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Original Paper

Anagallis Arvensis as A Natural Allelopathic Agent: Effects on Growth of Zea Mays, Triticum Aestivum, and Pennisetum Glaucum

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***Abstract*— This study aimed to investigate the allelopathic effects of Anagallis arvensis on Zea mays under controlled laboratory conditions during the period 2022–2024. The aqueous extracts of A. arvensis were tested for their influence on seed germination, seedling growth, fresh weight, and dry weight of Zea mays, Triticum aestivum, and Pennisetum glaucum. Results revealed that a 20 g leaf extract applied for 72 hours significantly inhibited germination percentage, radicle length, fresh weight, and dry weight compared to the control. The degree of inhibition increased with both extract concentration and soaking duration. Treatments with 10 g, 20 g, and 30 g of extract initially enhanced germination over time, with the highest rates observed at 48 hours. However, the 20 g extract caused a notable reduction in germination at this same time point. Overall, a 72-hour treatment duration led to reduced mean germination rates across all concentrations. At lower extract concentrations, extended soaking time had minimal impact on germination. Notably, at 24 hours, germination increased with rising extract concentration; similarly, at 48 hours, germination improved with concentration except at 20 g, where a decline was observed. The only exception to the general trend was an increase in plumule length under the 10 g extract treatment. These findings suggest that the presence of A. arvensis leaf and stem litter in agricultural fields may negatively impact the germination and growth of associated crops, ultimately leading to reduced yield.**

Keywords*— Allelopathic effect, Anagallis arvensis, Pennisetum glaucum and Triticum aestivum, Zea mays

I. INTRODUCTION

The term allelopathy is derived from the Greek components allelo and pathy, meaning "mutual harm" or "suffering," and was first introduced in 1937 by the Austrian scientist Hans Molisch in his book The Effect of Plants on Each Other (Acheampong et al., 2023). Early studies highlighted observations such as poor regeneration of forest species, crop damage, yield reduction, replant problems in tree crops (Subhan et al., 2023), the appearance of weed-free zones, and other changes in vegetation patterns (Agyei et al., 2023). The term pathos also translates to “feeling” or “sensitive,” and may thus describe both positive (sympathetic) and negative (pathetic) interactions between organisms (Sora et al., 2023).

The concept of allelopathy gained renewed attention in 1974 with the publication of the first English-language book on the subject by Elroy L. Rice (Olalekan, 2025). According to the International Allelopathy Society, allelopathy is defined as (Ullah et al., 2024): “Any process involving secondary metabolites produced by plants, micro-organisms, viruses, and fungi that influence the growth and development of agricultural and biological systems (excluding animals), including positive and negative effects” (Mekonnen and Wasie, 2025). The allelopathic potential of plants can be effectively harnessed for controlling pathogens and weeds (Assefa et al., 2025).

Allelopathy refers to the beneficial or detrimental effects of one plant on another whether crop or weed through the release of biochemicals known as allelochemicals (Ullah and Shakir, 2023). These chemicals may be released via leaching, root exudation, volatilization, residue decomposition, and other processes within both natural and agricultural ecosystems (Sisay, 2025; Ullah, 2019). Allelochemicals are secondary metabolites not essential for the plant’s metabolism, growth, or development. Among these, pseudoguaionolides present in both shoots and roots are significant allelochemicals (Ullah et al., 2019). These include compounds such as parthenin, anhydro parthenin, ambrosian, coronopilin, and damson, which exhibit cytotoxic effects, inhibit mitochondrial oxidative phosphorylation, and have strong allelopathic activity (Ullah et al., 2018; Teshome et al., 2025).

Among these, parthenin has been identified as the principal active component, showing strong allelopathic effects and potential for allergic reactions (Ullah et al., 2018). This contributes to considerable yield losses, ranging from 40% to 90% annually, in both crops and forage-producing grasslands (Nath, 1988; Khan et al., 2025). Specifically, in sorghum crops, yield losses of similar magnitude have been reported (Gedamu, 2025). Negative allelopathic effects serve as a crucial plant defense mechanism against herbivory. In 1971, Whittaker and Feeny published a landmark study in science, defining allelochemicals as chemical agents responsible for interactions among organisms (Ullah et al., 2023). These substances play a key role in plant defense strategies (Hasan, 2025), influencing both biodiversity and the structure of plant communities. The production of allelochemicals varies with the plant's phenological stage, and different plant parts accumulate these compounds during specific developmental phases. They are typically released into the environment via volatilization, leaching, root exudation, and decomposition of plant residues in the soil (Lema et al., 2025).

Anagallis arvensis, commonly known as scarlet pimpernel, also referred to as red pimpernel, red chickweed, poor man's barometer, poor man's weather glass, shepherd's weather glass, or shepherd's clock, is a low-growing annual herb. Native to Europe and Western North Africa, this species has been widely dispersed by humans, either intentionally for ornamental purposes or unintentionally (Tembo et al., 2025). Though often labeled as a weed, it is an indicator of light soils, though it can opportunistically grow in clay-rich environments as well. The name pimpernel is derived from the Middle English term pympernele (Ullah et al., 2023). The plant is best known as the symbol of the fictional character "The Scarlet Pimpernel" (Nwosu et al., 2025). The primary objective of this research is to investigate the allelopathic potential of Anagallis arvensis by examining its effects on the germination and early growth of three major crops, namely Zea mays (maize), Triticum aestivum (wheat), and Pennisetum glaucum (pearl millet) (Sher et al., 2018). The study aims to determine whether the phytochemicals released by A. arvensis can inhibit or promote seed germination, seedling length, and biomass accumulation in these species. Another objective is to compare the degree of allelopathic influence across the three crops in order to identify which species is most sensitive or resistant to the plant extracts of A. arvensis. Finally, this research seeks to assess the ecological significance and potential practical application of A. arvensis as a natural bio-herbicidal agent, offering an environmentally friendly alternative for weed management and sustainable agricultural practices.

II. Material And Methods

A. *Collection, Drying, and Storage of Plant Materials*

A series of experiments was conducted to evaluate the allelopathic potential of Anagallis arvensis on the germination and seedling growth of Triticum aestivum, Zea mays, and Pennisetum glaucum. Specimens of A. arvensis were collected from various locations in the Mardan district, including Garhi Kapura, Shehbaz Garhi, and the Shanker area (Shakir et al., 2025). The collected plant materials were shade-dried at room temperature (25–30°C) to preserve bioactive compounds. Once fully dried, the plant materials (leaves, stems, and roots) were separately crushed into powder and stored in labeled paper bags for subsequent extraction (Sajid et al., 2023).

B. *Surface Sterilization*

All glassware used in the experiments was sterilized in an autoclave at 121°C for 15 minutes after being thoroughly washed with sterilized water. Seeds of the test species were surface sterilized by immersion in 5% ethanol for 5 minutes, followed by three successive rinses with distilled water to remove any residual ethanol (Rusdianto et al., 2024).

C. *Preparation of aqueous extract*

Aqueous extracts of A. arvensis were prepared from plant parts (leaves, stems, and roots) collected at three phenological stages: vegetative, reproductive, and post-reproductive. For each treatment, 10 g, 20 g, and 30 g of shade-dried plant powder were soaked in 250 ml of distilled water and left to stand for 24, 48, and 72 hours, respectively. After soaking, the mixtures were filtered, and the filtrates were stored at 10°C for later use when not immediately applied (Manan et al., 2025). Petri dishes were sterilized in an autoclave at 121°C for 2 hours. Sterile filter papers were then placed in the dishes and moistened with 3 ml of the respective aqueous extract. Seeds of T. aestivum, Z. mays, and P. glaucum were placed equidistantly on the filter papers. The prepared dishes were incubated at 25°C for 72 hours. A control group was also maintained, in which seeds were treated with distilled water under identical conditions. After the incubation period, radicle and plumule lengths, as well as fresh and dry weights of seedlings, were measured (Mitiku et al., 2024).

D. *Recorded Parameters*

The following parameters were recorded for each test species:

1. Germination percentage
2. Plumule length
3. Seedling dry weight
4. Seedling fresh weight
5. Total length of plumule and radicle

III. Results

A. *Maize Results*

In the 24-hour treatment for maize, a negative effect on seedling germination was observed, with a noticeable reduction in germination compared to the control group. However, among the treatment concentrations, the 30-gram extract showed a relatively positive effect, resulting in higher seedling germination rates than the 10-gram and 20-gram treatments. The differences in germination were statistically significant, as illustrated in Fig 1.

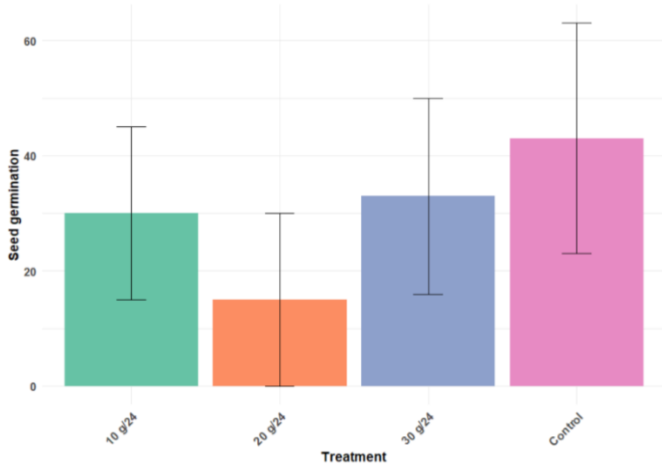

Fig. 1. Seeds germination (24-hour treatment)

In the 24-hour treatment for maize, the extract exhibited a negative effect on seedling growth. Among the different concentrations, the 20-gram treatment was the most effective in reducing plant biomass, specifically both fresh and dry weights of the seedlings. The effects of Anagallis arvensis on the fresh and dry weights of maize seedlings are presented in Fig 2.

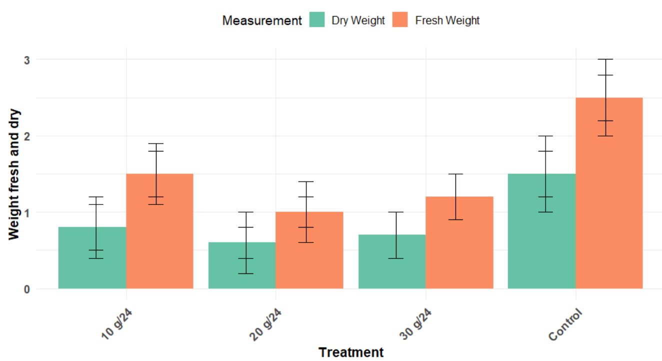

Fig. 2. Fresh and dry weight (24 hours)

In the 24-hour treatment for maize, a significant effect on seed germination was observed compared to the control. As the extract concentration increased, both plumule and radicle lengths showed a corresponding decrease, indicating inhibited seedling growth. Among the treatments, the 20-gram concentration had the most pronounced negative effect, particularly in reducing plumule length compared to the 10-gram and 30-gram treatments.

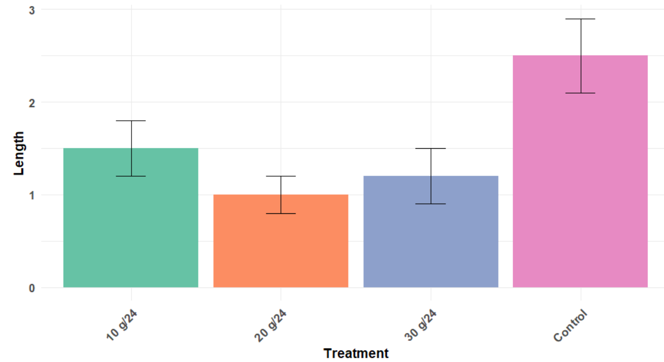

Fig. 3. Length of plumule and radical (24-hour treatment)

1) Effects of Anagalis arvensis (5ml extract) on (a) maize seed germination (b) fresh and dry weight, and (c) plumule and radical.

In the 48-hour treatment for maize, a significant reduction in seedling germination was observed compared to the control. However, among the treatments, the 10-gram extract showed a relatively positive effect, resulting in higher seedling germination rates than the 20-gram and 30-gram treatments. These differences were statistically significant, as shown in Figure 4.

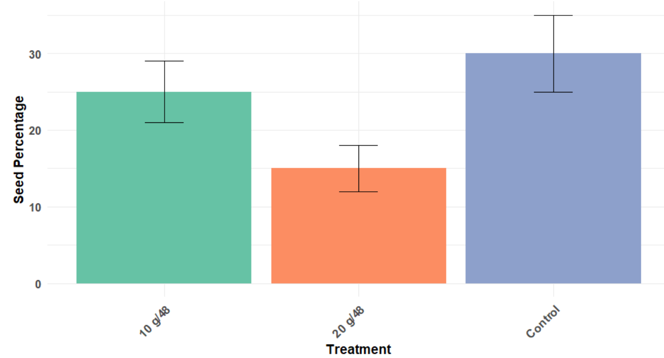

Fig. 4. Seed germination (28 hours)

In the 48-hour treatment for maize, a negative effect on seedling growth was observed in all extract treatments compared to the control. The data indicate a progressive decline in seedling growth with increasing concentrations of Anagallis arvensis extract. As shown in the graph, higher extract concentrations resulted in reduced fresh and dry weights of the seedlings. The effects of A. arvensis on seedling biomass are illustrated in Fig 5.

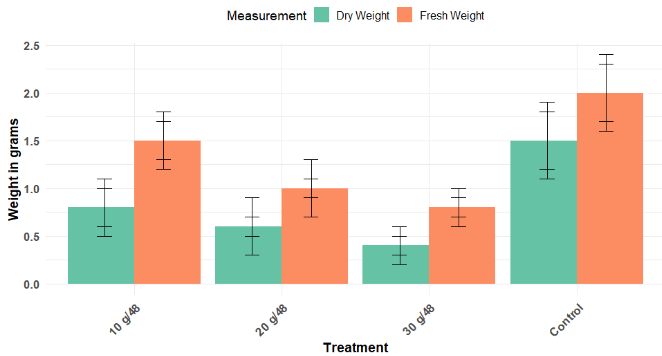

Fig. 5. Fresh and dry weight (28 hours)

In the 48-hour treatment for maize, the 30-gram concentration of Anagallis arvensis extract enhanced the length of both the plumule and radicle compared to the control, indicating a stimulatory effect on seedling growth. In contrast, the other treatments showed inhibitory effects, reducing plumule and radicle lengths relative to the control. Overall, the 10-gram treatment also demonstrated a positive impact by slightly increasing the lengths of the plumule and radicle. The effects of A. arvensis on plumule and radicle development are illustrated in Fig 6.

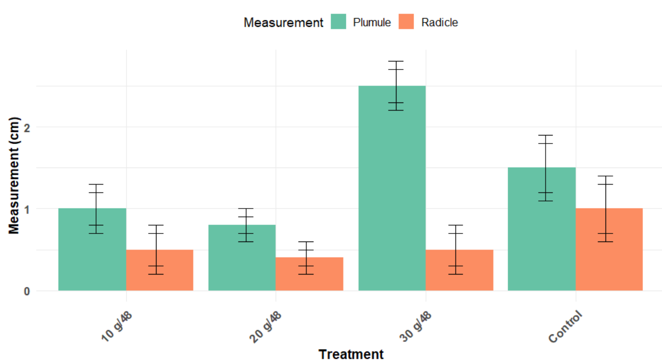

Fig. 6. Length of plumule and radical (48 hours)

2) Effects of Anagalis arvensis (5ml extract) on (a) maize seed germination (b) fresh and dry weight, and (c) plumule and radical.

In the 72-hour treatment for maize, a negative effect on seedling germination was observed, with germination rates significantly reduced compared to the control. Among the treatments, the 10-gram extract showed the most pronounced inhibitory effect, resulting in lower germination compared to the 20-gram and 30-gram treatments. These differences were statistically significant, as presented in Fig 7.

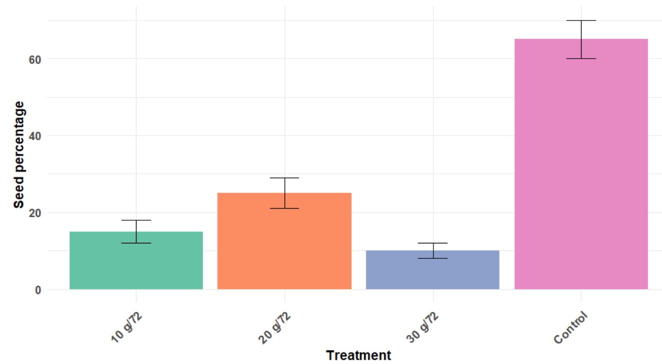

Fig. 7. Seed germination (72 hours)

In the 72-hour treatment for maize, the application of Anagallis arvensis extract had a significant effect on seedling biomass, resulting in a noticeable reduction in both fresh and dry weights compared to the control. Among the treatments, the 10-gram extract was the most effective in decreasing plant biomass, showing greater inhibition than the 20-gram and 30-gram treatments. The effects of A. arvensis on the fresh and dry weights of maize seedlings are illustrated in Fig 8.

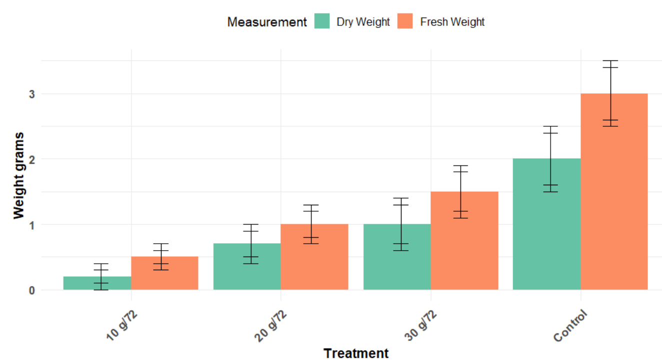

Fig. 8. Fresh and dry weight (72 hours)

In the 72-hour treatment for maize, a negative effect on seedling germination was observed, with reduced germination rates compared to the control. Among the treatments, the 10-gram extract had the most pronounced inhibitory effect, resulting in a greater decrease in seedling germination than the 20-gram and 30-gram treatments. The effects of Anagallis arvensis on plumule and radicle length are illustrated in Fig 9.

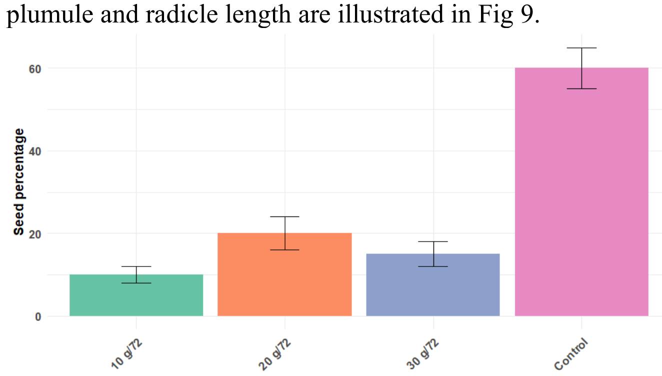

Fig. 9. Length of plumule and radical (72 hours)

B. *Wheat Results*

In the 24-hour treatment for wheat, a significant reduction in seed germination was observed compared to the control, with germination decreasing as the concentration of Anagallis arvensis extract increased. Among the treatments, the 10-gram extract was relatively less inhibitory and even showed a slight increase in seed germination compared to the 20-gram and 30-gram treatments. These results were statistically significant, as shown in Fig 10.

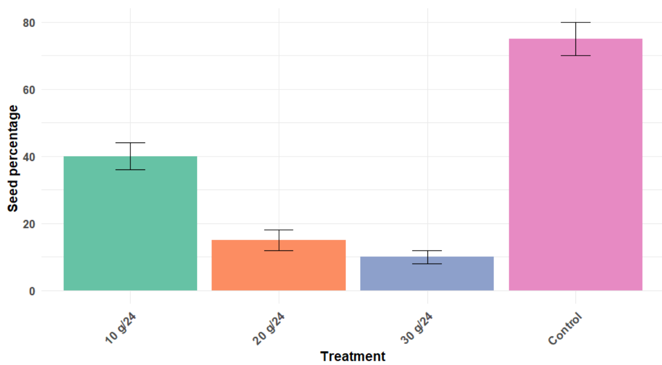

Fig. 10. wheat seed germination (24 hours)

In the 24-hour treatment for wheat, a significant reduction in seedling growth was observed, with both fresh and dry weights decreasing compared to the control. This decline became more pronounced as the concentration of Anagallis arvensis extract increased. Among the treatments, the 10-gram extract had a comparatively positive effect, resulting in higher fresh and dry weights of the seedlings than the 20-gram and 30-gram treatments. The effects of A. arvensis on seedling biomass are illustrated in Fig 11.

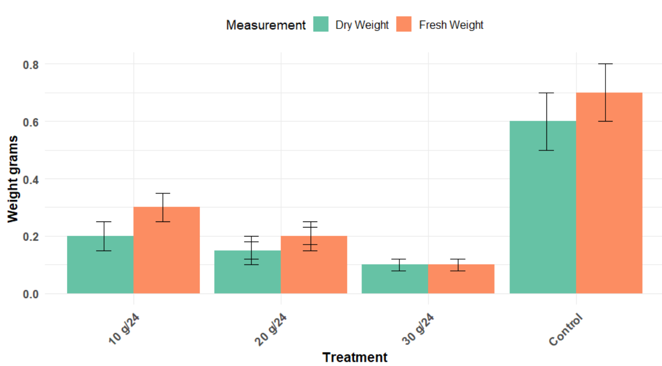

Fig. 11. Fresh and dry weight (24 hours)

In the 24-hour treatment for wheat, no significant effect was observed on plumule length across the treatments compared to the control. However, the radicle was negatively affected, with a reduction in its length compared to the control group. Among the treatments, the 10-gram extract showed a relatively positive effect, resulting in increased radicle length compared to the 20-gram and 30-gram treatments. The effects of Anagallis arvensis on the plumule and radicle development are illustrated in Fig 13.

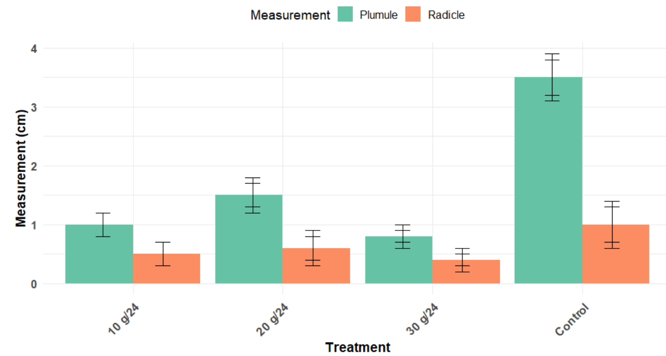

Fig. 12. Length of plumule and radical (24 hours)

1) Effects of Anagalis arvensis (5ml extract) on (a) wheat seed germination (b) fresh and dry weight, and (c) plumule and radical.

In the 48-hour treatment for wheat, a negative effect on seed germination was observed compared to the control, with overall germination rates decreasing. However, among the treatments, the 10-gram and 20-gram extracts showed relatively positive effects, resulting in higher germination rates compared to the 30-gram treatment. These differences were statistically significant, as presented in Figure 13.

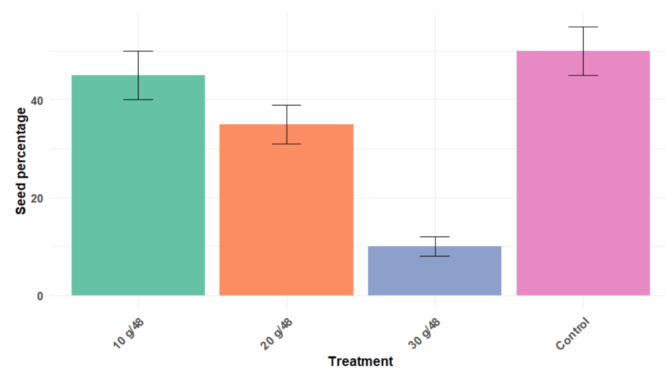

Fig. 13. Seed germination (24 hours)

In the 48-hour treatment for wheat, the 10-gram extract showed a positive effect by enhancing the fresh weight of seedlings compared to the control, while the 20-gram and 30-gram treatments resulted in reduced fresh weight. A similar trend was observed for dry weight, where the 10-gram treatment increased seedling dry weight, whereas the higher concentrations led to a greater reduction than the control. Overall, the 10-gram treatment positively influenced both fresh and dry weights. The effects of Anagallis arvensis on seedling biomass are illustrated in Fig 14.

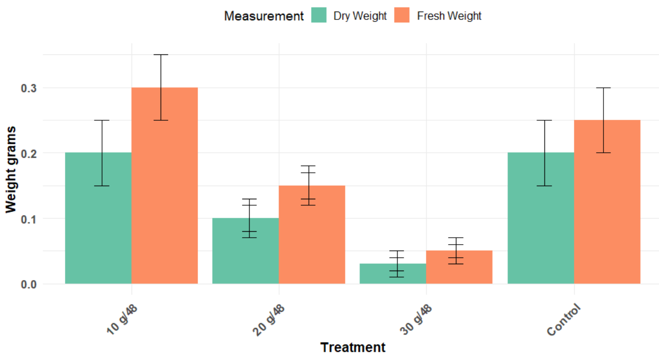

Fig. 14. Fresh and dry weight (24 hours)

In the 48-hour treatment for wheat, a negative effect on seedling growth was observed, with a reduction in plumule and radicle lengths compared to the control. However, among the treatments, the 10-gram and 20-gram extracts showed relatively positive effects, resulting in increased lengths of both plumule and radicle compared to the 30-gram treatment. The effects of Anagallis arvensis on plumule and radicle development are illustrated in Fig 16.

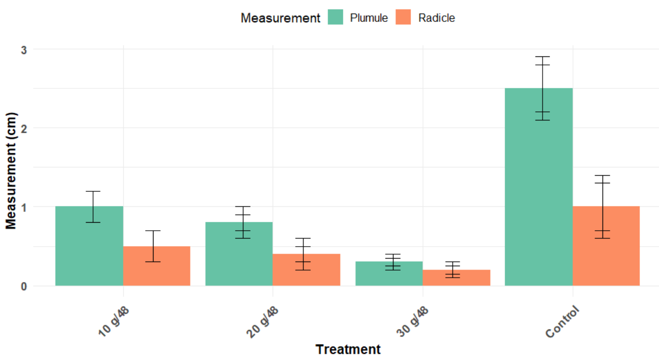

Fig. 15. Length of plumule and radical (48 hours)

2) Effects of Anagalis arvensis (5ml extract) on (a) wheat seed germination (b) fresh and dry weight, and (c) plumule and radical.

In the 72-hour treatment for wheat, a negative effect on seed germination was observed, with a reduction in seedling growth compared to the control. However, among the treatments, the 10-gram and 20-gram extracts showed relatively positive effects, promoting higher seedling germination and growth compared to the 30-gram treatment. These differences were statistically significant, as shown in Fig 16.

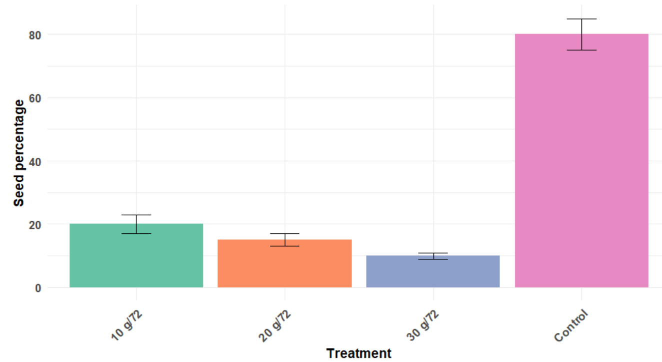

Fig. 16. Seed germination (72 hours)

In the 72-hour treatment for wheat, a negative effect on seedling growth was observed, with both fresh and dry weights reduced compared to the control. However, among the treatments, the 20-gram extract showed a relatively positive effect by increasing the dry weight of the seedlings compared to the 10-gram and 30-gram treatments. The effects of Anagallis arvensis on the fresh and dry weights of wheat seedlings are presented in Fig 17.

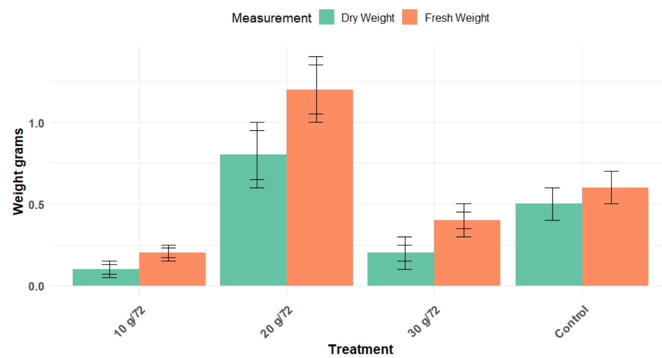

Fig. 17. Seed germination (72 hours)

In the 72-hour treatment for wheat, a negative effect on seedling growth was observed, with a decrease in the length of both the plumule and radicle compared to the control. Among the treatments, the 20-gram and 30-gram extracts showed relatively positive effects, resulting in increased plumule and radicle lengths compared to the 10-gram treatment. The effects of Anagallis arvensis on plumule and radicle development are illustrated in Fig 18.

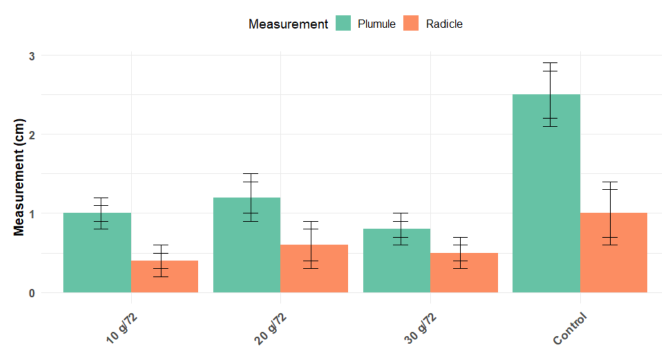

Fig. 18. Length of plumule and radical (72 hours)

C. Pearl millet Results

In the 24-hour treatment for Pennisetum glaucum, a negative effect on seedling germination was observed, with reduced germination compared to the control. However, among the treatments, the 20-gram extract demonstrated a relatively positive effect by enhancing seedling germination compared to the 10-gram and 30-gram treatments. These results were statistically significant, as shown in Fig 19.

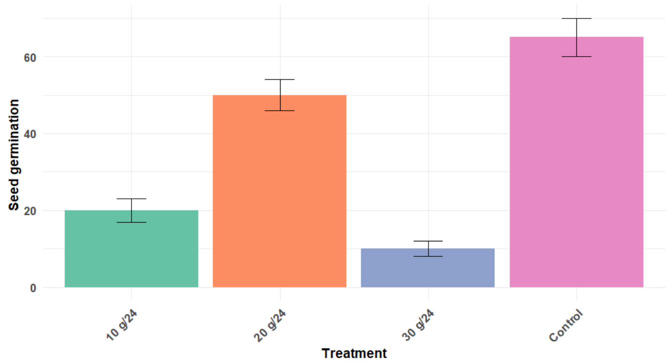

Fig. 19. Seed germination (24 hours)

In the 24-hour treatment for Pennisetum glaucum (pearl millet), the application of Anagallis arvensis extract had a negative effect on seedling growth, with reductions in both fresh and dry weights compared to the control. Among the treatments, the 10-gram and 30-gram extracts showed more pronounced inhibitory effects, while the 20-gram extract had a relatively lesser negative impact. The effects of A. arvensis on the fresh and dry weights of seedlings are illustrated in Fig 20.

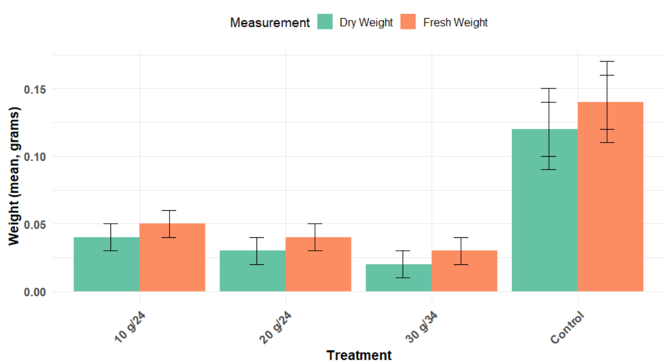

Fig. 20. Fresh and dry weight (24 hours)

In the 24-hour treatment for Pennisetum glaucum (pearl millet), a significant effect on seedling growth was observed compared to the control. Among the treatments, the 30-gram extract had the most pronounced negative effect, leading to a greater reduction in the lengths of both the plumule and radicle compared to the 10-gram and 20-gram treatments. The effects of Anagallis arvensis on plumule and radicle development are illustrated in Fig 21.

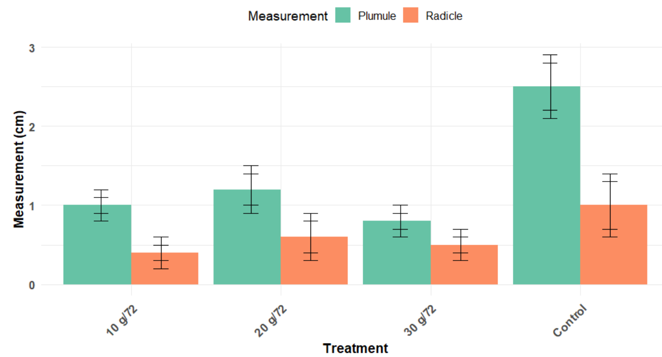

Fig. 21. Length of plumule and radical (24 hours)

1) Effects of Anagalis arvensis (5ml extract) on (a) pennistum glaucum seed germination (b) fresh and dry weight and (c) plumule and radical.

In the 48-hour treatment for Pennisetum glaucum, a negative effect on seedling germination was observed, with reduced germination compared to the control. However, among the treatments, the 30-gram extract showed a relatively positive effect, resulting in higher seedling germination compared to the 10-gram and 20-gram treatments. These differences were statistically significant, as presented in Fig 22.

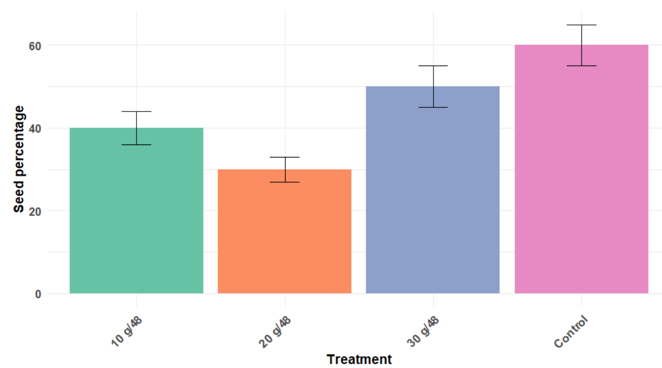

Fig. 22. Seed germinations (48 hours)

In the 48-hour treatment for Pennisetum glaucum (pearl millet), there was a non-significant effect on seedling germination compared to the control. However, among the treatments, the 30-gram extract showed a relatively positive effect, particularly in increasing the fresh weight of the seedlings compared to the 10-gram and 20-gram treatments. The effects of Anagallis arvensis on the fresh and dry weights of seedlings are illustrated in Fig 23.

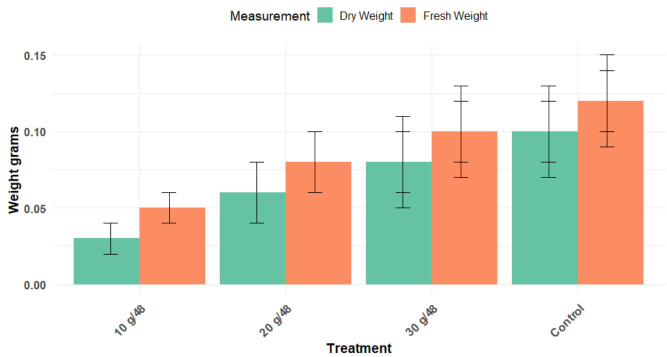

Fig. 23. Fresh and dry weight (48 hours)

In the 48-hour treatment for Pennisetum glaucum, a negative effect on seedling growth was observed, with a reduction in the lengths of both the plumule and radicle compared to the control. However, among the treatments, the 30-gram extract demonstrated a relatively positive effect, resulting in increased plumule and radicle lengths compared to the 10-gram and 20-gram treatments. The effects of Anagallis arvensis on plumule and radicle development are illustrated in Fig 24.

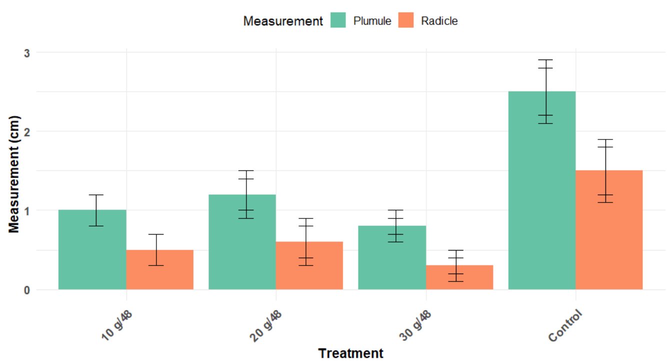

Fig. 24. Length of plumule and radical (48 hours)

2) Effects of Anagalis arvensis (5ml extract) on (a) Pennistum glaucum seed germination, (b) fresh and dry weight, and (c) plumule and radical.

In the 72-hour treatment for Pennisetum glaucum, the 30-gram extract enhanced seed germination compared to the control, while the other treatments inhibited or reduced germination. Among the treatments, the 20-gram extract showed the most negative effect, resulting in a greater reduction in seedling germination compared to the 10-gram and 30-gram treatments. The differences were statistically non-significant, as shown in Fig 25.

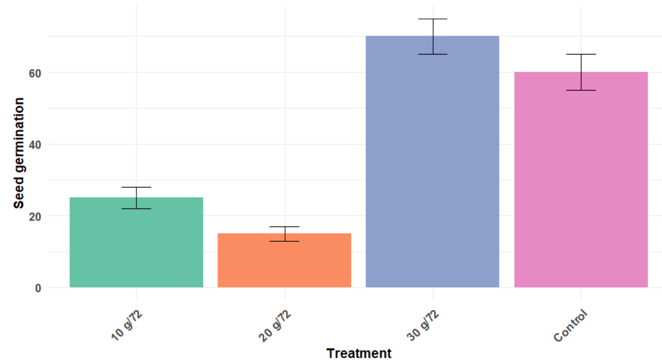

Fig. 25. Seed germinations (48 hours)

In the 72-hour treatment for *Pennisetum glaucum*, the 10-gram extract had a non-significant effect on seedling growth compared to the control, with a slight increase observed in fresh weight. In contrast, the 20-gram and 30-gram extracts had significant negative effects, leading to a decrease in both fresh and dry weights of the seedlings. Among the treatments, the 10-gram extract was the least inhibitory and showed an increase in fresh weight relative to the higher concentrations. The effects of *Anagallis arvensis* on the fresh and dry weights of seedlings are illustrated in Fig 26.

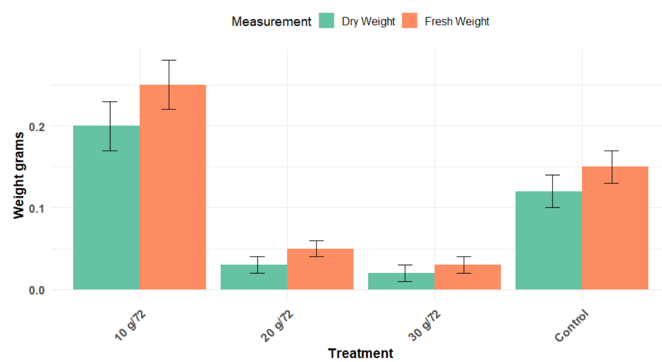

Fig. 26. Fresh and dry weight (48 hours)

In the 72-hour treatment for Pennisetum glaucum (pearl millet), a negative effect on seedling growth was observed, with reduced plumule and radicle lengths compared to the control. Among the treatments, the 30-gram extract showed a relatively positive effect, resulting in increased plumule and radicle lengths compared to the 10-gram treatment.

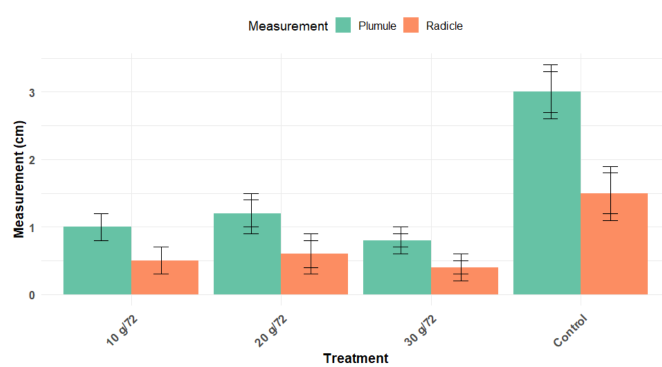

Fig. 27. Length of plumule and radical (48 hours)

3) Effects of Anagalis arvensis (5ml extract) on (a) Pennistum glaucum seed germination (b) fresh and dry weight, and (c) plumule and radical.

In the treatment with a 15-gram root extract of Anagallis arvensis, wheat and maize showed enhanced seedling germination compared to the control, indicating a positive effect on growth. In contrast, Pennisetum glaucum (pearl millet) exhibited a negative response, with reduced seedling germination relative to the control. Among the test species, maize demonstrated the most pronounced positive effect, with a higher germination rate compared to both wheat and pearl millet. The observed differences were statistically non-significant, as presented in Fig 28.

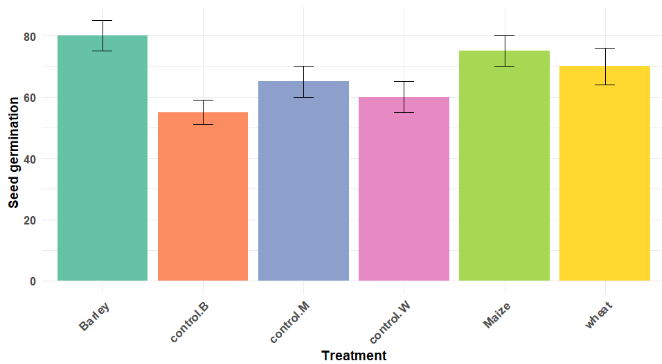

Fig. 28. Seed germination (48 hours)

In the 15-gram root extract treatment, a negative effect was observed on wheat and pearl millet, with a reduction in both fresh and dry weights of the seedlings compared to the control. In contrast, maize showed a positive response, with an increase in both fresh and dry weights relative to the control. Among the test species, pearl millet was the most negatively affected, showing the greatest reduction in seedling biomass compared to wheat and maize. The effects of Anagallis arvensis root extract on the fresh and dry weights of seedlings are illustrated in Fig 29.

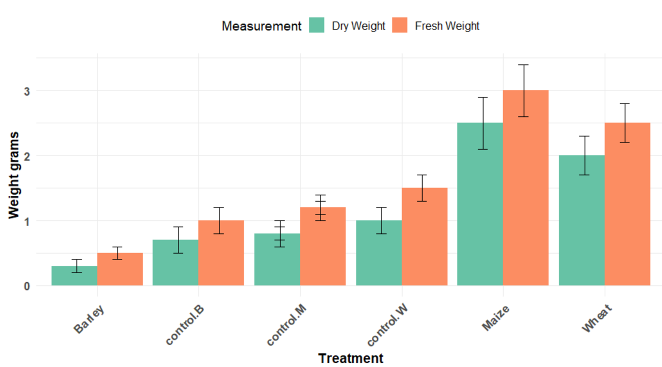

Fig. 29. Fresh and dry weight (48 hours)

In the 15-gram root extract treatment, a negative effect on seedling growth was observed in all three species, wheat, maize, and pearl millet, with a reduction in plumule and radicle lengths compared to the control. However, among the treatments, pearl millet showed a relatively positive response, exhibiting greater plumule and radicle lengths compared to wheat and maize. The effects of Anagallis arvensis root extract on plumule and radicle development are illustrated in Fig 32.

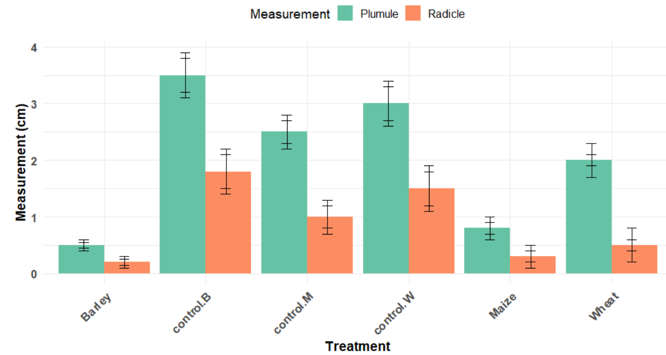

Fig. 30. Effects of Anagalis arvensis (5ml extract) on (a) Maize, Wheat and Pearl millet seed germination (b), fresh and dry weight and, (c) plumule and radical

IV. Discussion

In the present study, the allelopathic effects of Anagallis arvensis were evaluated on seed germination, plumule length, radicle length, fresh weight, and dry weight of Zea mays and Pennisetum glaucum. The results showed that treatments with 10 g, 20 g, and 30 g of leaf extract led to an overall increase in germination over time, with the highest germination observed at 24 hours. However, at 48 hours, germination decreased significantly with the 20 g treatment. In general, the 72-hour treatments reduced seed germination across all concentrations, indicating that prolonged exposure intensified inhibitory effects. At lower concentrations, increasing treatment duration had a minimal impact on germination (Ullah et al., 2025).

The data also revealed that at 24 hours, germination increased with rising extract concentration. This trend continued at 48 hours, except in the 20 g treatment, which exhibited a decline. These findings indicate that higher concentrations and longer durations of A. arvensis aqueous extract produce more pronounced inhibitory effects on germination, plumule length, radicle length, fresh weight, and dry weight of the test species. Specifically, extended exposure times negatively affected plumule and radicle elongation compared to the control (Asif et al., 2025).

Leaf extracts of Anagallis arvensis showed a particularly inhibitory effect on maize germination, aligning with previous findings by Mudi et al., (2024) and Mitu et al. (2022), who also noted strong phytotoxic effects from foliar leachates. A comparative analysis of extract concentration and duration revealed that the 48-hour treatment significantly inhibited plumule and radicle lengths (Cheng and Cheng, 2015). Additionally, the 24-hour, 15 g treatment showed a marked reduction in fresh weight. Overall, inhibitory effects increased proportionally with both extract concentration and soaking duration (Khamare et al., 2022). These observations are consistent with the findings of (Das and Ray, 2022), who reported decreased germination and seedling growth in rice and cowpea under increasing concentrations of Acacia auriculiformis leaf leachates (Khan et al., 2024).

Similar allelopathic effects of plant aqueous extracts have been documented in other studies as well. Rusdianto et al. (2022) reported that leaf extracts of Eucalyptus camaldulensis inhibited root growth in multiple crop species. This highlights the potential for allelochemicals from A. arvensis leaves and stems to act as inhibitory agents' post-decomposition, affecting neighboring or succeeding crops (Einhellig and Leather, 1988). Variations in phytotoxicity may be attributed to the differing concentrations of bioactive compounds in various plant parts (Batish, 2001). The phytotoxic potential of aqueous extracts has also been noted in recent studies involving Chrozophora oblique and Rhazya stricta (Wandita et al., 2020), supporting the idea that allelochemicals released during aqueous extraction processes can significantly impact plant development (Weston, 2005).

In wheat and pearl millet, the allelopathic effects of Anagallis arvensis leaves, stems, and roots were similarly observed. The study found a significant increase in plumule length at 10 g concentration after 72 hours, while the 30 g concentration had greater inhibitory effects than the 10 g, 15 g (root), and 20 g treatments (Olofsdotter, 2002). The 24-hour treatments had a generally more positive effect on seed germination, fresh and dry weight, and plumule and radicle length than the 48-hour and 72-hour treatments (Chengxu, 2011). This suggests that allelochemical production intensifies over time, and that higher concentrations are more detrimental to seedling development (Gopal and Goel, 1993).

Comparative analysis showed that the 48-hour, 15 g treatment significantly reduced plumule length. These findings are in agreement with Beze and Wale, A. (2023), who also reported a decrease in seedling fresh weight with increasing concentrations of A. arvensis extract. Specifically, the 30 g concentration increased fresh weight in some cases compared to 10 g, 15 g, and 20 g treatments. Similarly, within the duration variable, the 24-hour treatment generally resulted in higher fresh weight than the 48- and 72-hour treatments, indicating that shorter exposure durations may allow seedlings to partially resist allelopathic stress. The dry weight of test species also followed a similar trend (Halbrendt, 1996). The 30 g concentration increased dry weight compared to the lower concentrations, and the 24-hour treatment had a more favorable impact than longer durations (Cummings, 2012). These observations again support the notion that leaf extracts are particularly phytotoxic, as confirmed in several other studies (Raza et al., 2021).

CONCLUSION

The present investigation demonstrated that the germination and growth-inhibitory effects of Anagallis arvensis are likely due to allelochemicals released from its leaves, either through direct leaching into the soil or as a result of decomposition. These allelochemicals may negatively impact neighboring or successional plant species, thereby influencing plant community dynamics. To further elucidate the underlying mechanisms of allelopathy, additional studies are recommended to explore the physiological and biochemical pathways involved. Since this experiment was conducted under controlled laboratory conditions, it is also suggested that future research be extended to greenhouse and field environments, where varying ecological factors may influence the outcomes. Moreover, expanded investigations on the allelopathic effects of A. arvensis on a broader range of plant species are warranted to fully understand its ecological impact and potential applications.

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