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Comparative Allelopathic Effects of Aqueous Leaf Extracts of Selected Plants on Seed Germination and Seedling Growth of *Triticum aestivum* L.

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Abstract

Allelopathy is a biological phenomenon in which plants release chemicals that affect the germination and growth of nearby plants. This study was conducted to evaluate the allelopathic effects of aqueous leaf extracts of *Parthenium hysterophorus, Lantana camara, Ageratum conyzoides,* and *Azadirachta indica* on seed germination and early seedling growth of *Triticum aestivum* (wheat). Leaf samples were shade-dried, powdered, and used to prepare extracts of 5%, 10%, and 15% concentrations. The experiment was carried out under controlled laboratory conditions using a completely randomized design with proper control and replications.

In this study, parameters such as germination percentage, root growth, shoot growth, and seedling vigour index were evaluated. The results showed that all plant extracts had inhibitory effects, which increased with higher concentrations. Among them, *Ageratum conyzoides* exhibited the strongest inhibition on both root and shoot growth, followed by *Lantana camara. Parthenium hysterophorus* showed a moderate inhibitory effect, while *Azadirachta indica* showed no significant effect, indicating minimal allelopathic influence.

Overall, the study demonstrates that allelopathic plants can negatively affect crop establishment and productivity. Therefore, proper management of these plants is necessary to improve crop growth and yield.

Keywords: Allelopathy, seed germination, seedling growth, inhibitory effects

Introduction

Allelopathy is a natural biological phenomenon in which plants influence the growth and development of other plants through the release of chemical substances known as allelochemicals (Rice, 1984). These compounds are released into the surrounding environment through various pathways such as leaching from leaves, root exudation, volatilization and decomposition of plant residues (Inderjit & Duke, 2003). Depending on their concentration and chemical nature, allelochemicals may exhibit either stimulatory or inhibitory effects on neighboring plants; however, in most agricultural conditions, their effects are predominantly inhibitory.

In recent years, allelopathy has received considerable attention in agricultural and ecological research due to its significant role in plant–plant interactions and weed management (Einhellig, 1995). Many plant species, especially weeds, produce secondary metabolites that can interfere with seed germination, root elongation, nutrient uptake and overall plant growth of crops (Weston & Duke, 2003). These interactions often result in poor crop establishment and reduced yield, making it important to study allelopathic effects for sustainable agriculture.

Several invasive and problematic weed species are well known for their strong allelopathic potential. Among them, *Parthenium hysterophorus* is considered one of the most aggressive weeds due to its rapid spread and production of toxic compounds that inhibit the growth of nearby plants (Batish et al., 2002). Similarly, *Lantana camara* has been reported to suppress the growth of surrounding vegetation through the release of allelochemicals, thereby reducing biodiversity and crop productivity (Sharma et al., 2005). *Ageratum conyzoides* is another weed species commonly found in agricultural fields and is known to exhibit allelopathic effects that negatively impact crop growth (Kohli et al., 2006).

On the other hand, *Azadirachta indica* (neem) is a multipurpose medicinal plant widely recognized for its antimicrobial, pesticidal and therapeutic properties (Biswas et al., 2002). Although neem contains various bioactive compounds, its allelopathic effects are generally less severe compared to highly invasive weeds like *Parthenium hysterophorus*. Therefore, comparing these plant species provides valuable insights into differences in allelopathic intensity and their potential impact on crops.

Wheat (*Triticum aestivum L.)* is one of the most important cereal crops globally and plays a vital role in ensuring food security, especially in countries like India (FAO, 2020). The germination and early seedling growth stages are critical for the successful establishment of wheat crops. However, these stages are highly sensitive to environmental stresses, including the presence of allelopathic substances in the soil. Even minor inhibitory effects during germination can lead to poor plant establishment and ultimately affect crop yield.

Aqueous leaf extract method is widely used in allelopathic studies to evaluate the effect of plant-derived chemicals under controlled laboratory conditions (Singh et al., 2009). By using different concentrations of extracts, it is possible to assess the dose-dependent impact of allelochemicals on seed germination and seedling growth. This method provides a clear understanding of how plant residues or weed infestation may influence crop performance in natural conditions.

The present study is therefore aimed at evaluating the comparative allelopathic effects of aqueous leaf extracts of selected plant species, namely *Parthenium hysterophorus, Lantana camara, Ageratum conyzoides and Azadirachta indica,* on the seed germination and seedling growth of *Triticum aestivum L.* The study focuses on key growth parameters such as germination percentage, root length, shoot length and seedling vigour index under different concentrations of leaf extracts.

The outcomes of this study will contribute to a better understanding of allelopathic interactions and their impact on crop growth. It will also help in developing effective weed management strategies and promoting sustainable agricultural practices.

Materials and Methods

a) Collection of Plant Material

Fresh and healthy leaves of *Parthenium hysterophorus, Lantana camara, Ageratum conyzoides, and Azadirachta indica* were collected from nearby areas. The collected leaves were thoroughly washed with tap water, followed by distilled water to remove dust and impurities. After washing, the leaves were shade-dried at room temperature for several days until they became completely dry. The dried leaves were then ground into fine powder using a grinder and stored in airtight containers for further use.

b) Preparation of Aqueous Leaf Extracts

The powdered leaf material of each plant was used to prepare aqueous extracts. A known quantity of leaf powder was mixed with distilled water to obtain different concentrations of extract (5%, 10%, and 15%). The mixtures were kept for 24 hours at room temperature to allow proper extraction of bioactive compounds. After that, the solutions were filtered using muslin cloth followed by filter paper to obtain clear extracts. These extracts were used fresh for the experiment.

c)Seed Material

Healthy and uniform seeds of *Triticum aestivum L.* (wheat) were selected for the experiment. The seeds were surface sterilized using a mild disinfectant solution (such as 0.1% mercuric chloride or distilled water wash) to prevent fungal contamination. After sterilization, the seeds were rinsed thoroughly with distilled water.

d) Experimental Design

Healthy and uniform wheat seeds were selected and divided into different treatment groups along with a control group. Aqueous leaf extracts of *Parthenium hysterophorus, Lantana camara, Ageratum conyzoides* and *Azadirachta indica* were prepared in different concentrations (5%, 10%and 15%), and each concentration was applied separately to assess its effect.

For each treatment, a fixed number of sterilized seeds were placed in Petri dishes lined with moist filter paper. Distilled water was used in the control set, while different concentrations (5%,10% and 15%) of plant extracts were used in the treatment sets. Each treatment was replicated three times to ensure the accuracy and reliability of the results. The Petri dishes were maintained at room temperature under suitable moisture conditions, and observations were recorded after a fixed period of incubation.

Data Collection and Analysis

a) Germination Percentage

Germination percentage is an important parameter used to evaluate the viability and performance of seeds under different treatment conditions. It indicates the proportion of seeds that successfully germinate in a given sample and reflects the overall effect of allelopathic substances on seed viability.

In the present study, germination was recorded when the radicle (root tip) emerged from the seed coat. The total number of germinated seeds in each treatment was counted after the incubation period, and the germination percentage was calculated using the following formula:

Germination (%) = (Number of seeds germinated / Total number of seeds) × 100

b) Measurement of Root and Shoot Length

The growth of seedlings was evaluated by measuring root length and shoot length of germinated seeds. The measurements were taken in centimetres, and the average values were calculated for each treatment group. These parameters indicated the effect of allelopathic extracts on seedling development.

c)Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) was applied to determine the statistical significance of differences among control and treatment groups. The test was performed at a 5% level of significance ($p \leq 0.05$). ANOVA helped in identifying whether the observed differences in germination percentage, root length and shoot length were significant or due to random variation.

Results

a) Germination Percentage

The effect of different concentrations of aqueous leaf extracts on the germination percentage of *Triticum aestivum L.* is presented in the table below. The control treatment showed a germination percentage of 73%, indicating the normal germination capacity of seeds under standard conditions.

Table.1: Germination Percentage

Different dosages of solution (treatments)					
Different Concentration	**Control**	***Parthenium hysterophorus***	***Lantana camara***	***Ageratum conyzoides***	***Azadirachta indica***
5%	73%	93%	90%	86%	76%
10%		83%	86%	96%	96%
15%		80%	96%	93%	83%

Effects of Aqueous Leaf Extracts of Selected Plants on Seed Germination

Parthenium hysterophorus showed a clear inhibitory effect on wheat, as germination decreased with increasing extract concentration (93% at 5%, 83% at 10%, and 80% at 15%), along with reduced root and shoot growth. In contrast, *Lantana camara* did not show a consistent pattern, with germination decreasing from 90% at 5% to 86% at 10%, and then increasing to 96% at 15%. Similarly, *Ageratum conyzoides* showed variable results, with germination rising from 86% at 5% to 96% at 10%, followed by a slight decrease to 93% at 15%. *Azadirachta indica* (Neem) also showed an inconsistent trend, with germination increasing from 76% at 5% to 96% at 10%, and then decreasing to 83% at 15%.

Overall, the results indicate that allelopathic effects on seed germination vary among plant species, and no uniform pattern is observed across all extracts.

b) Root length

The statistical analysis of radicle length under different weed treatments showed that *Ageratum conyzoides* (27.8119*) exhibited the strongest inhibitory effect on root length. *Lantana camara* (10.2804*) also showed a strong inhibitory effect, but it was lower compared to *Ageratum conyzoides*. *Parthenium hysterophorus*

had a moderate effect on root length. In contrast, *Azadirachta indica* showed a less significant and mild effect on root growth.

Table.1: ANOVA

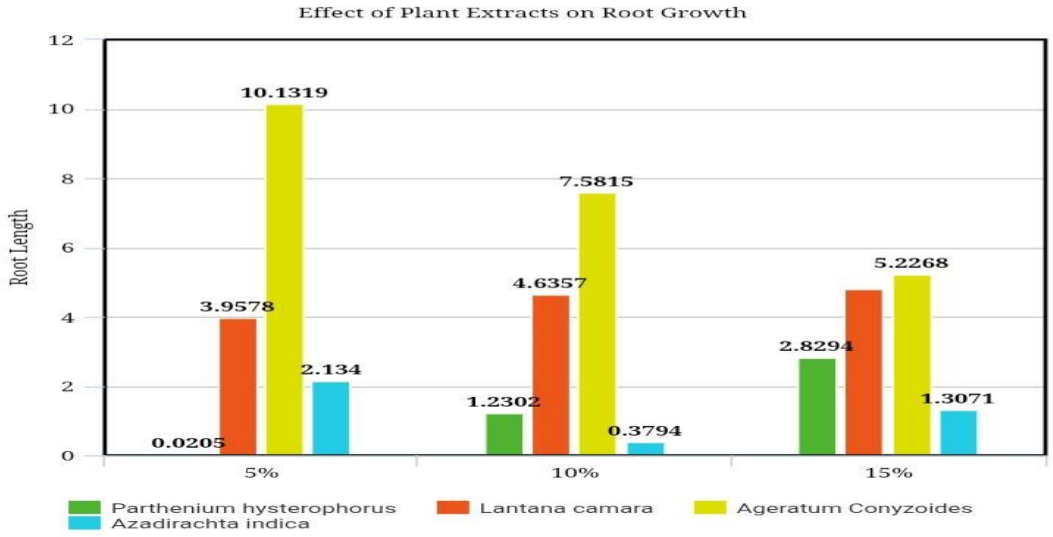
Weeds	Radical
Parthenium hysterophorus	4.2227*
Lantana camara	10.2804*
Ageratum Conyzoides	27.8119*
Azadirachta indica	2.1817

'*': Significant difference between control and weeds (5% level of significance)

Table.1: Paired T-test

Weeds	Radical		
Concentrations	5%	10%	15%
Parthenium hysterophorus	0.0205	1.2302	2.8294*
Lantana camara	3.9578*	4.6357*	4.8084*
Ageratum Conyzoides	10.1319*	7.5815*	5.2268*
Azadirachta indica	2.1340*	0.3794	1.3071

'*': Significant difference between control and weeds (5% level of significance)



Ageratum conyzoides showed a strong and statistically significant inhibitory effect on root growth at all concentrations (5%, 10%, and 15%), with values of 10.1319*, 7.5815*, and 5.2268*, respectively. This indicates its strong allelopathic potential. In the case of *Lantana camara,* all concentrations (5%, 10%, and 15%) also showed significant inhibitory effects, with values of 3.9578*, 4.6357*, and 4.8084*. *Parthenium hysterophorus* did not show significant effects at all concentrations; only the 15% concentration showed a significant inhibitory effect with a value of 2.8294*. This suggests that only higher concentrations of

Parthenium hysterophorus exhibit allelopathic effects. *Azadirachta indica* showed a significant effect only at the 5% concentration, with a value of 2.1340*. The effects at higher concentrations were not statistically significant, indicating a weak and inconsistent allelopathic influence.

c) Shoot length

The statistical analysis of shoot length under different weed treatments revealed that *Ageratum conyzoides* (20.4047*) exhibited the strongest inhibitory effect on shoot length. *Lantana camara* (8.9721*) also showed a strong inhibitory effect, but it was lower compared to *Ageratum conyzoides*. *Parthenium hysterophorus* (4.5597*) showed a moderate effect on shoot length. In contrast, *Azadirachta indica* (1.3964) showed a non-significant effect, suggesting a comparatively weak or negligible influence on shoot growth.

Table.1: ANOVA

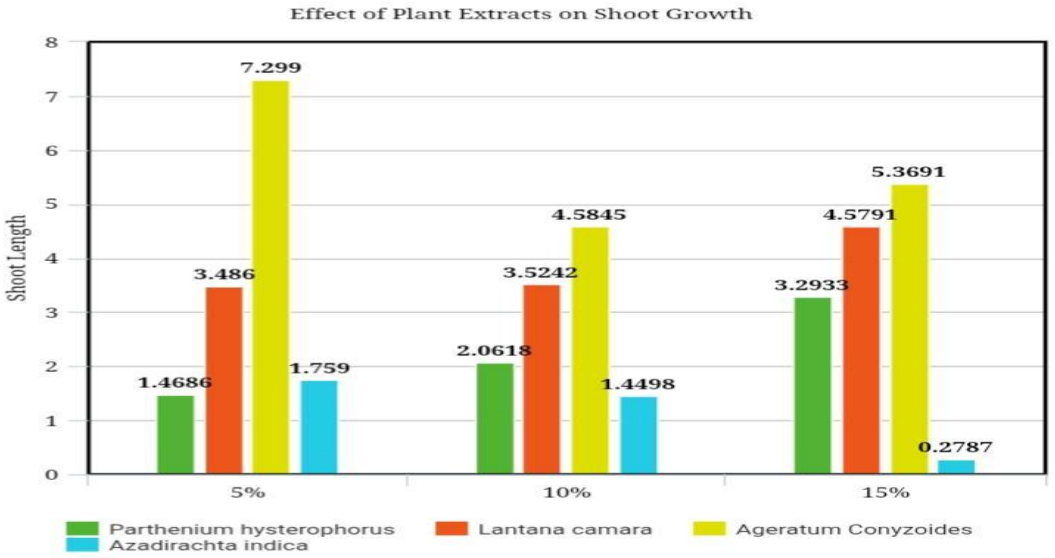
Weeds	Coleoptile
Parthenium hysterophorus	4.5597*
Lantana camara	8.9721*
Ageratum Conyzoides	20.4047*
Azadirachta indica	1.3964

'*': Significant difference between control and weeds (5% level of significance)

Table.2: Paired T-test

Weeds	Coleoptile		
Concentrations	**5%**	**10%**	**15%**
Parthenium hysterophorus	1.4686	2.0618*	3.2933*
Lantana camara	3.4860*	3.5242*	4.5791*
Ageratum Conyzoides	7.2990*	4.5845*	5.3691*
Azadirachta indica	1.7590	1.4498	0.2787

'*': Significant difference between control and weeds (5% level of significance)



Ageratum conyzoides showed a strong and statistically significant inhibitory effect on shoot growth at all concentrations (5%, 10%, and 15%), with values of 7.2990*, 4.5845*, and 5.3691*, respectively. This indicates its strong allelopathic potential on shoot growth. In the case of *Lantana camara*, all concentrations (5%, 10%, and 15%) also showed significant inhibitory effects, with values of 3.4860*, 3.5242*, and 4.5791*, respectively.

Parthenium hysterophorus did not show a significant effect at 5% concentration, whereas the 10% and 15% concentrations showed significant inhibitory effects with values of 2.0618* and 3.2933*, respectively. This suggests that higher concentrations of *Parthenium hysterophorus* exhibit allelopathic effects. *Azadirachta indica* did not show any significant effect on shoot length at any concentration, indicating that its effect on coleoptile growth is minimal and not statistically significant.

Discussion

This study indicates that aqueous leaf extracts prepared from selected weeds have varying effects on seed germination and seedling growth of wheat. As the concentration of the extracts increases, their effects also change and generally become more pronounced. Among all the tested plants, *Ageratum conyzoides* showed the strongest inhibitory effect on seedling growth. This suggests that allelochemicals present in these plants affect important physiological processes such as enzyme activity, water uptake, and cell division.

Lantana camara and *Parthenium hysterophorus* also showed inhibitory effects, but their impact was less than that of *Ageratum conyzoides*. However, at higher concentrations, they can also exhibit strong inhibitory effects. In contrast, *Azadirachta indica* showed a very weak effect on wheat. Although neem contains several bioactive compounds, its allelopathic impact appears to be less severe, possibly due to lower toxicity or slower release of active substances. This indicates that not all allelopathic plants have equally harmful effects on crop growth. Another important observation is that allelochemicals have a stronger inhibitory effect on root growth than on shoot growth. This is because roots remain in direct contact with the treated medium, which limits water and nutrient uptake, thereby affecting overall growth.

The results of this study are consistent with previous research, which has shown that allelopathic plants, especially invasive weeds, can significantly suppress crop germination and growth. Such interactions may lead to poor crop establishment and reduced agricultural productivity if not properly managed. Therefore, the presence of allelopathic plants such as *Parthenium hysterophorus, Lantana camara,* and *Ageratum*

conyzoides in agricultural fields should be carefully controlled. Understanding these interactions can help in developing effective weed management strategies and improving crop yield in a sustainable manner.

Conclusion

The present study concludes that aqueous leaf extracts of selected plant species exhibit significant allelopathic effects on the seed germination and seedling growth of *Triticum aestivum*. All extracts showed inhibitory effects, which increased with higher concentrations. Among the tested species, *Ageratum conyzoides* showed the strongest inhibitory effect on germination, root length, shoot length, and seedling vigour index, indicating high allelopathic potential. *Lantana camara* and *Parthenium hysterophorus* exhibited moderate effects, while *Azadirachta indica* showed a comparatively mild impact.

The study also revealed that root growth was more sensitive than shoot growth, which may affect overall plant development. These findings suggest that allelopathic weeds, especially invasive species, can negatively influence crop establishment and productivity. Therefore, proper management of such plants is essential for better crop growth and yield.

This study provides a foundation for future research in allelopathy. Further studies can focus on identifying specific allelochemicals, testing their effects under field conditions, and understanding their physiological and biochemical mechanisms. There is also potential to use such plants as eco-friendly herbicides for sustainable weed management.

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