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Agronomic performance and soil chemical attributes in a banana tree orchard fertigated with humic substances¹

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ABSTRACT

Fertigation with humic substances products has been adopted in commercial banana tree plantations. However, there are few studies on the procedure to confirm its technical feasibility. This study aimed at assessing the effects of fertigation with humic substances on the chemical attributes of a Dystric Densic Xantic Ferralsol cultivated with the 'BRS Princesa' banana tree cultivar and on the agronomic performance of the orchard. The experiment was conducted using a randomized blocks design, with six treatments and four replications. Treatments consisted of a monthly application of humic substances doses based on the commercially recommended reference dose for the banana plantation (12.09 kg ha⁻¹ cycle⁻¹). The doses used were equivalent to percentages of the reference dose (100 %, 150 %, 200 %, 250 % and 300 %), in addition to the control. No significant effects of the fertigation with humic substances that could justify the use of the product at the doses assessed were observed on the soil chemical attributes, banana growth and yield.

KEYWORDS: *Musa* sp.; soil conditioner; drip irrigation.

RESUMO

Desempenho agrônômico e atributos químicos do solo em pomar de bananeira fertirrigado com substâncias húmicas

A fertirrigação com produtos à base de substâncias húmicas vem sendo adotada em plantios comerciais de bananeiras. No entanto, tal procedimento ainda carece de mais estudos para comprovar sua viabilidade técnica. Objetivou-se avaliar os efeitos da fertirrigação com substâncias húmicas nos atributos químicos de um Latossolo Amarelo distrocoeso cultivado com bananeira 'BRS Princesa' e no desempenho agrônômico do pomar. O experimento foi conduzido em delineamento de blocos casualizados, com seis tratamentos e quatro repetições. Os tratamentos consistiram da aplicação mensal de doses de substâncias húmicas, calculadas a partir da dose de referência (12,09 kg ha⁻¹ ciclo⁻¹) recomendada comercialmente para o cultivo da bananeira. As doses utilizadas foram equivalentes a porcentagens da dose de referência (100 %, 150 %, 200 %, 250 % e 300 %), além da testemunha. Não foram observados efeitos significativos da fertirrigação com substâncias húmicas que justificassem o emprego do insumo nas doses avaliadas sobre os atributos químicos do solo, crescimento e produção das bananeiras.

PALAVRAS-CHAVE: *Musa* sp.; condicionador de solo; irrigação localizada.

INTRODUCTION

Humic substances are the primary constituents of the soil organic matter, corresponding generically to the final product of organic waste decomposition in nature. They exhibit high stability, reactivity and persistence in the soil, besides being considered recalcitrant to biodegradation (Santos et al. 2008). Concerning their chemical nature, they display a high complexity and structural diversity, and are composed of humin, as well as humic and fulvic acids (Primo et al. 2011).

These carbon-rich organic materials exert a series of beneficial effects on soil attributes, including

positive effects on water storage capacity, soil aggregate formation and maintenance, cationic exchange capacity and nutrient availability (Mbagwu & Piccolo 1989, Seyedbagheri 2010, Selim & Mosa 2012, Baldotto & Baldotto 2014, Caron et al. 2015). Humic substances may also stimulate the plant physiology, depending on the species and humic substance characteristics, such as concentration, molecular weight, organic acid structure and material of origin (Lodhi et al. 2013, Muscolo et al. 2013, Zandonadi et al. 2013, Canellas & Olivares 2014, Caron et al. 2015).

Mahmoud & Hafez (2010) and Selim et al. (2010) obtained encouraging results with humic

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substances fertigation of potato crops in sandy soil. These authors reported positive effects on the chemical attributes of the sandy soil, including K content, and reduced leaching with the use of humic substances in association with mineral fertilization. Under controlled conditions, Arjumend et al. (2015) observed positive effects on N, P, K and organic matter content in pots filled with clay and silty-clay soils cultivated with wheat. In addition, Bezerra et al. (2015) reported a greater P availability after the application of humic substances to pots containing Neossol and Argissol cultivated with sugarcane.

In relation to the banana tree, Nomura et al. (2012) and Russo et al. (1995) reported positive results after applying these substances to seedlings grown under controlled conditions. Coelho et al. (2016) studied the drip irrigation of humic substances (doses up to 42.42 L ha⁻¹ cycle⁻¹), in a Dystric Densic Xantic Ferralsol cultivated with 'BRS Princesa' banana trees, and found no effects on the plant performance or soil physical-hydraulic attributes, during the first production cycle of the orchard.

According to López (2005), an important issue regarding the application of humic substances in commercial crops is that the high costs involved mean that the recommended doses are low, and are therefore frequently insufficient to improve the soil attributes and crop performance. Jones et al. (2007), Hartz & Bottoms (2010) and Little et al. (2014) found no effects that would justify the use of these substances at the doses and conditions studied.

There is little information about the effects of fertigation with these organic substances on the chemical attributes of a Dystric Densic Xantic Ferralsol and on the performance of banana trees, in consecutive production cycles.

This study aimed at assessing the direct effects of fertigation with humic substances, using a microsprinkler system, on the chemical attributes of a Dystric Densic Xantic Ferralsol cultivated with 'BRS Princesa' banana trees, in addition to evaluating the agronomic performance of the orchard.

MATERIAL AND METHODS

The experiment was conducted at the experimental field of the Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical (12°40'19"S, 39°06'23"W and altitude of 225 m), in Cruz das Almas, Bahia State, Brazil. The local climate is

classified as hot humid tropical (Aw to Am), according to the Köppen-Geiger classification. Annual average records for the area have been collected in the last five years (2011-2015) at its automatic weather station, showing maximum, minimum and average temperatures, relative humidity and accumulated rainfall of 29.02 °C, 20.8 °C, 23.9 °C, 82.8 % and 1,069 mm year⁻¹, respectively.

The experiment was conducted between 2012 and 2015, during two production cycles of a 'BRS Princesa' banana tree plantation. The first production cycle was considered the time between the seedling transplantation and the first harvest, while the second cycle comprised the time between the first and second harvest. The orchard was cultivated in a soil classified as Dystric Densic Xantic Ferralsol, considering the world reference base for soil resources (IUSS Working Group WRB 2014), or Latossolo Amarelo distrocoeso, according to the Brazilian soil classification (Santos et al. 2013).

The physical-hydraulic and chemical attributes of the soil in the experimental area were determined before the transplantation of banana seedlings. The soil was sampled at two depths (0-0.20 m and 0.20-0.40 m), with four repetitions. Only the average values were considered for the initial characterization of the soil attributes (Table 1).

The experimental area was prepared before the micropropagated 'BRS Princesa' seedlings were transplanted (October 20, 2012), with spacing of 2.0 m x 2.5 m. The planting holes had 0.5 m x 0.5 m and depth of 0.30 m. Fertilizer was applied to each hole using 12 L of hardened cow manure, 70 g of a micronutrient mixture of FTE BR 12 and 150 g of single superphosphate. There was no need for liming.

The control of invasive plants was conducted manually through weeding, thinning and defoliation (Alves et al. 2004).

Microsprinkling was the irrigation system employed. The emitters used a self-compensating pressure mechanism, flow of 54 L h⁻¹ and action radius of around 2.15 m. The microsprinklers were distributed to irrigate four plants per emitter. The system used an operating pressure of 2.0-2.2 bars. The fertilizers and humic substances applied during the experiment were injected into the hydraulic network by a dismountable injector piston pump with a regulatable flow rate of up to 60 L h⁻¹.

Artificial water replacements were determined based on the crop evapotranspiration obtained by the

Table 1. Analysis of the physical-hydraulic and chemical attributes of the soil before transplanting the banana seedlings.

Soil physical properties												
Horizon	Porosity (%)			Sd	Granulometry (g kg ⁻¹)			Textural classification				
Depth (m)	Total	Macro	Micro	g cm ⁻³	Total sand	Silt	Clay	(Type)				
0.00-0.20	30.49	9.9	20.59	1.76	732	87	181	Sandy loam				
0.20-0.40	27.53	5.25	22.28	1.79	629	68	303	Sandy clay				
Soil hydraulic properties												
Horizon	Gravimetric moisture water retention (%) by tension (atm)						Available water	Saturated hydraulic conductivity				
Depth (m)	0.1	0.33	1	3	15	%		mm h ⁻¹				
0.00-0.20	10.318	9.588	9.43	9.057	7.824	2.494		3.847				
0.20-0.40	10.72	9.733	9.023	8.562	7.813	2.907		3.3				
Soil chemical properties												
Horizon	pH	P ⁽¹⁾	K ⁽¹⁾	Ca ⁽²⁾	Mg ⁽²⁾	Al ⁽²⁾	Na ⁽¹⁾	H+Al	TEB	CEC	V	OM ⁽³⁾
Depth (m)	H ₂ O	mg dm ⁻³	cmol _c dm ⁻³									
0.00-0.20	6.7	16	0.1	2.5	0.9	0	0.01	0.7	4	4.3	84	7.0
0.20-0.40	6.0	6	0.1	1.7	0.7	0	0.01	1.4	3	3.9	64	5.9

SHC: saturated hydraulic conductivity; TEB: total exchangeable bases; CEC: cation exchange capacity; V: base saturation; OM: organic matter. ⁽¹⁾ Mehlich-1 extraction;

⁽²⁾ KCl 1M extraction; ⁽³⁾ modified Walkley & Black method (Silva et al. 1999).

product of the reference evapotranspiration, which, in turn, was calculated using the modified Penman-Monteith equation (Allen et al. 1998) and crop coefficients described by Coelho et al. (2006). The analysis of the water used in the experiment, collected during the dry season, is presented in Table 2.

Fertigations were initiated following the emergence of new leaves (around 30 days after

transplanting), with weekly doses of N and K and quarterly doses of P, in the form of urea, potassium chloride (KCl) and monoammonium phosphate, respectively. The amount of fertilizer applied was calculated based on the soil analysis and recommendations by Borges & Souza (2009). The amount of fertilizers applied is presented in Table 3.

A randomized blocks design was adopted, with six treatments, four replications and eight plants per experimental unit (40 m²), six of which were used. Treatments consisted of the monthly application of humic substances doses, which corresponded to the fractions of a reference dose of 24.18 kg ha⁻¹. Reference doses were calculated for the two orchard production cycles, based on the commercial recommendations of the product for fertigation (12.09 kg ha⁻¹ cycle⁻¹). The doses used were equivalent to the following reference percentages: T1: 100 %; T2: 150 %; T3: 200 %; T4: 250 %; and T5: 300 %, in addition to the control (T6: 0 %).

The product used during the experiment contained humic substances extracted from a

Table 2. Analysis of the chemical attributes of the irrigation water used in the experiment.

Parameters analyzed ⁽¹⁾	Unit	Result
Electrical conductivity	dS m ⁻¹	0.65
Ca	mg L ⁻¹	28.00
Mg	mg L ⁻¹	17.00
K	mg L ⁻¹	0.80
Na	mg L ⁻¹	100.00
pH	-	7.60
Sodium adsorption ratio	-	3.60
Total hardness (CaCO ₃)	mg L ⁻¹	140.00
Irrigation water quality classification	-	C ₂ S ₁

⁽¹⁾ Analysis of the water samples collected at the hottest and driest periods.

Table 3. Sources of nutrients, nutrient concentration in fertilizers, frequency of application and dose applied.

Source (Fertilizer)	Nutrient (Element)	Concentration ⁽¹⁾ g kg ⁻¹	Frequency (Interval)	Amount ⁽²⁾ kg ha ⁻¹ cycle ⁻¹
Urea	N	450	Weekly	445
MAP	P ₂ O ₅	480	Quarterly	150
KCl	K ₂ O	500	Weekly	600

⁽¹⁾ Approximate concentration on the label of the product, according to the manufacturer; ⁽²⁾ amount of fertilizers used in both cropping cycles, based on the recommendations by Borges & Souza (2009).

mineraloid rich in organic carbon known as leonardite, which exhibited the following specifications: humic acids = 100 g kg⁻¹; fulvic acids = 102 g kg⁻¹; K = 26.6 g kg⁻¹; and density = 1.14 kg dm⁻³.

The application of humic substances initiated at the end of December 2012, while the last dose was applied at the beginning of January 2015, totaling 25 applications, 14 of which were applied by the end of the first production cycle. Total and fractionated humic substances doses per treatment are shown in Table 4.

With respect to the assessment of the soil chemical attributes, samples were collected at the end of the second cycle, considering the total dose applied during the experiment. For purposes of soil sampling, a collection pattern was adopted, whereby samples were removed at 0.30 m from the pseudostem of one of the plants used in the experimental plot, at depths of 0.0-0.20 m and 0.20-0.40 m, toward the irrigation emitters.

The following soil chemical attributes were assessed: P, K, Ca, Mg and Na concentrations, as well as total exchangeable bases, cationic exchange capacity and base saturation (%), following the methodology proposed by Embrapa (2011). The organic matter content was measured according to the modified Walkley & Black method, as described by Silva et al. (1999).

Biometric data regarding the agronomic performance of banana plants were recorded at flowering and harvest. The following measures were taken at flowering: pseudostem height, considering the height from the ground to the apical meristem; pseudostem diameter, measured at 0.20 m from the ground; and number of viable leaves (completely

open leaves with more than 2/3 of limbs intact). At harvest, the following items were assessed: banana bunch mass, banana hand mass, banana stalk mass, number of hands per bunch, number of fruits per bunch, average fruit length, average fruit diameter, relative hand yield, relative bunch yield and time from transplanting to bunch harvest.

The banana bunch mass, banana hand mass and banana stalk mass were measured immediately after harvest, using a scale with an accuracy of 0.1 kg. The average fruit length and average fruit diameter were obtained by assessing the median fruit from the second cluster of the bunch. The relative hand yield and relative bunch yield were respectively determined from the product of banana hand mass and banana bunch mass and orchard density (2,000 plants ha⁻¹), with the data recorded in t ha⁻¹.

The data obtained were statistically analyzed using the Sisvar 5.3 software. Analyses of variance (Anova) were conducted with the F-test. For significantly affected traits, a regression analysis (5 %) was performed to assess the mathematical adjustment and determine the optimal dose to affect the trait through humic substances fertigation.

RESULTS AND DISCUSSION

The analysis of variance ($p < 0.05$) showed no significant effect of humic substances doses on the chemical attributes of the Dystric Densic Xantic Ferralsol, at the end of the experiment. The means per treatment and coefficient of variation per variable are shown in Table 5.

The absence of effects for the humic substances fertigation may be related to the doses applied, which

Table 4. Total and monthly doses of humic substances applied per treatment.

Amount/Treatment	Total humic substances doses applied during the experiment (% of the recommended dose)					
	100 %	150 %	200 %	250 %	300 %	0 %
Total applied (L ha ⁻¹) ⁽¹⁾	105.00	157.50	210.00	262.50	315.00	0.00
Total applied (kg ha ⁻¹)	24.18	36.27	48.36	60.45	72.54	0.00
Total applied (g plant ⁻¹) ⁽²⁾	12.09	18.14	24.18	30.23	36.27	0.00
Amount/Treatment	Monthly humic substances doses applied (% of the recommended dose) ⁽³⁾					
	100%	150%	200%	250%	300%	0%
Total applied (L ha ⁻¹)	4.20	6.30	8.40	10.50	12.60	0.00
Total applied (kg ha ⁻¹)	0.97	1.45	1.93	2.42	2.90	0.00
Total applied (g plant ⁻¹)	0.48	0.73	0.97	1.21	1.45	0.00

⁽¹⁾ Amount of humic substances, considering the commercial product with a density of 1.14 kg dm⁻³ and the following chemical composition: humic acids (100 g kg⁻¹), fulvic acids (102 g kg⁻¹), potassium (26.6 g kg⁻¹). ⁽²⁾ Amount of humic substances, considering the orchard density of 2,000 plants ha⁻¹. ⁽³⁾ Calculated considering the fractionation of the recommended dose (24.18 kg ha⁻¹) into 25 monthly doses applied starting in December 2012.

may have been insufficient to promote beneficial effects on the soil. López (2005) reported that doses commercially recommended are often low and compromise the effect of humic substances, regardless of the quality of the product used in fertigation. This author related the experiences by Spanish producers with humic substances and explained that promising results were only found when the commercially recommended dose applied was concentrated. However, it is important to note that these humic substances are expensive.

The monthly fractionating of the doses may have attenuated the effect of the humic substances fertigation on the soil chemical attributes. Selim & Mosa (2012) recorded positive effects on N, P, K, Fe, Mn and Zn contents, in sandy soil cultivated with broccoli submitted to NPK drip fertigation with doses of humic substances. These authors used doses of 120 L ha⁻¹, which corresponded to 21.96 kg ha⁻¹ (humic acids + fulvic acids), fractionated into only three applications, during the four-month experiment. Zhang et al. (2013) also obtained positive results for soil nutrient content, in a Cambisol cultivated with apples. For two years, these authors incorporated a 247.5 kg ha⁻¹ year⁻¹ dose of humic substances containing 85 % of humic acid and NPK.

The absence of humic substances effects was also reported by Hartz & Bottoms (2010), who assessed the impact of applying different humic

substances products extracted from leonardite, using doses of less than 5 kg ha⁻¹, in pots containing different types of soil cultivated with tomato or lettuce. Little et al. (2014) observed the absence of effects on the performance and nutrient absorption of forage legumes such as alfalfa. Jones et al. (2007) reported a similar result for the content and absorption of nutrients in pots containing wheat. Moreover, Lodhi et al. (2013) found differences in content among several humic substances products. These authors described variations in the response of the products tested, with respect to the performance of beans, corn and wheat.

In relation to the agronomic performance of the 'BRS Princesa' banana tree, there was also a lack of significant effects of the humic substances fertigation on growth and yield ($p > 0.05$). The only exception occurred for days from transplantation to bunch harvest, in the second production cycle, whose response fitted a quadratic model. The absence of positive effects from the humic substances fertigation on the soil chemical attributes may explain the lack of significant effects on the growth and yield properties of the orchard. This corroborates the findings by Coelho et al. (2016), who reported similar results for the agronomic performance of the 'BRS Princesa', during its first production cycle. The average values reported for the biometric variables are presented in Table 6.

Table 5. Average values of the soil chemical attributes per treatment and depth.

Depth	Treatment ⁽¹⁾	pH	P ⁽²⁾	K ⁽²⁾	Ca ⁽³⁾	Mg ⁽³⁾	Na ⁽²⁾	TEB	CEC	V	OM ⁽⁴⁾
m	kg ha ⁻¹		mg dm ⁻³							%	g kg ⁻¹
0.00-0.20	0.00	6.88	20.00	0.17	2.23	1.05	0.43	3.91	4.33	90.00	12.75
0.00-0.20	24.18	6.55	16.00	0.16	1.67	0.92	0.69	3.03	3.71	81.00	9.50
0.00-0.20	36.27	6.55	15.00	0.19	1.87	0.95	0.67	3.27	3.94	82.00	9.50
0.00-0.20	48.36	6.85	23.00	0.19	2.58	1.26	0.35	4.40	4.75	91.00	14.50
0.00-0.20	60.45	6.83	34.00	0.22	2.22	1.08	0.50	3.80	4.30	88.00	12.00
0.00-0.20	72.54	7.03	25.00	0.22	2.19	1.11	0.32	3.77	4.09	92.00	12.50
CV (%)	-	4.37	57.74	31.54	20.86	24.24	92.72	17.83	12.89	12.76	34.43
Mean	-	6.78	22.00	0.19	2.13	1.06	0.49	3.70	4.19	88.00	11.79
0.20-0.40	0.00	6.88	10.00	0.09	1.75	0.89	0.44	3.32	3.75	88.00	8.00
0.20-0.40	24.18	6.40	38.00	0.11	1.56	0.92	1.21	2.95	4.16	72.00	8.75
0.20-0.40	36.27	6.10	10.00	0.13	1.35	0.88	1.26	2.67	3.93	68.00	7.00
0.20-0.40	48.36	6.73	23.00	0.06	1.76	1.01	0.37	3.34	3.70	91.00	8.75
0.20-0.40	60.45	6.48	19.00	0.10	1.61	0.94	0.88	3.11	3.99	77.00	8.50
0.20-0.40	72.54	6.33	9.00	0.11	1.21	0.87	1.12	2.56	3.67	68.00	9.25
CV (%)	-	5.32	113.83	26.47	26.47	23.66	48.73	21.56	15.90	13.21	28.78
Mean	-	6.48	18.00	0.10	1.54	0.92	0.88	2.99	3.87	77.00	8.38

TEB: total exchangeable base; CEC: cation exchange capacity; V: base saturation; OM: organic matter. ⁽¹⁾ Considering the total dose applied during the experiment;

⁽²⁾ Mehlich-1 extraction; ⁽³⁾ KCl 1M extraction; ⁽⁴⁾ modified Walkley & Black method (Silva et al. 1999).

Considering the number of viable leaves at flowering reported by Nomura et al. (2013), those obtained here were higher and similar in the first and second production cycles, with averages of 16.1 and 11.5 leaves, respectively. These authors found the same variation in pseudostem height and pseudostem diameter between the first and second production cycles, with average pseudostem height values of 3.5-4.5 m and pseudostem diameter of 0.25-0.30 m, respectively. The yields were relatively higher or similar to those reported by Roque et al. (2014): 112 and 163.43 fruits for number of fruits per bunch; 0.158 m and 0.147 m for average fruit length; 0.385 m and 0.359 m for average fruit diameter; 12.26 kg and 14.29 kg for banana hand mass; 14.02 kg and 16.46 kg for banana bunch mass; 20.42 t ha⁻¹ and 23.81 t ha⁻¹ for relative hand yield; and 23.56 t ha⁻¹ and 27.42 t ha⁻¹ for relative bunch yield, considering the first and second orchard production cycles, respectively.

In relation to the time between transplanting and bunch harvest, a tendency to a shorter time may be observed in the second production cycle, as the humic substances dose is decreased to the minimum point of the quadratic model curve (Figure 1).

According to the adjusted model, the shortest time between transplanting and harvest (735 days) occurred with the application of 13.17 kg ha⁻¹, with a 43-days decrease, if compared to the control

(778 days). It was found that the averages recorded for transplanting to bunch harvest are very close to those reported by Nomura et al. (2013), who obtained values of 453.4 ± 19.2 and 747.1 ± 27.9 days for the first and second ‘BRS Princesa’ cultivation cycles, respectively, without applying humic substances.

The significant effect of humic substances on transplanting to bunch harvest may likely be explained by the stimulating effects, albeit not significant, of humic substances on plant metabolism (Baldotto & Baldotto 2014, Canellas & Olivares 2014, Caron et al. 2015). On the other hand, there

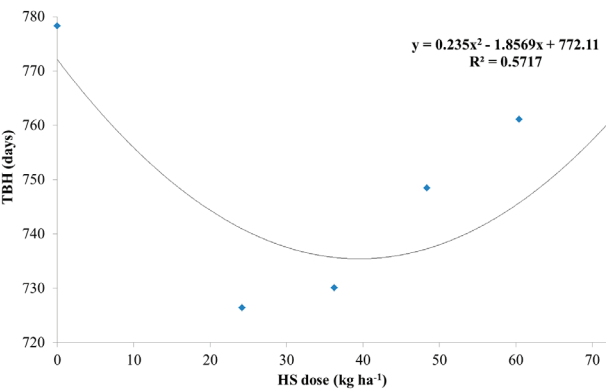


Figure 1. Graphic representation of the quadratic adjustment of the response of time between transplanting and bunch harvest (TBH) to the application of humic substances (HS).

Table 6. Average growth and yield properties, as a function of cycle and total dose applied

Production cycle	Treatment kg ha ⁻¹	PSH	PSD	NLF	TBH	BBM	BHM	BSM	NHB	NFB	AFL	AFD	RBV	RHY
		m	m	unit	days	kg	kg	kg	unit	unit	cm	cm	ton ha ⁻¹	ton ha ⁻¹
1 st	0.00	3.250	0.280	10.00	460.00	17.64	15.94	1.75	8.00	123.00	15.90	3.97	34.38	31.88
	13.58	3.220	0.270	10.00	446.00	16.36	14.72	1.64	8.00	118.00	15.70	3.95	32.71	29.44
	20.30	3.170	0.280	10.00	435.00	16.26	14.52	1.74	8.00	112.00	15.20	3.94	32.52	29.04
	27.02	3.400	0.280	9.00	433.00	15.56	13.82	1.74	7.00	107.00	16.20	3.93	31.11	27.64
	33.08	3.220	0.270	10.00	423.00	16.33	14.63	1.69	8.00	116.00	15.90	4.04	32.65	29.27
	40.60	3.370	0.270	10.00	442.00	16.05	14.45	1.59	8.00	116.00	16.00	3.94	32.01	28.91
CV (%)		4.630	7.750	7.70	4.00	11.21	11.44	12.16	4.68	9.48	3.59	2.58	11.21	11.44
Mean		3.272	0.275	10.00	440.00	16.37	14.68	1.69	8.00	115.00	15.80	3.96	32.73	29.36
2 nd	0.00	4.240	0.280	13.00	778.00	14.58	13.09	1.49	9.00	139.00	16.30	3.44	29.16	26.18
	24.18	4.330	0.290	12.00	726.00	15.32	13.72	1.60	8.00	117.00	16.00	3.43	30.63	27.43
	36.27	4.410	0.290	12.00	730.00	13.28	11.95	1.43	9.00	135.00	15.50	3.33	26.77	23.91
	48.36	4.230	0.280	12.00	748.00	16.45	14.67	1.77	9.00	150.00	16.40	3.47	32.90	29.35
	60.45	4.360	0.290	12.00	761.00	15.27	13.71	1.56	9.00	142.00	15.80	3.40	30.54	27.41
	72.54	4.210	0.280	12.00	748.00	14.52	13.11	1.41	9.00	142.00	15.00	3.35	29.05	26.22
CV (%)		4.840	9.530	3.82	2.23	10.62	10.71	14.79	6.22	9.36	4.10	2.26	10.62	10.71
Mean		4.297	0.285	12.00	749.00	14.90	13.37	1.54	9.00	137.00	15.80	3.40	29.84	26.75

PSH: pseudostem height; PSD: pseudostem diameter; NLF: number of viable leaves at flowering; TBH: time from transplanting to harvest; BBM: banana bunch mass; BHM: banana hand mass; BSM: banana stalk mass; NHB: number of hands per bunch; NFB: number of fruits per bunch; AFL: average fruit length; AFD: average fruit diameter; RBV: relative bunch yield; RHY: relative hand yield.

is no consensus regarding the mechanisms of action of these organic acids, given the varied responses of plants with concentration, molecular weight, organic acid structure and sources of humic substances, in addition to variations by plant species (Lodhi et al. 2013, Muscolo et al. 2013, Zandonadi et al. 2013, Caron et al. 2015).

The results of the present study demonstrate the need for additional researches that assess the effect of fertigation with high doses of humic substances, considering different sources such as coal, peat, humus, plant and animal waste. Other aspects that need to be elucidated are the ideal concentration of injection and frequency and application time per plant species, as well as soil type.

CONCLUSIONS

1. There was no effect of the humic substances doses evaluated on the chemical attributes of a Dystric Densic Xantic Ferralsol;
2. The application of humic substances did not interfere with the agronomic performance of the 'BRS Princesa' banana trees in either production cycle.

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