UNIVERSIDADE FEDERAL DO PARANÁ
BIOFIX Scientific Journal v. 7 n. 2 p. 125-132 2022
DOI: dx.doi.org/10.5380/biofix.v7i2.84091

SOIL FUNGI PROMOTE VIGOR IN SEEDS FROM BRAZILIAN DRY SEASONAL FOREST

FUNGO DE SOLO *PROMOVE VIGOR EM SEMENTES DO BIOMA CAATINGA*

Thiago Costa Ferreira[1], Aldrin Martin Perez Marin[2]

[1]Universidade Estadual da Paraíba, Catolé do Rocha, Paraiba, Brasil – professor.thiagoferreira1@gmail.com
[2]Instituto Nacional do Semiárido, Campina Grande, Paraíba, Brasil – aldrin.perez@insa.gov.br

ABSTRACT

The Brazilian Dry Seasonal Forest (Caatinga Biome) is poorly studied about possible interactions between seeds, seedlings, and *Trichoderma harzianum* strains to promote vegetal vigor in seedlings. So, this research aims to study the *T. harzianum* strain promotion of vigor in different species from Caatinga Biome in nursery. For assays, we used: *Aspidosperma pyrifolium, Cnidoscolus quercifolius, Handroanthus impetiginosus, Pseudobombax marginatum*, and *Tabebuia aurea* species and the *T. harzianum* IBLF 006 based-product-inoculant. We tested these assays in nursery conditions. *T. harzianum* solution (0.5% v/V) was used in the nursery assay (applied over soil after the sowing). For this research, we evaluated variables of vigor and germination and there was a control treatment (non-inoculated). About nursery assay results, there was a positive interaction for all species between seeds and seedlings and *T. harzianum*, except for T. *aurea* and *C. quercifolius*. For all species tested in this research, we suggest that other seed or soil treatments can be tested in environmental Caatinga Biome conditions to expand this knowledge about the interaction between *Trichoderma harzianum* and seedlings and seeds from Caatinga biome.

KEYWORDS: ***Trichoderma harzianum*****, Caatinga Biome, Brazilian Semiarid, Seed Technology.**

RESUMO

A Floresta Estacional Seca Brasileira (Bioma Caatinga) é pouco estudada sobre as possíveis interações entre sementes e mudas com isolados de *Trichoderma harzianum* para promoção de vigor vegetal. Assim, esta pesquisa tem como objetivo estudar a promoção do vigor de *T. harzianum* em diferentes espécies do bioma Caatinga em condições de viveiro. Para os ensaios, foram utilizadas sementes das espécies *Aspidosperma pyrifolium, Cnidoscolus quercifolius, Handroanthus impetiginosus, Pseudobombax marginatum e Tabebuia aurea* e um produto comercial a base de *T. harzianum* IBLF 006. O experimento foi realizado em condições de viveiro. A solução de *T. harzianum* (0,5% v / V) foi aplicada sobre o solo após a semeadura. Sendo avaliadas as variáveis de vigor e germinação, houve um tratamento controle (não inoculado). Sobre os resultados dos ensaios no viveiro, houve interação positiva entre sementes e plântulas com o isolado de *T. harzianum* para todas as espécies estudadas, exceto para *T. aurea* e *C. quercifolius*. Para todas as espécies testadas neste trabalho, pode ser sugerido que outros tratamentos de semente ou solo possam ser testados em condições ambientais do Bioma Caatinga, para expandir o conhecimento sobre a interação entre isolados de *Trichoderma harzianum*, mudas e sementes provenientes do bioma Caatinga.

KEYWORDS: ***Trichoderma harzianum*****, Bioma Caatinga, Semiárido Brasileiro, Tecnologia de Sementes.**

INTRODUCTION

Trichoderma is a common gender soil-borne fungi found in some different biomes around the world. Species of *Trichoderma* have several ecological characteristics such as biological control of other organisms, vegetal growth promotion, breaking of soil substances, and symbiosis (SOUZA et al., 2016). Due to its diversity, some different researchers approach these characteristics for sustainability; some strains are studied nowadays, but for farm production, the *T. harzianum* species is the most studied (SILVA et al., 2020). Zhang et al. (2021) affirm that this gender is an important symbiotic and endophytic, mainly to ecosystem regulation around the world.

Carvalho et al. (2021), Michelena-Álvarez & Martínez-Hernández (2021), and Silva et al. (2021), describe the importance of this fungi gender in symbiosis with plants from the Caatinga, the Brazilian Dry Seasonal Forest, such as a promoter of resistance to the dry season, biological control of pathogens and vegetal growth promotion. On the other hand, the Caatinga is characterized by severe drought events, average luminosity, and high annual temperatures, being adapted to xerophilic conditions, endemism, and high factor of anthropization, and desertification (FERREIRA et al., 2021 a).

Meiado et al. (2012) also describe the need for research with plants from the Caatinga, to improve technologies of conservation and recuperation. And, following Ferreira *et al.* (2021 b), it can be described that this biome is poorly studied and it's breaking down before it's understood. Then, the studies for conservation and recuperation of Caatinga are important for promoting sustainability in this area, and the sustainable production of native species seedlings (FERREIRA et al., 2021a; FERREIRA et al., 2021 b).

Caatinga wood is used to timber and landscaping is the Bignoniaceae group, in this paper. it represented *Handroanthus impetiginosus* (Mart. ex DC.) Mattos (Bignoniaceae), as described by Almeida *et al.* (2020) and Araújo *et al.* (2020), and *Tabebuia aurea* (Silva Manso) Benth. & Hook. f. ex S. Moore (OLIVEIRA et al., 2012; SANTO et al., 2012; BRITO et al., 2021).

Cnidosclus quercifolius Pohl is an important species in the semiarid region because it is used for ethnobotanical (medicament) and forage (DIAS JÚNIOR et al., 2019). *Pseudobombax marginatum* (A. St.-Hil. Juss. & Cambess.) A. Robyns (Malvaceae) is a tree species found in several Brazilian biomes, commercially used to produce fibers, medicines, and timber (AMORIM et al., 2009). *Aspidosperma pyrifolium* Mart. & Zucc. is an important plant species from Caatinga Biome used to timber, cosmetic, and medicinal (FERREIRA & CUNHA, 2000; PEREIRA et al., 2016; ANDRADE JÚNIOR et al., 2020).

The production of seedlings in nurseries has an important role in the revitalization of Caatinga areas and supports commercial forest production. These facts are supported by the perspective of the production of vigorous seeds and seedlings (DANTAS et al., 2020; OLIVEIRA et al., 2020). Then, this research aims to study the *T. harzianum* strain promotion of vigor in different species from Caatinga Biome (*Aspidosperma pyrifolium, Cnidoscolus quercifolius, Handroanthus impetiginosus, Pseudobombax marginatum* and *Tabebuia aurea*).

MATERIAL AND METHODS

Seeds and experimental localization

The assays were realized in the nursery from Semiarid Nacional Institute (Campina Grande, Paraiba State, Brazil) in the second semester of 2021. The region shows the BSh climate classification, with temperature variables between 20to 32°C, for research occasion (FERREIRA et al., 2021a; FERREIRA et al., 2021 b). For these assays, we used *Aspidosperma pyrifolium, Cnidoscolus quercifolius, Handroanthus impetiginosus, Pseudobombax marginatum* and *Tabebuia aurea* seeds ceded by NEMA (Núcleo de Ecologia e Monitoramento Ambiental) for UNIVASF (Universidade Federal do Vale do São Francisco) (Table 1).

Nursery assay

We sowed the seeds in the nursery of soil (Neossolo regolith soil), to protect the environment (somber 50%) (Table 2). The treatments used were *T. harzianum* IBLF 006 SC based-product-inoculant (TRICHODERMIL®, Koppert) was used in nursery assay (applied over the soil after the sowing) in solution (0.5% v/V), according to methodologies describes to Ferreira *et al.* (2020). In this assay, we evaluated variables of vigor and germination and there was a control treatment (non-inoculated).

Due to the experimental assay, we have the variables in the third day after sowing, the variables: emergence speed index (ESI), average emergence time (AET), average emergence speed (AES), and dry weight variable (DW), according to Ferreira *et al.* (2021 a). The percentage variables of emergence in 14 (14 E), 21 (21 E), and 28 (28 E) days of sowing were analyzed according to Ferreira et al. (2021 b).

Table 1. Family botanical, genus, species, geographic parameters, and germination of seeds used in this research.

Family	Gender	Species	Localization	Latitude	Longitude	Altitude (m)	Germination (%)
Apocynaceae	*Aspidosperma*	*pyrifolium*	Pernambuco| Petrolina	-8.77	-40.53	418	97
Bignoniaceae	*Handroanthus*	*impetiginosus*	Ceará| Brejo Santo	-7.59	-38.88	409	91
Bignoniaceae	*Tabebuia*	*aurea*	Pernambuco| Petrolina	-9.32	-40.55	390	83
Euphorbiaceae	*Cnidoscolus*	*quercifolius*	Pernambuco| Floresta	-8.55	-38.04	457	71
Malvaceae	*Pseudobombax*	*marginatum*	Pernambuco| Salgueiro	-8.12	-39.19	441	86

Fonte: NEMA.

Table 2. Chemical characters from substrate of nurseries (0-20 cm deep).

pH	P	K^+	Na^+	$H^+ + Al^{+3}$	Al^{+3}
H_2O (1:2,5)	mg.dm³		-------------------------------- cmolc.dm³ ------------------------		
5.4	3.3	98.09	0.11	3.37	0,2
Ca^{+2}	**Mg^{+2}**	**V%**	**CTC**	**OM**	
-------------------------------- cmolc.dm³ --------------------------------				g.kg	
3.34	0.32	54.4	7.39	6.46	

P, K, Na: Extractor 1 of Mehlich; H + Al: Extrator Ca acetatate 0,5 M, pH 7,0; pH 7,0; Extractor Al, Ca, Mg: KCl 1 M; OM: Organic Matter - Walkley-Black; V% (FERREIRA et al., 2021).

Statistical analyses

The treatments were analyzed using the Chi-square analysis (X^2), at 5% significance, the test was performed at a significance level of 5%, and in this case, H0 is rejected when p-value ≤ 0.05 and accepts H0 otherwise. Also, the means obtained were treated using non-parametric statistics (mean per treatment, general mean, coefficient of variation, standard error, and deviation).

RESULTS AND DISCUSSION

About the emergence at 14 days after sowing variable (14 E) results we would observe that in all vegetal species there were significant differences between the treatments, except *A. pyrifolium* species. The *T. harzianum* presence promotes the best average to *C. quercifolius*, and there were positive Pearson Correlations to *T. aurea* species for this variable (Table 3).

Regarding the percentage of emergence at 21 days after sowing variable results (21 E), for all vegetal species there were significant differences between the treatments, except to *A. pyrifolium* seeds; The *T. harzianum* presence promotes the best average all species, except to *A. pyrifolium* seeds (Table 3).

About the percentage of emergence at 28 days after sowing variable (28 E), for all vegetal species there were significant differences between the treatments and the *T. harzianum* presence promotes the best average for *C. quercifolius* and *P. marginatum* seeds (Table 3).

About the Emergence Speed Index variable (ESI), for all vegetal species, there were significant differences between treatments, except to *Tabebuia area* seeds. *T. harzianum* presence promotes the best average to *Tabebuia area* and *C. quercifolius* seeds, and there were positive Pearson Correlations to all species for this variable (Table 3).

Regarding the Average emergence time Index variable (AET), for all vegetal species, there were significant differences between the treatments and the *T. harzianum* presence promotes the best average of all species, except to *H. impetiginosus* and *T. aurea* seeds (Table 3).

Concerning the average time index (AES), for all vegetal species studied there were significant differences following between the treatments and the *Trichoderma harzianum* presence promotes the best average for all species, except to *Tabebuia aurea* (Table 3).

And about the dry weight variable (DW), in all the species there were statisticals differences between the treatments, and the promotion of biomass production to *Trichoderma* present were better than the control Regarding the variable dry weight, all species, differences between treatments; the presence of *Trichoderma* promoted better mean in the species *Anadenanthera colubrina, Handroanthus impetiginosus,* and *Cnidoscolus quercifolius.* The importance of contextualized studies about the forest production in Caatinga biome areas in its summary to the sustainable development of semi-arid regions, in accordance with Carvalho et al. (2021) (Table 3).

Table 3. Averages and nonparametric statistic to variables Emergence Speed Index (ESI), Average Emergence Time (AET), Average Emergence Speed (AES), Dry Weight Variable (DW), And Percentage Variables of Emergence in 14 (14 E), 21 (21 E), and 28 (28 E) on seeds of *Aspidosperma pyrifolium, Cnidoscolus quercifolius, Handroanthus impetiginosus, Pseudobombax marginatum*, and *Tabebuia aurea* sowing on nursery with soil treated or non-treated with *Trichoderma harzianum*.

	E14	E21	E28	ESI	AET	AEI	DW
		%			Index		g.plant^{-1}
		Cnidoscolus quercifolius					
Control	55.00	62.00	66.00	2.31	16.49	0.06	1.70
Trichoderma harzianum	49.00	60.00	61.00	2.13	15.25	0.07	1.58
Chi-square test	0.34	0.76	0.39	0.30	0.36	0.33	0.80
Standard deviation	9.56	6.68	7.84	0.22	2.32	0.01	0.51
Coefficient of variation (%)	18.39	10.94	12.34	10.01	14.62	12.56	30.88
Average	52.00	61.00	63.50	2.22	15.87	0.06	1.64
Pearson Correlation	0.52	-0.48	0.26	0.21	0.67	0.71	-0.21
		Handroanthus impetiginosus					
Control	52.00	68.00	65.00	2.32	17.33	0.06	0.68
Trichoderma harzianum	66.00	57.00	69.00	2.65	15.28	0.07	0.62
Chi-square test	0.07	0.15	0.39	0.01	0.32	0.32	0.53
Standard deviation	11.66	10.24	10.20	0.34	2.57	0.01	0.36
Coefficient of variation (%)	19.77	16.38	15.22	13.49	15.76	14.57	55.60
Average	59.00	62.50	67.00	2.49	16.30	0.06	0.65
Pearson Correlation	0.65	0.25	0.74	0.92	0.08	0.26	0.99
		Pseudobombax marginatum					
Control	70.00	81.00	84.00	2.96	20.08	0.05	0.54
Trichoderma harzianum	73.00	71.00	74.00	3.17	17.21	0.06	0.61
Chi-square test	0.75	0.28	0.19	0.56	0.19	0.18	0.57
Standard deviation	10.13	11.11	9.97	0.36	2.61	0.01	0.12
Coefficient of variation (%)	14.16	14.62	12.62	11.73	14.02	13.04	20.29
Average	71.50	76.00	79.00	3.07	18.64	0.05	0.58
Pearson Correlation	-0.29	-0.04	0.18	-0.42	-0.14	-0.08	-0.82

Table 3. Averages and nonparametric statistic (Cont...).

	E14	E21	E28	ESI	AET	AEI	DW
		%			Index		g.plant-1
			Tabebuia aurea				
Control	63.00	71.00	71.00	2.96	18.14	0.06	0.50
Trichoderma harzianum	65.00	71.00	73.00	2.80	16.00	0.06	0.70
Chi-square test	0.88	1.00	0.80	0.62	0.29	0.30	0.18
Standard deviation	11.51	8.21	8.28	0.31	1.95	0.01	0.22
Coefficient of variation (%)	17.99	11.57	11.50	10.85	11.45	11.21	36.24
Average	64.00	71.00	72.00	2.88	17.07	0.06	0.60
Pearson Correlation	-0.90	0.39	-0.39	-0.79	-0.95	-0.91	0.66
			Aspidosperma pyrifolium				
Control	52.00	67.00	62.00	2.60	16.61	0.06	0.49
Trichoderma harzianum	69.00	83.00	74.00	3.27	16.62	0.06	0.49
Chi-square test	0.02	0.21	0.34	0.00	1.00	0.99	0.98
Standard deviation	10.13	14.46	13.35	0.41	3.05	0.01	0.16
Coefficient of variation (%)	16.74	19.28	19.64	13.91	18.33	19.94	32.05
Average	60.50	75.00	68.00	2.94	16.61	0.06	0.49
Pearson Correlation	0.00	-0.24	-0.56	0.70	-0.70	-0.66	-0.73

Michelena-Álvarez & Martínez-Hernández (2021) affirm that the actions of recuperations and wood production in Caatinga area areas are incipient because technologies adapted to the conditions, achievements, and possibilities of the region are lacking in the literature. Nevertheless, Silva et al. (2021), the use of environmental management that promotes the symbiosis organism and native plants from the Caatinga biome is poorly studied (DANTAS et al., 2019; DANTAS et al., 2020). In this paper (Table 3), we argued about the interaction between the *Trichoderma harzianum* strain and important species from the Caatinga biome.

Ferreira et al*.* (2021 a), declare that nursery production supports forest production, since continuing with extractivism is not sustainable for the Earth. Meiado et al. (2012), Ferreira et al. (2021 b), and Silva et al. (2021) are necessary for the conservation and recuperation of Caatinga and the promotion of seed technologies adapted for this land (Table 3). Adding to this idea, Ferreira et al. (2021 b) affirm that the Caatinga biome is an emerging location in the recovery of its areas, due to the loss of biodiversity, low development economical, and social and environmental problems.

For Carvalho et al. (2021), Michelena-Álvarez & Martínez-Hernández (2021) the presence of *Trichoderma* species such as symbiotic in the Caatinga can viabilize the utilization this gender in projects of forest production. Carvalho et al. (2021) describe that *Trichoderma* strains from the Caatinga can be an evolutionary ratio between the local vegetation. *Trichoderma harzianum,* used in this paper is an important species found in forest (SOUZA et al., 2016), with the importance of the control of other organisms, vegetal growth promotion, breaking of soil substances, and symbiosis, according to writings of Silva et al. (2020). The *T. harzianum* IBLF 006 is a strain described in the literature such as a vegetal growth promoter in lettuce (PEREIRA et al., 2019), *Jacaranda* mimosifolia (FERREIRA et al., 2021 c), and Moringa oleifera (FERREIRA et al., 2020). Oliveira et al. (2019), describe that the *T. harzianum* IBLF 006 strain is resistant to high temperatures and ultraviolet radiation, a factor important to be considered in Caatinga conditions, such as for Silva *et al.* (2021). The results for each of the species studied in this research will be discussed below (Table 3).

About the *Handroanthus impetiginosus* the interaction is positive (Table 3), possibly a great emergence and vigor, as described by Almeida et al. (2020) and Araújo et al. (2020). The *H. impetiginous* seeds are light and with great cellulose content, what it confers for then the possibility to dispersion more saturated. Almeida et al. (2020) and this may be the proposal that promotes the positive interaction between its *T. harzianum* strain.

The results obtained to *Pseudobombax marginatum* are so positive to interaction and use of *Trichoderma* on nursery soil (TableS 2 and 3), probably the mucilages produced for these seeds in the emergence (AMORIM et al., 2009) promote a good place for colonization of *T. harzianum* and this microorganism promotes a positive interaction, according to Michelena-Álvarez & Martínez-Hernández (2021).

Also, for *Aspidosperma pyrifolium* the presence of *T. harzianum* is positive, probably to the low tanines counts, and the morphology of seeds taht help to *Trichoderma* to open to internals tissue of seeds (FERREIRA & CUNHA, 2000; PEREIRA et al., 2016; ANDRADE JÚNIOR et al., 2020) (Table 3).

About *Tabebuia aurea* and *Cnidoscolus quercifolius* species (Table 3) the interactions were negative, probably for interactions between these seeds, inherent to the natural constitution (DANTAS et al., 2019; DANTAS et al., 2020). For example, the seed of *Tabebuia aurea* produces a pigment in emergence to repel insects and other microorganisms, it can be dangerous to *T. harzianum* too (OLIVEIRA et al., 2012; SANTO et al., 2012; BRITO et al., 2020). Seeds of *Cnidoscolus quercifolius* are made up of oil content (DIAS JÚNIOR et al., 2019). Although the microbiome present in the seeds of this lot may repel some microorganisms, because there was an intimate ecological action between species from Caatinga and other microorganisms, such as describe Carvalho et al. (2021) and Michelena-Álvarez & Martínez-Hernández (2021).

CONCLUSIONS

About the results, there was a positive interaction for all species between seeds and seedlings and *T. harzianum*, except for T. *aurea* and *C. quercifolius*. For all species tested in this paper, we suggest that other seed or soil treatments can be tested in environmental conditions to expand this knowledge about the interaction between *Trichoderma harzianum* and seedlings and seeds from Caatinga.

CONGRATULATIONS

We are grateful to CNPq, MCTIC and INSA for the opportunity to conduct this research. Also, we would also like to thank the group of Ecology and Environmental Monitoring - NEMA / UNIVASF, the Project for the Integration of the São Francisco River with the Hydrographic Basins of the Northeast Northeast - PISF and the Ministry of Regional Development - MDR for the availability of the seeds and for the kindness in providing material used in this research. More information about this group can be viewed on the website (accessed on 10/13/2021): http://www.nema.univasf.edu.br/site/index.php?page=home

REFERENCES

ALMEIDA, R.S. et al. Emergência e vigor de *Handroanthus impetiginosus* (Mart. ex DC.) Mattos em função de diferentes tempos de imersão em água. **Revista Brasileira de Gestão Ambiental e Sustentabilidade**, v.7, n.15, p.31-41, 2020.

ANTUNES, C.G.C. et al. Germinação de sementes de *Caesalpinia pyramidalis* Tul. (Catingueira) submetidas a deficiência hídrica. **Revista árvore**, v.35, p.1007-1015, 2011.

ARAÚJO, M.A.S. et al. Conservação de sementes de *Handroanthus impetiginosus* (Mart. ex DC.) Mattos. **Cadernos de Agroecologia**, v.15, n.4, 2020.

BISPO, J.S. et al. Size and vigor of *Anadenanthera colubrina* (Vell.) Brenan seeds harvested in Caatinga areas. **Journal of Seed Science**, v.39, n.4, p.363-373, 2017.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Manual de Análise de Sementes**. Ministério da Agricultura. Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. – Brasília: Mapa/ACS, 2009.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Instrução para a Análise de Sementes de Espécies Florestais.** Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. – Brasília: Mapa/ACS, 2013.

BRITO, W.L. et al. Avaliação da viabilidade de sementes de *Tabebuia aurea* por meio do teste de tetrazólio. **Revista Caatinga**, v.33, n.4, p.993-999, 2020.

CÂMARA, T. et al. Effects of chronic anthropogenic disturbance and rainfall on the specialization of ant–plant mutualistic networks in the Caatinga, a Brazilian dry forest. **Journal of Animal Ecology**, v.87, n.4, p.1022-1033, 2018.

CARVALHO, C.R. et al. Diversity, Ecology, and Bioprospecting of Endophytic Fungi in the Brazilian Biomes of Rupestrian Grasslands, Caatinga, Pampa, and Pantanal. In: **Neotropical Endophytic Fungi: Diversity, Ecology, and Biotechnological Applications**, Spring, p.151-170, 2021.

CORREIA, L.A.D.S. et al. Morphometric descriptors and physiological seed quality for selecting *Aspidosperma pyrifolium* Mart. matrix trees. **Revista Caatinga**, v.32, n.3, p.751-759, 2019.

DANTAS, B.F. et al. Biosaline production of seedlings of native species from the Caatinga dry forest. **Ciência Florestal**, v.29, p.1-17, 2019.

DANTAS, B.F. et al. Rainfall, not soil temperature, will limit the seed germination of dry forest species with climate change. **OECOLOGIA**, v.192, p.529-541, 2020.

ANDRADE JÚNIOR, F.P. et al. Botanical, agronomic, phytochemical and biological characteristics of *Aspidosperma pyrifolium* Mart.: A review. **Research, Society and Development**, v.9, n.7, p.e14973784, 2020.

FERREIRA, N.C.F. et al. Trichoderma spp. in Growth Promotion of *Jacaranda Mimosifolia* D. Don. **Journal of Agricultural Studies**, v.9, n.2, p.335-346, 2021.

SOUZA, J.T. et al. Plants from the Caatinga biome harbor endophytic *Trichoderma* species active in the biocontrol of pineapple fusariosis. **Biological control**, v.94, p.25-32, 2016.

FELIPPI, K.G.M. et al. Germinação de sementes de *Aspidosperma parvifolium* A. DC. em função de diferentes formas de coleta. **Ciência Florestal**, v.26, n.3, p.979-984, 2016.

FERREIRA, A.S. et al. Production of *Pityrocarpa moniliformis* (Benth.) Luckow & RW Jobson (Fabaceae) seedlings irrigated with saline water. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.25, p.182-188, 2021.

FERREIRA, R.A.; CUNHA, M.C.L. Aspectos morfológicos de sementes, plântulas e desenvolvimento da muda de craibeira (*Tabebuia caraiba* (Mart.) Bur.) - Bignoniaceae e pereiro (*Aspidosperma pyrifolium* Mart.) - Apocynaceae. **Revista Brasileira de Sementes**, v.22, p.134-143, 2000.

FERREIRA, T.C. et al. Tratamento de solo com *Trichoderma harzianum* para a promoção de vigor em sementes e plântulas de *Moringa oleifera*. **Cadernos de Agroecologia**, v.15., 2000.

FERREIRA, T.C. et al. Hydropriming para a promoção da emergência e do vigor em sementes provenientes de populações do bioma Caatinga. **Research, Society and Developmen**t, v.10, n.4, p.e17910414142, 2021.

FERREIRA, T.C. et al. Ultrasound and water immersion to promoting vigor in seeds and seedlings of *Cnidoscolus quercifolius*. **BIOFIX Scientific Journal**, v.6, n.1, p.69-74, 2021.

MATIAS, J.R. et al. Germination of *Cenostigma pyramidale* seeds under different temperatures and salinities. **Informativo ABRATES**, v.28, n.1, p.115-118,2018.

MEIADO, M.V. et al. Flora of the caatingas of the São Francisco River: natural history and conservation**. Diaspore of the caatinga: a review**. Rio de Janeiro: A. J. Estúdio Editorial, 2012.

MELO, L.D.F.A. et al. Temperature and substrate effects on the germination of Caesalpinia ferrea Mart. Ex Tul. **African Journal of Agricultural Research**, v.12, n.47, p.3348-3354, 2017.

OLIVEIRA, J.V. et al. Fauna and conservation in the context of formal education: a study of urban and rural students in the semi-arid region of Brazil. **Journal of Ethnobiology and Ethnomedicine**, v.16, p.1-12, 2020.

OLIVEIRA, K.N. et al. Ontogenetic and temporal variations in herbivory and defense of *Handroanthus spongiosus (Bignoniaceae*) in a Brazilian tropical dry forest. **Environmental entomology**, v.41, n.3, p.541-550, 2012.

OLIVEIRA, L.L.B. et al. Influência da temperatura e radiação ultravioleta no desenvolvimento de isolados de *Trichoderma* spp. **Revista Brasileira de Meteorologia**, v.34, p.423-430, 2019.

PEREIRA, F.T. et al. Growth promotion and productivity of lettuce using *Trichoderma* spp. commercial strains. **Horticultura Brasileira**, v.37, p.69-74, 2019.

REZA-ESCANDÓN, S.E. et al. Biocontrol by Trichoderma spp. as a Green Technology for the Agri-Food Industry. In: **Green Materials and Environmental Chemistry**. Apple Academic Press, 2021.

SANTO, F.S.E. et al. Two new species of *Handroanthus Mattos* (*Bignoniaceae*) from the state of Bahia, Brazil. **Acta Botanica Brasileira**, v. 26, n.3, p.651-657, 2012.

SILVA, J.H.C.S. et al. Emergência de plântulas e vigor de sementes de *Anadenanthera colubrina* (Vell.) Brenan (Fabaceae) em diferentes substratos e profundidades de semeadura. **Caderno Verde de Agroecologia e Desenvolvimento Sustentável**, v.9, n.7, p.7054, 2019.

SILVA, H.F. et al. Bioprospection of *Trichoderma spp*. originating from a Cerrado-Caatinga ecotone on *Colletotrichum truncatum*, in soybean. **Revista Brasileira de Ciências Agrárias (Agrária)**, v.15, n.1, 2020.

SILVA, R.M. et al. Biometric aspects of fruit and seed of Caesalpinia ferrea Mart. ex Tul. from semiarid baiano. **Revista de Agricultura Neotropical**, v.4, n.3, p.85-91, 2017.

SILVA, H.F. et al. Molecular identification and phylogenetic analysis of Trichoderma isolates obtained from woody plants of the semi-arid of Northeast Brazil. **Nova Hedwigia**, v.3, p.485-500, 2021.

WALTER, L.S. et al. Influência de tratamentos pré-germinativos e crescimento inicial de plântulas de *Libidibia ferrea*. **Pesquisa Florestal Brasileira**, v.38, p.55-70, 2018.

ZHANG, F. et al. Medicago sativa and soil microbiome responses to Trichoderma as a biofertilizer in alkaline-saline soils. **Applied Soil Ecology**, v.153, p.103573, 2020.

Recebido em 20-12-2021 *Aceito em 08-03-2022*