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NUTRITIONAL STATUS AND PRODUCTIVITY OF GUAVA TREE (PSIDIUM GUAJAVA L.) IRRIGATED WITH SALINE WATER AND TREATED WITH BIOSTIMULANTS

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ABSTRACT

Neste Obtaining high productivity in guava is achieved, among other factors, by mineral nutrition balanced with foliar nutritional levels in appropriate ranges. Salt stress causes nutritional imbalance that can be accompanied by toxicity, causing damage and yield drop. With the application of products such as biostimulants, the plant can acquire a new state of nutritional homeostasis, thus being able to obtain satisfactory productivity, even under stressful conditions. Therefore, the objective of this research was to evaluate the nutritional status and productivity of 'Paluma' guava tree irrigated with saline water and treated with biostimulants. The experiment was set up in a factorial scheme (2 x 4), referring to the spraying with Aminoagro Raiz® (Without and With) and the application of Codasal® and, or Amianoagro Raiz® via irrigation (Without, Codasal®, Aminoagro Raiz® and Codasal® + Aminoagro Raiz®), the treatments were distributed in randomized blocks with four replications. The determination of leaf N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, Zn and Na was carried out in two phenologic phases (Flowering and Fruit growth). In the fruits, the levels and export of N, P, K, Ca and Mg were determined. Fruit yield was also obtained. It was verified that the treatments did not improve the nutritional status of the 'Paluma' guava tree, nor the fruit yield.

Keywords: Psidium Guajava. Macro and Micronutrients. Yield. Lignosulfonate. Seaweed Extracts.

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INTRODUCTION

Guava cultivation is widespread in the Northeast region of Brazil, with a planted area of 10,525 ha in 2020, which corresponds to 48% of the total cultivated area in the country (IBGE, 2022). Most of this area planted with guava is located in the semi-arid region of the Brazilian Northeast, with favorable climatic conditions; however, the water used for irrigation generally has high levels of salts (≥1.5 dS m^{-1}) (MEDEIROS et al., 2003; LIMA et al., 2020), which can lead to soil salinization and limit productivity.

The guava variety that stands out the most in the Northeast region is 'Paluma', it has dual aptitude, red pulp, pear-shaped shape and productive potential of 100 t ha^{-1} (NATALE et al., 2002). Despite the high productive potential, the average productivity of this variety in fruit crops that irrigate predominantly with saline water (≈3.0 dS m^{-1}), as in the municipality of Picuí-PB, Brazil, is around 6.00 t ha^{-1}, well below the average productivity of the Northeast region, which is around 26 t ha^{-1} (IBGE, 2022).

The drop in crop productivity caused by saline stress is a consequence of the reduction of the osmotic potential of the soil solution and the ionic imbalance resulting from the high concentrations of Na^+ and Cl^- and changes in the relationships between nutrients, resulting in a cascade of physiological and metabolic disorders (WILLADINO; CAMARA, 2010).

Under optimal cultivation conditions, nutrient foliar contents of 'Paluma' guava tree to reach maximum productivity are 20-23 g kg^{-1} of N; 1.4-1.8 g kg^{-1} of P; 14-17 g kg^{-1} K; 7-11 g kg^{-1} of Ca; 3.4-4.0 g kg^{-1} Mg; 2.5-3.5 g kg^{-1} of S; 20-25 mg kg^{-1} of B; 20-40 mg kg^{-1} of Cu; 60-90 mg kg^{-1} of Fe; 40-80 mg kg^{-1} of Mn; 25-35 mg kg^{-1} of Zn (NATALE et al., 2002). However, under saline stress conditions, maintaining these levels is more difficult due to the adverse effects of salts (GRATTAN; GRIEVE, 1999). In this sense, Ebert et al. (2002) stated that saline stress with NaCl caused a reduction in the N, K and Ca content and increased the Na content in guava seedlings. Chiveu et al. (2020) also reported that salt stress reduces the nutritional contents of guava leaves, affecting the contents of K, P, Mg, S, B and Fe.

Regarding the macro and micronutrient contents of 'Paluma' guava fruit, Natale et al. (2002) described the following values: 8.5 g kg^{-1} of N; 0.9 g kg^{-1} of P; 11.3 g kg^{-1} of K; 0.7 g kg^{-1} of Ca; 0.8 g kg^{-1} of Mg; 0.8 g kg^{-1} of S; 5 mg kg^{-1} of B; 10 mg kg^{-1} of Cu; 14 mg kg^{-1} of Fe; 14 mg kg^{-1} of Mn and 14 mg kg^{-1} of Zn. The same author reported that for each ton of fresh fruit, 1,179 g of N; 121 g of P; 1,554 g of K; 94 g of Ca; 107 g of Mg; 107 g of S; 0.67

Revista ARACÊ
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g of B; 1.34 g of Cu; 1.88 g of Fe; 1.88 g of Mn and 1.88 g of Zn are extracted and exported with the harvest.

Salinity causes changes in the nutritional contents not only of the leaves but also of the fruits, as can be seen by the results of Keutgen and Pawelzik (2008), who reported that salt stress increases the amount of toxic ions (Na and Cl) in fruits and nutrients such as N, K and Zn. Rouphael et al. (2017) reported that salt stress affects Ca and Mg contents of fruits, but has no effect on K and P contents.

Considering the damage caused by saline stress, it is necessary to carry out research in order to mitigate its deleterious effects. In this theme, the use of biostimulants has been highlighted lately as a viable alternative to contain the effects of stress on plant nutrition and consequently increase productivity. In the research carried out by Rouphael et al. (2017), the authors reported that a biostimulant based on seaweed extracts raised K levels and reduced Na levels in plant leaves, additionally increasing fruit productivity. In research carried out by Mutale-joan et al. (2021), it was reported by the authors that the application of microalgae-cyanobacteria extract recovers the nutritional homeostasis of plants under saline stress.

Humic substances and analogous compounds such as lignosulphonate are another class of biostimulants widely used as attenuator of saline stress in plants. increasing productivity and reducing the Na content in tissues (ELSAWY et al., 2022). In the research by Çimrin et al. (2010) it was reported that the application of humic acid increased the contents of N, P, K, Ca, Mg, S, Mn and Cu and reduced the Na contents of plants under salt stress.

Considering the above, the objective of this research was to evaluate the performance of biostimulants applied via foliar and irrigation on fruit production and on the nutritional status of ‘Paluma’ guava tree irrigated with saline water.

MATERIAL AND METHODS

LOCATION AND CHARACTERISTICS OF THE EXPERIMENTAL AREA

The experiment was installed in a commercial orchard (6°26'29.2"S, 36°14'01.3"W) of three-year-old ‘Paluma’ guava tree, with seedlings propagated by cuttings, located at Sítio Boca da Mata, Municipality of Picuí, State of Paraíba, Brazil. The climate in the region is BSh type according to the Köppen classification, that is, hot semi-arid with summer and autumn rains (MASCARENHAS et al., 2005). The rainfall during the execution of the

Revista ARACÊ
ISSN: 2358-2472

experiment is shown in table 1, obtaining a total of 595.5 mm of accumulated rain (AESA, 2020).

Table 1 - Distribution of rainfall (mm) during the experiment period (AESA, 2020)

---------- 2019 ----------					---------- 2020 ----------		
August	September	October	November	December	January	February	March
9.6	4.9	13.8	1.0	0.0	76.2	83.7	406.3

The soil in the area where the guava orchard was installed at 6 x 6 m spacing is classified as Oxisol (USDA, 2015). Before the beginning of the experiment, soil sampling was carried out in the layers of 0–20 and 20–40 cm to carry out the fertility and physical analysis according to the EMBRAPA method manual (2017), also salinity analysis according to Richards (1954), the results are shown in table 2.

Table 2 - Chemical (fertility and salinity) and physical attributes of Oxisol cultivated with 'Paluma' guava tree before application of treatments

Fertility											
Depth (cm)	pH	P	K^+	Na^+	H^++Al^{+3}	Al^{+3}	Ca^{+2}	Mg^{+2}	SB	CEC	SOM
	$H_2O_{(1:2,5)}$	-- mg dm^{-3} --		---------- $cmol_c$ dm^{-3} ----------							-- g kg^{-1} --
0-20	5.2	14.66	36.27	0.08	2.33	0.25	0.53	1.19	1.89	4.22	8.06
20-40	4.6	6.58	32.00	0.08	2.06	0.50	0.20	0.89	1.25	3.31	3.71

Physical											
Depth (cm)	Sand 2-0,05 mm	Silt 0,05-0,002 mm	Clay < 0,002 mm	Cdw	Df	Sd	Pd	Tp	Moisture (Mpa) 0.010	0.033	1.500
	---------- g kg^{-1} ----------			g kg^{-1}	dag kg^{-1}	kg m^{-3}	kg dm^{-3}	m^3 m^{-3}	--------- g kg^{-1} ---------		
0-20	831	36	133	25	81.2	1.31	2.65	0.51	69	57	44
20-40	801	25	174	25	85.6	1.21	2.67	0.55	77	64	49

Salinity												
Depth (cm)	pH	ECes	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	K^+	CO_3^{-2}	HCO_3^-	Cl^-	SAR	Classification
		dSm^{-1}	---------- $mmol_c$ L^{-1} ----------									
0-20	6.50	0.56	0.34	1.25	5.50	2.69	0.66	0.00	17.50	5.00	1.47	Normal
20-40	6.10	0.46	0.10	2.00	12.50	2.20	0.52	0.00	17.50	7.50	0.82	Normal

Fertility - P, K^+, Na^+: Mehlich-1 extractor; SB: Sum of exchangeable bases (Ca^{2+}+Mg^{2+}+K^++Na^+); (H^++Al^{3+}): 0.5 M calcium acetate extractor; CEC: Cation exchange capacity [SB + (H^++Al^{3+})]; Al^{3+}, Ca^{2+}, Mg^{2+}: 1 M KCl extractor; SOM: Soil organic matter by the Walkley-Black method.
Physical attributes – Cdw: Clay dispersed in water; Df, Sd, Pd and Tp: Respectively, degree of flocculation [Df = (clay-Cdw/clay) x 100], soil density, particle density and total porosity [Tp = (Pd-Sd)/Pd x 100].
Salinity - ECse.: Electrical Conductivity of the saturation extract at 25 ºC; SAR: Sodium adsorption ratio {$Na^+/[(Ca^{2+}+Mg^{2+})/2]^{1/2}$}.

TREATMENTS AND EXPERIMENTAL DESIGN

The treatments were organized in a 2 x 4 factorial scheme, referring, respectively, to the foliar application (with and without) of Aminoagro Raiz® (BIO1) and to the application via irrigation water of the following biostimulants: control (without biostimulant), Codasal®

Revista ARACÊ
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(BIO2), BIO1 and BIO1+BIO2. Thus, totaling eight treatments. The treatments were arranged in randomized blocks with four replications, each experimental plot was composed of five established plants.

Aminoagro Raiz® is composed of agroindustrial organic waste of plant origin, seaweed extract, urea, potassium chloride and water, whose composition is total organic carbon (10%), free amino acids (6.0%), lignosulphonate (2. 6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1.0%). The other biostimulant studied was Codasal® composed of water; calcium oxide, lignosulfonates and nitric acid. With the following relative composition: calcium (8.7%), lignosulphonates (14.7%) and water-soluble nitrogen (6.0%).

BIO1 foliar applications were performed at 20, 62 and 132 days after production pruning, at a dose of 1.75 mL per plant. For this purpose, 60 liters of syrup were prepared with 280 mL of the product and applied with a knapsack sprayer, with a capacity of 20 L, on the 160 plants. Treatment applications via irrigation water were started 20 days after pruning and repeated every two weeks until 10 applications were completed. In each application, 11.25 mL of BIO2 and 1.75 mL of BIO1 were used per plant. The amount of biostimulant for each treatment, via irrigation, was diluted to 250 L of water and then applied via microsprinkler with a flow rate of 80 L h^{-1}. The respective application doses of the products were carried out according to the manufacturers recommendations.

LIMING AND FERTILIZATION

Mineral fertilization was carried out weekly via fertirrigation, with 20 fertilizations being applied during the experiment, in the following amounts per plant: 44 g of N, 44 g of K and 2.44 g of P, using urea (45% of N), potassium chloride (60% K_2O) and monoammonium phosphate (12% N and 44% P_2O_5). Organic fertilization was carried out after production pruning, with 20 L of bovine manure per plant placed in the canopy projection. The chemical analysis of manure follows in table 3.

Table 3 - Chemical characterization of cattle manure used in the experiment

C.O	N	P	K	Ca	Mg	S	Cu	Zn	Fe	Mn	B
---------- g kg^{-1} ----------							---------- mg kg^{-1} ----------				
99.0	6.48	2.15	8.43	27.70	7.60	3.01	13.39	65.46	10,156.10	266.53	87.22

N, P, K, Ca and Mg: Digestion with H_2O_2 and H_2SO_4; S, Fe, Cu, Mn, Zn and Na: Digestion with HNO_3 and $HClO_4$; B: Extraction by dry combustion; C.O.: Wet oxidation with dichromate

Soil liming was carried out according to Santos and Quaggio (1996), aiming to increase base saturation to 70%, for which purpose the amount of limestone was calculated

Revista ARACÊ
ISSN: 2358-2472

for 8% (crown projection) of the total area, which corresponded to 700 g of dolomitic limestone per plant (41.68% CaO, 15.39% MgO, 100% relative efficiency and 113.74 relative power of total neutralization).

CHARACTERIZATION OF WATER AND IRRIGATION

Irrigation was performed with saline water from a deep well (Table 4), with an 80 L water depth applied per plant with a 36 hour irrigation shift. A microsprinkler system with a flow rate of 80 L h^{-1} was used.

Table 4 - Analysis of salinity of water used in irrigation

pH	EC	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SAR	Classification
	dS m^{-1}	---------- $mmol_c\ L^{-1}$ ----------									
4.7	3.07	2.40	2.39	5.17	15.54	1.43	0.00	1.00	26.25	7.99	C4S3

EC: Electrical Conductivity at 25 ºC SAR: Sodium Adsorption Ratio
C4: Very High Risk of Salinization S3: High Risk of Sodicity

SAMPLING OF LEAVES

Leaf samplings were carried out in two phenological phases, at full flowering of the plants and 70 days after full flowering. The third pair of developed leaves, intact and free of any type of damage, was collected in the region of the middle third of the canopy, in the positions of the four cardinal points of the plant (NATALE et al., 1994).

Then, the leaves were washed in running water and rinsed in distilled water, placed in paper bags and placed to dry in an air circulation oven at 65±5 ºC until reaching constant weight. After drying, the leaves were ground in a knife mill and stored to carry out the analytical determinations.

ANALYSIS OF LEAVES AND FRUITS

I- Digestion for analysis of Na, S, Fe, Cu, Mn and Zn

The samples were digested by mixing nitric acid with hydrochloric acid in a ratio of 1:3 (v/v) (MCGRATH; CUNLIFFE, 1985). Initially, one gram of the sample was taken in a digestion tube and 3 ml of HNO_3 + 9 ml of HCl were added, left to rest for 16 h. Subsequently, the samples were slightly shaken and taken to the digester block at a temperature of 100 ºC for 1 h, the temperature was raised to 135 ºC, remaining there until 1 ml of acid remained. The tubes were removed from the block and another 1 ml of HNO_3 + 3 ml of HCl was added, the samples were returned to the digester block at a temperature of 100 ºC, after 1 h the

Revista ARACÊ
ISSN: 2358-2472

temperature was increased to 135 ºC, remaining until 1 ml of acid, the procedure was repeated two more times until the resulting extract was clear. After digestion, dissolution was carried out with deionized water to a final volume of 20 ml and filtered through quantitative filter paper.

II- Digestion for analysis of N, P, K, Ca and Mg

For the determination of N, P, K, Ca and Mg, digestion with sulfuric acid and hydrogen peroxide was performed, as described by Tedesco et al. (1995).

III- Digestion for analysis of B

Dry digestion in a muffle furnace, as described by Tedesco et al. (1995).

IV- Determination of N, P, K, Ca, Mg, Na, Fe, Cu, Mn, B and Zn

Nitrogen was determined by the Kjeldahl method and the content of other elements was obtained by spectrometry according to the methodology described by Tedesco et al. (1995).

V - Determination of S

For the analysis of S, an aliquot of 1 ml of the extract was taken in 50 ml beakers, 9 ml of deionized water, 1 ml HCl containing 20 mg L^{-1} of S and 0.5 g of the BaCl+Gelatin mixture, previously ground in a mortar, in the proportion of 3.3/1 (m/m), were added. The mixture was stirred until the dissolved the BaCl+Gelatin, left to rest for 5 minutes and read in a spectrophotometer adjusted with a wave length of 420 nm (CARMO et al., 2000).

EXPORT OF NUTRIENTS

Nutrient export was obtained by the following equation:

$$EN = NC*DM \quad (1)$$

Where:

EN = Export of the nutrient in the fruit (g t^{-1} of fresh fruit);

NC = Nutrient content in the fruit (g kg^{-1});

DM = Fruit dry mass (kg t^{-1})

Revista ARACÊ
ISSN: 2358-2472

FRUIT PRODUCTION PER PLANT

The fruits of each plot were harvested at maturation stage 3 (CAVALINI et al., 2006) and weighed on a digital scale.

STATISTICAL ANALYSIS

Data were evaluated for normality (Kolmogorov-Smirnov) and homogeneity (Levene) of variances. Fulfilling this assumption, the analysis of variance was performed and, according to the significance of the F test ($p \leq 0.05$), the Scott-Knott test was performed ($p \leq 0.05$), using the ExpDes.pt statistical package (FERREIRA; CAVALCANTI; NOGUEIRA, 2014) in the R CORE TEAM (2020) software.

RESULTS AND DISCUSSION

NUTRITIONAL CONTENTS IN LEAVES

The interaction between the forms of application of the biostimulants and the isolated treatments did not have a significant effect on the N content of the leaves at flowering, with an average content of 23.40 g kg^{-1} (Table 5). In the fruit growth phase, the interaction between foliar and irrigation application of biostimulants was significant, with a reduction in the N content of leaves that received BIO1 via foliar with BIO1+BIO2 via irrigation (Figure 1A).

Table 5 - 'F' values with the respective means of macronutrients (g kg^{-1}) of guava leaves, collected at full bloom (FB) and fruit growth (FG) (70 days after flowering), according to forms of application and type of biostimulant

Source of variation	N		P		K		Ca		Mg		S	
	FB	FG	FB	FG	FB	FG	FB	FG	FB	FG	FB	FG
FA ('F' value)	2.5022^{ns}	0.0998^{ns}	0.0263^{ns}	0.3108^{ns}	0.0001^{ns}	24.8365*	3.7235^{ns}	6.3547*	0.8420^{ns}	3.1067^{ns}	1.8093^{ns}	0.1451^{ns}
Without	23.00a	21.60a	2.07a	1.93a	18.49a	17.72a	8.36a	20.60a	4.23a	8.82a	3.95a	3.74a
With	23.80a	21.70a	2.05a	1.89a	18.50a	15.56b	6.75a	18.10b	3.98a	7.85a	4.48a	3.65a
AW ('F' value)	0.4939^{ns}	0.2017^{ns}	0.5098^{ns}	0.7422^{ns}	0.8571^{ns}	0.4665^{ns}	0.4765^{ns}	0.8985^{ns}	0.0916^{ns}	0.6734^{ns}	3.2895*	0.5189^{ns}
Control	23.22a	21.70a	2.06a	1.94a	18.96a	16.29a	7.93a	18.30a	4.05a	7.67a	3.72a	3.58a
BIO2	23.73a	21.80a	2.13a	1.90a	18.61a	16.54a	7.96a	18.90a	4.08a	8.45a	4.99a	3.91a
BIO1	23.66a	21.60a	2.03a	1.84a	17.81a	16.72a	6.73a	20.20a	4.23a	8.55a	3.67a	3.54a
BIO1+BIO2	22.98a	21.50a	2.02a	1.97a	18.63a	17.00a	7.62a	20.20a	4.08a	8.67a	4.45a	3.74a
FA x AW ('F' value)	1.4679^{ns}	4.0042*	0.1599^{ns}	0.2191^{ns}	0.0503^{ns}	1.4622^{ns}	1.8252^{ns}	11.3812*	0.8999^{ns}	9.1104*	0.6018^{ns}	1.4671^{ns}
CV (%)	6.13	4.00	9.98	10.03	8.06	7.37	27.06	14.47	18.73	18.67	23.56	17.99

* and ns: Significant and not significant, respectively, by the F test at 5% probability; Means followed by equal letters in the column do not differ from each other, by the F or Scott-Knott test ($p \leq 0.05$). FA = foliar application of BIO1; AW = application via irrigation water; BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon

Revista ARACÊ
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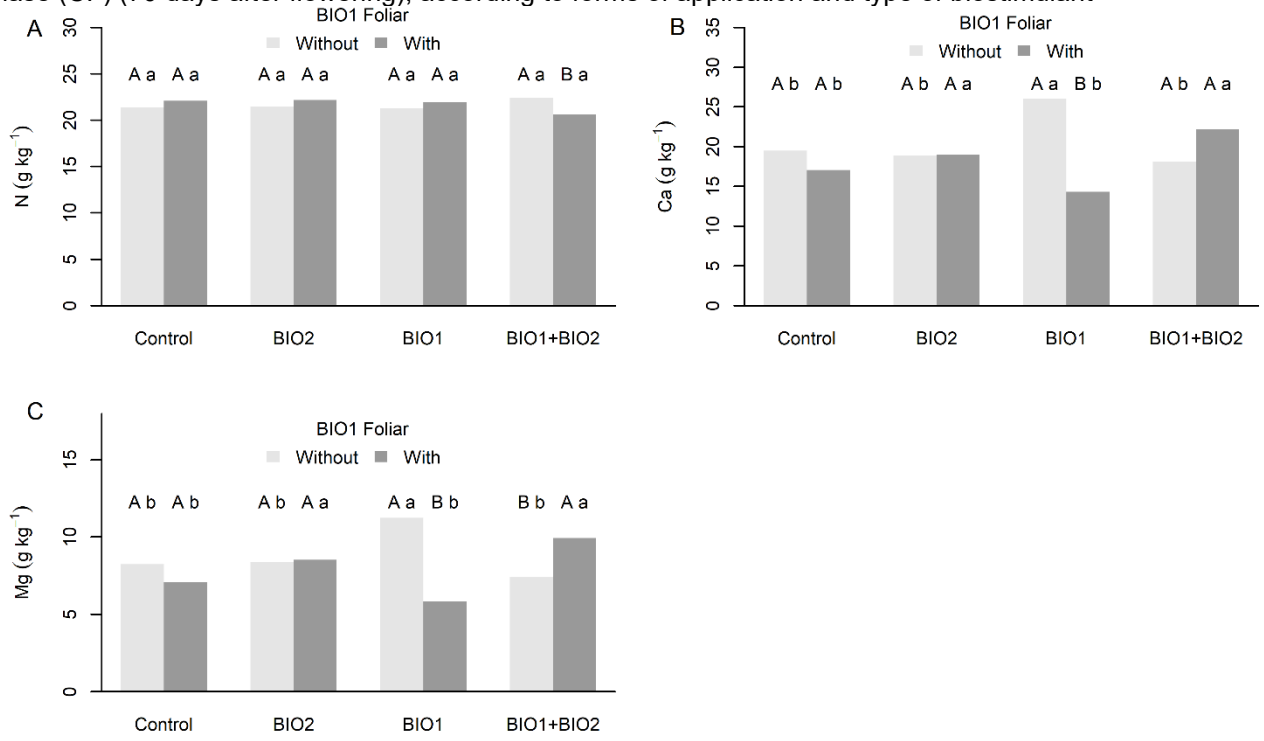
(10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%); CV: coefficient of variation.

Figure 1 - Nitrogen (A), calcium (B) and magnesium (C) content of guava leaves, collected in the fruit growth phase (CF) (70 days after flowering), according to forms of application and type of biostimulant



Equal uppercase letters for foliar application and equal lowercase letters between treatments via irrigation do not differ from each other, according to the Skott-knott test (p≤0.05); BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%).

When considering that salinity reduces the N content of guava leaves (EBERT et al., 2002), it can be inferred, based on the N levels found in this research, that the nitrogen fertilization was adequate for the stress conditions saline to which the orchard was exposed, especially because in all treatments at the two leaf collection times, the N contents are in accordance with the values considered adequate by Natale et al. (2002) (20 to 23 g kg^{-1}) for 'Paluma' guava tree. With regard to the effects of biostimulants on the N content, in the scientific literature there are records of results opposite to those found in this experiment, as an example we can highlight the research by Rady et al. (2016) reported that the application of humic acids increases the N content of plants under salt stress. In research carried out by Mutale-joan et al. (2021) using a biostimulant based on microalgae-cyanobacteria, it was evidenced that the product increases N absorption in up to 182.95% of plants under saline stress.

Revista ARACÊ
ISSN: 2358-2472

There was no significant effect of the interaction between the application forms and the isolated treatments on the leaves P content, in both stages of leaves collection (Table 5). The mean P content at flowering was 2.06 g kg^{-1} and at the fruit growth stage it was 1.91 g kg^{-1}, close to the values recommended by Natale et al. (2002) for 'Paluma' guava tree (1.4 to 1.8 g kg^{-1}). In the research carried out by Chiveu et al. (2020), the authors reported that salinity reduces P content in guava leaves. Therefore, the phosphorus fertilization performed in this experiment was adequate for the saline stress conditions that the crop was submitted.

Although there was no effect of the biostimulants on the P content of the guava tree, recent studies say that there is an increase in the P content with the application of biostimulants based on humic substances and seaweed extract. This result can be verified in research by Rocha et al. (2019), who reported that the application of a biostimulant based on humic substances increases the P content of guava leaves. A similar result was reported by Mutale-joan et al. (2021), with the application of a biostimulant based on microalgae-cyanobacteria, registering a 78.35% increase in P absorption by plants under salt stress.

For K, in the flowering phase, there was no significant effect of the interaction between the forms of application and neither of the isolated treatments, with an average value of 18.50 g kg^{-1} (Table 5), close to the value reported by Natale et al. (2002) as being ideal for this guava cultivar (14 to 17 g kg^{-1}). In the fruit growth phase, there was no effect of the interaction between the forms of application, however the foliar application of BIO1 reduced the K content of the leaves. There was no effect from the application of biostimulants via irrigation (Table 5). The K content of leaves in the fruit growth phase ranged from 15.56 to 17.72, these levels are considered adequate according to Natale et al. (2002).

The salinity of the irrigation water did not negatively affect the K contents, this may be related to an adequate potassium nutrition for the stressful conditions, considering that saline stress causes a reduction in the K contents in guava leaves (EBERT et al., 2002; CHIVEU et al., 2020). Regarding the application of biostimulants, there are reports in the scientific literature, contrasting with what was obtained in this research, being reported that the application of humic acids via foliar and soil (KHALED; FAWY, 2011), of putrescine and humic acid via foliar (AHMED et al., 2013), calcium lignosulphonate via irrigation (ELSAWY

Revista ARACÊ
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et al., 2022) and biostimulant manufactured from microalgae-cyanobacteria via irrigation (MUTALE-JOAN et al., 2021) increase the K content in plants under salt stress.

Concerning the Ca content, the interaction between the forms of application of the biostimulants and the isolated treatments did not differ statistically for the leaves collected in the flowering phase (Table 5), presenting an average value of 7.56 g kg^{-1}, considered adequate according to Natale et al. (2002). In the leaves collected in the fruit growth phase, there was a significant interaction between the foliar application and the application via irrigation of the biostimulants. Noting that the application of BIO1 via irrigation increases the leaves Ca content, however when the application via irrigation of BIO1 is combined with foliar application, there is a decrease in the Ca content, presenting the lowest values of the nutrient (Figure 1B). At the time of fruit growth, Ca content ranged from 14.32 to 26.02 g kg^{-1}, above the recommended by Natale et al. (2002) for 'Paluma' guava tree (7 to 11 g kg^{-1}).

Under saline stress conditions, the Ca content of guava leaves may remain unchanged (CHIVEU et al., 2020) or decrease (EBERT et al., 2002). Regarding the effect of biostimulants on the Ca content of plants, the results in the scientific literature are adverse. In the experiment carried out by Ahmed et al. (2013), it was observed that the foliar application of humic acids and putrescine causes a decrease in the foliar calcium content of plants under salt stress. In the research by Gulmezoglu and İzci (2020), the authors found that the application of humic acid via foliar and/or soil causes an increase in the calcium content of plants under saline stress. In contrast, it was reported by Mutale-joan et al. (2021), that the application of biostimulant based on microalgae-cyanobacteria does not affect the Ca content of plants under saline stress.

The Mg content had an effect similar to that of Ca. In the flowering phase, the Mg content was not affected by the interaction between the forms of application of the biostimulants and neither by the isolated treatments (Table 5), with an average value of 4.11 g kg^{-1}, which according to Natale et al. (2002) is considered adequate. The interaction between foliar and irrigation application of biostimulants affected the Mg content in leaves collected during the fruit growth phase (Table 5). The application of BIO1 via irrigation provided the highest Mg content in the leaves. When BIO1 applied via irrigation was combined with foliar application, there was a reduction in Mg contents (Figure 1C). The Mg contents of 'Paluma' guava leaves in the fruit growth phase ranged from 5.85 to 11.25 g kg^{-1}, above the recommended by Natale et al. (2002) for this guava cultivar (3.4 to 4.0 g kg^{-1}).

Revista ARACÊ
ISSN: 2358-2472

Depending on the magnitude of salt stress, a decline in Mg content of guava leaves may occur (CHIVEU et al., 2020). In research carried out by Liu et al. (2020), the authors found that saline stress causes a decrease in the Mg content of pomegranate trees. In this experiment, even under saline stress, the Mg content was higher than recommended for the culture under study. This high accumulation of Mg in the guava tree was possibly favored by liming and irrigation water with high levels of Mg (Table 4). As for the application of biostimulants, it was found in the literature that the use of humic acids promote an increase in the Mg content of plants under saline stress (ÇIMRIN et al., 2010). In the research by Rouphael et al. (2017) the authors verified that the foliar application of seaweed extracts in plants under saline stress does not change the Mg content.

In both phases of leaves sampling, the interaction between the forms of application of the biostimulants and the isolated treatments were not statistically significant for the S content (Table 5). The average S content was 4.22 and 3.69 g kg^{-1} for leaves collected during flowering and fruit growth, respectively. These contents are close to those considered adequate by Natale et al. (2002) for 'Paluma' guava tree (2.5 to 3.5 g kg^{-1}).

Salt stress with chloride causes a reduction in foliar levels of S in guava (CHIVEU et al., 2020) and pomegranate (LIU et al., 2020). In the present research, it is possible to verify that the irrigation water salinity of 3.07 dS m^{-1} did not affect the S content of the guava plants to the point of discrepancy with the recommended range for the culture, indicating that fertilization and the sulfate contained in the irrigation water and in the soil were sufficient to keep the plants adequately nourished. When it comes to the application of biostimulants, there are reports in the literature that the application of humic acids and seaweed extracts increase the S content of plants under salt stress (ÇIMRIN et al., 2010; EL-SHARKAWY et al., 2017).

The sodium content of the leaves in the flowering phase was significantly affected by the interaction between the foliar application and the application via irrigation of the biostimulants (Table 6), being verified that the application of BIO1 via foliar with BIO1 or BIO1+BIO2 via irrigation favors the increase in Na content (Figure 2A). The interaction between the forms of application of the biostimulants was not significant for the Na content of the leaves in the fruit growth phase. It was possible to verify that BIO1 applied via foliar application or through irrigation promotes an increase in the Na content of the leaves (Table 6).

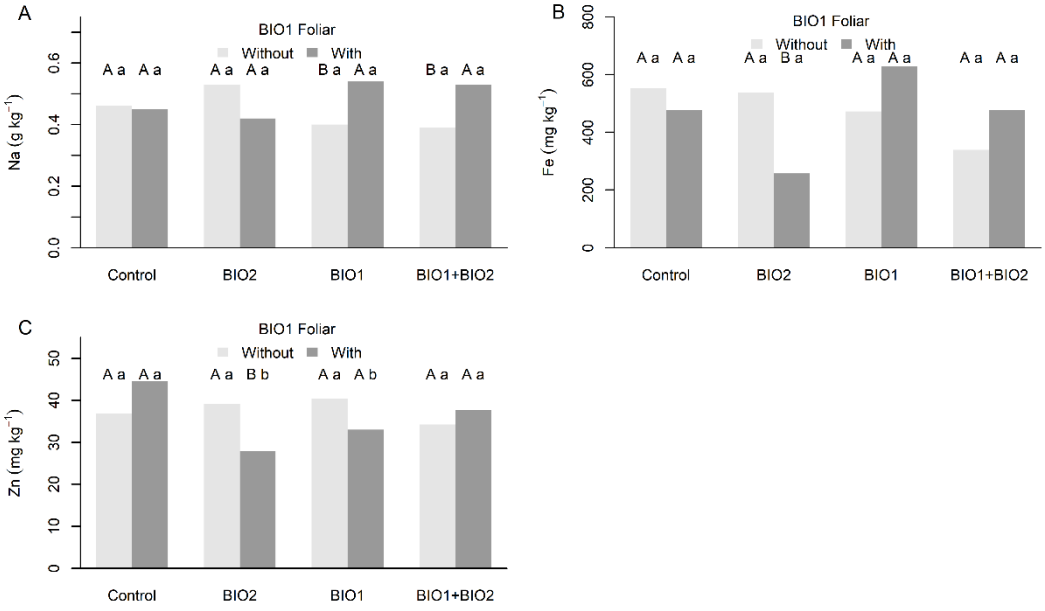
Revista ARACÊ
ISSN: 2358-2472

Table 6 - 'F' values with the respective means of sodium content (g kg^{-1}) and micronutrients (mg kg^{-1}) of guava leaves, collected at full bloom (FB) and fruit growth (FG) (70 days after flowering), according to forms of application and type of biostimulant

Source of variation	Na		B		Fe		Cu		Mn		Zn	
	FB	FG	FB	FG	FB	FG	FB	FG	FB	FG	FB	FG
FA ('F' Value)	1.6837^{ns}	7.6989*	1.7689^{ns}	5.2204*	0.2386^{ns}	9.1681*	0.0096^{ns}	8.3467*	0.1853^{ns}	3.5155^{ns}	0.5525^{ns}	0.8523^{ns}
Without	0.44a	0.58b	67.56a	110.61b	485.00a	308.76a	13.30a	6.79a	76.18a	149.22 a	53.16a	37.70a
With	0.49a	0.67a	72.34a	118.25a	472.00a	257.17b	13.48a	5.46b	78.49a	135.73 a	50.85a	35.40a
AW ('F' Value)	0.0896^{ns}	3.7748*	1.4247^{ns}	0.1961^{ns}	2.2641^{ns}	2.0301^{ns}	0.2348^{ns}	0.7516^{ns}	1.1924^{ns}	0.7780^{ns}	1.3757^{ns}	2.9242^{ns}
Control	0.46a	0.56b	66.68a	113.46a	528.00a	311.17a	14.01a	5.78a	74.81a	133.29 a	54.49a	40.20a
BIO2	0.47a	0.60b	65.83a	114.74a	417.00a	292.86a	12.19a	6.03a	82.72a	146.62 a	54.59a	33.60a
BIO1	0.47a	0.72a	74.10a	116.39a	561.00a	258.20a	13.29a	6.70a	79.67a	143.60 a	52.45a	35.40a
BIO1 + BIO2	0.46a	0.63b	73.18a	113.13a	407.00a	268.22a	13.83a	5.99a	70.74a	145.27 a	46.90a	36.00a
FA x AW ('F' Value)	3.5700*	3.1909^{ns}	0.0578^{ns}	1.4609^{ns}	4.4343*	1.4559^{ns}	2.3088^{ns}	1.7038^{ns}	1.0532^{ns}	0.3507^{ns}	2.6557^{ns}	3.9429*
CV (%)	19.12	15.72	14.54	8.26	26.70	15.34	28.68	21.21	17.04	16.06	15.61	13.26

* and ns: Significant and not significant, respectively, by the F test at 5% probability; Means followed by equal letters in the column do not differ from each other, by the F or Scott-Knott test (p≤0.05). FA = foliar application of BIO1; AW = application via irrigation water; BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%); CV: coefficient of variation.

Figure 2 - Sodium (A) and iron (B) content of guava leaves, collected at full bloom and zinc content (C) of guava leaves collected in the fruit growth phase (FG) (70 days after flowering), according to forms of application and type of biostimulant



Equal uppercase letters for foliar application and equal lowercase letters between treatments via irrigation do not differ from each other, according to the Skott-knott test (p≤0.05); BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic

Revista ARACÊ
ISSN: 2358-2472

carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%).

Although the biostimulants did not contribute to the reduction of foliar Na levels, possibly the correction of the soil and balanced fertilization carried out in the experiment allowed for greater discrimination by the plants in the absorption of Na, that is, the competition between the applied nutrients and the sodium, favored so that the sodium did not reach toxic levels to the plants. According to Chiveu et al. (2020) it is possible to visualize NaCl toxicity symptoms in guava from the irrigation water salinity of 2.80 dS m^{-1}, which corresponds to an average accumulation of foliar Na of 3.16 g kg^{-1}. Ferreira, Távora and Hernandez (2001) also reported damage by NaCl in guava tree under water saline stress from 4.5 dS m^{-1}, translating into a foliar Na content of 4.2 g kg^{-1}.

Contrary to the results obtained with this research, in the literature there are reports that biostimulants can favor the mechanism of exclusion of sodium toxic to plants, as an example we highlight the experiment by Çimrin et al. (2010), which found that the application of humic acid favors the decrease of foliar Na content in plants. In research carried out by Elsawy et al. (2022), the authors reported that the application of a biostimulant based on calcium lingnosulphonate also reduces foliar Na content. Similar to the aforementioned studies, Rouphael et al. (2017) reported that the application of seaweed extracts via foliar promotes a decrease in the foliar Na content of plants under NaCl stress.

In both phases of the plants there was no effect of the interaction between the forms of application of the biostimulants on the levels of B (Table 6). The application of biostimulants did not alter the B content of the leaves collected in the flowering phase (Table 6), however the B content of the leaves in the fruit growth phase was increased with the application of BIO1 via foliar (Table 6). The average B content in the flowering phase was 69.95 mg kg^{-1}, while in the fruit growth phase the B content ranged from 110.61 to 118.25 mg kg^{-1}. The values observed in this study are higher than the values considered adequate by Natale et al. (2002) for 'Paluma' guava tree (20 to 40 mg kg^{-1}).

The high B content verified in the present study may be related to the salinity of the irrigation water, however, no symptoms of B toxicity were seen in the orchard. Despite the common occurrence of B toxicity in arid and semi-arid regions that irrigate with saline water due to the composition of the water containing high levels of B (GRATTAN; GRIEVE, 1999). In a study carried out by Chiveu et al. (2020) salt stress with NaCl caused a reduction in

Revista ARACÊ
ISSN: 2358-2472

guava leaf B content. Freire et al. (2015) reported that NaCl stress via irrigation water also causes reduction in the uptake of B.

The interaction between the forms of application of biostimulants was significant for the Fe content of leaves collected at flowering (Table 6). There was a reduction in the Fe content when the foliar application of BIO1 was performed together with the BIO2 via irrigation (Figure 2B). For the fruit growth phase, there was no effect of the interaction between the forms of application on the Fe content of the leaves (Table 6). The Fe content of the leaves in the fruit growth phase decreased with the foliar application of BIO1 (Table 6). The average Fe content of the leaves at flowering phase ranged from 257.23 to 628.14 mg kg^{-1} and of the leaves at the fruit growth phase the Fe content ranged from 257.17 to 311.17 mg kg^{-1}. Such values are much higher than those considered adequate by Natale et al. (2002) for this guava cultivar (60 to 90 mg kg^{-1}).

These high Fe values may have been a consequence of organic fertilization, considering that the Fe content of the manure used in fertilization was 10,156.10 mg kg^{-1} (Table 3). It is also important to note that the plants did not show symptoms of iron toxicity. Regarding the effect of salinity on the Fe content, it was reported by Chiveu et al. (2020) that saline stress with NaCl causes a reduction in Fe content in guava. Souza et al. (2020a) found that high irrigation water salinity favors an increase in foliar Fe content. In research carried out by Merwad (2020), it was reported that the foliar application of biostimulants favors the absorption of Fe in plants under salt stress, which was also registered with the application of humic acids, via soil and foliar (KHALED; FAWY, 2011).

The Cu contents of the leaves collected at flowering were not affected by the interaction between the forms of application of the biostimulants and neither by the isolated treatments (Table 6), with an average content of 13.39 mg kg^{-1}, lower than that recommended by Natale et al. (2002) for 'Paluma' guava, which is 20 to 40 mg kg^{-1}. In the fruit growth phase, there was no effect of the interaction between the forms of application of the products on the foliar Cu content, however the foliar application of BIO1 reduced the Cu content (Table 6). The average Cu content of leaves collected during the fruit growth phase ranged from 5.46 to 6.79 mg kg^{-1}, lower than that suggested by Natale et al, (2002). Despite the Cu contents being below the recommended for the crop, the plants did not show symptoms of deficiency. According to Rady et al. (2016) salt stress reduces leaf Cu content, however the application of humic acids can reverse the negative effect of salinity. Çimrin et

Revista ARACÊ
ISSN: 2358-2472

al. (2010) also reported a positive effect of humic acid application on the Cu content of plants under salt stress.

There was no effect of the interaction between the forms of application of the biostimulants, much less for the isolated treatments on the levels of Mn in the leaves, in both sampling phases (Table 6), with the average levels of 77.26 and 142.24 mg kg^{-1} for leaves collected during flowering and fruit growth, respectively. The Mn content of the leaves collected at flowering is considered adequate, however the Mn content of the leaves sampled during the fruit growth phase is higher than indicated by Natale et al. (2002) (40 to 80 mg kg^{-1}). In the scientific literature, there are contrasting results regarding the effect of salinity on foliar Mn levels (RADY et al., 2016; CHIVEU et al., 2020; LIU et al., 2020), while research by Rady et al. (2016) and Çimrin et al. (2010), had concordant results, providing an increase in Mn contents with the application of humic acid in plants under saline stress.

The interaction between the forms of application of the biostimulants and the isolated treatments did not influence the Zn content of the leaves at flowering (Table 6), with an average content of 52.12 mg kg^{-1}. The adequate value of Zn for 'Paluma' guava tree according to Natale et al. (2002) is 25 to 35 mg kg^{-1}. The interaction between the forms of application of the biostimulants affected the Zn content in the fruit growth phase, with a decrease in the Zn content with the application of BIO1 via foliar together with BIO2 or BIO1 via irrigation (Figure 2C). The average Zn content of leaves sampled in the fruit growth phase ranged from 27.95 to 44.61 mg kg^{-1} (Table 6). Therefore, all treatments presented values sufficient or superior to those recommended for this guava variety (NATALE et al. 2002). With regard to the effects of saline stress on the Zn content, in the literature there are divergent results, with increase in the content (LIU et al. 2020), reduction (RADY et al., 2016) and absence of effect (CHIVEU et al., 2020). Regarding the effects of biostimulants, in general, it has provided an increase in Zn absorption (ÇIMRIN et al., 2010; RADY et al., 2016; MERWAD, 2020).

When analyzing the nutritional status of the guava tree, it is verified that the plants are adequately nourished, this was provided by liming and management of mineral and organic fertilization, preventing the salinity of the irrigation water from causing ionic stress and, consequently, nutritional imbalance. This statement is corroborated by research carried out by Khan et al. (2016), these authors reported that adequate nutrition with N, P, K and Zn combined with manure application, favors the reduction of leaves Na content and increase of N, P, K and Zn, culminating in greater plant resistance to saline stress.

Revista ARACÊ
ISSN: 2358-2472

Additionally, it was reported by Freire et al. (2013) that bovine manure biofertilizer provides attenuation of saline stress by maintaining the nutritional balance of plants. Thus, the saline stress of the irrigation water was attenuated by the management imposed on the plants, causing the effect of the biostimulants to be supplanted.

NUTRITIONAL CONTENTS IN FRUITS AND EXPORTATION WITH THE HARVEST

The interaction between the forms of application of the biostimulants were not significant for the N, K, Ca and Mg contents of the fruits, as well as the isolated treatments did not affect the N, K and Mg contents either (Table 7).

Table 7 - 'F' values with the respective means of macronutrients content (N, P, K, Ca e Mg) (g kg^{-1}) of guava fruits, according to forms of application and type of biostimulant

Source of variation	N	P	K	Ca	Mg
FA ('F' value)	2.8400^{ns}	1.7446^{ns}	0.0830^{ns}	14.910*	0.8385^{ns}
Without	12.24a	1.45a	20.47a	1.61a	0.60a
With	12.90a	1.54a	20.61a	1.23b	0.62a
AW ('F' value)	0.3461^{ns}	1.6322^{ns}	1.2540^{ns}	0.1209^{ns}	0.4889^{ns}
Control	12.42a	1.50a	20.94a	1.47a	0.63a
BIO2	12.34a	1.38a	19.86a	1.39a	0.59a
BIO1	12.84a	1.53a	20.36a	1.41a	0.61a
BIO1+BIO2	12.67a	1.54a	21.01a	1.42a	0.61a
FA x AW ('F' value)	3.0482^{ns}	3.5688*	2.9567^{ns}	1.0142^{ns}	2.7264^{ns}
CV (%)	8.76	10.92	6.62	19.39	10.52

* and ns: Significant and not significant, respectively, by the F test at 5% probability; Means followed by equal letters in the column do not differ from each other, by the F or Scott-Knott test ($p \leq 0.05$). FA = foliar application of BIO1; AW = application via irrigation water; BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%); CV: coefficient of variation.

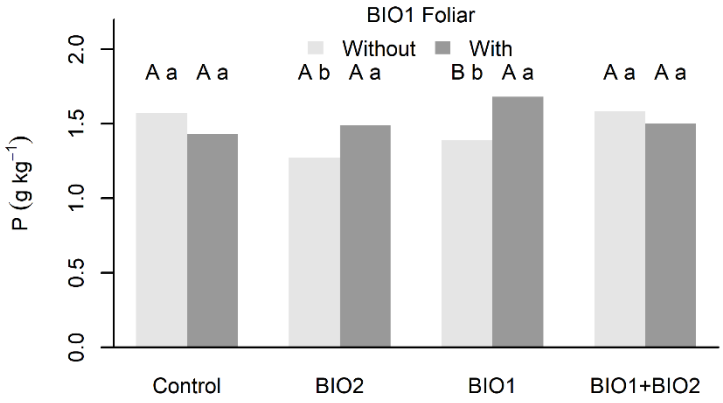
The average nitrogen content in the fruits was 12.57 g kg^{-1}, a value above that reported by Natale et al. (2002) (8.5 g kg^{-1}). The salinity of the irrigation water can cause an increase in the N content of the fruit, as reported by Keutgen and Pawelzik (2008) and Gurgel et al. (2008). The application of biostimulants can also increase the N content of fruits of plants under saline stress, as reported by Turan et al. (2021).

The interaction between foliar application and via irrigation was significant for the P content of the fruits (Table 7), with the highest P content in the fruit, the plants that received BIO1 via foliar together with BIO1 via irrigation and the lowest levels for the treated plants only with BIO2 or BIO1 via irrigation (Figure 3). The P contents of the fruits ranged from 1.27 to 1.68 g kg^{-1}, values higher than those reported by Natale et al. (2002) for 'Paluma'

Revista ARACÊ
ISSN: 2358-2472

guava fruits (0.9 g kg^{-1}). Salinity can cause adverse effects on the P content of fruits, it was reported by Keutgen and Pawelzik (2008) that salt stress causes an increase in the P content of fruits, while Gurgel et al. (2008) reported that severe salt stress reduces the P content of fruits. However, the application of biostimulants can increase the P content of fruits of plants under saline stress (TURAN et al., 2021).

Figure 3 - Phosphorus Content of fruit guava, according to forms of application and type of biostimulant



Equal uppercase letters for foliar application and equal lowercase letters between treatments via irrigation do not differ from each other, according to the Skott-knott test (p≤0.05); BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%).

With regard to fruit K, an average content of 20.54 g kg^{-1} was recorded, higher than the value reported by Natale et al. (2002) for this guava variety, which was 11.3 g kg^{-1}. Gurgel et al. (2008) reported that severe saline stress causes a reduction in the potassium content of fruits, however, Keutgen and Pawelzik (2008) presented opposite results. As for the effect of applying biostimulants on the K content of fruits, there are controversial results in the literature. In the research by Turan et al. (2021) it was described that the application of biostimulants increases the K content of fruits of plants under saline stress, whereas Di Stasio et al. (2020) reported the opposite result.

As for the Ca content of the fruit, there was a reduction with the application of BIO1 via foliar (Table 7). The calcium content of the fruits ranged from 1.23 to 1.61 g kg^{-1}, well above the value reported by Natale et al. (2002) for this fruit (0.7 g kg^{-1}). Severe salinity can increase (GURGEL et al., 2008) or reduce (KEUTGEN; PAWELZIK, 2008) the Ca contents of fruits, there is attenuating effect of salinity on Ca levels with the application of biostimulants (KEUTGEN; PAWELZIK, 2008). Corroborating with the results of this

Revista ARACÊ
ISSN: 2358-2472

research, Di Stasio et al. (2020) reported that the application of biostimulants also causes a reduction in Ca contents in fruits.

The average magnesium content of the fruits was 0.61 g kg^{-1}, close to the value reported by Natale et al. (2002), which was 0.8 g kg^{-1}, for the same guava cultivar. In research carried out by Gurgel et al. (2008) evidenced that the Mg content of fruits are reduced by severe salinity, the same result was reported by Keutgen and Pawelzik (2008). However, with the application of biostimulants, there is an increase in the Mg content even under saline stress. On the other hand, Di Stasio et al. (2020) emphasized that the application of biostimulants causes a reduction in the Mg content of fruits of plants under saline stress.

The interaction between foliar and irrigation application of biostimulants was not significant for nutrient export (Table 8). Treatment with BIO1 via foliar reduced the export of K and Ca, with no effect on the export of N, P and Mg (Table 8). Regarding the application of biostimulants via irrigation, there was no significant effect on the export of N, P, K, Ca and Mg (Table 8). When comparing the nutrient export of the present research with the results reported by Natale et al. (2002), for the same guava cultivar, only the Mg export was lower than the results of that author.

Table 8 - 'F' values with the respective means of macronutrients export (N, P, K, Ca e Mg) (g t^{-1}) of guava fruits, according to forms of application and type of biostimulant

Source of variation	N	P	K	Ca	Mg
FA ('F' value)	0.0394 ns	0.0268 ns	8.1197*	20.8939*	0.3970 ns
Without	1,679a	199a	2,809a	222a	82a
With	1,670a	198a	2,668b	160b	80a
AW ('F' value)	0.6281 ns	2.3594 ns	2.6546 ns	0.2290 ns	0.7867 ns
Control	1,679a	202a	2,826a	200a	84a
BIO2	1,632a	182a	2,631a	185a	78a
BIO1	1,722a	205a	2,738a	191a	81a
BIO1+BIO2	1,666a	202a	2,759a	187a	80a
FA x AW ('F' value)	2.0423 ns	2.9299 ns	2.0805 ns	0.9533 ns	2.2927 ns
CV (%)	7.95	9.8	5.12	20.12	10.34

* and ns: Significant and not significant, respectively, by the F test at 5% probability; Means followed by equal letters in the column do not differ from each other, by the F or Scott-Knott test ($p \leq 0.05$). FA = foliar application of BIO1; AW = application via irrigation water; BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%); CV: coefficient of variation.

Revista ARACÊ
ISSN: 2358-2472

FRUIT PRODUCTION PER PLANT

The interaction between the forms of application of biostimulants and the isolated treatments did not exert significant effects on the production of fruits per plant (Table 9), obtaining an average of 41.63 kg plant^{-1}, corresponding to a yield of 11.50 t ha^{-1}. This yield is much lower than that registered for the Northeast region, which is around 26 t ha^{-1} (IBGE, 2022). The low productivity obtained in this research is attributed to low flowering and floral abortion, which possibly was caused by osmotic stress, considering that the flowering phase of the plants coincided with the time of irrigation exclusively with saline water (EC=3.07 dS m^{-1}). This result is supported by Shrivastava and Kumar (2015), who reported that salt stress affects microsporogenesis and elongation of stamen filaments, causes abortion of ovules and senescence of fertilized embryos.

Table 9 - 'F' values with the respective means of production of guava fruits per plant, according to forms of application and type of biostimulant

Source of variation	Production (kg plant^{-1})
FA ('F' value)	0.9468^{ns}
Without	43.52a
With	39.73a
AW ('F' value)	0.4357^{ns}
Control	42.23a
BIO2	39.04a
BIO1	44.95a
BIO1 + BIO2	40.28a
FA x AW ('F' value)	0.7049^{ns}
CV (%)	26.52

* and ns: Significant and not significant, respectively, by the F test at 5% probability; Means followed by equal letters in the column do not differ from each other, by the F or Scott-Knott test (p≤0.05). FA = foliar application of BIO1; AW = application via irrigation water; BIO2 = biostimulant composed of calcium (8.7%), lignosulphonates (14.70%) and nitric acid (27%); BIO1 = biostimulant composed of total organic carbon (10%), free amino acids (6.0%), lignosulphonates (2.6%), seaweed extract (2.0%), nitrogen (11%) and potassium (1. 0%); CV: coefficient of variation.

The lack of effect of biostimulants on fruit production may have been caused by the low number of applications that preceded the onset of flowering. Bearing in mind that the application of biostimulants increase the production of different plant species under saline stress. In research carried out by Turan et al. (2021) it was reported that biostimulants based on humic substances increase the productivity of tomato fruits under saline stress. In research by Souza et al. (2020b) and Hernández-Herrera, et al. (2022) also there was biostimulants based on seaweed extracts increase the productivity, respectively, of zucchini and tomato under saline stress.

Revista ARACÊ
ISSN: 2358-2472

CONCLUSIONS

With the exception of copper, the other foliar nutrients (N, P, K, Ca, Mg, S, B, Fe, Mn and Zn) are in the sufficiency range or higher than that recommended for the crop. The management adopted in the experiment with balanced mineral and organic fertilization, provided adequate nutrition to the plants, thus the effect of the biostimulants was supplanted. Regarding fruit production, although the plants were well nourished, the osmotic stress caused by the salinity of the irrigation water favored low flowering and flower abortion, preventing high yields from being achieved. The lack of effect of biostimulants on production was caused by the low number of applications before the flowering phase.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Agência Executiva de Gestão de Águas - AESA. (2020). Meteorologia – Chuvas. Disponível em: <http://www.aesa.pb.gov.br/aesa website/meteorologia chuvas/formdate=20201122&produto=municipio&periodo=personalizado>. Acesso em: 22 de novembro de 2020.

2. Ahmed, A. H. H., Darwish, E., Hamoda, S. A. F., & Alobaidy, M. G. (2013). Effect of putrescine and humic acid on growth, yield and chemical composition of cotton plants grown under saline soil conditions. *American-Eurasian Journal of Agricultural & Environmental Sciences, 13*(4), 479-497.

3. Carmo, C. A. F. S., Araújo, W. S., Bernardi, A. C. C., & Saldanha, M. F. C. (2000). *Métodos de análise de tecidos vegetais utilizados na Embrapa Solos* (Circular Técnica, 6). Rio de Janeiro: Embrapa Solos.

4. Cavalini, F. C., Jacomino, A. P., Lochoski, M. A., Kluge, R. A., & Ortega, E. M. M. (2006). Maturity indexes for 'Kumagai' and 'Paluma' guavas. *Revista Brasileira de Fruticultura, 28*(2), 176-179.

5. Chiveu, J., Ubbenjans, U., Kehlenbeck, K., Pawelzik, E., & Naumann, M. (2020). Partitioning of dry matter and minerals in Kenyan common guava under salt stress: Implications for selection of adapted accessions for saline soils. *Forests, Trees and Livelihoods, 29*(2), 99-118.

6. Çimrin, K. M., Türkmen, Ö., Turan, M., & Tuncer, B. (2010). Phosphorus and humic acid application alleviate salinity stress of pepper seedling. *African Journal of Biotechnology, 9*(36), 5845-5851.

7. Di Stasio, E., Cirillo, V., Raimondi, G., Giordano, M., Esposito, M., & Maggio, A. (2020). Osmo-priming with seaweed extracts enhances yield of salt-stressed tomato plants. *Agronomy, 10*, 1559.

8. Ebert, G., Eberle, J., Ali-Dinar, H., & Lüdder, P. (2002). Ameliorating effects of Ca(NO3)2 on growth, mineral uptake and photosynthesis of NaCl-stressed guava seedlings (*Psidium guajava* L.). *Scientia Horticulturae, 93*, 125-135.

9. El-Sharkawy, M., El-Beshsbeshy, T., Al-Shal, R., & Missaoui, A. (2017). Effect of plant growth stimulants on alfalfa response to salt stress. *Agricultural Sciences, 8*, 267-291.

10. Elsawy, H. I. A., Alharbi, K., Mohamed, A. M. M., Ueda, A., Alkahtani, M., Alhusnain, L., Attia, K. A., Abdelaal, K., & Shahein, A. M. E. A. (2022). Calcium lignosulfonate can mitigate the impact of salt stress on growth, physiological, and yield characteristics of two barley cultivars (*Hordeum vulgare* L.). *Agriculture, 12*, 1459.

11. Embrapa Solos – Centro Nacional de Pesquisa de Solos. (2017). *Manual de métodos de análise de solo* (3ª ed.). Brasília: EMBRAPA.

Revista ARACÊ
ISSN: 2358-2472

12. Ferreira, R. G., Távora, F. J. A. F., & Hernandez, F. F. F. (2001). Distribuição da matéria seca e composição química das raízes, caule e folhas de goiabeira submetida a estresse salino. *Pesquisa Agropecuária Brasileira, 36*(1), 79-88.

13. Ferreira, E. B., Cavalcanti, P. P., & Nogueira, D. A. (2014). ExpDes: An R Package for ANOVA and Experimental Designs. *Applied Mathematics, 5*, 2952-2958.

14. Freire, J. L. O., Cavalcante, L. F., Dias, T. J., Dantas, M. M. M., Medeiros, L. P. M., & Azevedo, T. A. O. (2015). Micronutrient content in soil and leaf tissue of yellow passion fruit under the use of attenuators of saline stress. *Agropecuária Técnica, 36*(1), 65-81.

15. Freire, J. L. O., Cavalcante, L. F., Nascimento, R., & Rebequi, A. M. (2013). Teores de clorofila e composição mineral foliar do maracujazeiro irrigado com águas salinas e biofertilizante. *Revista de Ciências Agrárias, 36*(1), 57-70.

16. Grattan, S. R., & Grieve, C. M. (1999). Salinity-mineral nutrient relations in horticultural crops. *Scientia Horticulturae, 78*, 127-157.

17. Gurgel, M. T., Gheyi, H. R., Oliveira, F. H. T., Fernandes, P. D., & Silva, F. V. (2008). Nutrição de cultivares de meloeiro irrigadas com águas de baixa e alta salinidade. *Revista Caatinga, 21*(5), 36-43.

18. Gulmezoglu, N., & Izci, E. (2020). Ionic responses of bean (*Phaseolus vulgaris* L.) plants under salinity stress and humic acid applications. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 48*(3), 1317-1331.

19. Hernández-Herrera, R. M., Sánchez-Hernández, C. V., Palmeros-Suárez, P. A., Ocampo-Álvarez, H., Santacruz-Ruvalcaba, F., Meza-Canales, I. D., & Becerril-Espinosa, A. (2022). Seaweed extract improves growth and productivity of tomato plants under salinity stress. *Agronomy, 12*, 2495.

20. IBGE – Instituto Brasileiro de Geografia e Estatística. (2022). Produção Agrícola Municipal. Disponível em: https://sidra.ibge.gov.br/tabela/5457. Acesso em: 29 de setembro de 2022.

21. Khaled, H., & Fawy, H. A. (2011). Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. *Soil & Water Research, 6*(1), 21–29.

22. Khan, H. R., Ashraf, M., Shahzad, S. M., Imtiaz, M., Aziz, A., Piracha, M. A., & Siddiqui, A. R. (2016). Additional application of plant nutrients with farm yard manure for improving the adaptation of cotton crop to salinity stress. *Journal of Applied Agriculture and Biotechnology, 1*(2), 48-57.

23. Keutgen, A. J., & Pawelzik, E. (2008). Quality and nutritional value of strawberry fruit under long term salt stress. *Food Chemistry, 107*, 1413-1420.

24. Lima, B. R., Oliveira, E. P., Donato Júnior, E. P., & Bebê, F. V. (2020). Uso e qualidade de água subterrânea utilizada por agricultores familiares no Território Sertão Produtivo,

Revista ARACÊ
ISSN: 2358-2472

Estado da Bahia, Nordeste do Brasil. *Revista Brasileira de Gestão Ambiental e Sustentabilidade, 7*(16), 679-689.

25. Liu, C., Zhao, X., Yan, J., Yuan, Z., & Gu, M. (2020). Effects of salt stress on growth, photosynthesis, and mineral nutrients of 18 pomegranate (*Punica granatum*) cultivars. *Agronomy, 10*(27).

26. Mascarenhas, J. C., Beltrão, B. A., Souza Júnior, L. C., Morais, F., Mendes, V. A., & Miranda, J. L. F. (2005). Projeto cadastro de fontes de abastecimento por água subterrânea: Diagnóstico do município de Picuí, estado da Paraíba. *Recife: CPRM/PRODEEM*, 10 p.

27. McGrath, S. P., & Cunliffe, C. H. (1985). A simplified method for the extraction of the metals Fe, Zn, Cu, Ni, Cd, Pb, Cr, Co and Mn from soils and sewage sludges. *Journal of the Science of Food and Agriculture, 36*(9), 794-798.

28. Merwad, A.-R. M. A. (2020). Mitigation of salinity stress effects on growth, yield and nutrient uptake of wheat by application of organic extracts. *Communications in Soil Science and Plant Analysis, 51*(9), 1150-1160.

29. Medeiros, J. F., Lisboa, R. A., Oliveira, M., Silva Júnior, M. J., & Alves, L. P. (2003). Caracterização das águas subterrâneas usadas para irrigação na área produtora de melão da Chapada do Apodi. *Revista Brasileira de Engenharia Agrícola e Ambiental, 7*(3), 469-472.

30. Mutale-Joan, C., Rachidi, F., Mohamed, H. A., El Mernissi, N., Aasfar, A., Barakate, M., Mohammed, D., Sbabou, L., & El Arroussi, H. (2021). Microalgae-cyanobacteria-based biostimulant effect on salinity tolerance mechanisms, nutrient uptake, and tomato plant growth under salt stress. *Journal of Applied Phycology, 33*, 3779-3795.

31. Natale, W., Coutinho, E. L. M., Boaretto, A. E., & Banzatto, D. A. (1994). Influência da época de amostragem na composição química das folhas de goiabeira (*Psidium guajava* L.). *Revista de Agricultura, 69*(3), 247-255.

32. Natale, W., Coutinho, E. L. M., Pereira, F. M., & Boaretto, A. E. (2002). Nutrients foliar content for high productivity cultivars of guava in Brazil. *Acta Horticulturae, 594*, 383-386.

33. R Core Team. (2020). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing.

34. Rady, M. M., Abd El-Mageed, T. A., Abdurrahman, H. A., & Mahdi, A. H. (2016). Humic acid application improves field performance of cotton (*Gossypium barbadense* L.) under saline conditions. *The Journal of Animal & Plant Sciences, 26*(2), 487-493.

35. Richards, L. A. (1954). *Diagnosis and improvement of saline and alkaline soils.* USDA - United States Department of Agriculture, Nº. 60, 166p.

Revista ARACÊ
ISSN: 2358-2472

36. Rocha, L. F., Cavalcante, L. F., Nunes, J. C., Cavalcante, Í. H. L., & Beckmann-Cavalcante, M. Z. (2019). Crop management advances for nutritional status and fruit yield of guava in semiarid. *Journal of Plant Nutrition, 42*(8), 1-11.

37. Rouphael, Y., De Micco, V., Arena, C., Raimondi, G., Colla, G., & De Pascale, S. (2017). Effect of *Ecklonia maxima* seaweed extract on yield, mineral composition, gas exchange, and leaf anatomy of zucchini squash grown under saline conditions. *Journal of Applied Phycology, 29*, 459–470.

38. Santos, R. R., & Quaggio, J. A. (1996). Goiaba. In Raij, B. van, Cantarella, H., Quaggio, J. A., & Furlani, A. M. C. (Eds.), *Recomendações de adubação e calagem para o Estado de São Paulo* (p. 143). Campinas: Instituto Agronômico. (Boletim Técnico, 100).

39. Soil Survey Staff. (2015). *Illustrated guide to soil taxonomy* (Version 2.0). Lincoln, Nebraska: USDA - United States Department of Agriculture. Natural Resources Conservation Service, National Soil Survey Center. 681p.

40. Souza, J. T. A., Cavalcante, L. F., Nunes, J. C., Araújo, D. L., & Oliveira, F. F. (2020a). Soil salinity, micronutrients and passion fruit production irrigated with saline water and using organomineral fertilization. *Scientia Plena, 16*(7), 070205.

41. Souza, M. W. L., Torres, S. B., Oliveira, F. A., Marques, I. C. S., Pereira, K. T. O., & Guimarães, Í. T. (2020b). Saline-water irrigation and plant growth regulator application on zucchini fruit yield and quality. *Revista Brasileira de Engenharia Agrícola e Ambiental, 24*(10), 679-684.

42. Tedesco, M. J., Gianello, C., Bissani, C. A., Bohnen, H., & Volkweiss, S. J. (1995). *Análise de solo, plantas e outros materiais* (2ª ed.). Porto Alegre: Universidade Federal do Rio Grande do Sul. (Boletim Técnico, 5).

43. Turan, T., Yildirim, E., Ekinci, M., & Argin, S. (2021). Effect of biostimulants on yield and quality of cherry tomatoes grown in fertile and stressed soils. *HortScience, 56*(4), 414-423.

44. Willadino, L., & Camara, T. R. (2010). Tolerância das plantas à salinidade: aspectos fisiológicos e bioquímicos. *Enciclopédia Biosfera, 6*(11), 1-23.