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Production and quality of watermelon subjected to biofertilizer fertilization

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Abstract

The expansion of the area with organic agriculture is due to the market trend towards the consumption of healthier foods. However, with the increase in the cost of fertilizers imported by the country, the adjustment of doses and management practices with alternative sources for plant nutrition, such as biofertilizer, can be an alternative for the sustainability of properties. The experiment was conducted in the experimental field of Bebedouro (CEB) of EMBRAPA Semi-Arid Region in Petrolina-PE, Brazil, from September to December 2019, to evaluate the effect of biofertilizer doses on the production aspects of three watermelon varieties in the semi-arid region. The experimental design was randomized blocks, in a 6 x 3 factorial scheme, corresponding to six doses of biofertilizer (0; 80; 160; 240; 320 and 400 mL plant^{-1}) and three varieties of watermelon (Explorer, Red Heaven, and Majestic), with four replicates. Yield, number of fruits per plant, average fruit mass, fruit diameter, fruit length, length: diameter ratio, pulp firmness, rind thickness, pH, total soluble solids, titratable acidity and soluble solids/titratable acidity ratio were analyzed. The number of fruits per plant was not altered by biofertilizer doses. However, the variables yield and average fruit mass were altered by the interaction between varieties and biofertilizer doses. With yield of 40.22 t ha^{-1} obtained at the dose 201.33 mL plant^{-1}, the Explorer variety proved to be more efficient with the use of biofertilizer in organic system. Positive responses to biofertilizer application in postharvest quality attributes were obtained in Explorer and Red Heaven varieties.

Keywords: *Citrullus lanatus,* organic agriculture, semi-arid region, yield

Introduction

In 2020, Brazil was the fifth world producer of watermelon, reaching 2.3 million tons of fruits (22.00 t ha^{-1}) (FAO, 2020) whith, China, Iran, Turkey, In the first three positions, and finally Uzbekistan with the production estimate of 79,276,300 tons (42.88 t ha−1), 4,059,786 tons (29.81 t ha−1), 4,011,313 tons (41.99 t ha−1), 2,314,700 tons, and 2,030,992 tons (39.81 t ha−1), respectively. According to IBGE (2019), the states of Rio Grande do Norte, Rio Grande do Sul, São Paulo, Goiás, Tocantins and Bahia are responsible for about 70% of the Brazilian production.

Conventional watermelon cultivation is based on the large-scale use of industrialized inputs, but the lack of adequate fertilization management puts agricultural production, consumer health and the environment at risk. However, due to the increased demands of the consumer market, which seeks healthy foods, free of chemical residues and produced in a sustainable way, studies have been carried out to develop techniques that contribute to increasing production efficiency, considering the reduction in the use of synthetic and industrial inputs, as well as environmental sustainability. In this context, one of these techniques considered quite promising is organic agriculture (Santos et al., 2014).

Organic cultivation involves the use of natural inputs, and the supply of different sources of organic matter and nutrients in agricultural production promotes improvements to the soil, meeting the nutritional needs of plants (Batista et al., 2019; Oliveira et al., 2013a), in addition to having low costs and ease of acquisition (Oliveira et al., 2013b; Figueiredo et al. 2018).

The positive effects of biofertilizers on production, plant nutrition and fruit quality aspects have been reported in the results of several studies aimed at obtaining appropriate formulations and doses for crops. Batista et al. (2019) obtained positive responses in the growth variables

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studied using biofertilizer II in melon. In a study with 'BRS Caatingueiro' maize, Rodrigues et al. (2019), found that biofertilizer application promoted greater growth and development of plants. Santos *et al*. (2014), found an increase in melon yield with increased biofertilizer doses, as did Dutra et al. (2016), when evaluating biofertilizer doses along with organic matter sources on watermelon.

The development of trials with different alternative cultivation lines is of great importance to improve production techniques and induce better choices of genetic materials aiming at the demand of the consumer market of organic products (Boyhan et al., 2019).

In this context, the present study aimed to evaluate the effect of biofertilizer doses on the production and fruit quality of three watermelon varieties in an organic system in the semi-arid region.

Material and Methods

The experiment was conducted from October to December 2019, in the experimental field of Bebedouro (CEB) belonging to EMBRAPA Semi-Arid Region, in Petrolina-PE, located at 09° 09' S latitude, 40° 22' W longitude and 365.5 m altitude. According to Köppen's classification, the climate of the region is BSwh', semi-arid tropical, with average precipitation around 500 mm year^{-1}, irregularly distributed.

The soil of the experimental area is classified as a Eutrophic Red Yellow Argisol, sandy texture (Santos, 2013). Samples collected in the 0-0.2 m layer for chemical characterization, according to EMBRAPA, showed the following characteristics: pH (0.01 mol L^{-1} $CaCl_2$) - 6.20; EC - 0.051 dS m^{-1}; P (Mehlich-1) - 106.93 mg dm^{-3}; K^+ - 0.64 cmol$_c$ dm^{-3}; Ca^{2+} - 2.33 cmol$_c$ dm^{-3}; Mg^{2+} - 1.30 cmol$_c$ dm^{-3}; H + Al - 0.7 cmol$_c$ dm^{-3}; and base saturation - 86.9%.

A randomized block design was used, arranged in a 6 x 3 factorial scheme, with six doses of biofertilizers (0; 80; 160; 240; 320 and 400 mL plant^{-1}) and three varieties of watermelon (Explorer, Red Heaven and Majestic), with 4 replicates, totaling 72 experimental plots, each plot consisting of 6 plants. The spacing was 3.0 m between planting rows and 0.5 m between plants.

Sowing was carried out in polystyrene trays filled with the commercial substrate Plantmax®, by placing one seed per cell at a depth of about 2/3 of the seed size, with irrigation twice a day. Transplanting to the final cultivation site was performed seven days after sowing, when the seedlings had one true leaf. Soil tillage consisted of deep plowing and harrowing, and then a furrower was used to raise beds intended for planting.

Foundation fertilization and crop cover were performed according to the results of soil analysis and following recommendations from the Pernambuco Agronomic Institute, for cultivation in an irrigated production system. The sources used for fertilization and consequently for supplying the nutrients N (120 kg ha^{-1}), P (30 kg ha^{-1}), K (30 kg ha^{-1}), Ca (2 kg ha^{-1}) and Mg (25 kg ha^{-1}) were respectively: castor cake, Yoorin Master® phosphate, Ekosil®, Commax Algas® and Magnesium Sulfate. Micronutrients were supplied by foliar spraying using the products Sea Spray® and Fertibocash®.

For the formulation of 1000 L of biofertilizer, 50 kg of humus, 25 kg of castor meal, 20 kg of MB-4 (commercial formula containing micronutrients), 10 kg of Yoorin Master®, 5 L of sugarcane molasses, 300 g of probiotic DBR and 1000 L of water were used. The total period of time to prepare the biofertilizer was 15 days, and aeration was performed with an air compressor, at scheduled one hour intervals. In each application, the solution to be applied received 0.5 L of Vita Complex®, a liquid concentrate rich in organic elements from a microbial fermentation process. The chemical characterization of biofertilizer is presented in (**Table 1**).

Irrigations were carried out by drip irrigation, with a daily shift and water depths calculated by the evapotranspiration of the crop, based on the crop coefficient (Kc) and on the evaporation of the class A tank installed close to the site. Phytosanitary treatments were performed as needed, by spraying Nat ZB®, Agree®, lime sulfur and Primecur®. The application of biofertilizer doses, via irrigation water, was performed weekly from 12 days after transplantation (DAP). After being filtered through a cloth, the biofertilizer was injected into a system assembled with PVC tubes (lungs) in which the diluted solution enters the system by pressure difference.

The harvest was carried out at 60 DAT, in all plants of the plot with fruits in the stage of maturation, using the drying of the tendril as an indicator of the harvest point. The production characteristics evaluated were: total productivity (TP) represented by average fruit production per area; number of fruits per plant (NF); mean mass (MM); diameter (DT) and length (CP) of the fruits, and the length:diameter ratio (C:D). For the determinations, a

Table 1. Chemical characterization of biofertilizer

pH in H_2O	EC(dS m^{-1})	N	P	K	Ca	Mg	S	Cu	Mn	Zn	Fe
		--------------- g/L -----------------						---------- mg/L -----------			
6.1	4.3	0.6	50.0	0.9	3.4	0.6	0.02	1.1	11.7	16.3	68.3

Analyzes performed in accordance with the Manual of Analytical Methods for Fertilizers and Correctives (MAPA, 2017).

digital scale caliper and millimeter ruler were used.

Three representative fruits were sampled per plot to evaluate the following characteristics: pulp firmness, using manual penetrometer equipped with a tip of 8 mm in diameter, with results expressed in Newtons (N); rind thickness, using a digital caliper; pH, using a digital pH meter; total soluble solids content (TSS), determined by refractometry, with results expressed in °Brix; titratable acidity (TA), determined by titration with standardized 0.1 N NaOH solution, using phenolphthalein as indicator, with results expressed as percentage of citric acid; and soluble solids/titratable acidity ratio (SS/TA), calculated by dividing the absolute values of SS by the absolute values of TA.

Qualitative data were subjected to analysis of variance by the F test and Tukey test. Quantitative data were subjected to analysis of variance and, according to the significance level of 1 and 5% probability, polynomial regression analysis was performed, presenting the polynomial models with the best fit, based on the coefficient of determination (R^2). Statistical analyses were carried out with the program Sisvar version 5.6 (FERREIRA, 2011).

Results and Discussion

As the experiment was conducted during the hot season of the year, referring to the months from October to December, with average temperatures of 29 °C, the phenological cycle of the studied varieties was shorter than that presented by the companies, and harvest was performed at 60 days after transplanting.

Yield had a significant difference caused by the interaction between biofertilizer doses and watermelon varieties, indicating that the varieties showed different responses to the applied doses. When analyzing the varieties separately at each dose applied (**Figure 1**), a quadratic response as a function of the doses can be observed; the Explorer variety obtained maximum yield of 40.22 t ha^{-1} at the dose of 201.33 mL plant^{-1}, while Red Heaven and Majestic obtained maximum yields of 37.78 and 19.74 t ha^{-1} when 77.14 and 190 mL plant^{-1} were applied. It is important to highlight that the varieties Explorer and Red Heaven showed yield above the national average for conventional watermelon cultivation, around 23.00 t ha^{-1} in 2018 (IBGE, 2019).

The Explorer variety showed 7% higher productivity compared to the red variety. Heaven as well as increased efficiency in the use of biofertilizer, with an increase of 70.29 kg of fruit produced per mL of biofertilizer applied. In the Majestic variety, the use of biofertilizer provided an increase of 38 kg of fruit per mL applied, while Red Heaven

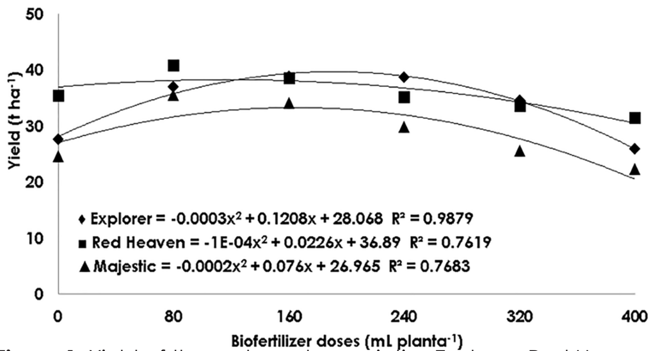


Figure 1. Yield of the watermelon varieties Explorer, Red Heaven and Majestic as a function of biofertilizer doses. Juazeiro-Bahia, 2020.

showed the lowest efficiency among the varieties, with an increase of only 5 kg of fruit per mL applied. So, the Red Heaven, despite showing excellent productivity in the organic production system, was not responsive to the use of biofertilizer. Explorer and Majestic varieties were more responsive to the use of biofertilizers, showing considerable increases in production with doses close to 200 mL plant $^{-1.}$ It is worth mentioning that the high doses of the biofertilizer significantly reduced the production of the evaluated varieties.

Some studies with biofertilizers and organic sources report lower yields when compared to the present study. According to Araújo *et al.* (2010), the maximum yield obtained among the four genotypes evaluated in an irrigated organic cultivation system in the São Francisco Valley was 17.52 t ha^{-1} for the Nova Crimson variety.

However, Dutra *et al*. (2016), observed higher maximum yield for watermelon, reaching 67.49 t ha^{-1} when using biofertilizer doses and three different sources of organic matter (Humus, Cattle manure and Goat manure) in the cultivation of the Crimson Sweet variety. It is worth highlighting that the positive influence of organic sources applied via soil on production aspects of agricultural crops is related to their nutritional effect, which may be the reason for the difference in the production results obtained by Dutra *et al*. (2016), who used sources of organic matter in their study. Yield values were similar to those found by Nowaki *et al*. (2017) and Barros *et al*. (2012), who reported maximum yields of 38.96 and 40.43 t ha^{-1} when evaluating the effect of nitrogen fertilization on watermelon.

The high yield of these varieties, compared to the conventional system, can be justified by the influence of genetic factors and the adaptability of the studied materials to organic cultivation, as well as the environmental conditions that act directly on yield. In addition, the application of biofertilizer to the soil can improve its chemical and biological conditions, increasing the availability of nutrients to plants, thus contributing to their yield (Marrocos *et al*., 2012).

Chemical analysis of the biofertilizer showed that it has a high phosphate content. Biofertilizers produced with P-solubilizing microorganisms have benefits, highlighting the mechanisms of solubilization of phosphate minerals (Mendes et al., 2017), production of phytohormones (Lubna et al., 2018) and growth promotion potential (Araújo et al., 2018). All these benefits can contribute to greater root growth, greater exploitation of soil resources and greater vegetative growth. The yield results presented show that the biofertilizer contributed to the nutritional needs of watermelon, stimulating good growth and development, thus making it possible to obtain fruits.

Regarding the number of fruits (NF), no significant effect was observed, indicating that the treatments were not sufficient to influence this variable, resulting in an estimated average of 1.0 fruit per plant for the evaluated varieties, regardless of the biofertilizer dose applied. The results presented corroborate those reported by Oliveira *et al.* (2013a) and disagree with those reported by Dutra *et al.* (2016), who found in watermelon an increasing linear trend in the number of fruits, with maximum values of 4.4, obtained with the increase in the doses of the organic inputs used. Cavalcante *et al.* (2010), when fertilizing watermelon plants with cattle manure and goat manure at dose of 30 t ha^{-1}, obtained the number of 3.0 fruits per plant.

Regarding the average fruit mass (AFM), the response was similar to that observed for yield (**Figure 2**), increasing significantly as the biofertilizer dose increased. The maximum AFM points, reached with biofertilizer doses of 210.00, 165.00 and 175.00 mL $plant^{-1}$ were 7.9, 7.0 and 5.6 kg $fruit^{-1}$ for the varieties Explorer, Red Heaven and Majestic, respectively. The application of the biofertilizer provided greater efficiency in fruit weight gain in the Explorer variety, with 13 g per mL applied, followed by Red Heaven (10.27 g per mL) and Majestic (8.28 g per mL)

Araújo *et al.* (2010), in an organic cultivation system, were able to obtain watermelon fruits of the varieties Nova Crimson, Opara and Holla with an average mass of 6.15 kg, values close to those found in the present study. In melon, Santos *et al.* (2014), found linear increase in the average fruit mass as a function of the bovine biofertilizer doses.

In the national market, the value of the watermelon fruit is calculated based on its mass, a fundamental characteristic in its commercialization. In this study, the varieties Explorer and Red Heaven had heavier fruits compared to Majestic, under the experimental conditions imposed. The average values of fruit mass found, however, are below the commercial classification for the conventional cultivation system. Resende & Yuri (2019), selecting watermelon cultivars for conventional cultivation under the conditions of the São Francisco Valley observed that the Explorer and Red varieties Heaven showed yields of 55.6 and 57.2 t ha^{-1}, with average fruit weight of 9.1 and 11 kg, respectively, for the period from August to October. However, the fruits obtained in the organic system of the present study are considered of great acceptance by consumers.

According to the values obtained for the variables fruit diameter (D) and fruit length (L) (**Figure 3** A and B), there was no interaction between the analyzed factors, and only the biofertilizer dose factor was significant. Thus, it can be seen that the model that most closely approximates the observed conditions is the quadratic polynomial model.

Regarding fruit diameter, the maximum value (22.31 cm) observed at the biofertilizer dose of 275 mL $plant^{-1}$ is similar to that found by Yau *et al.* (2010), when analyzing the production characteristics of seedless red flesh watermelons produced in the Selangor state, Malaysia. Santos *et al.* (2014), found effect of mixed and

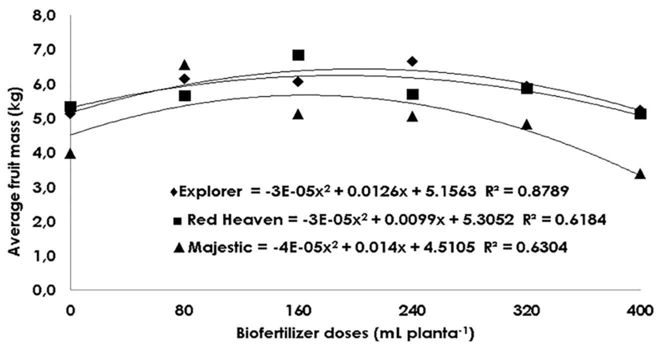


Figure 2. Average fruit mass of watermelon varieties as a function of biofertilizer doses. Juazeiro-Bahia, 2020

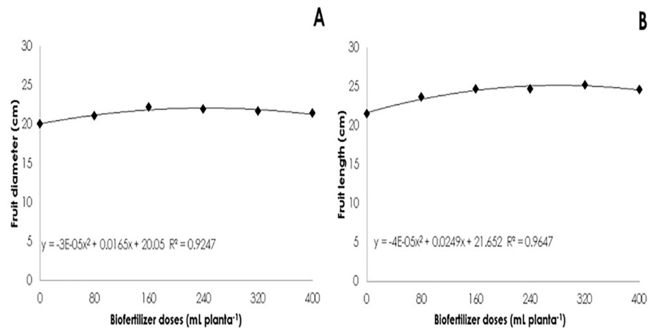


Figure 3. Diameter (A) and Length (B) of watermelon fruits as a function of biofertilizer doses. Juazeiro-Bahia, 2020.

bovine biofertilizer doses on the diameter of melon fruits, with values of 14.13 cm at the dose of 2.0 L/plant/week.

Contrary to the results observed in this experiment, Oliveira *et al.* (2013a), evaluated the effects of organic and mineral fertilization sources on the Crimson Sweet watermelon variety and found no significant differences for fruit diameter. Likewise, Silva *et al.* (2016), when studying the effect of sources and forms of P application on the conservation of seedless watermelon in a conventional cultivation system, also found no significant response of fruit diameter, with values close to 19.16 cm.

For fruit length, a maximum value of 25.52 cm was found at the biofertilizer dose of 311.25 mL plant^{-1}, higher than those found by Silva *et al.* (2016) and Yau *et al.* (2010), who detected values of 20.17 and 21.8 cm, respectively.

Although the use of biofertilizer, under the climatic conditions under study, did not provide the standard biometry (length and width) of the varieties studied, it is worth noting that the results obtained are desirable, considering that fruits with longer formats, due to their difficulty in handling and transport, have been despised by consumers, who prefer more round and oblong fruits, and currently with smaller sizes.

The length: diameter ratio (L:D) as a function of biofertilizer doses was significant, showing an increasing linear behavior (**Figure 4**), with maximum value of 1.16 cm at the dose of 400 mL plant^{-1}, however, they did not change the shape of the fruit.

The length to diameter ratio (length:diameter - L:D) gives an indication of the shape of the fruit. Values of this ratio equal or close to one indicate a round or almost round fruit, while the higher ratios (1.7-2.0) indicate oblong fruits (BOYHAN *et al*., 2019). In general, the L:D ratio means found are acceptable, since the characteristic shape of the fruits of the studied varieties is close to the spherical. Barros *et al*. (2012), found no significant effect on L:D ratio, obtaining an average of 1.07 cm, for Crimson Sweet watermelon subjected to nitrogen fertilization.

According to the results obtained, there was no significant difference in watermelon pulp firmness and rind thickness caused by the factors analyzed (cultivars and biofertilizer doses) in the evaluated characteristic regarding pulp firmness and watermelon rind thickness.

The average rind thickness for the three varieties was 1.17 cm, indicating low values of rind thickness, which confers lower postharvest resistance and requires greater care in fruit handling and transport. According to Boyhan *et al.* (2019), rind thickness influences fruit quality; the thicker the rind, the more resistant to breakage, but from the aesthetic point of view the thin rind is usually more appreciated by the consumers. Oliveira *et al*. (2019), when studying seeded watermelon hybrids in conventional cultivation, observed similar results, but with average rind thickness values lower than those found in the present study.

The average pulp firmness for the three varieties was 6.61N. Mendonça Junior et al. (2020), check the effect of different intervals and application rates biofertilizer the base algae promoted average values 00 of 8.09 N. The firmness of the pulp should vary between 9.00 and 16.00 N for watermelon (ALMEIDA et al., 2010).

The analysis of variance of the data related to the pH of the watermelon pulp showed that there was a significant effect of the Variety factor at 1% probability level (**Figure 5**).

The pH represents an indirect and inverse measure of the degree of acidity of fruits and vegetables, and the results obtained show that the Explorer variety was less acidic, with an average value of 5.63. Massri & Labban (2014), verified values close to those of this study, with pH of 5.6 in watermelon pulp with application of 30 m³ ha^{-1} of poultry manure throughout the cycle. The pH obtained in the varieties Red Heaven and Majestic were similar, with mean values of 5.39 and 5.29, respectively, approaching the mean value of 5.3 found by Araújo

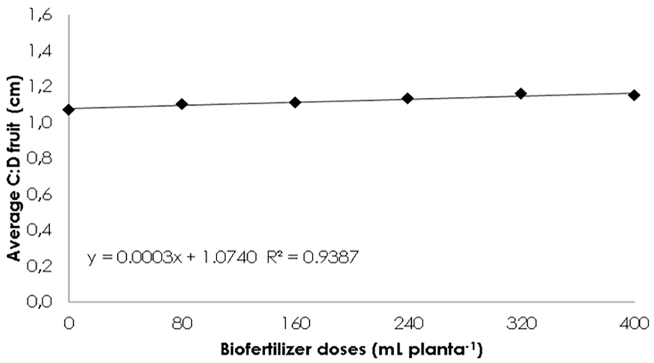


Figure 4. Length:diameter ratio (L:D) of watermelon fruits as a function of biofertilizer doses. Juazeiro-Bahia, 2020.

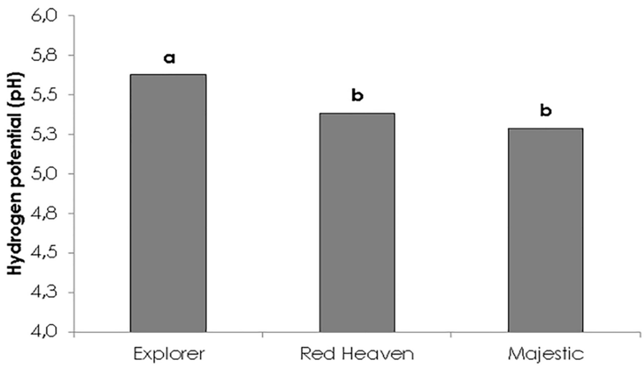


Figure 5. pH values of fruits of three watermelon varieties grown in organic system. Juazeiro-Bahia, 2020.

et al. (2010), in watermelon genotypes under organic cultivation, and Barros *et al*. (2012), when studying nitrogen rates in Crimson Sweet watermelon. Dal Mora et al. (2021), evaluating the cultivar Smile and Champagne reported values of 5.6 and 5.7, respectively. Similar results were obtained by Yıkmış (2020), and these authors report that the increase in pH in fruits can cause a decrease in the content of organic acids, as well as changes in soluble solids and total soluble sugars.

The total soluble solids contents were significantly affected by the interaction between the biofertilizer doses applied and the watermelon varieties (**Figure 6**). Soluble solids are an important criterion to evaluate the quality of watermelon and represent an indirect measure of the concentration of sugars in the fruit pulp (BARROS, et al. 2012). The soluble solids content indicates the concentration of compounds responsible for the sweet taste of watermelon, a characteristic that has an influence on the direct acceptance of the product by the final consumer.

When analyzing the varieties alone at each dose applied, it can be observed in (Figure 6) that the total soluble solids contents were described by the quadratic polynomial model, reaching a maximum value of 9.33 °Brix at the dose of 235.00 mL plant^{-1} and 10.28 °Brix at the dose of 180.00 mL plant^{-1} in the Explorer and Red Heaven varieties, respectively.

The application of biofertilizer reduced the total soluble solids content in the Majestic variety, being higher in the fruits of plants that did not receive biofertilizer (10.03 °Brix), reaching a minimum of 9.23 °Brix at a dose of 400 mL plant $^{-1,}$ however, remained within the minimum acceptable value for the foreign market (9 ° Brix).

Although the application of the biofertilizer showed low efficiency in increasing the productivity of the Red Heaven variety, it provided an increase in the total soluble solids content, with 17.5 mL/°Brix, while in Explorer the efficiency was 25.2 mL/°Brix.

Similar results were found by Silva *et al*. (2016), with values ranging from 9.94 to 10.21 °Brix with application of biofertilizer in seedless watermelon in the São Francisco Valley. In organic watermelon cultivation in Georgia, Boyhan *et al*. (2019), obtained soluble solids contents ranging from 9.2 to 11.2 °Brix. Araújo *et al.* (2010) and Dutra *et al.* (2016), observed maximum contents of 8.8 °Brix for watermelon under organic management, with values lower than those found in this study. Likewise, Chaves *et al.* (2013) and Ramos *et al.* (2009), observed values lower than 9.02 °Brix in conventional cultivation.

Different results obtained increments in soluble solids content with higher doses of biofertilizers applied in Sugar Baby watermelon. This difference can be attributed to the genetic characteristics of the tested varieties, with Majestic being less responsive to the application of biofertilizer in organic cultivation. In any case, the decrease in soluble solids content caused by the application of biofertilizer doses in the majestic variety compromise product acceptance, as consumers prefer sweeter fruits (CUQUEL *et al*., 2012). High temperatures influence fruit quality due to higher production of secondary compounds, and consequently, allow the plant to accumulate higher concentrations of soluble sugars. In addition, the total soluble solids content is also greatly influenced by varietal and nutritional factors, so the conditions and organic management made it possible to obtain satisfactory results of soluble solids contents for the studied varieties, indicating good commercial quality, considering that the minimum content suggested for harvesting by the European Union is 9.00 Brix. However, values above 10.00 Brix should be preferred, as they are more accepted by the internal market (DIAS & LIMA, 2010).

Regarding the values obtained for titratable acidity, it was found that there was no interaction between the analyzed factors and that only the variety factor was significant (**Figure 7**).

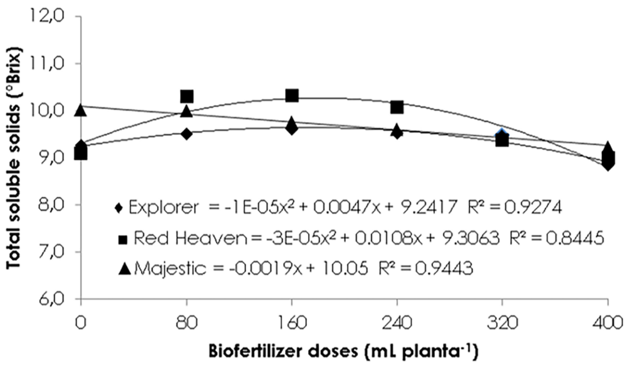


Figure 6. Total soluble solids in watermelon fruits as a function of biofertilizer doses. Juazeiro-Bahia, 2020.

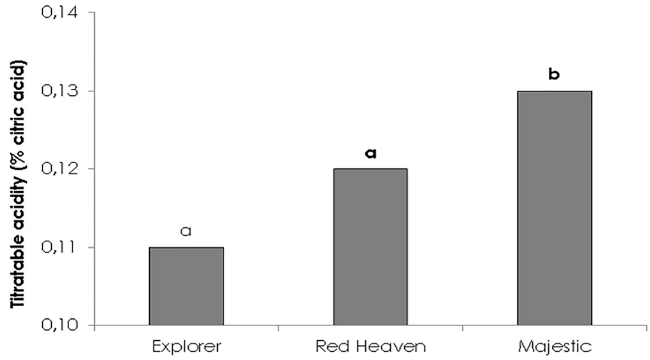


Figure 7. Titratable acidity of fruits of three watermelon varieties grown in organic system. Juazeiro-Bahia, 2020.

The Majestic variety showed higher titratable acidity, with an average of 0.13% citric acid, followed by 0.12 and 0.11% in the varieties Red Heaven and Explorer, respectively.

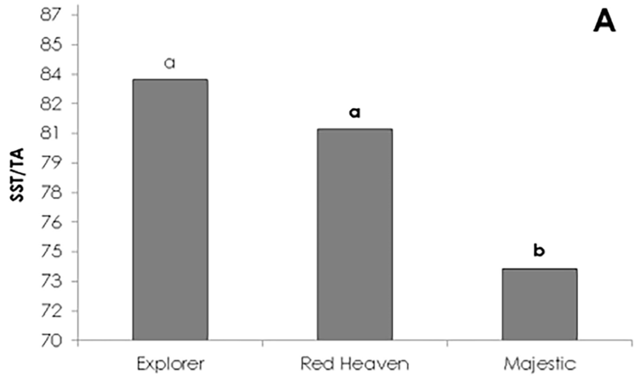
Results similar to that obtained in this study were reported by Araújo *et al*. (2010), who observed a maximum value of 0.13% citric acid for the varieties Nova Crimson and Holla subjected to the application of organic fertilizers. In the experiment conducted by Oliveira *et al.* (2019), titratable acidity ranged from 0.11 to 0.14% citric acid in seedless watermelon hybrids in conventional cultivation.

Values higher than those observed in this study were found by Oliveira *et al.* (2015), for the varieties Crimson Sweet, Olímpia and Denver in the region of Mossoró (RN). The acidity data make it possible to verify the main components of flavor (taste and aroma) in the fruits. According to Barros et al. (2012), soluble solids are an important criterion for evaluating watermelon quality and represent an indirect measure of the concentration of sugars in the fruit pulp. With ripening, organic acids tend to decrease due to their consumption in the respiration process, thus increasing the amount of sugars in the fruits, which justifies the contents of total soluble sugars being higher in the Explorer and Red Heaven varieties with the application of biofertilizer.

There was a significant simple effect of the varieties and biofertilizer doses applied on the SS/TA ratio, but there was no effect of the interaction between the factors (**Figure 8**).

Considering the SS/TA ratio, Explorer and Red Heaven stand out as the sweetest varieties, and Majestic differed statistically from the others, showing higher acidity (Figure 8A). For fruits to have good quality, it is important that the contents of organic acids be low, so that the ratio, relationship between soluble solids and titratable acidity, can achieve values that allow the characteristic of greater palatability of the fruit (BARROS *et al.,* 2012; SANTOS *et al.,* 2014). The ratio allows a good evaluation of fruit flavor, being more representative than the isolated measurement of sugars or acidity, because it provides a good idea of the balance of these components and thus the real flavor of the fruit. According to Aguiar *et al*. (2015), the higher this ratio, the greater the sensation of sweetness in the palate, and the ratio values may vary according to the cultivar, site and harvest period.

There was a difference between the biofertilizer doses applied regardless of the variety, and the maximum point of the SS/TA ratio, 82.51, was obtained at the dose of 216.00 mL plant^{-1} (Figure 8B), followed by a decrease



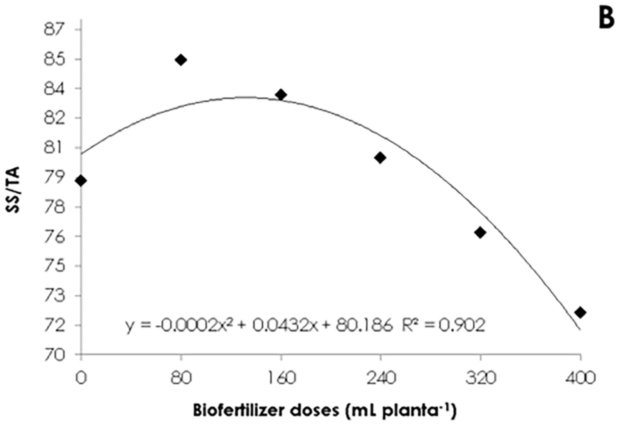


Figure 8. Soluble solids to titratable acidity ratio (SS/TA) of watermelon fruits as a function of varieties (A) and as a function of biofertilizer doses (B). Juazeiro-Bahia, 2020

in the ratio at the biofertilizer doses of 240, 320 and 400 mL plant^{-1}., The SS/TA ratio, which determines better fruit flavor, has already been determined in some crops; in melon, for example, when acidity is equal to or lower than 0.5% and the ratio is greater than 25:1, the fruits are considered adequate for consumption. According to Dal Mora et al. (2021), for watermelon this index is not yet well defined, where in their research the value of 70.13 was observed, where results of other research with ratio values such as 22.8 are still reported (Farias Barreto et al., 2016); 57,45 a 64,21 (Campagnol et al. 2012), in different cultivars of red watermelons.

Results similar to those of the present study were found by Oliveira *et al.* (2019), with SS/TA ratios from 63.72 to 86.24 in seedless watermelon hybrids under conventional management. Lower values than those of this study were observed by Oliveira et al., (2015).

Martins et al. (2013), observed that in watermelon, biostimulants influenced both the productivity (fruit length), as well as post-harvest quality (soluble solids and titratable acidity) of the fruits. Thus, we can infer that the quality of the fruit is related to the increase in the levels of SS/AT, which will be reflected in a good palatability of the fruit, considering the preference of Brazilian consumers.

Conclusions

All varieties showed good adaptability to the organic production system, showing good yields.

The Explorer variety was the most responsive to the use of biofertilizers in an organic production system, with a productivity of 40.22 t ha $^{-1,}$ showing good post-harvest quality.

The application of red variety biofertilizers Heaven does not provide considerable increases in productivity, but it does provide better post-harvest quality, meeting the requirements for commercialization.

The application of the biofertilizer had beneficial effects on the post-harvest quality attributes of the Explorer and Red varieties. Heaven providing satisfactory values of total soluble solids and soluble solids to titratable acidity ratio for the commercialization of the fruits.

Regardless of the variety, for greater benefits in productivity gain and fruit quality, biofertilizer doses ranging from (180-220) or a dose of 200 mL plant $^{-1}$ are recommended.

References

Aguiar, R.S., Zaccheo, P.V.C., Stenzel, N.M.C., Sera, T., Neves, C.S.V.J. 2015. Produção e qualidade de frutos híbridos de maracujazeiro amarelo no norte do Paraná. *Revista Brasileira de Fruticultura* 37: 130-137.

Almeida, M.L.B., Silva, G.G., Rocha, R.H.C., Morais, P.L.D., Sarmento, J.D.A. 2010. Caracterização físico-química de melancia 'Quetzali' durante o desenvolvimento. *Revista Caatinga* 23:28-31.

Araújo, V.C., Rossati, K.F., Xavier, L.V., Oliveira, V.A., Santos Carmo, G.J., Assis, G.A., Oliveira Mendes, G. 2020. Enhanced growth in nursery of coffee seedlings inoculated with the rhizosphere fungus Aspergillus niger for field transplantation. *Rhizosphere* 15: e100236.

Araújo, J.F., Silva, M.B., Costa, N.D., Dias, R.C.S., Souza, J.H.F, Silva, T.C.F.S., Silva, R.C.B. 2010. Genótipos de melancia sob sistema de cultivo orgânico irrigado no Submédio São Francisco. *Horticultura Brasileira* 28: 2911-2917.

Barros, M.M., Araújo, W.F., Neves, L.T.B.C., Campos, A.J., Tosin, J.M. 2012. Produção e qualidade da melancia submetida a adubação nitrogenada. Revista Brasileira de Engenharia Agrícola e Ambiental 16: 1078-1084.

Batista, G.S., Silva, J.L., Rocha, D.N.S., Souza, A.R.E., Araújo, J.F., Mesquita, A.C. 2019. Crescimento inicial do meloeiro em função da aplicação de biofertilizantes no cultivo orgânico. *Revista Brasileira de Agricultura Sustentável* 9: 24-32.

Boyhan, G.E., O'Connell, S., Mcneill, R., Stone, S. 2019. Evaluation of Watermelon Varieties under Organic Production Practices in Georgia. *HortTechnology hortte* 29: 382-388.

Campagnol, R., Mello, S.C., Barbosa, J.C. 2012.Vertical growth of mini-Watermelon according to the training height and plant density. *Horticultura Brasileira, Vitória da conquista* 30: 726-732.

Cavalcante, Í.H.L., Rocha, L.F., Silva Júnior, G.B., Amaral, F.H.C., Falcão Neto, R., Nóbrega, J.C.A. 2010. Fertilizantes orgânicos para o cultivo da melancia em Bom Jesus-PI. Revista Brasileira de Ciências Agrárias 5: 518-52.

Chaves, P.P.N., Ferreira, T.A., Alves, A.F., Pereira, P.R., Nascimento, I.R. 2013. Caracterização físico-química e sensorial de famílias de melancia tipo crimson sweet selecionadas para reação de resistência a potyvirus. *Revista Verde de Agroecologia e Desenvolvimento Sustentável* 8: 120-125.

Cuquel, F.L., Oliveira, C.F.S., Lavoranti, O.J. 2012. Sensory profile of eleven peach cultivars. *Ciência e Tecnologia de Alimentos* 32: 70-75.

Dal Mora, M.R., Rocha, R.R., Diamante, M.S., Guedes, S.F., Seabra Júnior, S. 2021. Atributos físico-químicos e bioquímicos de melancia vermelha e amarela minimamente processada, durante o armazenamento. *Scientific Electronic Archives* 14: 13-21.

Dias, R.C.S., Lima, M.A.C. Colheita e Pós-colheita. 2010. Disponível em: https://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Melancia/SistemaProducaoMelancia/colheita.htm <Acesso em 05 Set. 2022>

Dutra, K.O.G., Cavalcante, S.N., Vieira, I.G.S., Costa, J.C.F.D., Andrade, R. 2016. A adubação orgânica no cultivo da melancieira cv.Crimson sweet. *Revista Brasileira de Agropecuária Sustentável (RBAS)* 6: 34-45.

FAO. Food and Agriculture Organization. 2019. Disponível em: http://www.fao.org/land-water/databases-and-software/crop information/watermelon/en/ <Acesso em 05 Set. 2022>

Farias Barreto, C., Hofmann, J.F., Ilone Dambros, J., Radmann, E.B., Valmor Rombaldi, C. 2016. Qualidade de fatias de melancia armazenadas sob refrigeração e atmosfera modificada. *Revista Iberoamericana de Tecnología Postcosecha* 17: 288-295.

Ferreira, D.F. 2011. Sisvar: Um sistema computacional de análise estatística. *Ciência e Agrotecnologia* 35: 1039-1042.

Figueiredo, L.F., Maia Júnior, S.O., Figueredo, J.P., Silva, J.N., Ferreira, R.S., Andrade, R. 2018. Desempenho agronômico de amendoim sob diferentes fontes e doses de biofertilizantes. *Acta Iguazu* 7: 17-26.

IBGE. 2019. Produção Agrícola Municipal 2018. *IBGE* 45: 1-8.

Lubna, L., Asaf, S., Hamayun, M., Gul, H., Lee, I.J., Hussain, A. 2018. Aspergillus niger CSR3 regulates plant endogenous hormones and secondary metabolites by producing gibberellins and indoleacetic acid. Journal of Plant Interactions 13: 100-111.

Mapa. Ministério Da Agricultura e Pecuária. 2017. Disponível em: http://www.agricultura.gov.br/assuntos/insumos-agropecuarios/insumos-agricolas/fertilizantes/legislacoes <Acesso em: 30 Nov. 2019>

Martins, J.C.P., Aroucha, E.M., Medeiros, J.F., Nascimento, I.B., Paula, V.S. 2013. Características pós-colheita dos frutos de cultivares de melancia, submetidas à aplicação de bioestimulante. *Revista caatinga* 26: 18-24.

Oliveira, G., Galvez, A., Vassileva, M., Vassilev, N. 2017. Fermentation liquid containing microbially solubilized P significantly improved plant growth and P uptake in both soil and soilless experiments. *Applied Soil Ecology* 117: 208-211.

Marrocos, S.T.P., Junior, J.N., Grangeiro, L.C., Ambrosio, M.M.Q., Cunha, A.P.A. 2012. Composição química e microbiológica de biofertilizantes em diferentes tempos de decomposição. *Revista Caatinga* 25: 34-43.

Massri, M., Labban, L. 2014. Comparison of Different Types of Fertilizers on Growth, Yield and Quality Properties of Watermelon (Citrllus lanatus). *Agricultural Sciences* 5: 475-482.

Mendonça Júnior, A.F., Rodrigues, A.P.M.S., Sales, R., Negreiros, A.M.P., Bettini, M.O., França Júnior, E.O., Gonçalves Neto, A.C., Gonçalves, R.J.S., França, K.R.S. 2020. Production and quality of watermelon grown under seaweed extract. *Australian Journal of Crop Science* 14:1701-1706.

Nowaki, R.H.D., Filho, C.A.B., Faria, R.T., Wamser, A.F., Cotez, J.W.M. 2017. Effect of nitrogen fertilization on yield and quality of watermelon, cv. Top gun. *Revista Caatinga* 30: 164-171.

Oliveira Filho, F.S., Pereira, F.H.F., Brito, M.E.B., Medeiros, J.E., Lacerda, F.H.D., Júnior, J.E.C. 2019. Yield, quality and nutrient accumulation in watermelon as a function of organo-mineral fertilization. *Comunicata Scientiae* 10: 141-149.

Oliveira, J.B., Grangeiro, L.C., Sobrinho, J.E., Moura, M.S.B. Carvalho, C.A.C. 2015. Rendimento e qualidade de frutos de melancia em diferentes épocas de plantio. *Revista Caatinga* 28: 19-25.

Oliveira, F.S., Hafle, O.M., Abrantes, E.G., Oliveira, F.T., Santos, V.M. 2013. Produção de mudas de mamoeiro em tubetes com diferentes fontes e doses de adubos orgânicos. *Revista Verde de Agroecologia e Desenvolvimento Sustentável* 8: 96-103.

Oliveira, W., Matias, S., Silva, R., Alixandre, T.F., Nobrega, J. 2013. Crescimento e produção de melancia Crimson Sweet com adubação mineral e orgânica. *Revista Verde de Agroecologia e Desenvolvimento Sustentável* 8: 77-82.

Ramos A.R.P., Dias R.C.S., Aragão C.A. 2009. Densidades de plantio na produtividade e qualidade de frutos de melancia. *Horticultura Brasileira* 27: 560-564.

Resende, G.M., Yuri, J.E. 2019. Yield performance of watermelon cultivars in two growing seasons in the lower middle of the São Francisco Valley. *Brazilian Journal of Irrigated Agriculture* 13: 3533-3539.

Rodrigues, J.S., Garrido, M.S., Silva, J.A.B., Simões, W.L., Silva, R.A., Amorim, M.N. 2019. Growth and nutritional status of maize plants in response to different doses and application frequencies of biofertilizer. *Científica* 47: 123-131.

Santos, H.G., Jacomine, P.K.T., Anjos, L.H.C., Oliveira, V.Á., Lumbreras, J.F., Coelho, M.R., Almeida, J.A., Cunha, T.J.F., Oliveira, J.B. 2013. *Sistema Brasileiro de Classificação de Solos*. Embrapa, Brasília, Brasil. 353 p.

Santos A.P.G., Viana T.V.A., Sousa G.G., Azevedo B.M., Santos A.M. 2014. Produtividade e qualidade de frutos do meloeiro em função de tipos e doses de biofertilizantes. Horticultura Brasileira 32: 409-416.

Silva, A.C., Aroucha, E.M.M., Chaves, S.W.P., Medeiros, J.F., Paiva, C.A., Araújo, N.O. 2016. Efeito de diferentes doses, formas de aplicação e fontes de P na conservação de melancia sem sementes. *Horticultura Brasileira* 34: 529-536.

Yıkmış, S. 2020. Sensory, physicochemical, microbiological and bioactive properties of red watermelon juice and yellow watermelon juice after ultrasound treatment. *Journal of Food Measurement and Characterization* 14: 1417-1426.

Yau, E.W., Rosnah, S., Noraziah, M., Chin, N.L.E., Osman, H. 2010. Physico-chemical compositions of the red seedless watermelons (Citrullus lanatus). *International Food*

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