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LEAF GAS EXCHANGE AND FLOWERING OF MANGO SPRAYED WITH BIOSTIMULANT IN SEMI-ARID REGION[1]

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ABSTRACT - The aim of the present study was to evaluate the effect of biostimulant containing amino acids and yeast extract on the physiological and reproductive characteristics of mango cv. Tommy Atkins during the shoot maturation phase in tropical semi-arid region. The experimental design consisted of randomized blocks with five treatments, five replications and five plants per plot. Treatments consisted of: T1) two foliar sprays with [biostimulant + KCl] + two foliar sprays with K_2SO_4; T2) No biostimulant and four foliar sprays with K_2SO_4; T3) three individual foliar sprays with biostimulant and one foliar spray with K_2SO_4; T4) two foliar sprays with biostimulant and two foliar sprays with K_2SO_4; and T5) two foliar sprays with [biostimulant + K_2SO_4] + one foliar spray with K_2SO_4. There is a positive effect of the biostimulant containing amino acids and yeast extract on transpiration, internal CO_2 concentration, water-use efficiency and number of reproductive and non-differentiated shoots of mango cv. Tommy Atkins cultivated under tropical semi-arid condition, with attenuating effect on plant abiotic stress. For shoot maturation of mango cv. Tommy Atkins, three foliar sprays with biostimulant containing amino acids and yeast extract (10 mL per plant) and one with K_2SO_4 (3%), starting at 45 days after paclobutrazol application (T3), can be recommended.

Keywords: *Mangifera indica* L. Abiotic stress. Shoot maturation. Production system.

TROCAS GASOSAS FOLIARES E FLORESCIMENTO DE MANGUEIRA PULVERIZADA COM BIOESTIMULANTE NA REGIÃO DO SEMIÁRIDO

RESUMO - O objetivo com este estudo foi avaliar efeito de bioestimulante contendo aminoácidos e extrato de levedura nas respostas fisiológicas e reprodutivas de mangueiras cv. Tommy Atkins durante a fase de maturação de ramos, em condição semiárida tropical. O delineamento experimental foi em blocos ao acaso, com cinco tratamentos, cinco repetições e cinco plantas por parcela. Os tratamentos foram: T1) Duas pulverizações com bioestimulante + KCl e duas pulverizações com K_2SO_4; T2) Quatro pulverizações com K_2SO_4 sem bioestimulante; T3) Três pulverizações individuais com bioestimulante e uma pulverização com K_2SO_4; T4) Duas pulverizações com bioestimulante e duas pulverizações com K_2SO_4; e T5) Duas pulverizações com bioestimulante + K_2SO_4 e uma pulverização com K_2SO_4. Há efeito positivo do bioestimulante contendo aminoácidos e extrato de levedura na transpiração, concentração interna de CO_2, eficiência do uso da água e número de gemas reprodutivas e não-diferenciadas da mangueira cv. Tommy Atkins cultivada em condição semiárida tropical, com efeito atenuador no estresse abiótico vegetal. Para a maturação de ramos de mangueira cv. Tommy Atkins pode-se recomendar três pulverizações foliares de bioestimulante contendo aminoácidos e extrato de levedura (10 mL por planta) e uma de K_2SO_4 (3%), iniciando aos 45 dias após aplicação de paclobutrazol (T3).

Palavras-chave: *Mangifera indica* L. Estresse abiótico. Maturação de ramos. Sistema de produção.

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INTRODUCTION

Brazil is the seventh largest producer of mango, with an annual production of 1.087 million tons, in 64.463 hectares of cultivated area, with an average yield of 17.012 t ha^{-1} (FAO, 2017). São Francisco Valley (semi-arid climate) is the main production center, responsible for 89% of Brazilian exports (AGROSTAT/MAPA, 2018), especially for the cultivar Tommy Atkins (ARAÚJO; MORAES; CARVALHO, 2017).

In Northeast Brazil, the semi-arid climate is predominant, characterized by high temperatures and low air humidity. Under such conditions, the flowering management of mango (*Mangifera indica* L.), a complex process affected by genetic, environmental, hormonal and nutritional factors (TIWARI; PATEL; PANDEY, 2018), involves a set of agronomical practices such as pruning, plant growth regulators, water stress and shoot maturation (DAVENPORT, 2003; CAVALCANTE et al., 2018). It must be pointed out that in mango trees, high temperatures not only inhibit the vegetative growth, but also cause considerable reduction in photosynthetic rates (LAXMAN; ANNAPOORNAMMA; BIRADAR, 2016).

The shoot maturation phase, which precedes floral induction, is crucial to obtain uniform flowerings especially in the tropical semi-arid region (CAVALCANTE et al., 2018). At this stage, irrigation should be reduced to below the crop needs to stimulate the synthesis of ethylene, the hormone responsible for improving mango flowering (DAVENPORT, 2006), as well as foliar applications, especially with potassium and sulfur, considering that the former affects photosynthesis, respiration and translocation of solutes (HAWKESFORD et al., 2012) and the latter is required during the Yang cycle to promote ethylene biosynthesis (TAIZ et al., 2017). As a result of this management and the local conditions with high temperatures and low air humidity, plants are constantly under stress (SANTOS et al., 2016).

An alternative to mitigate abiotic stresses in plants has been the use of biostimulants (DU JARDIN, 2015), which are biological substances capable of improving the nutritional efficiency, yield and quality of agricultural products (YAKHIN et al., 2017). Moreover, the reduction of the stress caused by drought was associated with the use of biostimulants containing amino acids and yeast extract (HAMMAD; ALI, 2014), because amino acids influence plant physiological activities, while the yeast extract works as a natural source of cytokinin and beneficial substances, such as vitamins B1, B2, B3 and B12 and organic compounds, proteins, carbohydrates, nucleic acid and lipids (ABD EL-MOTTY et al., 2010).

In a study conducted with the mango cv. Palmer in Brazilian semi-arid region, Cavalcante et al. (2018) recorded beneficial effects on shoot maturation when using biostimulant containing free amino acids and *Ascophyllum nodosum* seaweed extract; however, the physiological responses depends on mango cultivar and on the composition of the biostimulant used.

Therefore, this study was conducted aiming to evaluate the effect of biostimulant containing amino acids and yeast extract on the physiological and reproductive characteristics of mango cv. Tommy Atkins during the shoot maturation phase in tropical semi-arid region.

MATERIAL AND METHODS

Mango cv. Tommy Atkins with uniform crown size and vigor, and twenty years of age, was used in this study. The experiment was carried out in 2017 and 2018 in an orchard located on the Barreiro de Santa Fé farm, municipality of Casa Nova (9° 23'S and 40 ° 43' W, altitude of 402 above sea level), Bahia state, Brazil. The climate of the region is classified as Bsh, characterized as semi-arid with an annual rainfall average below 500 mm (ALVARES et al., 2013). During the execution of the experiment (from August to February), the meteorological data were monitored by an automatic weather station, which recorded the highest and lowest air temperatures of 38.76 and 16.36 °C, respectively, with an average of 27.56 °C; the average air humidity was 52.81%.

The plants, at spacing of 10.0 m between rows and 5.0 m between plants, were submitted to daily irrigation by micro sprinkler, with two emitters per plant and a flow rate of approximately 40 L h^{-1} each. Management practices such as weed and phytosanitary control, use of the growth regulator paclobutrazol (PBZ) (28.1 mL per plant of Cultar®), and dormancy break (potassium nitrate and calcium nitrate at 3.0%) were carried out every seven days, as recommended by Albuquerque, Medina and Mouco (2002), while fertilizing management was carried out via fertigation according to plant demand (SILVA et al., 2002; BARBOSA; CAVALCANTE; LIMA, 2016). The production pruning was carried out mechanically, while manual tip pruning was performed to synchronize the vegetative canopy flushes.

Before shoot maturation began, foliar samples were collected to determine the nutritional status of the plants used. Mature leaves of the last vegetative flush of the shoots located in the central part of the plant canopy were collected to determine macro and micronutrient contents (Table 1). After that, the leaves were washed with distilled water and dried at 65 °C until reaching a constant weight and posteriorly chemically analyzed following the method of Malavolta, Vitti and Oliveira (1997).

Table 1. Leaf nutrient concentrations of the mango orchard cv. Tommy Atkins before the experiment.

N	P	K	Ca	Mg	Mn	Fe	Zn	B
——— g kg^{-1} ———					——— mg kg^{-1} ———			
21.11	1.54	12.75	8.86	2.01	138.57	31.02	76.11	98.70

The experimental design was randomized blocks with five treatments, five replications and five plants per plot. The treatments adopted were defined according to plant demands and physiological changes that occur during shoot maturation, which precedes the floral induction in the production system adopted in the São Francisco Valley, as described by Albuquerque, Medina and Mouco (2002). Therefore, the treatments were formed by combinations of a biostimulant and potassium, consisting of: T1) Two foliar sprays with biostimulant (10 mL per plant) + KCl (120 mg per plant, 60% K_2O) and two foliar sprays with K_2SO_4 (120 mg per plant, 50% K_2O); T2) four foliar sprays with K_2SO_4 without biostimulant; T3) three foliar sprays with biostimulant (10 mL per plant) and one foliar spray with K_2SO_4 (120 mg per plant, 50% K_2O); T4) two foliar sprays with biostimulant (10 mL per plant) and two foliar sprays with K_2SO_4 (120 mg per plant, 50% K_2O); and T5) two foliar sprays of biostimulant (10 mL per plant) with K_2SO_4 (120 mg per plant, 50% K_2O) and one more foliar spray of K_2SO_4 (120 mg per plant, 50% K_2O).

The biostimulant utilized was the Bulk (Alltech®), composed of water-soluble K (12% de KCl), organic carbon (9.87%), amino acids (20%), anionic surfactants and yeast extract. Treatments application was based on the number of days after the application of gibberellin inhibitor, paclobutrazol (PBZ) ([(2RS, 3RS)-1- (4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-il) pentan-3-ol]), with intervals of ten days between each application, beginning at 45 days after PBZ (T3) and 60 days after PBZ (T1, T2, T4 and T5), based on the commercial management adopted in the São Francisco Valley, corresponding to control treatment (T2). The determination of quantity of days after PBZ for T3 was performed following the recommendations of Cavalcante et al. (2018).

During the pre-flowering (130 days after PBZ application) and full-flowering (157 days after PBZ application), the following parameters were evaluated: i) net photosynthesis – *A* (µmol of CO_2 m^{-2} s^{-1}); ii) stomatal conductance – *gs* (mol of H_2O m^{-2} s^{-1}); iii) transpiration – *E* (mmol of H_2O m^2 s^{-1}); iv) internal CO_2 concentration – *Ci* (mmol of CO_2 m^{-2} s^{-1}); v) water-use efficiency (*WUE*) (µmol of CO_2/ mmol of H_2O) calculated as the ratio between net photosynthesis and transpiration, through an infrared gas analyzer (IRGA) (Mod. Li-COR®6400 XT). The evaluations were carried out with mature leaves between 9:00 and 11:00 am.

The water amount at the pre-flowering phase corresponded to 50% of crop evapotranspiration (ETc) and, at the full-flowering phase it corresponded to 100% of ETc.

At the bud differentiation phase (142 days after PBZ application, for all treatments), the reproductive and non-differentiated (quiescent, vegetative and mixed) buds were quantified within a 1 m^2 quadrate made with polyvinyl chloride pipe, placed randomly on east and west sides in each tree (RAMÍREZ et al., 2010); at the full-flowering stage, the proportions of staminate and monocline flowers from two panicles a plant, collected from east and west sides of three plants per repetition, were determined.

The data of all variables were submitted to analysis of variance (ANOVA) and posteriorly to Tukey's multiple comparison test ($p<0.05$). Statistical analyses were performed using the SISVAR software (FERREIRA, 2011).

RESULTS AND DISCUSSION

For net photosynthesis (*A*) and stomatal conductance (*gs*), no difference was recorded among the shoot maturation strategies evaluated at the pre-flowering and full-flowering stages, although the internal CO_2 concentration (C_i), transpiration (*E*) and water-use efficiency (*WUE*) were affected by the biostimulant during the pre-flowering phase (Table 2).

The average result for net photosynthesis during pre-flowering was 4.076 µmol of CO_2 m^{-2} s^{-1} and, at the full-flowering, it was 9.476 µmol of CO_2 m^{-2} s^{-1} (Table 2). It must be emphasized that the difference recorded between the phases occurred not only due to the mango phenological changes, but also due to different water managements carried out in each evaluated period; at pre-flowering the plants were submitted to water stress, even if moderately (reduction of 50% of initial water amount), a technique recommended for mango floral induction management in semi-arid region (ALBUQUERQUE; MEDINA; MOUCO, 2002), while at the full-flowering phase the irrigation was normally applied according to crop demand.

The increment in photosynthesis values from pre-flowering to full-flowering contradicts the results found in the scientific literature, since according to Urban et al. (2008) leaf photosynthesis tends to be negatively affected by the flowering process. However, the same authors mention the difficulty in establishing a photosynthetic pattern in plants submitted to water stress conditions even if it is not severe, a strategy commonly performed in

floral induction process of mango production in semi-arid regions. In the present experiment, it can be seen that the reduction of water amount negatively affected the photosynthetic metabolism of mango trees, which is in agreement with Taiz et al. (2017), and indicates a different photosynthetic pattern for mango under tropical semi-arid conditions due to the management adopted in this crop production system.

Table 2. Net photosynthesis (*A*), stomatal conductance (*gs*), internal CO_2 concentration (C_i), transpiration (*E*) and water-use efficiency (*WUE*) in mango cv. Tommy Atkins as a function of shoot maturation management.

SV	*A* µmol of CO_2 m^{-2} s^{-1}	*gs* mol of H_2O m^{-2} s^{-1}	*Ci* mmol of CO_2 m^{-2} s^{-1}	*E* mmol of H_2O m^2 s^{-1}	*WUE* µmol of CO_2/mmol of H_2O
			Pre-flowering		
Value 'F'	0.7177^{ns}	0.0633^{ns}	0.0003*	0.0069*	0.0001**
T1	3.42	0.02	90.08c	0.70c	4.89a
T2	3.78	0.02	103.69bc	0.75bc	5.04a
T3	4.34	0.03	117.76bc	1.19abc	3.65b
T4	4.58	0.04	169.04ab	1.59ab	2.88bc
T5	4.26	0.04	190.11a	1.71a	2.49c
CV (%)	37.83	37.95	24.46	36.83	14.32
			Full-flowering		
Value 'F'	0.4842^{ns}	0.3978^{ns}	0.1234^{ns}	0.3050^{ns}	0.07^{ns}
T1	7.93	0.06	148.85	2.48	3.20
T2	12.02	0.11	165.74	3.76	3.20
T3	8.21	0.07	152.62	2.61	3.15
T4	9.88	0.10	186.39	3.58	2.76
T5	9.34	0.09	193.04	3.42	2.73
CV (%)	30.42	37.82	17.64	30.09	12.87

SV: Sources of variation. Means followed by the same lower-case letter in the column do not differ from each other by the Tukey test at 5% probability; **: significant ($p < 0.01$); *: significant ($p < 0.05$); ns: not significant; CV%: coefficient of variation. T1: two foliar sprays with (biostimulant + KCl) + two foliar sprays with K_2SO_4; T2: no biostimulant and four foliar sprays with K_2SO_4; T3: three individual foliar sprays with biostimulant and one individual foliar spray with K_2SO_4; T4: two individual foliar sprays with biostimulant and two individual foliar sprays with K_2SO_4; and T5: two foliar sprays with (biostimulant + K_2SO_4) + one individual foliar sprays with K_2SO_4.

Stomatal conductance averages were 0.03 and 0.09 mol m^{-2} s^{-1} at the pre-flowering and full-flowering, respectively (Table 2). When the plant is put under stresses, the tendency is that the stomata close and, as a result, there is a reduction of transpiration to achieve a minimal loss of the water contained in the plant (SILVA et al., 2019). In addition, Schaffer et al. (2009) infer that stomatal conductance is the main factor to control the net photosynthesis in mango trees, including with linear and exponential relations between these variables, due to a decrease in CO_2 supply to the mesophyll cells caused by stomatal closure, resulting in lower net photosynthetic rate (LAXMAN; ANNAPOORNAMMA; BIRADAR, 2016). In this context, the present study shows that the treatments that promoted the highest stomatal conductance also led to highest net photosynthesis (Table 2).

Lu et al. (2012), when evaluating the net photosynthesis and stomatal conductance of five mango cultivars, including 'Tommy Atkins' cultivated in northern Australia, found reduction for both variables in the dry season and maximum responses during the rainy season, conditions that can be compared to the two phases in which the analyses of this work were carried out, and agree with the results contained in (Table 2).

For internal CO_2 concentration during pre-flowering (Figure 1A), T5 was similar to T4 and superior to the other treatments, while T1 obtained the lowest result, not differing from T2 and T3; the difference between T1 and T5 was 100.03 mmol m^{-2} s^{-1}. In general, the values found in this study are lower than those reported by Santos, Martinez and Donato (2013), in 'Tommy Atkins' mango grown in semi-arid region, which had maximum values of 210 mmol m^{-2} s^{-1}. The high internal CO_2 concentration in leaves tend to favor the photosynthesis process (TAIZ et al., 2017); however, no relation was identified between the studied variables in this experiment, a behavior similar to that observed by Vieccelli et al. (2018) in 'Tommy Atkins' mango grown in Minas Gerais State, Brazil.

For transpiration (*E*) at pre-flowering stage, T5 reached the highest rate (1.71 mmol de H_2O m^2 s^{-1}), 144% superior to that of T1, which was the lowest value recorded (Figure 1B). The results recorded for T3, T4 and T5 are similar to those reported by Faria et al. (2016) in a study carried out with mango cv. Tommy Atkins in semi-arid region, a range of 1.23-2.87 mmol of H_2O m^2 s^{-1}, as a function of irrigation management, and also similar to the results reported by Rymbai et al. (2014), who evaluated the physiological indexes of mango

cultivars in different agroclimatic regions of India and recorded values between 1.19 and 2.43 mmol of H_2O m^2 s^{-1}. Under higher transpiration levels, as verified for T3, T4 and T5, plants tend to accumulate more solutes for cell turgor maintenance (TAIZ et al., 2017), which may positively facilitate the process of shoot maturation.

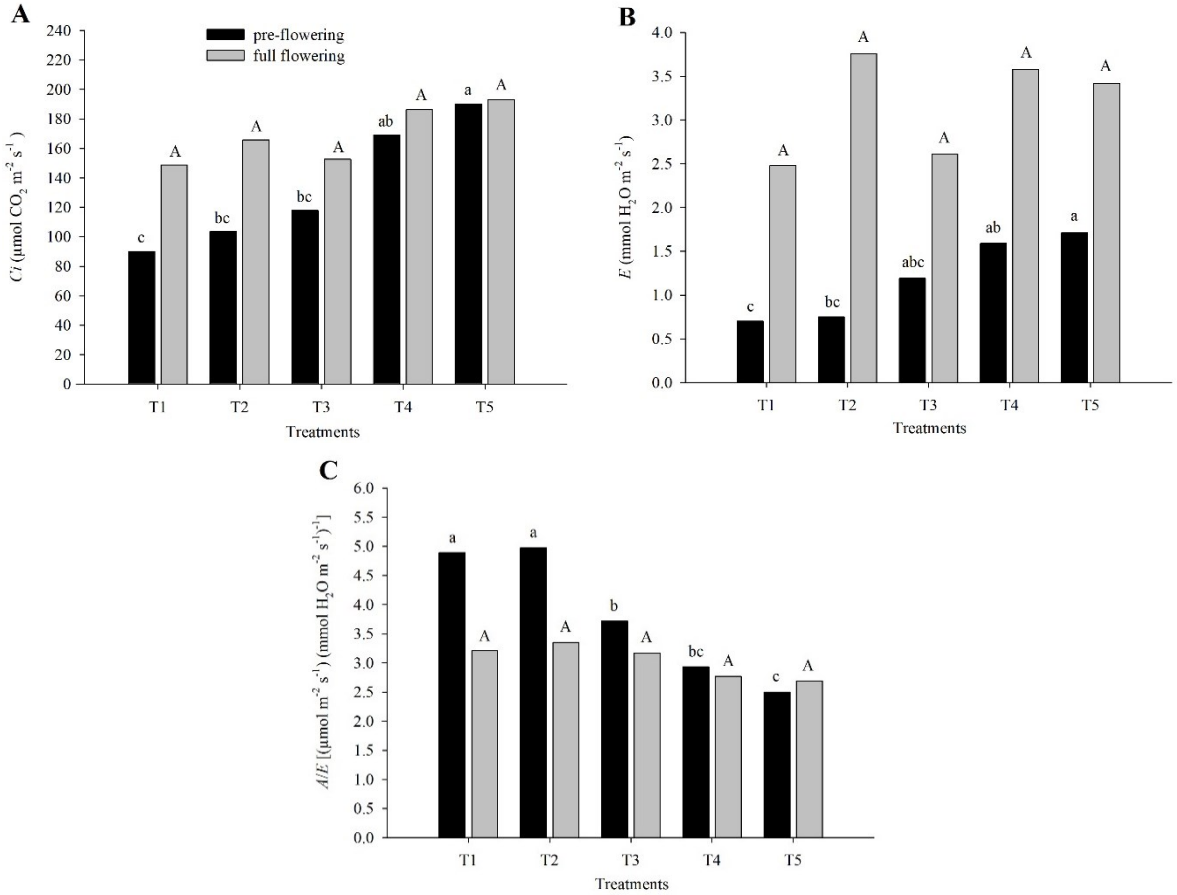

Figure 1. Internal CO_2 concentration – *Ci* (A), transpiration – *E* (B) and water-use efficiency - *A*/*E* (C) of mango cv. Tommy Atkins evaluated at pre-flowering and full-flowering as a function of shoot maturation management.
Bars with same color and letter do not differ by Tukey's test ($p < 0.05$). T1: two foliar sprays with (biostimulant + KCl) + two foliar sprays with K_2SO_4; T2: no biostimulant and four foliar sprays with K_2SO_4; T3: three individual foliar sprays with biostimulant and one individual foliar spray with K_2SO_4; T4: two individual foliar sprays with biostimulant and two individual foliar sprays with K_2SO_4; and T5: two foliar sprays with (biostimulant + K_2SO_4) + one individual foliar sprays with K_2SO_4.

Regarding the water-use efficiency during the pre-flowering, T1 and T2 had the highest results, while T5 was the less efficient treatment (Figure 1C). Faria et al. (2016) recorded a variation from 0.92 to 4.35 µmol of CO_2/mmol of H_2O in mango cv. Tommy Atkins growing in semi-arid environment, a broader range than the one recorded in this study where the results, even those found at the full-flowering, reached a mean of 3.17 mmol H_2O L^{-1}.

Silva, Campos and Azevedo (2009) reported that mango trees under low water availability showed the highest water-use efficiency. Thus, under the conditions of the present study, although the responses were lower for this variable, it is highlighted that T4 and T5 promoted a better water maintenance in the plants. The fact that T1 and T2 promoted superior results is probably attributed to the higher K^+ amount in such treatments, because this ion acts positively on cell osmotic regulation (HAWKESFORD et al., 2012).

Through empirical knowledge (data not published), photosynthesis is expected to affect shoot maturation in mango due to the supply of photoassimilates; however, the scientific literature does not have studies associating variables such as internal CO_2 concentration, transpiration and water-use efficiency with the physiological shoot maturation in mango trees. In this study, it can be seen that greater internal CO_2 concentration (Figure 1A), greater transpiration (Figure 1B), and lower water-use efficiency (Figure 1C) at the pre-flowering phase can be associated with a greater number of reproductive shoots produced (panicles) (Figure 2).

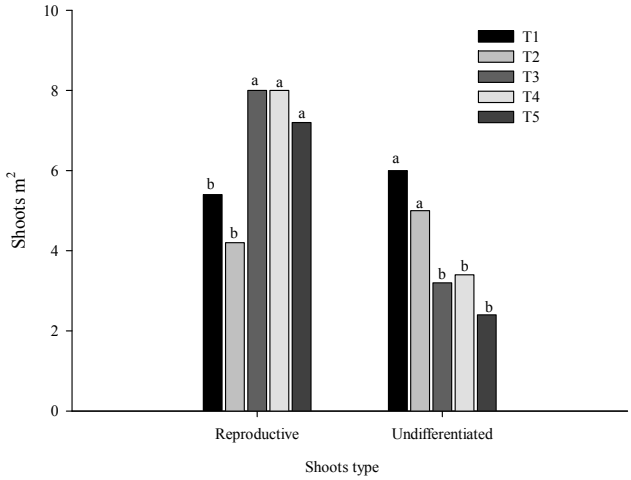

Figure 2. Number of reproductive and non-differentiated shoots per m^2 in mango cv. Tommy Atkins as a function of shoot maturation management.
Bars followed by the same letter do not differ by Tukey's test ($p<0.05$) to the same type of branch. T1: two foliar sprays with (biostimulant + KCl) + two foliar sprays with K_2SO_4; T2: no biostimulant and four foliar sprays with K_2SO_4; T3: three individual foliar sprays with biostimulant and one individual foliar spray with K_2SO_4; T4: two individual foliar sprays with biostimulant and two individual foliar sprays with K_2SO_4; and T5: two foliar sprays with (biostimulant + K_2SO_4) + one individual foliar sprays with K_2SO_4.

In general, according to the physiological variables evaluated, it can be seen that T3, T4 and T5 promoted a greater internal CO_2 concentration and also a greater transpiration, probably as a result of the greater stomatal opening when compared to T1 and T2 (Table 2), which had lower results. The activity of leaf stomata in the mango crops shows fast responses to environmental conditions such as CO_2 concentration, temperature and water restriction, the last one being the most incisive factor (URBAN; JANNOYER, 2004). Usually, any reduction in stomatal conductance and transpiration associated with water-use efficiency increase tends to decrease plant production capacity (FERRAZ et al., 2012); therefore, based on the results obtained, T3, T4 and T5 positively stood out compared to the other treatments. Similar responses were reported by Cavalcante et al. (2018) when evaluating mango cv. Palmer cultivated in semi-arid region in response to a biostimulant containing *Ascophyllum nodosum* seaweed extract combined with potassium, which acted on nutritional and carbohydrate contents, and also on fruit production.

In relation to the number of reproductive and non-differentiated shoots, there was a significant effect of the treatments, while there was no significant difference for the proportion of flowers (Table 3).

Table 3. Number of reproductive and non-differentiated shoots per m^2 in mango cv. Tommy Atkins as a function of shoot maturation management.

SV	Shoot		Proportion of flowers (%)	
	Reproductive	Undifferentiated	Monocle flowers	Staminate flowers
Value 'F'	0.6928^{*}	0.47^{*}	0.5056^{ns}	0.5056^{ns}
T1	5.4b	6.0a	51.58	48.42
T2	4.2b	5.0a	45.13	54.87
T3	8.0a	3.2b	33.21	66.79
T4	8.0a	3.4b	46.50	53.50
T5	7.2a	2.4b	52.09	47.91
CV (%)	76.93	84.69	27.13	23.36

SV: Sources of variation. Means followed by the same lower-case letter in the column do not differ from each other by the Tukey test at 5% probability; **: significant ($p<0.01$); *: significant ($p<0.05$); ns: not significant; CV%: coefficient of variation. T1: two foliar sprays with (biostimulant + KCl) + two foliar sprays with K_2SO_4; T2: no biostimulant and four foliar sprays with K_2SO_4; T3: three individual foliar sprays with biostimulant and one individual foliar spray with K_2SO_4; T4: two individual foliar sprays with biostimulant and two individual foliar sprays with K_2SO_4; and T5: two foliar sprays with (biostimulant + K_2SO_4) + one individual foliar sprays with K_2SO_4.

The treatments T3, T4 and T5 led to the best results for the number of reproductive and non-differentiated shoots with an average of 7.7 reproductive shoots per m^2 of crown (Figure 2). It evidences that the same treatments inversely had the lowest responses for the number of non-differenced shoots. In mango tree, the induction of reproductive and vegetative shoots has been conditioned by the proportion between florigenic and vegetative promoters (RAMÍREZ; DAVENPORT, 2010), which consequently is affected by different factors, such as plant and shoots age, nutritional status and climate conditions (TIWARI; PATEL; PANDEY, 2018).

It is important to note that T3 and T4 treatments, differently from the others, consist of initial sprays (1st, 2nd and 3rd, and 1st and 2nd, respectively) with biostimulant, which favored the process of reproductive shoot differentiation. The association of biostimulant with K_2SO_4 (T5) also promoted beneficial responses by increasing the number of reproductive shoots; however, the T1, in which KCl was added to substitute K_2SO_4 in the first two sprays, promoted low performance resembling the results of the control treatment (T2), without the use of biostimulant. In this aspect, it is possible to evidence that the K sources used for shoot maturation have a significant influence on the results. The depressant effect of KCl on some characteristics of mango tree is due its sensitivity to salinity, especially to the chloride excess of this source (ZUAZO; RAYA; RUIZ, 2003).

The positive effects of applying amino acids in mango cv. Tommy Atkins have already been reported by Mouco et al. (2009) in plants grown under semi-arid conditions. However, in that research, the treatments were applied during the sprouting and fruiting stages, phases subsequent to the ones adopted in the present experiment.

The yeast extract present in the biostimulant sprayed during the shoot maturation promoted beneficial effects for mango crop that can be attributed to its composition rich in nutrients, proteins, B vitamins and natural growth phytohormones, especially cytokinins (ABD EL-MOTTY et al., 2010). These results corroborate with Yu-juan et al. (2018), who inferred that mango shoot differentiation is affected by factors such as protein synthesis and processing, gene expression, hormonal balance, synthesis of secondary metabolites, and levels of starch and sucrose.

Regarding the proportion of staminate and monocline flowers, the treatments did not cause significant effect (Table 3), leading to average values of 45.7% and 54.3% for monocline and staminate flowers, respectively. These results are in consonance with Sousa, Pigozzo and Viana (2010), who affirmed that there is predominance of staminate flowers in relation to monocline flowers in mango; however, it is below the proportion recorded by Siqueira et al. (2008), which was 1:2 (monocline:staminate) for cv. Tommy Atkins grown in Petrolina-PE.

Mangifera indica L. is classified as a facultative xenogamic species, i.e., it has crossed reproduction that justifies a higher investment in the male function, since the transport of pollen grains among the flowers, generally, leads to losses (SIQUEIRA et al., 2008). Therefore, the presence of staminate flowers represents a positive reproduction strategy.

CONCLUSION

There is a positive effect of the biostimulant containing amino acids and yeast extract on physiological and reproductive variables during the shoot maturation phase of mango cv. Tommy Atkins grown in tropical semi-arid region.

For shoot maturation of mango cv. Tommy Atkins, three foliar sprays with biostimulant containing amino acids and yeast extract (10 mL per plant) and one with K_2SO_4 (3%), starting at 45 days after paclobutrazol application (T3), can be recommended.

The use of biostimulant containing amino acids and yeast extract during shoot maturation phase alleviates plant abiotic stress.

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