Agrotrópica 34(2): 131 - 138. 2022.
Centro de Pesquisas do Cacau, Ilhéus, Bahia, Brasil

POTENTIAL OF ENDOPHYTIC FUNGI OF *Aechmea multiflora* AS GROWTH PROMOTERS OF THE HOST PLANT

Eliane Santana Rodrigues[1], Aurélio José Antunes de Carvalho[3], Edna Dora Martins Newman Luz[2], Ana Cristina Fermino Soares[1], José Luiz Bezerra[1]

[1]Federal University of Recôncavo da Bahia, Postgraduate Program in Agricultural Sciences - PPGCAG, 44380-000, Cruz das Almas, BA, Brazil; elianesantanar@gmail.com; acsoares@ufrb.edu.br; jlulabezerra@hotmail.com. [2]State University of Santa Cruz, Postgraduate Program in Plant Production - PPGPV, 45662-900, Ilheus, BA, Brazil; ednadora@yahoo.com.br. [3]Federal Institute of Education, Science and Technology of Bahia - IF Baiano, 45320-000, Santa Inês, BA, Brazil; aurelio.carvalho@ifbaiano.edu.br

This study aimed to assess endophytic fungi isolated from *Aechmea multiflora* for their capacity of promoting growth of host plantlets. The experiment was conducted in a greenhouse under a completely randomized experimental design with 11 treatments plus control and 12 repetitions. The treatments consisted of: T1: *Aspergillus* 1; T2: *Aspergillus* 3; T3: *Chaetomium* 1; T4: *Chaetomium* 2; T5: *Lasiodiplodia*; T6: *Mycelia sterilia*; T7: *Polyschema*; T8: *Trichoderma* 12; T9: *Trichoderma* 2; T10: *Trichoderma* 4; T11: *Trichoderma* 5; T12: Control (distilled water). Fifteen agronomic parameters were assessed and were statistically analyzed, with the means of the treatments clustered by Scott-Knott test (5%). The endophytic fungi inoculated impacted plant and stem length, stem diameter, fresh mass of the leaf, stem, root, and total fresh mass, and dry mass of the stem and root in relation to control. They did not influence, however, the yield of variables such as number of leaves, basal and median D leaf width, root length, leaf dry mass, and total dry mass. The strains "*Aspergillus* 1", "*Aspergillus* 3," "*Mycelia sterilia*," "*Chaetomium* 1," and "*Chaetomium* 2" positively contributed to nearly all parameters analyzed that were statistically significant.

Key words: Bromeliaceae, endophytism, growth promotion.

Potencial de fungos endofíticos de *Aechmea multiflora* como promotores de crescimento da planta hospedeira. Neste trabalho objetivou-se avaliar fungos endofíticos isolados de *Aechmea multiflora* quanto a sua capacidade de promover crescimento de mudas do hospedeiro. O experimento foi conduzido em casa de vegetação, sob delineamento experimental inteiramente casualizado, com 11 tratamentos mais controle e 12 repetições. Os tratamentos consistiram em: T1: *Aspergillus* 1; T2: *Aspergillus* 3; T3: *Chaetomium* 1; T4: *Chaetomium* 2; T5: *Lasiodiplodia*; T6: *Mycelia sterilia*; T7: *Polyschema*; T8: *Trichoderma* 12; T9: *Trichoderma* 2; T10: *Trichoderma* 4; T11: *Trichoderma* 5; T12: Controle (água destilada). Foram avaliados quinze parâmetros agronômicos que foram estatisticamente analisados e as médias dos tratamentos agrupadas pelo teste de Scott-Knott (5%). Os fungos endofíticos inoculados interferiram no comprimento da planta, do caule, diâmetro do caule, massa fresca da folha, do caule, da raiz, total, massa seca do caule e da raiz em relação ao controle. Mas não influenciaram o rendimento de variáveis como número de folhas, largura basal e mediana da folha D, comprimento da raiz, massa seca da folha e massa seca total. As cepas "*Aspergillus* 1", "*Aspergillus* 3", "*Mycelia sterilia",* "*Chaetomium* 1" e "*Chaetomium* 2" contribuíram positivamente para quase todos os parâmetros analisados que foram estatisticamente significativos.

Palavras-chave: Bromeliaceae, endofitismo, promoção de crescimento.

Recebido para publicação em 17 de junho de 2022. Aceito em 08 de agosto de 2022.
DOI:10.21757/0103-3816.2022v34n2p131-138

Introduction

In recent decades, the use of biological approaches to improve agricultural production has gained special attention among environmentalists and agronomists due to greater awareness on environmental conservation (Ahemad and Kibret, 2014). The use of microorganisms to increase the productivity of plant species may be a sustainable, low-cost possibility (Graças et al., 2015), thus minimizing the use of chemical inputs and easing soil and water pollution, which makes it a major tool for environmental remediation (Khan et al., 2015).

Microbial endophytes colonize the internal and healthy tissues of the host plant without causing symptomatic damage, competing for space in the same ecological niches as microbial pathogens (Hassan, 2017). Endophyte-host interactions, according to environmental conditions, may range from mutualism to antagonism depending on the nature of the biocommunication between the host plant, the microorganism, and environmental conditions (Schulz and Boyle, 2005).

Endophytes occupy the same ecological niche as most pathogens, so they are believed to use the same strategy for colonization of host tissue, through successful penetration of the plant's outer protective layers, mechanical fractures of these tissues or the synthesis of enzymes resulting in digestion of the cuticular and epidermal layers (Petrini, Stone and Carroll, 1982).

For Wang et al. (2007), the colonization of endophytic microorganisms in the host plant can also occur through the penetration of plant organs through natural openings such as stomata and/or hydathodes and through secondary roots. Infection can also occur vertically, through the seeds of the host, systematically infecting the plant after seed germination and thus being able to inhabit the plant tissue throughout its life (Chapla, Biasetto and Araújo, 2013; Dutta et al., 2014).

Studies aiming at clarifying the role of microbial endophytic communities in increasing plant sanity and as growth promoters have been developed (Vurukonda, Giovanardi and Stefani, 2018). Those studies have shown that endophytes are able to improve biomass production and the formation of extra-radicular hyphae for nutrient absorption, stimulate root growth, alter plant metabolism to promote nutrient absorption, promote the growth of the host plant in a direct way through the synthesis of phytohormones, such as indole-acetic acid (Johnston-Monje et al., 2019), gibberellins (Khan et al., 2011), and cytokinins (Arkhipova et al., 2007), thus improving solubilization of phosphate (Spagnoletti et al. (2017), potassium, and zinc (Colla et al., 2014), and enabling greater efficiency in nitrogen fixation (Yang et al., 2015).

Some endophytic microorganisms are able to increase host resistance to abiotic and biotic stresses such as pests and diseases, possibly contributing indirectly to the growth and development of the host plant (Sudha et al., 2016). In recent decades, studies have reported the production of several bioactive compounds with antimicrobial, insecticide, and cytotoxic properties (Khan et al., 2015).

A beneficial interaction of the microorganism with the plant requires efficient colonization of endophytes in the host plant, comprising a series of phenomena such as fixation, entry, motility, transmission, and multiplication of endophyte populations in the host plant (Kumar et al., 2020). The process of the microorganism entering into the host tissue comprises the secretion of different signaling compounds by endophytes, while the perception of the microorganism on the cellular surface of the plant sets off defense responses to slow down or block microbial growth (Araújo et al., 2020).

Endophytic fungi of ornamental plants, such as bromeliads, are still relatively little investigated. Studies involving the microorganisms associated with *Aechmea multiflora* L.B. Sm and their benefits for the production of plantlets are non-existent. Therefore, the present study aimed to assess the behavior of endophytic fungi isolated from *A. multiflora* for their capacity of promoting growth of host plantlets.

Materials and Methods

The experiment was conducted between January and December at the Cruz das Almas - BA campus of the Universidade Federal do Recôncavo da Bahia (UFRB). The municipality of Cruz das Almas is located at 12°40'0"S and 39°06'0"W at 200 m altitude, with climate Aw to Am, tropical hot and humid according to the Köppen classification. The mean annual temperature is 24.5 °C with mean annual rainfall around 1,224 mm.

The seeds used came from healthy ripe fruits of *A. multiflora* collected in the municipality of Milagres - BA, "12º52'14" South Latitude and 39º51'4" West Longitude. The seeds extracted from the fruit were washed in running water over a fine-mesh sieve and then placed onto absorbent paper to dry in a well-ventilated shaded place (Figure 1). To obtain the seedlings, the seeds were disinfested in 1% hypochlorite solution and seeded in plastic tubes containing commercial substrate for bromeliads Vitaplan® and kept in a greenhouse.

After 37 days, period during which it was possible to observe the development of the first three definitive leaves on the seedlings and they were transferred to acrylic containers with approximately 400 mL capacity containing 180 mL of a formulation of Vitaplan®, pine bark, and earthworm humus at a 2:1:1 proportion. The substrate was chosen considering an adequate supply of organic matter in order to allow good aeration and drainage of irrigation. The containers were kept on shelves in a growing room with controlled photoperiod of 12 h at room temperature (25 ± 2 °C).

The experimental design employed was fully randomized with 12 treatments and 12 repetitions, consisting of one plant, the experimental unit, for a total of 144 experimental units. Eleven endophytic strains were selected from the 65 isolated from the aerial part and root system of *A. multiflora*, belonging to the genera: *Aspergillus*, *Trichoderma*, *Lasiodiplodia*, *Chaetomium*, *Polyschema*, and *Mycelia sterilia*.

The treatments were laid out as follows: T1- *Aspergillus* 1; T2- *Aspergillus* 3; T3- *Chaetomium* 1; T4- *Chaetomium* 2; T5- *Lasiodiplodia*; T6- *Mycelia sterilia*; T7- *Polyschema*; T8- *Trichoderma* 12; T9- *Trichoderma* 2; T10- *Trichoderma* 4; T11- *Trichoderma* 5; T12 - Control (distilled water).

All isolates were seeded in 9 cm Petri dishes containing PDA (Potato-Dextrose-Agar) culture medium and incubated at 28 °C for a period long enough for the development of spores (varying from 2 to 5 weeks). After incubation, the inoculum was prepared with suspension of spores for the isolates of *Aspergillus*, *Trichoderma*, and *Chaetomium*.

To each dish containing the colonies, 15 mL sterile distilled water and two drops of Tween 20® were added and the colonies were scraped using a Drigalski spatula. The spore concentration of the suspension was adjusted to the final desired concentration (10^7 conidia.mL^{-1}) by counting spores in the Newbauer chamber using an optical microscope, with dilution of the suspension when needed.

For the isolates that did not produce spores in enough quantity, such as *Lasiodiplodia*, *Polyschema*, and *Mycelia sterilia*, mycelial suspensions were performed. The mycelian suspension consisted of grinding the mycelium produced by the colonies with the same amount of sterile distilled water used in the spore suspension.

The first inoculation was carried out 30 days after the first transplant and consisted of spraying the entire extension of the plantlets with fungal suspensions with an application of 0.5 mL of the suspension in each plantlet (Figure 2). The control treatment was sprayed with 0.5 mL distilled water. After inoculation, the containers returned to the growing room and were placed on shelves with controlled photoperiod of 12 h at room temperature (25 ± 2 °C) for 65 days.

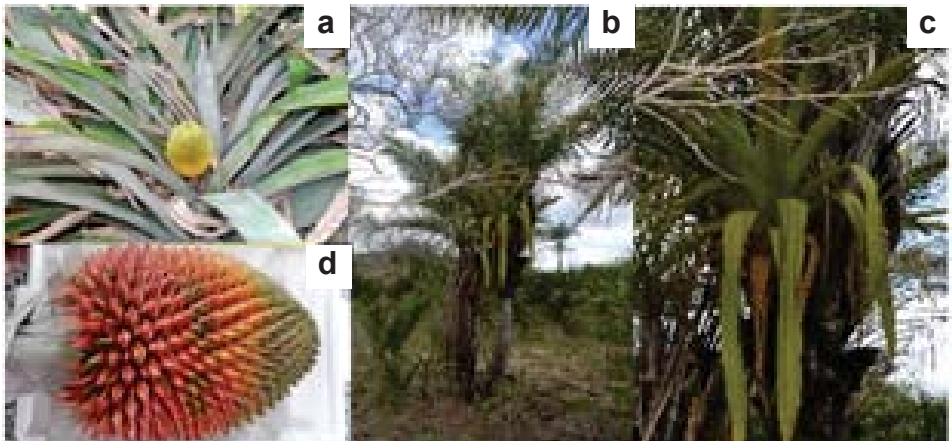
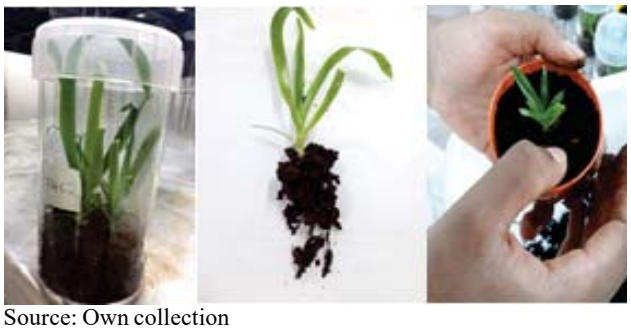


Figure 1. **(a,b) -**Inflorescence of *Aechmea multiflora*; **(c,d)**-*Aechmea multiflora* under Licurizeiro (*Syagrus coronata*), in Comunidade Jatobá-BA. Source: Own collection

After the 65-day period, the plantlets were taken to a greenhouse and transplanted into vases of approximately 180 mL capacity with holes in the bottom for water drainage (Figure 3). The substrate used was formulated with

Source: Own collection

Figure 2. Inoculation performed 30 days after the first transplant (0.5 mL of suspension in each seedling).



Source: Own collection

Figure 3. 65 days after the first inoculation: transplanting to pots.

Vitaplan®, pine bark, and earthworm humus at 2:1:1 proportion. Initially, a humid chamber was assembled with plastic canvas for acclimatization of the plantlets.

The second inoculation took place 90 days after the second transplant and consisted of spraying each plant with 6.0 mL of the fungal suspension corresponding to each isolate used as treatment, with the same amount of distilled water used for the control treatment.

At 206 days after the second transplant, the plantlets were assessed for morphological characteristics. Plant length was determined using a graded ruler (cm) considering the interval between the insertion point of the D leaf in the stem and the extremity of the foliar limb. The number of leaves per plant was determined through counting from the basal leaf until the last open leaf, disregarding the ones in senescence process. The basal and median widths of the D leaf were measured with a graded ruler (cm), the width of the base of the D leaf, where the foliar limb began; the median width considered the median distance between the base of the leaf and the peak of the foliar limb of the D leaf.

Stem length and diameter were determined using calipers (cm) after all leaves were plucked. Root length was measured as the distance from the crown to the extremity of the main root. Fresh masses of leaves, stem, and root were obtained by immediate weighing using a precision electronic scale (g). The total fresh mass was inferred from the sum of the fresh mass of the entire aerial part and fresh mass of the root system of the plant, expressed in g. To determine the dry masses of leaf, stem, and root, the plant organs were stored in paper bags and placed in a forced air oven at 65 °C until constant weight. After that, they were weighed using a precision electronic scale (g). Total dry mass was inferred from the sum of the dry mass of the entire aerial part and dry mass of the root system of the plant, expressed in g.

The data were submitted to analysis of variance (ANOVA) using the software R-Studio. The means were compared by Scott-Knott test at 5% significance when the value of the F-test in the ANOVA was significant.

Results and Discussion

Considering the treatments in general, the following variables were significant at 5% probability: plant and stem length; stem diameter; fresh masses of leaves, stem, root, and total fresh mass; dry mass of stem, root, and total dry mass (Tables 1 and 2).

Plant length was significantly influenced by the treatments applied (Table 3). The highest value (23.34 cm) corresponded to the plants inoculated with the suspension of the endophytic "*Aspergillus* 1" while the lowest (18.75 cm) corresponded to those that received distilled water as control treatment. Only two treatments did not differ from the control: *Polyschema* and *Trichoderma* 5. The other nine endophytes tested were effective for this variable and did not differ among themselves. Bilal et al. (2018) also observed that a strain, identified as *Aspergillus fumigatus* TS1, positively influenced the length of the aerial part of plantlets of mutant Waito-C rice, besides contributing to root development and biomass production, which was attributed to the production of some phytohormones.

Table 1. Summary of the analyses of variance of the number of leaves (NL), length (LEN), basal width (BASWID), and median width (MEDWID) of the D leaf, stem length (SL), stem diameter (SD), and root length (RL) of *Aechmea multiflora* plantlets as a function of the endophytic fungi inoculated

		Mean Square						
SV	**DF**	**NL**	**LEN**	**BASWID**	**MEDWID**	**SL**	**SD**	**RL**
Treatment	11	3.4242^{ns}	21.8530*	0.53954^{ns}	0.21917^{ns}	0.148273*	0.070152*	13.3855^{ns}
Residue	108	2.1278	7.8279	0.24856	0.13143	0.047463	0.033815	8.5842
CV (%)	-	8.07	13.01	14.34	13.01	19.9	13.34	17.48

* Significant effect according to F-test at 5% probability level; n.s. - non-significant

Table 2. Summary of the analyses of variance of the leaf fresh mass (LFM), stem fresh mass (SFM), root fresh mass (RFM), total fresh mass (TFM), leaf dry mass (LDM), stem dry mass (SDM), root dry mass (RDM), and total dry mass (TDM) of Aechmea plantlets as a function of the endophytic fungi inoculated

		Mean Square							
SV	**DF**	**LFM**	**SFM**	**RFM**	**TFM**	**LDM**	**SDM**	**RDM**	**TDM**
Treatment	11	169.37*	0.66191*	1.8550*	211.674*	0.36997^{ns}	0.0074763*	0.0315299*	0.62955^{ns}
Residue	108	3,885.8	0.12487	0.2372	40.547	0.25838	0.0009416	0.0044024	0.29186
CV (%)	-	19.95	21.13	16.87	18.39	18.73	17.93	14.9	16.22

* Significant effect according to F-test at 5% probability level; n.s. - non-significant

Table 3. Result of the Scott-Knott Test, at a 5% probability level, between the inoculated treatments, for each of the variables: number of leaves (NF), length (COMP), basal width (LARBAS) and, median width (LARMED) of leaf D, stem length (CC), stem diameter (DC), root length (CR), leaf fresh mass (MFF), stem fresh mass (MFC), root fresh mass (MFR), total fresh mass (MFT), leaf dry mass (MSF), stem dry mass (MSC), root dry mass (MSR) and total dry mass (MST) of *Aechmea multiflora* seedlings

Fungi	**COMP (cm)**	**CC(cm)**	**DC(cm)**	**MFF(g)**	**MFC(g)**	**MFR(g)**	**MFT(g)**	**MSC(g)**	**MSR(g)**
Aspergillus 01	23.34 a	1.17 a	1.46 a	35.11 a	1.99 a	3.29 a	40.39 a	0.19 a	0.52 a
Aspergillus 03	23.27 a	1.22 a	1.43 a	32.78 a	1.83 a	3.59 a	38.22 a	0.18 a	0.50 a
Mycelia sterilia	22.33 a	1.16 a	1.45 a	33.54 a	1.76 a	2.97 b	38.28 a	0.19 a	0.44 a
Chaetomium 01	22.68 a	1.28 a	1.53 a	31.97 a	2.09 a	2.98 b	37.06 a	0.19 a	0.47 a
Chaetomium 02	21.66 a	1.01 b	1.42 a	33.25 a	1.65 a	2.50 c	37.42 a	0.18 a	0.41 b
Controle	18.75 b	0.99 b	1.23 b	20.70 b	1.26 b	2.29 c	24.26 b	0.12 b	0.34 b
Lasiodiplodia	21.51 a	0.98 b	1.33 b	31.36 a	1.44 b	2.88 b	35.68 a	0.17 a	0.47 a
Polyschema	20.34 b	1.14 a	1.37 b	24.67 b	1.55 b	2.04 c	28.26 b	0.15 b	0.38 b
Trichoderma 012	21.00 a	1.04 b	1.33 b	30.67 a	1.48 b	2.95 b	35.10 a	0.14 b	0.37 b
Trichoderma 02	22.37 a	0.93 b	1.34 b	29.07 a	1.68 a	3.22 a	33.99 a	0.14 b	0.49 a
Trichoderma 04	21.66 a	1.25 a	1.37 b	30.38 a	1.90 a	3.03 b	35.32 a	0.20 a	0.45 a
Trichoderma 05	19.16 b	0.97 b	1.28 b	27.31 b	1.37 b	2.86 b	31.56 b	0.13 b	0.44 a
Média	21,50	1,09	1,37	30,06	1,66	2,88	34,62	0,16	0,44

* Means followed by the same letters and in the same column do not differ statistically from each other, by the Scott Knott Test, at the 5% probability level.

The production of plant and biochemical hormones by microorganisms depends on a series of conditions such as pH, temperature, incubation period, types of microorganism, growth dynamics, and internal physiology (Khan et al., 2012). In this study, in addition to the strains "*Aspergillus* 1" e "*Aspergillus* 3", *Mycelia sterilia*, "*Chaetomium* 1", "*Chaetomium* 2", "*Lasiodiplodia*", "*Trichoderma* 2", "*Trichoderma* 4", "*Trichoderma* 12" promoted growth of the aerial part of *A. multiflora* in a similar manner. The length corresponds to the distance between the base of the plant and the apex of the D leaf.

The mean stem diameter was 1.37 cm and was positively influenced only by the fungi "*Chaetomium* 1", "*Chaetomium* 2", "*Aspergillus* 1", "*Aspergillus* 3" and *Mycelia sterilia*. However, for the variable stem length, "*Polyschema*" and "*Trichoderma* 4" were also determinant. Stem diameter is a relevant quality parameter for plantlets given its importance in supporting the aerial part of the plant. Plants with small diameter may have difficulty in remaining erect after planted in the field, possibly suffering with deformations or even death (Lima et al., 2020). The least efficient treatments to increase stem diameter were "*Polyschema*", *Trichoderma* 4", "*Trichoderma* 2", "*Trichoderma* 5", and "*Lasiodiplodia*, which behaved in a similar manner as control.

According to Table 2, the highest values of fresh mass of leaf corresponded to plants that received the treatments "*Aspergillus* 1", "Chaetomium 1", "*Chaetomium* 2", "*Aspergillus* 3", *Mycelia sterilia*, "*Lasiodiplodia*, "*Trichoderma* 4", "*Trichoderma* 12", and "*Trichoderma* 2", which did not differ statistically.

Total fresh mass ranged from 40.39 to 24.26 g per plant and, similarly to leaf fresh mass, the best results were found for the plantlets inoculated with "Aspergillus 1", "*Chaetomium 1", "Chaetomium* 2", "*Aspergillus* 3", *Mycelia sterilia*, "*Lasiodiplodia*", "*Trichoderma* 4", "*Trichoderma* 12", and "*Trichoderma* 2", which also did not differ statistically, but were significantly different in the treatments Control, "*Polyschema*", and "*Trichoderma* 5", which had inferior gains of total fresh mass.

Regarding the root fresh mass, the plantlets inoculate with "Aspergillus 1", "*Aspergillus* 3", and "*Trichoderma* 2" with 3.29, 3.59, and 3.22 g, respectively, showed significantly better responses than the witness.

For the contents of leaf dry mass and total plant dry mass, no statistical difference was found between the treatments with the endophytes and the witness, with the plants having, on average, 2.70 g of leaf dry mass and 3.32 g of total plant dry mass. Hence, the treatments applied did not influence organic matter accumulation in the plant. The highest value of FMS was obtained with *Chaetomium* 1 (2.09 cm), which did not significantly differ from *Aspergillus* 1, *Aspergillus* 3, *Mycelia sterilia*, *Chaetomium* 2, *Trichoderma* 2, or *Trichoderma* 4, except for treatments Control, *Lasiodiplodia*, *Polyschema, Trichoderma* 12, and *Trichoderma* 5, which showed low values.

For the variable RDM, the highest variable was found for treatment "*Aspergillus* 1", which did not statistically differ from treatments *Aspergillus* 3, *Mycelia sterilia*, *Chaetomium* 1, *Lasiodiplodia*, *Trichoderma* 2, *Trichoderma* 4, or *Trichoderma* 5, differing only from treatments *Chaetomium* 2, Control, *Polyschema*, and *Trichoderma* 12.

Treatment *Trichoderma* 4 led to a higher increase in stem dry mass (0.20 g), however, it did not statistically differ from treatments "*Aspergillus* 1", *Aspergillus* 3, *Mycelia sterilia*, Chaetomium 1, *Chaetomium* 2, *Lasiodiplodia*, or *Trichoderma* 5. Treatments Control, *Polyschema*, *Trichoderma* 12, *Trichoderma* 2, and *Trichoderma* 5 reached the lowest averages (0.12; 0.15; 0.14; 0.14; 0.13 g, respectively) for this characteristic.

The control treatment, which had no fungal inoculation, showed inferior performance, with the lowest averages for the six variables studied (LEN, SD, FML, DML, DMS, and DMR), which suggests the plantlets developed better in the presence of endophytes. Treatments *Aspergillus* 1, *Aspergillus* 3, *Mycelia sterilia*, *Chaetomium* 1, and *Chaetomium* 2 stood out for the efficiency in improving several variables.

According to Salvatore; Andolfi and Nicoletti (2020), there is a fine line between pathogenicity and endophytism, seen as many pathogens have a latent stage in their life cycles during which they are asymptomatic to the host. The duration of this stage is variable and depends on changes in susceptibility of the host induced by environmental stresses.

Although many records of the genus *Lasiodiplodia* as a phytopathogenic are found, it is also acknowledged in other hosts for its capacity of colonizing plant tissues with no apparent symptom (Cardoso et al., 2009). The results found in this study show that the treatment applied, composed of the mycelial suspension of *Lasiodiplodia*, positively contributed to growth parameters such as length, leaf fresh mass, total fresh mass, stem dry mass, and root dry mass, obtaining higher mean values compared to the control treatment.

In this study, the treatments with *Trichoderma* were not uniform regarding the agronomic parameters

assessed, unlike the results obtained by Aguiar et al. (2013), who showed that *Trichoderma* spp. increased the fresh mass of the aerial part of bean plants.

In plantlets of *Camellia sinensis*, *T. asperellum* TC01 promoted an increase in shoot height, stem diameter, fresh weight of the shoot, fresh weight of the root, dry mass of the shoot, and dry mass of the root 45 days after inoculation in a greenhouse (Shang, Liu and Xu, 2020).

The data obtained show that the inoculation with the endophytic "*Aspergillus* 1" positively influenced the variables length, leaf fresh mass, total fresh mass, and root dry mass, which exhibited significant differences in relation to the control treatment (CON), thus showing that the association with the fungus favored nutrient absorption. Araújo et al. (2020), when assessing the growth-promoting potential of *Aspergillus niger in coffee* (*Coffea arabica* L.) plantlets, also obtained significant increases in length and root dry mass. Similar results were obtained by Abdel-Motaal et al. (2020) when assessing the growth-promoting potential of the endophyte *Aspergillus flavus* in tomato plants (*Solanum lycopersicum* L.), with the inoculation with *A. flavus* significantly increasing plant length compared to the control. Soybean plants inoculated with a new strain of *A. fumigatus* significantly increased the length and fresh biomass of the aerial part through the production of gibberellins (Khan et al., 2011).

According to Hung and Rutgers (2016), fungi of the genus *Aspergillus* have the potential of promoting the growth of plants via a broad range of mechanisms, such as helping in phosphate absorption, production of biologically active compounds such as auxins, gibberellins, and other compounds similar to phytohormones, besides a series of secondary metabolites.

It was observed that treatment C1, corresponding to the endophytic fungus "*Chaetomium* 1," contributed to stem length and diameter and to an increase in fresh mass also of the stem (FMS). Khan et al. (2012) observed that the endophyte *Chaetomium globosum*, isolated from the roots of pepper plants (*Capsicum annuum* L.), significantly promoted growth of the aerial part, chlorophyll content, and biomass of rice plantlets. According to Schulz and Boyle (2005), plants treated with endophytes are constantly healthier than those without the endophyte-host symbiosis. That can be attributed to the endophyte secreting phytohormones such as gibberellins and IAAs (Khan et al., 2012).

Conclusions

The endophytic strains "*Aspergillus* 1", "*Aspergillus* 3", "*Mycelia sterilia*", "*Chaetomium* 1" and "*Chaetomium* 2" presented the best results in terms of promoting growth of the bromeliad *A. multiflora*, given their positive contribution to all parameters evaluated and statistically significant.

Literature Cited

ABDEL-MOTAAL, F. et al. 2020. Early blight suppression and plant growth promotion potential of the endophyte *Aspergillus flavus* in tomato plant. Annals of Agricultural Sciences 65(2):117-123. https://doi.org/10.1016/j.aoas.2020.07.001

AGUIAR, A. R. et al. 2013. Seleção de isolados de *Trichoderma* spp. na promoção de crescimento de mudas do feijoeiro cv. Carioca e controle de *Sclerotinia sclerotiorum*. Ciência e Natura 34(2*):47-58. Disponível em https://www.redalyc.org/pdf/4675/467547684002. Acesso em 21 Abr. 2021.

AHEMAD, M.; KIBRET, M. 2014. Mechanisms and applications of plant growth promoting rhizobacteria: current perspective. Journal of King saud University-science 26(1):1-20. https://doi.org/10.1016/j.jksus.2013.05.001

ARAÚJO, V. C. et al. 2020. Enhanced growth in nursery of coffee seedlings inoculated with the rhizosphere fungus *Aspergillus niger* for field transplantation. Rhizosphere 15:100236.

ARKHIPOVA, T. N. et al. 2007. Cytokinin producing bacteria enhance plant growth in drying soil. Plant and Soil 292(1):305-315. https://doi.org/10.1007/s11104-007-9233-5

BILAL, L. et al. 2018. Plant growth promoting endophytic fungi *Asprgillus fumigatus* TS1 and *Fusarium proliferatum* BRL1 produce gibberellins and regulates plant endogenous hormones. Symbiosis 76(2):117-127. https://doi.org/10.1007/s13199-018-0545-4

CARDOSO, J. E. et al. 2009. Ocorrência endofítica de *Lasiodiplodia theobromae* em tecidos de cajueiro

e sua transmissão por propágulos. Summa Phytopathologica 35(4):262-266. https://doi.org/10.1590/S0100-54052009000400002

CHAPLA, V. M.; BIASETTO, C. R.; ARAÚJO, A. R. 2013. Fungos endofíticos: uma fonte inexplorada e sustentável de novos e bioativos produtos naturais. Revista Virtual de química, 421-437. https://orcid.org/0000-0001-7616-9652

COLLA, G. et al. 2014. Co inoculation of Glomus intraradices and *Trichoderma atroviride* acts as a biostimulant to promote growth, yield and nutrient uptake of vegetable crops. Journal of the Science of Food and Agriculture 95(8):1706-1715. https://doi.org/10.1002/jsfa.6875

DUTTA, D. et al. 2014. Endophytes: exploitation as a tool in plant protection. Brazilian archives of Biology and Technology, 57(5):621-629.

GRAÇAS, J. P. et al. 2015. Microrganismos estimulantes na agricultura. Piracicaba, SP, ESALQ. 56 (Série Produtor Rural, 59).

HASSAN, S. E. 2017. Plant growth-promoting activities for bacterial and fungal endophytes isolated from medicinal plant of *Teucrium polium* L. Journal of advanced research, 8(6):687-695. https://doi.org/10.1016/j.jare.2017.09.001

HUNG, R.; RUTGERS, S. L. 2016. Applications of *Aspergillus* in plant growth promotion. In: New and Future Developments in Microbial Biotechnology and Bioengineering. Elsevier, p.223-227. https://doi.org/10.1016/B978-0-444-63505-1.00018-X

JOHNSTON-MONJE, D. et al. 2019. Paying the rent: how endophytic microorganisms help plant hosts obtain nutrients. Elsevier. https://doi.org/10.1016/B978-0-444-64046-8.00253-6

KHAN, A. L. et al. 2011. Gibberellins producing endophytic *Aspergillus fumigatus* sp. LH02 influenced endogenous phytohormonal levels, isoflavonoids production and plant growth in salinity stress. Process biochemistry 46(2):440-447.

KHAN, A. L. et al. 2012. Role of endophyte *Chaetomium globosum* lk4 in growth of *Capsicum annuum* by production of gibberellins and indole acetic acid. Pakistan Journal of Botany 44(5):1601-1607.

KHAN, A. L. et al. 2015. Endophytic fungi: resource for gibberellins and crop abiotic stress resistance. Critical reviews in biotechnology, 35(1):62-74.

KUMAR, A. et al. 2020. Entry, colonization, and distribution of endophytic microorganisms in plants. In: Microbial Endophytes. Woodhead Publishing, p.1-33. https://doi.org/10.1016/B978-0-12-819654-0.00001-6

PETRINI, O.; STONE, J.; CARROLL, F. E. 1982. Endophytic fungi in evergreen shrubs in western Oregon: a preliminary study. Canadian Journal of Botany, 60(6):789-796. https://sci-hub.hkvisa.net/10.1139/b82-102

LIMA, A. F. L. de, et al. 2020. Diferentes substratos na formação de mudas de biribazeiro (*Rollinia mucosa* [Jacq.] Bail) em Humaitá, AM. Scientia Plena, 16(7):01-08. https://doi.org/10.14808/sci.plena.2020.070202

SALVATORE, M. M.; ANDOLFI, A.; NICOLETTI, R. 2020. The thin line between pathogenicity and endophytism: The case of *Lasiodiplodia theobromae*. Agriculture 10(10):488. https://doi.org/10.3390/agriculture10100488

SCHULZ, B.; BOYLE, C. 2005. The endophytic continuum. Mycological research, 109(6):661-686. https://doi.org/10.1017/S095375620500273X

SHANG, J.; LIU, B.; XU, Z. 2020. Efficacy of *Trichoderma asperellum* TC01 against anthracnose and growth promotion of *Camellia sinensis* seedlings. Biological Control 143:104205. https://doi.org/10.1016/j.biocontrol.2020.104205

SPAGNOLETTI, F. N. et al. 2017. Dark septate endophytes present different potential to solubilize calcium, iron and aluminum phosphates. Applied Soil Ecology 111:25-32. https://doi.org/10.1016/j.apsoil.2016.11.010

SUDHA, V. et al. 2016. Biological properties of endophytic fungi. Brazilian Archives of Biology and Technology, v.59. https://doi.org/10.1590/1678-4324-2016150436

VURUKONDA, S. S. K. P.; GIOVANARDI, D.; STEFANI, E. 2018. Plant Growth Promoting and Biocontrol Activity of Streptomyces spp. as Endophytes. Revista internacional de ciências moleculares 19(4):952.

YANG, B. et al. 2015. Fungal endophyte *Phomopsis liquidambari* affects nitrogen transformation processes and related microorganisms in the rice rhizosphere. Frontiers in microbiology 6:982. https://doi.org/10.3389/fmicb.2015.00982

WANG, B. et al. 2007. Fungal endophytes of native Gossypium species in Australia. Mycological Research 111(3):347-354.