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Promoting fruit seedling growth by encapsulated microorganisms

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Abstract – The use of microorganisms capable of promoting plant growth has been accepted as an alternative to reducing the use of chemical fertilizers. The aim of this study was to evaluate the inoculation of plant growth promoting microorganisms in seedlings of fruit species, verifying the interaction of the inoculums with encapsulating agents such as clay and alginate. Microbial inoculums contained the following species: *Azospirillum brasilense*, *Burkolderia cepacia*, *Bacillus thuringienses*, *Bacillus megaterium*, *Bacillus cereus*, *Bacillus subtilis*, *Tricoderma* spp. and isolate 411. The fruit species evaluated were: *Myrciaria cauliflora* (DC.) O. Berg; *Myrciaria glazioviana* (Kiaersk.) G. Barros & Sobral; *Myrciaria dubia* (Kunth) Mc Vaugh; *Eugenia brasiliensis* Lam.; *Diospyroskaki* L.; *Garcinia brasiliensis* Mart.; *Annona muricata* L.; *Duguetia lanceolata* A. St.-Hil.; *Chrysophyllum cainito* L.; *Anacardium occidentale* L.; *Eriobotrya japonica* (Thunb.) Lindl. and *Litchi chinensis* Sonn. The experimental design was completely randomized, in a factorial scheme 3 (control, sodium alginate and clay) x 2 (presence and absence of microbial inoculum) with five replicates (one seedling per replicate). Seedlings were maintained in 50% of illumination at an average temperature of 22.5 °C for ninety days, and plant height, diameter, root and shoot dry mass were evaluated. Plant growth promoting microorganisms, regardless of encapsulation used, promote higher development of *C. cainito* and *L. chinensis* seedlings.
Index terms: Fruit plants, development, encapsulation, plant-growth promoting agents.

Promoção do crescimento de mudas frutíferas por meio de microrganismos encapsulados

Resumo – A utilização de microrganismos capazes de promover o crescimento vegetal tem sido aceita como alternativa à redução do uso de adubos químicos. O objetivo deste trabalho foi avaliar a inoculação de microrganismos promotores do crescimento de plantas em substrato de mudas de espécies frutíferas, verificando a interação do inóculo com agentes encapsulantes: argila e alginato. O inóculo microbiano continha as seguintes espécies: *Azospirillum brasilense, Burkolderia cepacia, Bacillus thuringienses, Bacillus megaterium, Bacillus cereus*, *Bacillus subtilis*, *Tricoderma* spp. e isolado 411. As espécies frutíferas avaliadas foram: *Myrciaria cauliflora* (DC.) O. Berg (jabuticabeira); *Myrciaria glazioviana* (Kiaersk.) G. Barros & Sobral (cabeludinha); *Myrciaria dubia* (Kunth) Mc Vaugh (camu-camu); *Eugenia brasiliensis* Lam. (grumixama); *Diospyros kaki* L. (caqui); *Garcinia brasiliensis* Mart. (bacupari); *Annona muricata* L. (graviola); *Duguetia lanceolata* A. St. – Hil. (pindaíba); *Chrysophyllum cainito* L. (caimito); *Anacardium occidentale* L. (caju); *Eriobotrya japonica* (Thunb.) Lindl. (nêspera) e *Litchi chinensis* Sonn. (lichia). O delineamento experimental foi o inteiramente casualizado (DIC), em esquema fatorial 3 (controle, alginato de sódio e argila) x 2 (presença e ausência de inóculo microbiano), com cinco repetições (uma muda por repetição). As mudas foram mantidas em 50% de iluminação, à temperatura média de 22,5 °C, durante noventa dias, sendo avaliados a altura e o diâmetro do colo das plantas, e a massa seca da parte aérea e das raízes. Microorganismos promotores de crescimento de plantas, independentemente do encapsulamento utilizado, promovem desenvolvimento superior de mudas de caimito e de lichia.
Termos para indexação: Plantas frutíferas, desenvolvimento, encapsulamento, promotores de crescimento vegetal.

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Introduction

The production of fruit seedlings is influenced by abiotic factors, such as light, temperature, gas exchange, water, moisture, substrate and nutrition, and biotic factors, such as pathogens, pests and rhizosphere microorganisms (HARTMANN et al., 2010).

In relation to the substrate, it must be dense and firm, highly decomposed and stable, sufficiently porous to drain excess water, free of pests, diseases and weeds, present low salinity, pasteurized or chemically treated, have high cation exchange capacity (CEC), nutrient retention and easy availability (HARTMANN et al., 2010). In addition, biotic factors, such as rhizosphere microorganisms (mycorrhizal bacteria and fungi), can influence the development of seedlings, and plant growth promoting bacteria (PGPB) exert beneficial effects by stimulating, for example, nitrogen fixation (BEUTLER et al., 2016), nutrient solubilization (MAJEED et al., 2015), production of plant regulators (FAHAD et al., 2015) and increase of root absorption capacity (PII et al., 2006).

Indirectly, PGPB acts as biological control agents against pathogens present in the substrate, possibly through the production of hydrocyanic acid, bactericides and antibiotics, by space competition, uptake of Fe^{+3} and other nutrients, parasitism, resistance induction and cross protection (MOTA et al., 2017).

In relation to PGPB species, the genus *Azospirillum* has several species that grow widely in the rhizosphere of grasses and, after being isolated and used in plant production, presented positive responses on productivity and on biological nitrogen fixation (BNF) (HUNGRIA et al., 2015; MÜLLER et al., 2016; PEREG et al., 2016). *Burkholderia cepacia* is another important species of bacteria in the BNF process (GÓES et al., 2015). *Bacillus* isolates have been shown to have satisfactory effects when used as biocontrol agents and to promote plant growth, highlighting *Bacillus subtilis* and *Bacillus cereus* isolates (SOUZA et al., 2017), *Bacillus thuringienses* (CONSTANSKI et al., 2015) and *Bacillus megaterium* (ZHOU et al., 2016). Among fungi, *Trichoderma* spp. stands out as a biocontrol agent (CONTRERAS-CORNEJO et al., 2016) and also in plant growth promotion ((NIETO-JACOBO et al., 2017).

One way of incorporating PGPB into substrates is to encapsulate solid, liquid and gaseous materials into small capsules that release their contents under controlled conditions. Encapsulation is important for maintaining the stability of microorganisms and for increasing the resistance of bacteria in the substrate. Among the many types of encapsulating materials, calcium and sodium alginate, as well as whey proteins and gums have been the most widely used (SCHOEBITZ et al., 2013; VEMMER; PATEL, 2013). Clay is also a good encapsulating agent with properties different from alginate, but maintaining the desired properties of an encapsulating agent. The use of clay for the preservation of conidia has demonstrated satisfactory effect in storage, guaranteeing the viability of this for a long period (SHI, 1988).

The isolated or combined inoculation of microorganisms may constitute a biotechnological tool of interest in the production of fruit plants. In this context, the aim of this study was to evaluate the effect of inoculation of microorganisms (PGPB) on substrate used for seedlings of fruit species, verifying the interaction of the inoculum with encapsulating agents clay and sodium alginate.

Material And Methods

The experiment was conducted between March 16 and June 16, 2015 (90 days) in the Fruit field of the School of Agricultural and Veterinarian Sciences, São Paulo State University (UNESP), Campus of Jaboticabal, located in the following geographical coordinates (lat 21º14'05''S, long 48º17'09''W, 590 m above sea level). The climate of the region, according to the Köppen classification is Cwa, with average annual temperature of 22 ºC.

The inoculum used contained the following species of microorganisms: *Azospirillum brasilense, Burkolderia cepacia, Bacillus thuringienses, Bacillus megaterium, Bacillus cereus, Bacillus subtilis, Tricoderma* spp. and isolate identified as 411. All microorganisms are preserved in the collection of the Laboratory of Soil Microbiology of the Department of Plant Production - UNESP, Campus of Jaboticabal.

Microorganisms were separately cultured in flasks containing nutritive broth for seven days and incubated in B.O.D. oven (Biochemical Oxygen Demand) (Eletrolab, model 347 F, Brazil), at 25 ºC. After the incubation period, microorganisms were separately centrifuged at 10,000 rpm for 10 min at 28°C (Novatecnica, model MLW K24, Brazil). The inoculum concentration was standardized as recommended by Barry and Thornsberry (1991) and Sahm and Washington II (1991) in 1 x 10^7 CFU mL^{-1}, using a spectrophotometer (Micronal, model B382, Brazil) at absorbance at 695 nm.

To each microorganism solution, sodium alginate solution ($NaC_6H_7O_6$) at concentration of 1% (w/v) was added. The microorganism solutions added of sodium alginate were dripped in 0.1M calcium chloride solution ($CaCl_2$), giving rise to beads with the microbial inoculum (SHEU; MARSHALL, 1993; SULTANA et al., 2000). Beads were then washed with distilled water using a sieve and submitted to drying in a laminar flow chamber for a period of six hours and stored at room temperature (17-28 °C). For each 1 mL of microorganism solution, 12 beads were created. Since eight different microorganisms were

applied in each pot, each seedling received 96 microbial beads, which were incorporated into the substrate in a hole at approximately 10 cm in depth in order to guarantee a greater proximity of the material deposited in the substrate with the roots of seedlings. Treatment containing alginate received only sodium alginate beads without the presence of the microbial inoculum, and 96 beads per pot were added.

In order to inoculate microorganisms with clay, suspension was prepared containing 1 mL of each microorganism was prepared for 1 mL of clay in the dilution of 1: 3 (w/v) distilled water (adapted from CARNEIRO, GOMES, 1997). Each pot received a total of 8 mL of microbial inoculum added to 8 mL of clay, which were incorporated into the substrate in hole of approximately 10 cm in depth, totaling 16 mL per pot. For treatment containing only clay, the same procedure was performed, excluding only the addition of the microbial inoculum.

All seedlings of fruit species studied were originated from seeds obtained from mother plants belonging to the Germplasm Active Bank of UNESP, Campus de Jaboticabal, conducted in one plant per pot. Microorganisms were inoculated on substrates where seedlings of the following fruit species were being conducted: *Myrciaria cauliflora* (DC.) O. Berg (jabuticaba); *Myrciaria glazioviana* (Kiaersk.) G. Barros & Sobral (cabeludinha); *Myrciaria dubia* (Kunth) Mc Vaugh (camu-camu); *Eugenia brasiliensis* Lam. (grumixama); *Diospyros kaki* L. (Persimmon); *Garcinia brasiliensis* Mart. (bacupari); *Annona muricata* L. (graviola); *Duguetia lanceolata* A. St.-Hil. (pindaíba); *Chrysophyllum cainito* L. (caimito); *Anacardium occidentale* L. (cashew); *Eriobotrya japonica* (Thunb.) Lindl. (medlar) and *Litchi chinensis* Sonn. (lychee).

The substrate used was composed of a 3: 1: 1 (v/v/v) mixture of soil, sand and bovine manure, disposed in polyethylene bags (22 x 11 cm). Irrigation was manual, daily, according to substrate moisture monitoring. Seedlings were kept under a 50% luminosity cover for a period of 90 days. During the experiment, the minimum temperature was 17 °C and the maximum temperature was 28 °C.

The seedlings selected for this experiment were standardized according to stem height and diameter before inoculation. At the end of 90 days, they were evaluated as to plant height (cm), measuring from the plant base to the apex; stem diameter (mm), in the neck region with the aid of a digital caliper; shoot dry mass (g) and roots dry mass (g) (65 °C, 72 h), as described by Araújo Neto et al. (2015).

Due to the different growth patterns of each fruit species, statistical analysis comparing the results among species was not performed. Thus, for each fruit species, completely randomized design was used in a factorial scheme 3 (control, sodium alginate and clay) x 2 (presence and absence of microbial inoculum) with five replications (one repetition), totaling 30 plants. Data were submitted to analysis of variance (ANOVA) and means compared by the Tukey test ($p \leq 0.05$), using AgroEstat Software (BARBOSA; MALDONADO JÚNIOR, 2009).

Results and Discussion

Significant effect ($P<0.01$) of the growth promoter microorganisms was observed only for *C. cainito* L. (caimito) plant height, both for encapsulation in sodium alginate and for microorganisms used in the inocula (Table 1). For the other species, no significant differences were observed for plant height, indicating that the microorganisms did not influence the growth of seedlings, regardless of type of encapsulation (clay or sodium alginate).

It was reported by Spassin et al. (2016) that bacterial isolates may have beneficial or no beneficial effects in relation to the survival and rooting of *Eucalyptus dunnii* (Myrtaceae), which raises the hypothesis that the establishment of growth-promoting microorganisms and their association with the plant species may vary according to species, management and, possibly, the place of study. However, Salla et al. (2014) concluded that the use of PGPB (*Streptomyces* PM9 rhizobacteria) resulted in higher yield of indoleacetic acid and a better potential for root induction, as well as in the levels of phenolic compounds and flavonoids involved in the defense mechanism of *Eucalyptus grandis* and *E. globulus* plants. The authors also reported alteration in secondary metabolism, suggesting an induced systemic response, indicating their potential use as a biological control in forestry activities.

When analyzing the height variable for the caimito species, it was observed that the encapsulation with clay yielded better results compared to sodium alginate encapsulation, since it did not differ statistically from the control (Table 2). Lower growth of untreated (control) seedlings when compared to growth in the other treatments was also observed (Table 2), suggesting that the use of microorganisms promoted the development of caimito seedlings. Thus, it could be inferred that the associations of bacterial communities associated with the rhizosphere of fruit species are hosts dependent on the taxon, that is, on the species itself, as concluded by Lambais et al. (2014), who studied the rhizosphere of arboreal species of the Atlantic Forest and showed that the bacterial communities associated to trees were specific to the hosts of plants.

In relation to stem diameter, significant effect ($P<0.01$) was observed for *M. dubia* (Kunth) Mc

Vaugh (camu-camu) seedlings. For this species, the stem diameter was higher when growth promoting microorganisms were not used, either encapsulated or not (Table 3). This can occur when the microorganisms used present some incompatibility with the native microbiota associated with the plant rhizosphere, which will generate competition between them, altering the positive effects of the target microorganism and, consequently, an unsuitable development of seedlings. Another possible result is due to variable root colonization due to inoculum survival problems or to unfavorable conditions for microorganisms, since the rhizosphere colonization depends on a set of abiotic and biotic factors, including plant genotypes and microorganisms, environmental conditions and the dynamic network of plant interactions (HARDOIM et al., 2015). However, for *C. cainito* (caimito) and *L. chinensis* (lychee) species, the opposite occurred, that is, larger stem diameter was observed in both species when seedlings were inoculated with microorganisms (Table 3). This result confirms the result observed for plant height variable, in which changes in plant growth may be related to the interaction between microorganisms and rhizosphere.

One possible explanation for this is that soil microorganisms found in the root zone affect plant growth and development, but the potential to take advantage of these benefits depends on the abundance and diversity of individuals influencing the beneficial effects on the plant (PANKE-BUISSE et al., 2015). In addition, the same plant species can stimulate diverse microbial communities from one site to another, which provides different responses to the inoculation of a single isolated growth promoter (XU et al., 2016). Additionally, genetic variability in seed propagated seedlings may be considered a factor of plant growth differentiation (HARTMANN et al., 2010).

Lychee seedlings presented significant increases ($P<0.05$) in the dry mass (DM) content of the plant shoots with the presence of microorganisms, regardless of whether they were encapsulated or not (Table 4). This result suggests that there may have been an association with the rhizosphere of lychee seedlings, which promoted better establishment of microorganisms and, consequently, provided larger stem diameter, possibly as a function of the higher DM content.

Root dry mass was significantly different only in caimito seedlings treated with growth promoting microorganisms (Table 5). In this species, root DM accumulation was higher when the substrate was inoculated with microorganisms, regardless of type of encapsulant used.

When evaluating eleven isolates of the genus *Acremonium* (GFR6 and GRR1), *Colletotrichum* (GFR4 and PFR4), *Phomopsis* (PFR3 and GCR4), *Cylindrocladium* (GRR4), *Chaetomium* (GRR7) and *Fusarium* (GRR5, PRR1 and PRR6), Silva et al. (2006) reported effects of these microorganisms on growth the parameters of *Annona squamosa* L. and *Annona muricata* L. seedlings with an increase in the shoot dry matter content of *Annona squamosa* L. seedlings between 23.2 and 32.7%, but no isolate affected the root dry mass content, similar to that observed in this study.

Silva et al. (2006) also reported that 20 isolates had a negative effect on the root dry matter content of *Annona squamosa* L. seedlings, and observed that in apparently healthy *Annona squamosa* L. and *Annona muricata* L. tissues, some fungi that could promote the growth of shoots were found, but others could reduce root growth and others that would not affect the growth of seedlings. Another interesting observation is that isolates that promoted the growth of sugar apple seedlings came from graviola, evidencing that isolates from one host can easily colonize hosts of different species, even with greater intensity (Silva et al., 2006). These characteristics may be associated to the efficiency of root colonization by microorganisms, since the exudation of different compounds attracts different microbial populations (SOUZA et al., 2015).

Table 1. Height of jabuticaba (*Myrciaria cauliflora*), cabeludinha (*Myrciaria glazioviana*), camu-camu (*Myrciaria dubia*), grumixama (*Eugenia brasiliensis*) (*Myrtaceae*); persimmon (*Diospyros kaki*) (Ebenaceae); bacupari (*Garcinia brasiliensis*) (Clusiaceae); graviola (*Annona muricata*), pindaiba (*Duguetia lanceolata*) (Annonaceae); caimito (*Chrysophyllum cainito*) (Sapotaceae); cashew (*Anacardium occidentale*) (Anacardiaceae); medlar (*Eriobotrya japonica*) (Rosaceae) and lychee (*Litchi chinensis*) (Sapindaceae) seedlings 90 days after inoculation with growth promoter microorganisms in two encapsulation methods.

Treatments	Jabuticaba	Cabeludinha	Camucamu	Grumixama	Persimmon	Bacupari	Graviola	Pindaíba	Caimito	Cashew	Medlar	Lychee
Encapsulation (A)	Height (cm)											
Control	33.91 a	24.83 a	46.50 a	12.66 a	56.16 a	31.16 a	59.16 a	9.66 a	75.08 a	47.00 a	41.66 a	62.50 a
Clay	34.91 a	24.83 a	38.16 a	11.00 a	59.75 a	41.91 a	58.16 a	8.08 a	77.66 a	43.83 a	40.16 a	44.33 a
Sodium alginate	41.33 a	26.16 a	41.75 a	11.83 a	57.66 a	37.16 a	60.83 a	7.83 a	54.33 b	48.16 a	43.08 a	49.83 a
Inoculum (B)	Height (cm)											
With inoculum	36.77 a	24.66 a	38.72 a	11.44 a	56.44 a	41.00 a	57.33 a	8.88 a	68.50 a	44.44 a	44.94 a	55.22 a
Without inoculum	36.66 a	25.88 a	45.55 a	12.22 a	59.27 a	42.05 a	61.44 a	8.16 a	69.55 a	48.44 a	38.33 a	52.55 a
CV (%)	22.29	18.57	26.63	21.52	20.19	31.02	15.26	27.67	15.08	15.31	18.88	20.37
F Test												
Encapsulation (A)	1.45^{ns}	0.16^{ns}	0.83^{ns}	0.64^{ns}	0.14^{ns}	0.63^{ns}	0.13^{ns}	1.06^{ns}	9.06^{**}	0.60^{ns}	0.21^{ns}	2.77^{ns}
Inoculum (B)	0.00^{ns}	0.30^{ns}	1.67^{ns}	0.42^{ns}	0.26^{ns}	0.02^{ns}	0.93^{ns}	0.42^{ns}	0.05^{ns}	1.28^{ns}	3.18^{ns}	0.27^{ns}
A x B	0.01^{ns}	0.16^{ns}	0.42^{ns}	0.32^{ns}	0.00^{ns}	0.26^{ns}	0.56^{ns}	1.18^{ns}	8.70^{**}	1.17^{ns}	0.79^{ns}	0.05^{ns}

(1)Means followed by the same letter in the column do not differ by the Tukey test, * significant at 5% probability, ** significant at 1% probability and ns not significant.

Table 2. Behavior of height variable of caimito (*Chrysophyllum cainito*) seedlings (cm) 90 days after inoculation with growth-promoting microorganisms as a function of encapsulation.

Encapsulation (A)	Inoculum (B)	
	Absence (B1)	Presence (B2)
	Plant height (cm)	
Control (A1)	65.33 aB	84.83 aA
Clay (A2)	74.50 aA	80.83 aA
Sodium alginate (A3)	68.83 aA	39.83 bA

*Means followed by the same letter in the column do not differ by the Tukey test ($p \leq 0.05$).

Table 3 . Stem diameter (DIAM) of jabuticabra (*Myrciaria cauliflora*), cabeludinha (*Myrciaria glazioviana*), camu-camu (*Myrciaria dubia*), grumixama (*Eugenia brasiliensis*) (Myrtaceae); persimmon (*Diospyros kaki*) (Ebenaceae); bacupari (*Garcinia brasiliensis*) (Clusiaceae); graviola (*Annona muricata*), pindaíba (*Duguetia lanceolata*) (Annonaceae); caimito (*Chrysophyllum cainito*) (Sapotaceae); cashew (*Anacardium occidentale*) (Anacardiaceae); medlar (*Eriobotrya japonica*) (Rosaceae) and lychee (*Litchi chinensis*) (Sapindaceae), 90 days after inoculation with growth promoting microorganisms in two encapsulation methods.

Treatments	Jabuticaba	Cabeludinha	Camucamu	Grumixama	Persimmon	Bacupari	Graviola	Pindaíba	Caimito	Cashew	Medlar	Lychee
Encapsulation (A)						DIAM (mm)						
Control	7.12 a	2.90 a	3.83 a	2.13 a	6.85 a	6.65 a	9.61 a	2.58 a	9.21 a	7.76 a	4.22 a	9.37 a
Clay	7.00 a	2.93 a	3.60 a	2.02 a	5.93 a	6.24 a	8.69 a	2.18 a	9.07 a	6.98 a	3.54 a	8.68 a
Sodium alginate	7.22 a	2.50 a	3.50 a	1.96 a	7.43 a	7.07 a	8.51 a	2.31 a	7.31 a	7.77 a	4.05 a	8.31 a
Inoculum (B)						DIAM (mm)						
With inoculum	7.14 a	2.84 a	3.32 b	2.07 a	6.77 a	6.31 a	9.00 a	2.37 a	9.27 a	7.24 a	3.92 a	9.64 a
Without inoculum	7. 10 a	2.71 a	3.97 a	2.00 a	6.70 a	6.99 a	8.87 a	2.35 a	7.79 b	7.77 a	3.93 a	7.93 b
CV (%)	11.69	19.19	12.14	17.43	15.23	36.12	10.59	22.49	16.68	14.28	16.32	17.82
F Test												
Encapsulation (A)	0.11^{ns}	1.25^{ns}	0.84^{ns}	0.35^{ns}	3.24^{ns}	0.18^{ns}	2.33^{ns}	0.89^{ns}	3.33^{ns}	1.08^{ns}	1.83^{ns}	0.71^{ns}
Inoculum (B)	0.01^{ns}	0.28^{ns}	9.55^{**}	0.19^{ns}	0.02^{ns}	0.36^{ns}	0.08^{ns}	0.00^{ns}	4.89^{*}	1.10^{ns}	0.00^{ns}	5.38^{*}
A x B	2.02^{ns}	0.50^{ns}	0.11^{ns}	0.35^{ns}	1.05^{ns}	0.21^{ns}	2.85^{ns}	0.94^{ns}	0.30^{ns}	0.90^{ns}	0.22^{ns}	0.16^{ns}

(1)Means followed by the same letter in the column do not differ by the Tukey test, being * significant at 5% probability, ** significant at 1% probability and ns not significant.

Table 4. Shoot dry matter (SDM) of jabuticaba (*Myrciaria cauliflora*), cabeludinha (*Myrciaria glazioviana*), camu-camu (*Myrciaria dubia*), grumixama (*Eugenia brasiliensis*) (Myrtaceae); persimmon (*Diospyros kaki*) (Ebenaceae); bacupari (*Garcinia brasiliensis*) (Clusiaceae); graviola (*Annona muricata*), pindaíba (*Duguetia lanceolata*) (Annonaceae); caimito (*Chrysophyllum cainito*) (Sapotaceae); cashew (*Anacardium occidentale*) (Anacardiaceae); medlar (*Eriobotrya japonica*) (Rosaceae) and lychee (*Litchi chinensis*) (Sapindaceae), 90 days after inoculation with growth promoting microorganisms in two encapsulation methods

Treatments	Jabuticaba	Cabeludinha	Camucamu	Grumixama	Persimmon	Bacupari	Graviola	Pindaíba	Caimito	Cashew	Medlar	Lychee
Encapsulation (A)						SDM (g)						
Control	9.79 a	4.83 a	6.34 a	4.40 a	12.04 a	21.18 a	11.92 a	4.89 a	33.52 a	12.04 a	15.42 a	10.86 a
Clay	9.26 a	5.14 a	4.61 a	4.62 a	11.49 a	18.16 a	12.19 a	4.62 a	34.60 a	11.49 a	12.05 a	11.59 a
Sodium alginate	12.35 a	6.66 a	4.59 a	4.89 a	10.47 a	22.21 a	14.23 a	4.89 a	23.95 a	10.12 a	13.36 a	11.69 a
Inoculum (B)						SDM (g)						
With Inoculum	10.35 a	5.14 a	4.60 a	4.67 a	11.70 a	16.97 a	11.53 a	4.71 a	35.51 a	11.46 a	14.85 a	12.22 a
Wthout Inoculum	10.58 a	5.95 a	5.76 a	4.60 a	10.97 a	24.97 a	14.04 a	4.89 a	25.88 a	10.97 a	12.38 a	10.54 b
CV (%)	32.50	29.17	31.91	9.46	15.81	75.66	28.17	10.25	40.53	16,17	30.25	13.80
F Test												
Encapsulation (A)	1.41^{ns}	0.21^{ns}	2.21^{ns}	1.86^{ns}	1.18^{ns}	0.11^{ns}	0.74^{ns}	0.61^{ns}	1.33^{ns}	1.79^{ns}	1.02^{ns}	0.50^{ns}
Inoculum (B)	0.02^{ns}	1.12^{ns}	2.19^{ns}	0.13^{ns}	0.74^{ns}	0.94^{ns}	2.17^{ns}	0.56^{ns}	2.70^{ns}	0.33^{ns}	1.62^{ns}	5.15^{*}
A x B	0.30^{ns}	0.74^{ns}	0.32^{ns}	0.67^{ns}	0.17^{ns}	0.50^{ns}	3.37^{ns}	1.06^{ns}	0.70^{ns}	0.46^{ns}	1.64^{ns}	0.88^{ns}

(1)Means followed by the same letter in the column do not differ by the Tukey test, being * significant at 5% probability, ** significant at 1% probability and ns not significant.

Table 5. Root dry matter (RDM) of jabuticaba (*Myrciaria cauliflora*), cabeludinha (*Myrciaria glazioviana*), camu-camu (*Myrciaria dubia*), grumixama (*Eugenia brasiliensis*) (Myrtaceae); persimmon (*Diospyros kaki*) (Ebenaceae); bacupari (*Garcinia brasiliensis*) (Clusiaceae); graviola (*Annona muricata*), pindaíba (*Duguetia lanceolata*) (Annonaceae); caimito (*Chrysophyllum cainito*) (Sapotaceae); cashew (*Anacardium occidentale*) (Anacardiaceae); medlar (*Eriobotrya japonica*) (Rosaceae) and lychee (*Litchi chinensis*) (Sapindaceae), 90 days after inoculation with growth promoting microorganisms in two encapsulation methods

Tratamentos	Jabuticaba	Cabeludinha	Camucamu	Grumixama	Persimmon	Bacupari	Graviola	Pindaíba	Caimito	Cashew	Medlar	Lychee
Encapsulation (A)						RDM (g)						
Control	6.03 a	1.26 a	2.97 a	1.31 a	5.85 a	7.02 a	8.18 a	1.18 a	10.54 a	1.97 a	3.17 a	3.33 a
Clay	5.25 a	1.33 a	2.09 a	1.25 a	5.82 a	5.53 a	6.82 a	1.23 a	11.09 a	1.95 a	2.47 a	3.62 a
Sodium alginate	7.28 a	1.86 a	1.74 a	1.08 a	5.77 a	6.57 a	5.95 a	1.01 a	6.85 a	2.02 a	2.49 a	3.16 a
Inoculum (B)						RDM (g)						
With Inoculum	5.97 a	1.44 a	2.01 a	1.25 a	5.91 a	6.07 a	6.98 a	1.11 a	11.76 a	1.92 a	2.79 a	3.74 a
Wthout Inoculum	6.41 a	1.53 a	2.40 a	1.18 a	5.72 a	6.68 a	6.99 a	1.17 a	7.22 b	2.04 a	2.63 a	2.99 a
CV (%)	23.26	39.65	32.86	16.24	7.98	68.71	49.33	15.15	43.31	19.80	54.63	26.43
F Test												
Encapsulation (A)	3.03^{ns}	1.86^{ns}	3.26^{ns}	2.03^{ns}	0.04^{ns}	0.18^{ns}	0.64^{ns}	2.69^{ns}	1.89^{ns}	0.05^{ns}	0.43^{ns}	0.40^{ns}
Inoculum (B)	0.42^{ns}	0.11^{ns}	1.29^{ns}	0.58^{ns}	0.78^{ns}	0.09^{ns}	0.00^{ns}	0.64^{ns}	5.50^{*}	0.38^{ns}	0.05^{ns}	3.17^{ns}
A x B	0.62^{ns}	0.85^{ns}	0.33^{ns}	1.22^{ns}	0.84^{ns}	0.21^{ns}	2.59^{ns}	0.57^{ns}	0.47^{ns}	0.63^{ns}	1.95^{ns}	1.01^{ns}

(1)Means followed by the same letter in the column do not differ by the Tukey test, being * significant at 5% probability, ** significant at 1% probability and ns not significant.

Conclusion

Plant growth promoting microorganisms, regardless of encapsulation used, promote higher development of caimito and lychee seedlings.

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