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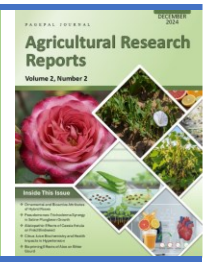

Allelopathic Potential of Cassia fistula Aqueous Extract in Suppressing Germination and Growth of Field Bindweed (*Convolvulus arvensis*)

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Abstract

In winter 2018, the study was conducted during the winter season at the Weed Science Laboratory, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan, to find out whether Amaltas (C. fistula) causes allelopathy in C. arvensis. A total of three replicates were used in a CRD design. Extracts of Amaltas were mixed at 2%, 4%, 6%, and 8% and added to field bindweed seedlings at 0.25%, 0.50%, 1%, 2%, 4%, and 8%. Water extracts from C. fistula were used in laboratory experiments. This study used established methods to gather data on seedling emergence, seedling shapes, and the weights of C. arvensis seedlings. A Fisher analysis of variance was used, and results with a 5% probability level were considered significant. It was found that the aqueous extracts from C. fistula significantly suppressed the growth and germination of field bindweed. In particular, the percentage of germination, average germination time, germination index, and the time required for half of the seeds to germinate were all affected by the presence of C. fistula extracts. These compounds also notably cut down on the seedling shoot length, root length, root fresh weight, shoot fresh weight, root dry weight, and shoot dry weight. It is possible that the phenolics and flavonoids in extracts of C. fistula subdued growth by disrupting the systems important for seeds to grow and expand. It was suggested in the study that water extracts of C. fistula could act as natural herbicides to help manage weeds sustainably. In-depth findings could lead to better application rates, timing, and methods, as well as reveal which allelochemicals cause these effects.

1. Introduction

Convolvulus arvensis is one of the most damaging weeds in agriculture, restricting productivity because of its long, creeping root system and vigorous ability to regenerate after fragmentation, making it difficult to control (Ma, 2023; Farag, 2018). Consequently, crops are treated with increasingly larger amounts of synthetic herbicides, but the continued use of herbicides has resulted in developing populations and weeds that are resistant to herbicides, with serious environmental and health implications (Davis *et al.*, 2018; Alotaibi *et al.*, 2023). Herbicide resistance is a growing problem, with serious consequences for ecosystem health and function as well as for the health of humans and other animals (Ikram *et al.*, 2018). However, research suggests that more sustainable approaches to weed control show promise and are worthy of consideration. Several researchers have demonstrated the herbicidal activity of fungi such as *Myrothecium verrucaria* against *C. arvensis*. This raises the possibility of less harmful methods of weed control for arvensis and other weeds (Ibrahim & Tawfik, 2019; EL Sabagh *et al.*, 2020). Other approaches, such as crop rotation and integrated weed management, have also shown promise in reducing populations of *C. arvensis* while also having less reliance on chemical herbicides (Hettinger, 2023). All this research highlights the fact that the management of field

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bindweed needs to be considered in a more sustainable context.

Now, the biochemical interactions between plants called allelopathy have found another use for their potential in sustainable weed management. All plants release allelochemicals, such as phenolics, flavonoids, and terpenoids, as metabolites that inhibit the germination and growth of other plants, including weeds (Kostina-Bednarz *et al.*, 2023; Rahaman *et al.*, 2022). Exploiting the allelopathic properties of plants is an environmentally friendly alternative to synthetic herbicides and a way to significantly reduce chemical inputs for plant growth control in agriculture (Hussain *et al.*, 2021; Scavo & Mauromicale, 2021).

Due to the wide variety of bioactive compounds, the allelopathic potential of *C. fistula* leaves, bark, and seeds is reported, respectively (Liu *et al.*, 2011; Chaves *et al.*, 2023). Nevertheless, the impacts of *C. fistula* on weed growth, especially on field bindweed, are still inadequately studied, suggesting that the gaps in the knowledge regarding the allelopathic potential of *C. fistula* should be further revised to better apply it in the control of weed-related problems (Rahmadhani *et al.*, 2020; Abbas *et al.*, 2021). In conclusion, the integration of allelopathic plants, such as *C. fistula*, into the agrosystem may considerably improve sustainable weed control and the balance of the ecosystem (Scavo Mauromicale, 2021; Srikrishna, 2019).

The main objective of our research is to evaluate the allelopathic activity of the aqueous extract of *C. fistula* on field bindweed. Therefore, we are to examine if the application of an aqueous extract of *C. fistula* could inhibit the germination of field bindweed seedlings and the growth and development of early seedlings. In alignment with our objective, the result obtained from this study was a useful contribution towards the need to find a natural allelopathic agent to suppress the weed population in the agricultural landscape.

2. Materials and Methods

2.1. Experimental site

This experiment was conducted under a completely randomized design (CRD) in factorial arrangement with three replications to study the allelopathic effects of *C. fistula* (Amaltas) on perennial weed, namely Field bindweed, in the laboratory. Dried pods were used as material for the aqueous extracts of *C. fistula*. Materials were collected from a seed store in Faisalabad, Pakistan, and stored at 4°C until use. Dried pods of *C. fistula* were broken into small pieces of about 4 cm. Then, dried samples were irrigated individually in water for 48 hours at a ratio of 1:10 to get aqueous extracts. The soaked material was poured through cotton cloth, and extracts were diluted for each treatment, 0, 0.25, 0.5, 1, 2, 4, and 8%. For this experiment, 10 seeds of Field bindweed were planted in 7 Petri dishes. The petri dishes were kept in a growth chamber at a12-h photoperiod at 25±2 o C. . Then prepare 7 dilutions of *C. fistula* pod extracts in Petri dishes and cover them.

2.2. Experiment treatments

The study was comprised of different treatments: T_1: Distilled water (control), T_2: 2.5% (2.5 ml extract of plant + 247.5 ml distilled water), T_3: 5% (5ml extract of plant + 245 ml distilled water), T_4: 10% (10 ml extract of plant + 240 ml distilled water), T_5: 20% (20 ml extract of plant + 230 ml distilled water), T_6: 40% (40 ml extract of plant + 210 ml distilled water), T_7: 80% (80ml extract of plant + 170 ml distilled water).

2.3. Observations for laboratory bioassays

uring laboratory experiments, different parameters given below were observed by using standard procedures:

2.3.1. Emergence

The seed emergence time for each replication of all treatments was recorded daily, following the method outlined by the Association of Official Seed Analysts (1990). The following parameters were documented for emergence.

2.3.2. Seed Germination Percentage (%)

Data was collected daily for two weeks to determine the number of seeds that had emerged. Seeds were counted once the seedling length reached approximately 1 to 2 cm upon emergence. After two weeks, the seed emergence percentage for each treatment replication was calculated using the formula provided below.

$$GP=\frac{\text{Germinated Seeds at final count}}{\text{Total Seeds}}\times 100$$

2.3.3. Mean Germination Time (MET)

Mean emergence time was recorded by using the equation suggested by Mordi Dezfuli *et al.* (2008)

$$MGT=\frac{\sum D_n}{\sum n}$$

where D = Number of total days starting from the germination of seeds. And n is the number of seeds that emerge on D days.

2.3.4. Time taken for 50% Germination (Days)

The time required for 50% emergence was determined using an equation first proposed by Coolbear *et al.* in 1984 and subsequently modified by Farooq *et al.* in 2004.

$$T_{50}=t_i+\frac{\left(\frac{N}{2}-n_i\right)(t_J-t_i)}{(n_J-n_i)}$$

where N represents the total number of seeds that emerged, where n_i *and* n_J *are the cumulative numbers of seeds that emerged at times* t_i *and* t_J*, respectively.*

2.3.5. Germination Index (GI)

The germination index was calculated following the process outlined by the Association of Official Seed Analysts (1990). The equation used to determine the germination index of the seeds is provided below.

$$GI=\frac{N_1}{D_1}+\frac{N_2}{D_2}\dots\frac{N_L}{D_L}$$

where D_1 *is the days to first count,* N_1 *is the no. of germinated seeds on the first day,* N_L *is the no. of germinated seeds at the final count, and* D_L *is the days to final count.*

2.3.6. Seedlings root length (cm)

This was measured using a measuring tape with a ruler in cm. The root length of all seedlings in each treatment replication was measured. The root-shoot junction was identified, and the root was separated from the seedling body base at this point. The length of the root from the junction point to the root tip was measured. The average root length was calculated, and then its counterpart shoot length.

2.3.7. Seedlings shoot length (cm)

By using a measuring tape, all seedlings' shoot lengths for all treatments of each replication were measured in centimeters. The junction points at which the root and shoot are attached. Separate the shoot from this point to measure the shoot length. Then measure the shoot length from that junction point to the shoot tip. The average shoot length was calculated after measuring the average root length.

2.3.8. Seedling shoot fresh weight (mg)

All plant shoots of one treatment were separated, and then the fresh weight of these seedling shoots was measured. This process was done separately for all treatments of each replication. Weight was measured in grams by using an electronic weighing balance.

2.3.9. Seedling root fresh weight (mg)

All plant roots of one treatment were separated, and then the fresh weight of these seedling roots was measured. This process was done separately for all treatments of each replication. Weight was measured in grams by using an electronic weighing balance.

2.4. Statistical analysis

We analyzed all experimental data using one-way analysis of variance (ANOVA) based on Fisher's method (Steel *et al.*, 1997) in SPSS 28.0 (or Statistica 8.1). For post-hoc comparisons between group means, we applied Fisher's Least Significant Difference (LSD) test at a significance level of $\alpha = 0.05$. Before analysis, we verified all ANOVA assumptions, including homogeneity of variance (Levene's test) and normality of residuals (Shapiro-Wilk test). Results are presented as means ± standard error (SE). All analyses were considered statistically significant at $p \leq 0.05$.

3. Results and Discussion

The present study also covers the inhibitory effect of *Cassia fistula* aqueous extract on the germination and growth of field bindweed. Findings revealed that the germination and growth parameters were significantly inhibited in the presence of *C. fistula.* Germination percentage, mean germination time, germination index, and time to 50% germination were recorded (Figure 1). Our results conform with other studies, which prove the allelopathic effect of *C. fistula* on other weed species like *Parthenium hysterophorus* and Eichhornia crassipes (Saraf *et al.*, 2014; Sarkar *et al.*, 2012; Saleem *et al.*, 2017). The *C. fistula* extract was effective in hindering the germination ability of seeds. It was likely due to the elements called allelochemicals, which were water-soluble, that inhibited the physiological processes that led to the germination of seeds (Li *et al.*, 2010; Minhas *et al.*, 2024).

Besides, *C. fistula* extract treatment markedly decreased shoot length, root length, root, shoot fresh weight, root and shoot dry weight among field bindweed seedlings (Figure 2). Our results are consistent with (Tripathi *et al.*, 2011; Ikram *et al.*, 2025a, b) who reported the phytotoxic effect of *C. fistula*

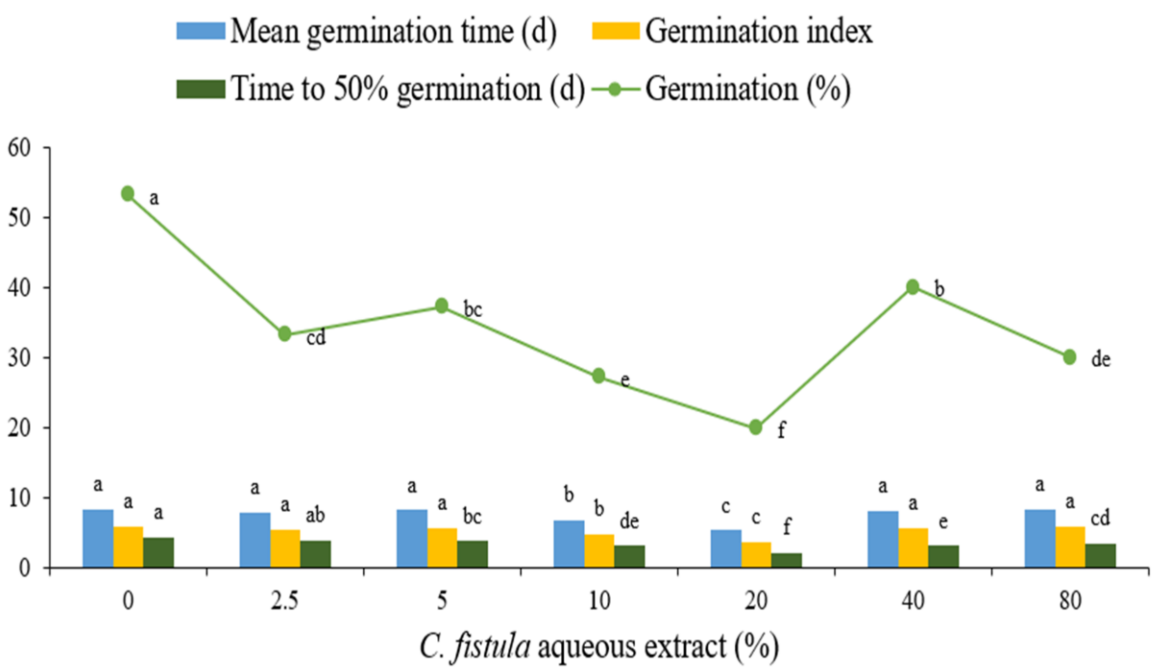

Figure 1. Allelopathic effect of *C. fistula* aqueous extract on seed quality attributes
Critical Values of Comparison: (Germination: 5.67, Mean germination time: 0.48, Germination index: 0.35, Time to 50% germination: 0.39).

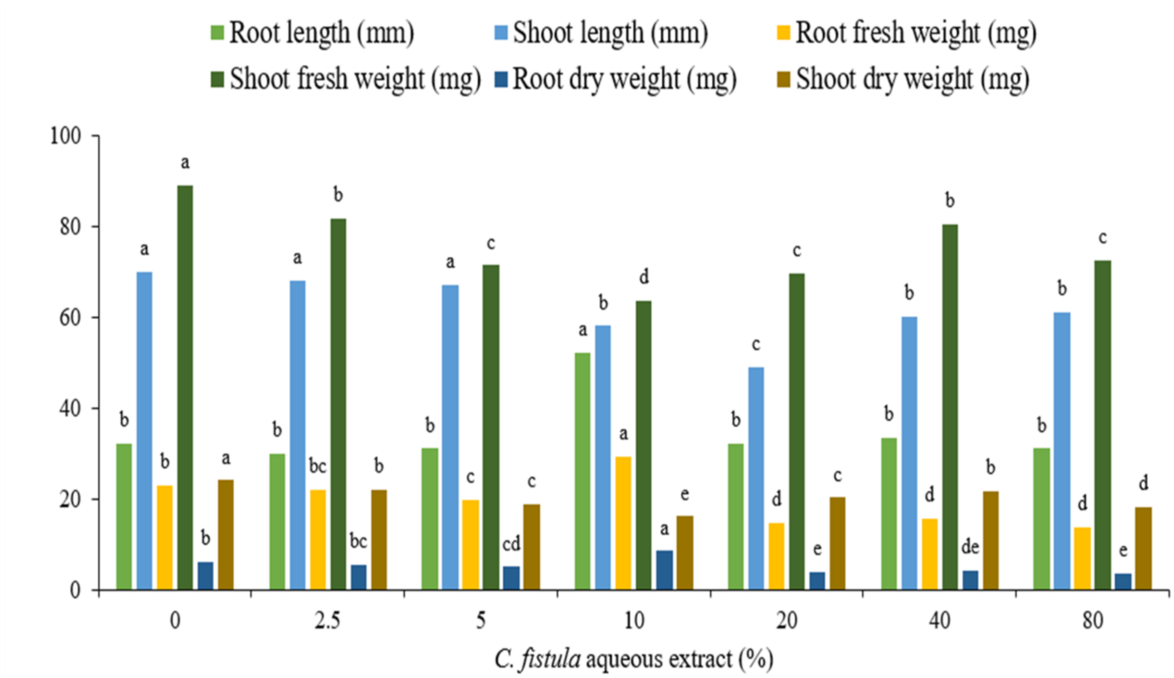

Figure 2. Allelopathic effect of *C. fistula* aqueous extract on seedling quality attributes
Critical Values of Comparison: (Shoot length: 4.00, Root length: 4.00, Root fresh weight: 2.45, Shoot fresh weight: 5.66, Root dry weight: 0.97, Shoot dry weight: 1.09).

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leaf extract on some crops. The decrease in seedling growth might be attributed to allelopathic compounds (such as phenolics and flavonoids) in *C. fistula* extract, which can interrupt cell division, elongation, and differentiation processes (Cheng, 2015; Nadeem *et al.*, 2018).

Principal component analysis (Figure 3) and correlation analysis (Figure 4) of the variation in fourteen parameters were studied to document the allelopathic effects of *C. fistula* extract on field bindweed and infer the linkage between them. The strong positive correlation coefficient among growth parameters indicates that the allelopathic activity of *C. fistula* extract could be applied to all aspects of seedling development of field bindweed. The presence of ferulic acid in the concentration of *C. fistula* extract (Table 1) could have a key influence on the allelopathic effect of *C. fistula* because it is a compound that shows a strong allelopathic activity and inhibits weed growth (Nguyen *et al.*, 2016; Minhas *et al.*, 2025).

These results demonstrated the potential of *C. fistula* aqueous extract as an allelopathic agent for the management of field bindweed, as the extract significantly inhibited the germination and suppressed the early growth of field bindweed. In practice, it may be useful for integrated weed management, which could cut the use of synthetic herbicides (Farooq *et al.*, 2011; Ikram *et al.*, 2024 a, b). To test the field use of this extract and improve its application, further studies are needed in controlled settings as well as in real agricultural settings. A more specific way to manage weeds is possible once we understand which chemical compounds in the plants are responsible for allopathy.

4. Conclusion

In this study, the effects of *C. fistula* aqueous extracts on Field bindweed germination and growth were studied. *C. fistula* extract proved to be a very effective inhibitor of important growth processes in field bindweed, such as percent germination, time to germination, germination index, and the amount of time needed for 50% germination. The extracts decreased seedling shoots, root lengths, fresh, and dry weight, suggesting a big influence from allelopathy. The disruptive impact on seed germination and seedling development is probably a result of the phenolics and flavonoids found in the extract of *C. fistula*. The results point out that using *C. fistula* extracts could provide a safe and lasting solution for controlling weeds instead of using artificial herbicides. The optimal approach for using *C. fistula* extracts in fields needs to be identified by additional research. Recognizing which substances are causing these influences would improve the development of management solutions for

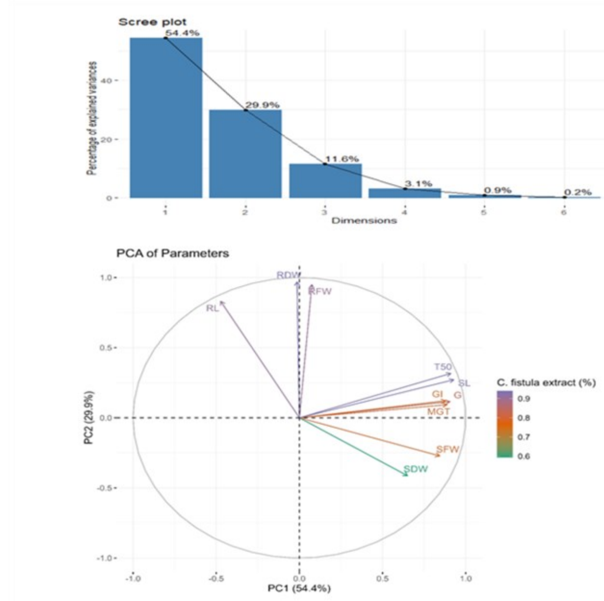

Figure 3. Scree plot and principal component analysis of the parameters under study.

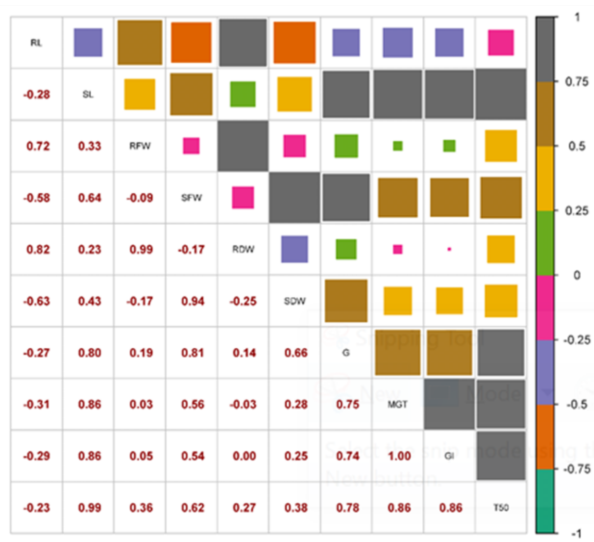

Figure 4. Correlation of the parameters under study

weeds. It is recommended that future studies evaluate the lasting ecological effects of using allelopathic agents in agriculture and how they may be used within integrated weed management schemes. *C. fistula* aqueous extracts have the potential to reduce weeds sustainably, which is good for the environment and for farmers.

5. Funding

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6. Acknowledgment

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7. Conflict of Interest

The authors declare no conflict of interest.

8. Authors' Contribution

B.K. contributed data analysis and experimental work, A.A. wrote the manuscript, and R.M. and M.A.N. designed the experiment and M.I. critically revised it.

9. SDGs Addressed

This study supports SDG 2 (Zero Hunger) and SDG 15 (Life on Land) by exploring eco-friendly weed management through natural plant extracts, reducing reliance on synthetic herbicides and promoting sustainable agriculture.

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