RESEARCH ARTICLE

TECHNOLOGICAL PARAMETERS OF SUGARCANE VARIETIES ATTACKED BY DIATRAEA SACCHARALIS.

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Manuscript Info

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Abstract

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An alternative to the control of sugarcane borer is the choice of the more resistant varieties that adapt themselves to different production systems, guarantying a better productivity. This work aimed to evaluate technological parameters of sugarcane varieties attacked by *Diatraea saccharalis.* The experiment was implemented in a randomized 2x9-factorial scheme, from 2 different cultivation cycles, 2016 and 2017, with 9 varieties of sugarcane: CTC-9001; CT04-6043; CTC-7; CTC-22; CTC-25; CTC-9003; RB97-5952; RB96-6928 e RB85-5453, with 4 repetitions, 36 plots in total. At the end each cultivation cycle (2016 and 2017), it was evaluated the following parameters: tons of sugarcane´s stem per hectare (TSH); percents of attacked stems (%AS); Pol percents in broth (%Pol); percents of sugarcane´s fiber (%Fiber); percents of purity in broth (%Purity); Brix value of broth (°Brix); and total-recoverable sugar per ton of sugarcane (TRS). The varieties CT046043 and CTC7 had lower values of fiber and higher incidence of borer. The presence of sugar cane drill reduced the quality and quantity of sugarcane stalks. The variation of 10% in fiber content in sugarcane caused a 71% difference in the incidence of *Diatraea saccharalis.*

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Introduction:-

The demand of new sources of renewable energy sets sugarcane culture as an alternative to electric power and fuel (Lima et al., 2008), which leads to greater budgets in sugarcane sector in order to search varieties with better productive responses. According to Costa et. Al. (2011) a few works relate interactions between planting environments and cultivation cycles, being necessary the knowledge of the responses of the genetic interferences to the culture´s environmental factors.

Aude (1993) reports that sugarcane produces more dry mass per planting area than others forages, the author also states that a marked tillering occurs in the early stages that may result in a higher number of stem able to industry at the final harvest (Souza et al., 2016; SINGH et al., 2016). During the cultivation cycles, the plant is susceptible to plagues´ attack; one of them is the sugarcane borer (*Diatraea saccharalis* Fabr. (Lepidoptera: Crambidae)). This negatively influences in the productive process, thus causes damages in the raw material at the end of the process.

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Borer´s attack affects on the quality of the technological parameters of the sugarcane, mainly on its brix value, which measures the total reactive sugar and tons of sugarcane per hectare (Dinardo-Miranda, 2008).

An alternative to the control of sugarcane borer is the choice of more resistant varieties (Medeiros et al., 2016) or that have a higher fiber content in the stems making a physical barrier to the sugarcane borer. Elevation in fiber content is acceptable till the limit between 10,5 to 12,5% (Rodolfo Junior et al., 2016), since a greater value turns into a limitation factor in the milling process (Souza et al. 2005). Alongside the borer´s attack, biotic stresses and biotic can influence the technological parameters of sugarcane (Showler, 2016); such as chemical soil attributes (Zambrosi et al., 2017) and even the choice of the harvest method.

That way, this work aimed to evaluate technological parameters of sugarcane varieties attacked by *Diatraea saccharalis*.

Materials and methods:-
Installing the experiment:-
The experiment was installed on August, 2015, at Usina Ipê, in Nova Independência, São Paulo State, Brazil; geographic coordinates 21 ° 9'58.739 "S and 51 ° 28'1.660" W; with altitude of 337 m. According to Koeppen the region´s climate is classified as Aw with rainy summers and dry winters.

The experimental area was implemented in a 2% slope soil relief, in a soil classified as Argissolo Vermelho-amarelo férrico (Embrapa, 2013), displaying the following chemical attributes: 4.8 pH (CaCl2); 11.0 g of Organic Matter dm-3; 9.0 mg of Pdm^{-3} (resin); 1.3 mmol of K dm^{-3} (resin); 13.9 mmol of Ca dm^{-3} (resin); 5.94 mmol of Mg dm^{-3} (resin); 17.0 mmol of H + Al dm^{-3}; 0.4 mmol of Al dm^{-3}; 21.1 mmolc of saturation of bases dm^{-3}; 38.1 mmol c CMC dm^{-3}; 55.4 Saturation per base (V%); 1.9 Saturation per Al (m%), and was fertilized according to Raij et al. (1996).

The experiment was implemented in a randomized 2x9-factorial scheme, from 2 different cultivation cycles, 2016 and 2017, with 9 varieties of sugarcane: : CTC-9001; CT04-6043; CTC-7; CTC-22; CTC-25; CTC-9003; RB97-5952; RB96-6928 e RB85-5453, with 4 repetitions, 36 plots in total. Each plots was made of 4 lines with 20 m length and 1.5 m spacing, 120 m in total. Eighteen viable gems were planted, by using mechanization, per linear meter of groove; 0.5 L ha^{-1} of piraclostrobin and 0.1 L ha^{-1} of *Bacillus subtilis* and *Bacillus licheniformis* were applied on gems.

During the conduction of the experiment, all the cultivars treatments were carried out when it was necessary. Figure 1 shows the average values of rain while the experiment was conducted.
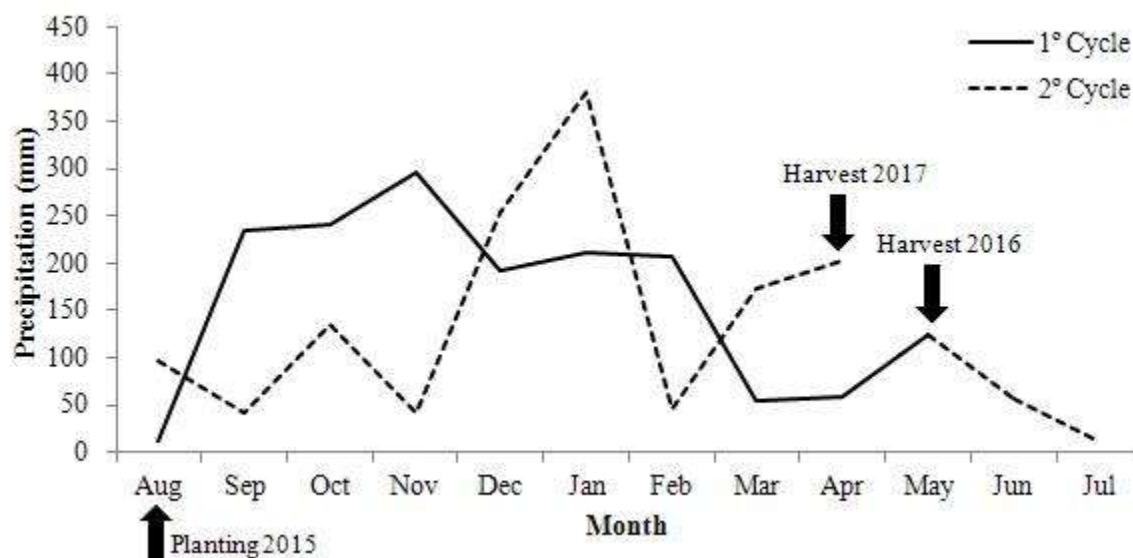

Figure 1:- The average values of rain while the experiment was conducted.

Evaluation of parameters:-
The harvest were done on May, 2016 and April, 2017 by using mechanization in total plots, in which the values were converted in tons of sugarcane´s stem per hectare (TSH). Also, twenty-five longitudinally cut stems were randomly selected to determine of percents of attacked stems (%AS).

The following parameters were evaluated as well: Pol percents in broth (%Pol); percents of sugarcane´s fiber (%Fiber); percents of purity in broth (%Purity); Brix value of broth (°Brix); and total-recoverable sugar per ton of sugarcane (TRS) (Consecana, 2006).

Statistical analysis:-
The data were submitted to analysis of variance by the F test (p <0.05) and their averages were compared by the Scott-Knott test at 5% probability (Banzatto and Kronka, 2013). The statistical program Assistat 7.7 (Silva and Azevedo, 2016) was used.

Results and discussion:-
On the parameter Pol percents in broth, it was not observed an interaction between the factors, as Chart 1 shows. Varieties CT046043; CTC25; CTC9003 and RB855453 showed lower average values as compared to the others, with a 14,92%-difference between them, being an important data in the choice of varieties.

Chart 1:- Average values of Pol percents in broth (%Pol); percents of sugarcane´s fiber (%Fiber); percents of purity in broth (%Purity) and Brix value of broth (°Brix) of sugarcane attacked by borer.

	Pol (broth)	%Fiber (broth)	%Purity (broth)	°Brix (broth)
Varieties (V)				
CTC9001	13,52a	12,04a	81,41b	17,78a
CT046043	12,89b	11,67a	81,69b	16,79b
CTC7	13,38a	11,56a	82,07b	17,36a
CTC22	13,39a	12,13a	83,31a	17,25a
CTC25	12,50b	11,70a	81,08b	16,44b
CTC9003	12,61b	12,06a	82,14b	16,26b
RB975952	14,34a	12,40a	85,24a	17,98a
RB966928	13,71a	12,17a	83,04a	17,49a
RB855453	12,20b	11,95a	79,74b	16,11b
F(V)	4,3643**	1,6421ns	4,5268**	5,4490**
Year (year)				
2016	15,81a	12,35a	85,81a	18,41a
2017	10,53b	11,57b	78,57b	15,69b
F(Y)	599,1681**	29,6543**	220,0146**	197,2045**
CV%	6,94	5,04	2,52	4,82
GA	13,17	11,96	82,19	17,05
VxY	1,7628 ns	2,2523*	2,2270*	1,8038ns
MSD: Minimum Significant Difference; CV: coefficient of variation; MG: General Average and F: value of F, calculated from the factors; V: variety; Y: year; **significant at 1% level of probability (p<0.01); * significant at 5% level of probability (p<0.01) (0,01=<p<0.05); ns – non-significant (p>=0.05). Averages on columns followed by the same letter do not differ ecstatically. It was used Scott-Knott test at 5% probability.				

As the cultivation cycle factor is considered, the first year of cultivation presented a higher average value, being this difference of 33.39% when compared to the second cycle. This result can be explained by the fact that the plant presents greater vigor, which allows a greater accumulation of sucrose in its stems. The variation of Pol can affect the sugar´s quality and even alcohol´s, Ekpélikpézé et al. (2016) stated that this variation is an important factor to choose the best variety, since they easily adapted to different production systems, their genetic potential is expressed (Tyagi and Naidu, 2016).

Due to the capacity of adaptation of sugarcane varieties to the ambient, their anatomic ultrastructures can be potentialized, mainly on quality and amount of lignin in the fibers, which is an important characteristic on resistance

to plagues´attack, even on the break of stems (Daniel et al. 2016). An interaction between the parameter percents of sugarcane´s fiber (%Fiber) was observed, as Chart 1 shows.

At the first cultivation cycle, varieties CT046043 and CTC7 displayed lower values on percents of sugarcane´s fiber (%Fiber), with a 10%-difference from the varieties that showed a higher value. However this variation was not observed at the second cultivation cycle. CT046043 and CTC7 are new varieties available on the sugarcane energy sector, it is recommended their use with low wind incidence, which can lead to the fall of its stems, as Chart 2 shows.

Chart 2:- Average Values of %Fiber (broth) of sugarcane varieties of sugarcane attacked by borer.

	2016	2017
CTC9001	12,46aA	11,62aA
CT046043	11,78bA	11,55aA
CTC7	12,02bA	11,09aB
CTC22	12,30aA	11,96aA
CTC25	11,66aA	11,74aA
CTC9003	13,09aA	11,03aB
RB975952	12,71aA	12,09aA
RB966928	12,49aA	11,84aA
RB855453	12,63aA	11,27aB
Averages followed by the same letter do not ecstatically differ between them. It was used Scott-Knott test at 5% probability. Collum: Captal letters; Rows: Small letters.		

The fiber content of less than 10.5% is an undesirable factor for the sugar and alcohol industry, as the boilers use sugarcane bagasse originated in milling of stems to generate steam, being recommended as ideal a fiber content between 10,5 and 12,5% (RODOLFO JUNIOR et al., 2016). That way, despite varieties CT046043 and CTC7 have show lower values as compared to other varieties, their fiber content is suitable.

According to Souza et al. (2005), a higher fiber content in stem can be considered an uneconomic factor to industry, thus mills are set to grind sugarcane with nearly 12,5 % fiber content., in case of an addition o between 0,5 and 1,0%, the milling process would be impaired, which could lead to 1,85 Kg of sugar per ton of grinded sugarcane.

It was observed a interaction between factors, as Chart 1 shows to the variable Purity%. Chart 3 shows average Values of %Purity (broth) of sugarcane varieties of sugarcane attacked by borer.

Chart 3:- Average Values of %Purity (broth) of sugarcane varieties of sugarcane attacked by borer.

	2016	2017
CTC9001	83,65bA	79,17bB
CT046043	85,06bA	78,33bB
CTC7	85,20bA	78,95bB
CTC22	85,50bA	81,12aB
CTC25	85,29bA	76,87bB
CTC9003	86,08bA	78,20bB
RB975952	88,48aA	82,00aB
RB966928	87,93aA	78,16bB
RB855453	85,12bA	74,35cB
Averages on columns followed by the same letter do not differ ecstatically. It was used Scott-Knott test at 5% probability. Column: Capital letters; Rows: Small letters.		

Souza et al. (2005) reported that values toward purity of broth must be over than 80% in the beginning of crop and 85% in its middle, most valued varieties are those ones which display greater values than 85%. Only variety CTC9001 showed values lower than the recommended, 83,65% of purity, as varieties RB975952 and RB966928 showed the highest values, 88,48 and 87,93%. In 2017, the second cultivation cycle, all the varieties were lower than recommended (80 – 85%), however, among the studied varieties, only RB975952 ecstatically differed and showed a suitable purity value, 82%.

This interaction between the cultivation cycle shows that even it occurs a suitable management, the reduction of technological parameters could has happened due to the decrease in force of new plants of regrowth in the following year. Other factors may influence on these parameters as soil fertility (Zambrosi et al., 2017), biotic and abiotic stress, which favors a higher attack of plagues; harvest method (Showler, 2016) and even the adaptation to production ambience of the chosen variety.

However, it was not observed an interaction between the factor in the parameter total-recoverable sugar per ton of sugarcane (TRS), as Chart 4 displays.

Chart 4:- Average values of total-recoverable sugar per ton of sugarcane (TRS), percents of attacked stems (%AS) and tons of sugarcane´s stem per hectare (TSH) of sugarcane varieties of sugarcane attacked by borer.

	TRS (kg t^{-1})	%AS	TSH
Varieties (V)			
CTC9001	124,77a	7,61b	99,29a
CT046043	119,57b	10,98a	86,60b
CTC7	112,66b	14,27a	91,34b
CTC22	122,62a	9,10b	88,53b
CTC25	116,41b	7,74b	73,02c
CTC9003	115,33b	5,65b	90,83b
RB975952	130,08a	7,74b	76,77c
RB966928	125,21a	9,47b	86,22b
RB855453	124,34a	5,52b	72,57c
F(V)	4,4957**	5,1421**	12,2561**
Year (Y)			
2016	133,58a	9,66a	95,72a
2017	108,87b	7,69b	74,31b
F(Y)	195,5512**	6,0233*	153,0204**
CV%	6,18	39,17	8,64
MG	121,22	8,67	85,02
VxY	1,7720ns	4,0393**	2,2532*
MSD: Minimum Significant Difference; CV: coefficient of variation; MG: General Average and F: value of F, calculated from the factors; V: variety; Y: year; **significant at 1% level of probability (p<0.01); * significant at 5% level of probability (p<0.01) (0.01=<p<0.05); ns – non-significant (p>=0.05). Averages on columns followed by the same letter do not differ ecstatically. It was used Scott-Knott test at 5% probability.			

The first cultivation cycle showed a higher average value of TRS with 133,58 kg t^{-1} of sugarcane, resulting in a 18,49% difference towards the second cultivation cycle. Varieties CT046043; CTC7; CTC25 and CTC9003 showed lower TRS values, this decrease coincides with varieties that displayed a greater incidence of sugarcane borer, as Chart 5 shows.

	2016	2017
CTC9001	7,93bA	7,29bA
CT046043	14,47aA	12,31aA
CTC7	17,27aA	11,27aB
CTC22	11,53aA	6,68bA
CTC25	11,96aA	3,51bB
CTC9003	5,21bA	7,50bB
RB975952	7,88bA	7,61bA
RB966928	6,62bB	6,09bA
RB855453	4,07bA	6,97bA
Averages on columns followed by the same letter do not differ ecstatically. It was used Scott-Knott test at 5% probability. Column: Capital letters; Rows: Small letters.		

It was observed an interaction between the factors, in which CT046043; CTC7; CTC22 and CTC25 displayed greater values of attacked stems on the first cultivation cycle, however, on the second one, only varieties CT046043 and CTC7 showed a higher plague´s influence as Chart 5 shows. This percentual variation reach 71,87% of attacked stems on the first cultivation cycle. This difference between the varieties with lower and higher borer attack index reach 71,48% on the second cultivation cycle.

Varieties CT046043 and CTC7 also showed lower values of fiber (Chart 2), which proves that borer´s attack can be decreased by using genetic modified varieties. That way, the 10-percent variation on the fiber content in sugarcane varieties can be favored plague´s incidence nearly 71% in varieties with lower fiber content. This characteristic is an important factor in the selection of plants to genetical enhancement programs. (Showler, 2016; Ekpélikpézé et al., 2016; Tyagi and Naidu, 2016).

Due to borer´s attack, an amount and quality reduction occurred in total-recoverable sugar (TRS), as observed in CT046043 and CTC7, which are among the varieties with the lowest TRS value (Chart 4). By decreasing sugar, sugarcane stems become lighter, consequently, a reduction in tons of sugarcane´s stem per hectare (TSH) occurs.

A significant interaction was observed between the studied cultivation cycles, as Chart 4 shows. Chart 6 displays Average values of percentual unfolding of sugarcane´s stem per hectare (TSH) attacked by borer.

Chart 6:- Average values of percentual unfolding of sugarcane´s stem per hectare (TSH) attacked by borer.

	2016	2017
CTC9001	117,14aA	81,44aB
CT046043	95,30bA	77,90aB
CTC7	100,09bA	82,60aB
CTC22	98,53bA	78,52aB
CTC25	78,32cA	67,72bB
CTC9003	103,94bA	77,73aB
RB975952	85,61cA	67,93bB
RB966928	101,34bA	71,09bB
RB855453	81,24cA	63,90bB
Averages on columns followed by the same letter do not differ ecstatically. It was used Scott-Knott test at 5% probability. Column: Capital letters; Rows: Small letters.		

On the first cultivation cycle, only variety CTC9001 displayed higher average TSH values, with a 33,13% difference as compared to CTC25, which showed the lowest average value. This result shows a positive response of variety CTC9001 to the production ambient. These results agree with Souza et al. (2006), as they studied sugarcane varieties on initial stages and verified that variety CTC9001 showed better response on dry mass production. While, on the second cultivation cycle, varieties CTC25; RB975952; RB966928 and RB855453 had a lower TSH production.

According to Silva et al. (2007), the fast and uniform initial growth of sugarcane allows infer in a good tillering stand, leading to a fast closing of the empty lines, consequently, to a effective control of invasive plants, as well as an increase on TSH. As described by Silva et al. (2017), a greater cover of leaves is an important factor on soil conservation and elevation in biomass production.

Conclusion:-
The varieties CT046043 and CTC7 had lower values of fiber and higher incidence of borer.
The presence of sugar cane drill reduced the quality and quantity of sugarcane stalks. The variation of 10% in fiber content in sugarcane caused a 71% difference in the incidence of *Diatraea saccharalis*.

Acknowledgments:-

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