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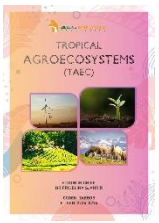

RESEARCH ARTICLE

ALLELOPATHIC EFFECTS OF AQUEOUS AND METHANOLIC EXTRACTS FROM AGERATUM CONYZOIDES L. ON THE GERMINATION OF SELECTED VEGETABLES

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ABSTRACT

This study investigates the impact of *Ageratum conyzoides* leaf and root extracts, both aqueous and methanol, and their profound influence on the germination, shoot elongation, and root growth of eight diverse vegetable crops. Control groups treated with water exhibited robust germination rates, ranging from 80.00% to 88.00%. However, the introduction of aqueous leaf extracts (AQE) triggered a concentration-dependent decline in germination, with some crops, like A. esculentus, plummeting to as low as 30.00% at a 5% concentration. Methanolic leaf extracts (MTE) exhibited variable effects on germination, with certain species, such as *A. esculentus* and *S. melongena*, maintaining relatively higher germination rates at 20% MTE. Both leaf extracts manifested phytotoxic impacts, with AQE generally exerting a more pronounced influence. The extent of inhibition diverged among species, implying distinct sensitivities to the extracts' phytochemical constituents. This study also scrutinized shoot elongation and root growth, revealing dose-dependent inhibitory effects of both AQE and MTE across various crops, highlighting varying levels of sensitivity among different species. Additionally, the study underscores the possible role of phenolic compounds in mediating these inhibitory, aligning with previous research findings. In summary, this investigation highlights the potential of *A. conyzoides* extracts as growth regulators and bioherbicides in agriculture but emphasizes the necessity for tailored application strategies and precise dosage control to optimize their benefits while safeguarding crop development.

KEYWORDS

Allelopathy, Leaf and Root extracts, Agricultural crops; Seed germination, Ageratum conyzoides.

1. INTRODUCTION

Ageratum conyzoides, or billygoat weed, is an invasive herbaceous annual from tropical America that has widely spread, especially in South-East Asian (Wardani, 2018; Kaur, 2023). It thrives in various habitats, causing economic losses by impeding both summer and winter crop growth. In rangelands, it disrupts native grass availability, leading to fodder scarcity and agricultural complications (Kaur, 2023). *A. conyzoides'* ability to dominate its surroundings can be attributed to allelopathy, a mechanism where living or decomposing plant parts release chemicals that harm nearby plants (Motmainna et. al., 2023). This allelopathic strategy is often used by invasive weeds to establish themselves successfully in an area (Thapa et. al., 2018). The chemical exudates from *A. conyzoides* interfere with the growth of neighboring plants, creating an ecological imbalance. The presence of phenolic acids like gallic acid, coumaric acid, and protocatechins acid in *A. conyzoides'* leaves plays a crucial role in its allelopathic capability. These phenolic compounds, classified under the phenol group, have the ability to inhibit the growth of specific plant (Hu and Kong, 2002; Motmainna et al., 2023)

Recently, there has been a growing interest in exploring the potential of allelochemicals to manage weed infestations, which can significantly impact crop yields (Khamare, 2022). Researchers, such as found that methanol extracts from twenty two weed species inhibit plant germination and identified ten allelochemicals in *Cephalaria syriaca*. This highlights allelochemicals' relevance in modern agriculture. Understanding crop allelochemicals is challenging due to their complex nature and diverse origins. Some compounds, like sorgoleone, inhibit photosynthesis and respiration (Weston et al., 2013). Modern crops have fewer allelochemicals compared to wild varieties as they're bred for yield, not defense. Conventional breeding and genetics offer potential to reintroduce allelopathic genes. Overall, grasping crop-weed interactions and developing allelopathic crops for targeted weed control can be beneficial (Cheng and Cheng, 2015).

The use of herbicides raises numerous concerns, including resistance development in organisms, environmental contamination, and potential health risks for both humans and livestock (Ofosu et al., 2023). These practices are unsustainable and cannot be continued indefinitely. Prior to the widespread adoption of herbicides, weed management primarily relied on cultivation techniques and crop rotation (Weisberger, 2024). The utilization of allelopathy presents a promising and environmentally friendly alternative to address pressing concerns in agriculture (Shrestha et al., 2021; Akter et. al. 2024). It aims to reduce environmental pollution and maintain ecological balance, emphasizing natural alternatives over chemical herbicides (Weisberger, 2024). Reintroducing beneficial allelopathic traits through breeding and genetic techniques is feasible (Ain, 2023). Allelochemicals like strigol and sorgolactone from plants can effectively manage parasitic weeds, while catch-and-trap crops aid integrated weed control (Macias, 2019). Weeds are no longer just nuisances; their ecological impact is recognized. Modern agriculture integrates allelopathic crops through cover crops, intercropping, green manure, and crop rotations (Khamare, 2022). This study investigates *A. conyzoides'* allelopathic effects on agricultural crops, focusing on leaf and

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root extracts' impact on germination and plant growth.

2. Materials and Methods

2.1 Sample Collection and Processing

In this research, the seed viability of eight distinct cucurbit crops, including *A. esculentus, C. annum; P. vulgaris, S. melongena, S. lycopersicum, Z. mays, C. sativus* and *C. arietinum* were assessed using a float test. For each crop, 100 seeds were selected and immersed in a 200-ml beaker filled with distilled water for a duration of 5 to 10 minutes. The assessment of seed viability was based on the seeds' buoyancy: those that floated were considered non-viable, while those that sank were deemed viable. Concurrently, fresh leaves and roots of *A. conyzoides* were collected from the botanical garden at the University of Chittagong. All experimental procedures were carried out at the Department of Botany, University of Chittagong, Chattogram, Bangladesh

2.2 Preparation of Extracts

In the current experiment, 200 grams of fresh *A. conyzoides* leaves and roots were initially cleaned in distilled water to eliminate any impurities or contaminants. Afterward, they were left to air dry at room temperature (28-30°C) for 24 hours, avoiding direct sunlight exposure, until all moisture was removed. Subsequently, these dried samples were placed in an oven at 80°C for 48 hours. Following drying, the leaves and roots were ground into a fine powder using an electric grinder and passed through an 8.0 mm aperture size wire mesh net screen for uniformity. To ensure sterility, all glass jars and beakers were heat-sterilized by placing them in an oven at 180°C for approximately 15 minutes. The ground samples were then stored in airtight glass jars until further use.

For the extraction process, separate quantities of 5, 10, 15, and 20 grams of the leaf and root powders were soaked in 100 ml of distilled water and 80% methanol, respectively (Figure 2), for a duration of 24 hours at room temperature with continuous stirring. Afterward, the solutions were filtered through a 2 mm mesh sieve to eliminate any remaining undissolved large particles and then subjected to centrifugation at 3500 rpm for 15 minutes. The resulting extracts from both methods were stored in conical flasks and kept refrigerated at 4°C until further use in subsequent experiments.

2.3 Preparation of Seed Culture

In this study, Petri dishes, each with a 9 cm diameter, were meticulously sterilized and prepared. Within each Petri dish, a Whatman No.1 filter paper was laid, and an appropriate soil medium was added. Ten seeds from various crop types were evenly sown in each dish, ensuring equal spacing. The experiment was conducted under controlled conditions at a constant room temperature of 23°C for 15 days to facilitate germination. Eight treatments (T1 to T8) were applied, including aqueous and methanolic extracts from Euphorbia hirta leaves and roots, along with a control group (T0) with seeds soaked in distilled water. Throughout the experiment, each dish received 5 ml of distilled water to maintain soil moisture. Seed germination success was determined by the emergence of a radicle exceeding 2 mm in length. After 15 days, the experiment was assessed for germinated seed count, root and shoot growth measurements, and the Final Germination Percentage (FGP) was calculated.

2.4 Data Analysis

The data underwent three repetitions of analysis using Microsoft Excel 2010, and the results were presented in terms of the mean (average) and the Standard Error of the Mean (SEM).

3. Results and Discussion

3.1 Deciphering Crop Seed Germination

The impact of *A. conyzoides* leaf and root extracts (aqueous ans methanol) on the germination of eight different vegetable crops was examined (Table 1). Control groups treated with water exhibited high germination percentages, ranging from 80.00% to 88.00%. However, aqueous leaf extracts (AQE) showed concentration-dependent inhibition of germination, with some crops experiencing a significant decrease, such as A. esculentus dropping to 30.00% at 5% concentration. Methanolic leaf extracts (MTE) also inhibited germination but had variable effects among species. For instance, *A. esculentus* and *S. melongena* maintained relatively higher germination rates at 20% MTE. The data indicated that both leaf extracts exhibited phytotoxic effects, with AQE generally having a stronger impact. Moreover, the extent of inhibition varied among species, suggesting differential sensitivities to the extracts' phytochemical constituents (Table 1).

However, in Table 2, treatment with 5% AQE led to a significant reduction in germination across all species, with *A. esculentus* dropping to 30.00%, and *S. lycopersicum* experiencing a more pronounced reduction. Higher concentrations of AQE (20%) further decreased germination rates. Methanol root extracts (MTE) also inhibited germination, but the response varied. *A. esculentus* exhibited a germination rate of 33.30% at 5% MTE, decreasing to 26.70% at 20% MTE. Interestingly, *S. melongena's* germination was less affected by MTE, with a rate of 36.70% at 20% concentration. Leguminous crop P. vulgaris showed moderate tolerance to the extracts, maintaining a relatively stable germination rate. *S. lycopersicum* had a differential response to AQE and MTE, with 15% AQE completely inhibiting germination but a 15% MTE concentration resulting in a germination rate of 26.70%. These findings highlight the concentration-dependent phytotoxic effects of *A. conyzoides* root extracts, with AQE generally exerting a stronger inhibitory effect than MTE. The results emphasize the need for cautious consideration of *A. conyzoides* root extracts' use in agriculture due to their varying impacts on crop germination.

Seed germination is vital for plant reproduction, diversity, and agriculture. It ensures plant continuity, supports biodiversity, and impacts food production, sustaining both human and animal populations (Beweley, 1994; Hasanuzzaman et al., 2013; Möhler et al., 2016). Allopathic weeds negatively impact seed germination of crops. leading to significant losses on plantations (Shah et. al., 2016; Yarnia et. al. 2024). These weeds emit chemicals that hinder the growth of both subsequent plants and neighboring vegetation. In this study we also found the inhibitory effect both aqueous and methanol extract which corroborated with the previous study (Shah et. al., 2016; Lalbiakdika and Lalruatsanga, 2022; Khedhri et al., 2023). These findings indicate that both aqueous and methanol extracts of *A. conyzoides* roots exhibit a dose-dependent inhibitory effect on shoot elongation in a variety of agricultural crops. The degree of inhibition varies significantly among species, suggesting that the sensitivity to these extracts is influenced by species-specific characteristics (Jefferson and Pennacchio, 2003).

Table 1: Germination percentage of eight vegetable crops to different concentrations of aqueous and methanolic leaf extract of A. conyzoides at 10 DAPS (Mean ± SEM).

Treatment	*A. esculentus*	*S. melongena*	*S. lycopersicum*	*P. vulgaris*	*C. annuum*	*Z. mays*	*C. arietinum*	*C. sativus*
Control	80.00±0.82	86.70±0.47	80.00±0.82	86.00 ±0.47	88.00±0.47	86.70±0.47	80.00±0.82	86.70±0.47
AQE 5%	30.00±0.82	26.70±1.25	30.00±0.82	40.00±0.82	16.70±0.94	20.00±0.82	43.30±0.47	63.30±1.69
AQE 10%	20.00±0.82	20.00±0.82	43.30±1.25	40.00±1.41	23.30±1.25	23.30±0.94	50.00±2.82	46.70±0.47
AQE 15%	23.30±0.47	16.70±0.47	0	36.70±0.47	16.70±0.47	33.30±0.94	50.00±0.82	33.30±0.47
AQE 20%	23.30±0.47	33.30±0.47	0	43.30±1.25	23.30±0.47	33.30±0.47	56.70±0.47	36.70±1.69
MTE 5%	36.70±0.47	36.70±0.47	0	40.00±0.82	23.30±0.94	20.00±0.82	43.30±1.25	36.70±1.24
MTE 10%	16.70±0.47	20.00±1.41	23.30±0.47	33.30±0.94	30.00±0.82	33.30±1.25	43.30±0.94	43.30±0.47
MTE 15%	46.70±0.47	30.00±0.82	0	23.30±0.47	20.00±0.82	56.70±2.05	50.00±1.63	63.30±0.47
MTE 20%	36.70±0.94	23.30±1.25	0	20.0±0.82	30.00±0.82	33.30±0.47	46.70±0.47	46.70±2.05

AQE: Aqueous extract; MTE: Methanol extract.

Table 2: Germination percent of receptor agricultural crops to distilled water (T_o) and different concentrations of aqueous and methanol Ageratum conyzoides root extracts (Mean ± SEM).

Treatment	*A. esculentus*	*S. melongena*	*S. lycopersicum*	*P. vulgaris*	*C. annuum*	*Z. mays*	*C. arietinum*	*C. sativus*
Control	Control	80.00±0.82	86.70±0.47	80.00±0.82	86.00±0.47	88.00±0.47	86.70±0.47	80.00±0.82
AQE 5%	30.00±0.82	30.00±0.82	50.00±0.82	60.00±0.82	40.00±0.82	16.70±0.47	73.30±1.69	53.30±0.47
AQE 10%	30.00±0.82	26.70±1.25	30.00±0.82	36.70±0.47	30.00±0.82	23.30±0.47	46.70±0.47	46.70±0.94
AQE 15%	26.70±0.94	20.00±0.82	0	50.00±0.82	23.30±1.25	33.30±0.47	53.30±0.47	36.70±1.69
AQE 20%	23.30±1.25	30±.00.82	40.00±1.63	40.00±0.82	20.00±0.82	20.00±1.41	26.70±0.47	23.30±0.47
MTE 5%	33.30±0.94	16.70±0.47	20.00±0.82	46.70±1.25	23.30±0.94	26.70±0.94	46.70±0.94	26.70±1.24
MTE 10%	33.30±1.25	43.30±0.47	0	26.70±0.47	26.70±0.47	26.70±0.94	23.30±0.47	20.0±0.82
MTE 15%	30.00±1.41	30.00±1.63	26.70±0.47	23.30±1.25	40.00±0.82	43.30±0.47	13.30±0.47	30±0.82
MTE 20%	26.70±1.25	36.70±0.94	0	16.70±0.94	30.00±0.82	36.70±0.47	23.30±0.94	26.70±0.47

AQE: Aqueous extract; MTE: Methanol extract

3.2 Leaf and Root Extracts Impact on Crop Shoot Elongation

In Table 3, under control conditions, *A. esculentus* reached an average of 19.1±0.08 cm, and *S. melongena* at 6.1±0.08 cm, while P. vulgaris and *Z. mays* had elongations of 31.83±0.62 cm and 8.1±0.08 cm respectively. However, treatment with aqueous leaf extracts (AQE) resulted in the reduction in shoot elongation depending on concentrations. *A. esculentus,* for instance, showed a decrease from 15.40±0.08 cm at 5% AQE to 10.1±0.08 cm at 20% concentration, indicating a substantial inhibitory effect. In contrast, *S. melongena* was less affected, with shoots measuring 6.37±0.12 cm at the highest AQE concentration. Methanolic leaf extracts (MTE) had a varied impact on shoot elongation among the crops. *A. esculentus* saw a significant reduction from 7.44±0.08 cm at 5% MTE to 3.44±0.08 cm at 20% MTE. *S. melongena's* shoots were less affected, measuring 7.23±0.17 cm at the highest concentration, closer to the control group length. Leguminous crop P. vulgaris showed resistance to lower concentrations of both extracts but experienced a decline in shoot length at higher concentrations, with 19.40±0.08 cm at 10% MTE compared to 32.40±0.08 cm in the control. Notably, *C. arietinum* showed a differing response to 15% AQE, exhibiting no growth, whereas at the same concentration of MTE, shoots measured 4.44±0.29 cm in *Z. mays*, indicating sensitivity to the type of extract.

In Table 4, treatment with 5% AQE resulted in a reduction in shoot elongation for all crops, with *A. esculentus* measuring 14.4±0.08 cm, and *S. melongena* at 9.17±0.12 cm. The inhibitory effect was concentration-dependent, with a 20% concentration reducing *A. esculentus* and *S. melongena's* shoot length to 14.4±0.08 cm and 5.47±0.17 cm, respectively. *S. lycopersicum* exhibited complete inhibition of shoot elongation at 15% AQE. Methanol root extracts (MTE) showed a similar trend, with 5% MTE reducing *A. esculentus* shoot length to 4.1±0.08 cm. At higher concentrations, the inhibitory effect intensified, with 20% MTE treatment leading to shoot lengths of 3.40±0.08 cm in *A. esculentus* and 5.33±0.17 cm in *S. melongena*. Notably, P. vulgaris maintained a shoot length of 18.2±0.08 cm even at the highest MTE concentration. *C. sativus* displayed a moderate decline in shoot elongation, with the least reduction observed at 5% MTE (11.47±0.12 cm) and a more significant decrease to 9.13±0.12 cm at 20% MTE.

In this study, methanolic leaf extracts (MTE) consistently demonstrated a more potent inhibitory effect on shoot elongation across various crops compared to aqueous leaf extracts (AQE). A. *esculentus, S. melongena,* and *Z. mays* were notably more sensitive to MTE, with substantial reductions in shoot length at higher concentrations. *P. vulgaris* also exhibited sensitivity to MTE, leading to a decline in shoot length, possibly due to enhanced allelochemical solubility implying higher potency or concentration in organic solvents (Chon et al., 2002). Similar results were observed by Jabeen and Ahmad, demonstrating delayed seedling growth in maize and wheat at higher concentrations suggesting that these extracts could serve as either crop growth inhibitors or stimulants, depending on dosage (Dorning and Cipollini, 2006; Maharjan et al., 2007). In contrast, while AQE did inhibit shoot elongation to some degree, its inhibitory effects were generally milder than those of MTE. These findings suggest that MTE has a stronger inhibitory impact on shoot growth in the tested crops, emphasizing the importance of extract choice and concentration management in crop cultivation practices (Van Oosten et al., 2017).

Table 3: Shoot elongation of receptor agricultural crops to distilled water (T_o) and different concentrations of aqueous and methanol *A. conyzoides* leaf extracts at 10 DAPS (Mean ± SEM).

Treatment	*A. esculentus*	*S. melongena*	*S. lycopersicum*	*P. vulgaris*	*C. annuum*	*Z. mays*	*C. arietinum*	*C. sativus*
Control	19.1±0.08	6.1±0.08	6.4±0.08	32.4±0.08	7.33±0.17	8.13±0.12	11.4±0.08	12.1±0.08
AQE 5%	15.4±0.08	6.2±0.08	4.8±0.08	21.1±0.08	7.43±0.17	10.17±0.12	6.17±0.12	9.5±0.08
AQE 10%	12.37±0.12	8.4±0.08	3.73±0.17	29.2±0.08	8.13±0.12	8.17±0.12	4.4±0.08	9.1±0.08
AQE 15%	14.4±0.08	7.7±0.08	0	19.2±0.08	9.13±0.12	9.1±0.08	6.1±0.08	12.13±0.12
AQE 20%	10.1±0.08	6.37±0.12	0	15.2±0.08	5.3±0.21	9.23±0,17	5.4±0.08	6.1±0.08
MTE 5%	7.44±0.08	7.43±0.17	0	22.4±0.08	6.7±0.21	5.13±0.12	2.8±0.08	10.4±0.08
MTE 10%	12.33±0.12	7.43±0.12	4.1±0.08	19.4±0.08	7.73±0.16	7.2±0.21	10.1±0.08	9.33±0.12
MTE 15%	9.1±0.08	5.13±0.12	0	10.2±0.08	8.43±0.20	4.4±0.29	5.4±0.08	10.13±0.12
MTE 20%	3.44±0.08	7.23±0.17	0	9.3±0.08	6.37±0.20	7.1±0.08	6.1±0.08	10.4±0.08

AQE: Aqueous extract; MTE: Methanol extract.

Table 4: Shoot elongation of receptor agricultural crops to distilled water (T_o) and different concentrations of aqueous & methanol *Ageratum conyzoides* root extracts at 10 days (Mean ± SEM).

Treatment	*A. esculentus*	*S. melongena*	*S. lycopersicum*	*P. vulgaris*	*C. annuum*	*Z. mays*	*C. arietinum*	*C. sativus*
Control	19.1±0.08	6.1±0.08	6.4±0.08	31.83±0.62	7.5±0.08	8.1±0.08	11.33±0.12	12.13±0.12
AQE 5%	14.4±0.08	9.17±0.12	4.33±0.17	7.2±0.16	8.53±0.12	7.27±0.20	5.1±0.08	10.4±0.08
AQE 10%	8.1±0.08	6.6±0.08	4.1±0.08	16.23±0.20	7.53±0.12	11.1±0.08	6.17±0.12	9.47±0.12
AQE 15%	10.17±0.12	7.5±0.08	0	23.17±0.12	5.63±0.12	6.1±0.08	4.17±0.12	10.2±0.16
AQE 20%	14.4±0.08	5.47±0.17	3.4±0.08	25±0.82	6.2±0.08	4.1±0.08	6.1±0.08	10.23±0.17
MTE 5%	4.1±0.08	8.2±0.16	6.1±0.08	23.67±0.23	6.13±0.12	9.2±0.16	4.33±0.12	11.47±0.12
MTE 10%	7.3±0,12	8.33±0.16	0	24.43±0.32	7.67±0.12	8.1±0.08	3.67±0.12	9.4±0.08
MTE 15%	10.4±0.08	7.5±0.08	4.4±0.08	10.2±0.16	8.27±0.12	7.1±0.08	4.4±0.08	12.17±0.12
MTE 20%	3.4±0.08	5.33±0.17	0	18.2±0.08	8.23±0.20	10.13±0.12	4.1±0.08	9.13±0.12

AQE: Aqueous extract; MTE: Methanol extract.

3.3 Root Elongation Modulation in Crops

In Table 5, root elongation dynamics among different crop species were examined under control conditions, revealing inherent variations. *A. esculentus* displayed robust root growth, reaching 6.1±0.08 cm, while *S. melongena* exhibited a similar trend at 6.13±0.12 cm. *C. sativus*, on the other hand, showed the lowest average elongation, measuring 5.13±0.12 cm. The introduction of aqueous leaf extracts (AQE) initiated a dose-dependent inhibition of root elongation across all species. *A. esculentus*, for instance, experienced a considerable reduction in root length, dwindling

to 4.47±0.12 cm at 10% AQE, and further decreasing to 5.44±0.08 cm at 20% AQE, signifying a substantial inhibitory effect. Notably, *S. lycopersicum* exhibited complete root growth inhibition at 15% and 20% AQE concentrations, underlining the potency of the extract. Methanolic leaf extracts (MTE) also impacted root elongation, albeit with diverse responses among the crops. *A. esculentus* roots were notably shortened to a mere 1.4±0.08 cm at 10% MTE, indicating a significant suppression in comparison to the control group. In contrast, *Z. mays* showcased enhanced tolerance to MTE, with root lengths of 24.37±0.12 cm at 5% MTE and 10.4±0.08 cm at 20% MTE. The legume *P. vulgaris* displayed a moderate level of sensitivity to the extracts, with root elongation decreasing from 13.10±0.08 cm in the control to 9.1±0.08 cm at 15% MTE. Conversely, *C. arietinum* and *C. sativus* demonstrated pronounced sensitivity to both AQE and MTE, exhibiting significant reductions in root elongation at higher extract concentrationsv. These findings indicate that both aqueous and methanol extracts of *A. conyzoides* roots exhibit a dose-dependent inhibitory effect on shoot elongation in various agricultural crops, with significant variation among species.

These results suggest that the aqueous leaf extracts (AQE) and methanolic leaf extracts (MTE) of *A. conyzoides* have a substantial, dose-dependent inhibitory impact on root elongation across a range of agricultural crop species (Van Oosten et al., 2017). The level of sensitivity to these extracts varies among different crops, with A. *esculentus* and *S. lycopersicum* being notably susceptible to both AQE and MTE. Conversely, *Z. mays* exhibited enhanced tolerance to MTE, while *P. vulgaris* displayed a moderate level of sensitivity.

Invasive plants are known to outcompete neighboring plants by releasing inhibitory phytochemicals, often water-soluble phenolics, which possess potential phytotoxic properties (Bargali et al., 1993; Qasem and Foy, 2001). The identified various phenolic compounds like gallic, coaumalic, protocatechuic, catechin, p-hydroxybenzoic acid in leaf debris, and ferulic acid in root exudates and residues (Batish et al., 2006a). These phenolics likely contribute to the observed inhibition in our study. In the present study, MTE negatively affected germination parameters of all crops seed germination, shoot and root growth resembles with the previous studies (Šoln et al., 2022). The reduction was observed concentration dependent (Wardani et al., 2018). Phenolic compounds are responsible for affecting the cell membrane permeability of the recipient plant which affects its nutrient uptake capacity, physiology, alter enzymatic activity and cell division pattern ultimately leading to reduce growth and development (Einhellig, 2003; Rahaman et al., 2022).

Table 5: Root elongation of receptor agricultural crops to distilled water (T_o) and different concentrations of aqueous and methanol *A. conyzoides* leaf extracts (Mean ± SEM).

Treatment	*A. esculentus*	*S. melongena*	*S. lycopersicum*	*P. vulgaris*	*C. annuum*	*Z. mays*	*C. arietinum*	*C. sativus*
Control	6.1±0.08	6.13±0.12	2.1±0.08	12.13±0.04	3.17±0.12	14.4±0.08	11.1±0.08	5.13±0.12
AQE 5%	4.3±0.17	4.5±0.08	3.1±0.08	6.1±0.08	2.53±0.24	11.1±0.08	13.17±0.12	1.167±0.12
AQE 10%	4.47±0.12	1.67±0.17	5.1±0.08	9.1±0.08	4.2±0.16	22.33±0.12	8.1±0.08	1.4±0.08
AQE 15%	5.13±0.12	2.53±0.20	0	13.13±0.12	1.33±0.12	7.1±0.08	7.47±0.12	3.33±0.12
AQE 20%	5.44±0.08	4.2±0.08	0	7.1±0.08	4.43±0.12	20.13±0.12	10.4±0.08	2.17±0.12
MTE 5%	6.1±0.08	3.27±0.12	0	13.1±0.08	3.5±0.08	24.37±0.12	9.1±0.08	6.1±0.08
MTE 10%	1.4±0.08	4.6±0.16	4.4±0.08	10.1±0.08	4.47±0.12	19.13±0.12	14.4±0.08	1.13±0.12
MTE 15%	4.33±0.12	5.27±0.12	0	9.1±0.08	2.3±0.24	18.2±0.16	4.17±0.17	5.17±0.12
MTE 20%	2.4±0.08	4.17±0.12	0	8.1±0.08	4.07±0.04	10.4±0.08	8.1±0.08	1.1±0.08

AQE: Aqueous extract; MTE: Methanol extract.

Table 6: Root elongation of receptor agricultural crops to distilled water (T_o) and different concentrations of aqueous and methanol *Ageratum conyzoides* root extractsat 10 days (Mean ± SEM).

Treatment	*A. esculentus*	*S. melongena*	*S. lycopersicum*	*P. vulgaris*	*C. annuum*	*Z. mays*	*C. arietinum*	*C. sativus*
Control	6.1±0.08	6.13±0.12	2.1±0.08	12.2±0.08	3.17±0.12	14.33±0.12	11.2±0.22	5.1±0.08
AQE 5%	5.1±0.08	4.37±0.12	4.17±0.12	8.13±0.12	3.47±0.20	15.37±0.12	8.3±0.22	1.3±0.08
AQE 10%	7.4±0.08	3.73±0.17	2.7±0.08	6.37±0.12	2.2±0.16	20.17±0.17	7.13±0.12	1.5± 0.08
AQE 15%	5.2±0.21	2.4±0.08	0	8.17±0.17	4.1±0.08	25.17±0.12	11.47±0.12	1.33±0.12
AQE 20%	8.5±0.08	2.63±0.12	3.2±0.08	9.1±0.08	3.33±0.12	17.1±0.08	4.47±0.12	5.4±0.08
MTE 5%	2.5±0.08	1.6±0.24	3.5±0.08	12.17±0.12	3.17±0.16	7.27±0.21	14.17±0.17	2.33±0.17
MTE 10%	3.17±0.17	5.2±0.16	0	8.17±0.17	3.3±0.16	19.23±0.17	5.5±0.08	1.17±0.12
MTE 15%	4.5±0.08	5.23±0.20	5.37±0.12	7.33±0.17	2.2±0.16	10.33±0.17	6.33±0.12	3.4±0.08
MTE 20%	2.3±0.17	4.5±0.08	0	8.17±0.12	2.5±0.32	22.17±0.12	17.23±0.17	3.13±0.12

AQE: Aqueous extract; MTE: Methanol extract.

4. Conclusions

A. conyzoides extracts hold promise for agriculture, but careful application is necessary to prevent adverse effects on crop growth due to their phytotoxic potential. Concentration-dependent inhibition highlights the need for precise dosage control to optimize benefits while mitigating phytotoxic effects on root development. *A. conyzoides* leaf extracts hold potential for strategic agricultural use, but tailored applications are essential for maximum efficacy. *A. conyzoides* root extracts, both aqueous and methanolic, significantly affect root elongation in a concentration-dependent manner, with varying species sensitivity. These findings reveal the intricate interplay of *A. conyzoides* aqueous and methanol leaf and root extracts on crop germination, root growth, and shoot elongation, indicating their potential as natural growth regulators and bioherbicides in agriculture. However, these effects vary across different crops, underlining the importance of tailored application strategies. Accurate dosage control is crucial to effectively harness the benefits while avoiding potential harm to crop development. These findings offer valuable insights for sustainable agricultural practices, promoting increased crop productivity and effective weed management while reducing reliance on synthetic chemicals.

References

Ain, Q., Mushtaq, W., Shadab, M. and Siddiqui, M.B., 2023. Allelopathy: an alternative tool for sustainable agriculture. Physiology and Molecular Biology of Plants, Pp.1-17.

Akter, P., Siddiqua, T., Begum, R., Ahmed, A., 2024b. Evaluation of the Allelopathic Activity of Aqueous and Methanol Extracts of Heliotropium indicum Leaves and Roots on Eight Cucurbit Crops. Horticulturae, 10(2), 135. https://doi.org/10.3390/horticulturae10020135

Ali, K. A., Sakri, F. Q., and Li, Q. X., 2012. Isolation and purification of allelochemicals from Cephalariasyriaca plant. Int. J. Bio. sci., 2, Pp. 90–103.

Bargali, S.S., Singh, R.P., 1993. Joshi Mukesh. Changes in soil characteristics in eucalypt

Batish, D.R., Singh, H.P., Kaur, S.,2006a. Kohli RK. Phytotoxicity of Ageratum conyzoides residues towards growth and nodulation of Cicer arietinum. Agriculture, Ecosystem and Environment, 113(1-4): Pp. 399–401.

Bewley, J.D., and Black, M. 2016. Physiology of Development and Germination. 2nd ed. New York: Plenum Press; Pp. 1994- 445.

Cheng, F., Cheng, Z., 2015b. Research Progress on the use of Plant Allelopathy in Agriculture and the Physiological and Ecological

Mechanisms of Allelopathy. Frontiers in Plant Science, 6. https://doi.org/10.3389/fpls.2015.01020

Chon, S.U., Choi, S.K., Jung, S., Jang, H.G., Pyo, B.S. and Kim, S.M., 2002. Effects of alfalfa leaf extracts and phenolic allelochemicals on early seedling growth and root morphology of alfalfa and barnyard grass. Crop protection, 21(10), Pp.1077-1082.

Dorning, M., and Cipollini, D., 2006. Leaf and root extracts of the invasive shrub, Lonicera maackii, inhibit seed germination of three herbs with no autotoxic effects. Plant Ecology, 184, Pp.287-296.

Einhellig, F. A., 2003. Mode of allelochemical action of phenolic compounds. In CRC Press eBooks , Pp. 217–238.

Hasanuzzaman, M., Nahar, K., Alam, M.M., Roychowdhury, R., and Fujita, M., 2013. Physiological, biochemical, and molecular mechanisms of heat stress tolerance in plants. International Journal of Molecular Sciences,14: Pp. 9643-9684.

Hu, F., Kong, C., 2002. Allelopathy of Ageratum conyzoides. VI. Effects of meteorological conditions on allelopathy of Ageratum conyzoides. Ying Yong Sheng Tai Xue Bao., 13(1): Pp. 76-80.

Inayat, N., 2020b. Phytochemical screening and allelopathic evaluation of aqueous and methanolic leaf extracts of Populus nigra L. Pure and Applied Biology, 9(1). https://doi.org /10.19045/bspab.2020.90100

Jefferson, L.V., and Pennacchio, M., 2003. Allelopathic effects of foliage extracts from four Chenopodiaceae species on seed germination. Journal of Arid Environments, 55(2), Pp.275-285.

Kaur, A., Kaur, S., Singh, H.P., Datta, A., Chauhan, B.S.,2023. Ullah H, Kohli RK, Batish DR. Ecology, Biology, Environmental Impacts, and Management of an Agro-Environmental Weed Ageratum conyzoides. *Plants.,* 12(12): Pp. 2329. https:// doi.org /10.3390/plants12122329

Khamare, Y., Chen, J., Marble, C., 2022. Allelopathy and its application as a weed management tool: A review. Frontiers in Plant Science, 13. https://doi.org/10.3389/fpls.2022.103 4649

Khedhri, S., Khammassi, M., Amri, I., Mabrouk, Y., Hanana, M., Gargouri, S., and Hamrouni, L., 2023. Allopathic potential of essential oil extracts on weeds germination and seedlings growth in sustainable agriculture: the phytochemical study of Tunisia's two Melaleuca species. Vegetos, Pp.1-8.

Lago-Olveira, S., Ouhemi, H., Idrissi, O., Moreira, M. T., González-García, S., 2024. Promoting more sustainable agriculture in the Moroccan drylands by shifting from conventional wheat monoculture to a rotation with chickpea and lentils. Cleaner Environmental Systems,100169. https://doi.org/10.1016/j.cesys.2024.100169

Lalbiakdika, L.F., and Lalruatsanga, H., 2022. Allelopathic effect of common weeds on germination and seedling growth of rice in wetland paddy fields of Mizoram, India. Plant Soil Environ, 68, Pp.393-400.

Macías, F.A., Mejías, F.J., and Molinillo, J.M., 2019. Recent advances in allelopathy for weed control: From knowledge to applications. Pest management science, 75(9): Pp. 2413-2436.

Maharjan, S., Shrestha, B.B., and Jha, P.K., 2007. Allelopathic effects of aqueous extract of leaves of Parthenium hysterophorus L. on seed germination and seedling growth of some cultivated and wild herbaceous species. Scientific world, 5(5), Pp.33-39.

Möhler, H., Diekötter, T., Herrmann, J.D., and Donath, T.W., 2018. Allelopathic vs. autotoxic potential of a grassland weed—evidence from a seed germination experiment. Plant Ecology and Diversity, 11(4), Pp.539-549.

Motmainna, M., Juraimi, A.S., Ahmad-Hamdani, M.S., Hasan, M., Yeasmin, S., Anwar, M.P.2023., Islam AKMM. Allelopathic Potential of Tropical Plants—A Review. *Agronomy.* 13(8):2063. https://doi.org/10.3390/agronomy13082063

Ofosu, R., Agyemang, E.D., Márton, A., Pásztor, G., Taller, J,, and Kazinczi G., 2023. Herbicide Resistance: Managing Weeds in a Changing World. Agronomy, 2023; 13(6): Pp. 1595.

plantations replacing natural broad leaved forests. Journal of Vegetation Science, 4: 25-28(1993).

Qasem, J.R., Foy, C.L., 2001. Weed allelopathy, its ecological impacts and future prospects:a review. Journal of Crop Production, 4(2): Pp. 43–119 (2001).

Rahaman, F., Juraimi, A. S., Rafii, M. Y., Uddin, K., Hassan, L., Chowdhury, A. K., Karim, S. M. R., Rini, B. Y., Oladosu, Y., Bashar, H. M. K., Hossain, A., 2022. Allelopathic potential in rice - a biochemical tool for plant defence against weeds. Frontiers in Plant Science, 13.

Shah, A.N., Iqbal, J., Ullah, A., Yang, G., Yousaf, M., Fahad, S., Tanveer, M., Hassan, W., Tung, S.A., Wang, L.,and Khan, A., 2016. Allelopathic potential of oil seed crops in production of crops: a review. Environmental Science and Pollution Research, 23, Pp.14854-14867.

Shrestha, J., Subedi, S., Timsina, K. P., Subedi, S., Pandey, M., Shrestha, A., Shrestha, S., &and Hossain, M. A., 2021. Sustainable Intensification in agriculture: An approach for making agriculture greener and productive. Journal of Nepal Agricultural Research Council, 7, Pp. 133–150.

Šoln, K., Horvat, M., Iskra, J., and Koce, J. D., 2022.. Inhibitory effects of methanol extracts from Fallopia japonica and F. × bohemica rhizomes and selected phenolic compounds on radish germination and root growth. Chemoecology, 32(4–5), Pp. 159–170.

Thapa, S., Chitale, V., Rijal, S.J., Bisht, N., Shrestha, B.B., 2018. Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya. PLoS ONE, 13(4): e0195752. https://doi.org/10.1371/journal.pone. 0195752

Van Oosten, M.J., Pepe, O., De Pascale, S., Silletti, S. and Maggio, A., 2017. The role of biostimulants and bioeffectors as alleviators of abiotic stress in crop plants. Chemical and Biological TechnoloTanprasit, P., 2005. Biological control of dengue fever mosquitoes (Aedes aegypti Linn.) Using leaf extracts of chan (Hyptis suaveolens (L.) Poit.) And hedge flower (Lantana camara Linn.) (Doctoral dissertation), 4, Pp.1-12.

Wardani, D. K., Darmanti, S., and Budihastuti, R., 2018. Allelochemical effect of Ageratum conyzoidesL. leaf extract on Soybean, Glycine max (L.) Merr. cv Grobogan, growth. Journal of Physics: Conference Series, 1025, 012044.

Weisberger, D., Ray, M.A., Basinger, N.T., and Thompson, J.J., 2024. Chemical, ecological, other? Identifying weed management typologies within industrialized cropping systems in Georgia (US). Agriculture and Human Values, Pp.1-19.

Weston, L.A., Alsaadawi, I.S., and Baerson, S.R., 2013. Sorghum allelopathy—from ecosystem to molecule. Journal of chemical ecology, 39, Pp.142-153.

Yarnia, M., Bolouri, P., and Sahin, F., 2024. Effects of Bermuda grass and Alfalfa extracts on callus induction of Rye embryo. Allelopathy Journal, 61(1), Pp.17-30. P

Zohaib, A., Abbas, T., Tabassum, T., 2016. Weeds cause losses in field crops through allelopathy. Notulae Scientia Biologicae, 8(1), Pp.47-56.