

***Metrodorea flavida* (K. Krause) EXTRACTS IN PATHOGEN CONTROL OF *Senegalia polliphyla* (DC.) SEEDS**

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ABSTRACT

This study aimed to determine the main pathogens present in *Senegalia polliphyla* (DC.) seeds and to evaluate the fungicidal potential of *Metrodorea flavida* (K. Krause) extracts. For this purpose, concentrations of 0.5, 1.0, 1.5 and 2.0% of the extract of *Metrodorea flavida* leaves were used, in an ethanolic or aqueous form. A thousand seeds were used to perform the experiment, of which four hundred seeds were separated for each extract (aqueous or ethanolic), with four repetitions for each treatment, 100 seeds were separated for the blank test and 100 seeds were separated for the control with fungicide. After this process, the experiment was carried out using the Blottertest method. Then, the seeds remained for seven days in a BOD camera at 25 °C and 12-hour photoperiod. After seven days, the pathogens were identified using an optical microscope. The seeds were also immersed in the different concentrations of the aqueous or ethanolic extract, for of fifteen minutes, to analyze the effects of the extracts on the germination and morphological characteristics of the seedlings. The aqueous and ethanolic extracts reduced the infestation of pathogens associated with *Senegalia polliphyla* seeds, as well as the main fungus found: *Aspergillus flavus* Link. It was also found that the extracts did not influence the germination and morphological characteristics of *Senegalia polliphyla* seedlings in all concentrations evaluated, thus being a promising alternative for pathogen control in forest seeds.

Keywords: Forest seeds. Phytopathology, Phyto-fungicides. Rutaceae.

1. INTRODUCTION

The demand for wood and forest products has increased in recent years in Brazil and as a result there has been an increase in reforested areas with fast-growing species [1]. Thus, studies with native forest species have grown significantly, seeking to expand the option of species for planting in different regions of Brazil. *Senegalia polliphyla* (DC.) (Fabaceae) has a great potential in silviculture, however, there are few researches about the silviculture in general of this species, and mainly on seed technology, with seeds being the main form of propagation of native forest species in Brazil [2].

One of the main problems in the production of forest seedlings is the attack of pathogens, mainly fungi and bacteria in the seeds, preventing or interfering with germination and seedling development. Thus, to have a good quality seedling production, it is necessary that the seeds have sanitary quality, since the pathogens cause irregularities and lesions in the seedlings and may deteriorate the seeds [3]. During germination the biggest problems in the seeds are caused by fungi [4], so, the production of forest seeds is essential for the production process, however, it presents sanitary restrictions, due to the large number of pathogens related to seeds [5].

To prevent problems with pathogens, the seeds can be treated with chemical products. However, in recent decades, society is rethinking the intensive and uncontrolled use of phytosanitary products that generate several problems to the environment, such as contamination of soil, water, animals and food intoxication of producers and farmers and removal of microorganisms responsible for the degradation of organic matter [6]. In view of these situations, the search for alternative and efficient methods for controlling pathogens in seeds that provide less impact to the environment has grown in recent years [7]. The use of plant extracts to control pathogens in seeds can be an alternative with less environmental impacts and also contribute to reduce expenses with commercial phytosanitary products [8].

In Brazil, there is a great demand for new antifungals, due to the high resistance of pathogens in forest seeds. There are several studies demonstrating that the use of extracts obtained by plant species has been efficient in controlling pathogens in forest species, due to their direct fungitoxic action [9]. Results of research with plant extracts to control pathogens have been promising among the other methods already used, but plant extracts act more satisfactorily when the mode of action of the active principles and the pathogen are known [10].

Considering the diverse flora of Brazil, the possibility of discovering new compounds with fungicidal action is significant, especially with species from the Rutaceae family, which has several secondary metabolic processes identified in plant protection. In light of the above, the present study aims to evaluate the fungicide potential of *Metrodorea flavida* (K. Krause) (Rutaceae) extracts in pathogens associated with *Senegalia polliphyla* seeds.

2. MATERIAL AND METHODS

The study was conducted in the Cytogenetics and Tissue Culture Laboratory and in the Microscopy Laboratory of the State University of Mato Grosso - UNEMAT, in Alta Floresta, MT. The evaluated extracts were obtained from *Metrodorea flavida* leaves collected in the municipality of Alta Floresta-MT.

For the preparation of ethanolic and aqueous extract, the plant material was dried in a forced air circulation oven at 65°C for 72 hours and ground in a Wiley type knife mill. Then, the ground material was weighed, and 100 grams of vegetable material powder was diluted in 500 ml of distilled water or 92.8% alcohol, thus obtaining a concentration of 20% (w/v). Subsequently, the solutions were stored in glass wrapped in aluminum foil to protect from the light, at room temperature for 72 hours. After this process, the material was filtered, stored in closed containers at 4°C and protected from light, until used. The concentrations 0.5%, 1.0%, 1.5% and 2.0% were obtained by dilution from the initial solution of 20%.

To perform the sanity test, one thousand seeds were used, of which four hundred were separated for each extract, aqueous or ethanolic, with four repetitions of 25 seeds for each treatment. One hundred seeds were also separated for the blank test and the control with fungicide (Dicarboxyde). The treatments consisted of *Metrodorea flavida* extract, in an aqueous or ethanolic form, in different concentrations: 0.5, 1.0, 1.5, and 2.0%. The seeds were immersed in the different concentrations of ethanolic or aqueous extract, for fifteen minutes, then dried at room temperature on a sterile filter paper for 30 minutes. The **Blottertest** method was used to evaluate the incidence of fungi in seeds.

After the application of the treatments, the seeds remained for seven days in BOD chamber at 25°C, and 12-hour photoperiod. Subsequently, the pathogens were identified by visualizing them with the naked eye, as well as counting the number of seeds contaminated by each pathogen in each treatment. The pathogens were removed using adhesive tape and with the use of blue cotton dye, the slides were assembled. After this process, the pathogens were identified using the optical microscopic.

To evaluate whether the extracts could interfere with germination and seedlings, a germination test was **also** performed. One thousand seeds were also used, distributed in four replicates of twenty-five seeds, with four hundred seeds to evaluate each extract (aqueous or ethanolic) and one hundred seeds for control. The seeds were distributed on two sheets of **germitest** paper, moistened with distilled water equivalent to 2.x the mass of the non-hydrated paper and overlaid on a third sheet of **germitest**. Then, they were rolled, packed in plastic bags and placed in the BOD chamber at 25 °C with 12-hour photoperiod for seven days [11].

In the germination test, the final germination and the following morphological characteristics of seedlings were evaluated: stem diameter (mm), root and shoot length (mm) and green weight (g). The experimental design used for the evaluations was the factorial (type of extract X concentrations) completely randomized with four repetitions per treatment, with analysis of variance comparison of the means by the Tukey test (P = .05) and normality analysis of the data. The data that did not presented normality (incidence of pathogens) were transformed by the arcsen formula $\sqrt{x/100}$. The analyses were performed by the statistical package SISVAR 5.6 [12]. **Statistical analysis**

3. RESULTS AND DISCUSSION

The contaminant fungi of *Senegalia polliphyla* seeds found in the health test are listed in Table 1. It **was** observed that the species *Fusarium oxysporum* (18.7%) and *Aspergillus flavus* (2.3%), were the pathogens with the highest occurrence (Table 1).

Table 1. Contaminant fungi and their incidence (%) in *Senegalia polliphyla* seeds.

Genera	Incidence (%)
<i>Fusarium oxysporum</i> Schtdl.	18.7
<i>Aspergillus flavus</i> Link.	2.3
<i>Penicillium</i> sp. Link	0.8
<i>Rhizoctonia</i> DC.	0.6
<i>Trichoderma</i> Persoon ex Gray	0.6
<i>Fusarium moniliforme</i> J.Sheld.	0.1

The genus *Fusarium sp.* is considered one of the most important genera to be studied, because it presents taxonomic difficulties and has a great variability in its characteristics that hinder its classification [13]. *Aspergillus flavus* deteriorates seeds and are producers of mycotoxins that are toxic to plants, animals and humans [14]. *Fusarium oxysporum* can also produce mycotoxins, causing a decrease in germination, discoloration or formation of stains, and rot of seeds [15].

The genera *Aspergillus sp.* and *Fusarium sp.* are common pathogens in seeds, occurring in several forest seed species, mainly when stored for long periods, thus affecting germination. These pathogens have already been found in seeds of: *Phaseolus vulgaris* (L.), *Vigna unguiculata* (L.), *Mimosa caesalpiniaefolia* (Benth.), *Arachis hypogaea* (L.), *Araucaria angustifolia* (Bertol.), *Senna macranthera* (DC. ex Collad.), *Cedrela fissilis* (Vell.), *Ligustrum japonicum* (Thunb.), *Handroanthus serratifolius* (Vahl) and *Pinus insularis* (Endl.) ([16]; [17]; [18]; [19]; [20]).

Analyzing the effect of *Metrodorea flavida* extracts in the incidence of pathogens in *Senegalia polliphyla* seeds (Table 2), it was verified that there was no interaction between the factors analyzed (concentration X type of extract), so the two extracts were analyzed separately for the total incidence of pathogens and the main genera or species identified (Tables 3 and 4).

Table 2. Effect of *Metrodorea flavida* extract on pathogen incidence (%) in *Senegalia polliphyla* seeds.

Concentration (%)	Ethanolico	Aqueous
0 (T1)	0.94 c	0.94 c
0,5 (T2)	0.39 b	0.54 bc
1,0 (T3)	0.30 b	0.38 b
1,5 (T4)	0.39 b	0.39 b
2,0 (T5)	0.43 b	0.39 b
Control (T6)	0.0 a	0.00 a

Means followed by the same lowercase letter in the column, do not differ statistically by tukey test ($P = .05$). Concentration: (T1) Blank test, (T2) Treatment with 5% concentration, (T3) Treatment with 10% concentration, (T4) Treatment with 15% concentration, (T5) Treatment with 20% concentration and (T6) Control with Dicarboxyde Fungicide. Data was transformed by the arcsen formula $\arcsen \sqrt{x/100}$.

The treatments with the extracts decreased the incidence of pathogens attack in the seeds, with no statistical difference between the four extracts evaluated (Table 2). There are several studies that prove the efficiency of plant extracts in the control of pathogens, however, the majority of research is carried out with medicinal and aromatic plants and only few of them are performed with forest species. For example, it was analyzed the effects of melon extracts (*Momordica charantia* L.) and *Allamanda blanchetti* L. on the incidence of pathogens in seeds of *Enterolobium contortisiliquum* (Vell.), *Manihot glaziovii* (Muell.) and *Caesalpinia pulcherrima* (L), which showed a fungitoxic action, inhibiting the rate of pathogens on the seeds of these species ([21], [22] [23]). Extracts of *Momordica charantia* also caused a significant decrease in pathogens of the genera *Fusarium sp.*, *Cladosporium sp.* Link, *Curvularia sp.* Boedijn and *Alternaria sp.* Nees Von Esenb.Ex Fries, influencing the high germination index of *Pterogyne nitens* (Tul.) seeds [24].

Other plants commonly studied that present fungicide action in seed pathogens are garlic (*Allium sativum* (L.)), ginger (*Zingiber officinale* Roscoe) and rue (*Ruta graveolens* L.), effectively in controlling mainly *Aspergillus sp.* and *Fusarium sp.* [8]; [15] [25], [10].

A forest species that has been studied as a possible fungitoxic is *Corymbia citriodora* Hook, mainly through its essential oil, being efficient in controlling the development of pathogens and inhibiting its growth [8]. The pathogen with the highest incidence in *Senegalia polliphyla* seeds was *Fusarium oxysporum*, and the effect of the extracts on its occurrence are presented in Table 3.

Table 3. Effect of *Metrodorea flavida* ethanolic and aqueous extracts on *Fusarium oxysporum* incidence in *Senegalia polliphyla* seeds.

Concentration (%)	Ethanolic	Aqueous
0.0 (T1)	52.00 c	52.00 c
0.5 (T2)	21.00 b	23.00 b
1.0 (T3)	18.00 b	15.00 b
1.5 (T4)	18.00 b	16.00 b
2.0 (T5)	19.00 b	15.00 b
Control (T6)	0.00 a	0.00 a

Means followed by the same lowercase letter in the column, do not differ statistically by tukey test ($P = .05$). Concentration: (T1) Blank test, (T2) Treatment with 5% concentration, (T3) Treatment with 10% concentration, (T4) Treatment with 15% concentration, (T5) Treatment with 20% concentration and (T6) Control with Dicarboxyde Fungicide.

All concentrations used for both aqueous and ethanolic extract decreased the incidence of *Fusarium oxysporum* in *Senegalia polliphyla* seeds (Table 3). Again, it is noted that there was no significant difference between the four concentrations analyzed, and none of them reached the control values. However, there was a significant reduction compared to the blank test. Since the concentrations used in this study are considered low, higher concentrations may cause more significant results.

Plant extracts have already been shown to be efficient in inhibiting pathogenic fungi in seeds, mainly the genus *Fusarium* sp. Ethanolic extract from all parts of *Senna alata* (L.) Roxb. is able to control the pathogen *Fusarium oxysporum* [23], the ethanolic extract of *Allium sativum* has an inhibitory action on *Fusarium oxysporum* [26], and the ethanolic extract of *Pachira aquatica* (Aubl.) seeds is able to inhibit the development of the pathogen *Fusarium* [27].

Analyzing the effects of extracts on germination and morphological characteristics, it is possible to note that both aqueous and ethanolic extracts of *Metrodorea flavida*, did not interfere in the germination or development of *Senegalia polliphyla* seedlings (Table 4).

Table 4. Morphological characteristics of *Senegalia polliphyla* seedlings submitted to aqueous and ethanolic extracts of *Metrodorea flavida*

Concentration (%)	Germination (%)	Aqueous extracts			
		Root collar (mm)	Root (cm)	Aerial part (cm)	Green weight (g)
0.0 (T1)	63.00 a	1.45 a	4.53 a	4.08 a	0.33 a
0.5 (T2)	58.00 a	1.07 a	4.26 a	3.02 a	0.29 a
1.0 (T3)	58.00 a	1.13 a	4.40 a	3.76 a	0.30 a
1.5 (T4)	54.00 a	1.04 a	4.41 a	3.58 a	0.31 a
2.0 (T5)	56.00 a	1.06 a	3.74 a	3.84 a	0.28 a

Control (T6)	48.00 a	1.06 a	2.86 a	4.03 a	0.28 a
Ethanollic extracts					
Concentration (%)	Germination (%)	Root collar (mm)	Root (cm)	Aerial part (cm)	Green weight (g)
0.0 (T1)	63.0 a	1.45 a	4.53 a	5.08 a	0.33 a
0.5 (T2)	68.00 a	1.08 a	3.65 a	4.64 a	0.34 a
1.0 (T3)	65.00 a	1.16 a	3.60 a	4.01 a	5.33 a
1.5 (T4)	63.00 a	1.05 a	3.68 a	4.01 a	0.29 a
2.0 (T5)	68.00 a	1.07 a	3.64 a	3.79 a	0.29 a
Control (T6)	58.00 a	1.06 a	3.86 a	4.34 a	0.28 a

Means followed by the same lowercase letter in the column, do not differ statistically by tukey test ($P = .05$). Concentration: (T1) Blank test, (T2) Treatment with 5% concentration, (T3) Treatment with concentration 10%, (T4) Treatment with concentration 15%, (T5) Treatment with concentration 20% and (T6) Control with Dicarboxyde Fungicide.

Extracts of plant species may have different influences on seed germination. The aqueous extract of *Sorghum bicolor* (L.) did not interfere in the germination of *Glycine Max* (L.) plants [28], similar to the results observed in this study (Table 4). Ethanollic extracts, when compared to aqueous extracts, drastically reduced the germination of *Brachiaria decumbens* (Trin.) seeds [29]. *Cinnamomum zeylanicum* Bl. extract reduced the germination and vigor of castor bean seeds (*Ricinus communis* L.), while *Zingiber officinale* extract did not affect the quality of castor bean seeds [30].

Thus, it is noted that studies focusing on the influence of plant extracts and their concentrations on germination and morphological characteristics, are extremely necessary to verify their possible use. Some substances from plant extracts can be toxic at high concentrations and beneficial or stimulants at low concentrations and may also be influenced by the part of the plant used in the preparation of the extract [31] [32].

Thus, it was observed that the extracts of *Metrodorea flavida* did not influence the germination or morphological characteristics of *Senegalia polliphyla* seedlings, and provided a decrease in pathogen infestation even at low concentrations, presenting a potential use as an alternative form of pathogen control in forest seeds.

4. CONCLUSION

The main pathogens found in *Senegalia polliphyla* seeds were *Aspergillus flavus* and *Fusarium oxysporum*.

Ethanollic and aqueous extracts showed good results in the inhibition of pathogens in *Senegalia polliphyla* seeds, even at low concentrations.

REFERENCES

1. Bomfim AA, Novaes ABde, São José AR, Grisi FA. Morphological evaluation of seedlings of new wood (*Pterogyne nitens* Tull.) Produced in plastic tubes and bags and their performance in the field. *Forest* 2009; 39 (1): 33-40. Portuguese. DOI: 10.5380 / rf.v39i1.13723
2. Araujo grandson JC, Aguiar IB, Ferreira VM. Effect of temperature and light on the germination of *Acacia polyphylla* DC seeds. *Rev. bras. Bot.* 2003; 26 (2): 249-256. Portuguese. DOI: 10.1590 / S0100-84042003000200013

3. Piveta G, Menezes VO, Pedroso DC, Muniz MFB, Blume E, Wielewicki AP. Overcoming dormancy in the quality of seeds and seedlings: influence on the production of *Senna multijuga* (L. C. Rich.) Irwin & Barneby. *Acta Amaz.* 2010; 40 (2): 281-288. Portuguese. DOI: 10.1590 / S0044-59672010000200006.
4. Medeiros JGF, Araujo Neto AC, Menezes NPC, Nascimento LC. Health and germination of *Clitoria fairchildiana* seeds treated with plant extracts. *Research flower. bras.* 2013; 33 (76): 403-408. Portuguese. DOI: 10.4336 / 2013.pfb.33.76.541
5. Moreau JS. Seed germination on different substrates and morphological characterization of *Anadenanthera macrocarpa* Benth.) Brenan seedlings. 2011. Accessed 17 september 2020. Available: http://www.florestaemadeira.ufes.br/sites/florestaemadeira.ufes.br/files/TCC_Julia%20Siqueira%20Moreau.pdf.
6. Frigheto STK. Influence of pesticide management on the environment. *Fitopatol. Bras.* 2000; 25 (8): 232-233. Portuguese.
7. Celoto MIB, Papa MdeFS, Sacramento LV Sdo, Celoto FJ. Antifungal activity of plant extracts to *Colletotrichum gloeosporioides*. *Acta Sci., Agron.* 2008; 30 (1): 122-126. Portuguese. DOI: 10.4025 / actasciagron.v30i1.1104
8. Lazarotto M, Girardi LB, Mezzomo R, Piveta G, Muniz MFB, Blume E. Alternative Treatments for the Control of Pathogens in Cedar Seeds (*Cedrela fissilis*). *Rev. Bras. Of Agroecology* 2009; 4 (2): 75-78. Portuguese.
9. Schwan-Estrada KRF, Stangarlin JR, Cruz MES. Use of plant extracts to control phytopathogenic fungi. *Forest* 2000; 30 (2): 129-137. Portuguese.
10. Venturoso LR, Bacchi LMA, Gavassoni WL, Conus LA, Pontim BCA, Bergamin AC. Antifungal activity of plant extracts on the development of phytopathogens. *Summa phytopathol.* 2011; 37 (1) 18-23. Portuguese. DOI: 10.1590 / S0100-54052011000100003.
11. Brazil, Ministry of Agriculture, Livestock and Supply. Rules for seed analysis. 2009. Accessed 17 september 2020. Available: https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/arquivos-publicacoes-insumos/2946_regras_analise__sementes.pdf.
12. Ferreira DF. SISVAR: A computer analysis system to fixed effects split plot type designs. *Brazilian Journal of Biometrics* 2019; 37 (4): 529-535. DOI: 10.28951 / rbb.v37i4.450.
13. Menezes M, Silva-Hanlin DMW. Practical guide for phytopathogenic fungi. Recife: Federal Rural University of Pernambuco - University Press; 1997.
14. Iamanaka BT, Oliveira IS, Taniwaki MH. Mycotoxins in food. *Annals of the Pernambuco Academy of Agricultural Science* 2010; 7: 138-161. Portuguese.
15. Souza AEF, Araújo E, Nascimento CA. Antifungal activity of garlic and campim-santo extracts on the development of *Fusarium proliferatum* isolated from corn grain. *Fitopatol. bras.* 2007; 32 (6): 465-471. Portuguese. DOI: 10.1590 / S0100-41582007000600003.
16. Ferreira FA. Forest pathology - main forest diseases in Brazil. Viçosa: SIF; 1989.
17. Carvalho WL, Muchovej JJ. Fungi associated with seeds of forest essences. *Revista Árvore* 1991; 15 (2): 173-178. Portuguese.
18. Ito MF, Bacchi LMA, Maringoni AC, Menten JOM. Comparison of methods for the detection of *Aspergillus* spp. and *Penicillium* spp. in peanut seeds (*Arachis hypogaea* L.). *Summa phytopathol* 1992; 18 (3): 262-268. Portuguese.

19. Silva JAdA, Pegado CMA, Ribeiro VV, Brito NMde, Nascimento LCdo. Effect of plant extracts on the control of *Fusarium oxysporum* f. sp. *tracheiphilum* in cowpea seeds. *Agrotec Science*. 2009; 33 (2): 611-616. Portuguese. DOI: 10.1590 / S1413-70542009000200039
20. Benetti SC, Santos AFDos, Jaccoud Filho DdeS. Survey of fungi in cedar seeds and evaluation of the pathogenicity of *Fusarium* sp. and *Pestalotia* sp. *Search. Florest. Bras*. 2009; 58 (10): 81-85. Portuguese.
21. Araujo AEDaS, Castro APGDe, Rossetto CAV. Evaluation of methodology for detecting fungi in peanut seeds. *Rev. bras. seeds* 2004, 26 (2): 45-54. Portuguese. Doi: 10.1590 / S0101-31222004000200007.
22. Martins MTCS, Nascimento LC, Araújo ER, Rêgo ER, Felix LP. Antifungal activity of São Caetano melon extract on maniçoba seeds. *Hortic. bras*. 2009; 27 (2): 1246-1253. Portuguese.
23. Medeiros JGF, Silva BB, Araújo Neto AC, Nascimento LC. Fungi associated with flamboyant-mirim (*Caesalpinia pulcherrima*) seeds: incidence, effect on germination, transmission and control. *Research flower. bras*. 2012; 32 (71): 303-308. Portuguese. DOI: 10.4336 / 2012.pfb.32.71.3
24. Medeiros JGF, Araújo Neto AC, Medeiros DSde, Nascimento LC, Alves EU. Plant extracts in the control of pathogens in seeds of *Pterogy nenitens*Tul. *Ambient forest*. 2013; 20 (3): 384-390. Portuguese. DOI: 10.4322 / floram.2013.029.
25. Lopes IS, Santos GJC, Assis MM, Bezerra MR, Rangel JAF. Fungal incidence with the use of garlic extract in seeds of *Anadenanthera colubrina*. *Environmental Engineering* 2011; 8 (4): 31-38. Portuguese.
26. Morais MS. Effect of two plant extracts on the development of *Fusarium Oxysporum* and incidence of wilt in green beans. 2004. Areia: Master in Agronomy, Federal University of Paraíba; 2004.
27. Souza DK, Abreu Lima R, Domingues CA, Pedroso LA, Alves FV, Castro GF, Reginaldo AM. Fungicidal potential of the ethanolic extract obtained from the seeds of *Pachira aquatica* AUBL. about *Fusarium* sp *Science and Natura* 2014; 36 (2): 114-119. Portuguese.
28. NM belt, Centurion MAPC, Alves PLCA. Influence of aqueous sorghum extracts on the germination and development of soybean seedlings. *Ciên. Rural* 2005; 35 (3): 498-503. Portuguese.
29. Souza MAA, Borges RSOS, Stark MLM, Souza SR. Effect of aqueous, methanolic and ethanolic extracts from medicinal plants on the germination of lettuce seeds and on the mycelial development of phytopathogenic fungi of agricultural interest. *Rural University Magazine* 2002; 22 (2): 181-185.
30. Catão HCRM, Aquino CF, Sales NLP, Rocha FS, Caixeta F, Civil N. Hydrolats and extracts vegetable action on quality of stored castor bean seeds in non-controlled conditions. *Rev. Bras. Cienc. Please*. 2018; 13 (2): e5539. DOI: 10.5039 / agraria.v13i2a5539
31. Belz RG, Cedergreen N, Duke SO. Herbicide hormesis - can it be useful in crop production? *Weed Research* 2011; 51 (4): 321-332. DOI: 10.1111 / j.1365-3180.2011.00862.x
32. Pina GO, Borghetti F, Silveira CES, Pereira LAR. Effects of *Eugenia dysenterica* leaf extracts on the growth of sesame and radish. *Allelopathy Journal* 2009; 23 (2): 313-322.