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ALLELOPATHIC ACTIVITY OF *Eragrostis plana* Nees ON THE GERMINATION OF PERSIAN CLOVER, RICE AND WHITE OATS

ATIVIDADE ALELOPÁTICA DE Eragrostis plana Nees NA GERMINAÇÃO DE TREVO-PERSA, ARROZ E AVEIA-BRANCA

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ABSTRACT

Eragrostis plana Nees is an exotic Poaceae with invasive potential in natural grassland areas of southern South America, due to its biological and ecological characteristics. This study was carried out to evaluate the possible allelopathic effect of *E. plana* on the germination of *Trifolium resupinatum* (persian clover), *Oryza sativa* (rice) and *Avena sativa* (white oats) seeds. To obtain the aqueous extract, previously dried aerial parts (leaf and stem) were used at a concentration of 1 g 10 mL^{-1}. Four different concentrations were used (25, 50, 75, and 100%) and the control (distilled water), with four replicates for each treatment. At the end of the experiment, the following parameters were assessed: first count, germination percentage, initial length, and dry mass of the seedlings. It was found that the aqueous extracts of *E. plana* significantly reduced all the parameters evaluated in the three agricultural species. For rice, the 100% concentration was the most inhibitory; for oats, there was a reduction in the parameters assessed from 75% onwards, except for biomass, which was reduced at the 100% concentration. Finally, persian clover showed a significant reduction in all the variables analyzed at the highest concentration. The results indicate that the aqueous extracts of *E. plana* have a negative influence on the germination and development of rice, oat, and persian clover seedlings; therefore, care should be taken when intercropping these cultivated species with this species, which is considered to be allelopathic.

Keywords: allelopathy; annoni-grass; aqueous extracts; biomass; initial growth.

RESUMO

Eragrostis plana Nees é uma Poaceae exótica com potencial invasivo nas áreas de pastagem natural do Sul da América do Sul, devido suas características biológicas e ecológicas. Este estudo foi realizado para avaliar o possível efeito alelopático de E. plana sobre a germinação de sementes de Trifolium resupinatum (trevo-persa), Oryza sativa (arroz) e Avena sativa (aveia branca). Para obtenção do extrato aquoso foram utilizadas

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partes aéreas (folha e caule) previamente secas na concentração de 1 g 10 mL^{-1}. Foram utilizadas quatro concentrações diferentes (25, 50, 75 e 100%) e o controle (água destilada), com quatro repetições para cada tratamento. Ao final do experimento, avaliou-se os seguintes parâmetros: primeira contagem, percentual de germinação, comprimento inicial e massa seca das plântulas. Verificou-se que os extratos aquosos de E. plana reduziram significativamente todos os parâmetros avaliados nas três espécies agrícolas. Para o arroz, a concentração de 100% foi a mais inibitória; já para a aveia, a partir de 75% houve redução nos parâmetros avaliados, exceto a biomassa que foi reduzida na concentração de 100%. E, por fim, o trevo-persa apresentou, na maior concentração, redução significativa em todas as variáveis analisadas. Os resultados indicam que os extratos aquosos E. plana apresentam influência negativa na germinação e desenvolvimento de plântulas de arroz, aveia e trevo-persa; sendo assim, deve-se ter cuidado no consórcio destas espécies cultivadas com esta espécie considerada alelopática.

Palavras-chave: *alelopatia; capim-annoni; extratos aquosos; biomassa; crescimento inicial.*

INTRODUCTION

Plants have mechanisms to protect themselves from environmental disturbances, such as invasive species that seek greater control over native species through a process known as allelopathy (GUIDO *et al*., 2020).

Allelopathy consists of the release of chemicals produced by secondary metabolism, allelochemicals, that affect different stages of plant development (BRUXEL *et al*., 2022; YU *et al*., 2022). Allelochemicals can have inhibitory effects on the germination process and cell division, reduce mineral absorption, interfere with enzyme activity, root growth, cellular respiration, and protein synthesis (CHENG; CHENG, 2015; FAVARETTO *et al*., 2019). In addition, these secondary metabolites have the potential to control spontaneous plants, so it is environmentally important to study them in order to reduce the use of pesticides that are harmful to the environment (FAVARETTO *et al*., 2015; LADHARI *et al*., 2020). This process contributes to the ability of certain exotic species to become dominant in some areas where native species occur, causing some ecological changes (FAVARETTO *et al*., 2015).

Furthermore, allelochemicals can be used as a natural resource for the production of natural herbicides, which are considered safe and efficient in the management of undesirable plants (FAVARETTO *et al*., 2019; ABD-ELGAWAD *et al*., 2021; BRUXEL *et al*., 2022). In addition, natural herbicides derived from essential oils or other components synthesized by the plant's secondary metabolism allow for agricultural practices that are less harmful to the environment (SILVA *et al*., 2021; BRUXEL *et al*., 2022).

Some of these allelopathic species show strong adaptability and can grow and spread rapidly in new environments, which can have negative consequences for the economy and ecology of a society (FAVARETTO *et al*., 2015), and among them, annoni grass (*Eragrostis plana* Nees) stands out, with some studies evaluating the allelopathic potential of this species on native and exotic species (HENDGES *et al*., 2021; MOTALEBNEJAD *et al*., 2023; MENDES *et al*., 2024).

The genus *Eragrostis* has the largest number of weed species in the Pampa biome, covering areas of Brazil, Uruguay, and Argentina (FONSECA *et al*., 2013; FAVARETTO *et al*., 2019), and is currently present in several regions of Asia, India, and the United States (FAVARETTO *et al*., 2019).

Eragrostis plana (Poaceae), a C4 grass known as annoni grass, is considered an invasive and exotic plant in Brazil, native to South Africa (ARTICO *et al*., 2020; BASTIANI *et al*., 2023). In the natural pastures of southern Brazil, it is estimated that more than 2 million hectares have already been invaded by the resistant *E. plana* (MEDEIROS; FOCHT, 2007). This grass has been used as fodder for some animals (ARTICO *et al*., 2020). However, it was found that its nutritional potential was low due to the large amount of fibers, leading to tooth wear, so its use as food was abandoned, but there was no proper management of the specimens, which spread due to easy reproduction and dispersal in the fields (TWARDOWSKI *et al*., 2018; FAVARETTO *et al*., 2019; ARTICO *et al*., 2020). Furthermore, this most abundant, aggressive, and difficult to control invasive species in the Pampa biome is responsible for altering the biological balance of this biome as well as native pastures (CARLOTO *et al*., 2020; BASTIANI *et al*., 2023).

It is a species known for its ability to compete with other plants, including species of economic interest (FERREIRA *et al*., 2008; HENDGES *et al*., 2021). It is documented by Carloto *et al*. (2020) that, among the grasses that affect rice crops (*Oryza sativa* L.), the species *E. plana* and *E. pilosa* stand out for their recent introduction into the environment and competition with the rice crop.

Some studies have shown that the possible allelopathic effect is due to the presence of secondary metabolites (allelochemicals) and in *E. plana* the presence of phenolic compounds (gallic, ellagic, caffeic and chlorogenic acid), flavonoids (quercetin and rutin) and tannins (epigenin, epicatechin and catechin) has already been established, as described in the studies by Favaretto *et al*. (2015), Fiorenza *et al*. (2016) and Favaretto *et al*. (2019).

In view of the above, the aim of this study was to evaluate the possible allelopathic effect of *E. plana* on *Trifolium resupinatum* L. (persian clover), *Oryza sativa* L. (rice) and *Avena sativa* L. (white oats).

MATERIAL AND METHODS

The work was carried out at the Seed and Plant Tissue Culture Laboratory of the Federal University of Santa Maria (UFSM). The aerial part (stem and leaves) of annoni grass (*Eragrostis plana* Nees) was collected at the Federal University of Pampa (UNIPAMPA), São Gabriel Campus, Rio Grande do Sul. 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, and the crude extract was obtained at a concentration of 1 g to 10 mL^{-1} (w/v) of distilled water.

The extract was diluted with distilled water at four different concentrations: 25, 50, 75, and 100%. Distilled water was used as the control treatment and “pure extract” was used for the 100% concentration.

Four replicates of 50 seeds of Persian clover (*Trifolium resupinatum* L.), white oats (*Avena sativa* L.) and rice (*Oryza sativa* L.) were used for each germination bioassay. For the germination tests, germ paper moistened with distilled water or an aqueous extract was used, the amount used to be 2.5 times the mass of the dry paper (BRASIL, 2009). The experiment was performed in a growth chamber with temperature control (25±2 ºC, 230 µmol m^{-2} s^{-1}) and light control (16-hour photoperiod).

After 7 days of the experiment, the following parameters were evaluated: initial number (%), length (cm) and dry mass (mg) of the seedlings (KRZYZANOWSKI *et al*., 2020), and after 14 days, the final germination percentage of the seeds was evaluated, with the seeds being considered germinated only when normal seedlings were obtained (BRASIL, 2009).

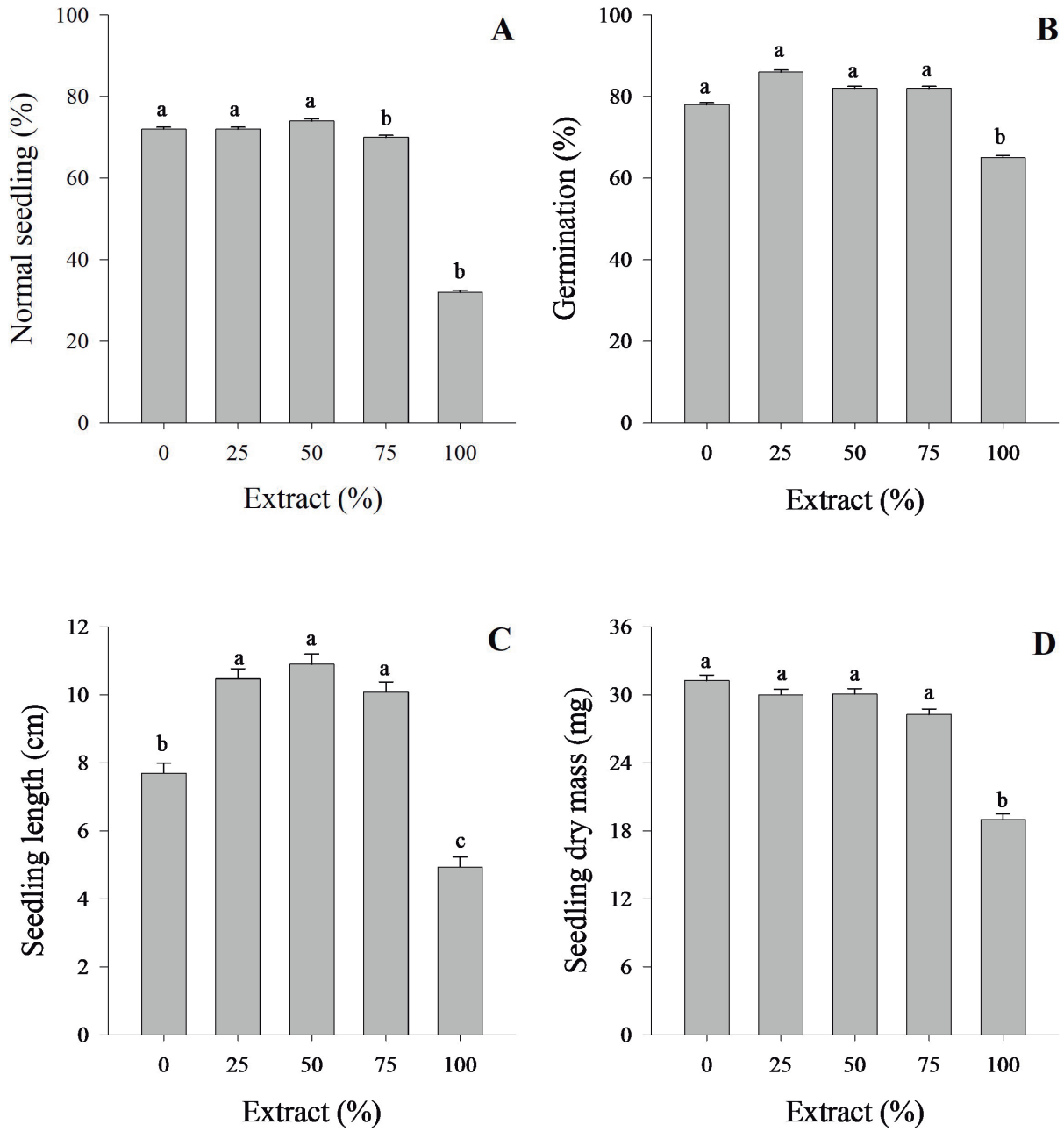
The design used was completely randomized, with four replicates of 50 seeds each. The information obtained was analyzed by variance, and when the treatments showed a significant difference ($p<0.05$), the means were compared using the Scott-Knott test at 5% probability.

RESULTS AND DISCUSSION

In the three species, the analysis of variance showed significant differences ($p<0.05$) depending on the different extracts of annoni grass for all the variables analyzed (Figures 1, 2 and 3).

It was found that the aqueous extracts of *E. plana* significantly affected the germination and initial development of *Oryza sativa* (rice) in all the parameters evaluated, where in the first count a reduction in normal seedlings was observed from 75% and, for the other parameters, the extracts reduced only the highest concentration (100%) compared to the control treatment (Figures 1A-D). For the initial length of seedlings, it was observed that at concentrations from 25 to 75% there was a stimulus, possibly due to the presence of allelochemicals in the extracts of this species, considered allelopathic, since this process can not only reduce physiological processes but also act by stimulating them.

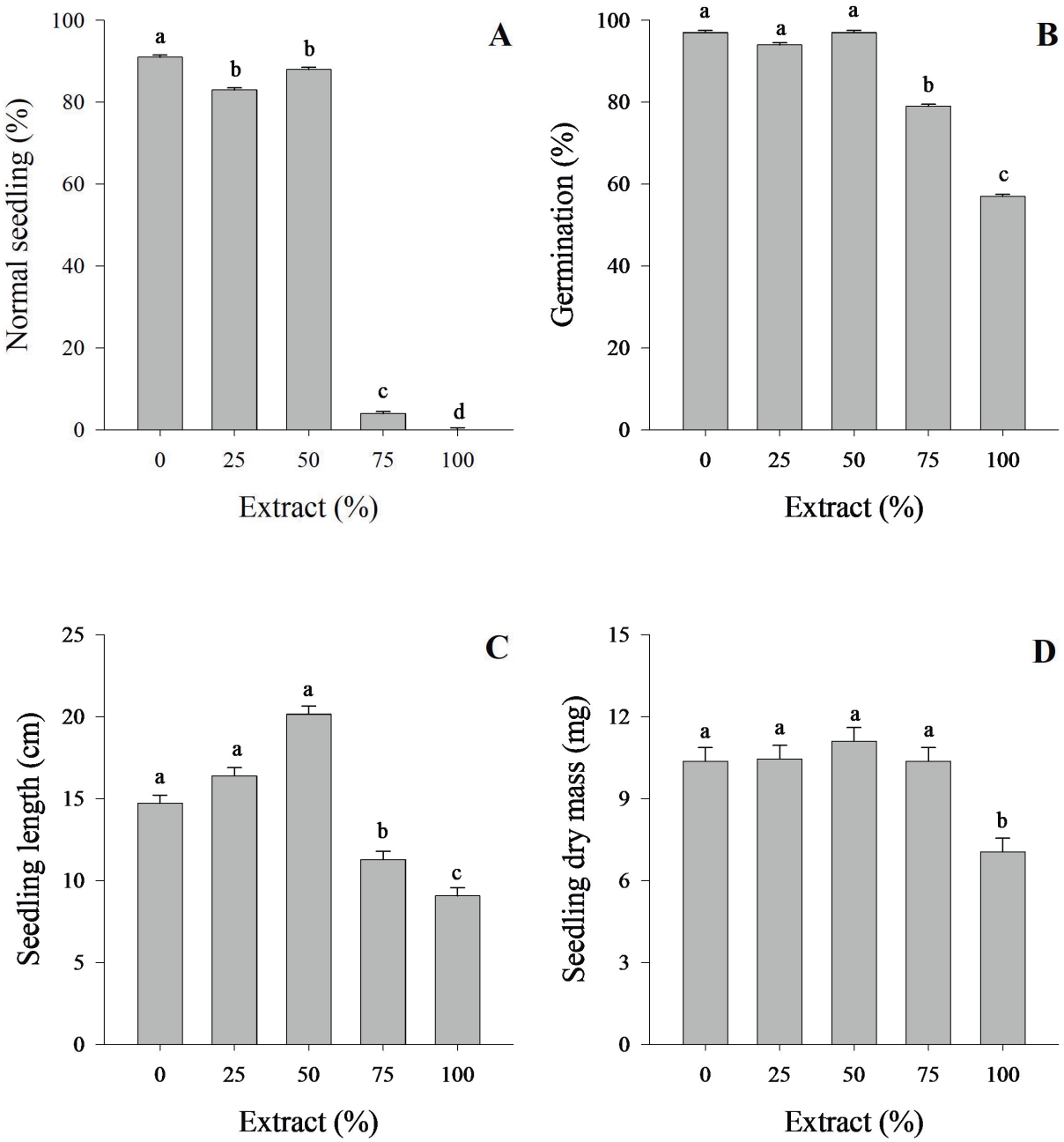
Figure 1 - Fist count (A), germination (B), length (C), and dry mass (D) of *Oryza sativa* L. seedlings exposed to different concentrations of *Eragrostis plana* Nees extracts.



*Means followed by the same letter are not different at 5% probability by Scott-Knott test.
Source: Authors (2024).

On the other hand, in white oats, the percentage of normal seedlings, assessed by the first count and germination, was reduced at the highest concentrations (75 and 100%) compared to the control treatment (Figures 2A-B). Among the parameters evaluated, the length of the seedlings was most affected by the extracts, especially the root system, since it is the first vegetative structure to come in contact with the aqueous extract and act in its absorption; unlike the germination of the seed, where it has reserves in the endosperm to maintain the germination process (Figures 2C and 2A).

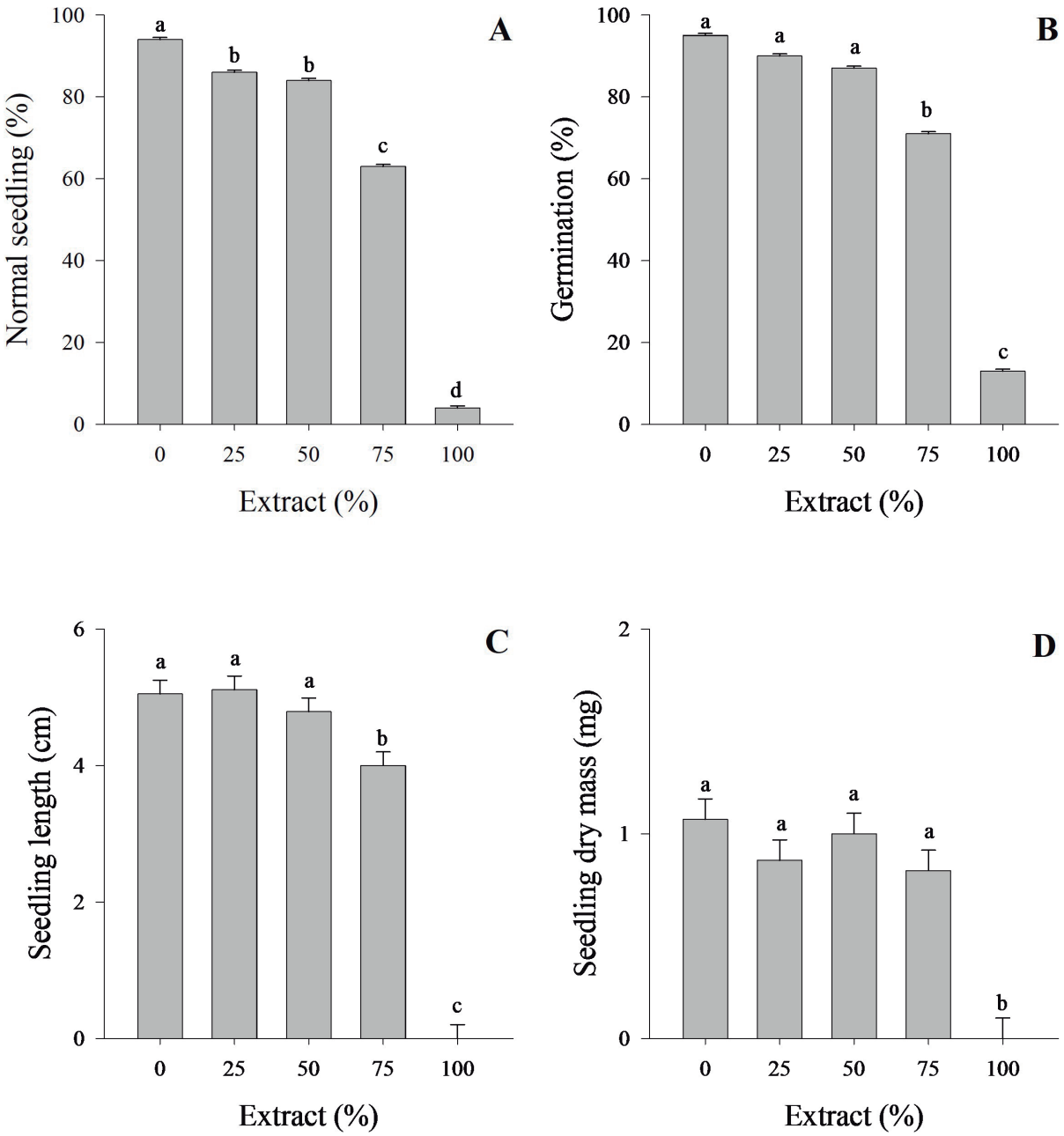
Figure 2 - First count (A), germination (B), length (C) and dry mass (D) of *Avena sativa* L. seedlings exposed to different concentrations of *Eragrostis plana* Nees extracts.



*Means followed by the same letter are not different at 5% probability by the Scott-Knott test.
Source: Authors (2024).

For persian clover, it was found that the extracts of annoni grass significantly reduced the parameters analyzed. The percentage of normal seedlings assessed in the first count showed a decrease from the 25% concentration, while germination and seedling growth were reduced from the 75% concentration (Figures 3A-C). In addition, seedling dry mass decreased at the highest concentration (100%) compared to the control treatment (Figures 3D). Of the parameters evaluated, both germination and initial seedling length were most affected, especially root system length, as this is the vegetative structure in direct contact with the annoni grass extract.

Figure 3 - First count (A), germination (B), length (C) and dry mass (D) of *Trifolium resupinatum* L. seedlings exposed to different concentrations of *Eragrostis plana* Nees extracts.



*Means followed by the same letter are not different at 5% probability by the Scott-Knott test.
Source: Authors (2024).

In previous studies, leaf extracts of *E. plana* showed a significant reduction in seed germination and hypocotyl elongation of white clover (*Trifolium repens* L.) seedlings (SCHEFFER-BASSO *et al*., 2019). l,It was noted that the primary root exhibited greater sensitivity to the effects of the extracts compared to the hypocotyl, with the effect depending on the phenological stage of the plants, post-harvest processing, and the amount of plant material used for extraction, which interact.

Results similar to this study have demonstrated the allelopathic effect of extracts of annoni grass leaves and roots on native vegetation, affecting the germination of other species

(FAVARETTO *et al*., 2011; FAVARETTO *et al*., 2015; FIORENZA *et al*., 2016; SILVA *et al*., 2020). Other authors have suggested that these extracts reduce the total length, aerial part and root of wheat (*Triticum aestivum* L.) and alfalfa (*Medicago sativa* L.), with the primary root being more affected than the hypocotyl and the degree of sensitivity varying according to each variable and extract used (BITTENCOURT *et al*., 2018). In another study conducted by these authors, where the effect of aqueous leaf extracts was tested on the species studied, it was observed that alfalfa was the species with the highest sensitivity to the aqueous extract, with both germination and seedling development inhibited, and *Braquiaria brizanta* (A. Rich.) Stapf. and wheat suffered only a negative allelopathic effect on seedling development, with *B. brizanta* being the only species that benefited from the aqueous extract, showing a lower number of abnormal seedlings (BITTENCOURT *et al*., 2020).

In addition, aqueous extracts of *Chloris gayana* Kunth (Rhodes grass) exerted an allelopathic effect on seed germination and soybean seedling growth at concentrations of 50 and 100%, respectively (LIMA *et al*., 2022), while the suppressive effect of *Eragrostis tef* (Zuc.) Trotter played a notable role in inhibiting the initial root growth and development of ryegrass (*Lolium perenne* L.) and radish (*Raphanus sativu*s L.), affecting their biomass, cover and density (GEBREHIWOT *et al*., 2020). Also, Motalebnejad *et al*. (2023), who evaluated the allelopathic activity of grasses of different species, concluded that the type of genotype and concentration of extract significantly decreased germination, hypocotyl and root length, and dry mass of *Eruca sativa* L. (Rocket) seedlings at concentrations of 75 and 100%.

In addition, allelopathy is a process in which one plant species stimulates or inhibits the growth of another species through certain secondary metabolites (XU *et al*., 2023). 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 annoni grass are detached or extracted during the mowing of pastures, becoming a source of allelochemical compounds.

Complementary studies on allelopathic effects have been carried out on different parts of the plant and it was found that aqueous extracts of leaves showed greater inhibition of germination, possibly due to greater metabolic activity, as they contain more allelochemical compounds than other tissues (CECCHIN *et al*., 2017; LIU *et al*., 2020). However, the main effect on early development is seen in the reduced growth of roots, which are sensitive to these chemicals. The phenolic compounds present in the extracts induce changes in cell membranes, reducing their permeability and causing changes in water conductivity and ion flux in plant roots (NOVAKOSKI *et al*., 2020). In addition, root growth is more susceptible to allelopathic plant extracts than other organs because roots are the first organ to come into contact with phytotoxic chemicals and have more absorbent tissue than other parts (WANDSCHEER; PASTORINI, 2008; ISLAM *et al*., 2019).

Sensitivity to allelochemicals may also be affected by seed size, with small seeds being more susceptible to allelopathic effects than larger seeds due to reduced carbohydrate reserves

(HARAMOTO; GALLANDT, 2005), as observed in Persian clover. In addition, some studies suggest that the reduction in seed germination at higher concentrations of aqueous extracts is due to reduced water absorption by the seeds and the presence of allelopathic compounds in the substrate. The uptake of these compounds by the seeds leads to their toxicity, resulting in reduced water and nutrient uptake and disruption of seedling growth and development (CHENG *et al*., 2021).

Another important point to consider is that the different responses to the aqueous extract in the germination process among the target species are justified, as the sensitivity and response of the seeds to the compounds are expected to vary among the plant species and families (ALMAGHRABI, 2012; BITTENCOURT *et al*., 2020). In addition, some seeds have a more developed or distinct integument composition, which acts as a protective tissue that controls the flow of substances to the embryo through selective processes (FAVARETTO *et al*., 2019), and the germination process is often less affected compared to early seedling growth (BITTENCOURT *et al*., 2020). In other species, some allelochemicals in the extract may act synergistically with certain plant hormones to promote increased germination and tissue growth, while others may act negatively, such as through auxin decarboxylation or by binding to gibberellic acid (BITTENCOURT *et al*., 2020; HENDGES *et al*., 2021). Cheng and Cheng (2015) and Taiz *et al*. (2021) point out that phytohormones can be negatively affected by allelochemicals, and changes in these growth regulators can affect seed germination and initial seedling growth.

The effects observed on the germination and initial growth of rice, oats, and Persian clover may be a consequence of the direct action of the compounds present in annoni grass extracts, involving changes at the cellular level, inhibiting or stimulating mitosis, phytohormone production, respiration, and specific enzyme activities (NOVAKOSKI *et al*., 2020). The reduction in root growth may be due to the interruption of mitosis, resulting in a reduction in root length and consequently a reduction in root volume. This effect on root growth may be responsible for the decrease in germination, root and aerial part length, and seedling biomass due to the reduction in moisture in the medium (AKTER *et al*., 2023).

It is worth noting that the allelopathic effect can be influenced by the displacement of allelochemicals on field soil conditions, so the allelopathic activity can be modified and not correspond to the results found in this work, as it was carried out in a controlled environment (SILVA *et al*., 2021). Finally, the results of this study showed that the allelopathic effects of annoni grass extracts are concentration and species dependent. This is important information for understanding how the species interacts with cultivated species in pasture areas and reinforces the potential damage caused by its presence.

CONCLUSION

This study shows that the aqueous extracts of the exotic grass *Eragrosti plana* have a negative influence on the germination and development of seedlings of rice (*Oryza sativa*), white oats

(*Avena sativa*) and persian clover (*Trifolium resupinatum*), so care should be taken when intercropping these species with annoni grass.

In rice, germination percentage and initial seedling development were affected at the highest concentration (100%), and in oats and wheat, these parameters were reduced at concentrations of 75 and 100% compared to the control treatment.

In order to better understand the allelopathic effects of this invasive species on the germination process and initial development of these agricultural species, fieldwork should be carried out to better elucidate this effect.

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