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Growth and initial development of passion fruit plants in different concentrations of biostimulants

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Abstract

The objective of this research was to evaluate the vegetative growth of yellow passion fruit seedlings, propagated by seeds, regarding the rates of use and application of two biostimulants in two types of soil. The experiment was carried out at the State University of Piauí (UESPI) - Campus de Corrente, with Passiflora edulis as a research culture, on a 50% brightness screen. The completely randomized design consisted of four treatments arranged according to the following application doses (0, 4, 8, 12 and 16 mL), using the biostimulant Solofull® and Stimulate® via soil, with six replicates per treatment, totaling 24 units experimental. The soil used came from two situations, soil 1 (area in the process of degradation, Gilbués - PI) and soil 2 (pasture area, Corrente, PI). At 65 days after sowing, height, stem diameter, number of true leaves, leaf area, plant height ratio and stem diameter and root length were evaluated. The data were submitted to analysis of variance. The application of the Stimulate® biostimulant in seedlings produced in soil cultivated by pasture, promoted the best development of the aerial and root system of the plants.

Keywords: plant stimulant, *Passiflora edulis*, seedling production, soil

Introduction

Passion fruit (*Passiflora edulis* Sims f. Flavicarpa Deg.) is a climbing fruit, semi-woody widely cultivated and commercialized in Brazil, both for industry and for fresh consumption. Currently Brazil, standing out as the world's largest producer and consumer of fruit, with a total production of 694.539 thousand tons in 50.8 thousand hectares of harvested area (Anuário Brasileiro de Fruticultura, 2017). The Northeast region is the largest producer, responsible for 44% of production, especially the states of Bahia, Ceará and Sergipe.

The production of seedlings is one of the most important stages in the industry, mainly due to the security in the implantation of a commercial plantation, guaranteeing the producer to mitigate the risks and, consequently, the greatest economic return (Krause et al., 2017). However, factors such as the growing substrate, the type of container, climate, nutritional and sanitary conditions, directly influence the development of seedlings (Sousa et al., 2016).

In this context, the use of techniques that favor the production of commercial seedlings is necessary to increase the quality and uniformity of the orchards, since this constitutes one of the most important stages of the productive system, directly influencing the development and productivity of the plant (Tomaz et al., 2014).

The application of biostimulants, emerges as a viable alternative, since these substances promote cell elongation, aiding in the absorption of essential nutrients for the development of plants (Calvo et al., 2014), causing them to become higher in less time (Gonçalves et al., 2018). Du Jardim (2015), defined biostimulants as substances that when applied to a set of plants, seeds or substrates in specific formulations have the ability to provide potential benefits for their growth and development.

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The quality evaluation of the seedlings must also be taken into account, because it is through it that the potential of a certain material for the composition of the substrate is known. Thus, they must present good physical, chemical, biological and sanitary conditions, to define the vigor, health and nutritional status of the seedlings (Alves et al., 2015).

Currently, the number of studies carried out to evaluate interferences of biostimulants in different cultures is increasing. Thus, the objective of this work was to verify the vegetative growth of yellow passion fruit seedlings, propagated by seeds, regarding the use and application rates of two biostimulants in two types of soil.

Material and Methods

Study area description

The study was conducted in 2018, from September to November on a 50% brightness screen, at the State University of Piauí (UESPI) / Campus Corrente, Piauí, Brazil (10° 26'S and 45° 09'W; 438 m above sea level). The region climate classified as Aw (tropical wet) with dry winter season (Koppen & Geiger, 1928).

The climatic data during the experiment were obtained by the Brazilian Institute of Meteorology (INMET, 2018), and are shown in Figure 1.

The average annual rainfall was 925 mm, with an annual mean temperature of 24.8 °C. The soil was classified as Yellow Latosol (Santos et al., 2013), and its physical and chemical characteristics are shown in Table 1.

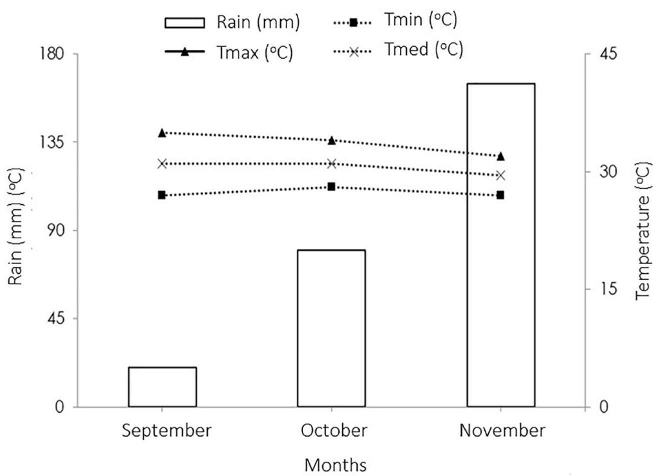

Figure 1. Climatic data, maximum temperature (maxT), mean (medT), minimum (minT) and rainfall, Corrente –PI.

Table 1. Chemical and physical characteristics of the soil at 0.0 – 0.20 m depth.

Soil characteristic	Soil degraded (Gilbués PI)	Soil pasture (Corrente PI)
pH (in water)	8.4	6.4
Ca^{2+} (cmolc dm^{-3})[b]	2.92	20.3
$H+Al^{3+}$ (cmolc dm^{-3})	0.00	1.14
K^{+} (cmolc dm^{-3})	0.32	0.91
Mg^{2+} (cmolc dm^{-3}) [b]	4.83	1.88
T (cmolc dm^{-3})	25.42	6.85
SB (cmolc dm^{-3})	25.42	5.71
P (mg dm^{-3})[a]	1.88	3.44
Fe (mg dm^{-3})	246.40	4.97
Mn (mg dm^{-3})	53.94	19.51
Cu (mg dm-³)	1.15	0.17
Zn (mg dm^{-3})	0.76	0.09
Clay (g kg^{-1})	28	58
Silt (g kg^{-1})	500	302
Sand (g kg^{-1})	472	640
Organic matter (%)	0.8	4.9
V (%)	100	83.4

[a]P: Resin 1; [b]Ca, Mg, and Al: KCl 1 M extractor.

Experimental design

The experiment was conducted in a completely randomized design, in a 2 × 2 × 5 factorial scheme, concerning soil types [ditch (S1) and cultivated (S2)], biostimulants [Solufull and Stimulate], and doses of soil biostimulant application at 25 days (0, 4, 8, 12, and 16 mL) plus biostimulant control (no application) with six replicates of five plants. To perform the applications, biostimulants were diluted with water (4 mL biostimulant / 200 mL water).

Conducting the experiment

For substrate preparation, two types of Yellow Latosol, medium texture, collected at a depth of 0.20 m (Santos et al., 2013) were used. Subsequently, the soil was air dried, deforested, and sieved in 2 mm Tamis. 5 kg of tanned cattle manure was used for every 10 kg of soil.

For the production of seedling, commercial seeds of yellow passion fruit were used. Sowing was performed 30 days after substrate preparation, in 10 × 20 cm plastic bags, laterally perforated, with a capacity of 0.5 kg of soil and three seeds per bag, at a depth of 3 cm. The bags were placed on a slab at 1.20 m in height.

When the seedlings reached 5 cm height, thinning was done by leaving one plant per bag. Manual irrigation was performed daily. Twenty-five days after seed germination, biostimulants were applied according to the established treatments.

The biostimulants used were Solofull® and Stimulate®. Solofull® (Global Crops Agri Solutions®) is a product based on *Ascophyllum nodosum* (L.) Le Jolis algae, composed of 4% (w / w) K_2O, 6% (w / w) Total

Organic Carbon, 10.0% algae extract, and 0.25% citric acid. Stimulate® composition includes 0.009% kinetin; 0.005% gibberellic acid, 0.005% indolbutyric acid, and 99.98% inactive ingredients.

Evaluations

At 65 days after sowing, the following characteristics of the vegetative growth of yellow passion fruit seedlings were evaluated: (H) height (cm), (SD) stem diameter (cm), (H / SD) plant height and diameter of the stem (cm / cm), (LA) leaf area ratio (m²), (SDM/RDM) shoot dry mass and root dry mass (g), and root length (RL) (cm).

Statistical analysis

The data were then tabulated and submitted to analysis of variance, by Tukey's test at p <0.01 of probability, to diagnose a significant effect and the interaction between factors in the ExpDes.pt package of software R, version 3.2.5 (R core team, 2018).

Results and Discussion

According to the analysis of variance (Table 2), all variables studied showed no significant interaction (p <0.05). It is only possible to study the isolated factors (Tables 3 and 4), which by the Tukey test, in their majority, were highly significant (p <0.01). The soil cultivated with pasture showed better results in the variables diameter, leaf area and root length, in relation to the degraded soil. The other variables did not differ by the Tukey test (p <0.05).

Table 2. Summary of the analysis of variance of the variables of *Passiflora edulis.*

Source of variation	DF	Fc					
		H (cm)	SD (cm)	H/SD (cm)	LA (m²)	SDM/RDM (g)	RL (cm)
Soil (S)	1	2.44 ^{ns}	5.55 **	2.34 ^{ns}	12.41 *	2.10 ^{ns}	11.44 *
Bio-stimulant (BS)	1	4.61 **	9.11 **	0.77 ^{ns}	16.85 *	5.73 **	5.02 *
Dose of bio-stimulant (DB)	3	1.30 ^{ns}	1.56 ^{ns}	0.94 ^{ns}	1.55 ^{ns}	0.81 ^{ns}	1.70 ^{ns}
S * BS	1	0.44 ^{ns}	0.12 ^{ns}	0.59 ^{ns}	1.26 ^{ns}	0.54 ^{ns}	0.00 ^{ns}
S * DB	3	0.55 ^{ns}	0.15 ^{ns}	1.43 ^{ns}	1.35 ^{ns}	0.05 ^{ns}	0.35 ^{ns}
BS * DB	3	0.40 ^{ns}	0.20 ^{ns}	0.54 ^{ns}	1.12 ^{ns}	0.21 ^{ns}	1.12 ^{ns}
S * BS * DB	3	1.27 ^{ns}	2.51 ^{ns}	0.33 ^{ns}	1.47 ^{ns}	0.13 ^{ns}	1.88 ^{ns}
Residue	80						
CV (%)		13.85	11.2	25.34	4.96	27.45	15.78

*Significant at p < 0.01, **Significant p < 0.05, ^{ns} not significant.

This is due to the nutritional balance (pH 6.4) of the soil cultivated with pasture, favoring the availability of nutrients present in the soil. In addition to having a good amount of calcium and organic matter, contributing to the good development of passion fruit seedlings, both in the aerial part and in the root system. Malavolta et al. (2002) describe that, organic matter acts as an energy source for useful microorganisms, improving the physical, chemical and biological structure of the soil.

Table 3. Analysis of the simple effect of the soil factor on the production of *Passiflora edulis.*

Source of variation	Soil (S)					
	H (cm)	SD (cm)	H/SD (cm)	LA (m²)	SDM/RDM (g)	RL (cm)
Soil ditch (S1)	20.10 ^{ns}	1.77 b	8.89 ^{ns}	22.30 b	6.84 ^{ns}	12.00 b
Cultivated (S2)	23.20 ^{ns}	2.20 a	10.43 ^{ns}	34.66 a	11.00 ^{ns}	16.34 a

Different letters in the column differ by Tukey's test at p <0.05 of significance, ^{ns} not significant.

There is also the fact that organic matter deteriorates over time, undergoing primary mineralogical changes that increase the capacity for cation exchange. The degraded soil, in turn, showed pH in alkaline water (8.4), promoting a decrease in the availability of phosphorus and molybdenum, and increasing the availability of metallic micronutrients such as manganese, iron, zinc and copper, which can cause inhibition of vegetative development.

Table 4. Analysis of the simple effect of the Bio-stimulant factor on the production of *Passiflora edulis.*

Source of variation	Bio-stimulant (BS)					
	H (cm)	SD (cm)	H/SD (cm)	LA (m²)	SDM/RDM (g)	RL (cm)
Solofull®	19.52 b	1.71 b	9.22 ^{ns}	21.28 b	5.49 b	12.73 b
Stimulate®	23.77 a	2.26 a	10.11 ^{ns}	35.68 a	12.35 a	15.61 a

Different letters in the column differ by Tukey's test at p <0.05 of significance, ^{ns} not significant.

According to McDowell et al. (1993), the concentration of chemical elements in the plant depends on the interaction of numerous factors, such as soil, plant species, maturation stage, yield, crop management and climate. However, the absorption potential is the main specific and genetically fixed factor for different nutrients and different plant species. Regarding the isolated effect of applying the biostimulants Solufull® and Stimulate® (Table 4), with the exception of the variable height and diameter ratio, a significant influence was observed among the other variables analyzed, differing from each other by the Tukey test ($p < 0.05$).

There was no significance regarding the types of application of biostimulants. This may be related to the time required for the evaluation, since the balanced use of plant stimulants provides an inducing effect on the different organs of plants, stimulating cell division, differentiation and elongation (Fagan et al., 2015).

In this way, the analogous reactions of the biostimulants between the application caused few variations in the metabolism and physiology of the plants, which in turn, presented uniform development. According to Reis et al. (2016), the evaluation time of 60 days is insufficient for the response of biostimulants in passion fruit seedlings. However, it is already possible to observe an advance in plant height, corroborating with the data observed in this work.

In the isolated analysis, the Stimulate® biostimulant showed better results in all analyzed variables, except for the variable height and diameter ratio of the plants. Dantas et al. (2012), when applying the biostimulant Stimulate® in tamarind seedlings (*Tamarindus indica*), also observed an increase in height and dry mass of the aerial and root system, verifying that the cellular elongation, boosted the growth in height without increasing the diameter of the stem.

Although the diameter was not influenced by the use of Stimulate®, there was an increase in leaf area and dry mass of the leaves. According to Taiz & Zeiger (2010), leaf growth occurs mainly through the physiological effect of cytokinins, plant hormones responsible for cell division. This fact was also observed by Tecchio et al. (2015), when applying 200 mL.L^{-1} of Stimulate® in citrus *Fortunella margarita* (Lour.) Swingle, obtained an increase in leaf area and dry mass, without expanding the seedling diameter.

According to Gonçalves et al. (2018), this happens when plants use their reserves to lengthen the stem at the expense of its diameter. Ferraz et al. (2014), show that for the passion fruit 'Roxinho', when the plants have greater height, the stem diameter tends to be smaller due to the hormonal balance of the plant, which increases the action of gibberish instead of auxin and cytokinin.

Ferrari et al. (2008), when applying 125 mL L^{-1} of Stimulate® via leaf to sweet passion fruit also observed greater leaf thickness, and consequently greater photosynthetic activity and greater growth of the root system. This is because biostimulants are chemical substances capable of transferring information that alter the physiological state of plant cells (Sharma et al., 2012). In this context, the same biostimulant is capable of causing different responses at different stages of plant development (Neumann et al., 2017).

According to Dantas et al. (2012), the application of biostimulants in the early stages of plant development promotes root growth, allows rapid recovery after water stress, increases resistance to insects, pests, diseases and nematodes, and promotes the establishment of plants in a fast and uniform that improves nutrient absorption. In future experiments, growth assessments should be carried out for a longer period, until the seedlings become adults, when greater differences can be verified.

Conclusions

It is concluded, therefore, that the Stimulate® biostimulant applied to seedlings produced in soil cultivated by pasture, promoted the best development of the aerial and root system of the plants, verifying greater height, leaf area, dry mass and root, and consequently better photosynthetic activity and growth.

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