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ALLELOPATHIC INTERACTION BETWEEN *Digitaria insularis* AND *Sesamum indicum*: DIFFERENTIAL RESPONSES IN SHOOT AND ROOT GROWTH

INTERAÇÃO ALELOPÁTICA ENTRE *Digitaria insularis* E *Sesamum indicum*: RESPOSTAS DIFERENCIAIS NO CRESCIMENTO DA PARTE AÉREA E DO SISTEMA RADICULAR

INTERACCIÓN ALELOPÁTICA ENTRE *Digitaria insularis* Y *Sesamum indicum*: RESPUESTAS DIFERENCIALES EN EL CRECIMIENTO DE LA PARTE AÉREA Y DEL SISTEMA RADICULAR

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ABSTRACT: This study aimed to evaluate the allelopathic effect of aqueous extracts of *Digitaria insularis* on the germination and early growth of sesame (*Sesamum indicum* L.) seedlings. The experiment was conducted under laboratory conditions in a completely randomized design, arranged in a 4 × 5 factorial scheme (cultivars × extract concentrations), with four replications. Four sesame cultivars (Seda, K3, Anahí, and Morena) and five extract concentrations (0, 2.5, 5, 10, and 20% w/v) were evaluated. The following variables were assessed: germination percentage, germination speed index, seedling height, root length, shoot and root fresh mass, and shoot and root dry mass. The results showed no significant effect of the extract on germination; however, significant changes were observed in seedling growth variables. An increase in seedling height and shoot biomass was observed with increasing extract concentrations, whereas root length decreased. Regression analysis indicated predominantly linear responses. These findings suggest that Digitaria insularis extract does not exert inhibitory allelopathic effects on sesame germination but induces differential physiological responses during early growth, possibly associated with hormetic effects.

Keywords: Allelopathy. Sesame. Germination.

RESUMO - O presente estudo teve como objetivo avaliar o efeito alelopático de extratos aquosos de *Digitaria insularis* sobre a germinação e o crescimento inicial de plântulas de gergelim (*Sesamum indicum* L.). O experimento foi conduzido em laboratório, em delineamento inteiramente casualizado, em esquema fatorial 4 × 5 (cultivares × concentrações do extrato), com quatro repetições. Foram testadas quatro cultivares de gergelim (Seda, K3, Anahí e Morena) e cinco concentrações do extrato (0, 2,5, 5, 10 e 20% p;v). Avaliaram-se a

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porcentagem de germinação, o índice de velocidade de germinação, a altura de plântulas, o comprimento de raiz, a massa fresca da parte aérea e de raiz, e a massa seca da parte aérea e de raiz. Os resultados indicaram ausência de efeito significativo do extrato sobre a germinação, porém evidenciaram alterações nas variáveis de crescimento. Observou-se incremento na altura de plântulas e na biomassa da parte aérea com o aumento das concentrações, enquanto o comprimento de raiz apresentou redução. Os modelos de regressão evidenciaram comportamento linear para a maioria das variáveis. Os resultados sugerem que o extrato de *Digitaria insularis* não exerce efeito alelopático inibitório sobre a germinação do gergelim, mas promove respostas fisiológicas diferenciadas no crescimento inicial, possivelmente associadas ao fenômeno da hormese.

Palavras chave Alelopatia. Gergelim. Germinação.

RESUMEN - Este estudio tuvo como objetivo evaluar el efecto alelopático de extractos acuosos de *Digitaria insularis* sobre la germinación y el crecimiento inicial de plántulas de sésamo (*Sesamum indicum* L.). El experimento se realizó en condiciones de laboratorio, en un diseño completamente aleatorizado, dispuesto en un esquema factorial 4 × 5 (cultivares × concentraciones del extracto), con cuatro repeticiones. Se evaluaron cuatro cultivares de sésamo (Seda, K3, Anahí y Morena) y cinco concentraciones del extracto (0, 2,5, 5, 10 y 20% p/v). Las variables analizadas incluyeron porcentaje de germinación, índice de velocidad de germinación, altura de plántula, longitud de raíz, masa fresca y seca de parte aérea y raíz. Los resultados mostraron ausencia de efecto significativo del extracto sobre la germinación; sin embargo, se observaron cambios en las variables de crecimiento. El incremento en la altura de plántulas y en la biomasa aérea estuvo asociado a mayores concentraciones del extracto, mientras que la longitud de raíz disminuyó. Los modelos de regresión indicaron respuestas predominantemente lineales. Estos hallazgos sugieren que el extracto de *Digitaria insularis* no ejerce efectos alelopáticos inhibitorios sobre la germinación del sésamo, pero induce respuestas fisiológicas diferenciales durante el crecimiento inicial, posiblemente relacionadas con fenómenos de hormesis.
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Palabras clave: Alelopatía. Sésamo. Germinación.

INTRODUCTION

Plant interference is one of the main factors affecting the establishment and development of agricultural crops, resulting from complex interactions involving both competition for resources and the release of chemical compounds into the environment. This latter mechanism, known as allelopathy, refers to the ability of certain plant species to produce and release secondary metabolites capable of positively or negatively influencing the growth

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and development of other plants (Inderjit & Dakshini, 1994; Weston & Duke, 2003; Souza Filho & Alves, 2002; Scavo & Mauromicale, 2021).

Allelopathic effects may manifest at different stages of the plant life cycle, particularly during germination and early growth, which are critical phases for crop establishment. Allelochemicals can act on fundamental physiological processes such as membrane permeability, enzymatic activity, respiration, and cell division, and their mechanisms of action are often associated with interference in specific metabolic pathways (Einhellig, 1996; Duke & Dayan, 2011; Macías et al., 2007). Furthermore, these effects may vary depending on compound concentration, the recipient species, and environmental conditions (Cheng & Cheng, 2015; Zeng et al., 2008; Aci et al., 2022).

Among weed species of increasing importance in Brazilian agricultural systems, *Digitaria insularis* (L.) Fedde, commonly known as sourgrass, stands out. This species exhibits high adaptive capacity, abundant seed production, and, in many cases, herbicide resistance, factors that contribute to its wide dissemination and difficult control. Although its interference is often attributed to competition for resources, there is evidence that compounds released by this species may also play a relevant role in its interaction with agricultural crops (Bais et al., 2003; Campos et al., 2020; Silva et al., 2024).

Sesame (*Sesamum indicum* L.) is a crop of growing economic interest, especially in tropical regions, due to its rusticity and the quality of its oil. However, the success of initial crop establishment may be influenced by biotic factors present in the environment, including possible allelopathic effects of weeds, which may affect germination and seedling vigor (Souza et al., 2021).

Additionally, recent studies have shown that the effects of allelochemicals are not necessarily exclusively inhibitory. At certain concentrations, these substances may stimulate plant growth, characterizing the phenomenon known as hormesis (Calabrese & Baldwin, 2003; Belz, 2008; Cedergreen, 2008; Scavo & Mauromicale, 2021). This type of response highlights the complexity of plant–plant interactions, in which effects depend on dose, plant organ, and the sensitivity of the recipient species.

Another relevant aspect is the possibility of differential responses among plant organs, since the root system, being in direct contact with the substrate, tends to be more sensitive to compounds present in the environment (Inderjit & Weston, 2003). In contrast, the shoot may

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respond differently, reflecting the selective action of compounds on specific physiological processes.

Therefore, this study aimed to evaluate the effect of aqueous extracts of *Digitaria insularis* on germination and early growth of seedlings from different sesame cultivars, seeking to understand not only possible inhibitory effects but also physiological responses associated with different extract concentrations.

MATERIAL AND METHODS

The experiment was conducted at the Seed Laboratory (LaSeM), linked to the Center for Research and Technology of the Southern Amazon (CEPTAM), at the State University of Mato Grosso (UNEMAT), Alta Floresta campus, MT, Brazil.

Seeds of four sesame (*Sesamum indicum* L.) cultivars—Seda, K3, Anahí, and Morena—were used, previously selected for physical uniformity and absence of apparent damage.

The aqueous extract of *Digitaria insularis* was obtained from plant material (roots only) collected from an agricultural area, shade-dried, and subsequently ground. The stock solution was prepared by immersing the material in distilled water at a proportion of 100 g L^{-1} (10% w/v), remaining at rest for 24 hours at room temperature. After this period, the extract was filtered through filter paper, constituting the crude extract.

From the crude extract, the concentrations of 0 (control, distilled water only), 2.5, 5, 10, and 20% (w/v) were prepared by dilution in distilled water.

Sowing was carried out on germination paper (germitest type), previously sterilized and moistened with the respective solutions at a proportion of 2.5 times the dry paper mass. The seeds were evenly distributed on the substrate and maintained in a germination chamber at 25 ± 2 °C, under a 12-hour photoperiod.

The experimental design was completely randomized, in a 4 × 5 factorial scheme (cultivars × extract concentrations), with four replications.

The following variables were evaluated: germination percentage (%G), germination speed index (GSI), seedling height (cm), root length (cm), shoot fresh mass (SFM, g), root fresh mass (RFM, g), shoot dry mass (SDM, g), and root dry mass (RDM, g).

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Germination was evaluated according to the Rules for Seed Testing, considering normal seedlings. The germination speed index was determined according to Maguire (1962).

Growth variables were measured at the end of the experimental period, using a millimeter ruler for length and an analytical balance for mass determination. For dry mass determination, samples were placed in a forced-air circulation oven at 65 °C until constant weight was achieved.

Data were subjected to analysis of variance (ANOVA), evaluating the effects of cultivars, extract concentrations, and their interaction. When significant, means were compared using Tukey's test at 5% probability. For the quantitative factor (concentrations), regression models were also fitted, selecting those with the highest significance and coefficient of determination.

RESULTS AND DISCUSSION

The analysis of variance revealed a significant effect of cultivars for most evaluated variables, except for root length, while the factor concentrations of the aqueous extract of *Digitaria insularis* significantly influenced the germination speed index (GSI), seedling height, root length, and root dry mass (Table 1). No significant interaction between cultivars and extract concentrations was observed, indicating that cultivar responses were consistent across the evaluated extract levels.

Table 1. Analysis of variance (ANOVA) for coefficient of variation (CV), germination percentage (%G), germination speed index (GSI), seedling height (Height), root length (Root), shoot fresh mass (SFM), root fresh mass (RFM), shoot dry mass (SDM), and root dry mass (RDM), as a function of cultivars, extracts, and their interaction.

CV	%G	GSI	Height	Root	SFM	RFM	SDM	RDM
Cultivar (C)	519,37*	7,614*	0,499*	15,704*	0,014ns	0,034*	0,016*	0,013*
Extract (E)	53,73ns	1,803ns	4,638*	2,301*	0,012*	0,001ns	0,004ns	0,011*
C × E	45,37ns	0,835ns	0,103ns	0,507ns	0,003ns	0,001ns	0,003ns	0,002ns
Residual	40,53	0,750	0,1527	0,428	0,006	0,001	0,002	0,002
CV (%)	7,04	7,95	10,51	13,76	12,69	13,75	11,64	19,51

Significant at 5% probability by the F test; ns = not significant. Source: authors (2026).

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The absence of a significant effect of the extract on germination percentage (%G) indicates that compounds present in *Digitaria insularis* did not interfere with the initial processes of imbibition and radicle protrusion. This behavior suggests that, under the adopted experimental conditions, there was no direct inhibition of germination, contrasting with the classical pattern of allelopathy, often characterized by reduced germinability (Rice, 2012; Scavo & Mauromicale, 2021).

On the other hand, GSI was affected by extract concentrations, indicating that although final germination was not compromised, the dynamics of the germination process were altered. This result suggests that compounds present in the extract may act by modulating the rate of metabolic reactions involved in germination without preventing its occurrence (Aci et al., 2022).

In the comparison among cultivars (Table 2), Anahí, Morena, and K3 showed higher germination percentages, while the cultivar Seda presented inferior performance. Cultivar K3 stood out for having the highest GSI, indicating greater initial vigor. These differences reflect intrinsic genetic characteristics of the cultivars, which directly influence the physiological potential of the seeds.

Table 2. Performance of sesame cultivars for germination percentage (%G), germination speed index (GSI), seedling height (Height), root length (Root), root fresh mass (RFM), shoot dry mass (SDM), and root dry mass (RDM).

Cultivar	**%G**	**GSI**	**Height**	**Root**	**RFM**	**SDM**	**RDM**
Seda	82,4 b	10,05 c	3,808 ab	4,63 b	0,056 b	0,0100 c	0,0058 b
Anahí	89,9 a	10,81 bc	3,52 b	6,03 a	0,081 a	0,0124 a	0,0077 a
Morena	94,1 a	10,97 ab	3,62 ab	3,53 c	0,051 b	0,0106bc	0,0056 b
K3	95,5 a	11,78 a	3,393 a	4,85 b	0,048 b	0,0113ab	0,0064 b
LSD	7,42	1,01	0,45	0,76	0,009	0,0015	0,0014

Means followed by the same letter in the column do not differ by Tukey’s test at 5% probability.
Source: authors (2026).

For growth variables, cultivar Anahí showed greater root development and higher biomass accumulation, indicating higher efficiency in resource allocation during early

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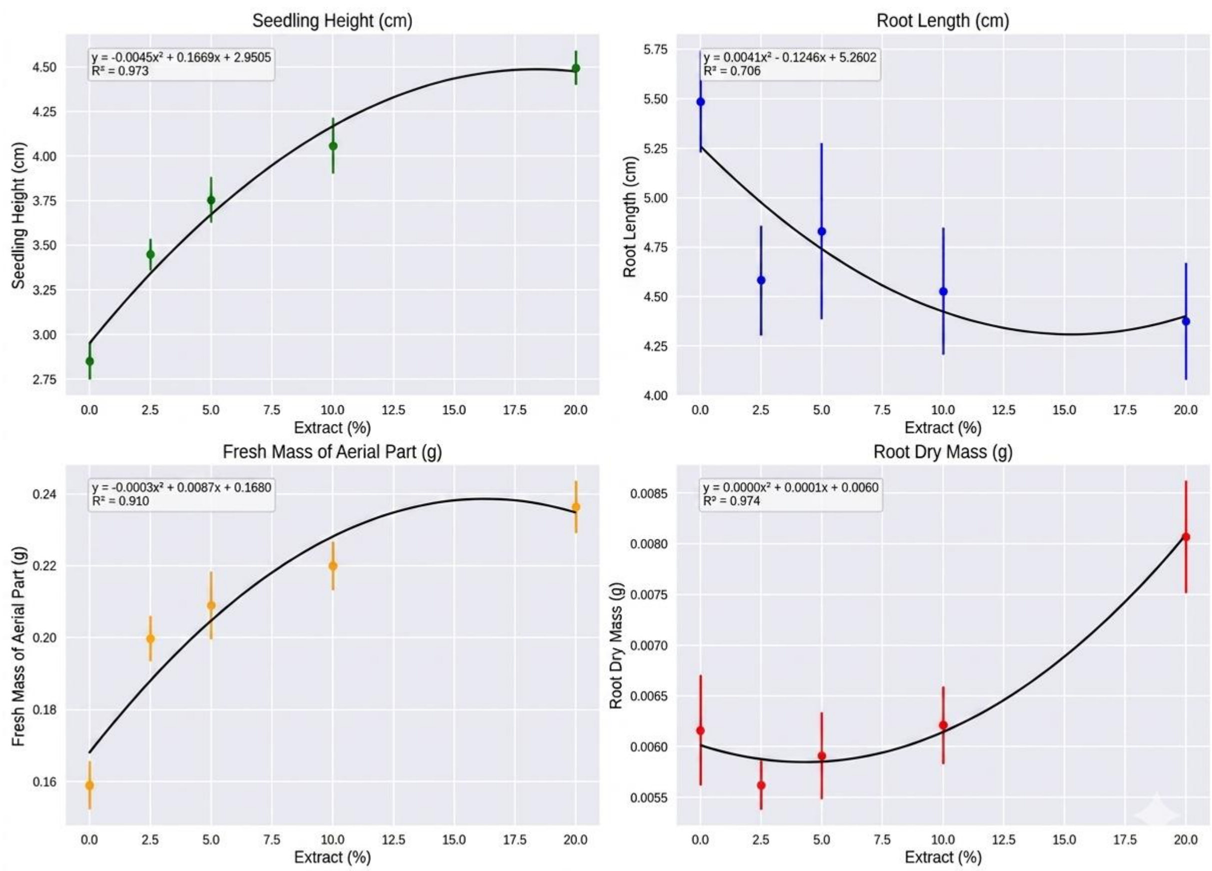
establishment. In contrast, cultivar Morena presented lower root length, which may indicate reduced exploratory capacity of the root system in early stages.

The effect of aqueous extract concentrations of *Digitaria insularis* was more evident in growth variables (Table 3). A progressive increase in seedling height was observed with increasing concentrations, with values ranging from 2.85 cm in the absence of extract to 4.49 cm at the 20% concentration. This behavior suggests a possible stimulatory effect, which is not uncommon in studies involving allelochemicals at low or moderate concentrations (Cedergreen, 2008; Belz, 2008).

Figure 1. Initial growth of sesame seedlings subjected to increasing concentrations of sourgrass aqueous extract: quadratic adjustments for height, root length, shoot fresh mass, and root dry mass.



Source: authors (2026)

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Similarly, shoot fresh mass and root dry mass increased with rising extract concentrations, indicating stimulation of growth and biomass accumulation. This pattern may be associated with the phenomenon known as hormesis, in which potentially toxic substances, at low concentrations, promote positive responses in plant growth (Calabrese & Baldwin, 2003; Cedergreen, 2008; Scavo & Mauromicale, 2021).

In contrast, root length showed a decreasing trend with increasing extract concentrations, indicating that the root system may be more sensitive to the presence of allelochemicals (Inderjit & Weston, 2003; Einhellig, 1996). This differential effect between shoot and root suggests that compounds present in the extract may specifically interfere with growing tissues, possibly affecting processes such as cell division and root elongation (Lee et al., 2021).

The absence of negative effects on germination, combined with the stimulation observed in growth variables, indicates that the aqueous extract of *Digitaria insularis* did not exhibit inhibitory allelopathic effects under the evaluated conditions (Nava et al., 2021). On the contrary, the results suggest the presence of compounds with growth-modulating potential, whose effects depend on concentration and the evaluated variable.

These findings reinforce the complexity of allelopathic interactions, in which effects are not exclusively negative and may include stimulatory responses under certain conditions. From an agronomic perspective, this indicates that interference by *Digitaria insularis* may occur more intensely through competition for resources than through direct allelopathic effects on crop germination such as sesame.

The results demonstrate that the aqueous extract of sourgrass (*Digitaria insularis*) exerts significant allelopathic effects on the early growth of sesame seedlings. Stimulation of the shoot (height and shoot fresh mass – SFM) was observed, while the root system showed reduced length, suggesting a physiological redistribution of resources. This pattern is consistent with the literature, which indicates that secondary compounds released by weed species can alter hormonal balance and plant metabolism, directly interfering with biochemical and physiological processes related to plant growth (Rice, 2012; Duke; Dayan, 2011).

Studies with maize and sorghum have already shown that extracts of *D. insularis* reduce germination and root development, directly impacting seedling vigor (Silva et al., 2014). In wheat, similar results have been reported, indicating that allelochemicals present in leaves and

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roots of *D. insularis* impair root elongation and nutrient uptake (Ferreira; Souza, 2016). These findings reinforce the consistency of the effects observed in sesame, confirming that the species has high allelopathic potential and competitiveness in agricultural systems.

On the other hand, studies with cover crops such as canola, forage radish, and ryegrass have demonstrated strong allelopathic effects on *Digitaria* spp., reducing emergence and early growth (Moraes et al., 2018). This reciprocity highlights that allelopathy is relevant both for weed management and for the development of natural bioherbicides (Pereira et al., 2023). In the case of sesame, the observed quadratic response suggests that intermediate extract concentrations may stimulate shoot growth, whereas higher concentrations intensify root inhibition, potentially compromising crop establishment under field conditions.

From an agronomic standpoint, the results indicate that the presence of *D. insularis* in sesame fields represents a risk to early crop establishment due to inhibitory effects on roots. At the same time, the observed stimulation of the shoot opens perspectives for future studies on the use of extracts from this species as potential biostimulants or bioherbicides, depending on concentration and application context.

In summary, the quadratic adjustments confirm that sourgrass extract exerts differential allelopathic effects on sesame: it stimulates the shoot and inhibits the root system. Comparisons with studies in maize, sorghum, and wheat strengthen the scientific basis, while research with cover crops shows that this phenomenon is recurrent and relevant for agricultural management (Fernandes et al., 2025). These results contribute to the understanding of interspecific interaction mechanisms and to the development of sustainable management strategies in sesame production systems.

These findings reinforce the complexity of allelopathic interactions, in which effects are not exclusively negative and may include stimulatory responses under certain conditions (Scavo & Mauromicale, 2021; Aci et al., 2022). From an agronomic perspective, this indicates that interference by *Digitaria insularis* may occur more intensely through competition for resources than through direct allelopathic effects on crop germination.

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CONCLUSIONS

The aqueous extract of *Digitaria insularis* showed differential allelopathic effects on sesame seedlings, without compromising the final germination percentage, but altering the speed of the germination process. Stimulation of the shoot (height and shoot fresh mass – SFM) and inhibition of root growth were observed, indicating differential sensitivity of plant tissues to the compounds present in the extract. These results suggest that the interference of *D. insularis* occurs more intensely on the early growth of sesame than on germination itself. From an agronomic perspective, the presence of this weed species in cultivated areas may compromise crop establishment, reinforcing the need for appropriate management strategies. Furthermore, the positive effects observed at low concentrations indicate potential for future studies on the use of extracts as biostimulants or natural bioherbicides.

CONFLICTS OF INTEREST

The authors declare that the work has no conflict of interest.

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