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Foliar Spray of Humic Substances on Seedling Production of Papaya (Pawpaw)

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Abstract: The objective of this research was to study the effect of humic substances on seedling production of papaya cv. Formosa. A completed randomized blocks design with five treatments (humic acid doses) was adopted, with five repetitions of 10 seedlings each, with a total of 250 seedlings. The following humic substances doses studied were 0 (unsprayed), 7.5, 15, 22.5 and 30 mL m^2 (0, 0.40, 0.80, 1.19 and 1.59 mL $seedling^{-1}$), were sprayed at 15, 25 and 35 days after sowing. At the end of the experiment (45 days after sowing) the following variables were recorded: (1) plant height; (2) stem diameter; (3) dry weight of shoots and roots; (4) root length; (5) root volume and (6) Leaf Chlorophyll. Thus, our studies demonstrate that: (1) humic substances sprayed positively affect aerial part and root system of papaya seedlings and (2) seedling quality of papaya are improved by humic acids foliar spray although further studies are need to obtain a dose recommendation.

Key words: *Carica papaya* L., seedling quality, humic substances

INTRODUCTION

Papaya (*Carica papaya* L.) is a popular fruit species native to tropical America widely grown in Brazil, the second main papaya producer country worldwide with 1.792.590 tonnes in 2009 (Fao, 2011). Papaya seedlings are almost entirely obtained from seeds for commercial cultivation and this process has been widely studied (Morales-Payan and Stall, 2003a, b; Medeiros *et al*., 2009; Costa *et al*., 2009, 2010), but on the other hand, the effects of humic substances on papaya seedling production has been poorly quantified.

Humic substances are recognized as a key component of soil fertility properties, since they control chemical and biological properties of the rhizosphere (Nardi *et al*., 2005) that are divided into three main fractions: humic acids, fulvic acids and humin. Accordingly, humic acids are the main fractions of humic substances and the most active components of soil and compost organic matter (Ferrara and Brunetti, 2010), which stimulate plant growth by acting on mechanisms involved in cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities (Nardi *et al*., 2002; Tahir *et al*., 2011) and hormones (Trevisan *et al*., 2010).

Humic substances have been used on plant production directly on soil or substrate due to the close relation of these substances with soil fertility and availability of nutrients (Eyheraguibel *et al*., 2008). But due to humic substances effects on plant nutrition and physiology, Trevisan *et al*. (2010) and Tahir *et al*. (2011) have been studied for use as foliar spray for wheat (Asik *et al*., 2009), grape (Ferrara and Brunetti, 2010), common bean (Kaya *et al*., 2005) and maize (Celik *et al*., 2010).

In this sense, the objective of this research was to study the effect of humic substances on seedling production of papaya cv. Formosa.

MATERIALS AND METHODS

Seeds of papaya (*Carica papaya* L.) cv. Formosa were used in this study (95% of germination).

The experiment was carried out from April 2011 to May 2011 in a canvassed shelter under 50% of luminosity of the Campus Profa. Cinobelina Elvas, Federal University of Piaui, Piaui State, Brazil. Pots of 16 cm in height and 26 cm in width were filled with a substrate composed by soil (red Oxisol):sieved sand:bovine manure at a 1:1:2 ratio which some chemical characteristics are in Table 1.

During the execution of the experiment, the climatic data of air temperature and air humidity (thermo-Hygrometer Instrutemp®, Brazil) and luminosity (digital light meter, Instrutherm®) were collected inside the canvassed shelter and they are in Fig. 1.

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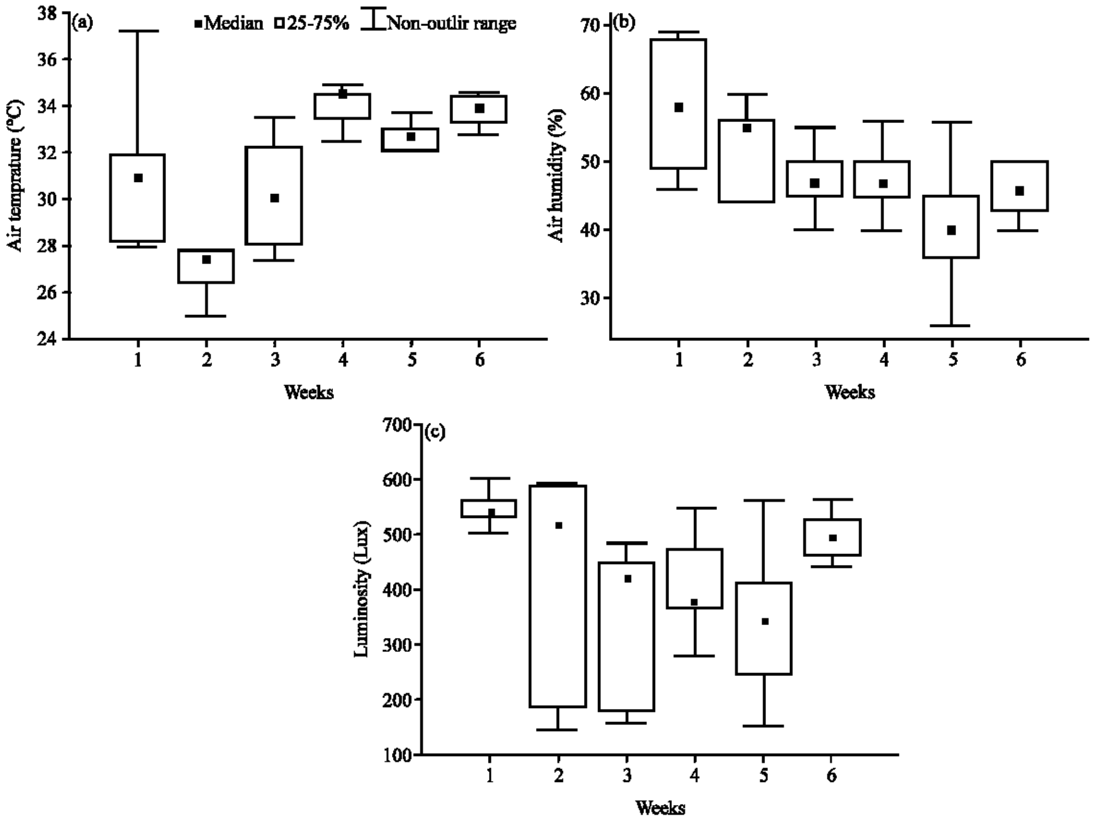

Fig. 1(a-c): Dispersion diagram of weekly average (a) air temperature, (b) air humidity and (c) luminosity inside the canvassed shelter during the execution of the experiment

Table 1: Chemical characteristics of the soil and bovine manure used in the experiment

Substrate component	Soil	Bovine manure
	------------ ($cmol_c$ dm^{-3})	------------------
pH (water)	5.30	9.09
Ca^{2+}+Mg^{2+}	0.56	5.90
Ca^{2+}	0.32	4.40
K^+	0.01	2.78
Na^+	0.01	19.58
H^++Al^{3+}	1.10	2.97
Organic matter (g kg^{-1})	2.33	156.00

K, Na: Melich 1; H+Al: Calcium acetate 0,5 M, pH 7; Ca, Mg: KCl 1 M

A completed randomized blocks design with five treatments (humic acid doses) was adopted, with five repetitions of 10 seedlings each, with a total of 250 seedlings. The following humic substances doses studied were 0 (unsprayed), 7.5, 15, 22.5 and 30 mL m^2, defined according to the 15 mL m^2 dose recommended by the producer and they are equivalent to 0 (unsprayed), 0.40, 0.80, 1.19 and 1.59 mL $seedling^{-1}$. The humic substances used in the experiment were extracted from leonardite and the source adopted was Humitec®, which complete composition is humic extract (16.5%), organic carbon (11.2%), humic acids (13.2%) and fulvic acids (3.3%).

Papaya seedlings were sprayed at 15, 25 and 35 days after sowing and daily manually irrigated according to plant requirements in an attempt to keep the substrates as lose as possible to field condition.

At the end of the experiment (45 days after sowing), the following variables were recorded: (1) plant height (cm): measured from the base of the plant to the insertion of the youngest leave; (2) stem diameter [obtained with a digital paquimeter (0.01-300 mm, Digimess®]; (3) dry weight of shoots and roots: plants were brought to the laboratory and dried at 70°C for 48 h and the weight of each plant part was determined in a Sartorious® brand precision balance (0.01 g precision) and expressed as g $plant^{-1}$; (4) root length (cm): determined using a millimeter ruler; (5) root volume (cm^3): measured according to methodology of Basso (1999) and (6) Leaf Chlorophyll (Index): it was measured using a Chlorophyll meter (Falker®, Brazil) in three leaves of each seedling following the methodology of El-Hendawy *et al.* (2005).

Statistical analyses included Analysis of Variance (ANOVA), followed by regression analysis of humic acid doses using Sigmaplot software and terms were considered significant at $p<0.01$.

RESULTS AND DISCUSSION

All variables studied were significantly affected by humic substances doses sprayed.

As can be seen in Fig. 2a, increasing humic acid doses promoted a significant average enhancement of 12% on plant height from the lower to the highest humic acid dose, showing the positive effect of these substances for papaya seedlings that is in agreement with Morales-Payan and Stall (2003b) in study about papaya in Dominican Republic. This way, Nardi *et al.* (2002) argued that physiological mechanisms through which humic substances exert their effects may depend on hormones and in particular, on the presence of auxin or auxin like components in their structure and consequently its effect on plant growth and development. Plant height registered under 30 mL m^2 of humic substances are compatible to results of Medeiros *et al.* (2009) and Costa *et al.* (2010).

For stem diameter (Fig. 2b), dry weight of shoot (Fig. 2c) and leaf chlorophyll (Fig. 2d) a similar data distribution was identified, i.e., higher averages until 15 mL m^2 dose, followed by a consecutive decay with humic acid dose increase. The positive effect of humic substances doses sprayed on plant variables recorded occurred as a function of the positive action of these substances on plants since Chen *et al.* (2004) argued that direct effects of humic substances are various biochemical actions exerted at the cell wall, membrane or cytoplasm and mainly of hormonal nature, acting in manner similar to plant growth substances (Kaya *et al.*, 2005) and agricultural humic substances are reputed to enhance nutrient uptake, drought tolerance, seed germination and overall plant performance, so in agreement with the findings of the present work. In addition, applications of humic substances to fruit species are very scarcely reported in the literature especially during seedling production.

Average values of stem diameter (Fig. 2b) are close to those registered by Medeiros *et al.* (2009) but below 4.74 mm average value reported by Araujo *et al.* (2006) also in study about papaya seedlings.

Dry weight of shoots (Fig. 2c) increased nearly 7.0% from unsprayed plant to those that received 15 mL m^2 that characterizes plant development and growth which could be explained by the direct effect of these substances on

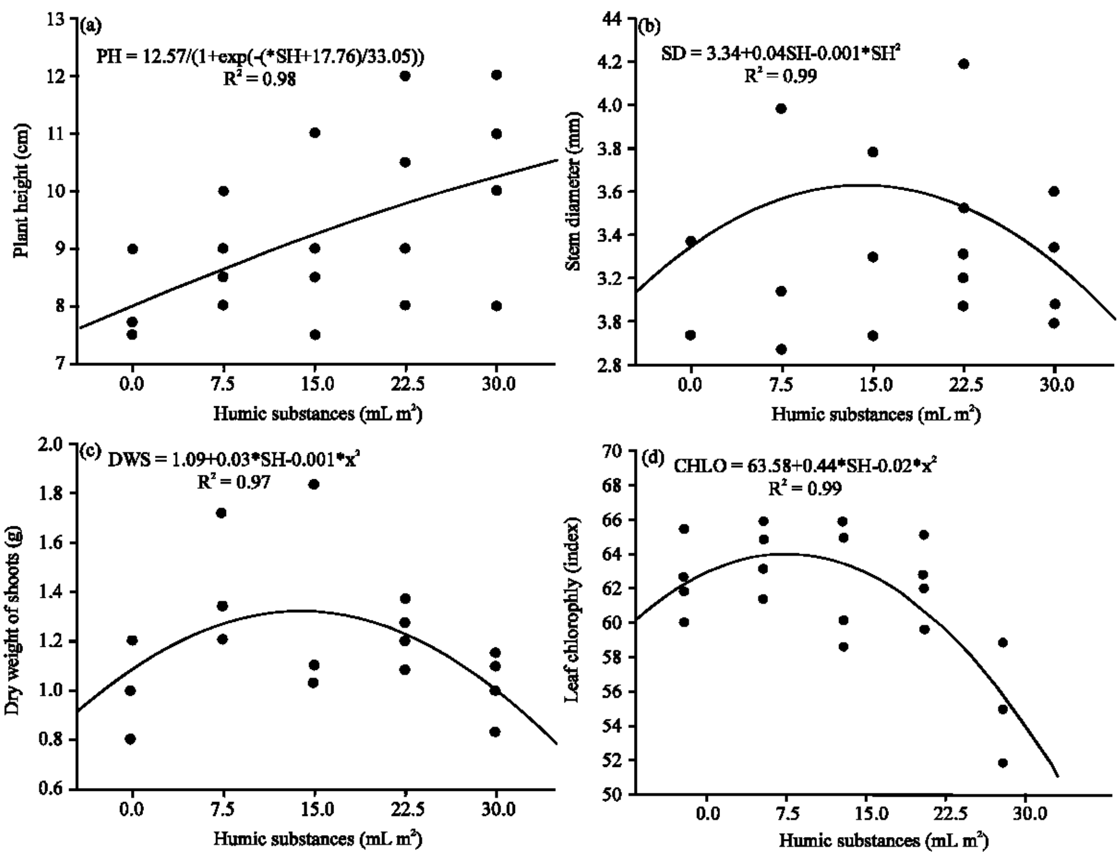

Fig. 2(a-d): (a) Plant height, (b) stem diameter, (c) dry weight of shoots and (d) leaf chlorophyll of papaya seedlings as a function of humic substances sprayed levels

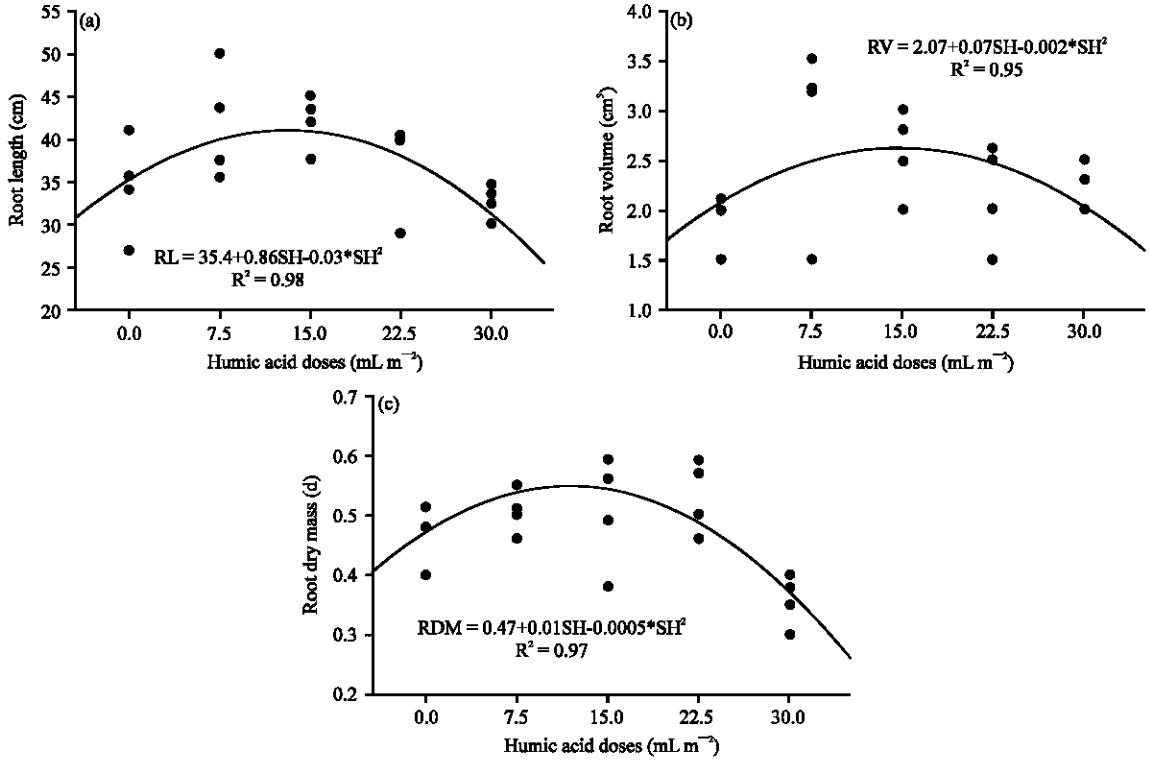

Fig. 3(a-c): (a) Root length, (b) root volume and (c) root dry weight of papaya seedlings as a function of humic substances sprayed levels

the processes associated with the uptake and transport of organic substances into the plant tissues (Nardi *et al*., 2002) and moreover, humic substances are also considered to improve soil nitrogen uptake and encourage the uptake of potassium, calcium, magnesium and phosphorus, making these more mobile and available to plant root system (Kaya *et al*., 2005). Although, the increase promoted by humic substances, the average value for seedlings under 15 mL m^2 is lower than average data reported by Morales-Payan and Stall (2003a) in Dominican Republic and Medeiros *et al*. (2009) in Brazil but, on the other hand, they are above 0.14-0.89 g range informed by Kousaku *et al*. (2006) in Japan. It is also important to infer that transplant quality of papaya seedlings can be affected by factors such as plant growth regulators, nutrients and substrates (Palmer-Rannie *et al*., 2002).

In relation to chlorophyll data, results obtained in the current experiment (Fig. 2d) agree with those of Ferrara and Brunetti (2008, 2010) and they seem to suggest that even one application of humic substances was able to increase chlorophyll content in grape leaves and/or and/or they delayed chlorophyll degradation.

Root length variables were affected by humic substances sprayed doses with quadratic data distribution but different peaks, i.e., root length (Fig. 3a) and root volume (Fig. 3b) were increased until 7.5 mL m^2 dose and consecutively decayed, while for root dry weight (Fig. 3c) the peak was registered under 15 mL m^2 dose. Whether compared to results of Kousaku *et al*. (2006) and Costa *et al*. (2009), root dry weight of Fig. 3c are extremely higher but, on the other way, lower than averages of Medeiros *et al*. (2009). These results are congruent to findings of Trevisan *et al*. (2010) who studied the biological effect of humic substances on lateral root initiation and showed that these substances induced lateral root formation and there is a positive effect of humic substances on specific targets of auxin action.

Accordingly, De Smet *et al*. (2006) argued that root growth and development is a complex process regulated by a number of exogenous, such as nutrient availability and endogenous factors like developmental and hormonal ones. However, lateral root formation has been shown to rely on auxins as a primary dominant signal in promoting mitotic activity of pericycle cells in the process of primordia initiation.

Thus, our studies demonstrate that: (1) humic substances sprayed positively affect aerial part and root system of papaya seedlings and (2) seedling quality of papaya are improved by humic acids foliar spray although further studies are need to obtain a dose recommendation.

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