American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)

ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

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http://asrjetsjournal.org/

Quality of seedlings of Copaifera langsdorffii Desf Cultivated in Alternative Substrates According to the Source and Methods of Application of Humic Acids

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Abstract

The objective of this study was to evaluate the effect of humic acid application methods on an alternative organic substrate in the quality of seedlings of Copaifera langsdorffii Desf. The experiment was carried out in a nursery of production of forest seedlings under cover of the dark type with 50% of luminosity retention, located in the municipality of Dianópolis state of Tocantins, in geographical coordinates, 11° 37′ 41″ S of latitude, 46° 49′ 17″ W of longitude, with altitude of 702 meters. The results revealed that the use of the commercial humic acid source applied via foliar promotes a higher quality of seedlings in relation to the alternative source and the absence of application of humic acids.

Keywords: Copaifera langsdorffii; Humic acid; Propagation; Seedlings.

1. Introduction

The Copaifera langsdorffii Desf. is a species of occurrence in both fertile and well-drained areas, as well as in poor, acid and alicos soils of the Cerrado, and its frequent occurrence in ciliary forests. However, the noblest and less destructive use has always been the extraction of oil, use that has recently added value for the preservation of the trees due to new harnesses in the pharmaceutical and cosmetics industry. Thus, in the face of the increase in the potentiality of the use of Copaiba products, the interest in technical knowledge that promotes the increase of production in commercial crops and in restocking of degraded areas is emerging. The use of quality seedlings results in less demand for cultural treatments and silvicultural and a reduction in mortality rates [1]. The morphological characteristics used to indicate the quality of the seedlings, but the survival and the initial growth, depend on the interaction of the characteristics of the seedlings in relation to the conditions found in the field [2]. One of the limiting factors for those who produce seedlings of native forest species is slow growth, especially those identified as late or climax [3].

In the case of native forest species, it is necessary to supplement the substrate with organic sources, because it favors the good development of seedlings [4]. Recently, researches have proven the alteration in morphology, physiology, and absorption of water and nutrients in the function of the supply of fertilizers containing humic acids in its composition. Reference [5] cite that humic acids may influence root, foliar development, increase in water absorption and nutrients beyond the regulation of enzymes important for plant metabolism, and proton pumps are Nutrient absorption by plants [6]. Describe the enzymatic alteration in acid ATPase facilitating the absorption of water and nutrients through the membrane, also cites the occurrence of an auxin-like action present in humic acids that promotes root growth. Reference [7] found that humic acids (SH) can directly alter the biochemical metabolism of plants and, consequently, influence growth and development. In SH the most bioactive fraction, humic acids (AH), are organic acids, soluble in water, present in different organic sources, such as sewage sludge, organic compost, leonardite, peat and commercial products [8], organic substrates Commercial, humified bovine manure, black land and carbonized rice husk [9;10]. Authors such as [11,12,13,14,15,16] reported that the application of humic acid-based fertilizers (SH) as nutrient supply and development promoter effect in commercial crops has been growing due to the responses obtained especially in crops with high Technological level. However, in forest species, there are still a few scientific results that show the potentiality of use [17]. The humic acids promote the increase of the root area and the number of physiologically active roots, being these effects dependent, of the species, age and the source and concentration of humeral acid used [18,19]. Thus, the recommendation for the use of humic acids as a promoter of plant development still requires studies, referring to sources, forms and times of application. In this context, the objective was to evaluate the effect of humic acid application methods on an alternative organic substrate in the quality of seedlings of Copaifera langsdorffii Desf.

2. Material and Methods

The experiment was carried out in a nursery of production of forest seedlings under cover of the dark type with 50% of luminosity retention, located in the municipality of Dianópolis state of Tocantins, in geographical coordinates, 11 ° 37 ′ 41 ″ S of latitude, 46 ° 49 ′ 17 ″ W of longitude, with altitude of 702 m. According to the Köppen classification [20], the climate of the region is of type Aw, has a longer period of the dry season with marked water deficit, defined as tropical hot and humid with a rainy season in summer and drought in winter. The seedlings were propagated via seeds, acquired from the Brazilian Institute of Forest - IBF, were collected in October 2015 in Goiânia - GO.

The seeds were seeded in a washed sandbox. At 15 days after germination, six seedlings were removed to be evaluated before the others were selected. Only those who obeyed the pre-established patterns, is 5 cm high and with at least eight leaves, were transplanted to the tubes. The trays were composed of 32 cells, being filled with the alternative substrate in a mixture of carbonized rice husk and subsoil in the proportion of 1:1:1 (Table 1), each cell with a capacity of 187cm ³ of a substrate, where they remained until the end of experiment.

The experimental design was completely randomized, with five replications, each repetition being a plot consisting of six plants. The treatments consisted of humic acids of commercial and alternative composition in different application methods, as described in Table 2.

The Commercial Product Fertiactyl® (SHC), which according to [21] has nitrogen (13%), phosphorus (10%), potassium (5%) and organic matter (humic and fulvic acids), and humic acid was obtained from alternative organic compounds (alternative humic acid-SHA), developed in the laboratory of Universidade Federal do Tocantins – UFT, Gurupi Campus. The humic acids were applied at intervals of 21 days, and the irrigation was suspended in advance of 24 hours, not being irrigated in the period from 07:00 to 07:00 hours of the next day. After this period, the application of humic acids was performed in the proportion of 5 ml of the substance to 995 ml of water, through the following procedures:

Table 1: Physicochemical composition of the raw materials used in the elaboration of substrates. Dianópolis-TO, 2016.

Analysis	Und.	Charred Rice Husk		Alternative Substrate	
		Dry Base 110ºC	Natural Humidity	Dry Base 110ºC	Natural Humidity
pH $CaCl_2$ 0,01M (Ref. 1:2,5)	pH	----	6,00	----	7,70
Density	g/cm^3	----	0,13	----	0,46
Umid. Lost to 60-65ºC	%	----	67,95	----	5,41
Umid. Perdida entre 65 e 110ºC	%	----	0,31	----	1,36
Total Humidity	%	----	68,26	----	6,77
Inert Materials	%	----	0,00	----	10,79
Total Nitrogen	%	0,35	0,11	0,92	0,76
Mat. Total Organic (Combustion)	%	71,79	22,78	48,05	39,61
Mat. Compostable Organic (Titration)	%	35,59	11,30	42,03	34,65
Mat. Composting-Resistant Organic	%	36,20	11,48	6,02	8,70
Total Carbon (Organic and Mineral)	%	39,88	12,66	26,69	19,63
Organic Carbon	%	19,77	6,28	23,35	17,17
Total Mineral Residue	%	28,30	8,98	52,75	43,49
Insoluble Mineral Residue	%	25,60	8,12	40,22	33,16
Soluble Mineral Residue	%	2,70	0,86	12,53	9,22
C/N Ratio (Total C and Total N)	----	114/1	115/1	29/1	26/1
C/N Ratio (Organic C and Total N)	----	56/1	57/1	25/1	23/1
Match (Total P2O5)	%	0,54	0,17	0,73	0,60
Potassium (K2O Total)	%	0,60	0,19	2,32	1,91
Calcium (Ca Total)	%	0,40	0,13	2,13	1,76
Magnesium (Mg Total)	%	0,20	0,06	0,70	0,58
Sulfur (S Total)	%	0,13	0,04	0,18	0,15
Boron (B Total)	mg/kg	3,00	1,00	24,00	20,00
Covers (Cu Total)	mg/kg	7	2	28	23
Iron (Fe Total)	mg/kg	2179	692	3488	2875
Manganese (Mn Total)	mg/kg	555	176	822	678
Zinc (Zn Total)	mg/kg	59	19	74	61

Table 2: Description of the methods of application of humic acids.

Method	Method
T0	No application of substances
T1AHA-I	Application of Alternative Húmic acid by Immersion of tubes
T1AHA-S	Application of Alternative Húmic acid in the Substrate
T1AHA-F	Application of Alternative Húmic acid via Foliar
T2AHC-I	Application of Commercial Húmic acid by Immersion of tubes
T2AHC-S	Application of Commercial Húmic acid in the Substrate
T2AHC-F	Application of Commercial Húmic acid via Foliar

2.1. Immersion treatment

In a container with a capacity of 10 L were added 7.2 L of solution, were immersed 8 cells at a time in the course of 10 seconds, after each immersion was restored the volume of solution that had been absorbed by the substrate, being these procedures used for both commercial and alternative substances. Application in the substrate: 1000 ml of each solution was distributed by equal volume with the aid of a syringe in the cells, and each cell received 25 ml volume because as the treatments were destructive the other seedlings could not receive higher doses.

2.2. Foliar application

This method was used as a manual sprayer with a capacity of 1 L, then sprayed 500 ml in the entire leaf area of the seedlings until the end of the solution. Evaluations occurred at 15; 42; 60; 90 and 114 days after the application of humic acid. To evaluate the effect of the method of application of humic acids on the *Copaifera langsdorffii* plants, the number of leaves (NL), leaf area (AL), plant height (AP), and root length (CR) and determined the dry mass of the aerial part (MSPA) were measured and Root (MSR). The weighing was performed after the complete drying of the seedlings in a forced air passage greenhouse at 60 °C for 72 hours. To do so, they were previously prepared, carefully torn apart and the aerial part then separated from the root system. The diameter was measured with a digital caliper graduated in millimeter and the seedling height and root length were measured using a graduated ruler in millimeter. The leaf area of the seedlings was estimated using the ImageJ software. The leaves were removed from the seedlings, after the identification to which the treatment was submitted, it was made available on a sheet of paper of size 21 × 29, 7cm (A4) containing a rectangle of black color, fully filled, measuring 3 × 15cm (45 cm ²) used for software calibration. Then, all leaves of the seedlings of *Copaifera langsdorffii* were photographed with the aid of a digital machine with 12.0 megapixels of resolution, which were subsequently subjected to area analysis through algorithms of contrasts and mathematical models Of the ImageJ software version 1.48. In addition, the total dry mass (MST), the ratios between height (AP) and diameter of the shoot (DC) and dry mass of the aerial part (MSPA) and root dry mass (MSR) were calculated at the end of the experiment, as well as the quality of the seedlings through the Seedling Quality Index (HEI) [22], through the equation:

$$IQD = \frac{MSTp}{\frac{AP}{DC}+\frac{MSA}{MSR}} \qquad (1)$$

Where: Dickson quality index (IQD); Total dry mass of the plant (MSTp); Plant height ratio with neck diameter (AP/DC) and air dry mass ratio with root dry mass (MSA/MSR). The results obtained were submitted to analysis of variance and the significance of the treatments tested by the F test using the Software Sisvar®. The development of seedlings as a function of time was evaluated by regression analysis. The study of the final quality of the seedlings was carried out using the mean (Tukey) test.

3. Results and Discussion

In Table 3 it is possible to verify that the characteristics studied, except for the root length (CR) showed a significant difference at the level of 1% of probability by the F test.

Table 3: Summary of analysis of variance for a number of leaves (NF), leaf area (PA), shoot dry mass (MSPA), plant height (AP), root dry mass (MSR), radicular length (CR), Dianópolis-TO, 2016.

FV	**GL**	**NF**	**AF**	**P**	**AP**	**MSR**	**CR**
		QM					
Treatment	6	112.02**	2505.35**	0.192**	48.65**	0.0663**	3.72[ns]
Date	4	1002.52**	30429.67**	1.889**	144.80**	0.8861**	312.07**
Treatment *Date	24	38.02**	1369.30**	0.025**	6.77**	0.0115**	5.67**
Error	170	16.35	165.44	0.007	2.74	0.0054	2.61
CV %	-	24.44	22.52	17.78	12.85	30.40	16.09

FV: Source of variation; **significant at the level of 1% probability; *significant at the level of 5% probability and not significant ns. It is also noted that in the application of humic acids, regardless of the method used promoted significant morphological alterations in the seedlings of Copaifera langsdorffii. In the analysis of treatment according to the dates of the application of humic acids, it was found that there was a significant difference at the level of 1% of probability by the F test. For the root length indicator (CR) of the seedlings of Copaifera langsdorffii showed no significant difference when subjected to treatments of the application of humic acids (Table 4). However, it is observed a significant difference in the root dry mass indicator (MSR), promoted by a higher root increment and development of the radicels.

Table 4: Number of leaves (NF), leaf area (PA), shoot dry mass (MSPA), plant height (AP), root dry mass (MSR), root length (CR), Dianópolis-TO, 2016.

Treatments	**NF**	**AF (cm²)**	**MSPA (g)**	**AP (cm)**	**MSR (g)**	**CR (cm)**
T0	12.63b	38.45c	0.317d	10.39d	0.174e	9.77[a]
T1AHA-F	18.42a	56.91ba	0.540a	14.15a	0.301[a]	9.68[a]
T1AHA-I	17.56a	64.89[a]	0.532ba	13.73cba	0.239dcb	9.92[a]
T1AHA-S	15.93a	54.69b	0.488cba	13.11cba	0.258cba	10.61[a]
T2AHC-F	17.90a	63.55ba	0.534ba	13.80ba	0.296ba	10.22[a]
T2AHC-I	17.03a	57.41ba	0.424c	12.55cb	0.198ed	9.78[a]
T2AHC-S	16.33a	63.80ba	0.466cb	12.45c	0.232ed	10.37[a]

*Averages followed by the same letter in the column did not differ statistically from each other, by Tukey test at 5% probability.

The method of foliar application of humic acid of alternative composition (T1AHA-F) promoted a greater increment of root dry mass. While the seedlings that did not receive an application of humic acids obtained the lowest dry weight of the root, although they did not differ statistically from the other seedlings submitted to treatments T2AHC-I and T2AHC-S when analyzed the parameter root dry mass.

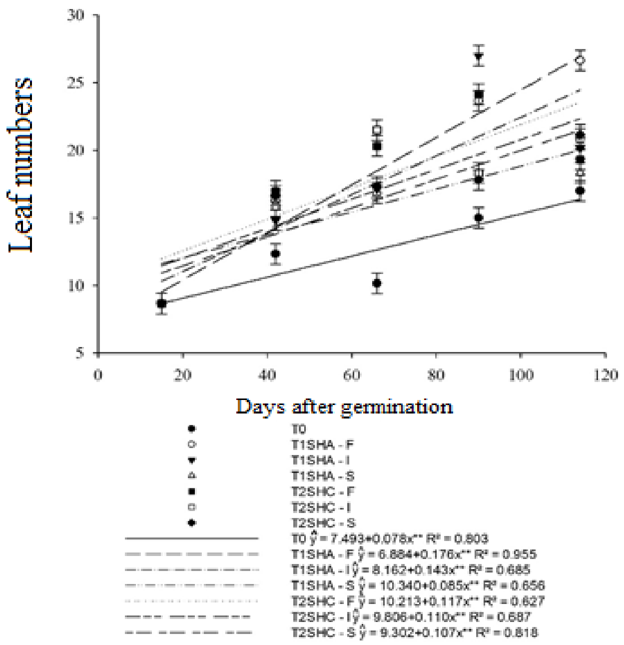

Figure 1: Number of leaves of *Copaifera langsdorffii* seedlings according to days after germination, submitted to methods of application of commercial and alternative humic acids.

The non-utilization of humic acids resulted in the lowest indexes of the studied characteristics since the use of humic acids promotes acceleration in the absorption of mineral nutrients, especially nitrogen, phosphorus, potassium, and sulfur [23]. Reference [24] concluded that AH modified the morphology of the root system and promoted an increase in the number of physiologically active roots and in the root area. The root system of the pineapple was also significantly altered with the application of HA, being observed increments in the fresh matter of the root, dry matter of the root and root area in the treatments with AH, corresponding to approximately 70, 57 and 39% compared to the control respectively [25]. There were differences among the treatments employed, the T1AHA-F, presented the best averages in quantitative leaves throughout the experiment. This is evidenced by the higher slope of the equation adjustment for T1AHA-F in relation to the other adjusted models (Figure 1). While the smallest increment in the number of leaves was observed when it did not use humic acids, confirmed by the lowest angular coefficient of adjustment of the equation to T0. A larger number of leaves means an increase in the photosynthetic area [26], reflecting in higher production of photoassimilates that are translocated for growth in height, the diameter of the stem and the formation of dry biomass [27]. In relation to leaf area growth, it is possible to verify in the results that the seedlings had a differentiated behavior regarding their leaf ontogenesis. The increase in leaf area of the seedlings of *Copaifera langsdorffii*. Was higher in the treatment T1AHC-F, the inverse was observed in the treatment T0, demonstrating that the absence of humic acids promoted a lower increase in the leaf area of the seedlings (Figure 2).

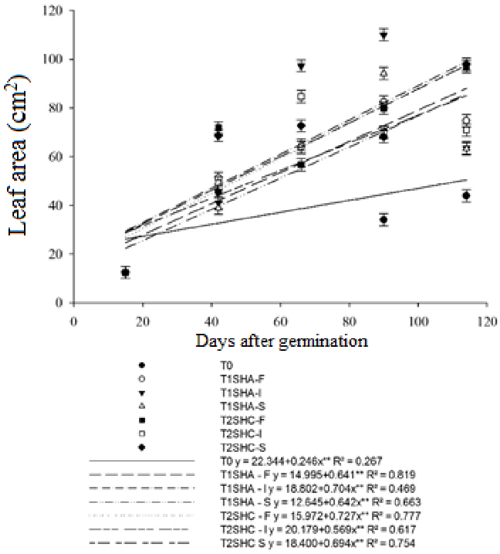

Figure 2: Leaf area of *Copaifera langsdorffii* seedlings according to days after germination, submitted to methods of application of commercial and alternative humic acids.

The leaves are the main photosynthetic organ [28]. It is known that the development of a plant begins with the fixation of carbon dioxide (CO_2), which will vary according to the quantity and quality of the incident solar radiation, and indirectly from the leaf area available in the plants. The carbon assimilates fixed by photosynthesis serve as raw material for the synthesis of the dry mass of the plant, which translates into growth and productivity [29], however, are the mineral nutrients acquired primarily in the form of ions inorganic through the root system of the plant that causes the assimilates of carbon to become functional or structural compounds. The highest dry mass production of the aerial part was obtained with the treatments T1AHA-F and T1AHA-I, corresponding to the method of application of humic acid of alternative composition via foliar and immersion (Figure 3).

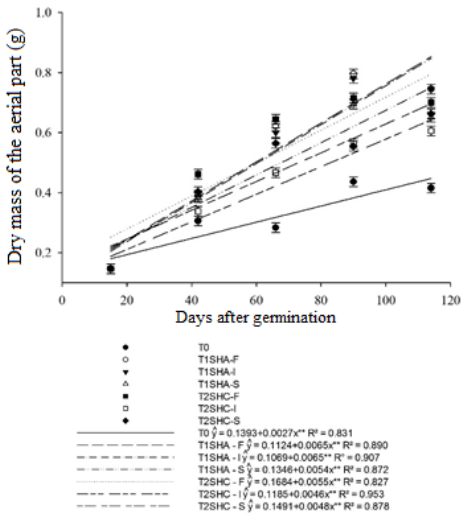

Figure 3: The dry mass of the aerial part of *Copaifera langsdorffii* seedlings as a function of days after germination, the to methods of application of commercial and alternative humic acids.

It was also found that the best results for the application of humic acid of commercial composition were obtained by the treatment T2AHC-F. This better performance is possible due to good assimilation of the substance via foliar application. Reference [30] studying the effect of the source of humic acids found an increment of 25.73% for a dry mass of the aerial part of lettuce plants for the commercial source Fertiactcyl®. For the treatments based on the humic acid of alternative composition, the T1AHA-S provided lower values in the development of leaf area, found in the angular coefficient of the adjustment model. For the treatments based on humic acid of commercial composition, the T2SHC-F presented the highest averages of leaf area, and there is no significant difference between the treatment T2SHC-F and the other treatments of alternative composition (table 4), this It is corroborating the fact that the plants absorb the substances better by the leaves. Reference [31] stated that these substances influence plant growth and development because they directly change the biochemical metabolism of plants. The seedling heights influenced the methods of application of humic acid of alternative composition, evidencing that the highest averages were obtained by the treatment T1SHA-F (Figure 4). Similarly, the T2SHC-F treatment showed the highest plant heights when compared to other methods of application of commercial humic acid.

Reference [32], working with methods of application and doses of humic acids, found a significant quadratic response in the increment of height in *Eucalyptus urograndis* seedlings by immersion treatment of the tubes. Height is an easy-to-obtain and non-destructive visual parameter.

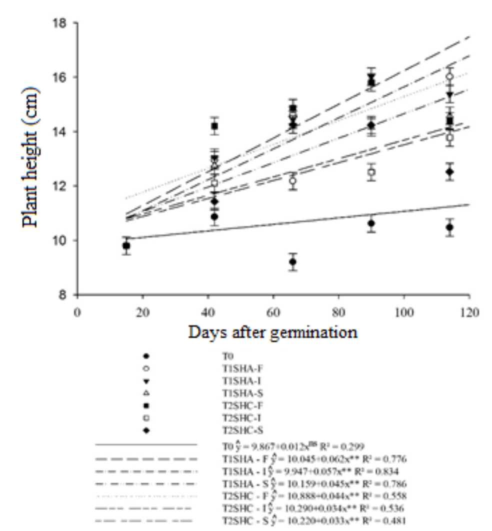

Figure 4: Increase in the height of *Copaifera langsdorffii* seedlings as a function of days after germination submitted to methods of application of commercial and alternative humic acids.

From its measurement, it is already possible to infer data on the quality of the seedlings. According to [33], a higher plant height implies a larger leaf area available for photosynthesis and transpiration, being an advantage in places where competition may be a problem. The seedlings without the application of the substance presented the mean height of 10.39 cm, lower than the average heights presented by the treated seedlings, demonstrating that the presence of humic acid influenced the best development of this parameter. Often, seedlings of higher height are not exactly the best in terms of survival in the field, especially when these are styolated. The influence of the methods of application of humic acids of commercial and alternative composition in the production of root dry matter is shown in Figure 5. The production of root dry mass followed the same trend, and the highest mass value was obtained by the T1SHA-F treatment, followed by T1SHA-S, which presented the same increment coefficient as T2SHC-F.

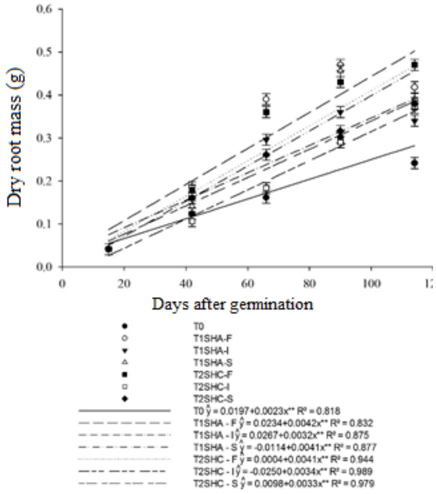

Figure 5: The dry root mass of *Copaifera langsdorffii* seedlings as a function of days after germination submitted to methods of application of commercial and alternative humic acids.

Reference [34] found a linear response in the production of dry mass of the root system with the application of increasing doses of humic acids extracted from coal. Reference [35] observed that the alternative humic acid promoted, based on the evaluation of root dry mass, greater root development (15.89%). Root growth has been presented as one of the main effects of humic acids, which may have an impact on crop production. The results obtained are in agreement with some studies cited in the literature that demonstrate the greater development of the root system with the utilization of doses of humic acids [36]. The large dry mass of the roots increase the capacity to absorb inorganic ions at low concentrations in the soil solution, make the mineral absorption by the plant a very effective process. After absorbed, the ions are transported to the various parts of the plant, where they are assimilated and used in important biological functions [37]. According to [38], the positive influence of the application of humic acids in the development of the root system may be due to the stimulating effect of humic acids similar to plant hormones, since the authors found that these Acids are able to provide an increase in an enzyme that promotes root expansion. Comparing the average root length obtained by the methods of application of humic acids, we observed the treatment T1SHA-S as the highest growth (table 2). This treatment is consistent with one that provided one of the greatest growths of the shoots of the seedlings, which would be expected since the conditions favoring the development of the root system positively reflect the aerial part. However, the treatment T0 presented a higher increment for this parameter by the mathematical model. It is inferred that this may have occurred due to the existence of a longer-length root, but with less dry mass (Figure 6).

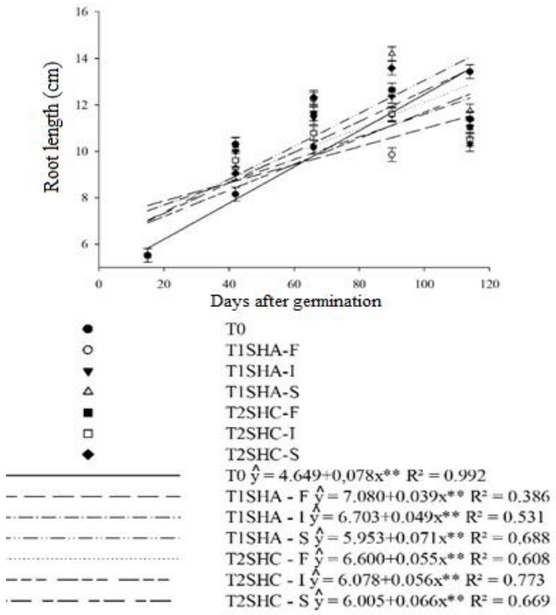

Figure 6: Root length of *Copaifera langsdorffii* seedlings as a function of days after germination submitted to methods of application of commercial and alternative humic acids.

It is also verified that foliar application had the lowest increment in root length between the application methods for each humic acid. Observing the variance analysis table for the final evaluation of the seedlings (at 114 days after germination) of *Copaifera langsdorffii*, it is possible to verify the existence of significant differences by the F test at the level of 1% for most of the characteristics studied, except for the parameters, root length, root dry mass and dry mass of the aerial part with root dry mass (table 3).

Table 5: Summary of the analysis frame of variance for number of leaves (NF), leaf area (PA), plant height (AP), neck diameter (DC), dry mass of shoot (MSA), root length (CR), dry mass of the root (MSR), ratio of shoot dry mass with mass root dryness (RPAR), ratio of shoot height with the diameter of the glue (RAD) and seedling quality index (IQD).

FV	GL	NF	AF (cm²)	AP (cm)	DC (cm)	MSA (g)	CR (cm)	MSR (g)	RPAR	RAD	IQD
		QM									
Treatment	6	57.00**	2193.95**	15.06**	1.021**	0.077**	6.33^{ns}	0.030^{ns}	0.343^{ns}	7.88**	0.0057**
Error	30	14.73	126.34	1.55	0.038	0.009	2.83	0.013	0.164	0.79	0.0011
CV %	-	18.72	15.41	8.89	8.81	15.08	14.77	31.28	22.28	13.76	26.74

FV: Source of variation; GL: Degree of freedom; **significant at the level of 1% probability; *significant at the level of 5% probability; not significant.

Data on leaf number, leaf area, plant height, stem diameter, shoot dry mass, root length, root dry mass, the aerial part ratio with root dry mass, aerial part height ratio with neck diameter and the quality index and seedlings are presented in table 6. According to the data, the seedlings that did not receive humic acids showed significantly lower height, the lower diameter of the collection and lower dry mass of the aerial part.

Table 6: Number of leaves (NF), leaf area (PA), plant height (AP), neck diameter (DC), shoot dry mass (MSA), root length (CR), dry root mass (MSR), ratio of shoot dry mass with dry root mass (RPAR), height ratio with the diameter of the collection (RAD) and seedling quality index (IQD).

Treatments	**NF**	**AF (cm^2)**	**AP (cm)**	**DC (cm)**	**MSA (g)**	**CR (cm)**	**MSR (g)**	**RPAR**	**RAD**	**IQD**
T0	17.00b	43.88c	11.47c	1.34c	0.41b	13.42a	0.24b	1.73ba	8.58[a]	0.06b
T1SHA-F	26.66a	74.79b	16.02a	2.26b	0.74a	10.52ba	0.41ba	1.86ba	7.11ba	0.13[a]
T1SHA-I	20.16ba	63.57cb	15.38a	2.36ba	0.74a	10.30b	0.34ba	2.29a	6.53cb	0.12ba
T1SHA-S	18.33b	63.20cb	14.58ba	2.21b	0.65a	11.74ba	0.39ba	1.78ba	6.62cb	0.12ba
T2SHC-F	19.33b	97.03a	14.38ba	2.42ba	0.70a	11.04ba	0.47a	1.51b	6.03cb	0.15[a]
T2SHC-I	20.83ba	70.94b	13.78ba	2.64[a]	0.60a	11.40ba	0.37ba	1.71ba	5.24c	0.14[a]
T2SHC-S	21.16ba	97.00a	12.52cb	2.35ba	0.66a	11.38ba	0.38ba	1.82ba	5.33c	0.14[a]

* Means followed by the same letter in the column do not differ statistically from each other, by Tukey test at 5% probability.

The plant height ratios with the diameter of the collection (RAD) were lower for the treatments T2SHC-I, T2SHC-S and T2SHC-F, with this infers that the humic acid of commercial composition provided equilibrium in the increment in height and diameter of the cervix. It was also found that RAD in the T0 treatment provided higher averages, indicating that the absence of humic acids may cause a similar effect to estiolation growing the seedling more in height than in diameter, hindering the survival of the seedlings in the post-planting. Commercial products of humic acids have shown increments in various crops [39] and the higher growth of seedlings when in the presence of these organic substances indicates the need of this component in the substrate for the production of seedlings of quality [40]. The Seedling Quality index (IQD) ranged from 0.06 to 0.15 when the treatment was the zero dose (T0) the index was 0.06 while the T2SHC-F treatment presented the highest index 0.15. On the other hand, in the other methods of application, the performances of the seedlings were intermediate between these two extremes, but always presenting significant difference when using humic acid, whether composition according to the data, the seedlings that did not receive humic acids showed significantly lower height, lower diameter of the collection and lower dry mass of the aerial part or alternative. The effect of humic acids is not easy to be explained, due to the complex nature still little known of these substances [41] and the response of plants to humic and fulvic acids is dependent on the source of these and, mainly of the species [42]. Establishing as standard the minimum value of 0.20 for the IQD according to the recommendation of [43], it is observed that no treatment provided this result, however this may be related to the size of the container used for production, as well as to the period established for the study, which ended at 114 days after seed germination. The IQD is one of the best indicators of seedling quality, because it takes into account several important morphological indicators at the same time, so that the use of these parameters in isolation raises the risk of mistaken choice of the higher seedlings in detriment of the lowest [44]. However, it is necessary to be cautious and to consider this value in relation to each species and conditions of cultivation [45].

4. Final considerations

The use of humic acid promotes greater leaf area in the seedlings of Copaiba, being the commercial humic acid applied via foliar to which promotes the highest increment. The alternative humic acid applied via foliar and by immersion of the tubes promotes the greater increase of dry mass of the aerial part in relation to the commercial source and the absence of application of humic acids. The application of humic acids promotes greater root dry mass when compared to seedlings that do not receive an application of humic acids. The absence of the application of humic acid promotes greater increment in root length. The use of the commercial humic acid source applied via foliar promotes a higher quality of seedlings in relation to the alternative source and the absence of application of humic acids.

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