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ALLELOPATHIC EFFECT OF ANNONI GRASS EXTRACTS ON *Vachellia caven* (MOLINA) SEIGLER & EBINGER GERMINATION AND INITIAL DEVELOPMENT

EFEITO ALELOPÁTICO DE EXTRATOS DE CAPIM-ANNONI NA GERMINAÇÃO E DESENVOLVIMENTO INICIAL DE Vachellia caven (MOLINA) SEIGLER & EBINGER

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ABSTRACT

Eragrostis plana Nees is one of the species with the greatest invasive potential in natural grassland areas in southern South America, due to its biological and ecological characteristics and the interactions it maintains with other plant species, especially native species. The aim of this study was to evaluate the allelopathic effect of *Eragrostis plana* on the germination of *Vachellia caven* (Molina) Seigler & Ebinger seeds. The experimental design was completely randomized with four replicates of 50 seeds per treatment. The seeds were placed on germitest paper containing aqueous extracts of *E. plana* in different concentrations (0, 25, 50, 75 and 100%) and placed in a controlled environment with 16 hours of light. It was observed that *E. plana* has a positive allelopathic effect on *V. caven*, stimulating the germination process and the initial development of the seedlings.

Keywords: allelopathy, aqueous extracts, *Eragrostis plana* Nees, germination process.

RESUMO

Eragrostis plana Nees é uma das espécies com maior potencial invasivo nas áreas de pastagem natural do Sul da América do Sul, devido às suas características biológicas e ecológicas e às interações mantidas com outras espécies vegetais, especialmente espécies nativas. O trabalho objetivou avaliar o efeito alelopático de Eragrostis plana sobre a germinação de sementes de Vachellia caven (Molina) Seigler & Ebinger. O delineamento experimental foi o inteiramente casualizado com quatro repetições de 50 sementes por

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tratamento. As sementes foram dispostas em papel germitest contendo extratos aquosos de E. plana em diferentes concentrações (0, 25, 50, 75 e 100%) e acondicionadas em ambiente controlado com 16 horas de luz. Observou-se que E. plana possui efeito alelopático positivo sobre V. caven, estimulando o processo germinativo e o desenvolvimento inicial das plântulas.

Palavras-chave: *alelopatia, extratos aquosos, Eragrostis plana Nees, processo germinativo.*

INTRODUCTION

Recently, with the increase in human activities and the strengthening of international trade, the transfer of biological resources of species from different habitats has become more frequent (FAVARETTO *et al*., 2015). Some of these species are highly adaptable and can grow and spread rapidly in new environments, which can have negative consequences for the economy and ecology of a society. From an ecological perspective, allelopathy is an important factor influencing the invasion and spread of exotic plants (ABD-ELGAWAD *et al*., 2021; OLIVEIRA *et al*., 2022). This process contributes to the ability of certain exotic species to become dominant in areas where native species predominate (FAVARETTO *et al*., 2015; SANTOS *et al.,* 2023).

Allelochemicals or phytotoxins are products of secondary metabolism and are present throughout the plant, especially in leaves and roots, and can be released into the environment through volatilization, root exudation, leaching, and decomposition of plant tissues (FAVARETTO *et al*., 2019), and act directly on plant physiological processes such as cell division and elongation, membrane permeability, photosynthesis, growth-inducing phytohormones, membrane permeability, stomatal opening, respiration, protein synthesis, and lipid and fatty acid metabolism (FERREIRA *et al*., 2008; FERRERAS *et al*., 2018). In addition, they have received attention for the possibility of identifying and isolating allelochemicals with bioherbicidal potential (FAVARETTO *et al*., 2015; FAVARETTO *et al*., 2019).

A species with proven allelopathic potential is annoni grass (*Eragrostis plana* Nees), a perennial C4 grass belonging to the family Poaceae, originally from South Africa (BITTENCOURT *et al*., 2018; BASTIANI *et al*., 2023). In Brazil, it is an invasive exotic species (FERREIRA *et al.,* 2008; ARTICO *et al*., 2020), widely recorded in Rio Grande do Sul, with smaller occurrences in the states of Minas Gerais, Bahia, Paraná, Santa Catarina, São Paulo, Mato Grosso do Sul, Mato Grosso, Tocantins, Pará and the Federal District. In the late 1950s, the species was accidentally imported from South Africa to the state of Rio Grande do Sul as a contaminant in lots of rhodes grass (*Chloris gayana* Kunth) and weeping grass (*Eragrostis curvula* (Schrad) Nees) seeds (MEDEIROS; FOCHT, 2007). This species is characteristic of the Pampa Biome, and among the 50 plant species that have invaded this biome, grasses of African origin stand out, such as brachiaria (*Urochloa* spp.) and annoni grass (FONSECA *et al*., 2013; ZENNI *et al*., 2024).

The management of this species is extremely difficult due to its wide distribution and invasion of native pastures in Brazil. The similarity between *E. plana* and other native Poaceae species makes it difficult to selectively control *E. plana* (GUIDO *et al*., 2019; BASTIANI *et al*., 2023). For some time, it was thought that *E. plana* would be a good alternative forage plant for feeding production animals (TWARDOWSKI *et al*., 2018); however, due to its low palatability, in addition to its rapid growth, long reproductive phase, presence of allelopathy and persistent seed bank in the soil, characteristics of an invasive plant that make it dominant and difficult to control and eradicate (FAVARETTO *et al*., 2015; CARLOTO *et al*., 2020). Lately, farmers have reported cases of herbicide failure to control this exotic species, even with the use of glyphosate, with plants often regrowing after application of this and other herbicides, and it has been reported that the effectiveness of herbicides on *E. plana* is influenced by the stage of development (BASTIANI *et al*., 2023).

E. plana produces allelochemicals with allelopathic potential that inhibit and delay the germination and growth of numerous native and exotic species, supporting its expansion into the native fields of RS (FAVARETTO *et al*., 2015; FIORENZA *et al*., 2016). Ferreira *et al.* (2008) and Hendges *et al.* (2021) mention that species of the genus *Eragrostis* contain amino acids, phenolic compounds, and glutamic acid, all of which have recognized allelopathic potential. In addition, Favaretto *et al.* (2015), Fiorenza *et al.* (2016), and Rosa *et al*. (2024) found that the presence of phenolic compounds (gallic acid, ellagic acid, caffeic acid, and chlorogenic acid), flavonoids (quercetin and rutin), and tannins (epicatechin and catechin) may be responsible for the allelopathic effect of this species. The presence of this species reduces the productivity of fields and livestock production; therefore it is necessary to study and understand the allelopathic effects of *E. plana* on species of the Pampa Biome, one of which is the *Vachellia caven* (Molina) Seigler & Ebinger.

Species of the genus *Vachellia* (Fabaceae) have attracted great interest in recent years due to their drought tolerance and the numerous goods (fodder, gums, resins, and medicines) and services (shade and living fences) they provide to local communities. Some species have been reported to maintain soil fertility by fixing atmospheric nitrogen (ODIRILE *et al*., 2019).

Vachellia caven (Molina) Seigler & Ebinger, popularly known as hawthorn, “aromo”, “aroma-criollo”, “aromito”, “espinilho-de-bañado”, “churqui”, “espinilho”, “santa-fé” and “cavén” (FERRERAS *et al*., 2018), is a species tree native to the extratropical region of South America, with a distribution in Argentina, Chile, Paraguay, Uruguay and, in Brazil, in the western states of Rio Grande do Sul and Mato Grosso do Sul (MARCHIORI, 1992; ESCOBAR *et al.,* 2010; VELASCO *et al*., 2023). In Chile, *V. caven* is considered a species with positive effects on the establishment of other species in the region (VELASCO *et al*., 2023), providing ecological conditions that can trigger the regeneration and recovery processes of native herbaceous and woody species, improving the abiotic microenvironment established in this region (MIRANDA *et al*., 2019; GOMÉZ-FERNÁNDEZ *et al*., 2023).

Additionally, the species can be used as an option in agroforestry systems to protect animals in the field, avoiding their exposure to the sun and excessive heat in the field region (MARCHIORI, 1992; FERRERAS *et al*., 2018). It is used in soil conservation and erosion control practices; furthermore, the species is important as a pioneer in the formation of environments, in which it creates favorable conditions for the development of other species (MARCHIORI, 1992; ESCOBAR *et al*., 2010; GOMÉZ-FERNÁNDEZ *et al*., 2023).

Considering the above, the aim of this study was to evaluate the possible allelopathic effect of annoni grass (*Eragrostis plana* Nees) on the germination of *Vachellia caven* (Molina) Seigler & Ebinger seeds.

MATERIAL AND METHODS

The experiment was carried out at the Seed and Plant Tissue Culture Laboratory of the Federal University of Santa Maria (UFSM), RS.

The aerial parts (stem and leaf) of annoni grass (*Eragrostis plana* Nees) were collected at the Federal University of Pampa (UNIPAMPA), São Gabriel Campus, RS. The collected plant material was then dried in an oven at 60 °C until a constant dry mass was obtained, and then ground in a Willey-type knife mill.

The ground plant material was used to obtain an aqueous extract at a concentration of 1 g 10 mL^{-1} of distilled water (weight/volume). The mixture was allowed to stand in the refrigerator (5 º ± 1 °C) for 48 hours, then filtered and diluted to four concentrations (25, 50, 75, and 100%). Distilled water was used as the control treatment (0%) and the 100% concentration was used as the crude extract. The pH of the different extracts was measured: 5.8 (control), 6.2 (25%), 6.1 (50%), 6.1 (75%) and 6.0 (100%), with no significant difference in pH values between the extracts.

The fruits of *Vachellia caven* (Molina) Seigler & Ebinger were obtained from matrices at the UFSM. The seeds were extracted by hand, excluding infected and dark seeds, and stored in paper bags in the refrigerator until the beginning of the experiments, without any cleaning treatment against fungi or similar agents.

To overcome the dormancy of *V. caven* seeds, the mechanical scarification treatment was used, which consisted of sanding the seeds in the region opposite the micropyle with water sandpaper nº. 80 and then immersing the seeds in distilled water for 3 hours.

For the germination test, the seeds were placed on germitest paper moistened with distilled water or with the aqueous extracts in different concentrations, all in an amount equivalent to 2.5 times the mass of the unmoistened paper (BRASIL, 2009). The experiment consisted of 4 replicates of 50 seeds for each treatment (extract), which were placed to germinate in a growth chamber with temperature (25 ± 2 ºC) and controlled light (photoperiod of 16 hours of light). Normal seedlings were those with a primary root and hypocotyl, according to the rules for seed analysis (BRASIL, 2009).

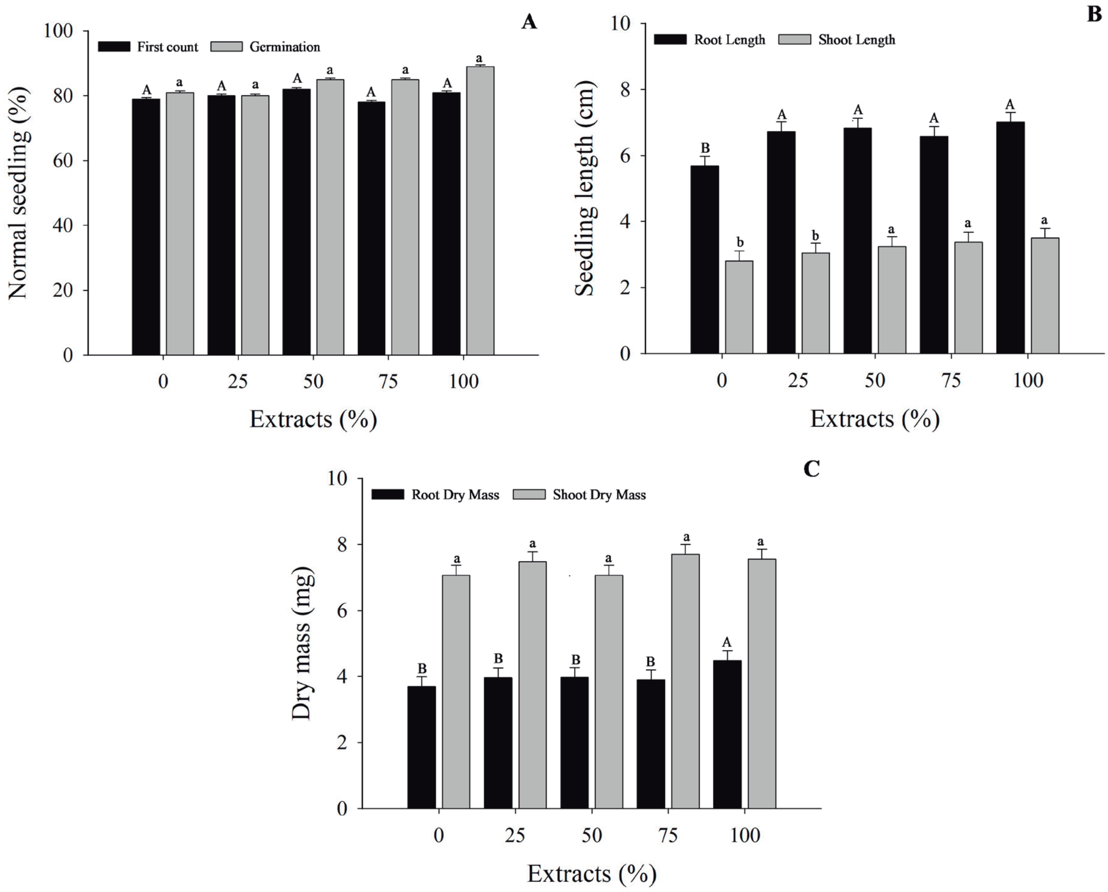
After 7 days, the first count, the length and dry mass of the shoot and the root system were evaluated, and after 14 days, the final germination percentage, using 10 seedlings per replicate of each treatment for the length and dry mass parameters (KRZYZANOWSKI *et al*., 2020).

The design used was completely randomized, with four replications of 50 seeds each. The results obtained were analyzed by analysis of variance and when the treatments showed a significant difference ($p<0.05$), the means were compared using the Scott-Knott test at 5% probability.

RESULTS AND DISCUSSION

In the experiments testing different concentrations of *E. plana* extracts on the germination of *V. caven* seeds, there were no statistical differences between the different extracts when compared to the control treatment (Figure 1A).

Figure 1 - (A) Normal seedling and seed germination (%); (B) seedling length (cm) (C) dry mass (mg) of *Vachellia caven* (Molina) Seigler & Ebinger, subjected to different concentrations of *Eragrostis plana* Nees extract.



* Uppercase and lowercase letters indicate significant differences between treatments within each variable. Criterion for significance ($p<0.05$).
Source: Authors (2023).

In terms of seedling length, statistical differences were observed with the use of the aqueous extracts; there was an increase in the length of the root system and the shoot of the seedlings from the concentrations of 25 and 50%, respectively, compared to the control treatment (Figure 1B).

Contrary to the length of the two vegetative structures, the data on the dry mass of the seedlings were statistically different only at the highest concentration for the root system, with an increase in this parameter, and for the biomass of the shoot of the *V. caven* seedlings, no significant differences were observed between the treatments when compared to the control treatment (Figure 1C).

Bioassays of seed germination in the presence of plant extracts are starting points for studying intra- and interspecific allelopathy effects, although there is controversy regarding this type of experiment. It is argued that seeds are less sensitive to allelochemicals than seedlings as a result of selective and evolutionary processes (FERREIRA *et al*., 2008; SARTOR *et al*., 2009). On the other hand, recent studies show that although the final germination percentage is not significantly affected by the action of allelochemicals, the germination pattern can be modified, with differences in the speed and synchrony of germination of seeds exposed to such compounds (Figures 1B and 1C).

Allelochemical action is a biochemical adaptation found in many plants that helps them defend themselves against other competing plant species. These substances are secondary metabolites that can be present throughout the plant, protecting both the aerial structures and the root system (HENDGES *et al.,* 2021; CHAUHAN *et al*., 2022). It has been previously documented that *E. plana* possesses allelochemical compounds with allelopathic potential, particularly those belonging to the flavonoid group, such as quercetin (FAVARETTO *et al.,* 2015; FIORENZA *et al*., 2016). Szwed *et al.* (2020) point out that allelopathy is not related to a single component but to a set of allelochemicals, and that these compounds can interfere with neighboring plants, causing positive physiological effects at low concentrations or negative effects such as germination inhibition and growth reduction (MASUM *et al*., 2018; LI *et al*., 2019). It is also common to find compounds with chemically diverse allelopathic properties in higher plants, and their amount and composition can vary depending on the species studied (SILVA *et al.,* 2021; BRUXEL *et al.,* 2022). In addition, allelopathy is a process in which one plant species stimulates or inhibits the growth of another species through certain secondary metabolites (YU *et al*., 2022). According to Scheffer-Basso *et al.* (2019), the extraction in water for the preparation of the extracts partially corresponds to the natural state of the plants (decomposition and leaching), where the leaves of *E. plana* are detached or extracted during the mowing of pastures, becoming a source of allelochemical compounds.

Some studies evaluating the allelopathic effect of this invasive species have already been presented by Favaretto *et al*. (2015), Cecchin *et al*. (2017), Favaretto *et al*. (2017), Bittencourt *et al*. (2018), Scheffer-Basso *et al*. (2019), Guido *et al*. (2019), Artico *et al.* (2020) and Carloto *et al*. (2020). Other studies, such as that of Ferreira *et al*. (2008), showed that the exotic fodder *Megathyrsus maximus* B. K. Simon and S. W. L. Jacobs) and *Lactuca sativa* L. did not suffer a negative allelopathic effect from the decomposition of *E. plana* plant tissues, possibly due to the rapid onset of the germination process of these two species. However, in other studies by these authors, negative effects on germination and initial growth of *Paspalum notatum* Flüggé and *Setaria sphacelata* (Schumach) Staff & C. E. Hubb ex Chipp were observed. On plants such as *Zea mays* L., *Avena sativa* L., *Lolium multiflorum* Lam., *Trifolium pratense* L. and *Lotus corniculatus* L. the allelopathic effect of *E. plana* reduced or inhibited the germination and initial development of seedlings, regardless of the concentration of the aqueous extract, with the effect being more pronounced at higher concentrations (50, 70, and 100%) (FIORENZA *et al*., 2016).

The aqueous extracts of *E. plana*, contrary to other studies showing allelopathic effects, had a stimulating effect on the parameters evaluated in *V. caven*. It should be noted that these data are important considering that *V. caven* has positive effects on the establishment of other species in the region (VELASCO *et al*., 2023), providing ecological conditions that can trigger the regeneration and recovery processes of native herbaceous and woody species, improving the abiotic microenvironment established in this region (MIRANDA *et al*., 2019; GOMÉZ-FERNÁNDEZ *et al*., 2023). In addition, *V. caven* can be cultivated in agroforestry systems to protect animals from the sun and high temperatures, for soil conservation and erosion control, and as a pioneer in the formation of environments (FERRERAS *et al*., 2018; CHAUHAN *et al*., 2021).

There are partially conflicting data indicating that plant extracts significantly affected root and shoot growth and, in some cases, the higher concentration showed a stronger inhibitory effect, while the lower concentration indicated a stimulatory effect (SARMA *et al*., 2019). Thus, based on the observation of the positive effect of *E. plana* extracts on the germination and initial growth of *V. caven*, it is possible to suggest that it can be introduced in an intercropped system due to its positive effects with tree species.

E. plana is an invasive species that causes great damage to livestock, and its proliferation reduces the quality and quantity of native species in the Pampa Biome (FONSECA *et al*., 2013; LEITE *et al*., 2024; ZENNI *et al*., 2024). In this way, the results of the tests carried out are relevant because they show that because *E. plana* is an invasive species, other species can grow and establish themselves in areas where this invasive species is present, especially in the Pampa Biome without affecting their growth and development. It can also be assumed that allelopathy can be used by the species in its process of agroecosystems invasion.

CONCLUSION

Eragrostis plana showed a positive allelopathic effect on seed germination and initial development of *Vachellia caven*. Thus, a consortium between these two species, a shrubby Fabaceae and an invasive Poaceae, is possible.

Furthermore, studies are needed to verify the efficiency of *E. plana* extracts on the germination and initial growth of *Vachellia caven* in the field. A better understanding of allelopathic effects will help in choosing appropriate management, helping to maintain this tree species and preventing future damage.

REFERENCES

ABD-ELGAWAD, A. M. *et al.* Phytotoxic effects of plant essential oils: a systematic review and structure-activity relationship based on chemometric analyses. **Plants**, v. 10, n. 1, p. 36, 2021. DOI: https://doi.org/10.3390/plants10010036

ARTICO, L. L. *et al.* Cytotoxic, genotoxic, mutagenic, and phytotoxic effects of the extracts from *Eragrostis plana* Nees, 1841 (Poaceae), grown in a coal-contaminated region. **Water, Air, & Soil Pollution,** v. 231, n. 81, 2020 DOI: https://doi.org/10.1007/s11270-020-4457-6

BASTIANI, M. O. *et al*. Ammonium sulfate improves the efficacy of glyphosate on south african lovegrass (*Eragrostis plana*) under water stress. **Weed Science**, v. 69, n. 2, p. 167-176, 2023. DOI: https://doi.org/10.1017/wsc.2020.97

BRASIL. **Ministério da Agricultura, Pecuária e Abastecimento.** Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília: Mapa/ACS, 2009. 399p;

BITTENCOURT, H. V. H. *et al.* Chemical ecology of *Eragrostis plana* helps understanding of the species' invasiveness in an agroecosystem community. **Crop Pasture Sci.**, v. 69, n. 10, p. 1050-1060, 2018. DOI: http://dx.doi.org/10.1071/CP18339

BRUXEL, F. *et al*. Phytotoxicity of *Hesperozygis ringens* (Benth.) epling essential oil on *Eragrostis plana* Nees. **Flora**, v. 297, p. 152167, 2022. DOI: https://doi.org/10.1016/j.flora.2022.152167

CARLOTO, B. W. *et al*. Response of *Eragrostis plana* and *Eragrostis pilosa* (L.) P. Beauv. submitted on flooded soil. **Acta Scientiarum Biological Sciences**, v. 42, n. 1, p. e47557, 2020. DOI: https://doi.org/10.4025/actascibiolsci.v42i1.47557

CECCHIN, K. *et al.* Allelopathy and allelochemicals of *Eragrostis plana* (Poaceae) and its relation with phenology and nitrogen fertilization. **Planta Danina**, v. 35, p. 1-12, 2017.

CHAUHAN, P. S. *et al.* Allelopathic effects of *Juglans regia* leaf extract on seed germination and seedling growth of wheat (*Triticum aestivum*) and rye (*Secale cereale*). **Archives of Agriculture and Environmental Science**, v. 7, n. 1, p. 8-11, 2022. DOI: https://doi.org/10.26832/24566632.2022.070102

ESCOBAR, T. A. *et al.* Superação de dormência e temperaturas para germinação de sementes de *Acacia caven* (Mol.) Mol. (espinilho). **Revista Brasileira de Sementes**, v. 32, n. 2, p. 124-130, 2010. DOI: https://doi.org/10.1590/S0101-31222010000200015

FAVARETTO, A. *et al.* Pattern of allelochemical distribution in leaves and roots of tough lovegrass (*Eragrostis plana* Nees.). **Australian Journal of Crop Science**, v. 9, n. 11, p. 1119-1125, 2015.

FAVARETTO, A. *et al.* New phytotoxic cassane-like diterpenoids from *Eragrostis plana*. **Journal of Agriculture and Food Chemistry**, v. 67, n. 7, p. 1973-1981, 2019. DOI: https://doi.org/10.1021/acs.jafc.8b06832

FERREIRA, N. R. *et al.* Potencial alelopático do capim-annoni-2 (*Eragrostis plana* Nees) na germinação de sementes de gramíneas perenes estivais**. Revista Brasileira de Sementes**, v. 30, n. 2, p. 043-050, 2008.

FERRERAS, A. E. *et al.* Different strategies for breaking physical seed dormancy in field conditions in two fruit morphs of *Vachellia caven* (Fabaceae). **Seed Science Research**, v. 28, n. 1, p. 8- 9, 2018. DOI: https://doi.org/10.1017/S096025851800003X

FIORENZA, M. *et al.* Análise fitoquímica e atividade alelopática de extratos de *Eragrostis plana* Nees (capim-annoni). **Iheringia, Série Botânica**, v. 71, n. 2, p. 193-200, 2016.

FONSECA, C. R. *et al.* Invasive alien plants in the pampas grasslands: a tri-national cooperation challenge. **Biol Invasions**, v. 15, p. 1751-1763, 2013. DOI: https://doi.org/10.1007/s10530-013-0406-2

GOMÉZ-FERNÁNDEZ, N. A. *et al.* Facilitation by pioneer trees and herbivore exclusion allow regeneration of woody species in the semiarid ecosystem of central Chile. **Applied Vegetation Science**, v. 26, v. 3, e12741, 2023. DOI: https://doi.org/10.1111/avsc.12741

GUIDO, A. *et al.* Are the invasive grasses *Cynodon dactylon* and *Eragrostis plana* more phytotoxic than a co-occurring native?. **Ecología Austral**, 30, p. 295-303, 2020. DOI: https://doi.org/10.25260/EA.20.30.2.0.1090

HENDGES, A. P. P. K. *et al.* Phytotoxic bioassays and fingerprinting by HPLC-DAD of *Eragrostis plana* Nees root extracts: application of chemometrics. **Anais da Academia Brasileira de Ciências**, v. 93, n. 1, e20200129, 2021. DOI: https://doi.org/10.1590/0001-3765202120200129

KRZYZANOWSKI, F. C. *et al*. Testes de vigor baseados em desempenho de plântulas. *In*: KRZYZANOWSKI, F. C. *et al*. (Orgs.). **Vigor de sementes**: conceitos e testes. Londrina: Abrates, 2020.

LI, J. *et al.* Fine-root traits of allelopathic rice at the seedling stage and their relationship with allelopathic potential. **PeerJ,** v. 7, p. e7006, 2019. DOI: https://doi.org/10.7717/peerj.7006

MARCHIORI, J. N. C. Anatomia da madeira e casca do espinilho (*Acacia caven* (Mol.) Mol.) **Ciência Florestal**, v. 2, n. 1, p. 27-47, 1992.

MASUM, S. M. *et al*. Isolation and characterization of allelopathic compounds from the indigenous rice variety 'Boterswar' and their biological activity against *Echinochloa crus-galli* L. **Allelopathy Journal**, v. 43, n. 1., p. 31-42, 2018. DOI: https://doi.org/10.26651/allelo.j./2018-43-1-1127

MEDEIROS, R. B. de; FOCHT, T. Invasão, prevenção, controle e utilização do capim-annoni-2 (*Eragrostis plana* Nees) no Rio Grande do Sul, Brasil. **Pesquisa Agropecuária Gaúcha**, v. 13, n. 1-2, p. 105-114, 2007.

MIRANDA, A. *et al*. Traits of perch trees promote seed dispersal of endemic fleshy-fruit species in degraded areas of endangered Mediterranean ecosystems. **Journal of Arid Environments**, v. 170, 103995, 2019. DOI: https://doi.org/10.1016/j.jaridenv.2019.103995

ODIRILE, O. *et al*. Responses of seeds of *Vachellia erioloba* (E. Mey.) P.J.H. Hurter in Botswana to different pre-sowing treatment methods. **International Journal of Biology and Biotechnology**, v. 16, n. 1, p. 181-188, 2019.

OLIVEIRA, E. B. *et al*. Investigação fitoquímica e atividade alelopática do extrato foliar da *Croton heliotropiifolius* Kunth sobre o desenvolvimento inicial de *Lactuca sativa* L. **Research, Society and Development**, v. 11, n. 14, p. e151111435613, 2022.

ROSA, E. da *et al*. Phytochemistry profile, antimicrobial andantitumor potential of the methanolic extract of *Tabernaemontana catharinensis* A DC and *Eragrostis plana* Nees. **Evidence-Based Complementary and Alternative Medicine**, v. 24, p. 1-12, 2024. DOI: https://doi.org/10.1155/2024/5513141

SANTOS, M. F. *et al.* Efeito alelopático de extratos foliares de *Portulaca oleracea* e *Raphanus raphanistrum* sobre a germinação de sementes de *Lactuca sativa* L. **Scientia Plena,** v. 19, n. 4, p. 1-13, 2023. DOI: https://doi.org/10.14808/sci.plena.2023.041201

SARMA, D. *et al.* Allelopathic impact of *Melastoma malabathricum* L. on the seed germination and seedling growth of three agricultural crops. **The Journal of Indian Botanical Society**, v. 98, p. 183-193, 2019.

SARTOR, L. R. *et al*. Alelopatia de acículas de *Pinus taeda* na germinação e no desenvolvimento de plântulas de *Avena strigosa*. **Ciência Rural**, v. 39, n. 6, p. 1653-1659, 2009.

SILVA, E. R. *et al*. Are phytotoxic effects of *Eucalyptus saligna* (Myrtaceae) essential oil related to its major compounds? **Australian Journal of Botany**, v. 69, n. 3, 174-183, 2021. DOI: https://doi.org/10.1071/BT20082

SCHEFFER-BASSO, S. M. *et al.* Influence of phenology and post-harvest processing of vegetal material on the allelopathy of annoni grass (*Eragrostis plana*) extracts. **Planta Daninha**, v. 37, p. 1-11, 2019.

SZWED, M. *et al*. If phenolic compounds in the soil with buckwheat residues affect the emergence and growth of weed seedlings?. **Acta Physiologiae Plantarum**, v. 42, n. 9, p. 154, 2020. DOI: https://doi.org/10.1007/s11738-020-03142-9

TWARDOWSKI, T. *et al*. A invasão do capim-annoni (*Eragrostis plana* Ness) em pastagens sul-brasileiras. **MilkPoint**, 2018.

VELASCO, N. *et al*. Dispersal syndromes of *Vachellia caven*: dismantling introduction hypotheses and the role of man as a conceptual support for an archaeophyte in South America. **Heliyon**, v. 9, 2023. DOI: https://doi.org/10.1016/j.heliyon.2023.e17171

ZENNI, R. D. *et al*. Status e tendências sobre espécies exóticas invasoras no Brasil. *In*: DECHOUM, M. S.; JUNQUEIRA, A. O. R.; ORSI, M. L. (Org.). **Relatório temático sobre espécies exóticas invasoras, biodiversidade e serviços ecossistêmicos.** 1. ed. São Carlos: Editora Cubo, 2024. p. 49-91. DOI: https://doi.org/10.4322/978-65-00-87228-6.cap2

YU, Y. *et al*. Does the salt stress intensify the independent allelopathy and the coallelopathy of *Solidago canadensis* L. and *Conyza canadensis* (L.) Cronq.?. **South African Journal of Botany**, v. 153, p. 37-45, 2022. DOI: https://doi.org/10.1016/j.sajb.2022.12.015