As Regiões Semiáridas e suas Especificidades

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APRESENTAÇÃO

A obra "*As Regiões Semiáridas e suas Especificidades*" aborda uma série de livros de publicação da Atena Editora, em seu I volume, apresenta, em seus 24 capítulos, com conhecimentos tecnológicos das regiões semiáridas e suas especificidades.

As Ciências estão globalizadas, englobam, atualmente, diversos campos em termos de pesquisas tecnológicas. O semiárido brasileiro tem característica peculiares, alimentares, culturais, edafoclimáticas, étnicos, entre outros. Tais, diversidades culminam no avanço tecnológico, nas áreas de Agronomia, Engenharia Florestal, Engenharia de Pesca, Medicina Veterinária, Zootecnia, Engenharia Agropecuária e Ciências de Alimentos que visam o aumento produtivo e melhorias no manejo e preservação dos recursos naturais, bem como conhecimentos nas áreas de políticas públicas, pedagógicas, entre outros. Esses campos de conhecimento são importantes no âmbito das pesquisas científicas atuais, gerando uma crescente demanda por profissionais atuantes no semiárido brasileiro e, também nas demais regiões brasileiras.

Este volume dedicado à diversas áreas de conhecimento trazem artigos alinhados com a região semiárida brasileira e suas especificidades. As transformações tecnológicas dessa região são possíveis devido o aprimoramento constante, com base em novos conhecimentos científicos.

Aos autores dos diversos capítulos, pela dedicação e esforços sem limites, que viabilizaram esta obra que retrata os recentes avanços científicos e tecnológicos, os agradecimentos do Organizador e da Atena Editora.

Por fim, esperamos que este livro possa colaborar e instigar mais estudantes e pesquisadores na constante busca de novas tecnologias para o semiárido brasileiro, assim, garantir perspectivas de solução para o desenvolvimento local e regional para as futuras gerações de forma sustentável.

Alan Mario Zuffo

SUMÁRIO

CAPÍTULO 6

ALELOPATIC ACTION OF BRAZILIAN SEMIARID SPECIES ALTER THE GERMINATION IN *Lactuca sativa* L. (Asteraceae)

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RESUMO: A alelopatia é caracterizada pelo efeito que uma planta pode causar em outra, e pode influenciar a germinação ou o desenvolvimento de outras espécies, através de compostos químicos liberados no meio ambiente. Assim, o objetivo deste trabalho foi avaliar a ação alelopática de extratos aquoso e etanólico de *Bauhinia forficata*, *Mimosa tenuiflora* e *Tabebuia aurea* sobre a germinação de *Lactuca sativa*. Extratos aquosos e etanólicos foram preparados a partir das folhas das três espécies testadas. Para os extratos aquosos as diluições foram utilizadas em água destilada: 20, 40, 60, 80 e 100%. Já para os extratos etanólicos nas concentrações: 2,4,6,8 e 10 mg / mL. Água destilada foi usada como controle. No germinador, as sementes foram submetidas a temperatura de 25 °C, fotoperíodo de 12 horas. Foram avaliados o percentual de germinação (% G), índice de velocidade de germinação (GSI) e tempo médio de germinação (AGT). Os extratos aquosos de *B. forficata, M. tenuiflora e T. aurea* reduziram a porcentagem de germinação das sementes de L. sativa, enquanto o extrato etanólico reduziu a porcentagem de germinação apenas quando *T. aurea* foi utilizado. O IVG foi reduzido com o uso dos extratos aquoso e etanólico *de B. Forficata, M. tenuiflora* e *T. aurea*, bem como o aumento do TMG com os extratos aquoso e etanólico das três espécies testadas. Portanto, os extratos aquoso e etanólico de *B. orficata, M. tenuiflora* e *T. aurea* apresentam efeito alelopático sobre a *L. sativa*.

PALAVRAS-CHAVE: Alelopatia. Alface. *Bauhinia forficata*. *Mimosa tenuiflora*. *Tabebuia*

aurea.

ABSTRACT: Allelopathy is characterized by the effect that a plant can cause on another, and can influence the germination or development of other species, through chemical compounds released into the environment. Thus, the aim of this paper was to evaluate the allelopathic action of aqueous and ethanolic extracts of *Bauhinia forficata, Mimosa tenuiflora* and *Tabebuia aurea* on *L. sativa* germination. Aqueous and ethanolic extracts were prepared from the leaves of the three species tested. For the aqueous extracts the dilutions were used in distilled water: 20, 40, 60, 80 and 100%. Already for the ethanolic extracts in the concentrations: 2,4,6,8 and 10 mg / mL. Distilled water was used as the control. In the germinator, the seeds were submitted to a temperature of 25 ºC, photoperiod of 12 hours. The percentage of germination (% G), germination speed index (GSI) and average germination time (AGT) were evaluated. The aqueous extracts of *B. forficata*, *M. tenuiflora* and *T. aurea* reduced the percentage of *L. sativa* germination seeds, whereas the ethanolic extract reduced germination percentage only when T. aurea was used. The IVG was reduced with the use of the aqueous and ethanolic extracts of B. Forficata, M. tenuiflora and T. aurea, as well as the increase of the TMG with the aqueous and ethanol extracts of the three species tested. Therefore, the aqueous and ethanolic extracts of *B. forficata, M. tenuiflora* and *T. aurea* present allelopathic effect on *L. sativa*.

KEYWORDS: Allelopathy. Lettuce. *Bauhinia forficata*. *Mimosa tenuiflora*. *Tabebuia aurea.*

INTRODUCTION

The term allelopathy was first proposed by Molish in 1937, meaning from the Greek allelon = from one to another, pathós = suffer (ALBUQUERQUE et al., 2011). This phenomenon refers to the inhibitory or stimulatory effect that one species can cause on another, through the release of chemical compounds that are released into the environment (MATIAS et al., 2017; ZHANGA et al., 2016). These compounds (allelochemicals) are derived from secondary metabolites and can be found in different concentrations in various parts of plants such as leaves, stems, roots, rhizomes, seeds, flowers and even pollen (ALBUQUERQUE et al., 2011, CRUZ-SILVA et al., 2015).

The discovery of new chemical molecules from extracts of native species with herbicidal activity is an alternative in the control of agricultural ecosystems, since numerous allelopathic researches are carried out to replace synthetic herbicides and can be used to improve the sustainability of production systems and the conservation of natural vegetation (WANDSCHEER et al., 2011).

The term semi-arid involves a climatic reference, which marks a characteristic of the ecosystem of this region, which is the low rainfall index, that is to say, less than 800 mm a year and as representative of this vast ecosystem is the Caatinga (TEIXEIRA, 2015).

In the Caatinga, vegetation characteristic of Brazil's semi-arid region, there is a great diversity of plants, of which it has already been proven that some species have high allelopathic potential (CENTENARO et al., 2009, COELHO et al., 2011, OLIVEIRA et al., 2009). Among the various species of the Alagoano Semi-arid, we can highlight the *Bauhinia forficata* Link, *Mimosa tenuiflora* Willd. Poir and *Tabebuia aurea* (Silva Manso) Benth. & Hook. f. (S), which are species with allelopathic potential, but few studies have been carried out to determine the best structures (leaves, fruits, stems, roots, etc.) and which concentrations and extractors to use, to better use the allelochemical potential of these species, and thus reduce the use of environmentally harmful synthesized chemicals.

The species *B. forficata* and *M. tenuiflora* belong to the Fabaceae family and *T. aurea* belongs to the Bignoniaceae family. The species *B. forficata* also known as pata-de-vaca presents arboreal or shrub size, with white flowers and fruits of the linear pod type. Because it is a native species, it is widely used in folk medicine, where its leaves and flowers are used to control diabetes (LORENZI, 2008).

M. tenuiflora, also known as jurema-preta, is a 4-6 m shrub or tree, with a sparse, irregular crown of new branches with viscous hairs (LORENZI, 2009). It is typical of Brazilian semi-arid and appreciated for its fodder potential, energy and medicinal properties, as in the treatment of wounds, acne and skin burns (SOUZA, 2008). *T. aurea*, known as a craibeira, has a high density of 12 to 20 m in height. Its yellow flowers are extremely ornamental, being considered the flower-symbol of the State of Alagoas. In Brazil it occurs in the Cerrado, Caatinga, Amazônia and Pantanal, besides Bolivia, Argentina, Paraguay, Peru and Suriname (LORENZI, 2009).

Due to the great biodiversity that exists in the most diverse Biomes of Brazil, and in particular attention to the Caatinga, which generates innumerable possibilities of accomplishment of scientific investigations in depth in the questions of allelopathy, since, species like craibeira, jurema-preta and pata-de-vaca are used in bioassays with the preparation of plant extracts tested in the laboratory, with possible stability studies of these molecules so that they can be more efficient when tested in the field and act similarly as natural herbicides, affecting the germination and development of the seedlings, playing a decisive role in weed control (ARAÚJO; ESPIRITO SANTO; SANTANA, 2010).

The objective of the present article was to evaluate the allelopathic effect of aqueous and ethanolic extracts of *B. forficata*, *M. tenuiflora* and *T. aurea* on *Lactuca sativa* germination.

MATERIAL AND METHODS

The experiment was carried out at the Laboratory of Plant Physiology and Organic

Chemistry of the Federal University of Alagoas (UFAL) - Arapiraca *Campus*, Alagoas, Brazil from July 2015 to April 2016. Matrix leaves were collected from *B. forficata*, *T. aurea* and *M. tenuiflora*, in the municipality of Arapiraca, is located to the west of the state capital, distant of this about 128 km, under coordinates 09 ° 42'01.4 "S; 36 ° -41 ° 14.0 ° W; and elevation of 264 m. In the experiment, fresh and dried leaves of the three species were used. The leaves were dried in a forced air circulation oven (Model TE-394/7, New Organic, Brazil), at a temperature of 60 ºC, for a period of 3 days. As a model organism we used seeds of *L. sativa* (lettuce) variety cv. 'saia veia'.

Preparation of the aqueous extract: fresh and dried leaves of *B. forficata*, *M. tenuiflora* and *T. aurea were* used. The fresh leaves were crushed with the aid of a Philips multiprocessor, power of 600 W, to the total homegeneration of the plant material (100 g of leaves and 400 ml of distilled water). The extract was filtered with the aid of funnel and filter paper, which is considered the crude extract. The dried leaves were ground in a mill (model OLSB, Nova Orgânica, Brazil), using 20g of crushed leaves to 380 ml of distilled water. For each crude extract (100%) the percentages of dilutions were made: 20%, 40%, 60% and 80%.

For the ethanolic extract, 100 g of crushed dried leaves were used for 200 ml of ethyl alcohol (98%), for a period of seven consecutive days using the cold remacheration technique (12). The ethyl alcohol was then removed using a rotary evaporator (model 801, Fisatom, Brazil), affording a powder which after addition of water gave the following concentrations 10, 8, 6, 4 and 2 mg mL^{-1}.

The pH of the aqueous and ethanolic extracts of the three plant species was measured using a bench pHmeter (model W3B, BEL Engineering, Italy). Electrical conductivity (EC) was measured using a portable conductivity meter (model CD-4301, Lutron, USA). The osmotic potential (Ψo) of the solutions was measured using a vapor pressure osmometer (model Vapro 5520, Wescor, USA), followed by the application of the Van't Hoff equation, whose values, initially expressed in atmospheres, were converted to Mpa: Ψo = -RTC Where: Ψo = Osmotic potential of the saline solution (atm); R = Universal gas constant (0.082 atm. $ºK^{-1}.L.mol^{-1}$); T = Absolute solution temperature (°K); C = Concentration of solutes in the solution (mol L^{-1}).

The allelopathic action tests were performed on Petri dishes (150 mm x 15 mm), in which two sheets of filter paper were placed moistened with 7.33 ml of the aqueous or ethanolic extract and distilled water as a control treatment. The filter papers inside the Petri dishes were moistened with distilled water whenever necessary to maintain moisture.

Fifty seeds of lettuce, with four replicates, were sown in each plate. The plates were distributed and placed in chamber type BOD (model SP225, LABOR, Brazil) with temperature at 25ºC and constant light, being observed germinated seeds each 24 hours (first count) for seven days.

The germination criterion was established according to the Rules for Seed Analysis (BRASIL, 2009). The percentage of germination was evaluated until the 7th day after sowing, simultaneously the germination speed index (GSI), and the average germination time (AGT), were measured. The percentage of germinated seeds was calculated using the formula described by Labouriau and Valadares (1976). The average germination time was evaluated according to the formula by Maguire (MAGUIRE, 1962). The mean germination time was calculated using the formula proposed by Labouriau (1983).

The results of the germination tests were submitted to ANOVA and the means were adjusted through the polynomial Regression at 5% probability using the SISVAR® version 5.1 5.3Build 77 (FERREIRA, 2014).

RESULTS AND DISCUSSION

The aqueous and ethanolic extracts of *B. forficata*, *M. tenuiflora* and *T. aurea* presented pH, electrical conductivity (EC) and osmotic potential (Ψo) within the values considered normal, between three and seven (MARSCHIN-SILVA; ÁQUILA, 2006), the pH is in the range of 4.93 to 6.91; EC between 0.24 and 2 dS and osmotic potential (Ψo) does not exceed -0.151 MPa, and these are not responsible for the interference in the germination process of lettuce (Table 1).

Treatment	Aqueous						Ethanolic		
	Fresh			Dry			Dry		
	pH	C.E.(dS)	Ψo(MPa)	pH	C.E.(dS)	Ψo(MPa)	pH	C.E.(dS)	Ψo(MPa)
C	6,90	0,04	-0,110	6,90	0,04	-0,110	6,90	0,04	-0,110
B1	6,26	0,40	-0,090	6,44	0,45	-0,087	5,68	0,28	-0,062
B2	6,25	0,82	-0,098	6,43	0,89	-0,094	6,23	0,44	-0,071
B3	6,21	1,32	-0,110	6,48	1,05	-0,110	6,32	0,56	-0,077
B4	6,18	1,74	-0,123	6,51	1,41	-0,128	6,35	0,67	-0,079
B5	6,00	1,98	-0,140	6,55	1,99	-0,131	6,40	0,75	-0,087
T1	6,40	0,76	-0,085	6,66	0,66	-0,085	6,15	0,31	-0,062
T2	6,42	1,01	-0,097	6,68	0,98	-0,095	6,13	0,44	-0,071
T3	6,30	1,39	-0,114	6,68	1,33	-0,106	5,79	0,56	-0,077
T4	6,25	1,66	-0,124	6,68	1,74	-0,123	5,73	0,80	-0,079
T5	6,20	2,00	-0,149	6,69	1,97	-0,132	5,43	0,82	-0,087
M1	6,15	0,45	-0,078	6,88	0,22	-0,083	6,91	0,24	-0,073
M2	5,91	0,86	-0,098	6,54	0,52	-0,095	6,49	0,50	-0,078
M3	5,78	1,34	-0,144	6,35	0,95	-0,105	6,31	0,54	-0,080
M4	5,73	1,74	-0,140	6,24	1,33	-0,115	5,54	0,60	-0,082
M5	5,82	1,98	-0,151	6,12	1,87	-0,130	4,93	0,70	-0,088

Table 1 - Physico-chemical characteristics of aqueous and ethanolic extracts from leaves of *B. forficata*, M. tenuiflora and T. aurea.

EC: Electrical conductivity; Ψo: Osmotic potential; C: control (distilled water); B1: B. forficata 20%; B2: B. forficata 40%; B3: B. forficata 60%; B4: B. forficata 80%; B5: B. forficata 100%; T1: T. aurea 20%, T2: T. aurea 40%, T3: T. aurea 60%, T4: T. aurea 80%, T5: T. aurea 100%; M1: M. tenuiflora 20%; M2: M. tenuiflora 40%; M3: M. tenuiflora 60%; M4: M. tenuiflora 80%; M5: M. tenuiflora 100%.

The decrease percentage of germination in lettuce seeds was not due to the pH of the extracts, since the lettuce presents a wide pH range for germination, (MARSCHIN-SILVA; ÁQUILA, 2006). The osmotic potential did not interfere with germination, as it did not exceed -0.2 MPa. The evaluation of the pH is important when the constitution of sugars, amino acids, organic acids, ions and other molecules of the extracts is not known, because very high values of pH can act on the seeds or seedlings and mask the allelopathic effect (FERREIRA; ÁQUILA, 2000). The EC analysis also did not cause changes in germination because was relatively low. In other studies it has been shown that with low and ethanolic extracts the low EC did not cause interference in the germinative behavior of lettuce and tomato (RIZZI et al., 2016).

The fresh extracts of *B. forficata* and *T. aurea* caused a reduction in the % G of lettuce seeds at 80% and 100% concentrations, germination was around 90%, the remaining concentrations were above 95% germination, the fresh extract of *M. tenuiflora* presented a more expressive reduction from the 40% concentration, ranging from 91% to 89.5% of germination (Figure 1A).

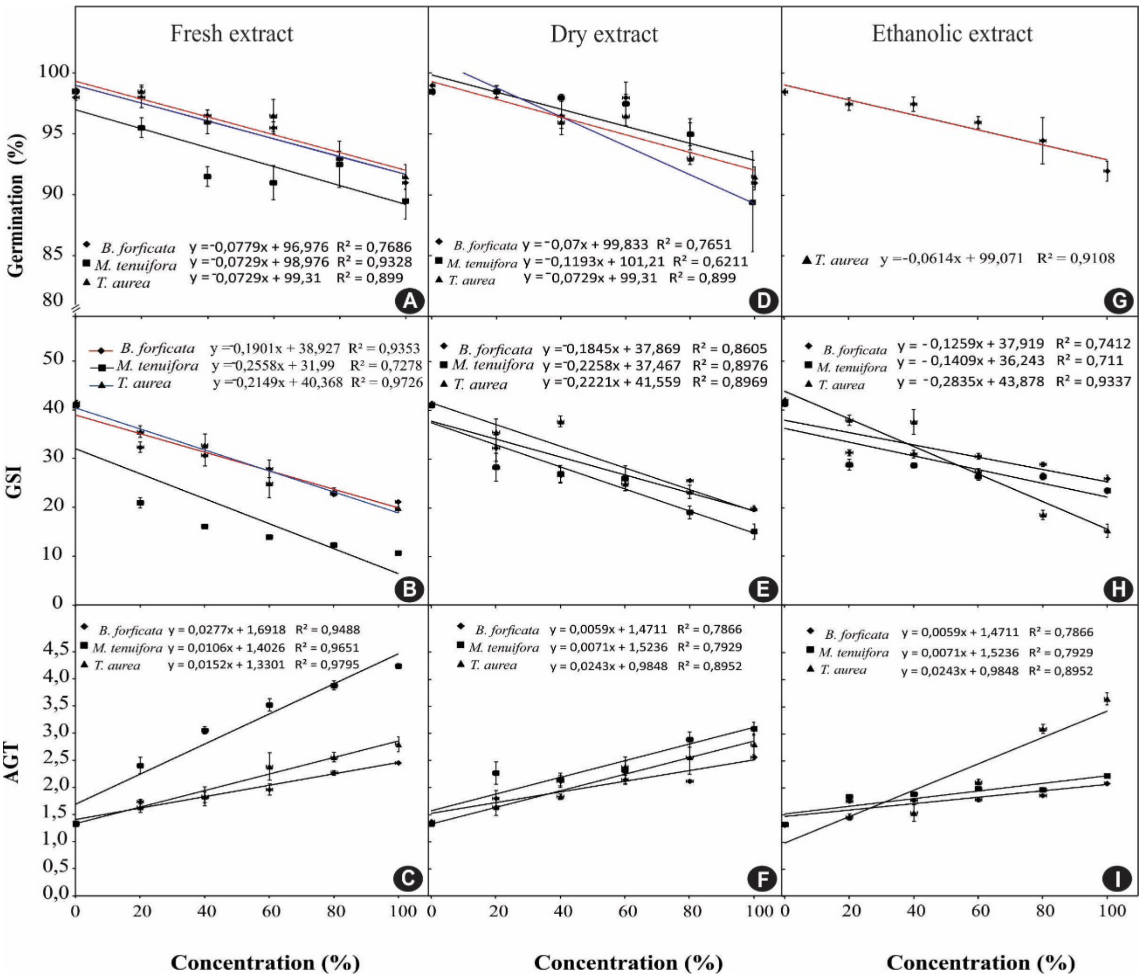

Figure 1 - Percentage of germination (A, D and G), germination speed index (B, E and H) and mean germination time (C, F and I) of L. sativa seeds submitted to different extracts of B forficata, M. tenuiflora and T. aurea. Percentage of germination (% G); Index of germination speed (IVG) and Mean germination time (TMG).

The aqueous extract of dry leaves of *B. forficata* and *T. aurea* promoted a reduction in the % G, in the concentration of 100%, obtaining a germination of 90%, with the extract of *M. tenuiflora* the germination was of 84%, in the 100% concentration (Figure 1D).

With the use of ethanolic extracts, a significant difference was observed in the % G only for *T. aurea*, presenting 92% of germinated seeds (Figure 1G). In studies with *E. velutina*, it was observed that ethanolic extracts and hydroalcoholic fractions influenced the germination of lettuce (CENTENARO et al., 2009).

In this study, a significant difference was observed in *L. sativa* % G when using the fresh and dry extract of the leaves of *M. tenuiflora*, but no influence was reported on germination in bark extracts of the same species (SILVEIRA; MAIA; COELHO, 2012). The difference in the allelopathic potential of different parts of the same plant can occur easily and in several species, by locating the allelochemicals, which may be located in different organs such as leaves, flowers, fruits, stems, roots and in seeds of several species of plants (FERREIRA; ÁQUILA, 2000). The presence of flavonoids in *M. tenuiflora* may be one of the indicators that this plant presents allelopathic action, due to the fact that this class of compounds have properties with allelopathic potential (CARVALHO et al., 2012).

The highest concentrations of the extracts of the three species studied in this study were decisive for the decrease of the %G observed for *L. sativa* seeds. The dose-dependent effect was also observed in other studies, such as fruit peel extracts and aqueous extract of the seeds of *Z. joazeiro* Mart. at concentrations of 75% and 100% (COELHO et al., 2011, OLIVEIRA et al., 2009).

When the fresh extract, regardless of the species used, was used, the index germination speed (IGS) was reduced as the concentrations increased, promoting a reduction of 48.90% with the *B. forficata* extract, 73.76 % with *M. tenuiflora* and 51.53% with *T. aurea* (Figure 1B). A decrease in IGS was observed when the dry leaves extract, regardless of the species used, was used as the concentrations increased, ranging from 52.19% with the application of the *B. forficata* extract, 62.95% with the extract of *M. tenuiflora* and 51.53% with *T. aurea* extract (Figure 1E). With the extract of *T. aurea* (Figure 1), the IGS was reduced in 38.24% with *B. forficata* extract, 43.09% using *M. tenuiflora* extract and 62.89%.

The IGS of the seeds was reduced by the extracts of fresh leaves and dry leaves of *B. forficata*, *M. tenuiflora* and *T. aurea*, were also observed with the *E. velutina* seed extract from the *Caesalpinia ferrea* Mart pods. ex Tul. var. ferrea (OLIVEIRA et al., 2012) and with the leaves extract of *Z. joazeiro* (COELHO et al., 2011). However, the same author used the aqueous extract of *Z. joazeiro* seeds and did not observe a significant difference in the IGS in relation to the control.

The average germination time (AGT) increased proportionally with the increase in fresh leaf extracts of *B. forficata* and *T. aurea*, increasing by 3 days when compared to the control (water), which presented 1.33 days, already with the fresh extract of *M. tenuiflora* an increase in germination time was observed around 4 days (Figure 1C). With the application of the dry leaves extract the AGT increased as the extracts concentrations were altered for all the species used, reaching 2.5 days for *B. forficata* and about 3 days for *T. aurea* and *M. tenuiflora* (Figure 1F). AGT with the application of the ethanolic extract showed an increase, in all concentrations, reaching levels higher than 3 days for the extract of *T. aurea* (Figure 1 I).

The increase in AGT in this study is also reported by other authors, in which the dried leaf extracts of *Cecropia pachystachya* Trec., *Peltophorum dubium* (Spreng.) Taub., *Psychotria leiocarpa* Cham. & Schltdl, Sapium glandulatum (Vell.) Pax and *Sorocea bonplandii* (Baill.) Burg., Lanj. And Boer, caused delay in the average germination time of lettuce seeds (MATIAS et al., 2017). It was not observed changes in AGT in relation to the control (OLIVEIRA et al., 2014). In a different way, it was observed in the studies using aqueous and ethanolic extracts of *Pouteria ramiflora* (Mart.) Radlk bark on lettuce seeds.

GSI and AGT are indirect ways of measuring seed vigor, so the reduction of these variables may influence the growth of the species. The delay in germination should be taken into account, since in natural environments this delay in the germination of native species may be determinant for the non establishment of certain species in that place, mainly in environments of dry vegetation such as that found in the semi-arid region of the northeast Brazilian.

The extracts of *B. forficata*, *M. tenuiflora* and *T. aurea* had negative effects on the target species, promoting reductions in germination percentage and germination speed index and increase in the average germination time of lettuce seeds.

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