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Substância húmica e substrato à base de caule decomposto de babaçu na produção de mudas de girassol

Humic substance and substrate based on babassu decomposed stem in the production of sunflower seedlings

Sustancia húmica y sustrato a base de tallo descompuesto de babasú en la producción de plántulas de girassol

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Resumo

Nosso objetivo foi investigar a influência de substratos alternativos à base de caule decomposto por babaçu e substâncias húmicas na produção de mudas de girassol. O delineamento experimental foi em blocos casualizados, em esquema fatorial 3 x 4 (substrato x substâncias húmicas). Doze tratamentos foram estudados: T1 (100% de caule decomposto de babaçu (BDS) + 0 ml L^{-1} HS), T2 (100% BDS + 12.5 ml L^{-1} HS), T3 (100% BDS + 25 ml L^{-1} HS), T4 (100% DBS + 50 ml L^{-1} HS), T5 (50% DBS + 50% LAd + 0 ml L^{-1} HS), T6 (50% DBS + 50% LAd + 12, 5 ml L^{-1} HS), T7 (50% DBS + 50% LAd + 25 ml L^{-1} HS), T8 (50% DBS + 50% LAd + 50 ml L^{-1} HS), T9 (100% LAd + 0 ml L^{-1} HS), T10 (100% LAd + 12.5 ml L^{-1} HS), T11 (100% LAd + 25 ml L^{-1} HS) and T12 (100% LAd + 50 ml L^{-1} HS). Cada tratamento foi realizado em quatro repetições, com uma muda por parcela, totalizando 48 parcelas. A interação DBSxHS proporcionou aumentos no comprimento, volume, diâmetro basal, número de folhas, altura das plantas e parâmetros relacionados à inflorescência. O substrato com caule de babaçu 100% decomposto, juntamente com a dose de 12,5% de substância húmica, é a melhor opção para a produção de mudas de girassol 'IAC Uruguay'. Mais pesquisas sobre o uso de DBS e HS são necessárias para abordar o uso e a finalidade na produção de novas culturas.

Palavras-chave: *Attalea speciosa* Mart.; *Helianthus annuus* L.; Nutrição.

Abstract

Our objective was to investigate the influence of alternative substrates based on stem decomposed by babassu and humic substances in the production of sunflower seedlings. The experimental design was randomized blocks, in a 3 x 4 factorial scheme (substrate x humic substances). Twelve treatments were studied, T1 (100% babassu stem decomposed (BDS) + 0 ml L^{-1} HS), T2 (100% BDS + 12.5 ml L^{-1} HS), T3 (100% BDS + 25 ml L^{-1} HS), T4 (100% DBS + 50 ml L^{-1} HS), T5 (50% DBS + 50% LAd + 0 ml L^{-1} HS), T6 (50% DBS + 50% LAd + 12, 5 ml L^{-1} HS), T7 (50% DBS + 50% LAd + 25 ml L^{-1} HS), T8 (50% DBS + 50% LAd + 50 ml L^{-1} HS), T9 (100% LAd + 0 ml L^{-1} HS), T10 (100% LAd + 12.5 ml L^{-1} HS), T11 (100% LAd + 25 ml L^{-1} HS) and T12 (100% LAd + 50 ml L^{-1} HS). Each treatment was performed in four replications with one seedling per plot, totaling 48 plots. The DBSxHS interaction provided increases in root length, root volume, basal diameter, number of leaves, plant height and parameters related to inflorescence. The substrate with 100% decomposed babassu stem, together with the dose of 12.5% humic substance, is the best option for producing 'IAC Uruguay' sunflower seedlings. Further research on the use of DBS and HS is needed to address the use and purpose in producing new crops.

Keywords: *Attalea speciosa* Mart.; *Helianthus annuus* L.; **N**utrition.

Resumen

Nuestro objetivo fue investigar la influencia de sustratos alternativos basados en tallo descompuesto por babasú y sustancias húmicas en la producción de plántulas de girasol. El diseño experimental fue en bloques aleatorizados, en un esquema factorial 3 x 4 (sustrato x sustancias húmicas). Se estudiaron doce tratamientos: T1 (100% de tallo de babasú descompuesto (BDS) + 0 ml L^{-1} HS), T2 (100% BDS + 12.5 ml L^{-1} HS), T3 (100% BDS + 25 ml L^{-1} HS), T4 (100% DBS + 50 ml L^{-1} HS), T5 (50% DBS + 50% LAd + 0 ml L^{-1} HS), T6 (50% DBS + 50% LAd + 12, 5 ml L^{-1} HS), T7 (50% DBS + 50% LAd + 25 ml L^{-1} HS), T8 (50% DBS + 50% LAd + 50 ml L^{-1} HS), T9 (100% LAd + 0 ml L^{-1} HS), T10 (100% LAd + 12.5 ml L^{-1} HS), T11 (100% LAd + 25 ml L^{-1} HS) y T12 (100% LAd + 50 ml L^{-1} HS). Cada tratamiento se realizó en cuatro repeticiones, con una plántula por parcela, totalizando 48 parcelas. La interacción DBSxHS proporcionó aumentos en longitud, volumen, diámetro basal, número de hojas, altura de la planta y parámetros relacionados con la inflorescencia. El sustrato con tallo de babasú 100% descompuesto, junto con la dosis de sustancia húmica al 12,5%, es la mejor opción para la producción de plántulas de girasol 'IAC Uruguay'. Se necesita más investigación sobre el uso de DBS y HS para abordar el uso y el propósito en la producción de nuevos cultivos.

Palabras clave: *Attalea speciosa* Mart.; *Helianthus annuus* L.; Nutrición.

1. Introduction

The sunflower (*Helianthus annuus* L.) is an annual dicot native to North America that belongs to the *Asteraceae*. In Brazil, sunflower cultivation has increased in recent years, mainly in off-season cultivation, due to its favorable characteristics such as wide adaptability to several areas, resistance to drought, cold, heat along with low production costs (Bacaxixi et al., 2011; Silva et al., 2014). In addition, sunflower's importance has been growing, mainly for edible oil market and biofuel production in the country (Amorim et al., 2017).

The sunflower production in Brazil on the 2018/2019 harvest was 104.6 thousand tons in the survey carried out in August, with a variation of 26.4% compared to the previous harvest of 2017/18, in which was 142.2 thousand tons was produced (CONAB, 2019). The sunflower yield was 1665 kg ha^{-1} in the 2018/2019 harvest, with a variation of 11.8% compared to the 2017/2018 crop, which was 1489 kg ha^{-1}.

In recent years, the production of seedlings has been used as a guarantee of production in several sectors, be it fruit, olericulture or floriculture, where they started to use regional materials and waste that are discarded in the environment in order to reuse them in agricultural activity (Ferreira et al., 2020).

In the production of sunflower seedlings, the use of alternative substrates has been increased (Silva et al., 2014). A reliable raw material guarantees a good development of the seedlings, being chose mainly considering the availability, cost along with physical-chemical characteristics of the product (Fonseca et al., 2017).

Babassu-based substrates, resulting from decaying palm trunks in the soil, are easily accessible and inexpensive in the Sub-region North of Brazil, being in addition excellent for producing fruit, flower and vegetable seedlings (Cordeiro et al., 2018; Oliveira et al., 2019; Cruz et al., 2018).

It is likely that the decomposed babassu stem showed successful results on the production of passion fruit seedlings (Pereira et al., 2019), açaí (*Euterpe oleracea* Mart.) (Oliveira et al., 2019), yellow melon (*Cucumis melo* L.) (Cordeiro et al., 2018), pomegranate 'Wonderfull' (Oliveira Neto et al., 2018) and ipe (Santana et al., 2019).

Another reliable source that alows a good seedlings performance is the humic substances. The use of humic substances in the production of seedlings has grown in recent years, in view of the good results obtained with their use (Jesus et al., 2020).

Among the benefits of using humic substances, are: improved substrate and/or soil fertility; immobilization of inorganic and organic pollutants; influence on the mercury cycle in nature; in addition to acting as biostimulants in vegetables, through an action similar to that of phytormones (Souza; Santana, 2014).

Although babassu stem substrate and humic substances are valuable and viable alternatives to be considered in seedling production, their uses have not yet been well established scientifically and constitute limitations to seedling development in some species, such as sunflower. Hence, this investigation was aimed to evaluate the response of sunflower seedlings in substrates based on decomposed babassu stem and increasing doses of humic substances.

2. Methodology

Site description and experimental design

The experiment was conducted from June to August 2019 at Agricultural and Environmental Sciences Center (03º44'17" S and 43º20'29" O) of the Federal University of Maranhão, Chapadinha, Maranhão State, Brazil.

Climate of the region, according to the Koppen-Geiger classification, is a hot and humid tropical type (Aw), with an average annual precipitation of 1600 to 1800 mm (INMET, 2019) and an average annual temperature of 27 °C (Passos et al., 2016).

The soil used was classified as yellow dystrophic latosol soil (LAd) (Santos et al., 2018).

A randomized block design was carried out in a 3 x 4 factorial scheme (substrate x humic substances). We studied twelve treatments, namely, T1 (100% babassu decomposed stem (BDS) + 0 ml L^{-1} HS), T2 (100% BDS + 12.5 ml L^{-1} HS), T3 (100% BDS + 25 ml L^{-1} HS), T4 (100% DBS + 50 ml L^{-1} HS), T5 (50% DBS + 50% LAd + 0 ml L^{-1} HS), T6 (50% DBS + 50% LAd + 12.5 ml L^{-1} HS), T7 (50% DBS + 50% LAd + 25 ml L^{-1} HS), T8 (50% DBS + 50% LAd + 50 ml L^{-1} HS), T9 (100% LAd + 0 ml L^{-1} HS), T10 (100% LAd + 12.5 ml L^{-1} HS), T11 (100% LAd + 25 ml L^{-1} HS) and T12 (100% LAd + 50 ml L^{-1} HS). Each treatment was performed in four replicates with one seedling per plot, totaling 48 plots.

Humic substance applied was Humitec WG®, composed of 17% K_2O, 31% organic carbon, 68% total humic extract, 52% humic acids and 16% fulvic acids.

Granulometric analysis of the LAd found that the soil used has: 384 g coarse sand kg^{-1}; 336 g fine sand kg^{-1}; 112 g of silt kg^{-1}; 168 g of total clay kg^{-1}; 38 g of natural clay kg^{-1}; Franco sandy textural classification; and a flocculation degree of 0.77 g g^{-1}.

Physical and chemical characterization of the substrates used was carried out at the Soil Science Laboratory of the Federal University of Ceará, Fortaleza-CE. For the chemical characterization (Table 1), the following were analyzed: pH, organic matter (OM) and the total contents of the macronutrients: phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) according to MAPA (2007).

Table 1. pH values, electrical conductivity (EC), and total levels of Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Sulfur (S) of the substrate with 100% babassu decomposed stem and 100% soil. Chapadinha- MA, 2019.

Substrates	pH	EC	N	P	K	Ca	Mg	S
		dS m^{-1}	g kg^{-1}	mg kg^{-1}			$cmol_c$ kg^{-1}	
BDS	5,32	4,34	5,88	33	3,63	20,6	15,2	41,5
LAd	5,06	0,10	0,63	13	0,07	0,80	0,30	1,5

BDS: babassu decomposed stem. LAd: yellow dystrophic latosol soil.
Source: Authors.

For physical characterization (Table 2), the following traits were analyzed: global density (GD), particle density (PD) and porosity (%), determined according to the procedures described by Schmitz (2002).

Table 2. Global density (GD), Particle density (PD) and porosity of the substrate with 100% babassu decomposed stem and 100% soil. Chapadinha- MA, 2019.

Substrates	Density (g cm^{-3})		Porosity (%)
	GD	PD	
BDS	0,33	0,97	65,95
LAd	1,44	2,67	45,99

BDS: babassu decomposed stem. LAd: yellow dystrophic latosol soil.
Source: Authors.

Experimental management

The DBS was obtained in the region of Chapadinha - MA, this material remaining and already found in the soil, with the material being removed manually, and then sieved through the 8 mm sieve for disaggregation and homogenization of the material. The soil used in the formulation of the substrate, went through the cleaning process to remove stony, branches and leaves, and subsequently, the formulation of the substrate was carried out.

The first application of HS was carried out on the day of sowing, after seed irrigation. The application was performed every seven days with the aid of 1 ml syringes.

The container used in the production of seedlings were large bottles with a capacity of 20-L. All the bottles were drilled at the base and on the sides to allow water to escape during irrigation and to avoid soaking the substrate. After filling the 48 bottles, three seeds were sown per bottle at a depth of 0.5 cm. The sunflower plants were watered twice a day, in the early morning and late afternoon, with the aid of a 5-L manual watering can, respecting a daily average of 208, 33 ml seedling^{-1}. Irrigation was carried out in a supplementary manner in the period without rain based on the evapotranspiration of the crop as described by Barreto et al (2014). At 62 days after sowing (DAS), the plants were taken to the laboratory for analysis of the quality of the sunflower seedlings.

Data collection

The following parameters were evaluated: i) plant height (cm) (PH): with the aid of a graduated ruler; ii) basal diameter (mm) (BD): obtained with a digital caliper (Digimess®) at 5 cm from the substrate level; iii) number of leaves (NL): obtained by counting the leaves of each plant in the experimental unit; iv) root length (cm): measured with the aid of a ruler graduated in millimeters; v) root volume (cm^3): performed by measuring the displacement of the water column in a graduated cylinder, according to the methodology described by Basso (1999); vi) shoot fresh mass SFM) and vii) root fresh mass (RFM): exressed in grams (g), after weighing on a semi-analytical balance with an accuracy of 0.01 g; viii) shoot dry mass (SDM); ix) root dry mass (RDM), expressed in grams (g), determined by the drying method, using Kraft paper bags, in a forced air circulation oven at a temperature of 65ºC for 72 hours and weighed in a semi-analytical balance with accuracy of 0.01 g; x) vertical inflorescence diameter (VID): measured with the aid of a caliper graduated in millimeters; xi) horizontal diameter of the inflorescence (HDI): measured with the aid of a caliper graduated in millimeters; xii) height of the inflorescence (HI): with the aid of a ruler graduated in millimeters; xiii) inflorescence thickness (TI): measured with the aid of a caliper graduated in millimeters; and xiv) Dickson's quality index (DQI): obtained by the formula of Dickson et al. (1960):

$$\mathrm{DQI} = \frac{\mathrm{MST\,(g)}}{\mathrm{PH\,(cm)/SD\,(mm) + SDM\,(g)/RDM\,(g)}}$$

Statistical analysis

The data were subjected to analysis of variance (ANOVA) for diagnosis of significant effect and the treatments compared with the Tukey test at 1% probability. The analysis was performed using SISVAR software version 5.6 (Ferreira, 2011).

3. Results and Discussion

The analysis of variance revealed a significant effect of the substrate, humic substances and interaction on almost all studied variables (*P<0.01*) (Table 3).

Overall, the use of humic substances and decomposed babassu stem showed to be promising on the production of sunflower seedlings, by the better performance compared to control. The treatment T2 showed the best results among all tested combinations in all studied parameters, being the most sustainable alternative for the production of sunflower seedlings.

Table 3. ANOVA summary of basal diameter (BD), plant height (PH), root length (RL), shoot fresh mass (SFM), shoot dry mass (SDM), number of leaves (NL), root fresh mass (RFM), root dry mass (RDM), vertical inflorescence diameter (VID), horizontal inflorescence diameter (HID), inflorescence height (HI), inflorescence thickness (TI) and Dickson's quality index (DQI) of sunflower seedlings.

Variation Sources	SD (mm)	PH (cm)	RL (cm)	SFM (g)	SDM (g)	NL
DBS	51,80 **	22,49 **	22,32 **	42,78 **	28,73 **	6,11 **
HS	9,94 **	10,05 **	6,92 **	13,58 **	12,84 **	1,73 ^{ns}
DBS x HS	6,58 **	6,17 **	5,25 **	8,85 **	7,13 **	5,24 **
Block	0,087 ^{ns}	0,41 ^{ns}	0,02 ^{ns}	1,12 ^{ns}	0,75 ^{ns}	0,84 ^{ns}
CV (%)	22,6	24,46	35,08	51,70	52,18	28,56

Variation Sources	RFM (g)	RDM (g)	VID (mm)	HDI (mm)	HI (cm)	TI (cm)	DQI
DBS	49,31 **	23,00 **	16,01 **	12,03 **	5,69 **	8,38 **	33,30 **
HS	11,80 **	5,02 **	7,86 **	6,25 **	3,75 **	3,10 **	7,81 **
DBS x HS	10,96 **	3,18 **	2,69 **	2,66 **	0,77 ^{ns}	3,61 **	5,31 **
Block	0,93 ^{ns}	0,80 ^{ns}	0,53 ^{ns}	0,90 ^{ns}	1,29 ^{ns}	0,48 ^{ns}	0,84 ^{ns}
CV (%)	69,36	79,09	35,75	36,68	61,46	32,15	63,11

DBS: Decomposed babassu stem; HS: humic substances; CV: coefficient of variation. **: significant at 1% probability; ^{ns}: not significant by the test Tukey (*P>0.01*).
Source: Authors.

HS act directly on root morphology, increasing the length and number of root hairs through the action of humic acids (Canelas et al., 2002). Such changes induce lead to a high physiological plant performance. For instance, a root system with a greater number of root hairs is more efficient in absorbing nutrients and, as a result, greater biomass production under conditions of limiting nutrients in the environment, providing greater resistance to nutritional

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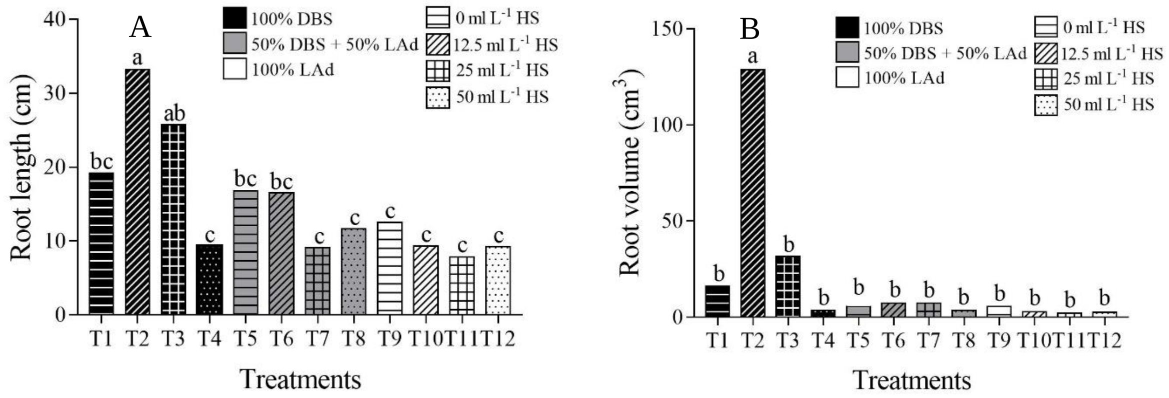
stresses (Pinton et al., 1999). This pattern was mirrored in our results to RL (*P<0.01*) and RV (*P<0.01*), that showed the best results by the use of T2, with 33.2 cm and 128.8 cm^3 for RL and RV, respectively (Figure 1).

Figure 1. Root length (A) and root volume (B) of 'IAC Uruguay' sunflower seedlings as a function of the application of humic substances and substrates based on decomposed babassu stem.



Source: Authors.

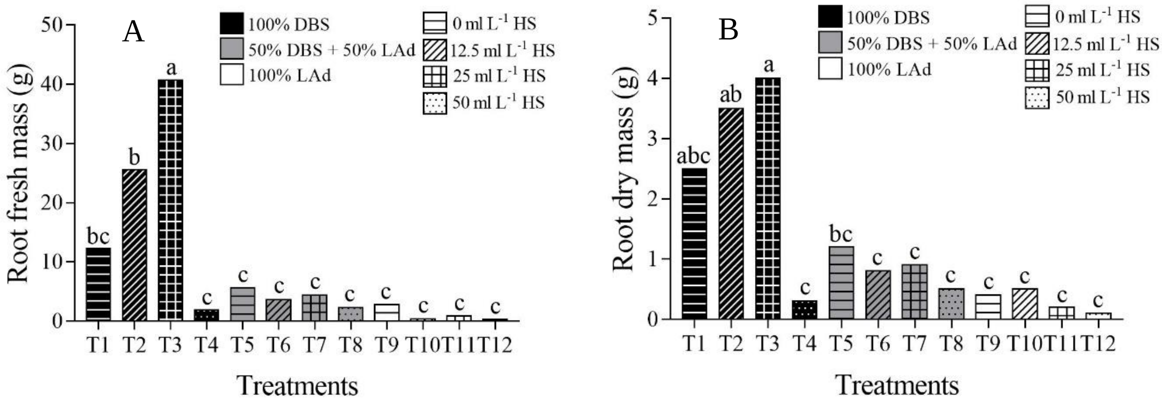
It was observed that the composition of the substrates influenced the root development in view of their porosity (Table 2). Oliveira et al. (2019) observed that the addition of DBS in the formulation of substrates provides significant increases in porosity and a low density, aloowing thus better aeration, infiltration and water drainage, crucial aspects for the development of quality seedlings. In addition, substrates from organic material, such as DBS, have a higher moisture retention capacity (Oliveira et al., 2014), which mitigated sunflower water stresses, in our study. The high porosity and high moisture retention capacity explain the excellent root development in treatments with 100% DBS (Figure 1). It was also observed that the doses, above 12.5 ml L^{-1} of HS, inhibited the development of RL and RV of the sunflower, regardless of the type of substrate used.

Our results revealed that the substrates which contained only the LAd, showed the lowest values in all analyzed variables. It was reported low fertility and low pH levels that are around 5.0 for the same soil used (Pereira et al., 2019; Santana et al., 2019), that might explains the low performance of sunflower in treatments that contained only LAd as a substrate (T9, T10, T11 and T12).

In addition, it was observed that the results obtained in T2 and T3 for RL and VR influenced RFM (*P<0.01*) and RDM (*P<0.01*), as in these treatments the highest values of

RFM and RDM were recorded. The longer and more voluminous roots might have increased the biomass deposition in the root system, which probably induced high values of RFM (40.7 g) and RDM (4.0 g), especially in T3 that had 25 ml L^{-1} of HS (Figure 2).

Figure 2. Fresh mass of the root system (A) and root dry mass (B) of 'IAC Uruguay' sunflower seedlings depending on the application of humic substances and substrate based on decomposed babassu stem.



Source: Authors.

SH act on the development of seedling roots and have a certain contribution in the transport of H^+ in the plasma membrane and, therefore, in the hydrolysis of ATP (Baldotto, Baldotto, 2014). They increase the activity of H^+ pumps and perhaps favour radicular hair emission, by thin lateral roots, which may increase the surface area of the root system (Baldotto; Baldotto, Ibidem, 2014; Oliveira et al., 2020).

It is reported that HS has in its suprastructural arrangement groups with auxinic activity, which may be released due to the exudation of organic acids, such as acetic acid, evidently allowing the rupture of the interactions between the HS components (Canellas, Olivares, 2014). This breakdown increases the mobility of humic and fulvic acid components. Among these more labile components there are bioactive molecules with auxinic activity, which may sensitize receptors both in the plasma membrane and in the cytoplasm, triggering typical responses to the action of this phytohormone (Borcioni et al., 2016). Thus, the auxinic activity of HS might enabled the development of the sunflower root system, promoting greater absorption of water and nutrients from the seedlings.

According to Taiz et al. (2017), the root system is responsible for the production of phytohormone known as cytokinin, responsible in large part for the development of the plant aerial part. With the root system well developed in the T2 and T3 treatments, there was greater

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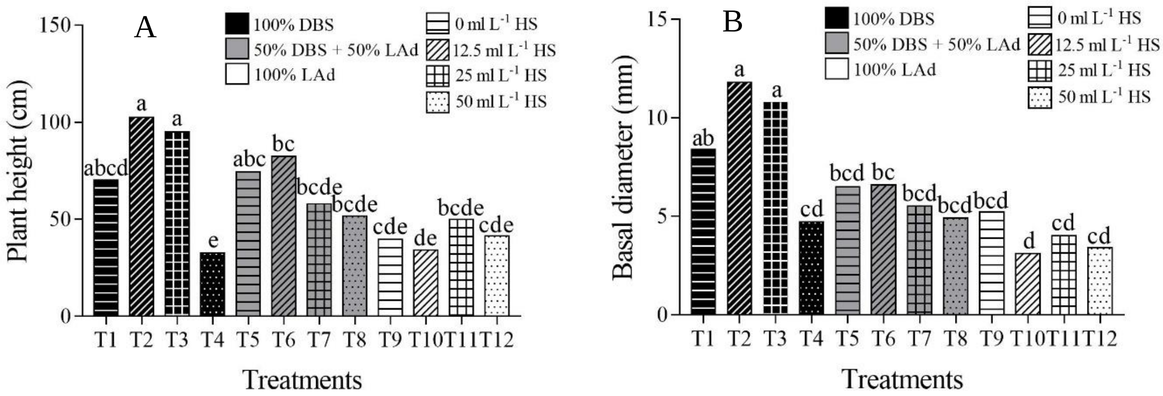
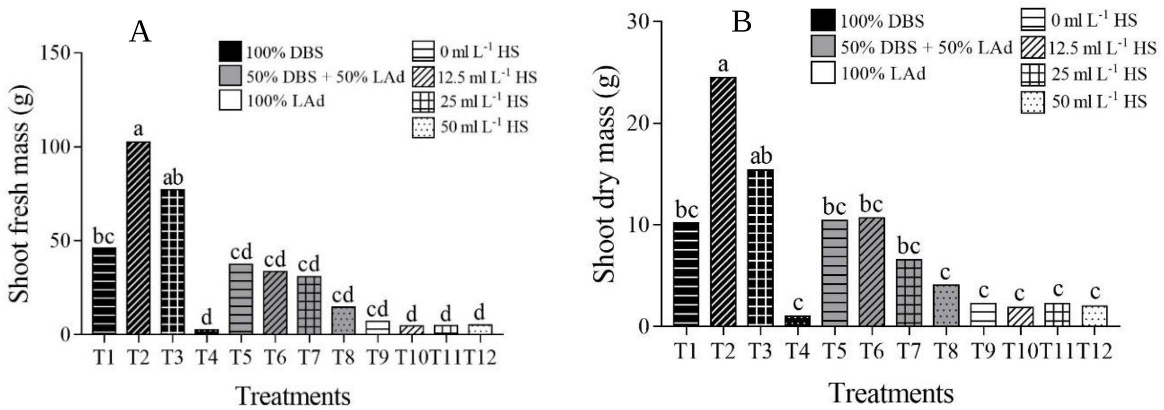
production of cytokinins in these treatments, which promoted greater growth and development of the aerial part both in T2 and T3. This pattern could be observed on the followed variables: PH, BD, SFM, SDM and NL (Figures 3, 4 and 5).

Figure 3. Plant height (A) and basal diameter (B) of IAC 'Uruguay' sunflower seedlings as a function of the application of humic substances and substrates based on decomposed babassu stem.



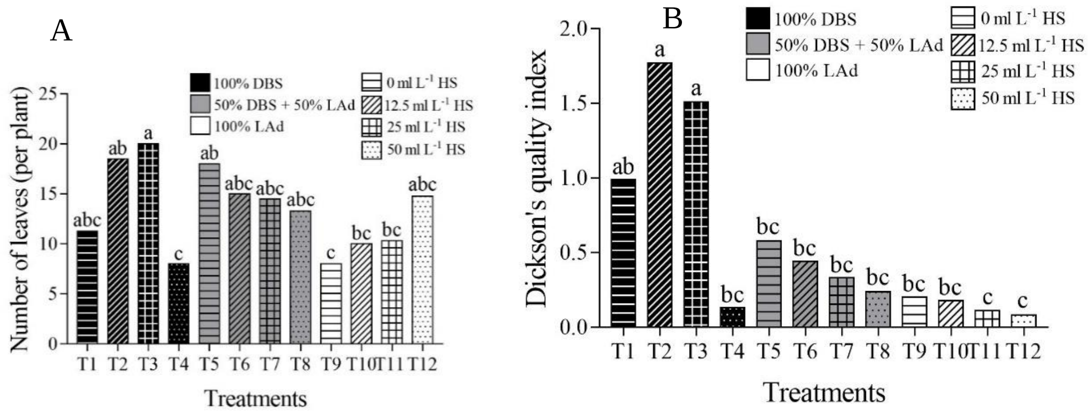
Source: Authors.

Figure 1. Shoot fresh mass (A) and shoot dry mass (B) of 'IAC Uruguay' sunflower seedlings depending on the application of humic substances and substrates based on decomposed babassu stem.



Source: Authors.

Figure 5. Number of leaves (A) and Dickson quality index (B) of 'IAC Uruguay' sunflower seedlings as a function of the application of humic substances and substrates based on decomposed babassu stem.



Source: Authors.

The average BD was 6.24 mm ranging from 3.1 mm in T10 to 11.8 mm in T2. However, as the HS doses increased (above 12.5 ml L^{-1}), the BD decreased, being the same pattern observed when the concentration of DBS in the treatment formulation decreased (Figure 3-B). BD allows greater survival capacity of the seedlings in the field (Fernandes et al., 2017), since seedlings with a well-developed BD have greater robustness, being more resistant to climatic variations, having a balanced growth, thus avoiding, the tipping of plants by the action of strong winds (Delarmelina et al., 2015).

In line with BD, PH showed the best results, by an average increase of 60.9 cm ranging from 32.5 cm (T4) to 102.5 cm (T2), by the lowest values in treatments with low or no percentage of DBS in the substrate formulation (Figure 3-A).

In regards of NL, our results showed the best result to T3 (20 leaves per plant) (Figure 5). The results are probable linked to plant growth and crop productivity (Soares et al., 2017), as the production of photoassimilates occurs in leaves through the photosynthetic process, which will be used in growth, development, stress reduction and crop productivity (Taiz et al., 2017).

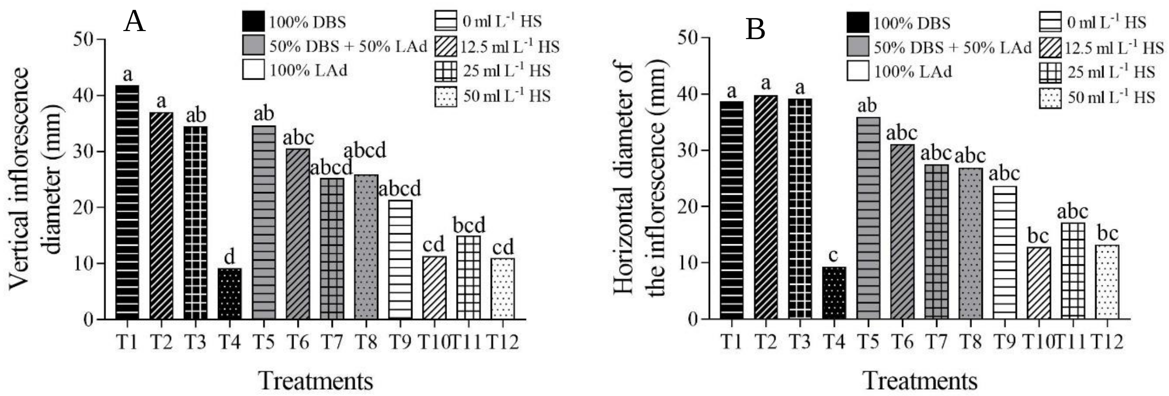
In relation to SFM and SDM, both obtained the best result in T2, with 102.4 g for SFM (Figure 4-A) and 24.5 g for SDM (Figure 4-B). These results may be attibuited to the good root development obtained in this treatment, which might allowed a large RV (Figure 1-B), longer roots (Figure 1-A) and greater deposition of mass in the root system (Figure 2- AB), which favoured greater absorption of water and nutrients. Another important factor was the existence of a larger leaf area in these treatments (which can be stipulated through the NL), which provided a greater photosynthetic production, allowing greater fixation of carbon dioxide in these treatments.

It was reported by Andrade et al. (2017), using the substrate with 100% DBS, an increase in SDM, considering that the substrates with higher DBS contents provided more nutrients for the seedlings, including nitrogen and potassium. Nitrogen directly participates in vegetative growth and potassium is an osmotic regulator and activator of enzymes that act in photosynthesis (Taiz et al., 2017), therefore, the two elements possibly acted positively in the good development of the aerial part of the sunflower.

The DQI is reported as an indicator of seedling quality, with a view to considering the robustness and balance of the phytomass distribution to weight the seedling quality, remembering that the higher the DQI, the higher the seedling quality (Freire et al., 2015). According to Gomes and Paiva (2006), a seedling to have an acceptable quality standard must obtain DQI values above 0.20. However, it is important to note that this index was developed for seedlings of tree species (*Picea glauca*), therefore, since seedlings with more herbaceous stems, tend to have lower DQI (Santos et al., 2016).

Regarding inflorescence, it is known that the Brazilian Institute of Floriculture (Ibraflor) (2017) and Silva (2017) clarify that the minimum diameter required for commercialization of cut sunflower for fully open chapters, for 80 and 90 cm stem lengths length, at least 60 mm and 75 mm. It was noted in our results that the VID and HDI showed similarly to the treatments tested. The VID obtained the best results in T1 and T2 (Figure 6-A) and HDI in T1, T2 and T3 (Figure 6-B).

Figure *6*. Vertical inflorescence diameter (A) and horizontal diameter of the inflorescence (B) of ‘IAC Uruguay’ sunflower seedlings depending on the application of humic substances and substrates based on decomposed babassu stem.

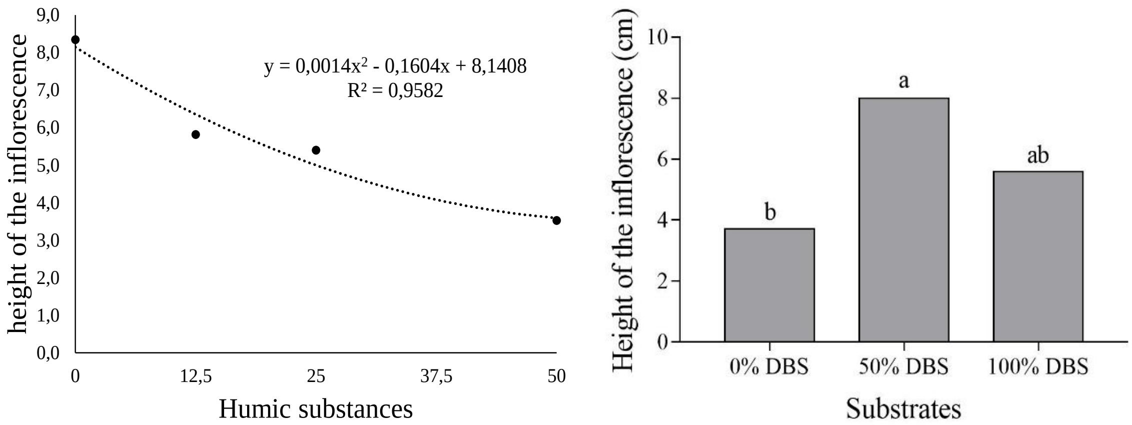


Source: Authors.

HDI and VID showed lower values than those reported by Oliveira et al. (2017) who defined the overall average of 85.1 mm of the diameters for the sunflower chapter. However, the values obtained were higher than those of Uhdre et al. (2017), who evaluated the PH, SD and diameter of the sunflower inflorescence and obtained an overall average of 12.4 mm for the inflorescence diameter.

The HI variable did not showed significance for HSxDBS. On the other hand, HI was affected by the factors HS and DBS (Table 3). According to Oliveira et al. (2017), the appropriate value for this variable is 18.52 cm. For the HS factor, the variable was adjusted to the decreasing linear model (Figure 7-A), the best value being obtained with the dose of 0 ml L^{-1} (8.34 cm). For the DBS factor, the best result was obtained with the formulation of 50% DBS + 50% LAd (Figure 7-B), with an average value of 7.95 cm.

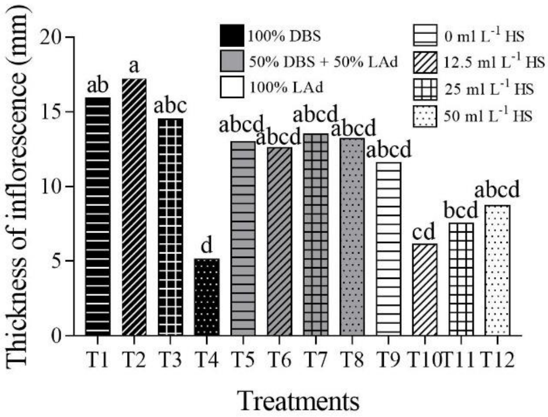
Figure 7. Inflorescence height of 'IAC Uruguay' sunflower seedlings as a function of the application of humic substances and substrates based on decomposed babassu stem.



Source: Authors.

TI showed similar results HDI and VID, by an decrease on the values as the DBS concentration decreased in the substrate. The best value was obtained at T2, with 17.2 mm (Figure 8).

Figure 8. Inflorescence thickness of ‘IAC Uruguay’ sunflower seedlings as a function of the application of humic substances and substrates based on decomposed babassu stem.



Source: Authors.

Here we reported a viable alternative for the production of sunflower seedlings showing the agricultural potential of DBS and HS. Our research shows an alternative to the use of DBS, which is usually unused in the environment. However, further research on the use of DBS and HS together on the production of ornamental seedlings is needed to develop new use and purpose methods for these materials.

4. Final considerations

Humic substances foster the development of the root system of plants through biomolecules with auxinical activity.

The use of humic substances with decomposed babassu stem as a substrate is a viable alternative to produce ‘IAC Uruguay’ sunflower seedlings.

It is recommended to apply 12.5 ml L^{-1} humic substances diluted in water with a substrate composed of 100% decomposed babassu stem for the production of ‘IAC Uruguay’ sunflower seedlings.

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