

IBA levels and substrates in the rooting of UENF/CALIMAN 02 hybrid papaya minicuttings in a semi-hydroponic system

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Abstract - Mini-cutting is a technique with large applications in various crops, mainly due to the increase in the percentage and quality of adventitious roots, reducing time for the formation of clonal seedlings. The aim of this study was to evaluate IBA levels and substrates on the rooting of UENF/CALIMAN 02 hybrid papaya mini-cuttings. To perform the experiment, papaya mini-cuttings were taken from mother plants grown in pots in greenhouse, induced to produce shoots through pruning and growth regulator applications. Mini-cuttings were fixed in vermiculite or coconut fiber substrates placed in alveolate trays with 4.5x4.5x5.0 cm cells, and styrofoam trays were placed in plastic trays where different IBA levels were added in a modified Hoagland solution. After 45 days, rooted buds were transplanted to plastic pots of 600 mL of volume with soil, sand, well-cured bovine fertilizer, in the proportion of 3:1:1, remaining for 45 days. When they were taken from pots, roots were carefully washed, and the length of shoots, length of the largest root, dried mass of shoots and radicular system and root percentage were measured. The experiment was set up in a randomized complete block 5 x 2 factorial design, with 5 IBA levels: 0; 2.5; 5.0; 7.5 and 10 mg L⁻¹, two substrates: vermiculite and coconut fiber, three replicates, with six plants per replicate. IBA levels of 5.0 mg L⁻¹ and substrate vermiculite are the most adequate for the rooting of 'UENF/CALIMAN 02' papaya mini-cuttings in semi-hydroponic system in alveolate styrofoam trays with 4.5x4.5x5.0 cm cells.

Index terms: *Carica papaya*, vegetative propagation, mini-cutting.

Níveis de AIB e substratos no enraizamento de miniestacas de mamoeiro híbrido UENF/CALIMAN 02 em sistema semi-hidropônico

Resumo - A miniestaquia é uma técnica com grandes aplicações em várias culturas, devido, principalmente, ao aumento dos percentuais e qualidade de enraizamento adventício, reduzindo o tempo para a formação da muda clonal. O objetivo deste trabalho foi avaliar níveis de ácido indolbutírico (AIB) e substrato no enraizamento de miniestacas de mamoeiro híbrido UENF/CALIMAN 02. Para a realização do experimento, as miniestacas de mamoeiro foram retiradas de plantas matrizes cultivadas em vasos, em casa de vegetação, induzidas a produzir brotos por meio de podas e aplicações de reguladores vegetais. As miniestacas foram afixadas em substrato vermiculita ou fibra de coco em bandejas alveoladas de isopor com células de 4,5x4,5x5,0 cm. As bandejas de isopor foram então colocadas em bandejas plásticas contendo solução de Hoagland modificada onde foram adicionados diferentes níveis de AIB. Após 45 dias, os brotos enraizados foram avaliados e transplantados para vasos plásticos, de 600 mL de volume, com terra, areia e esterco bovino bem curtido, na proporção 3:1:1, nos quais permaneceram por mais 45 dias, quando foram retirados dos vasos e realizada a avaliação final, quando suas raízes foram lavadas cuidadosamente e foram coletados os dados de comprimento da parte aérea, comprimento da maior raiz, massa seca da parte aérea e do sistema radicular e porcentagem de enraizamento. O experimento foi instalado em delineamento inteiramente casualizado, em esquema fatorial com cinco níveis de AIB: 0; 2,5; 5,0; 7,5 e 10 mg L⁻¹, dois substratos: vermiculita e fibra de coco, com três repetições e seis miniestacas por repetição. Os níveis de 5,0 mg L⁻¹ AIB e o substrato vermiculita foram os mais adequados para o enraizamento de miniestacas de plantas hermafroditas de mamoeiro 'UENF/CALIMAN 02' em sistema semi-hidropônico, em bandejas alveoladas de isopor, com células de 4,5x4,5x5,0 cm.

Termos para indexação: *Carica papaya*, propagação vegetativa, miniestaquia.

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Introduction

The importance of papaya vegetative propagation is based on several aspects, among them: at the moment of planting, formation of crops with 100% hermaphrodite plants, with reduction of inputs and labor, providing lower production cost and higher productivity.

The mini-cutting technique is the most used by large forestry companies to clone selected Eucalyptus genotypes (BRONDANI et al., 2014). It is used in other cultures, for example, passion fruit (ALEXANDRE et al., 2016). It is the innovation of conventional cutting that, in certain species, has increased productivity, uniformity and rooting percentage when specific nutritional and phytosanitary conditions are reached (TIMM et al., 2015).

Several factors directly and indirectly influence rhizogenesis in cuttings, among them, genotype, type of cutting and rooting environment, in addition to the presence of rooting inductors and inhibitors. For the initiation of the rhizogenic process in cuttings, an optimal endogenous level of auxin is indispensable. In the case of endogenous auxin at lower cutting level, it is necessary to apply synthetic auxin, which is capable of improving adventitious cutting rooting (Silva et al., 2007; Peña et al., 2015).

In research with rooting of papaya branches, the most used plant regulator is indolbutyric acid (IBA), due to its characteristics of good stability, greater action spectrum and less photo oxidation (CRUZ et al., 2008), localized action and lower sensitivity to biological action (KOYAMA et al., 2014).

The substrate used for the rooting of cuttings is a very important factor in vegetative propagation, and the ideal material for the production of seedlings varies according to the species to be propagated and must allow good supply of water and oxygen to the base of cuttings and for root development. The most suitable substrate must be inert, porous, must present good drainage and be capable of maintaining aeration and moisture, allowing the development of the root system (LIMA et al., 2009). The selection of the substrate should be based on the needs of the plant to be cultivated, on the cultivation system, on the physicochemical characteristics of the substrate, as well as on its availability (DONEGÁ et al., 2014).

Substrates for vegetative propagation should allow good water retention, prevent desiccation of the cutting base and have porous space to facilitate oxygen supply and to facilitate initiation and root development. The material must also have good adhesion to the cutting and must not contain substances phytotoxic to the species. Vermiculite, charred rice husk and coconut fiber are among the commonly used materials (Yamamoto et al., 2013).

Vermiculite is a substrate that presents high porosity and water retention capacity, showing good results in the cutting of several cultures, being used both as a single substrate and in mixtures with other constituents; coconut fiber presents excellent aeration, combined with good

water retention capacity and tendency to fix calcium and magnesium, release potassium in the medium, pH between 6.3 and 6.5 and intermediate to high salinity (RISTOW et al., 2012).

The aim of this study was to evaluate the IBA levels and substrates vermiculite and coconut fiber in the rooting of UENF / CALIMAN 02 hybrid papaya mini-cuttings in a semi-hydroponic system.

Material and methods

For the formation of clonal seedlings, UENF / CALIMAN 02 hybrid papaya seeds sown in a 132-cell styrofoam tray in plantimax® vegetable substrate were used. Of these, 37 seedlings were transplanted to plastic pots with capacity of 25 liters containing soil, sand and well-cured bovine manure in the proportion 3: 1: 1, respectively. Fertilizations were carried out every 20 days with 5 g of NPK formulation: 13-40-13 and 3.5 g of calcium nitrate per plant. Fungicide applications were carried out using copper oxychloride + mancozeb 2.5 g L⁻¹ up to flowering, which began at four months, after eight months, the sex of all plants could be identified, where 15 plants were hermaphrodite and 22 were female.

After flowering and sexing, hermaphrodite plants were decapitated at 1.50 m from the colon, receiving in the stem solution containing 300 mg L⁻¹ of BAP (6-benzylaminopurine) and 100 mg L⁻¹ of GA₃ (gibberellic acid) and fungicide based on copper oxychloride + mancozeb 2.5 g L⁻¹ at the cutting site. Two more solution applications were performed, with plant regulators at the same previous concentrations at weekly intervals.

Buds were formed in plant stems, which were collected by making a cut with the scalpel distant two to three buds from the stem. After the first collection, buds below the cutting site formed new shoots even without new applications of plant regulators.

Buds were collected at the beginning of summer, for which buds with the highest vigor, with an average length of seven centimeters and diameter of 7.5 mm, were selected according to their production and submitted to evaluations in which IBA levels and substrates for rooting were tested.

Buds were collected from mother plants and submerged for five minutes in solution with Ridomil® fungicide and fixed on coconut fiber or vermiculite substrates previously moistened in alveolar styrofoam trays for seedlings production, with 4.5 x 4.5 x 5.0 cm cells. Styrofoam trays were inside white plastic trays measuring 43 x 27 x 7.5 cm in length, width and height. After the introduction of mini-cuttings, each tray received two liters of modified Hoagland solution containing the IBA levels at each treatment.

Weekly, the nutrient solution was renewed, but without new additions of IBA. After 45 days in a semi-hydroponic system, mini-cuttings, rooted or not, were removed from the trays and the length of shoots, root and

diameter were evaluated. Immediately after evaluation, mini-cuttings were transplanted into plastic pots of 600 ml in volume with soil, washed sand and 3: 1: 1 cured bovine manure, remaining for 45 days receiving weekly fertilizations with 0.7 g l^{-1} of 13-40-13 formulation for N, P and K, and 0.5 g l^{-1} of calcium nitrate applied to 200 ml of solution in each pot with plant, maintained in greenhouse with micro-sprinkler irrigation, adjusting the pump to 20 minutes four times a day.

The experiment was installed in a factorial scheme with five IBA levels (Figure 1): 0; 2.5; 5.0; 7.5 and 10 mg L^{-1} , two substrates: vermiculite and coconut fiber, in

a completely randomized design with three replicates and six mini-cuttings per replicate. The final evaluation was performed at 90 days, when plants were removed from pots and had their roots carefully washed. The length of shoots, the length of the largest root, the dry mass of shoots and the root system, the rooting percentage and of live cuttings were evaluated from the initial number. Data were submitted to analysis of variance and the means were compared by the Tukey test at 5% probability, and for the dry mass of shoots and the root system, data were also submitted to regression analysis. The 'GENES' statistical software (CRUZ, 2016) was used.



Figure 1 – Mini-cutting stages of papaya in a semi-hydroponic system. a – Mother papaya plants with buds. b - Papaya buds. c - Rooting of papaya mini-cuttings in a semi-hydroponic system. - Clones of 'UENF / CALIMAN 02' papaya rooted in a semi-hydroponic system and transplanted to pots. e - Papaya clones exhibiting the root system. f - Papaya plant obtained by mini-cutting technique with 15 cm already presenting hermaphrodite flowers.

Results and discussion

The analysis of the rooting of UENF / CALIMAN 02 hybrid papaya mini-cuttings showed significant interaction between IBA levels and substrate. In the comparison of substrates for each IBA level, vermiculite allowed higher rooting compared to coconut fiber substrate, except for IBA level of 5.0 mg L⁻¹ (Table 1). According to Wendling & Dutra (2010), vermiculite

substrate is very porous, which is a beneficial feature to the rooting of cuttings. KOYAMA et al. (2014), in evaluations of the physical characteristics of different substrates, obtained greater liquid retention capacity, higher density and greater conductivity in coconut fiber in relation to vermiculite. However, these authors did not observe interaction between IBA concentrations and substrates regarding the survival and percentage of *Litchi chinensis* Soon rooting.

Table 1 - Rooting of UENF / CALIMAN 02 hybrid papaya mini-cuttings in two substrates in the presence of different indolebutyric acid (IBA) levels in a semi-hydroponic system.

Substrate	IBA (mg L ⁻¹)				
	0.0	2.5	5.0	7.5	10
Vermiculite	33.31 a	50.00 a	61.11 a	61.11 a	50.00 a
Coconut fiber	5.56 b	22.22 b	61.11 a	38.89 b	5.55 b

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

Figure 2 shows the quadratic rooting behavior as a function of IBA levels. In vermiculite substrate, the point of maximum rooting occurred with 6.17 mg L⁻¹ IBA, corresponding to 61.66% rooting. For coconut fiber substrate, maximum rooting occurred with IBA of 5.18 mg L⁻¹, corresponding to 49.74% rooting.

For the percentages of live plants (PV), shoot growth (CPA), stem diameter growth (DC), length of the largest root (CMR), shoot dry matter (MSPA) and root dry matter (MSR), no interaction between IBA and substrate was observed. In all features, except for CMR, the highest averages were for cuttings submitted to rooting in vermiculite substrate (Table 2).

Similar results were obtained by Hussain et al. (2014), who obtained greater length of shoots and largest root with the use of vermiculite than with coconut fiber in 'xavante' black mulberry (*Rubus* sp.). Agnihotri et al. (2004) obtained 95% rooting of papaya buds obtained by micropropagation with subculture for 24 hours in BM3 medium with micronutrients from the Knop's solution added of 10 mg L⁻¹ and 2% sucrose and thereafter, subculture in BM2 medium supplemented with 50 mg L⁻¹ myo-inositol, 0.25 mg L⁻¹ adenine sulfate and 2% sucrose for 15 days. The authors obtained 80% plant survival after transplantation to pots with 1: 1 (v/v) soil and vermiculite.

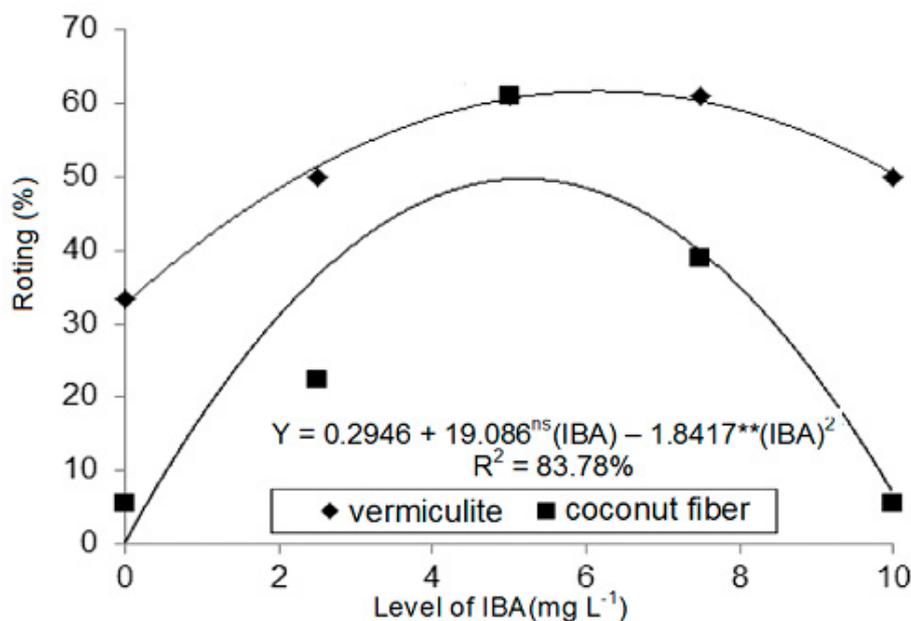


Figure 2 - Rooting of UENF / CALIMAN 02 hybrid papaya cuttings in two substrates as a function of different indolebutyric acid (IBA) levels in a semi-hydroponic system at the end of 90 days of evaluation.

Table 2 – Percentages of live plants (PV, in %), shoot growth (CPA, in cm), stem diameter growth (DC, in g), shoot dry matter (MSPA in g) part and root dry matter (MSR, in g) of UENF / CALIMAN 02 hybrid papaya mini-cuttings in two substrates in the presence of different IBA levels in a semi-hydroponic system

Substrate	Features				
	PV	CPA	DC	MSPA	MSR
Vermiculite	58.88 a	5.17 a	2.35 a	1.90 a	1.15 a
Coconut fiber	45.55 b	1.70 b	0.64 b	0.76 b	0.49 b

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

Regarding the percentage of live cuttings (PV) in relation to IBA levels, the behavior can be represented by a quadratic response (Figure 3 - item a), whose maximum point was 4.99 mg L⁻¹ of IBA, corresponding to 74.93% survival rate. There was an increase in the stem diameter of cuttings (Figure 3 - item b) obtained by the difference between the two evaluations, at 45 and 90 days. This increase, however, was influenced by the IBA level up to the maximum level of 4.45 mg L⁻¹. At this level, the increase in stem diameter corresponded to 2.31 mm.

The results presented by the difference between shoot evaluations (Figure 3 - item c) show that there was growth for this parameter also during the acclimation period and that this growth was influenced by IBA levels, with quadratic behavior. Maximum growth occurred with IBA of 5.01 mg L⁻¹, which corresponds to 4.67 cm of elongation. This growth is consistent with Taiz & Zeiger's (2013) statement. According to these authors, organs of excised plants respond intensely to exogenous auxin by the rapid increase of their growth rate to the levels observed in the intact plant. Oliveira et al. (2016) also observed greater vigor in seedlings of Black Lapacho (*Handroanthus heptaphyllus* Mattos) on cuttings treated with IBA.

Regarding the length of the largest root (Figure 3 - item d), the quadratic behavior regarding IBA levels showed that the highest roots reached about 22.75 cm in the presence of IBA of 5.28 mg L⁻¹.

These results are probably due to the low levels and prolonged exposure to the plant regulator used in this work, since, although lateral and adventitious root initiation is stimulated by high auxin concentrations, elongation is inhibited by concentrations above 10⁻⁸ M, since synthetic auxins are more efficient than AIA because they are not metabolized so quickly by the plant (TAIZ ;ZEIGER, 2013). Thus, there is a decrease in root elongation with elevation of the endogenous auxin level.

Regarding the dry matter content of the shoots of branches after 90 days of the evaluation period, it was observed that it was also influenced by the presence of IBA in the quadratic form (Figure 3 - item e). The maximum dry matter content of shoots was obtained with IBA of 5.61 mg L⁻¹, corresponding to 1.59 g per cutting.

The dry matter content of cutting roots also presented quadratic growth in the presence of IBA (Figure 3 - item f) up to the level of 5.38 mg L⁻¹, where the maximum dry matter content of roots was obtained, 1.09

g per cutting, and after, levels decreased. These results corroborate TOFANELLI et al. (2014), who observed that auxins at high concentrations become detrimental to rooting of vine cuttings (*Vitis* sp.).

According to these results, it could be inferred that the IBA level of 5.0 mg L⁻¹ with vermiculite or with coconut fiber is suitable for the rooting of UENF/CALIMAN 02 hybrid papaya mini-cuttings in semi-hydroponic system with the use of alveolate trays with 4.5x4.5x5.0 cm cells. It was verified that the later transplantation to pots with soil allowed the formation of seedlings of excellent quality, because some seedlings, despite the small size in relation to seedlings produced by sowing, already exhibited hermaphrodite flowers at the moment of experiment evaluation, thus guaranteeing planting in the field of 100% hermaphrodite seedlings with the use of this technique.

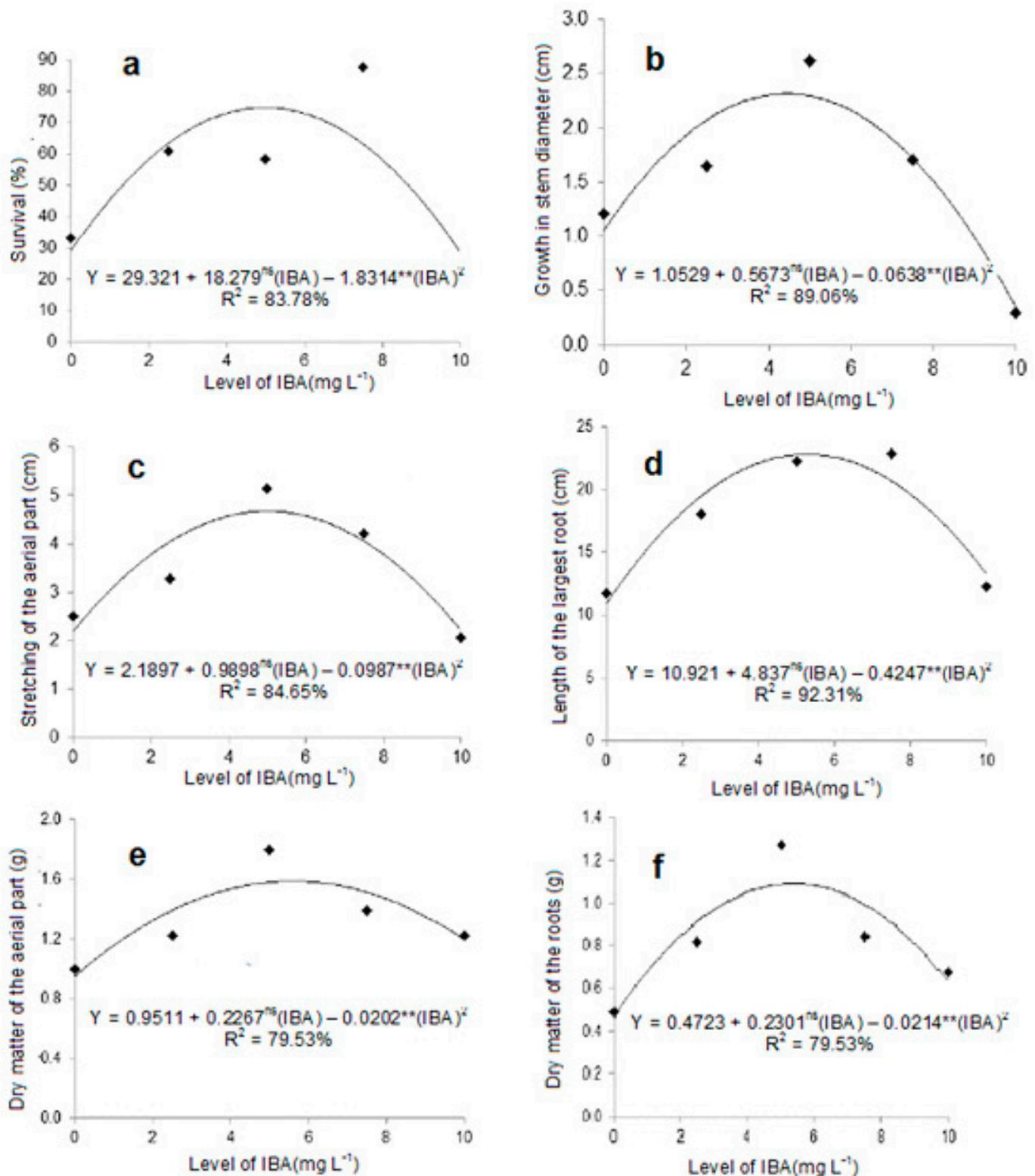


Figure 3 - Regression analysis for the rooting of UENF / CALIMAN 02 hermaphrodite papaya mini-cuttings in a semi-hydroponic system. a - Survival of cuttings at the end of 90 days of evaluation. b - Growth of the stem diameter of papaya cuttings during acclimation of 45 days. c - Elongation of shoots during acclimatization of 45 days. d - Length of the largest root after acclimatization at the end of 90 days of evaluation. e - Dry matter of shoots at the end of 90 days of evaluation. f - Dry matter of roots at the end of 90 days of evaluation.

Conclusion

IBA level of 5.0 mg L⁻¹ with vermiculite or coconut fiber is suitable for the rooting of UENF/CALIMAN 02 hybrid papaya mini-cuttings in semi-hydroponic system.

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