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IMPACT OF EXTRACTS FROM LEAVES AND ROOTS OF SMUTGRASS*(Sporobolus indicus*L.*)*ON THE GERMINATION AND GROWTH OF WHEAT *(Triticum aestivum* L.*)*

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ABSTRACT

Sporobolus indicus (L.), or smut grass, represents a perennial grass species that grows commonly in pastures and disturbed habitats. The species demonstrates resilience and exhibits allelopathic effects that could disrupt the growth of adjacent plants.

This study aimed to evaluate the allelopathic effects of aqueous extracts derived from the leaves and roots of Sporobolus indicus (L.) on the germination and early development of wheat (Triticum aestivum L.) seeds. Different concentrations of the extracts (100%, 50%, and 25%) were tested in comparison to a control (distilled water). Parameters assessed included germination percentage, germination speed index, root and shoot length, and biomass production. Higher extract concentrations from leaves demonstrated negative effects on seed germination and seedling growth. Lower extract concentrations derived from roots exhibited mild effects that actually stimulated certain growth parameters. The research shows that Sporobolus indicus's allelopathic effects depend on concentration levels, which could affect wheat growth in areas where this plant is present.

Different extract concentrations (25%, 50%, and 100%) were evaluated under controlled settings, with distilled water serving as the control. The results revealed that higher doses (100%) strongly hindered wheat root elongation and biomass buildup, notably with leaf extracts, which lowered root length to 0.66 cm from 6.86 cm at 25% and weight from 0.437 g to 0.089 g . Germination rates were mostly unaltered, however seedling development was reduced in a dose-dependent manner.

Keywords: *Sporobolus indicus, Triticum aestivum, allelopathy, germination*

INTRODUCTION

Sporobolus indicus (L.) (Indian dropseed) is a perennial grass commonly found in tropical and subtropical regions. Like many grasses, *S. indicus* has been shown to release allelopathic compounds that can affect the growth and development of neighboring plants. Allelopathy refers to the biochemical interactions between plants, where one plant releases chemicals that inhibit or stimulate the growth of other plants in the vicinity (Inderjit & Mohan, 2005). Such interactions can have significant implications for agricultural practices, particularly in the management of crop growth and weed control (Batish, Singh, & Kohli, 2008).

Sporobolus indicus (L.) R.Br., a perennial C4 grass native to the Americas, has been introduced and established in various parts of Europe, including at least 16 countries such as Spain, Italy, France, Serbia, and Greece (Vukov et al., 2023). The species typically colonizes roadsides, pastures, and disturbed lands, spreading rapidly along transportation corridors and degraded habitats (Galera, 2003; Euro+Med Plantbase, 2023). Its adaptability to diverse environmental conditions and potential allelopathic properties raise ecological concerns, particularly its impact on native and cultivated plant species (Holm et al., 1997; CABI, 2024).

Wheat (*Triticum aestivum* L.), a staple crop globally, is highly sensitive to environmental and biological factors that can influence its germination and growth (El-Basyoni & Abd El-Mageed, 2014). Understanding the potential impact of allelopathic substances on wheat is crucial for optimizing crop production and developing sustainable agricultural practices. While the allelopathic effects of several plants on wheat have been documented, the specific impact of *Sporobolus indicus* (L.) on wheat germination and development remains largely unexplored (Gao & Ding, 2012).

Allelopathy refers to biochemical interactions between plants in which one species produces chemical substances that affect the growth, survival, or reproduction of nearby plants (Rice, 1984). Allelochemicals, which can be found in leaves, roots, seeds, or decaying plant waste, can either restrict or encourage plant growth, depending on their concentration and environmental circumstances (Inderjit & Duke, 2003). Allelopathy is important in agricultural systems for weed control, crop competitiveness, and soil health, with implications for long-term farming methods (Farooq et al., 2011). For example, many cover crops and invasive weeds have substantial allelopathic effects, which can lessen the requirement for synthetic pesticides (Jabran et al., 2015). Understanding these relationships is vital for designing eco-friendly weed control tactics and maximizing crop output in agroecosystems (Weston).

This study aims to investigate the effect of water extracts from the leaves and roots of *S. indicus* on the germination and early growth stages of wheat seeds. We hypothesize that the water extracts from *S. indicus* may contain allelopathic compounds capable of inhibiting wheat germination and seedling growth. By analyzing the effects of these extracts on wheat's root and shoot development, this research will contribute to a better understanding of how *S. indicus* might influence wheat cultivation and provide insights into its potential as a natural growth regulator.

MATERIAL AND METHOD

The experiment took place in a laboratory at the University of the Azores, Terceira Island, in 2025. The Azores is an ultra-peripheral area of Europe (Rangel et al., 2011), Archipelago is located within the triple junction between the Eurasian, American and African plates and corresponds to nine volcanic islands, spread along 600 km near the mid-Atlantic ridge, 1600 km west from Portugal mainland and 3000 km east from the USA. Terceira is part of the Central Group (along with Faial, Pico, São Jorge and Graciosa).

Approximately 15 rooted plants were collected from the vicinity of the laboratory and underwent processes of sectioning in the bundle area, removal of panicles with seeds, washing and finally drying for 4 days at a temperature of 45° C in special trays inside of Heating cabinet ULE 600. Weighings were carried out once a day and the following values were recorded: Day 2: 69.88 g roots and 79.12 leaves Day 3: 68.58 g roots and 76.39 leaves On day 4, the same numerical values were recorded, which leads to the next stage.

The grinding of the dried parts was carried out using a device located in the basement of the building equipped with a 1.5 mm diameter sieve to obtain a fine powder . The operating principle was quite simple because it has a single button for starting and stopping, a funnel at the top where the raw materials are inserted and a hole at the bottom where a plastic bag can be attached to collect the result of the technological process inside.

Once the shredding was completed, the bags with the obtained contents were taken to the first floor of the building to follow the homogeneous mixing with distilled water for one hour and thirty minutes. The mixing was done using a special device on which two Erlenmayer beakers were placed in which 35 g of each category was placed and 350 ml of distilled water was added.After the 90 min, the glasses were covered and placed in the refrigerator until the next day when the total solution was divided into plastic containers for the 3 concentrations (25, 50, 100), then the seeds were placed in glass containers that had been previously washed and disinfected, on a filter paper for the application of the 4 ml of solution. Each container contained 5 wheat seeds and 4 containers corresponded to each concentration of solution.

Germination in a controlled environment was performed at a program of 20° C, 60% humidity and 12 hours of yellow light/12 hours of darkness in a climatic chamber-Fitoclima 750 E. The following notation was used for the containers: -L for leaves -R for roots -A for the sample with distilled water (0%) -B for the sample with 25% -C for the sample with 50% -D for the sample with 100% From 1 to 4 s the samples within each concentration were differentiated.The samples were in the Fitoclima 750E for a total of 6 days, of which no germination activity was recorded in the first two days and the data for the next 4 days are shown in the tables below. At the end of the centralization of germinated seeds, the roots and plants were separated, the length was measured with a ruler for the two component parts and their weighing was carried out with an electronic scale-Mettler AE260 deltarange.

The data was evaluated using one-way ANOVA and Tukey's post-hoc test (p ≤ 0.05) to identify significant differences between treatment groups (extract concentrations and plant parts). Treatments were compared for germination rates, root and shoot lengths, and biomass, with findings given as means ± standard errors. To analyze data variability, the coefficient of variation (CV%) was determined. Interactions between components (plant part x concentration) were investigated using two-way ANOVA. Statistical significance was designated as * (p < 0.05) or ** (p < 0.01), with non-significant (NS) data reported as needed. All analyses were carried out using IBM SPSS, ensuring strong confirmation of the reported allelopathic effects.

RESULTS AND DISCUSSIONS

The present study highlights the allelopathic potential of *Sporobolus indicus* (L.) aqueous extracts on wheat growth, emphasizing that both the concentration and plant part of origin play critical roles in determining the degree of phytotoxicity.The allelopathic effect of *Sporobolus indicus* (L.) water extracts on wheat (*Triticum aestivum* L.) seedlings was assessed through various morphological and biomass parameters (Table. 1). Significant differences were observed based on extract concentration and the source of plant material used (roots or aerial parts).

Table 1: Average values per plant obtained by different treatments, in wheat plants.

WHEAT		Lenght		Weight	
	G (%)	Roots (cm)	Aerial part (cm)	Roots (g)	Aerial part (g)
Parts of the plant					
Roots	78,3 a	6,37 a	2,79 a	0,222 a	0,320 a
Aerial Part	75,0 a	4,22 b	3,00 a	0,181 b	0,254 b
Concentrations					
100%	62,5 b	2,70 b	1,06 b	0,113 c	0,109 c
50%	75,0 ab	6,53 a	3,80 a	0,228 b	0,373 b
25%	92,50 a	6,64 a	3,82 a	0,264 a	0,380 a
Test treatment					
(distilled water)	95	5,5	3,5	0,22	0,39
F parts of plant	0,27NS	10,88**	0,14NS	393,61**	160,00**
F concentrations	7,48**	15,79**	10,82**	1946,80**	114,60**
F parts of plant x concentrations	2,95NS	4,26*	3,47*	1032,44**	305,60**
F treatmenst x test (destlled water)	4,75*	10,20**	5,75**	1270,42**	253,06**
CV (%)	19,65	29,9	45,5	2,46	1,45

Means followed by the same letter in the column do not differ from each other in the Tukey.
*, ** significant at 5 and 1% probability, respectively.
NS - non-significant, CV (%) = coefficient of variation

There was no statistically significant difference between treatments, with germination rates of 78.3% for root extract and 75.0% for aerial part extract. This suggests that neither extract significantly affected seed germination.A significant reduction in root length was observed with the aerial part extract (4.22 cm) compared to the root extract (6.37 cm). This indicates that the aerial part extract inhibited root elongation more strongly.Interestingly, plants treated with aerial part extract had a slightly greater shoot length (3.00 cm) than those treated with root extract (2.79 cm), although the difference was not statistically significant.

The fresh weight of roots was also significantly lower with the aerial extract (0.181 g) than with the root extract (0.222 g), reinforcing the idea that the aerial extract has a stronger inhibitory effect on root development. Similarly, shoot biomass was reduced in the aerial part extract treatment (0.254 g) compared to the root extract (0.320 g), and this difference was statistically significant.

Significant interactions were observed between plant parts and F concentrations for variables two through five, indicating that fluoride impact varies depending on both the tissue and the concentration. Furthermore, the interaction between treatment and the distilled water control was significant ($p \leq 0.05$ or $p \leq 0.01$) for all variables except the first, with F-values ranging from 4.75 to 1270.42. These results highlight the importance of both fluoride concentration and plant tissue type in modulating the physiological response, the results are similar to those of Svetlana O., the experiment being carried out on several species of weeds from the *poaceae* family (Svetlana O.,2023).

Table 2: Effect of the interaction of treatments (parts of the plant x at different concentrations) on the length of the roots part of wheat plants.

	Lenght	Roots (cm)
	Parts of the plant	
Concentrations	Roots	Leaves
25%	6,42 A a	6,86 A b
50%	7,93 A a	5,13 AB a
100%	4,75 B a	0,66 B b

Averages followed by the same letter do not differ from each other according to the Tukey test (P≤0.05), with capital letters comparing the effect of plant parts (vertical) and capital letters comparing the effect of concentrations (horizontal).

In Table 2, it is evident that S. indicus root extracts at 50% concentration yielded the longest wheat roots (7.93 cm), while aerial part extracts at 100% severely inhibited root growth (0.66 cm). These interactions underscore the varying phytotoxic potential of different plant tissues and their chemical compositions.

Root length showed clear sensitivity to increasing extract concentrations. The 25% concentration treatment promoted the greatest root growth (6,45 cm for roots extract and 6,86 cm for leaves extract), while the 100% concentration significantly reduced root length to 1,67 cm for roots extract and a considerable 6,2 cm for leaves extract (Table. 2).

Similar trends were observed in the **aerial part length** (Table. 3), with difference of 1,12 cm recorded between 25% an 100% extract concentration and a marked reduction to 0,56 cm at 100% leaves extract.

Table 3: Effect of the interaction of treatments (parts of the plant x at different concentrations) on the lenght of roots of radish plants.

	Lenght	Aerial part (cm)
	Parts of the plant	
Concentrations	Roots	Leaves
25%	2,68 AB b	4,96 A a
50%	4,12 A a	3,47 A a
100%	1,56 B a	0,56B a

Averages followed by the same letter do not differ from each other according to the Tukey test (P≤0.05), with capital letters comparing the effect of plant parts (vertical) and lowercase letters comparing the effect of concentrations (horizontal).

Interestingly, the aerial part extracts of *S. indicus* demonstrated stronger inhibitory effects than root extracts, especially at the highest concentration. This observation suggests a higher accumulation of bioactive compounds—likely phenolic acids, alkaloids, or terpenoids—in the shoots, as previously reported for other *Poaceae* species with allelopathic traits.

Biomass accumulation followed the same pattern. The highest root weight (0,322 g) and aerial part weight (0.461 g) were observed under the 25%

concentration for roots extract, while 100% concentration leaves treatments resulted in the lowest values (0,065 g and 0,089 g, respectively). The control group remained comparable to the 25% treatment, suggesting minimal allelopathic stress under these conditions.

Table 4: Effect of the interaction of treatments (parts of the plant x at different concentrations) on the weight of roots of wheat plants.

	Weight	Roots (g)
	Parts of the plant	
Concentrations	Roots	Leaves
25%	0,322 A a	0,273 A a
50%	0,182 B b	0,206 B b
100%	0,162 C a	0,065 C b

Averages followed by the same letter do not differ from each other according to the Tukey test (P≤0.05), with capital letters comparing the effect of plant parts (vertical) and capital letters comparing the effect of concentrations (horizontal).

There are significant difference between roots and leaves at all concentrations, but a significant difference at 100%. In conclusion, although both treatments negatively affect plant growth asconcentration increases, the leaf extract seems to impact root development more strongly, suggesting higher toxicity or more efficient absorption at the root level.

Table 5: Effect of the interaction of treatments (parts of the plant x at different concentrations) on the weight of aerial part of wheat plants.

	Weight	Aerial Parts (g)
	Parts of the plant	
Concentrations	Roots	Leaves
25%	0,461 A a	0,437 A a
50%	0,321 B b	0,282 B b
100%	0,176 C a	0,089 C b

Averages followed by the same letter do not differ from each other according to the Tukey test (P≤0.05), with capital letters comparing the effect of plant parts (vertical) and capital letters comparing the effect of concentrations (horizontal).

In both tables, the highest biomass values for roots and leaves are recorded at the lowest concentration (25%). In Table 4, the root weight begins at 0.322 g and declines to 0.162 g at 100%, while leaf weight drops from 0.273 g to 0.065 g. In contrast, Table 2 starts with higher values: 0.461 g for roots and 0.437 g for leaves at 25%, decreasing to 0.176 g and 0.089 g, respectively, at 100%. This indicates that the plants represented in Table 5 exhibit greater overall biomass across all concentrations, suggesting theymay be more resilient to the treatment or were grown under more favorable conditions.

Comparative analysis of wheat seedlings exposed to figure 1, standard control (distilled water) and 100% aqueous extract of *Sporobolus indicus* (L.) leaves show visible differences. Visible inhibition of root elongation (0.66 cm vs. 6.51 cm in control) and reduced biomass (0.231 g vs. 0.05 g in control) demonstrate the extract's allelopathic effects.

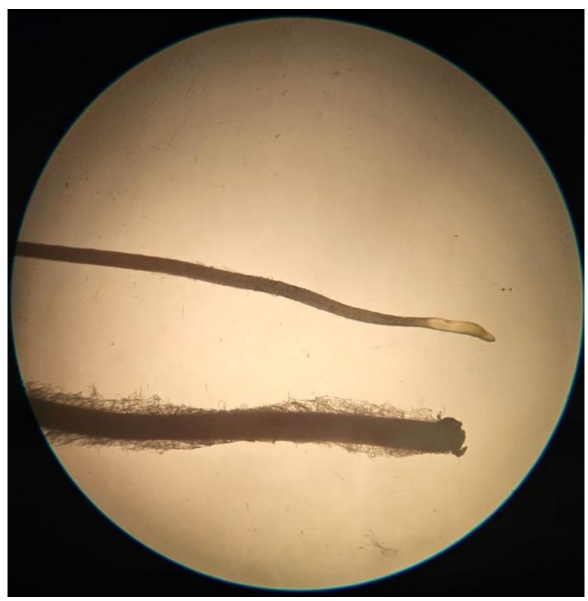

Figure 1. Comparative analysis of standard probe (down) and 100% *S. indicus* extract probe (up). Scale bar: 1 cm.

The suppression of both root elongation and biomass accumulation at higher extract concentrations may reflect interference with cell division and elongation, disruption of auxin and gibberellin signaling, or induction of oxidative stress in the treated wheat tissues, the differences are similar to 2025 study from university of Tikrit. The plumule and Radical length and their dry weight of wheat seeding had reduced when the aqueous extract vegetative parts of above weeds which used by 67.21 , 62.93 , 48.03 , and 44.71 %respectively (Modafer et al., 2025).Given that roots are often more directly exposed to allelochemicals through soil contact, the significant reductions in root parameters (length and weight) further reinforce the potent inhibitory nature of the S. indicus extracts.

The meaningful statistical interaction between plant part and concentration demonstrates the intricate relationship between chemical makeup and dosage levels during allelopathic effects. The study indicates that Sporobolus indicus (L.) has strongallelopathic capabilities which can impact the growth and establishment of nearby crops like wheat in both natural and cultivated environments.

CONCLUSION

Experiments reveal that *Sporobolus indicus* (L.) water extract produces substantial inhibition of both germination and seedling growth in *Triticum aestivum* (L.). Suppression of germination percentage along with radicle elongation and plumule growth increased with higher concentrations of allelopathic activity. The study reveals that *Sporobolus indicus* (L.) releases powerful allelochemicals which disrupt *Triticumaestivum*'s early development stages, showing its potential use as an ecological weed deterrent. Research should focus on identifying specific allelochemicals involved and examining their environmental persistence and ecological safety to enable the use of these findings in sustainable weed management strategies.

Aclear dose-response relationship was observed in the allelopathic effects of *S. indicus* extracts on wheat in the present study. In the case of leaf extracts the highest concentration (100%) decreased root length to only 0.66 cm (the root length was 6.86 cm at 25% of leaf extracts), and root biomass was reduced from 0.437 g to 0.089 g; however, the lowest concentration (25%) had had virtually no inhibitory effect, and growth was even stimulated in some case, for example, root extracts at 50% of root extracts promoted root elongation to the length of 7.93 cm. These findings are consistent with previous work on allelopathy that shows that at low concentrations, plant-released compounds can have a stimulatory effect (hormesis), while higher doses may bedeleterious (Inderjit & Duke, 2003). The phytotoxicity threshold would seem to be between 50% and 100% extract concentration setting, which was applied to the field.

A significant discovery was the greater inhibition produced by leaf extracts relative to root extracts. At 100% strength, leaf extracts suppressed the root length by 90% (0.66 cm), while the reduction obtained by root extracts was less pronounced (4.75 cm). The same was found for shoot biomass, 72% lower with leaf extract treatment (0.089 g to 0.176 g for roots). This discrepancy may be a result of the diffe-rences in allelochemicals composition, in particular the fact that the leaves may have accumulated amounts superior to those of phenolics or terpenoids (as has been observed for other allelopathic grasses) (Weston & Mathesius, 2013). The results indicate that S. indicus leaf materials have higher inhibitory compounds with the potential for either chemical isolation or bioherbicidal development.

The potential of *S. indicus* as a natural herbicide is demonstrated by the significant inhibition of wheat growth at high concentrations. For example, optimized formulations might be able to target invasive grasses specifically without the use of artificial chemicals if they could duplicate the effects of 100% leaf extracts,which decreased root biomass by 80%. To create standardized, environmentally friendly weed control solutions, future studies should also separate the active ingredients, possibly using mass spectrometry or HPLC.

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