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RESEARCH ARTICLE

AGRONOMIC PERFORMANCE OF SUGARCANE CROP IN NORTHWEST RIO GRANDE DO SUL STATE, BRAZIL

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ABSTRACT

The aim of this study is to verify, by introducing in the northwest of the RS of19 genotypes of sugarcane, that best respond for agronomic traits to three crop years, becoming promising for cultivation by farmers in the region. The traits evaluated were: total juicebrix, juiceyield and stem mass. The experimental design was a randomized complete block with three replications. Aiming at early production the genotypes RB765418, IAC 87-3396, IAC 91-5035 and Nova Iraí are more suitable for cultivation in northwest region of Rio Grande do Sul. The genotype IAC 87-3396 after the third crop year has higher productivity juice brix and stem mass. The genotype IAC 87-3396 stands out at the end of three years as the best genotype for juice yield and stem mass.

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INTRODUCTION

The sugarcane (*Saccharum spp*.) has an important role in the agricultural and socio-economic scenario of Brazil and a promising future in the world scenario, mainly because it is the main source of raw material in the production of biofuels (Maule *et al*., 2001; Dalchiavon *et al*., 2014). Currently, sugarcane crop is responsible for a significant strip of the gross domestic product (GDP), accounting for about 3.65% of the 2008/2009 agricultural GDP, generating foreign exchange from the export of sugar and alcohol in addition to generating jobs direct and indirect (Conab, 2014). The sugarcane is grown in much of Brazil being distributed in an area of 8.5 million hectares, with production of 602,179,000 megagramas per hectare (Mg ha^{-1}) of sugarcane stems processed by the sugar industry, which shows an average yield of 73 Mg ha^{-1}being the state of São Paulo, the largest producer (Conab, 2014). The sugarcane crop in Rio Grande do Sul holds around 35 thousand hectares (Nava *et al*., 2009) mostly in small areas of land or in marginal areas sharing space with other cultivated species.

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The state's average production is considered low, according to Conab estimate for the 2011/2012 harvest this value reaches 50 Mg ha^{-1} with 26.7% less than the Brazilian average. According to Casa Grande (1991) to respond with high productivity sugarcane requires fixed and balanced soils. In Brazil, the favorable climatic conditions for the development of culture extend throughout the country, except the Rio Grande do Sul (RS) and Santa Catarina (SC), that the severe winter, with risk of frost can compromise the establishment of sugarcane crop. But the RS state in 2009 according to the agro-ecological zoning pointed 1.5 million hectares with fitness to the cultivation of sugarcane crop (Manzatto *et al*., 2009), which extends the crop options for farmers, making If a new source of economic returns for the region. The knowledge of sugarcane plantation behavior in different crop years, as well as the different regions are required to evaluate, identify and indicate highly productive genotypes and with quality of raw material (Verissímo *et al*., 2012), mainly to the circumstances regions to which the genotypes were not evaluated for agronomic performance. The study of culture in their development environment it is necessary to observe the most recommended genotypes. Being that for northwest region of Rio Grande do Sul state, there is no recommended genotype

for planting according to soil and climate characteristics, highlighting this region has thermal constraints, with severe winter and occurrence of frosts, conditions that can harm the development of culture. The climate differentiation combined with type more abrupt relief and destination of production. The difference in the historical process of colonization are some factors that may link the planting of sugarcane in the gaúcha family farm, may be noted that family farms. It represents a large portion of the RS economy, being the source of income of many families (Verissimo *et al*., 2012).

In this sense, detailed studies on the behavior of genotypes become necessary to identify agronomically superior genotypes. In this context, the aim of this study is to verify, by introducing in the northwest of the RS of 19 genotypes of sugarcane, best respond for agronomic traits to three crop years, becoming it promising for cultivation by farmers in the region.

MATERIALS AND METHODS

The experiment is located in the experimental area of the Federal University of Santa Maria Campus Frederico Westphalen– RS, belonging to the Plant Breeding Laboratory and Plant Production, situated at latitude 27º 23'S; 53º 25'W longitude, 461 m of altitude, the climate of the region according Koppen climate classification is subtropical with an average annual temperature of 20.5ºC. The experimental design was a randomized complete block containing three repetitions, made up of five lines of five meters. The evaluations were conducted in three central rows, and the 15 m² of useful plotarea.For the study used 19 sugarcane genotypes, IAC SP 93-6006, IAC 91-2218, IAC87-3396, IAC91-5155, IAC 91-2195, RB 855453, RB 85506, Nova Iraí, LigeirinhaRoxa, Pernambucana, SP 716163, RB 785750, NA 56792, IAC 91-5035, Preguiçosa, Tucumã, Palhuda, RB 835089, RB 765418, from producers the region and research institutes. For the evaluations were taken two stems without straw of each plot, according to the methodology tested with two, four and six stems per experimental unit, and found that the use of two stems per plot was representative for analysis. The variables analyzed were: total juicebrix, juiceyield and stem mass. The brix was determined using a portable refractometer collecting a sample of the juice stems. The refraction in Brix scale, is a physical method for measuring the amount of soluble solids present in a sample, is based on a graduated system, specifically the analysis of sugars in general that are in solution (Marques and Silva, 2008).

The yield from juice was determined by extracting the juiceof two stems grinder with three rollers, where the measured volume of juice through a graduated cylinder. The measurement of the mass of stems was carried out by weighing stems without straw, and extrapolated to the number of stems of the plot, and from this value to the mass of stems per hectare. The evaluations were performed for three consecutive years 2008, 2009 and 2010 were adopted the winter period to conduct evaluations, considering that this is the most critical period for culture in the region due to climate constraints. Data were submitted to analysis of variance, and after the grouping means the method proposed by Scott-Knott (1974). The means were grouped together to identify interaction between genotypes and crop year separately to analyze which would best genotype within each year.

RESULTS AND DISCUSSION

Analysis of variance showed significant differences for the three traits evaluated for factor variation genotypes, but, showed no interaction for genotypes x years. However, the means were dismembered for each year with aim to identify the response of sugarcane genotypes within each year of evaluation. According to the technical study of taking advantage alternatives of sugarcane performed by Oliveira (2004), the harvest of sugarcane should occur between 12 and 14 months after planting or cutting, period in which the plant reaches its maturation point, indicated by the soluble solids in the juice, which is an ideal minimum of 18 degrees brix. The extent that sugarcane gets old, the normal tendency is to increase the brix, which could reach up to 23 degrees brix depending on the genotype, season of year and growing region. In the first year in which the crop is in the establishment phase is observed low brix values. Among the genotypes studied, may be highlight the genotypes of RB group with better averages (Table 1), being: RB765418, RB835089 and RB855453, whose percentages are 15.3%, 14.6% and 14.6%, but , they did not differ statistically from the other genotypes.

Table 1. Results for the year 2008 of 19 genotypes of sugarcane for traits total juice brix (%), juice yield (l ha^{-1}) and stem mass (kg ha^{-1}) in Frederico Westphalen – RS

Genotypes	Brix(%)	Juice (l ha^{-1})	Mass (kg ha^{-1})
IAC SP93- 6006	11.60 a*	7942.130 k	14389.013 l
IAC 91-2218	14.50 a	10612.963 g	21703.360 f
IAC 87-3396	13.73 a	13533.333 d	29732.196 c
IAC 915155	10.20 a	9461.573 j	17259.750 j
IAC 91-2195	13.33 a	17293.516 b	21524.853 f
RB 855453	14.66 a	6500.463 m	13245.593 n
RB 85506	13.33 a	6116.203 n	13870.42 m
Nova Iraí	13.33a	10491.666 h	26744.903 d
Ligeir. Roxa	13.93a	5455.556 p	11330.973 p
Pernambucana	9.23 a	3913.426 q	8352.960 r
SP 716163	12.33 a	2580.553 s	6545.386 s
RB 785750	12.23 a	3908.796 r	9544.746 q
NA 56792	12.33 a	10070.833 i	21486.160 h
IAC 91-5035	13.06 a	16871.296 c	33650.046 b
Preguiçosa	11.83 a	11884.723 f	25841.996 e
Tucumã	12.16 a	6548.146 l	15682.413 k
Palhuda	13.86 a	5517.593 o	12868.296 o
RB 835089	14.66 a	12692.130 e	20838.923 i
RB 765418	15.33 a	18398.150 a	36022.926 a
CV(%)	14.28	8.33	6.68

*Means followed by the same letter in the column do not differ statistically by Scott-Knott at 5% probability.

In regarding of production of juice (l ha^{-1}) can stand RB 765418 (18398.15 l ha^{-1}) and IAC 91-2195 (17293.51 l ha^{-1}) genotypes as the most productive, where genotypes SP 716163 (2580.553 l ha^{-1}) and RB 785750 (3908.79 l ha^{-1}) are those who had the lowest average magnitudes for juiceyield (Table 1). It may be noted that the respective genotypes showed values almost five times smaller than the superior genotypes. With the production of stems (Table 1) it is observed that the genotypes showed considerable discrepancies in the average mass ha^{-1}, being respectively of 36022 kg ha^{-1}

(RB 765418) and 6545.386 kg ha^{-1} (SP 716163). The genotypes RB 765418, IAC 87-3396, IAC 91-5035 and NovaIraí showed the best performance for the first crop year, which indicates they are earlier and more productive than the other genotypes. In contrast, genotypes with lower agronomic performance SP 716163, Pernambucana and RB 785750 all below 10 ton ha^{-1}.Both the magnitudes average higher as the lower, fall far short of the genotypes used in studies of Abreu *et al*. (2013), in the northeast region where the average sugarcane productivity (plant) exceeded 75 ton ha^{-1}. Demonstrating that the conditions of Northwest RS region, as well as other local state generate great influence on genotypes of sugarcane, mainly by the severe winter for much of the year. With regard the evaluations made in the second crop year (Table 2), noted that there was significance differences among genotypes for brix, and yet, the genotypes showed higher percentage of brix for the second crop year, in regard the first crop year. This fact is primarily the culture prioritize, in the first year, the directing their photo assimilates to the growth and vegetative development, after the establishment of the plant the sugar levels increase (Henrique *et al*., 2011).

Table 2. Results for the year 2000 of 19 genotypes of sugarcane for traits total juice brix (%), juice yield (l ha^{-1}) and stem mass (kg ha^{-1}) in Frederico Westphalen – RS

Genotypes	Brix (%)	Juice (l ha^{-1})	Mass (kg ha^{-1})
IAC SP93-6006	15.66 a*	17554.110 a	42682.396 e
IAC 91-2218	15.76 a	12872.870 i	39049.690 g
IAC 87-3396	17.50 a	15387.953 e	60663.526 a
IAC 91-5155	16.33 a	17228.436 d	38761.886 i
IAC 91-2195	17.33 a	17491.130 b	33041.866 l
RB 855453	17.50 a	7777.606 r	12768.456 r
RB 85506	18.66 a	10382.293 o	26598.860 q
Nova Iraí	16.83 a	11309.923 k	50231.686 c
Ligeir Roxa	17.01 a	12389.506 j	35700.106 j
Pernambucana	16.66 a	11071.193 l	29558.380 n
SP 716163	15.66 a	4967.050 s	7606.923 s
RB 785750	20.83 a	10837.140 m	28257.690 o
NA 56792	17.66 a	14201.783 g	42433.490 f
IAC 91-5035	17.01 a	14484.630 f	57436.573 b
Preguiçosa	17.00 a	10113.756 p	45804.860 d
Tucumã	18.66 a	9684.050 q	27498.456 p
Palhuda	16.16 a	17243.343 c	33075.116 k
RB 835089	19.33 a	10702.776 n	30838.360 m
RB 765418	18.16 a	13525.380 h	38923.220 h
CV(%)	9.77	5.8	6.04

*Means followed by the same letter in the column do not differ statistically by Scott-Knott at 5% probability.

For the juice yield trait (Table 2), the genotypes IAC SP 93-6006, IAC 91-2195 and Palhuda stood out positively with average 17554,11 l ha^{-1}, 17491,13 l ha^{-1} and17243,34 l ha^{-1}, respectively. The lower genotypes for the first year of evaluation continued with the lowest average magnitudes in the second crop year, indicating they are not promising for cultivation in edaphoclimatic conditions of the region. According to Oliveira *et al*. (2014), the growth in agricultural production of sugarcane may be obtained by increasing the stems production per unit area, the increase in sugar in the stems or higher longevity of the plantation. The appropriateness of using genotypes that suit ace soil conditions and local climate and fertilization, are two of the most important factors to achieve this goal. The genotypes IAC 87-3396, IAC 91-5035 and Nova Iraihad average stem mass (Table 2) of the 60,663.52 kg ha^{-1}, 57,436.57 kg ha^{-1} and 50231.68 kg ha^{-1}, and superior genotypes in relation to the mass of stem. Verissímo *et al*. (2012), points out that the evaluation, identification and indication of promising genotypes of sugarcane is of fundamental importance to the development of culture. According Dalchiavon *et al*. (2014), the socio-economic importance of the culture of sugarcane in Brazil is unquestionable, due to the use of various technological levels in the production.

In the third crop year (Table 3), the genotypes showed significant differences in brix content, reaching the best medium to 18 degrees, being Tucumã, RB 835089 and RB 85506. It is also observed that genotypes, Pernambucana, Preguiçosa and IAC 91-2218 had lower sugar content at 14.4%, 15.7% and 15.9%. The choice of variety is one of the points that deserve special attention, because every year there are new genotypes, and the risks in adopting a variety decrease the extent to which greater stability of the variety of climatic conditions of the region (Henrique *et al*., 2011). The genotype IAC 87-3396 showed the best development for the other variables followed by New Iraí. These genotypes averages 43861.11 l ha^{-1}, 33969.44 l ha^{-1} for juiceyield and 91630.88 kg ha^{-1}, 79,874.61 kg ha^{-1} for stem mass, respectively. It may be inferred that these genotypes showed higher magnitude for the traits in the third crop year, that indicates present late cyclebehavior compared to genotypes RB 765418, IAC 87-3396, IAC 91-5035, which showed higher juice yield and stem mass in the first two crop years.

Table 3. Results for the year 2010 of 19 genotypes of sugarcane for traits totaljuice brix (%), juice yield (l ha^{-1}) and stem mass (kg ha^{-1}) in FredericoWestphalen – RS

Genotypes	Brix (%)	Juice (l ha^{-1})	Mass (kg ha^{-1})
IAC SP93-6006	16.20 b*	17993.520 m	37910.550 n
IAC 91-2218	15.93 b	30798.150 c	61775.340 e
IAC 87-3396	16.60 b	43861.110 a	91630.883 a
IAC 91-5155	16.53 b	21213.890 i	47532.200 i
IAC 91-2195	17.76 a	20589.813 j	44707.803 k
RB 855453	17.03 b	8823.146 s	20506.553 s
RB 85506	18.06 a	11923.150 o	30019.136 o
Nova Iraí	18.00 a	33969.443 b	79874.610 b
Ligeir. Roxa	16.06 b	27021.293 f	54052.310 h
Pernambucana	14.43 b	11223.146 p	24588.180 q
SP 716163	16.00 b	9085.186 r	22362.480 r
RB 785750	16.60 b	9730.556 q	26843.803 p
NA 56792	16.83 b	17647.223 n	40655.906 l
IAC 91-5035	16.96 b	25075.926 h	56055.336 g
Preguiçosa	15.70 b	29836.113 d	71032.483 c
Tucumã	18.76 a	19527.725 k	46556.126 j
Palhuda	17.42 a	25206.483 g	59294.816 f
RB 835089	18.36 a	29317.593 e	69052.373 d
RB 765418	17.60 a	18545.370 l	38870.800 m
CV(%)	6.33	5.15	4.40

*Means followed by the same letter in the column do not differ statistically by Scott-Knott at 5% probability.

Regarding the brix content on the analysis of three crop years (Table 4) was observed that there were no significant differences among the genotypes. According to Matsuoka *et al*. (2005), the trait has additive gene effect, as soon as the influence of the crop year on the brix is small, but the plant breeding as well as the sugar sector seeks to identify of genotypes with high content of soluble solids, due to be a trait of great importance to industry.

Table 4. Results for the three years, 2008, 2009 and 2010 of 19 genotypes of sugarcane for traits to taljuice brix (%), juice yield (l ha^{-1}) and stem mass (kg ha^{-1}) in Frederico Westphalen – RS

Genotypes	Brix (%)	Juice (l ha^{-1})	Mass (kg ha^{-1})
IAC SP 93-6006	14.48 a*	14497 l	31661 m
IAC 91-2218	15.40 a	18095 e	40843 e
IAC 87-3396	15.94 a	24261 a	60676 a
IAC 915155	14.35 a	15968 j	34518 j
IAC 91-2195	16.14 a	18458 d	33092 l
RB 855453	16.40 a	7700 r	15507 r
RB 85506	16.68 a	9474 o	23496 o
Nova Iraí	16.05 a	18590 c	52284 b
Ligeirinha Roxa	15.50 a	14955 k	33694 k
Pernambucana	13.44 a	8736 p	20833 q
SP 716163	14.66 a	5544 s	12172 s
RB 785750	16.55 a	8159 q	21549 p
NA 56792	15.61 a	13973 m	34859 i
IAC 91-5035	15.51 a	18811 b	49047 c
Preguiçosa	14.84 a	17278 g	47560 d
Tucumã	16.53 a	10642 n	29912 n
Palhuda	15.81 a	15989 i	35079 h
RB 835089	17.45 a	17571 f	40243 f
RB 765418	17.03 a	16823 h	37939 g
CV(%)	9.89	6.8	5.99

**Means followed by the same letter in the column do not differ statistically by Scott-Knott at 5% probability.

Regarding the 19 genotypes in three crop years it can be inferred that the culture of sugarcane suffers from the unfavorable climate in the winter period due to thermal restrictions and the sunlight period that is less, where affect the accumulation sugars. The best genotypes were: RB 835089, RB 765418 and RB 85506 with averages of 17.4%, 17.0% and 16.6% just a little below the recommended to cut sugarcane for tropical regions. According to Henrique (2011), evaluating nine genotypes in different harvesting periods observed similar sugar content, ranging from 9% to 20% in the last time that corresponds to the about month of July. These values become smaller yet when observed genotypes in three years (Table 5), that is, 13.4%, 14.3% and 14.4% for the respective genotypes Pernambucana, IAC91-5155 e IAC SP 93-6006, with similarity among all analyzed genotypes. This genotype latter was also evaluated by Henrique (2011), behaving in an intermediate way upward trend among the four cutting times and nine genotypes.

Table 5. Average results in three years for traits juice brix (%), juice yield (l ha^{-1}) and stem mass (kg ha^{-1}) in Frederico Westphalen-RS

Anos	Brix (%)	Juice (l ha^{-1})	Mass (kg ha^{-1})
2008	12.93 b*	9492.79 c	18980.78 c
2009	17.36 a	12590.79 b	35838.50 b
2010	16.88 a	21652.04 a	48595.88 a
CV(%)	9.89	6.8	5.99

*Means followed by the same letter in the column do not differ statistically by Scott-Knott at 5% probability.

Regarding variables, juice yield and stem mass at the end of the three years of evaluation the genotype that stood out was IAC87-3396, with average values of 24261 l ha^{-1} and 60676kgha^{-1} to the respective traits. According to Crispim (2006), which describes the growing IAC87-3396 as late cycle, reveals a good production of stems and high brix, is also characterized as agenotype with high yield juice, good adaptation to low water availability and different soil types. The IAC 91-5035, Nova Iraí and IAC 91-2195, although lower, also reveal magnitudes by the average number of agronomically satisfactory values for the three traits, is another alternative to the IAC 87-3396 genotype and farmers in the northwest region of RS. The comparison among the three crop years 2008, 2009 and 2010 for the variable brix of the juice, the second and third year were higher by 34% and 20%, respectively, where the first year obtained the lowest average with 12.9% brix. Possibly this trait has been influenced by the implantation carried out in the first year for culture have priority growth and initial development. Results with the same tendency were obtained by Anjos (2007), which showed delayed harvest and increased sugar content. For traits juice yield and mass of stems, the sugarcane genotypes tend to increase the characters over the years. This is because of their establishment and the acclimation to environmental conditions, since the plant's ability to adapt their physiological functions to constant environmental changes is less affected, thus providing greater stability, resulting in agronomic performances generally higher (Henrique *et al*., 2011).

Conclusion

Aiming at an earlier production the genotypes RB 765418, IAC 87-3396, IAC 91-5035 and Nova Iraí are most suitable for cultivation in the Northwest Region of Rio Grande do Sul. The genotype IAC 87-3396 after the third crop year has increased juice yield and stem mass. The genotype IAC87-3396 stands out at the end of three years as the best genotype for juice yield and stem mass, being highly productive, but needs further establishment period to achieve their levels of productivity in the conditions of the region.

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