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CROP PRODUCTION

Quality and sensory acceptance of 'Pérola' pineapple grown in soil with application of organic fertilizer

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ABSTRACT: *Type of fertilizer and doses used are factors that influence the quality of pineapple fruit. This study aimed to evaluate the physico-chemical and sensorial quality of organically grown 'Pérola' pineapple and recommend the effective dose for best fruit quality, especially regarding sensorial acceptance. Effect of doses of 10, 20, 30, 40 and 50 t ha^{-1} of "bokashi" organic fertilizer on color, weight, pH, titratable acidity, soluble solids, soluble solids/titratable acidity ratio (SS/TA), vitamin C content, sensory acceptance and purchase intention was evaluated. Increasing doses of bokashi positively influenced weight and titratable acidity of the fruits and negatively affected the SS/TA ratio. Fruits produced with doses between 20t ha^{-1} and 40t ha^{-1}. had good sensorial acceptance and were considered to have ideal acidity, sweetness and texture by most consumers. The authors recommend using 20 t ha-1 of bokashi, as this dose promotes the production of high quality fruits, with satisfactory SS/TA ratio and high sensorial acceptance.*
Key words: *pineapple cultivation, organic farming, bokashi, sensory analysis.*

Qualidade e aceitação sensorial de abacaxi 'Pérola' cultivado em solo submetido à aplicação de fertilizante orgânico

RESUMO: *O tipo de adubo empregado e as doses ministradas são fatores que influenciam a qualidade do fruto de abacaxi. O estudo objetivou avaliar a qualidade físico-química e a aceitação sensorial de abacaxi 'Pérola' orgânico e recomendar a dose de adubo que produza frutos de melhor qualidade. Avaliou-se o efeito de doses de 10, 20, 30, 40 e 50 t de fertilizante orgânico do tipo "bokashi" ha^{-1} nas características cor, peso, acidez titulável, sólidos solúveis, ratio, vitamina C, aceitação sensorial e intenção de compra dos frutos. Doses crescentes de "bokashi" influenciaram positivamente a massa e a acidez titulável dos frutos e negativamente a relação sólidos solúveis/acidez titulável. Os frutos produzidos com doses entre 20t ha^{-1} e 40 t ha^{-1} tiveram boa aceitação sensorial e foram considerados com acidez, doçura e textura ideais pela maior parte dos consumidores. Recomenda-se o uso de 20 t de fertilizante orgânico do tipo "Bokashi" ha^{-1}, pois essa dose contribui para a produção de "frutos de primeira", com relação sólidos solúveis/AT satisfatória e elevada aceitação sensorial.*
Palavras-chave: *abacaxicultura, cultivo orgânico, "bokashi", análise sensorial.*

INTRODUCTION

The market for organic foods is expanding steadily in Brazil, bringing increased supply of organic fresh produce and processed products. However, pineapples are rarely grown in organic systems. The list of organic farmers of the Brazilian Ministry of Agriculture only contains 12 pineapple growers, six of them in the state of Paraná (MAPA, 2017). Among the factors that hinder organic cultivation of pineapple is the lack of technical information on establishment of the crop, preparation of the area, selection of varieties and planting material, crop treatment practices, management of diseases and pests, and harvesting and post-harvest management. Pineapple plants have high nutritional demands, so fertilization is generally essential to obtain a profit (SOUZA, 1999; OWUREKU-ASARE et al., 2015).

The application of organic fertilizers is an important tool for recovery of degraded soils and to boost crop yields. When correctly employed, these fertilizers promote notable improvements in the chemical, physical, physico-chemical and biological characteristics of the soil (OURIVES et al., 2010). Among various types of compost and fertilizer used in organic farming is bokashi, which according to the original japanese definition is any organic compound prepared with the addition of microorganisms that act in the fermentation of various materials, such as bran, manure and straw (FERREIRA et al., 2013). Because bokashi is very rich in organic matter, it can improve the soil in several aspects, among them a better structure (OURIVES et al., 2010).

Besides bokashi, the use of various rock powders provides macronutrients such as Ca, K, P

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and Mg, and micronutrients such as Co, Mo, B and Cu, helping to replenish or recondition soils degraded by intensive use or natural weathering (THEODORO et al., 2006).

Type and doses of fertilizer applied and the timing of application influence the internal and external quality of pineapple fruits (COELHO et al., 2007; GUARÇONI & VENTURA, 2011; MARQUES et al., 2011, OLIVEIRA et al., 2015). According to COELHO et al. (2007), the average fruit weight of the 'Jupi' pineapple was significantly higher at a dose of 93 g of NPK (20:05:20) plant^{-1} while the use of higher doses increased the contents of soluble solids and titratable acidity and reduced the soluble solids/ titratable acidity ratio. With respect to the timing of application, MARQUES et al. (2011) observed that the application of a total nitrogen dose of 30 g plant^{-1} after floral induction of the 'Smooth Cayenne' pineapple produced smaller fruits, with lower ripening index and higher titratable acidity. Fruit size was also related to the chemical quality, because small fruits contain higher levels of both soluble solids and titratable acidity (GUARÇONI & VENTURA, 2011). The SS/TA ratiois a physico-chemical trait that stands out for increasing the palatability and acceptance of fruits by consumers (VIANA et al., 2013).

This study aimed to evaluate the physico-chemical quality of organically grown 'Pérola' pineapple plants and to recommend a fertilizer dose that produces the best fruits according to sensorial acceptance by consumers.

MATERIALS AND METHODS

The experiment was conducted in the area belonging to the company Bioenergia Orgânicos, located in the municipality of Lençóis, Bahia, Brazil, in soil classified as red-yellow latosol, with clayey texture class, with the following characteristics in the topmost layer (0-20 cm) before transplantation: pH in water 5.8; P (Mehlich 1) 31.0 mg dm^{-3}; K 0.21 (Mehlich 1); Ca 2.9; Mg 1.6 and Al 0.0 cmolc dm-3 (all of them extracted by KCl 1 mol L^{-1}); CEC 9.6 cmol$_c$ dm^{-3}; V 50%; organic matter 2.5 g kg^{-1} soil (TEIXEIRA et al, 2017). The 'Pérola' cultivar was used. Plants were arranged in double rows with spacing of 1.2 m x 0.40 m x 0.40 m, for a total of 31,250 plants ha^{-1}, with micro spray irrigation. The experimental design was completely randomized with five treatments and eight repetitions. Each repetition was composed of a double row, with 30 plants per plots and a double row border between different treatments. The treatments were doses of 10, 20, 30, 40 and 50 tons of bokashi organic fertilizer per hectare. At planting, 150 grams.plant^{-1} of calcosilicated pyroxenite was added (30.0 g kg^{-1} of K_2O; 10.0 g kg^{-1} of P_2O_5; 52,0 g kg^{-1} of CaO; 30.0 g kg^{-1} of MgO; 63,0 g kg^{-1} of Fe_2O_3; 1.5 g kg^{-1}of MnO; 630 g kg^{-1} of SiO_2; 127mg kg^{-1}of Cu; 69mg kg^{-1} of Zn; and 5mg kg^{-1}of OM). The subsequent fertilizer applications were determined according to the organic treatments. The formulation of 1,000 kg of bokashi contained 150 kg of forest soil (0-0.05 m layer); 345 kg of cured cattle manure; 250 kg of castor bean cake; 25 kg of micronutrient (FTE); 10 kg of magnesium oxide; 20 L of molasses; and 200 kg of calcosilicated pyroxenite. Constituents were moistened with 100 L of water and mixed daily with a concrete mixer for a period of 10 days. The fertilization of each dose was divided into three-month intervals until the 10th month after planting and was applied at the plant base close to the oldest leaves of the stem. Constituents of the bokashi supplied potassium (K_2O) levels that varied from 5.63 g plant^{-1} (dose of 10 t ha^{-1}) to 28.16 g plant^{-1} (dose of 50 t ha^{-1}).

The fruits were harvested when up to 25% of the skin showed a yellow-orange color (CEAGESP, 2003) and were weighed on an analytic scale for subsequent classification in the calibers of classes from 1 to 4, according to the infructescence weight: 1- from 900 g to 1,200 g; 2- from 1,200 to 1,500 g; 3- from 1,500 to 1,800 g; and 4- greater than 1,800 g (BRASIL, 2002). Pineapple fruits weighing more than 1,500 g bring the highest prices in the market, so in this study they were designated as "grade A" (classes 3 and 4), "grade B" (class 2) and "grade C" (class 1), following the classification used by growers and merchants.

The fruits were transported to the Food Technology Laboratory of the Embrapa Cassava and Fruits, located in Cruz das Almas city, Bahia. For determination of the physical characteristics, three to five fruits per repetition were used, obtained from different rows of each treatment. The fruit weight (FW, in g) was determined with a semi-analytic scale and the color by the coordinates L^* (luminosity), C^* (chroma/saturation) and h^* (hue/color angle), using a Konica Minolta model CR400 color meter, according to the CIELAB D65 color space system (z = 93.6; x = 0.3133; y = 0.3195). Two color readings were performed at the base, two in the middle region and two at the apex of the fruit. For composition of the samples, three to five fruits of each repetition were ground in a blender to form homogeneous samples. These were used for evaluation of the following physico-chemical traits, in triplicate, of titratable acidity (TA, in % citric acid); soluble solids (SS, in

°Brix); pH; and SS/TA ratio, according to IAL (2008). Concentration of vitamin C was determined at 520 nm and expressed in mg 100 g^{-1} of pineapple pulp, as described by OLIVEIRA (2010).

Sensorial acceptance testing was conducted in the sensorial analysis laboratory, by 62 untrained judges. Fruits were cut into cubes and served to the judges in small plastic cups, for evaluation of the attributes color, aroma, flavor, texture and overall acceptance, by means of a nine-point hedonic scale, with the extremes being "I disliked extremely " to "I liked extremely", as established in the standard NBR 14141 (ABNT, 1998). In turn, the purchase intention was evaluated on a five-point scale, with the extremes of "I would certainly buy" (5) and "I certainly would not buy" (1). A five-point just about right (JAR) scale was applied for the intensities of the attributes sweetness, acidity and firmness, as described by FERREIRA et al. (2000) and BERILLI et al. (2011).

The results of the physical and physico-chemical evaluations were submitted to analysis of variance (ANOVA) and linear regression (FERREIRA, 2010). Significance of $p<0.05$ and the highest coefficient of determination (R2) were considered for choice of the regression model. The data from the acceptance test were also submitted to ANOVA and comparison of the means by the Tukey test ($p<0.05$). Finally, the data from the purchase intention and just right scale were computed in percentage.

RESULTS AND DISCUSSION

The application of bokashi doses greater than or equal to 20 t ha^{-1} permitted producing harvests where 90% of the fruits weighed more than 1,500 g (Table 1), which are called "grade A fruits" by growers/merchants and have the highest market value. When using organic fertilizer in doses greater than or equal to 20 t ha^{-1} and density of 31,250 plants ha^{-1}, the estimated yield of "grade A fruits" is more than 28 thousand fruits ha^{-1}, a very promising result, considering the higher value of these fruits.

Average weight of the fruits increased with rising doses of bokashi, reaching a maximum of 2,160 g at the dose of 36.77 t ha^{-1} (Figure 1a). In general, the nutrients that have the strongest positive influence on pineapple weight are nitrogen and potassium (PAULA et al., 1991; VELOSO et al., 2001). Based on the supply of nitrogen and potassium contained in the bokashi formulation, the average fruit weight increase can be attributed to the availability of these nutrients to the plants. Increased fruit weight due to high doses of nitrogen and potassium has also been observed in the Gold (GUARÇONI & VENTURA, 2011) and Smooth Cayenne pineapple cultivars (SPIRONELLO et al., 2004).

Weight is a variable used to classify fruits into homogeneous lots (BRASIL, 2002), and is not directly related to the pulp quality. For this reason, other traits must be considered to assess the quality of fruits produced by organic systems.

The titratable acidity of the fruits increased with rising doses of bokashi (Figure 1b), reaching a maximum of 0.62% for the dose of 32.25 t ha^{-1}. This increase in acidity caused the SS/TA ratio to decline (Figure 1c), conferring sweetness to the fruits, reaching the lowest value of 23.46, corresponding to application of a dose of 34.85 t ha^{-1} (Figure 1c). Considering that levels of K2O supplied by applying bokashi varied from 5.63 to 28.16 grams per plant, as mentioned before, the increase of acidity can be explained by the greater availability of potassium to plants, with consequent reduction of the SS/TA ratio. Similar results for the BRS Imperial cultivar were observed by OLIVEIRA et al. (2015) and CAETANO et al. (2013) when applying high doses of K2O. According to OLIVEIRA et al. (2015) and Etienne et al. (2013), the change in the acidity of pineapple fruits in response to supply of larger quantities of potassium can be attributed to the fact that K^+ is responsible for the balance of charges in the vacuoles, and thus affects the vacuolar synthesis or storage of organic acids in the fruit itself.

For the other physico-chemical attributes assessed, the bokashi doses did not have a significant effect (Table 2). The levels of soluble solids did not change with increasing doses of the organic fertilizer, and the fruits presented an average of 15.16 °Brix (Table 2), higher values than obtained by BERILLI et al. (2011), THÉ et al. (2010) and VIANA et al. (2013), who obtained values of 13.07, 11.50 and 12.33 °Brix, respectively, for fruits of the same variety produced by conventional cultivation. All doses employed led to the production of fruits with soluble solids levels higher than the minimum established in Brazilian regulations (BRASIL, 2002) for ripe fruits, 12 °Brix (Table 1). The absence of an effect of N and K on the levels of soluble solids in pineapple has been reported by various researchers (REINHARDT, 1980; PAULA et al., 1991; SOUZA et al., 1992; VELOSO et al., 2001).

The average level of vitamin C was 29.75 mg of ascorbic acid 100 g^{-1} (Table 2), a value higher than reported by THÉ et al. (2010) for the 'Smooth

Table 1 - Number[1] and percentage[1] of 'Pérola' pineapple fruits produced with different fertilizer doses, distributed in the three commercial classes and estimates[2] of production per hectare.

Fertilizer doses (t ha^{-1})	Number of "grade A" fruits (>1,500 g)	Estimate of "grade A" fruits(fruits ha^{-1})	Number of "grade B" fruits (>1,200 to 1,500 g)	Estimate of "grade B" fruits (fruits ha^{-1})	Number of "grade C" fruits (900 to 1,200 g)	Estimate of "grade C" fruits (fruits ha^{-1})
10	197 (82.20%)	25,688	31 (12.76%)	3,988	12 (5.04%)	1,575
20	218 (91.00%)	28,438	16 (6.67%)	2,084	6 (2.33%)	728
30	228 (94.93%)	29,666	7 (2.98%)	931	5 (2.09%)	653
40	230 (94.93%)	29,988	8 (3.03%)	947	2 (1.01%)	316
50	222 (92.59%)	28,934	10 (4.08%)	1,275	8 (3.33%)	1,041

[1]based on density of 31,250 plants ha^{-1}; [2] denomination assigned by pineapple merchants.

Cayenne' cultivar (19.19 mg of ascorbic acid 100g^{-1}) and VIANA et al. (2013) for the 'Pérola' cultivar (21.43 mg of ascorbic acid 100 g^{-1}), both grown conventionally. Higher levels of vitamin C are preferable because it is considered to be a functional compound that brings several health benefits (COMBS, 2003), and also for the fruit quality, since it prevents the development of symptoms of the anomaly known as internal browning (BOTREL et al., 2004).

The average value obtained for L* of 76.32 indicated light-colored pulp, because the nearer the value is to 100, the lighter the product's color is (Table 2). Average values obtained for color intensity (C*) and color angle (h*) demonstrated that the pulp of 'Pérola' pineapples in this study was light yellow,

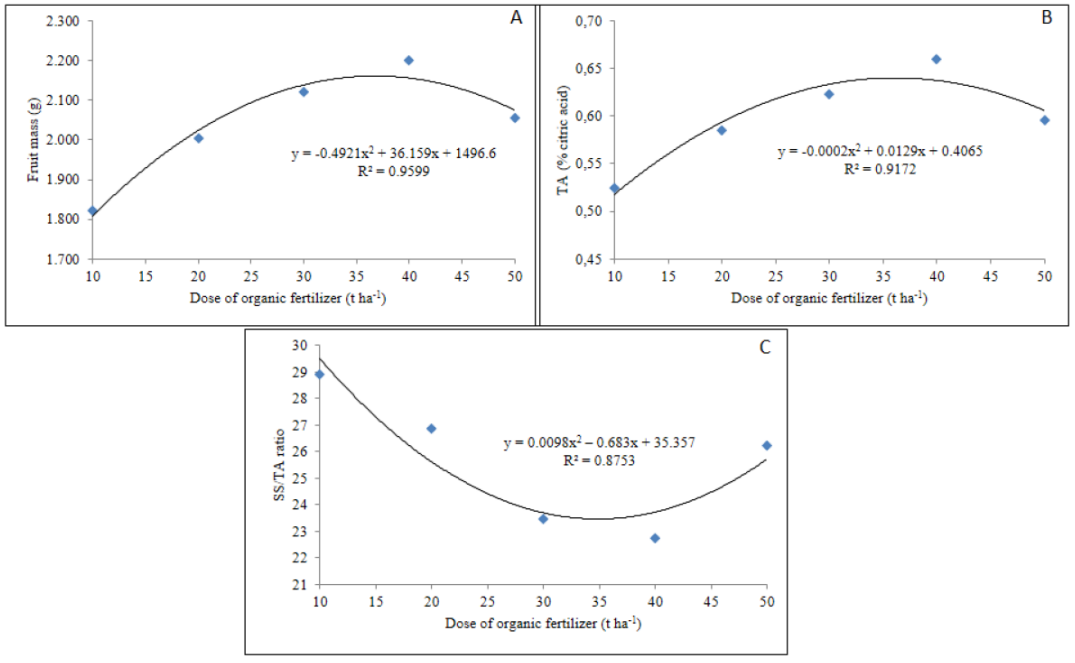

Figure 1 - Fruit weight (A), titratable acidity (B) and SS/TA ratio (C) of 'Pérola' pineapple plants cultivated with different fertilizer doses (bokashi) in an organic production system. Lençóis, Bahia, 2014.

Table 2 - Physico-chemical attributes of 'Pérola' pineapple plants grown with different fertilizer doses (bokashi) in an organic production system. Lençóis, Bahia, 2014.

Doses (t ha^{-1})	SS (ºBrix)	Vitamin C (mg100^{-1})	L*	C*	h*
20	15.57	28.71	78.83	18.11	100.07
30	14.58	29.01	77.61	15.88	99.56
40	14.93	30.85	75.25	18.24	100.22
50	15.61	30.33	73.94	16.58	99.22
Mean	15.16$^{n.s.}$	29.75$^{n.s.}$	76.32$^{n.s.}$	17.34$^{n.s.}$	99.57$^{n.s.}$
p-value	0.12	0.32	0.43	0.36	0.29

^{ns}not significant (P<0.05) by the F-test.

with low intensity. Light pulp is a characteristic of the Pérola cultivar, and the values were similar to those reported by VIANA et al. (2013) for fruits grown conventionally.

The overall acceptance of the fruits was influenced by the fertilizer doses. The highest approval percentages (above 90%) were obtained for fruits from plants cultivated with doses of 20 t ha^{-1} or higher, which were classified by the judges from "I liked moderately" and "I liked very much"in the hedonic descriptions (Figure 2a). Fruits from plants treated with 10 t ha^{-1} (Figure 2a) were less acceptable, with approval rating of 80.7%. Those fruits presented the highest SS/TA ratio (29.5) (Figure 1c); and although, a high value of this variable is considered favorable for fruit quality, our finding indicates this does not necessarily result in greater acceptance of the fruit. It also indicates that the low acidity of the fruits (0.55%) probably negatively influenced the sensorial acceptance of the judges.

With respect to positive purchase intention (categories "certainly would buy" and "possibly would buy"), the highest intention was assigned to the fruits cultivated with 20, 30 and 40 t ha^{-1} of organic fertilizer (greater than 77%), while the lowest intention was observed for fruits grown with the dose of 10 t ha^{-1} (62.07%), that is explained by the lower percentage of approval of these fruits by the panel of consumers (Figure 2b). A lower result was obtained by BERILLI et al. (2011) for the Pérola cultivar grown conventionally (70%), demonstrating the high sensorial quality of fruits evaluated in this study when

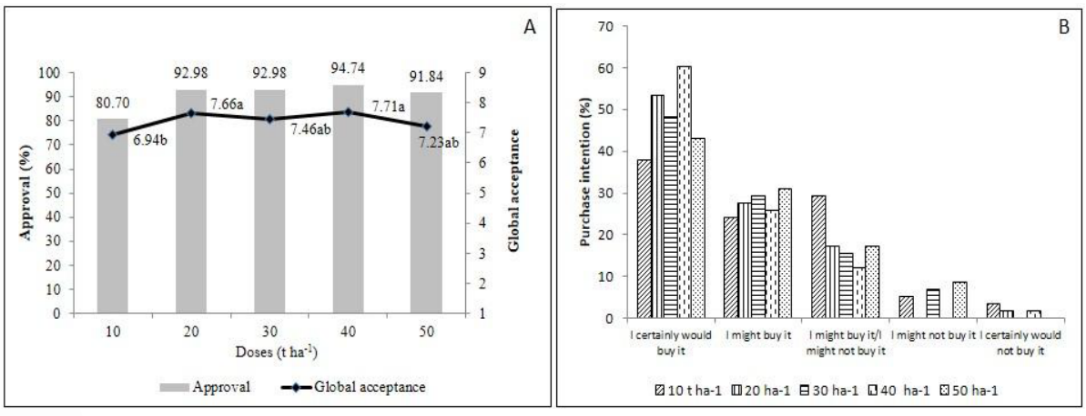

Figure 2 - Sensorial analysis of 'Pérola' pineapple fruits cultivated with different fertilizer doses (bokashi) in an organic production system. Lençóis, Bahia, 2014. A- Overall acceptance and approval % and B- Purchase intention.

applying fertilizer doses between 20 and 40 t ha^{-1}. The majority of the judges considered the acidity, sweetness and firmness of the fruits grown with doses of 20 and 30 t ha^{-1} to be "just about right"(Figures 3a, 3b and 3c). Lower values were reported by BERILLI et al. (2011), where 40% of the judges considered acidity to be "just about right" and 25% considered the sweetness to be "just right" in 'Pérola' pineapples grown conventionally. Fruits from plants that received 10 t ha^{-1} of organic fertilizer were rated as having "just about right" acidity and sweetness by less than 35% of the judges, factors that can explain the lower acceptance and purchase intention of these fruits (Figures 2a and 2b).

Results of this study showed that the use of 20 t ha^{-1} of fertilizer was satisfactory to obtain "grade A" fruits with good sensorial quality, without the need to use higher doses to produce organically grown pineapples.

CONCLUSION

Increasing doses of the bokashi organic fertilizer on pineapple plants positively influenced weight and titratable acidity of fruits and negatively affected the soluble solids/titratable acidity ratio.

The use of bokashi doses greater than or equal to 20 t ha^{-1} yielded harvests in which more than 90% of the fruits were rated as "grade A" according to the denomination of pineapple growers and merchants. The fruits produced using doses between 20 and 40 t ha^{-1} had good sensorial acceptance and were considered to have "just about right" acidity, sweetness and texture (firmness) by most of consumers.

We recommend using 20 t ha^{-1} of bokashi, since this level was sufficient to produce mostly "grade A" fruits, with high sensorial acceptance, at lower costs to growers.

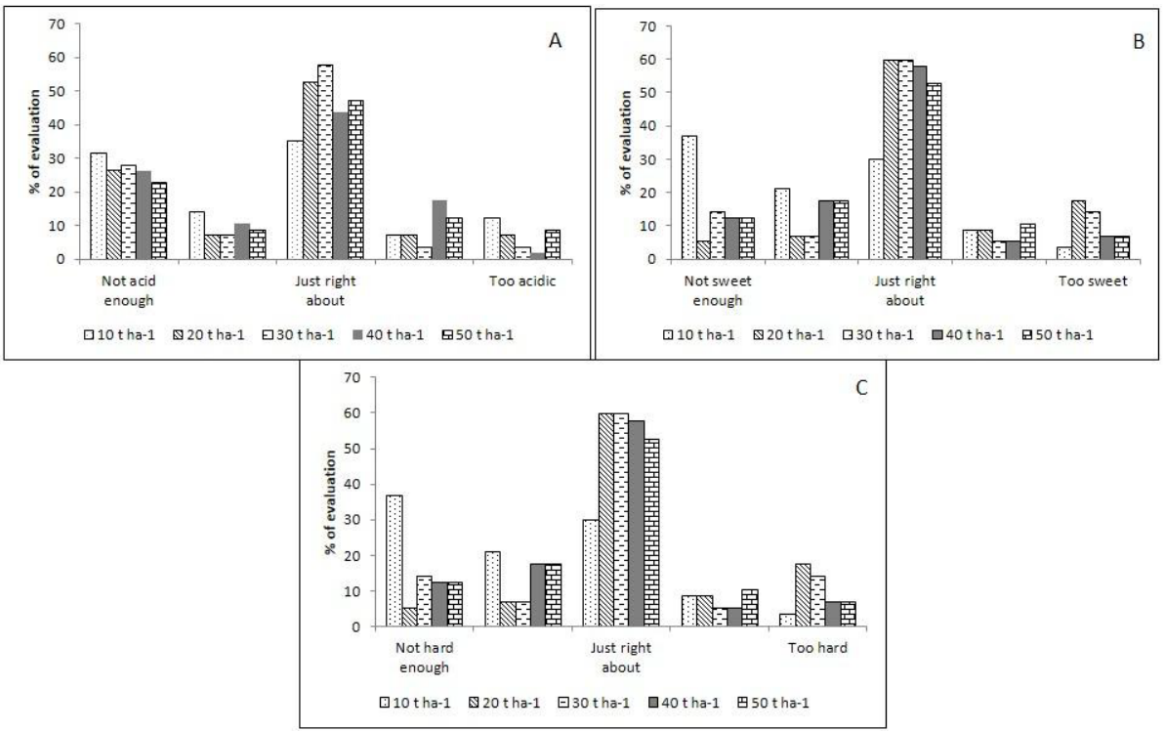

Figure 3 - Evaluation of acidity (A), sweetness (B) and texture/firmness (C) of 'Pérola' pineapple fruits cultivated with different fertilizer doses (bokashi) in an organic production system. Lençóis, Bahia, 2014.

DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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AUTHORS' CONTRIBUTIONS

Pádua, Matos and Carriello conceived and designed the field experiments. Viana and Reis coordinated the laboratory evaluations and performed the statistical tests on the experimental data. Viana wrote the first version of the manuscript. All the authors critically reviewed the manuscript and approved the final version.

ETHICS COMMITTEE

The research project was approved by the Research Ethics Committee of Universidade Estadual de Feira de Santana, under no. CAAE23109213.9.0000.5556.

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