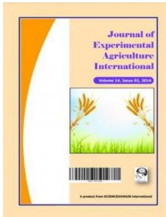

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Effects of Ethephon Associated with the Position of Gems on the Aspect of Sugar Cane in the Initial Development of Culture - Part I

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Authors' contributions

This work was carried out in collaboration among all authors. Author LAML designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RSL, ATC and JPBF managed the analyses of the study. Authors PAMF and EL managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The hormones are closely related to the emergence of gemstones contained seedlings of sugarcane, at the time of planting of the stems. The objective of this work was to evaluate the effects of the ethephon associated with the position of gemstones in the cane of sugar cane in the initial development of the culture. In March 2014, at the Rio Vermelho Plant, located in Junqueirópolis, State of São Paulo, a cane plant with a sugar cane plant was selected for seedlings with an approximate age of 11 months. Two areas with dimensions of 20x20 meters were

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demarcated. In one of the areas, ethephon was applied. At 15 days after application, the seedlings containing 1 and 2 buds were collected to compose two independent experiments. From the area where the product was not applied, seedlings were removed for the control and application treatments of Ethephon in the planting groove in pots. The gems were sent to the Faculty of Agrarian and Technological Sciences of the Paulista State University "Júlio de Mesquita Filho" - from Dracena, State of São Paulo. The seedlings came from the apex, middle and base of the canes of sugarcane. In this way, the experimental design was in a 3x3 factorial scheme, that is, the position of the seedlings in the canes of sugarcane and the modes of application of ethephon. The use of ethephon in the plant 15 days before planting together with seedlings from the sugar cane culms showed the best results for the rate of emergence; a number of tillers; dry matter weight of stem and leaves and leaf area.

Keywords: Sugarcane; hormone; ethephon; development; morphology.

1. INTRODUCTION

The tillering intensity varies among the different sugarcane cultivars and can occur up to four months after planting. In the vegetative phase of the crop, there is a decrease in the number of shoots, due to the natural competition for light, water and nutrients among the tiller [1,2]. To grow the plant, it needs light, carbon dioxide, water and minerals in sufficient quantities, which ensure the increase of its mass and volume. Among many extremely important factors, the temperature and time of exposure of the vegetable to light, together with the plant hormones should be highlighted [3].

Hormones, which are also called growth regulators, are compounds of organic origin produced in various parts of the individual, which act in a natural way and do not play a nutrient role. Their molecular structures are small, facilitating the entrance into the cells, promoting, inhibiting or modifying the physiology and, consequently, acting on the internal morphological processes of the tissues of the organisms [4], triggered by a complex of morphophysiological consume the reserves present in the minitoletes, mainly through hormonal and enzymatic actions [5].

All the processes that occur at the beginning of sprout budding promote morphological alterations of the tissues. The different environmental conditions to which the cultivated species are subjected can promote changes in the anatomy and physiology of different organs, such as leaves and roots [6,7]. The observation of the internal morphology of the plant has become an important tool in the evaluation of these alterations and their respective effects on the conditions of plant cultivation [8,9]. This internal morphology of sugarcane may undergo modifications in the presence of phytorregulators, which may promote changes in epidermal cells, vascular bundles and sclerenchyma fibres in leaves and stems [10].

The use of phytoregulars in agriculture has become an increasingly common process at the beginning of the 21st century. 2-chloroethylphosphonic acid, or ethephon, is a substance classified as a growth regulator with systemic performance in plants [11]. In the plant organism, ethephon rapidly undergoes degradation, being reduced in phosphoric acid, chloride ions and ethylene, which act on the growth process [9]. Several studies have already been carried out to characterize the effect of growth regulators applied in pre or post-emergence, or even in sprouting and initial development of sugarcane, aiming at better tillering and final yield of stalks [12,13]. However, there is little information available in the literature regarding the effects of ethylene application on leaf morphology or other organs of sugarcane [11].

The objective of this work was to evaluate the effects of the ethephon associated with the position of gemstones in the cane sugar cane in the initial development of the culture.

2. MATERIALS AND METHODS

2.1 Obtaining Sugarcane Seedlings

In March 2014 an area was chosen that contained a sugar cane plantation at the plant stage approximately 11 months old; destined to moult that presented a homogeneity of plants. The cultivar of sugarcane chosen for the installation of the experiment was RB966928. The area selected belonged to the Agroindustrial Production Unit of the Rio Vermelho Plant, located in Junqueirópolis, State of São Paulo, with geographic coordinates 21º29'35.34 "S and 51º16'13.60" W and altitude 416m. The climate of the region is characterized as Cwa according to Köppen, mesothermic, with rainy summers. The average temperature of the region is 24ºC, presenting the maximum of 31ºC and minimum of 19ºC.

The area was approximately 20 m wide by 40m long, which was divided into two distinct areas with the same films of 20x20m, one adjacent to another, in order to ensure homogeneity of application of the syrup and to ensure a lower border effect.

In one of the demarcated areas, under field conditions, the ethephon was applied using a CO_2 pressurized costal sprayer with a 6 m long, T-shaped bar with 6 flat AXI 11002 nozzles spaced at 0.5m, allowing simultaneous application in two lines, the nozzles were approximately 0.5 m from the target with an applied pressure of 40 psi pol^{-2}, at the dosage of 482.4 g ha^{-1} of the active ingredient of the product, with a volume of 150 L ha^{-1} and hydrochloric acid was used to adjust the pH to 2.8±2. Simultaneously, a similar, contiguous area received only water as a control. At the time of application, wind speedy was approximately 2.9 km h^{-1}, relative humidity at 77.6% and 25°C.

2.2 Installing the Experiment

Fifteen days after the application of the ethephon in the field, the experiments were started in an unprotected external environment at the FCAT - Faculty of Agrarian and Technological Sciences of the "Júlio de Mesquita Filho" State University, located in the city of Dracena, State of São Paulo, with geographic coordinates 21°46'04"S and 51°55'41" W and altitude 396 m.

The soil used in the experiments was classified as Dystrophic Yellow Red Argisol [14] with good drainage. At the time of installation of the experiment in April 2014, soil sampling was performed at depths of 20-40 cm for the physical and chemical analysis. A deeper soil was chosen in order to avoid an incidence of invasive plant seeds and homogeneity in their chemical and physical attributes.

The results of the soil chemical analysis were: pH $CaCl_2$= 5.0; MO= 14 g dm^{-3}; P= 8.0 mg dm^{-3} (resin); K= 2.3 mmol dm^{-3} (resin); Ca= 7.0 mmol dm^{-3} (resin); Mg= 5.0 mmol dm^{-3} (resin); H+Al= 20 mmol dm^{-3}; Al= zero mmol$_c$ dm^{-3}; Base Sum= 14.3 mmol dm^{-3}; CTC= 34.3 mmol dm^{-3}; Base saturation (V%)= 42; Saturation Al (m%)= zero; S (SO_4^{-2})= 3.0 mg dm^{-3}; Cu= 2.8 mg dm^{-3} (DTPA); Fe= 19 mg dm^{-3} (DTPA); Zn= 1.3 mg dm^{-3} (DTPA); Mn= 16.5 mg dm^{-3} (DTPA); B= 0.14 mg dm^{-3} (Hot water); Clay= 75 g kg^{-1}; Silt= 33 g kg^{-1} and Total sand= 893 g kg^{-1} [14,15].

All soil corrections were performed, according to [15] and [16]. On this occasion, in pots of 45 dm^3 containing sifted soil, where sugarcane seedlings were planted in two situations, containing 1 (one) and 2 (two) buds, composing this maniera, 2 (two) independent experiments. During the experiments, all necessary cultural treatments were carried out, such as phytosanitary control, elimination of invasive plants and cover fertilization. The pots were kept irrigated whenever necessary in order to meet the field capacity.

The experimental design was a completely randomized design in a 3x3 factorial design with 5 (five) replicates, totalling 45 plots or vessels. The factors pertinent to the treatments, as well as the respective levels were: position of the buds in the stem - apical region; median region and basal region and the form of application of ethephon - control (without ethephon); application of ethephon in the plant with fifteen days before planting and application of ethephon in the groove / pots at the time of planting.

To determine the positions of the gems on the stalks were counted all of the high nodes and dividing by three. In this way, the three parts of the stem were obtained, is an apical region; median and baseline. For the stems that presented odd numbers of nodes, we considered the basal third with the largest number.

For the treatment in the groove of the pot, the dosage of ethephon occurred according to the technical recommendation of the product, which provides for the dosage of 360 g ha^{-1} of the active ingredient of the product in the planting groove, with an application rate of 150 L ha^{-1}.

2.3 Non-destructive Assessments

During the initial 30 days, the emergency speed index was evaluated, as described by [17]. Also at 30, 60 and 90 days after the installation of the experiment the following characteristics were evaluated: the number of leaves determined through the direct count in the plant; height of plants measured with a ruler graduated in millimetres from ground level; number of tillers determined by direct counting; and tiller diameter determined with the use of a calliper graduated in millimetres ±1 centimetre above ground level.

2.4 The Destructive Evaluations

At 90 days after planting, the following characteristics were evaluated: stem and leaf dry matter weight; weight of dry matter of the root determined after drying in an oven with circulation and renewal of air at a temperature of 65ºC until reaching constant weight in grams; weight of total dry matter of the plant obtained by the sum of the dry matter of stem, leaf and root. For the determination of the leaf area in cm² was performed according to the methodology described by [18].

2.5 Statistical Analyses

The results were submitted to analysis of variance by the F test ($p \leq 0.05$) and their means by the Tukey test at 5% of significance, according to [19].

3. RESULTS AND DISCUSSION

In Tables 1 and 2, the mean values of the emergency speed index are presented; the number of leaves; plant height; the number of tillers and tillers diameter of the experiments with 1 and 2 buds at 30 days after installation of the experiment.

A significant effect was found for the characteristic emergency speed index in experiments with 1 and 2 buds at 30 days after planting. The treatments with gemstones from the tips of the stems and ethephon applied in the plant before the planting of the gemstones presented better indexes.

This fact can be explained by [5], who reports that the shoot tips are younger and have a higher concentration of glucose, nitrogen and especially water, which favours the emergence of the primary tiller due to the immediate availability of glucose and nitrogen in the cell division of the latent tissue, therefore, these effects were possibly potentiated by the use of ethephon applied in sugarcane fifteen days before planting of the seedlings.

The effect of the position of the yolk on the sugarcane stem influenced significantly the characteristic number of leaves in the experiments with 1 and 2 buds at 30 days after planting, which did not occur with the factor of application of ethephon. It is observed that gemstones at the apex presented larger leaf numbers in both experiments 5.66 and 6.33 respectively. The number of leaves is a limiting factor for the development of the plant, which shows a ratio in the highest number of leaves with the highest growth and especially in the height of the plant.

This result can be explained by the action of ethylene, which provides enzymatic actions in the region of leaf abscission of sugarcane, which can lead to a sharp fall of this organ of the plant [20]. The leaves play a primordial role in the photosynthetic process of the plant, which increases the production of sugars and, consequently, greater plant development [8,21]. The observed values are similar to those found by [22] when they studied the action of the ethephon associated with the position of the gems in the cane of sugarcane.

This potentiation of the initial growth of sugarcane resulted in a significant effect on the characteristic plant height in the experiment with only 1 yolk at 30 days after planting, showing an interaction among the factors.

When isolated, the positioning factor of the yolk on the stem, that is, the peak apex buds together with the control or with application of ethephon in the plant at 15 days after planting presented higher plants; in the buds from the middle of the stem, this application effect was not found; but in the yolk of the base a significant effect is found with the application of ethephon in the plant at 15 days before planting, in which it is possible to observe higher plants.

With the application of ethephon in the plant at 15 days before planting, the position factor of the yolk did not differ statistically, which occurred with the application of ethephon in the planting groove showed higher plants when it was used gemstones of the apex and the middle of the stem of sugarcane.

In general, these results showed that gemstones from the apex of sugarcane culms that were treated with ethephon 15 days before planting showed higher values (Table 2). According to [23], the use of ethephon in the early stages of sugarcane cultivation provides the greater initial development, making it an alternative in the induction of tillering in subtropical regions. This effect of interaction between the factors was not found in the experiment with 2 buds at 30 days after planting, but showed a significant effect only on the position of the yolk on the sugarcane stem, reinforcing that the position of the yolk on the stem is a limiting factor for the development of sugarcane in the early stages.

Table 1. Mean values of the emergency speed index; the number of leaves, the height of plants; the number of tillers and tiller diameter of the 1-yolk experiment at 30 days after the experiment was installed

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
		Emergency Speed Index		
Apex	0.0776	0.0784	0.0733	0.0764 a
Medium	0.0601	0.0725	0.0659	0.0661 b
Base	0.0528	0.0616	0.0494	0.0546 c
MFA(F2)	0.0635 B	0.0708 A	0.0628 B	
CV (%)	10.13			
MSD F1**e F2**	0.0059			
MSD F1xF2	-			
		Number of leaves		
Apex	5.40	6.20	5.40	5.66 a
Medium	4.75	5.20	5.20	5.05 a
Base	4.25	4.25	4.40	4.30 b
MFA(F2)	4.80 A	5.25 A	5.00 A	
CV (%)	16.40			
MSD F1** e F2	0.73			
MSD F1xF2	-			
		Height of plants (cm)		
Apex	38.60 aA	41.20 aA	28.80 aB	36.20 a
Medium	30.00 bA	34.80 aA	30.80 aA	31.86 b
Base	23.50 bB	36.75 aA	21.60 bB	27.28 c
MFA(F2)	30.70 B	37.58 A	27.06 B	
CV (%)	14.37			
MSD F1**e F2**	4.07			
MSD F1xF2*	7.05			
		Number of tillers		
Apex	1.00	1.00	1.00	1.00 a
Medium	1.00	1.00	1.00	1.00 a
Base	1.00	1.00	1.00	1.00 a
MFA(F2)	1.00 A	1.00 A	1.00 A	
CV (%)	-			
MSD F1 e F2	-			
MSD F1xF2	-			
		The diameter of tillers (mm)		
Apex	6.80 aB	8.60 aA	7.00 aB	7.46 a
Medium	5.75 aB	8.20 aA	7.40 aA	7.11 a
Base	5.75 aA	5.50 bA	5.00 bA	5.41 b
MFA(F2)	6.10 B	7.43 A	6.46 B	
CV (%)	13.35			
MSD F1**e F2**	0.79			
MSD F1xF2**	1.37			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

Table 2. Mean values of the emergency speed index; the number of leaves, the height of plants; the number of tillers and tiller diameter of the experiment with 2 buds at 30 days after the experiment was installed

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
	Emergency Speed Index			
Apex	0.1244	0.1580	0.1245	0.1356 a
Medium	0.1032	0.1349	0.1099	0.1160 a
Base	0.0624	0.1035	0.1034	0.0897 b
MFA(F2)	0.0966 B	0.1321 A	0.1125 AB	
CV (%)	19.42			
MSD F1**e F2**	0.0197			
MSD F1xF2	-			
	Number of leaves			
Apex	5.60	6.90	6.50	6.33 a
Medium	5.40	5.20	4.90	5.16 b
Base	4.00	4.80	4.87	4.55 b
MFA(F2)	5.00 A	5.63 A	5.42 A	
CV (%)	14.63			
MSD F1** e F2	0.69			
MSD F1xF2	-			
	Height of plants (cm)			
Apex	43.76	44.59	38.12	42.15 a
Medium	45.92	37.35	37.28	40.18 ab
Base	35.08	30.00	36.13	33.73 b
MFA(F2)	41.58 A	37.31 A	37.17 A	
CV (%)	20.61			
MSD F1*e F2	7.11			
MSD F1xF2	-			
	Number of tillers			
Apex	1.00	1.00	1.00	1.00 a
Medium	1.00	1.00	1.00	1.00 a
Base	1.00	1.00	1.00	1.00 a
MFA(F2)	1.00 A	1.00 A	1.00 A	
CV (%)	-			
MSD F1 e F2	-			
MSD F1xF2	-			
	The diameter of tillers (mm)			
Apex	7.50	10.40	9.40	9.10 a
Medium	9.20	8.50	8.40	8.70 a
Base	6.90	6.90	7.60	7.13 b
MFA(F2)	7.86 A	8.60 A	8.46 A	
CV (%)	19.29			
MSD F1**e F2	1.42			
MSD F1xF2	-			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level ($0.01 \le p < 0.05$). ** Significant at the 1% probability level ($p < 0.01$). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

For the characteristic number of tillers at 30 days, no significant effect was found by the factors in the experiments with 1 and 2 buds at 30 days after planting. This result was expected due to the short development time of the plant since the most pronounced tillering occurs at 30 to 35 days after planting [24]. For [25] reported that ethylene has been used to increase sprouting in vines in tropical regions because it was a C3 plant, the same behaviour was not observed.

In Table 3, it is possible to observe a significant interaction in the characteristic tiller diameter in the experiment with 1 yolk at 30 days after planting. When the yolk of the stem was used together with the application of ethephon in the plant at 15 days after planting, the largest development of the diameter of the stem of the sugar cane occurred. However, the yolk of the medium with the application of ethephon in the plant and in the furrow of planting presented larger diameter diameters but no effect was found regarding the use or not of ethephon in the gemstones of the base of the cane of sugarcane. In general, the position of the yolk on the stem together with the application of ethephon in the plant before the planting of the yolks showed higher averages.

This significant effect of interaction between the factors was not found in the experiment with 2 buds at 30 days after planting, but it was possible to observe a significant effect only on the position of the yolk in the sugarcane stem (Table 2), where buds from the apex and middle presented higher averages.

Table 3. Mean values of leaf number, plant height; the number of tillers and tiller diameter of the 1-yolk experiment at 60 days after the experiment was installed

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
		Number of leaves		
Apex	20.80	23.40	24.40	22.86 a
Medium	15.00	22.20	21.80	19.66 b
Base	14.50	15.25	15.20	14.98 c
MFA(F2)	16.76 B	20.28 A	20.46 A	
CV (%)	16.71			
MSD F1**e F2**	2.85			
MSD F1xF2	-			
		Height of plants (cm)		
Apex	73.00	80.80	69.80	74.53 a
Medium	62.00	73.60	75.00	70.20 a
Base	53.25	61.75	53.60	56.20 b
MFA(F2)	62.75 A	72.05 A	66.13 A	
CV (%)	18.06			
MSD F1** e F2	10.78			
MSD F1xF2	-			
		Number of tillers		
Apex	4.80	5.20	5.20	5.06 a
Medium	4.00	5.40	5.20	4.86 a
Base	4.25	4.00	4.80	4.35 a
MFA(F2)	4.35 A	4.86 A	5.06 A	
CV (%)	17.83			
MSD F1 e F2	0.75			
MSD F1xF2	-			
		The diameter of tillers (mm)		
Apex	6.39	6.82	5.84	6.35 a
Medium	5.60	5.63	5.93	5.72 a
Base	4.65	5.90	4.37	4.97 b
MFA(F2)	5.54 A	6.11 A	5.38 A	
CV (%)	14.57			
MSD F1** e F2	0.73			
MSD F1xF2	-			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

The higher stem diameter in the initial phase may provide a high accumulation of sucrose together with the greater volume of tissues developed, which can be explained by [26], stating that the emergence of the first tillering and its development in diameter is related to the size of the stem and thickness of the original stem. Studies conducted in vines by [27] have observed that the use of ethephon applied via foliar has become effective in the growth and increase in the diameter of branches.

In Tables 3 and 4, the average values of the number of leaves, the height of plants; the number of tillers and tillers diameter of the experiments with 1 and 2 buds at 60 days after installation of the experiment.

For the characteristic number of leaves in the experiment with 1 yolk at 60 days after planting, a significant effect was found. It showed that gemstones from the sugar cane stem together with the application of ethephon in the plant 15 days before planting and in the furrow showed a larger number of leaves (Table 3), however, only the effect of the use of ethephon provided significant effect in the experiment with 2 buds at 60 days after planting.

Table 4. Average values of leaf number, the height of plants; the number of tillers and tiller diameter of the experiment with 2 buds at 60 days after the experiment was installed

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
		Number of leaves		
Apex	14.60	26.40	21.90	20.96 a
Medium	14.80	19.50	19.40	17.90 a
Base	14.10	18.20	20.68	17.66 a
MFA(F2)	14.50 B	21.36 A	20.66 A	
CV (%)	26.36			
MSD F1e F2**	4.42			
MSD F1xF2	-			
		Height of plants (cm)		
Apex	74.30	77.70	76.10	76.03 a
Medium	65.70	71.80	70.70	69.40 a
Base	70.20	67.50	75.29	70.99 a
MFA(F2)	70.06 A	72.33 A	74.03 A	
CV (%)	14.88			
MSD F1 e F2	9.57			
MSD F1xF2	-			
		Number of tillers		
Apex	3.40	5.10	4.90	4.46 a
Medium	3.30	4.20	4.60	4.03 a
Base	3.60	4.10	4.72	4.14 a
MFA(F2)	3.43 B	4.46 A	4.74 A	
CV (%)	26.40			
MSD F1 e F2**	0.99			
MSD F1xF2	-			
		The diameter of tillers (mm)		
Apex	7.27	6.60	5.85	6.57 a
Medium	8.00	5.83	6.26	6.69 a
Base	6.94	5.47	6.22	6.21 a
MFA(F2)	7.40 A	5.97 B	6.11 B	
CV (%)	21.98			
MSD F1 e F2*	1.27			
MSD F1xF2	-			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

A higher number of leaves at 60 days after planting is an important feature in the establishment of sugarcane in its substrate, ensuring greater development of the clumps of this grass. Studies conducted by [22] using doses of ethephon in the production of sugarcane seedlings found different results. The use of these phytogulators did not alter the growth of the leaves, stems and roots, it still emphasizes that the use of doses higher than the recommended ones hinders the initial development of sugarcane.

In Table 3, it is possible to observe a significant effect for the characteristic plant height in the experiment with 1 yol at 60 days after planting, an effect that was found only on the position of the yolk in the cane sugarcane. Gemstones from the basal part of the stems had lower average values, this fact can be explained due to the age of the yolk and greater presence of sucrose and mineral salts, in which the plant needs more time to reduce sucrose in glucose + fructose. In this way, it becomes available for cellular development [5]. This significant effect was not found in the 2 egg yolk experiment (Table 4).

For the characteristic number of tillers at 60 days after planting, no significant effects were found with the treatments studied in the experiment with 1 yolk, but a significant effect was found only for the application factor of ethephon in the experiment with 2 buds, showing that the use of ethephon provided a higher number of sugarcane tillers in the initial phase, both in the application to the plant and in the furrow, corroborate with the studies carried out by [22] and [26].

In Table 3, it is possible to observe a significant effect for the characteristic tiller diameter in the experiment with 1 yolk, which presented higher averages when using buds coming from the apex and medium region of the shoots of the plant. In the experiment with 2 buds, the same effect was not found for the position of the yolk, but a significant effect was found regarding the non-use of ethephon, these results were not expected because the user provided a better development in other works such [22] and [28].

In Tables 5 and 6, the average values of leaf number, plant height, number of tillers and tillers diameter of the experiments with 1 and 2 buds at 90 days after installation of the experiment.

For the characteristic number of leaves at 90 days after planting, a significant effect was found only on the position of the yolk on the sugarcane stem, showing that gemstones originating from the apex provided a greater number of leaves in the experiment with 1 yolk.

The significant effect of the position of the yolk on sugarcane stem was not found in the experiment with 2 buds, but a significant effect was found regarding the method used in the application of ethephon, showed that the application of ethephon in sugarcane, sugar 15 days before the planting of the gemstones presented a greater number of leaves. [29], when studying sugarcane varieties, reported that applying the ethephon four weeks after emergence, increased the number of leaves in the shoots.

No significant effect was observed for the characteristic plant height at 90 days after planting the sugarcane buds in the experiments with 1 and 2 buds. The average values of plant height in the same period of this study were lower than those found by [28] when studying the doses of gibberellin and ethylene in the initial development of the crop, they also report that the effect of ethylene was observed up to 45 days after sprouting, results corroborate with those found in this study, where only significant effect was found up to 30 days after sprout initiation, which did not occur at 60 days.

In Table 5, it is possible to observe in the experiment with 1 yolk, a significant effect for the characteristic number of tillers at 90 days after planting showing that gemstones originating from the apex and application of ethephon in the planting groove showed a higher average number of stem. In Table 6, no significant effect was found for the yolk position factor, but it is possible to observe for the method of application of ethephon, highlighting the treatments with application in the plant at 15 days before planting the yolks and application in the furrow, which can [10,9]. In order to improve the yield of sugarcane, the use of sugarcane in sugarcane cultivation has been shown to be an alternative to planting systems.

For the characteristic tiller diameter at 90 days after planting in the 1-yolk experiment, no significant effect was found, but in the experiment with 2 yolks a significant interaction between the factors was found, showing that gemstones from the culm shoot together with the application of ethephon in the plant at 15 days before planting the yolk and applied to the furrow showed thicker stalks, results similar to those found by [22].

This characteristic is directly related to the accumulation of sucrose by the vegetable because larger diameters can store more sugar. Research on sugarcane breeding has sought cultivated varieties with smaller diameters and with higher sucrose contents, which makes the mechanized harvesting method more efficient [30].

Tables 7 and 8 show the mean values of stem and leaf dry matter weight; root dry matter weight; the weight of total dry matter and foliar area of the experiments with 1 and 2 buds at 90 days after installation of the experiment.

Table 5. Average values of leaf number, the height of plants; the number of tillers and tiller diameter of the 1-yolk experiment at 90 days after the experiment was installed

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
		Number of leaves		
Apex	44.80	47.00	55.60	49.13 a
Medium	39.25	44.40	47.60	43.75 b
Base	44.75	45.00	41.60	43.78 ab
MFA(F2)	42.93 A	45.46 A	48.26 A	
CV (%)	13.20			
MSD F1* e F2	5.36			
MSD F1xF2	-			
		Height of plants (cm)		
Apex	103.40	111.20	105.00	106.53 a
Medium	99.00	104.80	110.40	104.73 a
Base	92.75	105.25	99.20	99.06 a
MFA(F2)	98.38 A	107.08 A	104.86 A	
CV (%)	9.59			
MSD F1 e F2	8.84			
MSD F1xF2	-			
		Number of tillers		
Apex	6.80	7.40	9.20	7.80 a
Medium	5.50	7.40	8.00	6.96 ab
Base	5.50	6.50	7.60	6.53 b
MFA(F2)	5.93 C	7.10 B	8.26 A	
CV (%)	17.91			
MSD F1* e F2**	1.13			
MSD F1xF2	-			
		The diameter of tillers (mm)		
Apex	9.34	10.49	8.06	9.30 a
Medium	10.41	9.49	8.94	9.61 a
Base	9.14	8.57	8.25	8.65 a
MFA(F2)	9.63 A	9.52 A	8.42 A	
CV (%)	17.30			
MSD F1 e F2	1.41			
MSD F1xF2	-			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

Table 6. Average values of leaf number, the height of plants; the number of tillers and tiller diameter of the experiment with 2 buds at 90 days after the experiment was installed

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
		Number of leaves		
Apex	25.30	36.30	32.60	31.40 a
Medium	26.62	31.30	30.87	29.60 a
Base	30.50	31.00	30.95	30.81 a
MFA(F2)	27.47 B	32.86 A	31.47 AB	
CV (%)	15.12			
MSD F1e F2**	4.12			
MSD F1xF2	-			
		Height of plants (cm)		
Apex	96.10	96.90	90.92	94.64 a
Medium	99.25	95.40	99.57	98.07 a
Base	95.25	94.30	99.29	96.28 a
MFA(F2)	96.86 A	95.53 A	96.59 A	
CV (%)	8.43			
MSD F1 e F2	7.24			
MSD F1xF2	-			
		Number of tillers		
Apex	4.20	6.00	5.60	5.26 a
Medium	4.76	5.50	5.20	5.15 a
Base	5.41	5.50	5.87	5.59 a
MFA(F2)	4.79 B	5.66 A	5.55 A	
CV (%)	12.74			
MSD F1 e F2**	0.60			
MSD F1xF2	-			
		The diameter of tillers (mm)		
Apex	8.83 aA	8.45 aA	8.23 aA	8.50 ab
Medium	9.89 aA	7.84 aB	8.36 aB	8.70 a
Base	7.40 bA	7.55 aA	8.39 aA	7.78 b
MFA(F2)	8.71 A	7.95 A	8.33 A	
CV (%)	10.64			
MSD F1* e F2	0.79			
MSD F1xF2*	1.36			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

A significant effect was found for the dry matter weight of stem and leaves at 90 days after planting sugarcane buds. It is possible to observe that gemstones originating from the apex and application of ethephon in the plant 15 days before planting showed higher dry matter yield of the stem and leaves in the experiment with 1 yolk. However, no significant effect was found in the experiment with 2 buds for the use of ethephon, this result corroborates those found by [22] when using cyanamide bioregulator. It is possible to observe a significant effect for the weight of dry matter of stem and leaves when natural gemstones of the apex and medium of sugarcane stalks presented higher averages. It is likely that ethephon induced the weight of dry matter [11].

These results of stem and leaf dry matter weight are directly related to the production of sugarcane in the production systems, corroborating with [31], who cites that these systems seek high productivity; with higher phytomass production per planted area. In this way, it provides a greater agricultural yield of the crop. [25] report that this increase in the dry matter may be associated with a greater translocation of nutrients and carbohydrates from the leaves to other organs, such as branches, stem and roots, which are redistributed to the growing parts of the next vegetative cycle, a common phenomenon in the vine culture.

The dry matter weight of the root in the experiment with 1 yolk, shown in Table 7, has a significant effect on the interaction between the studied factors, it is possible to observe that gemstones from the stem apex and ethephon applied to the plant before 15 days of planting presented better results. When the application of the ethephon in the planting groove occurs in the gemstones of the culmination of the stem, it presented better averages for the highlighted characteristic.

This behaviour of interaction between the factors was not observed in the experiment with 2 buds, but it is possible to observe a significant effect only on the position of the gem in the stem, that gemstones of the stem presented higher root production.

Table 7. Mean values of stem and leaf dry matter weight; root dry matter weight; the weight of total dry matter and foliar area of the experiment with 1 yolk at 90 days after installation of the experiment

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
		Dry matter weight of stem and leaves (g)		
Apex	41.64	46.85	44.71	44.40 a
Medium	34.95	40.53	38.33	37.94 b
Base	26.36	39.62	31.23	32.40 c
MFA(F2)	34.31 B	42.33 A	38.09 AB	
CV (%)	15.67			
MSD F1** e F2**	5.34			
MSD F1xF2	-			
		Dry matter weight of the root (g)		
Apex	28.04 aA	32.09 aA	33.95 aA	31.36 a
Medium	19.35 bB	26.09 aAB	26.68 bA	24.04 b
Base	16.40 bB	29.86 aA	17.47 cB	21.24 b
MFA(F2)	21.26 B	29.34 A	26.04 A	
CV (%)	18.10			
MSD F1** e F2**	4.12			
MSD F1xF2*	7.14			
		Weight of total dry matter (g)		
Apex	69.69	78.95	78.67	75.77 a
Medium	54.30	66.63	65.02	61.98 b
Base	42.76	69.48	48.71	53.65 c
MFA(F2)	55.58 B	71.68 A	64.13 A	
CV (%)	13.87			
MSD F1**e F2**	7.89			
MSD F1xF2	-			
		Leaf area (cm^2)		
Apex	88653.02	100593.90	105681.60	98309.49 a
Medium	84389.97	99229.97	93243.71	92287.88 a
Base	73286.62	82770.07	89130.63	81729.11 a
MFA(F2)	82109.87 A	94197.96 A	96018.65 A	
CV (%)	20.83			
MSD F e F2	16862.40			
MSD F1xF2	-			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

Table 8. Mean values of dry matter weight of stem and leaves; root dry matter weight; the weight of total dry matter and leaf area of the experiment with 2 buds at 90 days after installation of the experiment

	Control	Plant/15DAP	Groove/Vases	MFP(F1)
	Dry matter weight of stem and leaves (g)			
Apex	58.40	65.32	57.26	60.33 a
Medium	53.92	54.92	53.80	54.22 ab
Base	48.17	57.45	55.57	53.73 b
MFA(F2)	53.50 A	59.23 A	55.54 A	
CV (%)	12.35			
MSD F1* e F2	6.17			
MSD F1xF2	-			
	Dry matter weight of the root (g)			
Apex	49.78	59.19	54.25	54.41 a
Medium	46.94	50.93	43.17	47.01 ab
Base	39.72	43.67	48.28	43.89 b
MFA(F2)	45.48 A	51.26 A	48.57 A	
CV (%)	23.36			
MSD F1* e F2	10.08			
MSD F1xF2	-			
	Weight of total dry matter (g)			
Apex	108.18	124.52	111.51	114.74 a
Medium	100.87	105.85	96.97	101.23 b
Base	87.90	101.12	103.85	97.62 b
MFA(F2)	98.98 A	110.50 A	104.11 A	
CV (%)	13.63			
MSD F1**e F2	12.70			
MSD F1xF2	-			
	Leaf area (cm^2)			
Apex	108693.90	123371.90	113196.70	115087.50 a
Medium	101779.70	122708.50	106769.90	110419.30 a
Base	98650.87	113662.10	136894.90	116402.60 a
MFA(F2)	103041.50 B	119914.10 A	118953.80 AB	
CV (%)	16.03			
MSD F1e F2*	16284.93			
MSD F1xF2	-			

*Note: Lowercase averages followed by the same letter in the column do not differ statistically from one another. Capital averages followed by the same letter on the line do not differ statistically from one another. * Significant at the 5% probability level (0.01≤p <0.05). ** Significant at the 1% probability level (p <0.01). CV - Coefficient of variation. MSD - Minimum significant difference. MFA - Average of the application factor of the ethephon. MFP - Mean of the position factor of the yolk on the sugarcane stem. DAP - Days after application.*
Source: Prepared by the author

In the same way, that gemstones of origin at the culmination of the stem provide greater dry matter yield of stem and leaves due to their already mentioned morphophysiological characteristics. The roots were also influenced by the availability of nitrogen and glucose for the cellular development of the roots and had a potential potentiation with the use of ethephon when applied to the plant 15 days before planting [5]. The production of leaf dry matter is a characteristic that allows understanding the organic translocation, facilitating the understanding of plant performance in terms of productivity, which should be higher in C4 plants [9].

For the characteristic dry matter weight of the plant, a significant effect was found on the position of the yolk on the sugarcane stem and with the use of ethephon when applied to the plant 15 days before planting and in the furrow. It is possible to observe that the gemstones from the apex and with the use of ethephon, presented higher averages of the total dry matter weight of the plant in the experiment with 1 yolk at 90 days after planting. However, in the experiment with 2 buds, no significant effect was found with the use factor of ethephon, but in relation to the position of the yolk in the sugarcane stem it is possible to observe a significant effect in which the gemstones at the apex of the stalks allowed greater production of total dry matter of the plant.

Higher dry matter yield per cultivated area provides higher productivity and may provide higher sucrose production due to the high accumulation of sucrose in the stalks [31]. According to [32] photosynthesis and carbohydrate contents induced by ethylene and water deficit in the maturation stage of sugarcane showed that sugar cane stimulation occurred in the accumulation of sucrose in the stem.

In the experiment with 1 yolk (Table 7), no significant effect was found for the characteristic leaf area at 90 days after planting, however, in the experiment with 2 buds, only a significant effect was found on the ethephon use factor (Table 8). It was observed with the application of ethephon in the plant at 15 days before planting presented higher averages for leaf area. These results may be associated with increased mobilization of leaf nutrients and carbohydrates [25]. In this way, the increase of the leaf area occurs naturally with the growth of the plant.

4. CONCLUSIONS

The use of ethephon in the plant 15 days before planting, together with seedlings from the culmination of sugarcane stalks, presented better results for Emergency Speed Index; the number of tillers; leaf area; dry matter weight of stem and leaves and leaf area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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