Performance of watermelon seedlings under the effect of different concentrations of humic substances in the Semi-arid Northeastern Region

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DOI: 10.29322/IJSRP.12.06.2022.p12608
http://dx.doi.org/10.29322/IJSRP.12.06.2022.p12608

Paper Received Date: 10th May 2022
Paper Acceptance Date: 27th May 2022
Paper Publication Date: 6th June 2022

Abstract- The destination of organic waste for the composting process can be an economically sustainable alternative. The objective of the present work was to evaluate the effect of humic substances extracted from composting organic waste in the semi-arid northeastern region on the production of watermelon seedlings. The study was developed at the State University of Bahia – UNEB, using a commercial cultivar. The experimental design used was completely randomized with 3 compounds and 5 doses, totaling 15 treatments and 5 replications for each dose of the compound, with a 3x5 factorial scheme. The doses used were 0.0 ml/plant, 0.5 ml/plant, 1.0 ml/plant, 2.0 ml/plant and 4.0 ml/plant. Based on the main results, it was possible to conclude that the dose of 0.5 mL/plant allowed for greater stem diameter (0.58 mm), shoot height (26.5 cm), chlorophyll content (60.21 $\mu g.cm^{-2}$), root length (13.9 cm), root fresh mass (1.20 g), root dry mass (0.52 g) and root volume (1.46 cm^3), in relation to the other doses, being, therefore, recommended for the production of watermelon seedlings in semi-arid conditions.

Index Terms- *Citrullus lanatus*, Economic alternative, Initial development, Organic acids, Sustainability.

I. Introduction

Watermelon (*Citrullus lanatus* (Thunb.) Matsum & Nakai) belongs to the *Cucurbitaceae* family, and it is one of the main vegetable crops grown in Brazil, where it is established as a vegetable crop with wide socioeconomic importance[1]. In the Northeast region, mainly in the semi-arid region, this crop is largely produced by small and medium-sized farmers, due to its low cost and easy handling compared to other crops[2].

Worldwide, watermelon reaches a production of 118 million tons, and a planted area of 3.5 million hectares[3]. In 2018, the Brazilian watermelon crop reached 2,143,763 tons, with a planted area of 90,722 hectares, with particular emphasis on the Northeast region, which had a 41.08% share in national production[4]. In 2017, Brazilian watermelon exports amounted to 73.85 thousand tons[5].

In agriculture, the production of seedlings is the first step to be developed in a cropping system, in this aspect, the formation of seedlings with agronomic quality is a decisive factor in the production process, being essential to meet the market demand[6]. Among the factors that influence seedling formation, the substrate must have physical and chemical characteristics, good temperature, water retention, sandblasting, nutrients, and absence of pathogens[7] in addition to low cost and easy access[8].

Agricultural and cattle raising production generate organic waste along its production chain, which when poorly managed can cause environmental problems due to accumulation and disposal in inappropriate environments[9]. Therefore, these generated products have large potential for exploitation, one of them being their reuse in agriculture aiming at the insertion of sustainable practices[10]. These residues are considered raw materials for the manufacture of substrates with agricultural and socioeconomic importance, helping to increase production, as well as food quality[11].

The use of organic matter in vegetable production provides benefits such as better soil structuring, greater water retention capacity, greater soil sandblasting, increased soil buffering, increase in soil microorganisms, in addition to the gradual release of nutrients, such as nitrogen, sulfur, among others[12,13]. Humic substances come from organic matter, being composed of humic acids and fulvic acids[14]. Lately, the use of humic substances in agriculture has been analyzed with the aim of increasing sustainability[15,16], by reducing the effects caused by the use of synthetic fertilizers[17].

Humic acids contained in humic substances play a significant role in seedling quality. The application of products based on humic acids has increased in recent years due to the benefits obtained in agriculture, mainly in the production of seedlings, through a greater use of macro and micronutrients from the soil, appropriate root system, less competition between plants[18]. However, although its use has increased in agricultural production, especially vegetable crops, it is essential to experimentally verify the prescribed dose of humic and fulvic acids to increase the productive potential of several crops through efficiency in the formation of seedlings.

In this scope, taking into account the favorable outcome of the use of humic substances in agriculture, researches have been carried out with organic acids in the production of vegetable seedlings. Some authors, working with the effect of humic acids on early lettuce development, found the beneficial effects through a greater increase in root and shoot dry mass of seedlings[19]. Other authors, also working with lettuce cultivation, found that the application of humic acids at a dose of 21.9 ml L^{-1} provides better seedling quality[20]. Further studies found that the application of fulvic acids to iceberg lettuce promoted greater plant growth, number of leaves and average head circumference, as well as root system elevation[21].

In Brazil, there are few studies that investigate the application of humic substances reused from organic waste in the agronomic characteristics of watermelon seedlings. Based on the above considerations, this work was carried out with the objective of evaluating the effect of humic substances extracted from composting organic waste in the Semi-arid Northeast Region on the production of watermelon seedlings.

II. EXPERIMENTAL WORK

A. Location of the experimental area

The experiment was carried out in a seedling nursery located at the State University of Bahia – UNEB, Department of Human Sciences and Technologies – DCHT, from November 10th to December 11th, 2019, in Euclides da Cunha, in the state of Bahia, at latitude 10° 32' 17.7" S, longitude 38° 59' 52.8" W. The town has an average altitude of 472 m. The climate of the region, according to the Köppen classification, is Aw[22]. The descriptions referring to the characteristics of the cultivar were obtained from the seed company's catalog.

B. Characterization of waste materials

In the selection of materials destined for the composting process, nitrogen contents were taken into account, being residues rich in nitrogen and poor in nitrogen. The proportions of the compound were determined based on literature, where an ideal C/N ratio of 30/1 was considered, with 30 parts of carbon for each part of nitrogen added[23,24]. The materials chosen according to regional availability were coconut fiber, quixabeira soil, cattle manure and humus.

C. Preparation and implementation of compounds

The three compounds were implemented in the Bernadino Menezes Pavilion, at UNEB, through the selection of three uniform stalls for use. In compost 1, all biomaterials were inserted into the compost piles (coconut fiber + humus + bovine manure + quixabeira soil). In compost 2, there was the absence of quixabeira soil (coconut fiber + humus + cattle manure), in the compost 3, the humus occurred in the absence of humus (coconut fiber + bovine manure + quixabeira soil).

In the stalls, piles of compounds were formed and the respective identifications were carried out. The composts were watered daily in the initial phase of composting, subsequently, the waterings were spaced three times a week. The temperature was measured using a skewer-type digital thermometer, proceeding with the introduction of the sensor into the compounds and recording the results in a chart. In order to accelerate the composting process, 250 mL of diluted demerara sugar were added to the three compounds. The optimum point of degradation of the compounds occurred 7 months after implementation, and the extraction of humic substances was carried out 1 month later.

D. Analysis of humic substances

The organic acids from the three compounds were analyzed in the Correctives, fertilizers and organic residues Laboratory of the Department of Soil Science of the Escola Superior de Agricultura Luiz de Queiroz from the University of São Paulo – ESALQ USP, and the physicochemical characteristics are found in Table 1 and 2.

Table 1 Result of the physical-chemical characterization of the organic acids from the three compounds used in the experiment for the attributes pH, electrical conductivity (EC), total carbon (CT), total nitrogen (NT), phosphorus (P_2O_5), potassium (K_2O), calcium (Ca), magnesium (Mg), total sulfur (SO4), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), sodium (Na).

Sample	pH	CE	CT	NT	P_2O_5	K_2O	Ca	Mg	SO_4	Cu	Zn	Mn	Fe	Na
	-	mS/cm^{-1}	g/L^{-1}							mg/L^{-1}				
acids compound 1	3.7	37.44	5.49	0.57	0.21	0.21	1.03	0.13	0.11	1	12	10	500	20000.00
acids compound 2	6.0	36.65	2.63	0.32	0.16	0.15	0.93	0.08	0.10	0	4	6	79	19250.00
acids compound 3	4.1	71.45	4.35	0.56	0.29	0.11	0.93	0.06	0.07	1	3	4	50	19250.00

Source: Correctives, fertilizers and organic residues Laboratory – ESALQ USP.

Table 2 Result of the physical-chemical characterization of the organic acids from the three compounds used in the experiment for the attributes density, organic matter (OM), mineral + organic residue 110 °C (RMO), soluble mineral residue (RMS), total mineral residue (RMT), insoluble mineral residue (RMI).

Sample	Density	M.O	R.M.O	R.M.S	R.M.T	R.M.I
	g/mL^{-1}	g/L^{-1}				
acids compound 1	1.03	9.88	38.97	29.09	34.71	5.62
acids compound 2	1.03	4.73	26.83	22.10	22.97	0.87
acids compound 3	1.03	7.83	29.63	21.80	23.46	1.66

Source: Correctives, fertilizers and organic residues Laboratory – ESALQ USP.

E. Soil collection and fertilization

The soil for the production of watermelon seedlings was collected, crushed, sieved through a fine mesh with 2.0 mm opening and placed in polyethylene seedling bags. Soil chemical analysis was performed (Table 2). After calculations, based on the fertilization manual of the state of Bahia[25], 8 g of monoammonium phosphate (MAP) were added to the seedling bags.

F. Culture implementation

Sowing took place through the introduction of three seeds per seedling bag in November 2019. Eight days after sowing, seedling emergence was observed. Thinning took place twelve days after sowing, leaving one plant per seedling bag. The experimental design used was a completely randomized design (DIC) in a factorial scheme with three compounds and five doses (3x5), totaling fifteen treatments with five replications for each dose of the compound. The treatments were: Treatment 1 (absolute control), Treatment 2 (0.5 mL plant), Treatment 3 (1.0 mL per plant), Treatment 4 (2.0 mL plant), Treatment 5 (4.0 mL plant).

G. Extraction and application of humic substances

In carrying out the extraction of humic substances, an extraction methodology was adapted from specific studies[26], in order to adapt the protocol to the reality of the field and the rural producer, caustic soda (NaOH) was used. 20 g of caustic soda were weighed on a precision analytical balance and added to three 1000 mL beakers, totaling 60 g. Mineral water was added at a rate of 1000 mL for each beaker and the solutions were homogenized with the aid of a glass rod until the contents dissolved. Subsequently, 100 g of the respective compounds from the three-composting performed were added to the solutions. With the aid of a glass funnel, the solutions were placed in three PET bottles of 2000 mL each, previously disinfected with 2% hypochlorite.

They were stirred for a period of 180 minutes, leaving them to rest for 24 hours. The solutions were sieved, strained and placed in 1000 mL beakers. With the aid of a benchtop pH meter, the pH of the samples was measured, which on average was around 13.0. With the addition of muriatic acid (HCl), the pH of the three samples was reduced to approximately 4.0. Finally, the solutions were placed in a flat-bottomed volumetric flask, sealed and identified.

The solutions were pipetted with the aid of an electronic pipettor, diluted in irrigation water and applied in the respective treatments. Two applications of humic substances were carried out on tomato seedlings within seven days.

H. Evaluated parameters

Thirty-one days after sowing, the following characteristics were measured: seedling height (cm); stem diameter (mm); chlorophyll content ($\mu g.cm^{-2}$); length of the largest root (cm); fresh root mass (g); dry mass of roots (g) and volume of roots (cm^3). To obtain the dry mass of the roots, all the material was placed in paper bags and dried in an oven with forced air circulation at a temperature of 65 °C, until constant mass. Simultaneously, the determination of the average root volume was performed by the water displacement method. In this way, the roots were placed in a graduated cylinder, containing a known volume of water. Due to the difference, the direct response of the volume of roots was obtained, according to the described methodology[27].

I. Data collection

With the aid of the statistical analysis software Sisvar®, the analysis of variance was performed[28]. Interactions, when significant, were broken down and studied through the test of means and regression at the level of 5% probability ($p<0.05$) according to the recommended methodology[29].

III. RESULTS AND DISCUSSION

A. Temperature

The temperature of compound 1 was initially 29 °C and, as the days went by, the temperature progressed to a value of 54.8 °C, thus reaching the thermophilic phase, and a few days later, the temperature dropped, reaching the cooling stage. After 210 days, the temperature declined, reaching the ambient temperature of 28.3 °C, which describes the humification process. Compound 2 had the same behavior as the previous one, and initially, the implantation temperature of the compound was 29.6 °C, evolving to a temperature of 56.7 °C, and in the cooling phase it declined to 21.1 °C. Compound 3 behaved similarly to the others, with an initial temperature of 29.3 °C, reaching a temperature of 65.2 °C, that declined to a temperature of 29.1 °C.

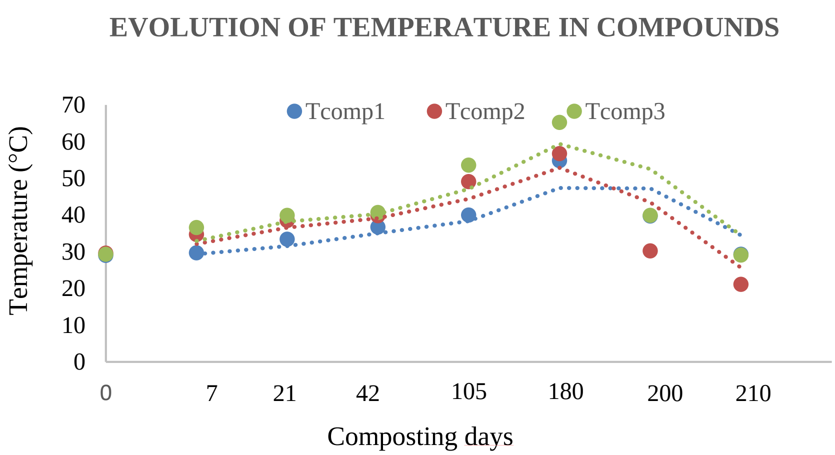

Fig. 1 Temperature evolution in compounds.

B. Parameters related to watermelon crop

When analyzing the data obtained, it was verified that there was a significant interaction between the treatments, in other words, the doses for the parameters of seedling height, stem diameter, chlorophyll content and root length at the level of 5% of probability. These results reinforce the strong influence of humic and fulvic substances on the variables evaluated.

Regarding the seedling height parameter, a statistically significant difference was observed only for the doses used, which shows that the compound alone does not significantly interfere in this variable. The interaction between compound and dose was not significant, considering 31 days after sowing. The best results were obtained at the dose of 0.5 mL/plant, due to the higher seedling height using the lowest dose of humic substances, regardless of the compound used.

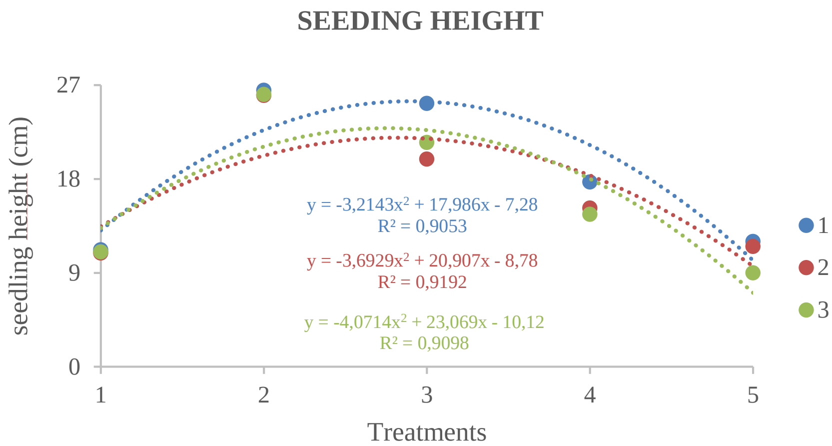

Fig. 2 Plant height of watermelon seedlings as a function of humic substances doses from organic residues.

Plant height was influenced by the ability of humic substances to promote the balanced synthesis of plant hormones, especially those that promote vegetative growth. Therefore, the application of organic acids in the watermelon crop may have activated the action of gibberellin, which is a plant hormone produced by young leaves and stem tissues, similarly to auxin, which also acts on plant growth[30]. Organic compounds have a wide availability of beneficial elements that act on vegetative growth, being a source of nitrogen and potassium[31]. Some authors claim that the optimal point for transplanting seedlings is when they reach 15 to 25 cm in height. In this regard, the results found at the standard dose of 0.5 mL/plant exceed these values with production of watermelon seedlings with 26.5 cm[32].

The same behavior is observed for the stem diameter parameter, where there was a statistically significant difference only for the doses used, which shows that the compound alone does not interfere significantly in this variable. The interaction between compound and dose was not significant. The best results were obtained at the dose of 0.5 mL/plant, due to the greater diameter of the stem using the lowest dose of humic substances, regardless of the compound used.

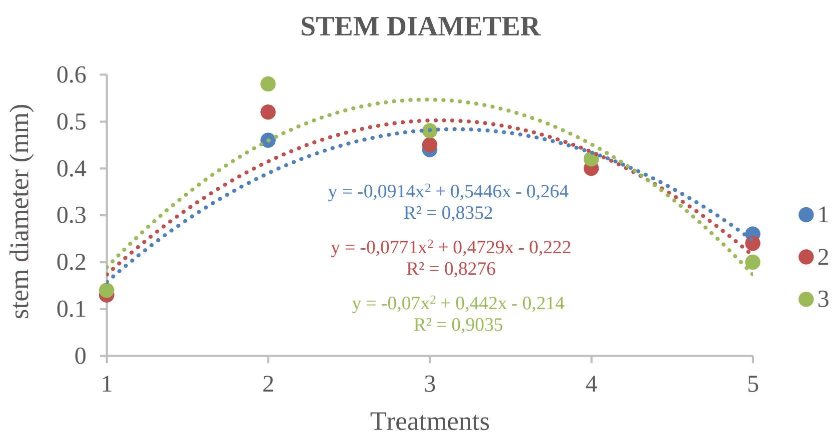

Fig. 3 Stem diameter of watermelon seedlings as a function of humic substances doses from organic residues.

The stem diameter has an extremely important function in the support of the plant, so that a larger diameter avoids a high rate of lodging, which will facilitate the mechanization process[33]. Humic substances have the potential to directly alter the physiology of the plant, acting as biostimulants, which may justify a larger stem diameter. Plants that have a larger stem diameter become more resistant to stem breakage, pressure exerted by the weight of the fruit, strong winds, or both[34].

In the chlorophyll level parameter, a statistically significant difference was observed only for the doses used, which shows that the compound alone does not significantly interfere in this variable. The interaction between compound and dose was not significant. The best results were obtained at the dose of 0.5 mL/plant, as it presented the highest chlorophyll level using the lowest dose of humic substances, regardless of the compound used.

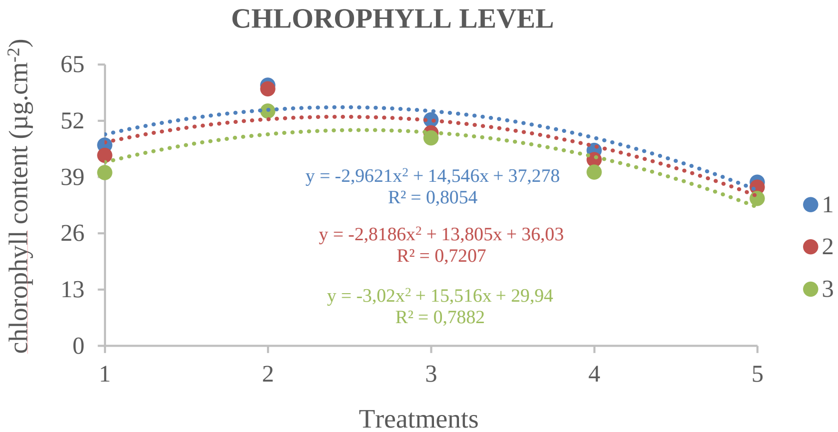

Fig. 4 Chlorophyll level of watermelon seedlings as a function of humic substances doses from organic residues.

The use of humic and fulvic acids presents positive results in several crops, mainly vegetables. Such benefits present, among other factors, better development and increase in chlorophyll level. Humic substances are derived from the decomposition of lignin, thus stimulating an increase in the chlorophyll content in plants. The increase in the chlorophyll level gives the plant greater light capacity, which stimulates the photosynthetic capacity, conferring a greater gain in carbon (C). A greater gain of C has fundamental importance to supply the plant with carbohydrates[35].

In general, organic waste materials have a slow release of nitrogen, compared to synthetic fertilizers because, for this release to occur, microbial degradation must occur. In this context, depending on the carbon-nitrogen ratio of the waste material, this release can be accelerated or delayed[36].

In the variable root length, a statistical difference was observed in relation to the doses used in the experiment. The interaction between compound and dose was not significant. The best results were obtained at the dose of 0.5 mL/plant, as it presented the highest chlorophyll level using the lowest dose of humic substances, regardless of the compound used.

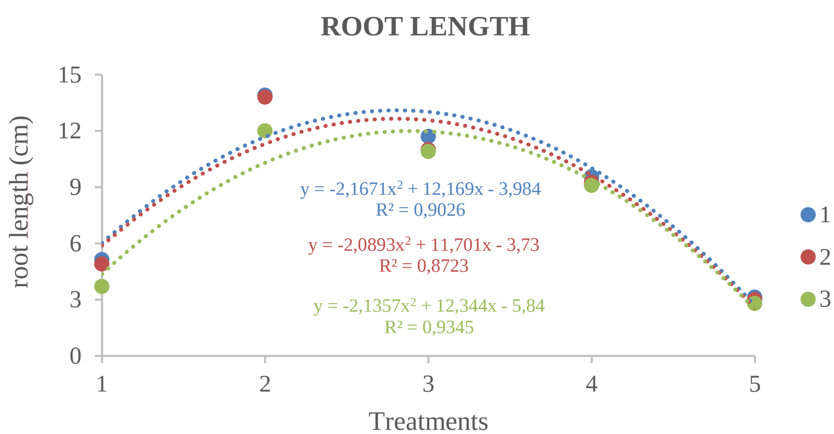

Fig. 5 Root length of watermelon seedlings as a function of humic substances doses from organic residues.

Roots are extremely important for plant fixation in the soil, better absorption of water and nutrients, as well as hormone synthesis. It is increasingly necessary to apply humic and fulvic substances, where their main action occurs in the roots, thus promoting positive effects on growth, increasing lateral ramifications or increasing root biomass[37]. These effects are directly related to the same effects of auxin. This occurs because the presence of organic acids stimulates the synthesis of auxins or acts similarly to it, promoting root growth[38].

Related to the parameters of fresh root mass, root dry mass and root volume, it was verified that there was a significant interaction between the treatments, in other words, the doses applied, and the interaction between compound and dose at the level of 5% of probability. The compound alone was not significant. These results reinforce the strong influence of humic and fulvic substances on the variables evaluated.

In the parameter fresh mass of the root, a statistical difference was observed related to the doses used in the experiment and the interaction between compound and dose. The best results were obtained at the dose of 0.5 mL/plant in compound 1, as it presented higher root fresh mass using the lowest dose of humic substances.

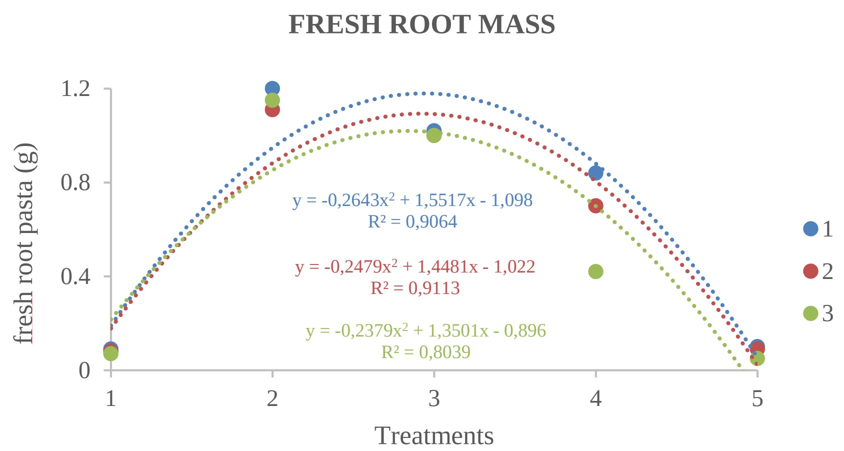

Fig. 6 Fresh mass of watermelon seedling root as a function of humic substances doses from organic residues.

In the variable dry mass of the root, a statistical difference was observed in relation to the doses used in the experiment and the interaction between compound and dose. The best results were obtained at the dose of 0.5 mL/plant in compound 1, due to the higher dry mass of the root using the lowest dose of humic substances.

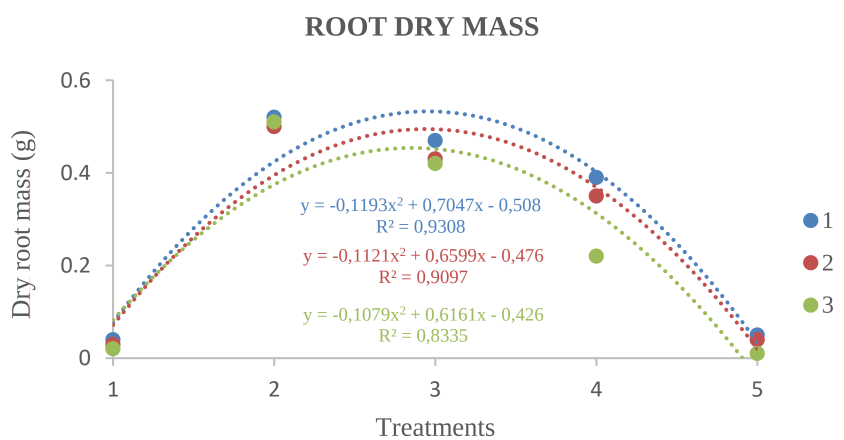

Fig. 7 Dry mass of watermelon seedlings as a function of humic substances doses from organic residues.

Regarding to the root volume parameter, a statistical difference was observed in relation to the doses used in the experiment and the interaction between compound and dose. The best results were obtained at the dose of 0.5 mL/plant in compound 1, as it presented greater root volume using the lowest dose of humic substances.

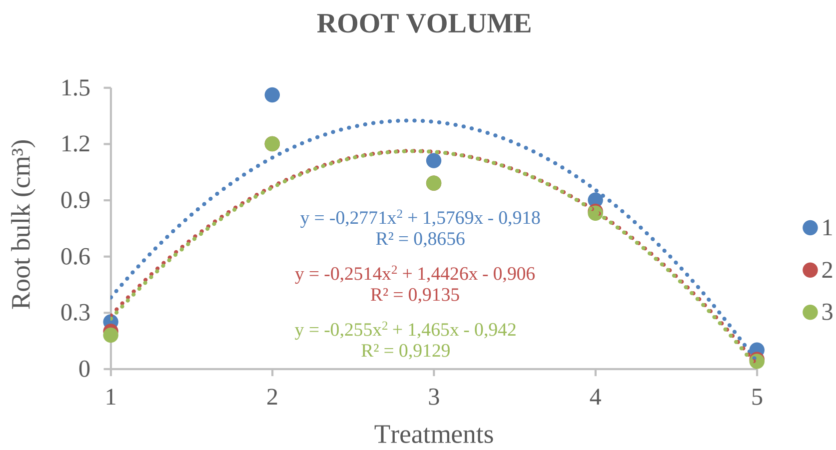

Fig. 8 Root volume of watermelon seedlings as a function of humic substances doses from organic residues.

Compounds of auxin synthesis nature present in humic substances, in addition to the auxin synthesized by the plant, signal at the root for the pericycle cells undergo cell division again, originating lateral roots. The activity of H+ATPases is activated, increasing proton extrusion and enzyme activity on the cell wall, favoring cell division and expansion via cell wall rearrangements. Nitric oxide induces auxin synthesis and the development of lateral roots. These lateral roots increase the volume of the root system, the contact surface and the dry mass of the organ, complementing the absorption capacity, the importance of productivity[39] corroborating the results of dry mass and roots that were found.

Studies are dedicated to studying the effect of humic substances on the fresh mass of the roots, as they offer the plant the ability to exploit a greater volume of soil, representing an important process in the adaptation of plants to environments with low levels of nutrients and water, because the effects of organic acids in vegetables are related to the increase in the absorption of nutrients, due to the influence that these substances have on the permeability of the cell membrane of the roots[40].

In this way, the use of humic and fulvic acids allows for greater resistance in plant seedlings, which results in an increase in the fresh and dry mass of the roots, as well as a greater length from the same[41].

IV. Conclusion

The dose of 0.5 mL/plant allowed for greater seedling height (26.5 cm), stem diameter (0.58 mm), chlorophyll level (60.21 $\mu g.cm^{-2}$), root length (13.9 cm), fresh root mass (1.20 g), root dry mass (0.52 g) and root volume (1.46 cm^3), in relation to the other doses.

The dose of 0.5 mL/plant of humic substances improves the initial development of the crop being, thus, recommended to the rural producer for the production of watermelon seedlings in conditions of the semi-arid region of Bahia.

It is fundamentally important that more studies are carried out in order to provide more information to the rural producer on the management and reuse of waste from the property applying in agricultural production, as well as the importance of organic matter in the availability of humic substances that will serve as promoters of vegetative growth.

Acknowledgment

To FACEPE, for granting a scholarship to the first and fifth author in the Masters in Agricultural Production at UFAPE. To CAPES, for granting the scholarship to the second author in the master's degree in Agricultural Production at UFAPE. To UNEB, for all the infrastructure made available to carry out this research.

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