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Management of Biostimulant and Silicon in Mineral Nutrition and Quality of Cotton Fiber

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Abstract

Silicon (Si) and biostimulant management have been proposed techniques to reduce the impacts of abiotic stresses and to increase the productivity of several crops, however, there are still few concise results of the management of this crop. The objective of this work was to evaluate the effects of biostimulant and silicon treatments on isolated or mixed applications on mineral nutrition, yield and fiber quality of two cotton varieties. For this, an experiment was carried out in a randomized block design in the municipality of Luís Eduardo Magalhães-BA, in a 4 × 2 factorial arrangement, with four replications, in which four biostimulant treatments (control, without application; Si; biostimulant; and Si + biostimulant) were evaluated in two cotton varieties (FM 954GLT and FM 983GLT). The nutrient content of leaves, relative water content, electrolyte leakage, fiber yield, and quality were evaluated, the data collected were submitted to the F test and means were compared by Tukey at 5% probability. At the end of the experiment, it was verified that the management of Si and biostimulants increase the integrity of the cell wall, the association of Si + biostimulant increases the levels of N, Fe and Si foliar and reduces the levels of B and Mn, and do not influence on yield and fiber quality.

Keywords: *Gossypium hirsutum* L., yield, fiber quality

1. Introduction

The cotton crop is considered the most important natural fiber source produced in Brazil and Bahia is one of the main producing states. In the 2016/17 crop year, the area cultivated with cotton in the state was 201.6 thousand hectares, with an average yield of 4293 kg ha^{-1}, while in the 2015/16 crop year, in a planted area of 235.2 thousand hectares the average productivity was 2629 kg ha^{-1} due to long drought periods (CONAB, 2017), representing a yield 63% lower than the 2016/17 harvest.

Several management techniques are adopted in the cotton production system, among them the application of silicon (Si) and the use of biostimulants has enabled a reduction of the biotic stresses in the plant, which in turn result in alterations in the development and growth of the plant and fiber, and plume quality. According to Luyckx et al. (2017), silicon acts reducing the effects of water stress and directly influences fiber growth, chiefly in the maintenance of stretching and fineness.

According to Zhu and Gong (2014), the effects of Si application in cotton plants consist of the formation of a double layer of silica under the leaf epidermis, which reduces water loss through cuticular transpiration and promotes root system elongation (Hattori et al., 2005), factors that may improve the plant`s ability to absorb nutrients from the soil. However, cotton is a Si-accumulating plant by specific channels (Reynolds et al., 2016) and it is essential to understand the effects of this element on the distribution of nutrients inside the plant, as well as its influence on fiber development and quality.

In relation to biostimulants, there is a vast literature that reports the effects of these products on the elevation of water stress tolerance by increasing the root system (Srivastava et al., 2016), maintaining the integrity of cell membranes (Soares et al., 2017), and by increasing nutrient assimilation and cotton fiber quality (Silva et al., 2016).

However, there are no reports on the effects of biostimulants with CaT™ technology on this crop. The CaT™ technology is a synthetic molecule that aims to stimulate the mobility and distribution of calcium in cell membranes and increase its concentration in the cytoplasm (Veritas™, 2017). The increment of cytosolic calcium for prolonged periods is one of the main mechanisms used by plants to induce tolerance to abiotic stresses, such as water and saline (Daszkowska-Golec & Szarejko, 2013).

Thus, the purpose of this study was to evaluate the effects of biostimulant and silicon treatments in isolated and/or in mixed applications on mineral nutrition, yield and fiber quality of two cotton varieties.

2. Method

The experiment was conducted in the research field of the Boiadeiro farm, located at 12°05′16.99″ S and 45°55′01.70″ W, in the municipality of Luís Eduardo Magalhães-BA. The climate in this region is classified as Aw (tropical climate with dry winter season), with an average temperature of 26.2 °C, rainfall of 1511 mm during the period of experimental conduction, and 810 meters of altitude.

The soil was classified as an Endoplinthic Ferralsol according to the WRB soil classification. The soil chemical characteristics in the 0-20 cm layer of the experimental area are: pH in $CaCl_2$ 6.2; 3.6% of organic matter; 54.51 mg dm^{-3} of P (Mehlich^{-1}); 0.62 mmol$_c$ dm^{-3} of K; 11.98 mmol$_c$ dm^{-3} of Mg; 55.56 mmol$_c$ dm^{-3} of Ca; 0.0 mmol$_c$ dm^{-3} of Al; 1.96 mg dm^{-3} of S; 0.51 mg dm^{-3} of B; 0.25 mg dm^{-3} of Cu; 11.20 mg dm^{-3} of Fe; 0.15 mg dm^{-3} of Mn; 0.43 mg dm^{-3} of Zn; 77.16 mmol$_c$ dm^{-3} of Cation Exchange Capacity (CEC). The soil presents sandy texture with 112, 39 and 849 g kg^{-1} of clay, silt, and sand, respectively.

The basal fertilization consisted of 55 kg ha^{-1} of N and 250 kg ha^{-1} of P_2O_5 provided by the application of mono-ammonium phosphate (MAP) at the time of sowing (09/12/2016), and the topdressing fertilization consisted of 400 kg ha^{-1} of KCl, corresponding to 240 kg ha^{-1} of K_2O, applied at 25 days after emergence (DAE), 200 kg ha^{-1} of ammonium sulfate (40 kg ha^{-1} of N and 44 kg ha^{-1} of SO_4) at 15 and 35 DAE, and 5 L ha^{-1} of Mn, 2 L ha^{-1} of B, 1 L ha^{-1} of Zn, and 4 L ha^{-1} of amino acids applied thrice throughout the crop cycle (20, 40 and 60 DAE). The amino acids applied and their respective concentrations were: L-glycine (5.08%), L-proline (2.94%), L-alanine (2.02%), L-aspartic acid (1.34%), L-arginine (1.65%), L-serine (0.65%), L-leucine (0.65%), and L-lysine (0.48%). The experiment was maintained free of pests and weeds through chemical control and manual weeding, respectively.

The experiment was arranged in a randomized complete block design, in a 4 × 2 factorial arrangement with four replicates, in which four biostimulant managements [control, without the application; Silicon (Si); biostimulant (Veritas); and Si + biostimulant (Veritas)] were evaluated in two cotton varieties (FM 954GLT and FM 983GLT). The treatments were composed of four applications of 2.5 kg ha^{-1} of Si and 1 L ha^{-1} of biostimulant.

The experiment installation occurred 40 days after the emergence (DAE) during the first application, and the other applications occurred at 60, 80 and 100 DAE. The applications were carried out using a CO_2-pressurized backpack sprayer (2 kgf cm^{-2}) coupled to a bar containing four XR 110.02 flat jet tips, with a flow rate of 200 L ha^{-1} of the mixture. The applications occurred in the morning with the temperature between 22 and 26 °C, and 60% of relative humidity of the upper air.

Data collection occurred at 120 DAE for electrolyte leakage, relative water content and nutrient contents in the leaves, and at 195 DAE for harvest and technological quality of the fiber, adopting the methodologies described below.

Considering the analysis of electrolyte leakage, the methodology proposed by Campos and Thi (1997) was adjusted using a copper drill to obtain ten leaf disks of 25 mm^2 each per experimental unit, which were washed and conditioned in beakers containing 20 mL of deionized water. After sealing with aluminum foil, the beakers were conditioned at 25 °C for 90 minutes and the initial conductivity of the medium (Xi) was measured using a benchtop conductivity meter. Subsequently, the beakers were subjected to a temperature of 80 °C for 90 minutes in a drying oven, and, after cooling the contents of the beakers the final conductivity (Xf) was measured. The electrolyte leakage was expressed as the percentage of conductivity in relation to the total conductivity after the exposure to the temperature of 80 °C per 90 minutes, as expressed in the equation:

$$\text{Electrolyte leakage} = [(Xi/Xf) \times 100] \quad (1)$$

Using a puncher (10 mm^2), 10 discs were removed from the diagnostic leaf in the basipetal direction of the plant, and the fresh matter (FM) of this material was recorded on an analytical balance. The disks were then transferred to beakers of 100 mL and submerged in deionized water for 24 hours to obtain the turgid mass of the material (TM). Afterwards, the discs were dried in a forced air oven at 70 °C for 48 hours to obtain their dry matter (DM), and the relative water content (RWC) was determined based on the following equation (Weatherley, 1950):

$$RWC = (FM - DM)/(TM - DM) \times 100 \tag{2}$$

The determination of the macro and micronutrient contents were performed at 120 DAE, where 20 diagnostic leaves were collected per plot and determined the contents of nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), copper (Cu), manganese (Mn), zinc (Zn), boron (B) and silicon (Si), following the criteria of diagnostic leaf classification described by Silva (1999).

The manual harvesting of the plot areas was carried out in order to evaluate the cotton productivity. Afterward, the material was weighed and the final yield was extrapolated to kg ha^{-1} following the methodology proposed by Santos et al. (2014).

The analysis of the technological characteristics of the fiber was carried out in the laboratory. Hence, 50 bolls of the middle third of the cotton plants were collected and de-stoned for this purpose and evaluated by HVI (High Volume Instrument) of the brand Zellweger Uster/Spinlab, series 900. The following variables were determined: micronaire index (MIC), fiber length (UHML), rupture strength (STR), length uniformity (UNF), fiber elongation (ELG), and short fiber index (SFI).

The data were submitted to analysis of variance by the F test and the means were compared by the Tukey test at 5% of probability using the software Sisvar 5.5 (Ferreira, 2011).

3. Results and Discussion

The variables leaf K content, UHML, UNF, and SFI showed differences between the two cotton varieties, while the biostimulant treatments influenced only the variables N, Mg, Fe, B, Si, and electrolyte leakage. The interaction variety x biostimulant management was significant for N and Mn contents, and for the other variables, it was not observed differences between the sources of variation evaluated (Table 1).

Table 1. Analysis of variance for the contents of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), boron (B), and silicon (Si), relative water content (RWC), electrolyte leakage (EXT), micronaire index (MIC), fiber length (UHML), rupture strength (STR), length uniformity (UNF), fiber elongation (ELG), short fiber index (SFI) and yield (PROD) of two cotton cultivars submitted to the application of biostimulants. Luís Eduardo Magalhães-BA, 2017

Source of variation	D.F.	Mean Squares					
		Macronutrients					
		N	P	K	Ca	Mg	S
Variety (V)	1	3.125^{ns}	0.031^{ns}	34.031*	13.781^{ns}	4.500^{ns}	0.125^{ns}
Management (M)	3	22.041*	0.197^{ns}	13.281^{ns}	16.447^{ns}	9.375*	0.125^{ns}
V × B	3	23.708*	0.197^{ns}	17.197^{ns}	5.614^{ns}	2.583^{ns}	0.458^{ns}
Block	3	1.208^{ns}	0.114^{ns}	7.531^{ns}	2.281^{ns}	5.208^{ns}	0.041^{ns}
Error	21	5.136	0.162	5.721	9.424	2.565	0.232
CV (%)		5.97	13.57	16.11	8.55	18.98	14.55
Source of variation	D.F.	Micronutrients					
		Cu	Fe	Mn	Zn	B	Si
Variety (V)	1	0.031^{ns}	105.125^{ns}	66.125^{ns}	0.781^{ns}	1.531^{ns}	0.031^{ns}
Management (M)	3	1.031^{ns}	441.750*	593.666*	16.781^{ns}	192.864*	0.531*
V × B	3	0.031^{ns}	102.375^{ns}	437.458*	20.614^{ns}	119.531^{ns}	0.197^{ns}
Block	3	0.0531^{ns}	349.916^{ns}	189.583^{ns}	21.197^{ns}	15.614^{ns}	0.197^{ns}
Error	21	0.816	140.011	131.607	13.007	59.186	0.126
CV (%)		16.53	9.85	17.86	12.61	17.37	5.52
Source of variation	D.F.	Technological Quality of the fiber					
		MIC	UHML	STR	UNF	ELG	SFI
Variety (V)	1	0.281^{ns}	13.781**	3.125^{ns}	36.125**	0.281^{ns}	57.781**
Bioestimulant (B)	3	0.031^{ns}	0.281^{ns}	1.708^{ns}	1.875^{ns}	0.114^{ns}	0.364^{ns}
V × B	3	0.281^{ns}	0.364^{ns}	0.375^{ns}	0.875^{ns}	0.114^{ns}	0.114^{ns}
Block	3	0.197^{ns}	1.614^{ns}	2.08^{ns}	1.208^{ns}	0.031^{ns}	0.614^{ns}
Error	21	0.245	0.590	2.613	2.184	0.150	0.459
CV (%)		12.49	2.56	5.23	1.82	6.50	7.20
Source of variation	D.F.	Physiological variables and crop productivity					
		RWC		EXT		PROD	
Variety (V)	1	112.500^{ns}		5.281^{ns}		604725.031^{ns}	
Management (M)	3	253.208^{ns}		46.364**		10548.947^{ns}	
V × M	3	152.250^{ns}		0.947^{ns}		232880.531^{ns}	
Block	3	56.375^{ns}		4.114^{ns}		462326.614^{ns}	
Error	21	85.994		2.662		156571.733	
CV (%)		11.11		9.18		6.63	

Note. ** significant at 1% of probability ($p < 0.01$), * significant at 5% of probability ($0.01 \leq p < 0.05$), ns not significant ($p \geq 0.05$). D.F.: Degrees of freedom.

Under the conditions of this study, it was verified that there were no differences for the contents of P, K, Ca, and S, and only the Mg content was significant (Table 2). According to the range of leaf nutrient content sufficiency for the cotton crop established by Kurihara et al. (2013), the values observed in this study are considered low for S, sufficient for P and K, high for Ca and in excess for Mg, both for the isolated application and in the silicon + biostimulant mixture. However, the content of Mg in the leaf observed for the control treatment, 9.87 g kg^{-1}, was higher than when the biostimulant was applied, 7.25 g kg^{-1}, and this possibly occurs because the product used favors the assimilation of Ca, which possibly reduced the leaf Mg content.

Regarding the two cotton cultivars studied, only the content of K showed differences between them, with K contents in the FM 954GLT and FM 983GLT varieties being equal to 15.87 and 13.81 g kg^{-1}, respectively, which correspond to a difference of 14%. In spite of the difference between the varieties, K levels are considered adequate for the crop, so this difference should be associated to the required level of each genetic material (variety) since potassium fertilization was based on the crop necessity.

Table 2. Contents of the macronutrients phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) in the leaves of cotton plants treated with biostimulants and silicon at 120 days after emergence. Luís Eduardo Magalhães-BA, 2017

Source of variation	P	K	Ca	Mg	S
	---------- g kg^{-1} ----------				
Biostimulants					
Control	3.00a	14.50a	35.75a	9.87a	3.12a
Silicon (Si)	2.75a	14.12a	36.50a	8.37ab	3.37a
Veritas (Ve)	3.12a	14.00a	37.37a	7.25b	3.37a
Si + Ve	3.00a	16.75a	34.00a	8.25ab	3.37a
Varieties					
FM 983GLT	2.93a	13.81b	36.56a	8.06a	3.25a
FM 954GLT	3.00a	15.87a	35.25a	8.81a	3.37a

Note. * Means followed by the same letter in the column do not differ by Tukey test at 5% of probability.

The micronutrient contents in the leaves were considered low for Cu, sufficient for Zn, suitable for B and high for Fe, according to the sufficiency levels proposed by Kurihara et al. (2013). The varieties did not show variation in the nutritional content of micronutrients (Table 3).

Table 3. Split of the interaction varieties × biostimulant and silicon management for the contents of nitrogen (N) and manganese (Mn) in the leaves of cotton plants treated with biostimulant and silicon at 120 days after emergence. Luís Eduardo Magalhães-BA, 2017

Source of variation	Cu	Fe	Zn	B	Si
	---------- mg kg^{-1} ----------				
Biostimulants					
Control	5.00a	114.50c	29.75a	50.00a	0.50b
Silicon (Si)	5.75a	115.25c	26.75a	44.62ab	0.62ab
Veritas (Ve)	5.75a	120.15b	28.12a	44.50ab	1.00a
Si + Ve	5.37a	130.62a	29.75a	38.00b	1.00a
Varieties					
FM 983GLT	5.50a	118.31a	28.43a	44.06a	0.75a
FM 954GLT	5.43a	121.93a	28.75a	44.05a	0.81a

Note.* Means followed by the same letter in the column do not differ by Tukey test at 5% of probability.

The management of Si and biostimulant did not affect the contents of Cu and Zn. The content of Fe, however, was higher in the treatment that received the application of Si + biostimulant, with 130.62 mg kg^{-1}, followed by the treatment with the application of biostimulant alone, which presented 120.15 mg kg^{-1} of Fe. The most interesting aspect of this result is the potentiation of the increase of Fe content in the leaf provided by the synergistic action of Si + biostimulant. According to Srivastava et al. (2016), biostimulants increase the capacity of nutrient accumulation by plants when used without the association with other products. However, there are no reports of this synergism with Si, thus, new research should be carried out to understand this behavior.

Contrary to the behavior presented for Fe, the management of Si + biostimulant reduced the content of B by 31% when compared to the control treatment, showing B contents of 38.00 and 50.00 mg kg^{-1}, respectively (Table 3). Boron is an element preferentially absorbed via the non-metabolic passive process, and the elevation of the transpiration and cell wall extensibility are the main mechanisms used for this nutrient assimilation (Hu & Brown, 1994; Hu & Brown, 1997). Thus, the application of Si + biostimulant aiming the reduction of transpiration and extensibility of the cell wall via accumulation of Si and Ca may have interfered in the main processes of B assimilation and, consequently, decreased its content in cotton leaves.

The application of Si + biostimulant and only biostimulant presented higher Si contents than the control treatment (Table 3). The control treatment presented 0.50 mg kg^{-1} of Si, while the use of biostimulant and Si + biostimulant showed contents of Si equal to 1.00 mg kg^{-1}. It is important to note that these levels represent a decrease of 50% of Si in the leaves when there is no biostimulant application. This is an indication that the biostimulant stimulates the elevation of this nutrient in the leaves, even in comparison to the foliar pulverization of Si.

The increase of nutrient assimilation due to the application of biostimulant is constantly reported in the literature, however, there is no record that the foliar pulverization of this nutrient is less effective than the stimulus caused by the biostimulant in absorbing the element. Perhaps, in the case of Si, this occurs due to the characteristics of essentiality of this nutrient in the cotton crop or because of the stimulation of the alternative Si assimilation routes described by Reynolds et al. (2016).

The content of N in the leaves, regarding the split of the interaction cultivars x biostimulant management, showed differences between varieties only when the biostimulant was applied, being the N content of the variety FM 983GLT (41.50 g kg^{-1}) 15% higher than the content observed for the FM 954GLT (36.00 g kg^{-1}). In relation to the content of Mn, the difference was verified only in the control treatments, being the Mn content higher in the leaves of the FM 983GLT variety, with 85.25 g kg^{-1}. These results indicate that the cultivar FM 983GLT is more responsive to the stimulation of N absorption via biostimulant and more demanding in Mn. However, the FM 954GLT variety, when stimulated with biostimulants responds similarly to FM 983GLT in relation to the content of Mn in the leaves (Table 4).

Table 4. Split of the interaction varieties × biostimulant and silicon management for the contents of nitrogen (N) and manganese (Mn) in the leaves of cotton plants treated with biostimulant and silicon at 120 days after emergence. Luís Eduardo Magalhães-BA, 2017

Biostimulants	Cultivar			
	FM 983GLT	FM 954GLT	FM 983GLT	FM 954GLT
	----------------- N (g kg^{-1}) -----------------		--------------- Mn (mg kg^{-1}) ---------------	
Control	37.00aB	36.50aB	85.25aA	66.75bA
Silicon (Si)	35.75aB	37.00aB	59.25aB	52.25aA
Veritas (Ve)	41.50aA	36.00bB	56.00bB	73.00aA
Si + Ve	38.75aAB	41.00aA	62.20aB	59.25aA

Note. * Means followed by the same uppercase letter in the column and same lowercase letter in the line do not differ by Tukey test at 5% of probability.

When analyzing the effect of the management within each variety, it is verified that the FM 954GLT variety presents higher N levels when the biostimulant is applied compared to the control and Si treatments, whereas for FM 983GLT the higher N content in the leaves is verified when Si + biostimulant was applied (Table 4). This result is in agreement with Nardi et al. (2016), who state that the application of biostimulants increases the activity of nitrogen metabolism in the plant, mainly through the activity of the enzymes of the nitrogenase complex and increase of chlorophyll.

The content of Mn in the leaves was higher in the control treatment than in the Si and biostimulant managements for the variety FM 983GLT, whereas there was no variation in the Mn content for the variety FM 954GLT regarding the type of management (Table 4). According to Sahebi et al. (2017), the reduction of Mn content when Si was applied occurs, indirectly, because of the fact that Si increases the capacity of P assimilation in plants, and as a consequence, there is a reduction in Mn availability. However, the reduction in the content of Mn caused by the application of the biostimulant is not fully understood, and new studies should be carried out to analyze how the CaT™ technology interacts with the mechanisms of Mn assimilation.

The application of biostimulant and/or silicon did not interfere in the relative water content nor in the yield of the cotton crop (Table 5). However, the treatments that received the application of just silicon or in mixture with the biostimulant presented electrolyte leakage 24% lower than the values observed for the control treatment, whereas the biostimulant presented a reduction of only 11%. This result validates the efficiency of both biostimulant and silicon in maintaining the integrity of the plants' cell wall, but the silicon is more efficient than the biostimulant.

Table 5. Relative water content (RCW), electrolyte leakage (EXT), and productivity (PROD) of the cotton crop submitted to the application of biostimulant in the treatment of seeds. Luís Eduardo Magalhães-BA, 2015

Source of variation	RWC	EXT	PRO
	-------------------------- %	-------------------------	---------- kg ha^{-1} ---------
Biostimulants			
Control	85.00a	20.87a	5961.75a
Silicon (Si)	75.12a	16.00c	5988.50a
Veritas (Ve)	86.25a	18.50b	5922.37a
Si + Ve	87.37a	15.75c	6005.75a
Varieties			
FM 983GLT	81.56a	18.18a	5832.12a
FM 954GLT	85.31a	17.37a	6107.06a

Note. * Means followed by the same letter in the column do not differ by Tukey test at 5% of probability.

This result corroborates the main lines of research that illustrate the efficiency of Si in overcoming the effects of biotic and abiotic stresses. Luyckx et al. (2017), for instance, report that Si is capable of suppressing the harmful effects of drought, high temperature, frost, salinity and, nutritional imbalance. According to Sahebi et al. (2015), these effects occur due to the fact that Si application increases the activity of the enzymes superoxide dismutase, guaiacol peroxidase, ascorbate peroxidase, and dehydroascorbate reductase. Biostimulants also act by increasing the activity of the antioxidant complex enzymes (Nardi et al., 2015) as a way to increase the cell wall integrity and decrease the leakage of ions from the cells.

The yields for both management and varieties were not statistically altered (Table 5). This result corroborates those described by Silva et al. (2016), who compared several biostimulants in the cotton crop and did not find out any differences between the treatments tested. In general, the changes caused by biostimulants in the cotton crop are related to the plant metabolism and do not always manifest in the form of increased production.

Reports of Si efficiency on the increase of cotton crop productivity are limited, especially regarding foliar pulverization. The most expressive study in relation to the increase of crop yield promoted by the application of Si was carried out by Boylston et al. (1990), who observed an increase of 12% in the yield.

The isolated or combined application of biostimulant and silicon did not influence the technological quality of the cotton fiber (Table 6). This result does not corroborate Silva et al. (2016), and Luyckx et al. (2017), who report that the application of biostimulants and silicon, respectively, alter the technological characteristics of the fiber. However, the biostimulant action is directly related to the active ingredients the product contains and products of different natures can induce different responses by plants.

Table 6. Micronaire index (MIC), fiber length (UHML), rupture strength (STR), length uniformity (UNF), fiber elongation (ELG), and short fiber index (SFI) of the cotton crop submitted to the application of biostimulants in the treatment of seeds. Luís Eduardo Magalhães-BA, 2015

Source of variation	MIC	UHML	STR	UI	ELG	SFI
	-- µg pol^{-1} --	---- mm ----	-- gf tex^{-1} --	----------------------	%	----------------------
Biostimulants						
Control	4.00a	30.12a	30.87a	81.25a	6.12a	9.75a
Silicon (Si)	4.00a	29.87a	31.00a	80.87a	6.00a	9.50a
Veritas (Ve)	3.87a	29.75a	30.37a	81.62a	6.25a	9.87a
Si + Ve	4.00a	30.12a	31.50a	80.50a	6.25a	10.00a
Varieties						
FM 983GLT	4.06a	29.31b	31.25a	80.00b	6.06a	11.12a
FM 954GLT	3.87a	30.62a	30.62a	82.20a	6.25a	8.43b

Note. * Means followed by the same letter in the column do not differ by Tukey test at 5% of probability.

The contents of Si in the cotton fiber rise during the second phase of fiber formation, during the elongation, reaching a maximum level in the tertiary phase of secondary wall deposition and the beginning of fiber maturation (Ferreira, 2008). Despite the evidence that silicon acts directly in the fiber formation process, in the present study the foliar application of this element did not interfere in the aspect of quality, and perhaps, in soil applications, the efficiency of the product is superior, just as reported by Boylston et al. (1990).

The cultivar FM 954GLT presented higher fiber length and uniformity, and lower short fiber index than the cultivar FM 983GLT (Table 6). Cotton cultivars have distinct fiber quality, mainly because that the characteristics that constitute the fiber classification are directly connected to the genotype (Saleem et al., 2011). However, according to Freire et al. (2017), the quality of the plume produced in the West of Bahia in the 2016/17 crop year is considered of great quality, being the micronaire index from 3.8 to 4.1 μg pol^{-1}, fiber length ranging from 28.9 to 29.9 mm, rupture strength from 28.0 to 29.9 gf tex^{-1}, length uniformity from 80.0 to 81.9% and, short fiber index ranging from 6.0 a 9.9%, the values most observed for the varieties FM 983GLT and FM 954GLT.

4. Conclusions

The management of Si and biostimulant decreased the levels of B and Mn in cotton leaves. However, there was an increase in the cell wall integrity, and in the contents of N, Fe, and Si in the leaves. Despite the positive effects, and these were related to the best nutrition of the plant, there was no change in yield and fiber quality. This means that the application of Si and biostimulants in the cotton crop may not be characterized as the best management of the crop since it will not result in an economic return to the producer.

The differences in the contents of N, K, and Mn in the leaves of the varieties FM 983GLT and FM 954GLT are related to the genetic characteristics of each material, so it is important to point out the correct choice of the cotton cultivar for the use in specific producing areas. The genetic characteristics of the variety may be better explored in regions to which they are already adapted, resulting in better yield and fiber quality results.

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