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Comparative analysis of physicochemical parameters in the different stages of sugarcane infection by the borer-rot complex

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ABSTRACT
Experienced researcher specializing in sugarcane agriculture and biofuel production in Northeast Brazil. Expertise in pest and disease management, focusing on reducing losses and optimizing yield. Proven track record in evaluating the impact of pests like sugarcane borers and diseases such as stem rot on crop quality and productivity. Skilled in experimental design and physicochemical analysis to assess crop resilience to biotic stresses. Dedicated to advancing sustainable practices in sugarcane cultivation to enhance ethanol and sugar production efficiency.

Keywords: Sugarcane production, Biofuel production, Pest management, Disease control, Northeast Brazil.

INTRODUCTION

Sugarcane is a crop that stands out in the area produced in Brazil. According to the survey carried out by the National Supply Company, estimates point to a 10.9% increase in sugarcane production, when compared to the 2022/2023 harvest, totaling 677.6 million tons and setting a new record (CONAB, 2024).

According to the National Bioenergy Union, the sugarcane units in the North and Northeast delivered 2.08 billion liters, 0.7% higher than the 2.06 billion liters in the same fortnight in the 2022/2023 harvest. In the case of anhydrous biofuel, mixed with gasoline, there was a retraction of 8.9%, with the production of 1.02 billion liters (UDOP, 2024).

In the 2022/2023 harvest, the State of Paraíba was the largest ethanol producing state, among other states in the Northeast, with a total of 472.77 million liters, an increase of 4.5% compared to the previous harvest (CONAB, 2023). However, despite the high potential of sugarcane cultivation registered in the state, several problems of phytosanitary origin contribute to losses and losses in the sugar and alcohol industry, such as the occurrence of pests and diseases.

Among the numerous pests that attack the sugarcane crop in the Northeast region, particularly in the state of Paraíba, the common borer (*Diatraea flavipennella*), sugarcane leafhopper (*Mahanarva*

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posticata), giant borer (*Telchinlicus licus*) and the Elasmo caterpillar (*Elasmopalpus lignosellus*) are responsible for large losses (ASPLAN, 2014).

Pests such as the sugarcane borer (*Diatraea saccharalis*) cause galleries that favor the penetration of fungi and other microorganisms. Culms are attacked simultaneously by fungi and the sugarcane borer,

characterize the symptom of the "borer-rot complex" that leads to a decrease in the purity of the juice and lower yield of sugar and ethanol, in addition to the contamination of the alcoholic fermentation process (Gallo *et al.*, 2002), with frequent reports of losses of 50% to 70% of sucrose (Santiago; Rossetto, 2023).

As for the main diseases that attack sugarcane, stem rot stands out. The phytopathogens *Colletotrichum falcatum* and *Fusarium sp.* causing, respectively, Red Rot and Pokkah boeng (stem rot), which in the holes made by the sugarcane borer, the fungus settles alone or in association with red rot (Tokeshi; Rago, 2005). Although they have some differences, both rots cause great damage in the industry, because the attacked stalks and fabrics dry out (there is no juice to be extracted), in addition to the fact that in contaminated tissues the inversion of sucrose can occur (Santiago; Rosseto, 2023).

Once the sugarcane borer and the rot-causing pathogens have established themselves in the production fields, the quality of the sugarcane industry's raw material is reduced. Consequently, this can lead to losses in the yield of ethanol and sugar production.

OBJECTIVE

To evaluate the effect of the borer-rot complex on the physicochemical quality of two varieties of sugarcane at different stages of infection, with 3% and 6% of symptoms of the borer-rot complex attack and without the symptoms of the borer-rot complex attack.

METHODOLOGY

EXPERIMENTAL LOCALIZATION

The research was carried out at the Unit Operations and Sugar and Alcohol Technology Laboratories, located at the Center for Technology and Regional Development (CTDR) of the Federal University of Paraíba (UFPB), between November and December 2023.

OBTAINING SUGARCANE STALKS

Culms of the varieties RB92579 and RB1443 were collected from the Monte Alegre Plant. The sugarcane stalks were harvested manually in the field without previous burning and harvested.

Soon after, part of the sugarcane stalks prepared in bundles were taken to the Unit Operations Laboratory of the Federal University of Paraíba, being crushed in a forage-type chopper and then pressed in a hydraulic press in portions of approximately 500g until reaching a volume of 2000 ml of juice per variety.

PHYSICOCHEMICAL ANALYSIS OF THE BROTH

The samples of sugarcane juices were analyzed in triplicate for the following physicochemical attributes.

Analyses carried out at the Sugarcane Technology Laboratory:

- pH: Determined by direct potentiometry (Instituto Adolfo Lutz, 1985).
- Titratable acidity: obtained after acid-base titration with NaOH (0.01N) as titrant (Instituto Adolfo Lutz, 1985).

Analyses carried out by the ASPLAN Laboratory:

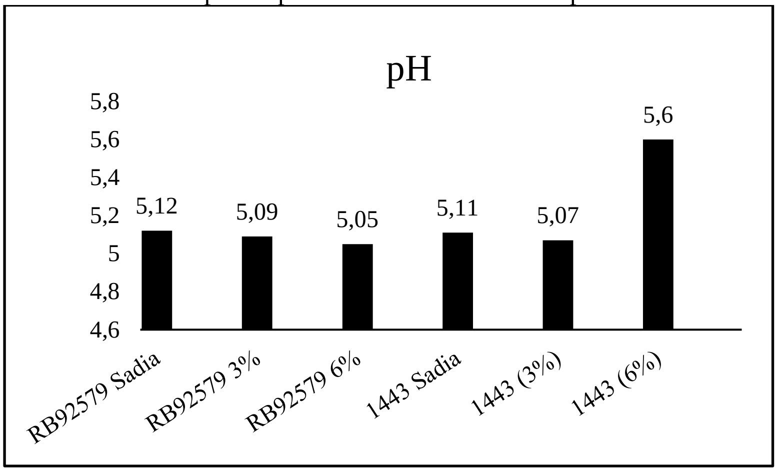
- Soluble solids (ºBrix): Determined by refractometer (CONSECANA, 2006).
- Pol (percentage of apparent sucrose mass): determined by polarimetry following that described by the Sugarcane Technology Center (CTC) (2011).
- Reducing sugars (RA): determined by the spectrophotometric method of Somogyi Nelson (Amorim, 1996).
- Juice purity: obtained by the Pol/Brix ratio (CTC, 2011).

DEVELOPMENT

When it comes to the quality of sugarcane, Ripoli and Ripoli (2004) explain that the apparent sucrose content is its main determinant, although there are other factors that directly influence the final quality, for example the physicochemical and microbiological characteristics.

In the samples analyzed, the pH values ranged from 5.1 to 5.6, the latter being obtained in the RB 1443 variety with 6% of borer infection – rot as observed in Graph 1.

Graph 1 – pH values found in the samples



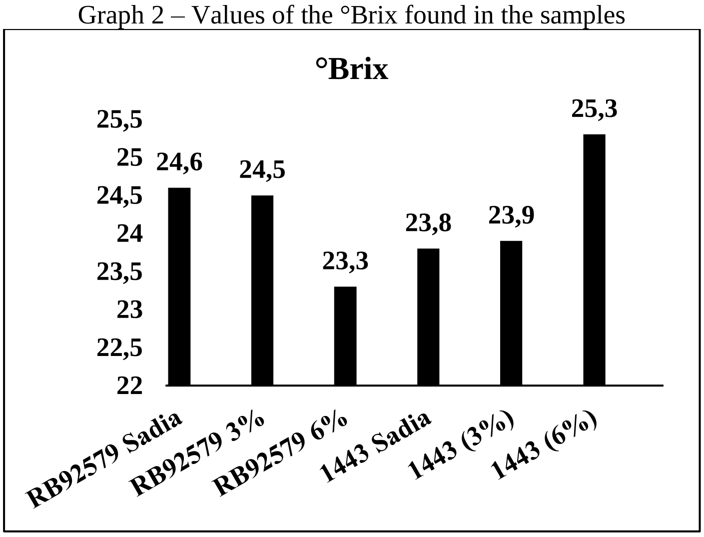
Source: The author (2024)

The pH values of the broth when they are between 5.2 and 5.6 represent that there has been no microbial deterioration, according to Yusof *et al.* (2000) the average time between cutting, spreading fire and extracting the juice is eight hours, as our samples were cut *in natura*, i.e., without burning, and the juice was extracted almost twelve hours after cutting, the pH value may have been lowered. According to Santos *et al.* (2008) The low pH value may represent the growth limit factor of pathogenic bacteria, so bacterial contamination would remain at low levels.

Chemical characteristics include the percentage by mass of apparent sucrose (POL), the °Brix, which is the amount of soluble solids percent of the broth, and the reducing sugars, represented by glucose and fructose (Klein, 2010).

According to Ripoli and Ripoli (2004), ° Brix should be greater than 18% and less than 25%. Graph 2 shows that the samples that were within the parameters did not have such a sudden variation between them.

Graph 2 – Values of the °Brix found in the samples

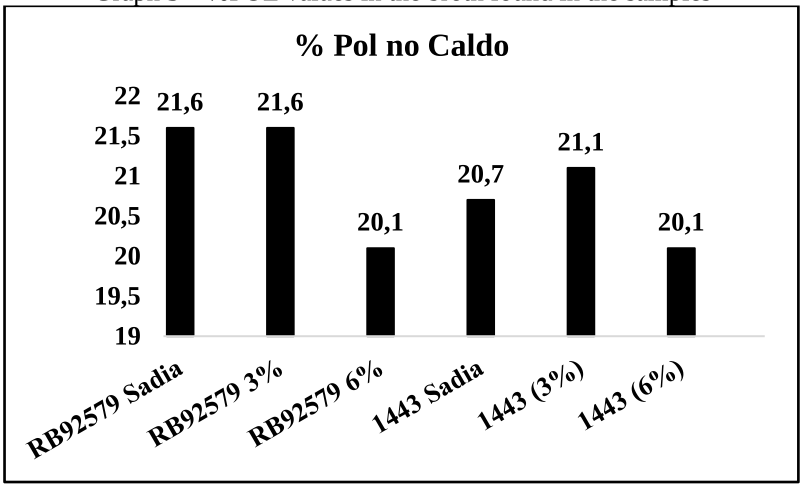


Source: The author (2024)

The sample of the RB 92579 variety with 6% infection showed the lowest value in relation to the healthy sugarcane of the same variety. The RB 1443 variety with 6% contamination by the "borer-rot complex" showed an increasing brix, which demonstrates that even contaminated the sugarcane maintained the high Brix.

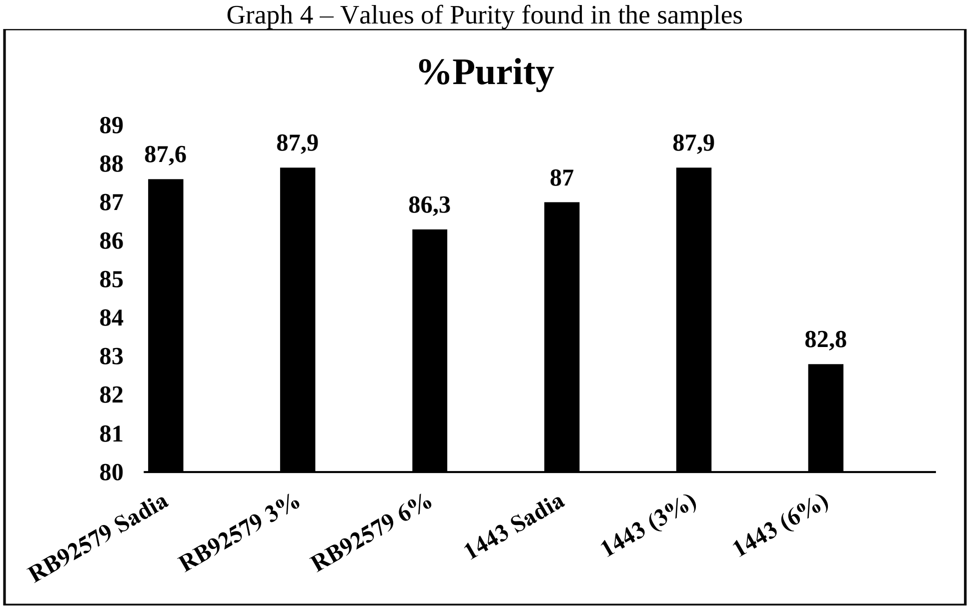
As previously seen, the POL is an indicator that verifies the amount of sucrose contained in sugarcane, which will then be done. A calculation made later between it and Brix will give the purity of this sucrose. The Pol value in the broth must be above 14 (Ripoli; Ripoli, 2004). Although this parameter is within the recommended standards, the lowest values found were for the varieties RB 92579 and RB 1443, both with 6% infection (Graph 3).

Graph 3 – %POL values in the broth found in the samples



Source: The author (2024)

Graph 4 – Values of Purity found in the samples



Source: The author (2024)

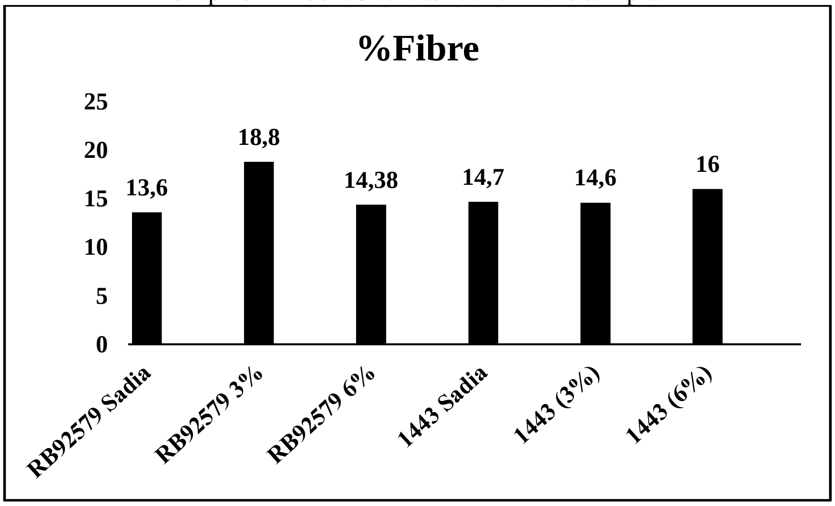
The purity of the broth is realized by the expression:

$$\left(\frac{Pol\ do\ caldo}{Brix} \times 100\right)$$

Its standard is adequate, values above 85% are recommended (UDOP, 2024). In the present study, only the RB 1443 variety, with 6%, had a result below this standard (Graph 4). The other samples of this variety (healthy and with 3% infection), as well as the other variety RB 92 579 (healthy, with 3% and 6% infection), had purity values all within the recommended standard, with minimal variation.

For the fiber percentage parameter, it is possible to observe an increase in fibers in all samples evaluated in the different varieties (Graph 5), with only the healthy RB 92579 variety that was closer to the appropriate standard, which according to Embrapa, (2022) should be between (11-13%).

Graph 5 – Fiber % values found in the samples



Source: The author (2024)

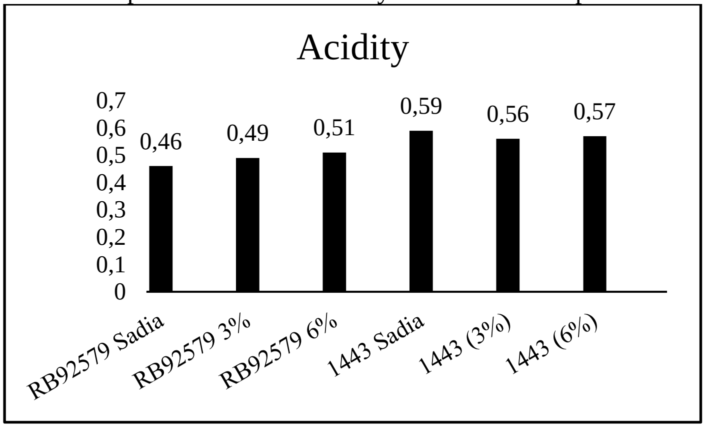
The chemical and bromatological characteristics of sugarcane have fibrous and non-fibrous carbohydrates that represent approximately 90% of the dry matter. Among the fibrous sugars we find cellulose, hemicellulose and lignin and the non-fibrous sugars are represented by soluble sugars, especially sucrose, but starch and pectin are also found (Klein, 2010). In the present study, it was found that the contaminated sugarcane samples (RB92579 3% and RB 1443 6%) of both varieties had an increased percentage of fibers in relation to healthy samples.

In the present study, it was found that sugarcane samples RB92579 3% and RB 1443 6% of infection of both varieties had an increased percentage of fibers in relation to healthy samples.

Regarding the fiber content of sugarcane, we know that pests and microorganisms prefer the regions of the sugarcane that have low fiber content, causing physical damage that affects the quality of the juice. (Santos, 2008) There is evidence that in the first 14 hours if sugarcane deteriorates, 93% of sucrose losses are due to the action of microorganisms, 5.7% to enzymatic reactions and 1.3% to chemical reactions resulting from acidity (Ripoli; Ripoli, 2004).

According to Ripoli and Ripoli (2004), the increase in fiber may be related to acidity, which should be below 0.80%. Graph 6 shows that all samples evaluated are within the normal range for this standard and that the highest value was for the sample RB 1443 Sadia, without borer infection.

Graph 6 – Values of Acidity found in the samples

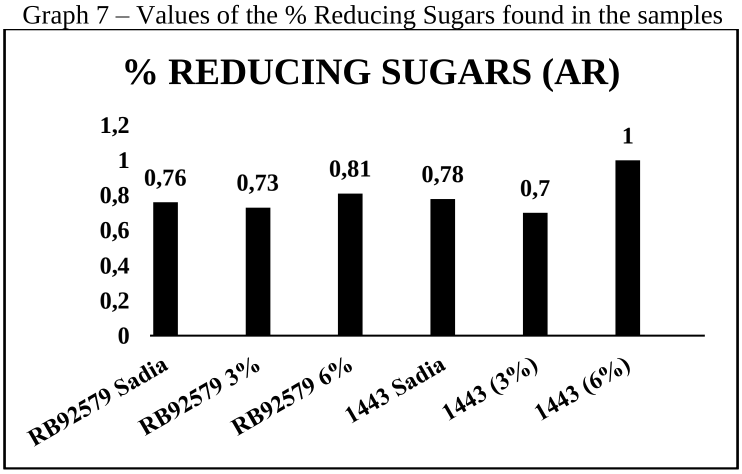


Source: The author (2024)

Acidity can be a significant problem in the production of alcohol and sugar, as it affects the quality of the broth and reduces the yield and lifespan of the machinery that is part of the manufacturing process. (Embrapa, 2022)

The ideal values of reducing sugars should be less than 0.8%, however, in Graph 7 it is observed that both varieties RB 92579 and RB 1443 with 6% of infection had alterations, with values higher than those recommended. The RB 1443 variety, with a very high AR, can have an excess of glucose and fructose that hinder the sugar production process, as previously mentioned.

Graph 7 – Values of the % Reducing Sugars found in the samples



Source: The author (2024)

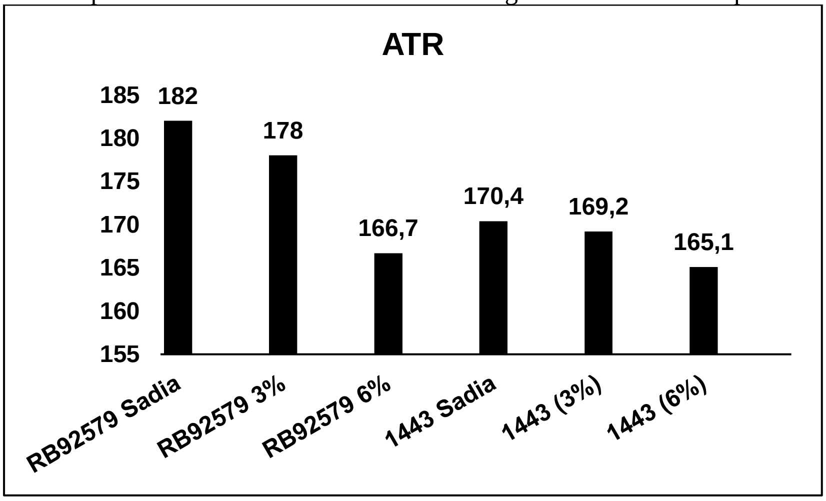
The parameters of Pol, Brix and Reducing Sugars (AR) are the percentages taken from the juice extracted by pressing and with these values have already been used for the payment of the sugarcane, knowing these parameters is of paramount importance to evaluate the quality of the sugarcane, because during the sugar manufacturing process the reducing sugars can influence the color and flavor of the final product. In the production of alcohol, they are fermented by yeasts to produce ethanol.

According to Asplan (2024), ATR can be expressed as follows:

$$(Pol\ da\ Cana\ \times 9{,}36814 + AR\ \times 8{,}9)$$

The value of should be higher: 119.0063 Kg/T, where the highest index was of the healthy variety RB 92579 and the lowest RB 1443 6 % (Graph 8).

Graph 8 – Values of Total Recoverable Sugars found in the samples



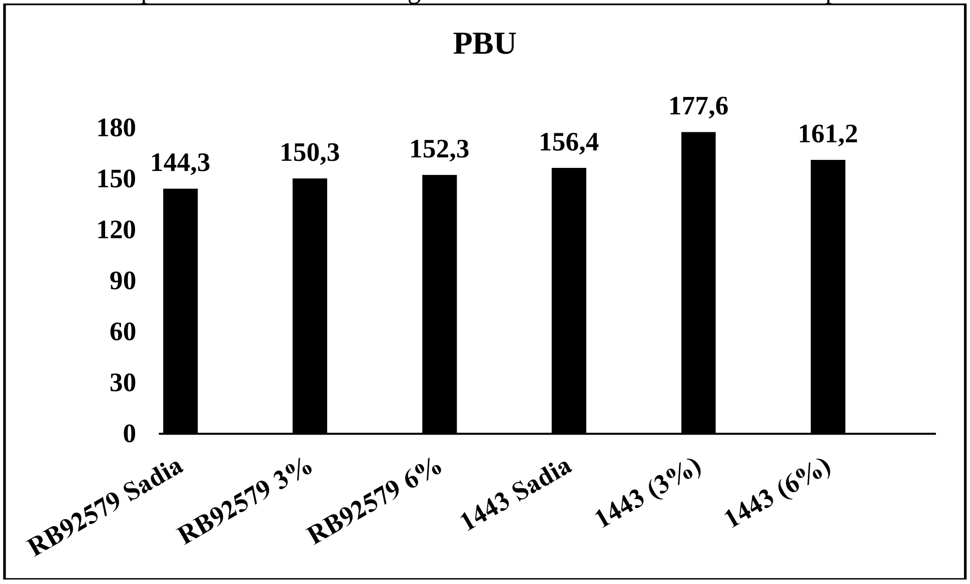
Source: The author (2024)

Currently, the value that is used for the purpose of performing the mass balances for the process controls and for the sugarcane payment system, as it is able to determine how much of the transformed raw material will result in production, so Consecana created a parameter that adds sucrose content with the content of reducing sugars present in sugarcane (Consecana, 2006).

According to information obtained from ASPLAN, the standard ATR value for Paraíba is 119.0063 Kg/Ton, being considered goodwill, any value above this standard and lower values indicate a discount in the profitability of sugarcane.

The Wet Cake Weight (PBU) is an important parameter for the payment system as well, as it comes from the fiber content that corresponds to the percentage of fibrous material present in the stalk. This value is estimated as a function of the weight of the fibrous dough, i.e., the moist cake that remains in the press after the juice is extracted. The Weight of the Wet Cake results after weighing 500g of shredded sugarcane. The highest values obtained for this parameter came from the RB 1443 variety, especially the samples with 3% infection of the rot borer (Graph 9).

Graph 9 – Values of the Weight of the Moist Cake found in the samples



Source: The author (2024)

FINAL THOUGHTS

A small decrease in the pH of the broth was observed with the increase of the infection index in the variety RB 92579. On the other hand, in the RB 1443 variety, a small decrease in pH was observed with an infection index of 3% and an increase in pH for an infection index of 6%.

The infection rate of 3% did not cause a significant variation in the brix of the two varieties analyzed. On the other hand, the infection rate of 6% caused a small decrease in the brix in the RB 92579 variety and an increase in the brix in the RB 1443 variety.

The Pol of the broth of the RB 92579 variety was not changed with the infection rate of 3%, but suffered a decrease when the infection rate increased to 6%. On the other hand, the RB 1443 variety showed an increase in Pol with an infection rate of 3% and a reduction in Pol with an infection rate of 6%.

The purity of the broth increased slightly at the infection rate of 3% and decreased with the infection rate of 6% for the two varieties analyzed.

The infection rates of 3% and 6% increased the percentage of fibers in relation to healthy sugarcane in the two varieties analyzed

The acidity increased slightly with the increase of the infection rate in the RB 92579 variety. On the other hand, in the RB 1443 variety, a slight decrease in acidity was observed in relation to the acidity of the healthy sugarcane for the infection rates 3% and 6%.

It was observed that the reducing sugars (RA) of the two varieties analyzed decreased when the infection rate was 3% and increased when the infection rate increased to 6%.

ATR decreased in both the RB 92579 and RB 1443 varieties with increasing percentage of infection.

The research is promising, and the results favorable showing that the percentage of infection can alter the results. However, we can conclude that such research is of paramount importance so that we can increase the productivity of Brazilian sugarcane plantations and reduce the rot borer complex.

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