recoverable theoretical sugars (RTS). The dataset was subjected to the Shapiro-Wilk, Fisher, Tukey, Pearson and multiple linear regression statistical tests ($p<0.05$). There was an interaction between causes of variation for almost all assessed characteristics except to RTS, only affected by the sampling period. As conclusion, it is possible to grow sweet sorghum (cv. CMSXS-646) till thirty-days after spraying of chemical ripeners, treated by glyphosate 0.4 l c.p. ha^{-1} or sulfumeturon-methyl 10 g c.p. ha^{-1}, because these doses caused feedstock with high °Brix, POL, total reducing sugars, purity levels.
Keywords: *Sorghum spp*., phytorregulators, glyphosate, sulfumeturon-methyl.

PERFIL TECNOLÓGICO DE CALDO DE SORGO SACARINO (cv. CMSXS-646) SUBMETIDO À APLICAÇÃO DE MATURADORES QUÍMICOS E ÉPOCAS DE AMOSTRAGEM

RESUMO – Há poucas informações sobre o comportamento da cultura do sorgo sacarino sob manejo de aplicação de maturadores químicos. Portanto, o objetivo desta pesquisa foi avaliar o perfil tecnológico de caldo de sorgo sacarino cv. CMSXS-646 submetido à aplicação de maturadores químicos e períodos de amostragem. Aplicou-se o delineamento de blocos inteiramente casualizados, em esquema de fatorial (7x2), correspondente a maturadores químicos - glifosato (0,2; 0,4 e 0,8 l p.c. ha^{-1}), sulfumeturon-metil (10, 20 e 30 g p.c. ha^{-1}) e tratamento controle (aplicação de água), com dois períodos de amostragem (15 e 30 dias após aplicação - DAA).. Após a colheita, destinaram-se colmos à moagem, realizada em prensa hidráulica, para extração de caldo; avaliaram-se sólidos solúveis totais (°Brix), sacarose aparente (POL), pureza (PRT), açúcares redutores (AR), açúcares redutores totais (ART), fibras (FIB) e açúcares teóricos recuperáveis (ATR). Ao conjunto de dados, aplicaram-se testes estatísticos, Shapiro- Wilk, Fisher, Tukey, Pearson e regressão múltipla, ao nível de 5% de probabilidade. Houve interação entre as causas de variação para quase todas as características, exceto ATR, influenciado, somente, pelo período de amostragem. Concluiu-se que a aplicação dos maturadores químicos glifosato 0,4 l c.p. ha^{-1} e sulfumeturon-metil 10 g p.c. ha^{-1} apresentou um incremento na qualidade da matéria-prima com alto teor de °Brix, POL, açúcares redutores totais e níveis de pureza trinta dias após a pulverização dos maturadores.
Palavras-chave: *Sorghum spp*., fitorreguladores, glifosato, sulfumeturon-metil.

Sugar-energy industry is very important to world sustainability since it offers job opportunities to population, both direct and indirectly, and produces food and feed resources for human and animal consumption, such as industrial sugars (crystal, VHP, brown, *etc*.), alcoholic beverages, silage and forage. In addition, provides services to the international carbon market, helps to reduce greenhouse-derived negative effects, and generates alternative biofuels to petroleum, natural gas, and coal, diversifying *Global Energetic Matrix* (Goldemberg et al., 2014; Milanez et al., 2015; Carvalho et al., 2017).

In Brazil, sugarcane (*Saccharum spp*.) crop is the most important lignocellulosic feedstock employed to industrialization of sugar and first-generation bioethanol. However, due to its morphological and physiological characteristics, regionalization and tillage seasonal planning, there is an ethanol shortage in the off-season period. Hence, government entities-financed centers of research and development are concentrating efforts in studies about sugar extraction from of beets, cassava, maize, sweet sorghum, among others amylaceous crops (Tsao et al., 2011; Carvalho et al., 2013; Carbonari et al., 2014).

Originating from the African continent, sweet sorghum (*Sorghum bicolor* L. Moench) is a rustic crop, resistant to both tropical regions and water stress, with a high photosynthetic capacity; moreover, this crop is well responsive to mechanized agriculture. Owing to its short commercial cycle (90 to 120-days) and high fermentable sugars concentration in stalks, sweet sorghum is widely desirable to sugar and ethanol complementary production, mainly along to sugarcane crop replacement in the off-season period, avoiding sugar-energy industry idleness (Bermann, 2008; Durães, 2011; Han et al., 2011).

Sweet sorghum energetic quality is almost always lowest than sugarcane crop, due to higher fibers content of its lignocellulosic share. However, it is possible overcome this technical problem adjusting the harvest time and/or using chemical ripeners. Theoretically, chemical ripeners (popularly called plant growth regulators) are synthetic products that act as plant hormones, applied to crops for improve its quality and, consequently, supply add-value feedstocks to the industrial processing. Nationally, glyphosate, methyl-sulfumeturon-methyl, ethephon, and ethyl-trinexapac, are the commonly tested main products at sugarcane tillages and, for this reason, there are little scientific information about the its benefits to sweet sorghum crop (Han et al., 2011; Meschede et al., 2011; Heerden et al., 2012; Viana et al., 2015; Muhwiridzwa et al., 2016; Viana et al., 2016).

Therefore, the aim of this study was to assess the technological profile of sweet sorghum (cv. CMSXS-646) juice under spraying of plant growth regulators and sampling periods.

Material and Methods

The research was carried out at São Paulo Agribusiness Technology Agency, located at Andradina, Brazil, geographical coordinates 50°55’23”S and 51°23’37”W. Climate is Aw according to Köppen-Geiger classification system, with rainy summer and dry winter. Moreover, the experimental field soil is a dystrophic yellow-red Latosol. A randomized complete block factorial experimental design was used with an additional control treatment (arrangement 7x2), comprised of chemical ripeners with three-doses, (glyphosate 0.2, 0.4, and 0.8 l c.p. ha^{-1} and methyl-sulfumeturon 10, 20, and 30 g c.p. ha^{-1}),two sampling periods (15 and 30-days after spraying - DAS) and one control treatment (water spraying), with four replications.

Regarding soil preparation, basis saturation was adjusted to 60 % using dolomitic limestone (90 % TNRP). After two-months, *i.e.*, in December 2016, sweet sorghum (cv. CMSXS 646) seeds were sowed at plots with five rows (10 m length) spaced 0.5 m. Finally, after twenty five-days tillage density was adjusted for 100.000 plants per hectare (Durães, 2011).

Sixty-days after sowing, glyphosate and methyl-sulfumeturon doses were sprayed using a CO_2-pressurized sprayer with six flat nozzles (AXI-11002) spaced at 0.5 m along to spraying boom body (Viana et al., 2016). The applications were performed in the morning, from 8:00 to 11:00 a.m., at 25 ± 2.5°C and 70 ± 5.0 % air relative humidity. There was no subsequent rainfall.

Before the flowering stage (± 70-days-age), sweet sorghum plants were randomly harvested considering three-intermediate rows of each plot, leaves were removed, and stalks were milled using a hydraulic press. The derived juice was assessed for soluble solids (°Brix), apparent sucrose (POL), purity (PRT), reducing sugars (RS), total reducing sugars (TRS), fibers (FIB) and recoverable theoretical sugars (RTS) (Durães, 2011; Viana et al., 2016). Although chemical ripeners represented the plots, it was decided to sample the subplots, due to the lower amount of material need to assure acceptable variation and consistence to the results and discussion, since on experimental designs involving chemical products management as plots are more susceptible to randomization effects.

The dataset was subjected to the statistical tests Shapiro-Wilk, Fisher, Tukey, Pearson and multiple linear regression ($p<0.05$). Despite to controversies, MLR techniques can be successful applied to both regular and non-equidistant numeric intervals, since the current computation machines easily solve orthogonal polynomials matrixes, pre-requisite basically preconized to make more easy data processing (Yaghoubi et al., 2017). The statistical analysis was carried out using the R Core Team (Version 3.3.1.) software.

Results and Discussion

The null hypothesis for the interaction level between the causes of variation (chemical ripener and sampling period) was rejected for almost all assessed traits, except RTS, which was only significantly affected by the last factor. Furthermore, low coefficient of variation values displayed compatibility between sweet sorghum crop management and the applied experimental design (Table 1).

Regarding the singular effects of the chemical ripener, glyphosate 0.8 l c.p. ha^{-1} and methyl-sulfumeturon 30 g c.p. ha^{-1} presented the best means for °Brix and no significant difference between doses. In addition, similar mean of °Brix was observed in the non-treated juice, indicating that the effects of plant growth regulators were not enough to significantly enhance soluble solids concentration (Table 2).

Glyphosate 0.4 l c.p. ha^{-1}, glyphosate 0.2 l c.p. ha^{-1} and methyl-sulfumeturon 20 g c.p. ha^{-1}, presented a negative effect on °Brix content, with 2% reduction, suggesting that higher ripener doses stimulated sugar fixation by the sweet sorghum plants owing to apical dominance removal associated with inhibition of invertase enzyme and blockage of the metabolic shikimic acid pathway, particularly the glyphosate herbicide(Meschedeetal.,2011;Carbonarietal.,2014). Assessing sweet sorghum (cv. Biomatrix 535), Viana et al. (2015) reported that some methyl-sulfumeturon and glyphosate doses increased the total soluble solids content of juice, corroborating the results of this study. Otherwise, studying methyl-sulfumeturon effects on qualitative aspects of sweet sorghum (cv. 80007) juice, Viana et al. (2016) observed an inverse relation between °Brix and dose of chemical ripener. According to Kumar et al. (2008), nutritional status, crop sanity, genotype, weather conditions, edaphic elements, and plant growth regulators-types can positively or negatively affect °Brix. Under the industrial viewpoint, sugarcane or sweet sorghum juices with about to 18 °Brix are desirable to sustainable production of sugar and first-generation bioethanol. So, based only on °Brix values, all treatments presented feasibility to sugar-energy industry.

Table 1. Summary of analysis of variance for effects of chemical ripeners and sampling period on technological profile of juice from sweet sorghum cv. CMSXS 646.

Causes of variation	Parameter of quality†						
	TSS	Sucrose	Purity	RS	TRS	Fibers	Sugar yield
	F-value						
Chemical ripeners (A)	141.6*	126.9*	74.3*	369.5*	474.5*	108.9*	1.9
Sampling period (B)	77.1*	996.7*	942.4*	956.1*	938.9*	80.2*	9.3*
Interaction (A x B)	104.4*	57.8*	54.4*	226.7*	731.8*	47.9*	2.2
Coefficient variation, %	1.1	2.1	2.6	1.4	1.3	1.0	10.6
Shapiro-Wilk's p-value	0.3*	0.3*	0.4*	0.5*	0.1*	0.9*	0.4*

*significance ($p<0.05$) and NS no significance ($p\geq0.05$).

†Total soluble solids (TSS), reducing sugars (RS) and total reducing sugars (TRS).

Table 2. Simple effect of chemical ripeners on technological profile of sweet sorghum (cv. CMSXS 646) juice.

Chemical ripeners	°Brix	Pol	Purity	RS(1)	TRS(1)	Fibers	RTS(1)
Glyphosate 0.2 l c.p. ha^{-1}	19.0c	10.3e	54.7d	1.9a	9.1d	20.0a	82.8a
Glyphosate 0.4 l c.p. ha^{-1}	18.7c	12.3c	66.12ab	1.4e	11.0b	17.4d	99.3a
Glyphosate 0.8 l c.p. ha^{-1}	21.2a	11.2d	52.9d	1.8b	10.4c	18.7b	94.1a
Methyl-sulf. 10 g c.p. ha^{-1}	20.3b	13.9a	68.6a	1.2f	11.7a	19.9a	94.3a
Methyl-sulf. 20 g c.p. ha^{-1}	19.0c	11.2d	59.5c	1.5c	10.4c	18.2c	94.3a
Methyl-sulf. 30 g c.p. ha^{-1}	21.1a	13.1b	62.1c	1.5c	11.6a	18.9b	104.3a
Control (water spraying)	21.0a	13.2b	62.6bc	1.5d	11.9a	20.2a	102.0a

Averages followed by same letters on columns had no difference by Tukey's test ($p<0.05$); (1)Reducing sugars (RS), total reducing sugars (TRS) and recoverable theoretical sugars (RTS).

Concerning sucrose apparent, methyl-sulfumeturon 10 g c.p. ha^{-1} reached the highest POL content. Compared with control treatment, all doses of chemical ripeners reduced POL by 1.5%, approximately, in contrast to the results obtained by Leite et al. (2009) and Silva et al. (2010). However, results of this work agree to Viana et al. (2016).

In general, purity percentages were higher than the values reported by Viana et al. (2016), who also verified positive effects on juice purity of sweet sorghum cv. 80007 by applying the chemical ripeners ethephon, methyl-sulfumeturon and thiadiazuron (TDZ).

The best RS percentages were displayed by juices extracted from plants that received glyphosate 0.2 l c.p. ha^{-1} and glyphosate 0.8 l c.p. ha^{-1}. There was no statistical diference between doses. Audilakshmi et al. (2010) and Viana et al. (2015, 2016) evaluating sweet sorghum hybrids obtained RS values similar to the observed in this study. Theoretically, feedstocks with high monosaccharide concentration are desirable for bioethanol industrialization, since they enhance alcoholic fermentation and partially reduce production costs associated with transport and electrical energy spent (Audilakshmi et al., 2010).

Non-treated juice of sweet sorghum reached highest TRS value. However, this treatment was not significant for methyl-sulfumeturon 30 g c.p. ha^{-1}. In general, chemical ripeners reduced juice TRS, especially glyphosate 0.2 l c.p. ha^{-1}.

Compared with control treatment, glyphosate 0.4 l c.p. ha^{-1} decreased 3% fiber percentage, approximately. Similar patterns were observed to the other doses. Data of this study corroborate the results reported by Silva et al. (2010) but disagree from Viana et al. (2016), suggesting that there is specificity between sweet sorghum cultivars and chemical ripener-types.

RTS was not significantly affected by the chemical ripeners. However, plants subjected to methyl-sulfumeturon 30 g c.p. ha^{-1} showed yield greater than control. Moreover, remaining doses had negative effects on RTS. Viana et al. (2016) obtained 87.2 kg t^{-1} RTS applying methyl-sulfumeturon 5 g c.p. ha^{-1}. Other authors found similar patterns (Meschede et al., 2009; Souza & Foloni, 2012). According to Viana et al. (2015), RTS is very important to sugarcane chain, as this technological trait is directly associated to price paid by feedstock to farmers. Sweet sorghum plants sampled at 15 DAS produced juice with higher °Brix than those sampled at 30 DAS, indicating an antagonistic effect, but no significance, from harvest time on feedstock total soluble solids concentration (Table 3).

Oliveira Filho et al. (2016) and Viana et al. (2016), studying sugarcane varieties and sweet sorghum, respectively, observed a positive association between °Brix and sampling periods: 18.4% and 19.3% at 15 and 30 DAS, and 12.7 and 14.3 % at 15 and 32 DAS, respectively, contrasting to the results of this research. According to Viana et al. (2015), there is an inverse relation between plant age and °Brix concentration, owing to intensive deposition oflignin on stalks, which considerably reduces carbohydrate accumulation into plant parenchymatic tissues.

In summary, juices from plants harvested at 30 DAS displayed best POL, purity, TRS, and RTS yields, corroborating results reported by Viana et al. (2016) and Oliveira Filho et al. (2016). Similarly, evaluating the response of sugarcane genotypes to plant growth regulators, Caputo et al. (2008) verified significant increases of °Brix, POL, purity, and RTS over to sampling periods.

Analysis of variance and multiple comparisons results for the interaction effect between chemical ripeners and sampling period are shown in Table 4.

Table 3. Simple effects of sampling period on technological profile of sweet sorghum (cv. CMSXS 646) juice.

Sampling periods	°Brix	Pol	Purity	RS$^{(1)}$	TRS$^{(1)}$	Fibers	RTS$^{(1)}$
15 DAS$^{(2)}$	20.3^{a}	10.6^{b}	52.5^{b}	1.8^{a}	10.7^{b}	19.4^{a}	101.7^{a}
30 DAS	19.7^{b}	13.7^{a}	69.4^{a}	1.3^{b}	11.7^{a}	18.7^{b}	90.0^{b}

Means followed by same letters on columns do not differ by Tukey's test (*p<0.05*); $^{(1)}$Reducing sugars (RS), total reducing sugars (TRS) and recoverable theoretical sugars (RTS); $^{(2)}$Days after spraying (DAS).

Table 4. Interaction effect of chemical ripeners and sampling periods on technological profile of sweet sorghum (cv. CMSXS 646) juice.

Periods	Chemical ripeners						
	Control	Glyphosate (L c.p. ha^{-1})			Mtethyl-sulfumeturon (g c.p. ha^{-1})		
	0.0	0.2	0.4	0.8	10	20	30
	°Brix (%)						
15 DAS$^{(1)}$	21.2^{aA}	19.9^{aBC}	19.5^{aC}	21.5^{aA}	18.7^{bD}	20.4^{aB}	21.3^{aA}
30 DAS	20.9^{bB}	17.9^{bC}	17.9^{bC}	20.8^{bB}	21.9^{aA}	17.7^{bC}	20.9^{bB}
	POL (%)						
15 DAS	10.5^{bC}	9.9^{bCD}	9.7^{bD}	10.4^{bCD}	12.3^{bA}	10.5^{bC}	11.4^{bB}
30 DAS	15.8^{aA}	10.8^{aD}	14.7^{aB}	12.0^{aC}	15.6^{aA}	11.9^{aC}	14.8^{aB}
	Purity (%)						
15 DAS	49.5^{bBC}	49.6^{bBC}	49.7^{bBC}	48.3^{bC}	65.8^{bA}	51.4^{bBC}	53.4^{bB}
30 DAS	75.8^{aB}	59.9^{aD}	82.6^{aA}	57.6^{aD}	71.5^{aC}	67.6^{aC}	70.9^{aC}
	Reducer sugars (%)						
15 DAS	1.9^{aA}	1.9^{aA}	1.9^{aA}	1.9^{aA}	1.3^{aC}	1.8^{aB}	1.8^{aB}
30 DAS	1.1^{bE}	1.8^{bA}	0.9^{bF}	1.7^{bB}	1.2^{bD}	1.3^{bC}	1.3^{bC}
	Total reducer sugars (%)						
15 DAS	10.9^{bA}	9.2^{aC}	9.2^{bC}	9.9^{bB}	10.6^{bA}	10.0^{bB}	10.5^{bA}
30 DAS	12.9^{aA}	8.9^{bC}	12.9^{aA}	10.9^{aB}	12.7^{aA}	10.8^{aB}	12.8^{aA}
	Fibers (%)						
15 DAS	10.9^{bA}	9.2^{aC}	9.2^{bC}	9.9^{bB}	10.6^{bA}	10.0^{bB}	10.5^{bA}
30 DAS	12.9^{aA}	8.9^{bC}	12.9^{aA}	10.9^{aB}	12.7^{aA}	10.8^{aB}	12.8^{aA}

Means followed by the same upper-case letters in the lines and lower-case letters in the columns, not differ at Tukey's test (*p<0.05*); $^{(1}$ Days after spraying (DAS).

Higher °Brix contents were observed in the juices from plants sprayed with methyl-sulfumeturon 10 g c.p. ha^{-1} and glyphosate 0.8 l c.p. ha^{-1}, sampled at 15 DAS. However, both treatments do not significantly differed from non-treated, indicating that chemical ripeners and sampling periods were not enough to considerably increase soluble solids level. °Brix yield is proportional to dry mass production, which increases significantly during physiological maturation of the crop (Leite et al., 2011).

Sugarcane and sweet sorghum are fit to mechanized harvest only when reach 15.5 to 16.5 °Brix, providing juice with high fermentation quality and increased ethanol yield (Prasad et al., 2007). In this sense, chemical ripeners-treated sweet sorghum (cv. CMSXS 646) could be harvested seventy five-days after sowing, preventing pests and diseases attacks and another adverse weather effects, factors which could cause sucrose inversion and reduction of energetic power quality on feedstock.

Regarding POL, non-treated samples from 30 DAS presented apparent sucrose percentage higher than samples from 15 DAS. Similar situations were observed for methyl-sulfumeturon 10 g c.p. ha^{-1}, methyl-sulfumeturon 30 g c.p. ha^{-1}, and glyphosate 0.4 l c.p. ha^{-1} treatments. Therefore, the largest sweet sorghum crop time on field increased sucrose concentration on stalks owing to higher exposure of plants to photosynthesis advantages, as well as advanced maturation degree.

The best purity value was displayed by the feedstock treated with glyphosate 0.4 g c.p. ha^{-1}, sampled at 30 DAS. Pure juices are more desirable to bioethanol production because of the ease industrial extraction of sugar (Viana et al., 2015).

Plants harvested at 15 DAS showed highest RS percentage compared to 30 DAS. In this last sampling period, there was great fiber deposition on feedstock; there is an inverse relation between reducing sugars and fibers (Caputo et al., 2008).

For the TRS, samples from 30 DAS treated with methyl-sulfumeturon 10 g c.p. ha^{-1}, methyl-sulfumeturon 30 g c.p. ha^{-1}, and glyphosate 0.4 l c.p. ha^{-1} produced 2% more juices, approximately, than samples from 15 DAS. However, these dosages were not statistically different from the control. Total soluble solids, purity, and TRS are the most important parameters associated with determining feedstock energetic quality (Caputo et al., 2008; Silva et al., 2010). For Viana et al. (2015), TRS is more important than Pol for technological analysis of sweet sorghum, since this parameter reveal the true feedstock quality status.

Compared to the control treatment, samples from 30 DAA sprayed with glyphosate 0.2 l c.p. ha^{-1} presented 4% less fiber percentage. Fibers are relevant to mechanical resistance of plants against pest attacks and prevent crop tumbling. However, this characteristic is undesirable under both industrial and economic viewpoints. In sugarcane chain, for example, milling operational capacity and RTS yield are reduced 15% and 1.85 kg t^{-1}, respectively, due to increases of 0.5 and 1% of fiber percentage, respectively (Carvalho et al., 2017). For these researchers, feedstocks with about 12.5% FIB are fit to industrialization of sugar and bioethanol. Pearson's correlation test results are shown in Table 5.

°Brix and POL presented inverse and direct correlations with purity, respectively. Sales et al. (2016) evaluated sugarcane genotypes and obtained positive correlation between °Brix and purity, unlike to the results of this study. According to Carvalho et al. (2017), pure feedstocks usually presented low °Brix percentage, supporting findings from this study.

POL it directly correlated with TRS and RTS and inversely with RS. A similar pattern was observed for purity, supporting results recorded by Carvalho et al. (2013), Dalchiavon et al. (2014) and Sales et al. (2016). According to these researchers, there are positive correlations between purity, TRS, and RTS. Adjusted multiple linear regressions to parameters that establishedsignificantcorrelationsareshowninTable6.

The mathematical interpretation of equations shows that apparent sucrose content would increase 0.15, 3.70 and 0.12% with unit increases of purity, RS, TRS, and RTS percentages, respectively.

Increases in RS and RTS content would decrease purity in 32.32% and 0.08%, respectively. On the other hand, this characteristic would be improved 0.23% with TRS increase.

Table 5. Linear associations between technological traits of sweet sorghum (cv. CMSXS 646) juice under spraying of chemical ripeners and sampling periods.

Traits(1)	POL	Purity	RS	TRS	Fibers	RTS
°Brix	$+0.11^{NS}$	-0.31^{NS}	$+0.24^{NS}$	$+0.23^{NS}$	$+0.24^{NS}$	$+0.20^{NS}$
POL		$+0.91^{*}$	-0.90^{*}	$+0.93^{*}$	$+0.16^{NS}$	$+0.96^{*}$
Purity			-0.97^{*}	$+0.81^{*}$	$+0.10^{NS}$	$+0.85^{*}$
RS				-0.84^{*}	$+0.06^{NS}$	-0.89
TRS					$+0.07^{NS}$	$+0.95^{*}$
Fibers						-0.02^{NS}

(1)Reducing sugars (RS), total reducing sugars (TRS) and recoverable theoretical sugars (RTS); *Significance (P < 0.05) and NSno significance (P ≥ 0.05).

Table 6. Adjusted multiple regressions to technological traits of sweet sorghum (cv. CMSXS 646) juice under spraying of chemical ripeners and sampling periods

Traits(1)	$Y_i = B_0 + B_1X_1 + B_2X_2 +...+ B_kX_k$	R^2_{adj}
Sucrose	POL (%) = $-16.97^{*} + 0.15PRT^{*} + 3.70RS^{*} + 0.18TRS^{NS} + 0.12RTS^{*}$	0.97^{*}
Purity	PRT (%) = $117.07^{*} - 32.32RS^{*} + 0.23TRS^{NS} - 0.08RTS^{NS}$	0.93^{*}
RS	RS (%) = $4.11^{*} - 0.02TRS^{NS} - 0.02RTS^{*} + 0.12POL^{*} - 0.03PRT^{*}$	0.97^{*}
TRS	TRS (%) = $12.87^{*} + 0.69\ POL^{*} - 0.10\ PRT^{*} - 2.68\ RS^{*}$	0.90^{*}
RTS	RTS (kg t^{-1}) = $109.16^{*} + 5.18POL^{*} - 0.83PRT^{*} - 24.25RS^{*} + 1.29\ RTS^{*}$	0.97^{*}

(1)Reducing sugars (RS), total reducer sugars (TRS) and recoverable theoretical sugars (RTS); *Significance ($p<0.05$) and NS no significance ($p\geq0.05$).

TRS share on physical-chemical composition of sweet sorghum juice would be decreased 2.68 and 0.10%, respectively, for each RS percentage point increase, indicating antagonistic effects of reducing sugars in the apparent sucrose yield.

Regarding RTS, significant increases of 5.18 and 1.29 kg t^{-1} were observed for each POL and TRS point. However, 24.15 kg t^{-1} depreciation occurred with increase in RS percentage.

Statistical analyses involving multiple regressions in studies about sugarcane and sweet sorghum are essential to the sugar-energy industry evolution, as the use of this information is helpful to define associated strategies to plant physiology, fertilization management, plant genetic breeding, and industrial operations, aiming to enhances feedstock quality to sustainable production of sugar and bioethanol (Dalchiavon et al., 2014).

Conclusions

The tested plant growth regulators (glyphosate and sulfumeturon-methyl) are recommendable to sugar-energy industry, due to the increase in °Brix, POL, PRT, TRS, and TRS averages, and reduction of FIB content, improving energetic power quality of sweet sorghum (cv. CMSXS-646) juice.

Sulfumeturon-methyl 10 g c.p. ha^{-1} was effective in adding value to sweet sorghum (cv. CMSXS-646) juice, since ripener product induces decreases in fibers content, while the plant growth regulator enhances POL and purity, and reduces RS percentage.

On another hand, it is possible grow sweet sorghum (cv. CMSXS-646) till thirty-days after spraying of chemical ripeners, glyphosate 0.4 l c.p. ha^{-1} or sulfumeturon-methyl 10 g c.p. ha^{-1}, because these doses induced high °Brix, POL, total reducing sugars and purity level.

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