

Research Article

Allelopathic Effect of *Chromolaena odorata* (L.) R. M. King & H. Rob. on Neighboring Crop Plants

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Abstract

The highly invasive weed *Chromolaena odorata* (L.) R. M. King & H. Rob. is well known for its strong allelopathic and competitive effects in agricultural ecosystems. The current study investigated the negative impact on the growth of three economically important crops—rice (*Oryza sativa* L.), moong dal (*Vigna radiata* L.), and sunflower (*Helianthus annuus* L.)—when grown in proximity to weeds. Laboratory experiments compared crop growth with and without *C. odorata*. The results revealed significant suppression of crop growth due to the weed's antagonistic effects. Among the crops, moong dal was most sensitive, with a 80% decrease in growth, followed by rice, which experienced a 72% reduction. In sunflowers, reproductive development was especially affected, with an 60% decrease in head size compared to control plants. These inhibitory effects are likely caused by allelopathic compounds released by *C. odorata* through root exudates and decomposing residues. These chemicals may interfere with normal physiological and developmental processes in neighboring crops. Overall, the findings highlight the ecological dominance of *C. odorata* and its potential to reduce crop yields in agricultural systems. Understanding these crop–weed interactions is crucial for developing effective weed management strategies to minimize yield losses and promote sustainable farming practices.

Keywords

Chromolaena Odorata, Allelopathy, Crop-weed Interaction, Growth Inhibition

1. Introduction

Allelopathy is a biological phenomenon where plants may interfere with the growth of their neighboring plants as well as microbes directly or indirectly through resource competition or chemical interaction [1]. Allelopathy is governed by one or more biochemicals that influence the germination, growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy)

effects on target organisms [2]. *Chromolaena odorata* (Siam weed) is a highly invasive plant mostly found in tropical and sub-tropical species of the Asteraceae family that dominates ecosystems through potent allelopathy, releasing phytochemicals (phenolics, alkaloids, terpenoids) from its leaves, roots, and decaying litter [3]. *C. odorata* shows morphological differences in terms of flower color, leaf shape, odor of the

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crushed leaves, and plant architecture in its native environment. The leaf of *C. odorata* contained ash (11%), crude fat (11%), fiber (15%), moisture (15%), crude protein (18%), and carbohydrate (31%). Its active phytochemical substances are as follows: flavonoid aglycones (flavanones, flavanols, flavones), including acacetin, chalcones, eupatilin, luteolin, naringenin, kaempferol, quercetin, quercetagenin, and sinensetin; terpenes and terpenoids, essential oils; alkaloids including pyrrolizidine; saponins and tannin; phenolic acids, including ferulic acid, protocatechuic acid; phytoprostane compound including chromomeric acid [4]. Currently, researchers are exploring plant extracts as potential antibacterial agents against human-pathogenic microbes, particularly to address antibacterial resistance [5]. The present work aims to study the allelopathic effects of *Chromolaena odorata* leaf litter on seed germination and seedling growth of rice (*Oryza sativa* L.), moong dal (*Vigna radiata* L.), and sunflower (*Helianthus annuus* L.) when grown in proximity to weed cultivars widely cultivated across various parts of India.

2. Materials and Methods

2.1. Collection of Plant Materials

Fresh and healthy plant aerial parts of *Chromolaena odorata* (L.) R. M. King & H. Rob. were collected from naturally growing populations in Rayagada district, Odisha, India. The plant was identified using standard floras, and the identification was confirmed by a plant taxonomist at Berhampur University, Berhampur. A voucher specimen (Voucher No.: 03/26) was preserved at the university for future reference.

2.2. Preparation of Aqueous Extracts

Collected plant materials were thoroughly washed under running tap water, followed by distilled water to remove dust and debris. The samples were air-dried at room temperature ($25 \pm 2^\circ\text{C}$) for 10–14 days and then ground into a fine powder using an electric grinder. Aqueous extracts were prepared by soaking 10 g of powdered plant material in 100 mL of distilled water (10% w/v) for 24 hours at room temperature with intermittent shaking. The mixture was then filtered through muslin cloth, then through Whatman No. 1 filter paper [6]. The filtrate was considered the stock solution (100%) and further diluted with distilled water to prepare different concentrations (e.g., 25%, 50%, 75%, and 100%).

2.3. Test Crop Selection

The study selected three economically important crops: rice (*Oryza sativa* L.), green gram (*Vigna radiata* L.), and sunflower (*Helianthus annuus* L.). Healthy, uniform seeds for each crop were obtained from a certified agricultural seed supplier.

2.4. Experimental Design

Seeds were surface-sterilized using a 0.1% mercuric chloride (HgCl_2) solution for 2–3 minutes, then thoroughly washed 3–5 times with sterile distilled water to remove any remaining sterilant. The experiment employed a Completely Randomized Design (CRD) with three replicates for each treatment. Treatments included a control (distilled water) and extracts at 25%, 50%, 75%, and 100%. Sterile 9 cm diameter Petri dishes were lined with Whatman No. 1 filter paper. Ten sterilized seeds from each crop were evenly spaced in each dish. Each dish was treated with 5 mL of the respective extract, while control dishes received distilled water. The dishes were incubated in a growth chamber at $25 \pm 2^\circ\text{C}$ with a 12-hour photoperiod. Observations were recorded daily over 7 days. Seeds were considered germinated when the radicle reached at least 2 mm in length.

2.5. Measurement of Growth Parameters

To evaluate the allelopathic effects under semi-natural conditions, a pot experiment was conducted. Sterilized soil was placed in plastic pots (20 cm in diameter), and seeds were evenly sown at a consistent depth. Plants were irrigated with specific extract concentrations at regular intervals (every 2 days), while control plants received distilled water. Growth parameters such as plant height, root length, leaf area, and head size of sunflower were measured at 7 and 14 days.

2.6. Statistical Analysis

All experimental data were expressed as mean $\pm$ standard error of mean (SEM) of three replicates.

3. Results

The effects of different concentrations of *Chromolaena odorata* leaf leachate on seedling growth of *Vigna radiata* L. revealed a clear concentration-dependent inhibitory trend. Germination percentage gradually decreased as leachate concentration increased, with the control showing the highest germination. Root and shoot growth were significantly suppressed, with roots being more sensitive than shoots [7]. Table 1 illustrates the effects of various concentrations of *Chromolaena odorata* leaf leachate on the seedling growth of moong dal (*Vigna radiata* L.). At higher concentrations, root elongation was severely restricted, indicating direct exposure of root tissues to allelochemicals. The fresh and dry biomass of seedlings also declined as leachate levels increased, reflecting reduced metabolic activity and impaired nutrient uptake [8]. The inhibitory effects may result from phytochemicals in *C. odorata*, such as phenolics and flavonoids, which disrupt enzymatic processes and hormonal balance. These findings confirm the strong allelopathic potential of *C. odorata*, suggesting its negative impact on crop establishment and emphasizing the

importance of effective weed management in agricultural systems.

Table 1. Effects of different concentrations of leaf leachate of *Chromolaena odorata* on seedling growth of moong dal (*Vigna radiata* L.). The values are the average of 3 replicates $\pm$ SEM.

Leachate Concentration	Length of the stem (in cm)		Length of the Root (in cm)		Area of leaf (in cm ²)	
	7DAT	14DAT	7 DAT	14DAT	7 DAT	14DAT
Control	8.4 $\pm$ 1.2	21.2 $\pm$ 1.2	5.2 $\pm$ 1.2	11.9 $\pm$ 1.2	60.2 $\pm$ 1.2	82.5 $\pm$ 1.2
25	6.7 $\pm$ 1	17 $\pm$ 1	4.2 $\pm$ 1	9.5 $\pm$ 1	48.2 $\pm$ 1	66.0 $\pm$ 1
50	5.4 $\pm$ 0.8	13.6 $\pm$ 0.8	3.4 $\pm$ 0.8	7.6 $\pm$ 0.8	39.0 $\pm$ 0.8	52.8 $\pm$ 0.8
75	4.32 $\pm$ 0.6	10.9 $\pm$ 0.6	2.7 $\pm$ 0.6	6.1 $\pm$ 0.6	31.2 $\pm$ 0.6	42.2 $\pm$ 0.6
100	3.4 $\pm$ 0.5	8.7 $\pm$ 0.5	2.1 $\pm$ 0.5	4.9 $\pm$ 0.5	25 $\pm$ 0.5	34.0 $\pm$ 0.5

*DAT: Days after treatment

Applying leaf leachate from *Chromolaena odorata* significantly impacted rice (*Oryza sativa*) seedling growth at both 7 and 14 days after treatment (Table 2). A concentration-dependent inhibition was evident, with higher leachate levels markedly reducing root length, shoot length, and overall biomass. The greatest inhibition was 72% relative to the control, demonstrating the weed's strong allelopathic potential. The effect was more pronounced at 14 days, indicating cumulative phytotoxicity over time. This reduction in growth is likely due

to allelochemicals, such as phenolics and flavonoids, released by *C. odorata* that interfere with cellular functions, including nutrient uptake, cell division, and enzyme activity [9]. These findings support previous research on allelopathic effects of invasive species. The study underscores the ecological threat posed by *C. odorata* in agroecosystems and highlights the need for effective management strategies to mitigate its adverse effects on crop productivity.

Table 2. Effects of different concentrations of leaf leachate of *Chromolaena odorata* on seedling growth of rice (*Oryza sativa* L.). The values are the average of 3 replicates $\pm$ SEM.

Leachate Concentration	Length of the stem (in cm)		Length of the Root (in cm)		Area of leaf (in cm ²)	
	7DAT	14DAT	7 DAT	14DAT	7 DAT	14DAT
Control	8.4 $\pm$ 1.2	21.2 $\pm$ 1.2	5.2 $\pm$ 1.2	11.9 $\pm$ 1.2	30.2 $\pm$ 1.2	45.6 $\pm$ 1.2
25	6 $\pm$ 1	15.2 $\pm$ 1	3.7 $\pm$ 1	8.6 $\pm$ 1	21.7 $\pm$ 1	32.9 $\pm$ 1
50	4.3 $\pm$ 0.9	11 $\pm$ 0.9	2.7 $\pm$ 0.9	6.2 $\pm$ 0.9	15.6 $\pm$ 0.9	15.6 $\pm$ 0.9
75	3.1 $\pm$ 0.8	7.9 $\pm$ 0.8	1.9 $\pm$ 0.8	4.5 $\pm$ 0.8	11.2 $\pm$ 0.8	11.2 $\pm$ 0.8
100	2.2 $\pm$ 0.6	5.7 $\pm$ 0.6	1.4 $\pm$ 0.6	3.2 $\pm$ 0.6	8.1 $\pm$ 0.6	12.3 $\pm$ 0.6

*DAT: Days after treatment

The seedling growth of sunflower (*Helianthus annuus*) was significantly affected by different concentrations of leaf leachate from *Chromolaena odorata*, as shown in Table 3. A clear concentration-dependent inhibitory trend was observed in growth parameters, including root length, shoot length, and seedling biomass. The maximum reduction in growth was 60%

relative to the control, indicating a strong phytotoxic effect of the leachate. The inhibitory effect increased with increasing concentration, reflecting the accumulation of allelochemicals in the growth medium [10]. The decrease in seedling growth may be due to bioactive compounds like phenolics, terpenoids,

and flavonoids released from *C. odorata*, which disrupt physiological and biochemical processes in sunflower seedlings [11]. These compounds are known to interfere with cell division, membrane permeability, and nutrient uptake. The findings suggest that *C. odorata* exerts significant allelopathic

pressure on sunflower, potentially affecting crop establishment and yield [12]. Therefore, proper management of this invasive species is crucial to lessen its negative effects on agricultural systems.

Table 3. Effects of different concentrations of leaf leachate of *Chromolaena odorata* on seedling growth of sunflower (*Helianthus annuus* L.). The values are the average of 3 replicates $\pm$ SEM.

Leachate Concentration	Length of the stem (in cm)		Length of the Root (in cm)		Area of leaf (in cm ²)	
	7 DAT	14 DAT	7 DAT	14 DAT	7 DAT	14 DAT
Control	8.4 $\pm$ 1.2	21.2 $\pm$ 1.2	5.2 $\pm$ 1.2	11.9 $\pm$ 1.2	30.2 $\pm$ 1.2	45.6 $\pm$ 1.2
25	6 $\pm$ 1	15.2 $\pm$ 1	3.7 $\pm$ 1	8.6 $\pm$ 1	21.7 $\pm$ 1	32.9 $\pm$ 1
50	4.3 $\pm$ 0.9	11 $\pm$ 0.9	2.7 $\pm$ 0.9	6.2 $\pm$ 0.9	15.6 $\pm$ 0.9	15.6 $\pm$ 0.9
75	3.1 $\pm$ 0.8	7.9 $\pm$ 0.8	1.9 $\pm$ 0.8	4.5 $\pm$ 0.8	11.2 $\pm$ 0.8	11.2 $\pm$ 0.8
100	2.2 $\pm$ 0.6	5.7 $\pm$ 0.6	1.4 $\pm$ 0.6	3.2 $\pm$ 0.6	8.1 $\pm$ 0.6	12.3 $\pm$ 0.6

*DAT: Days after treatment

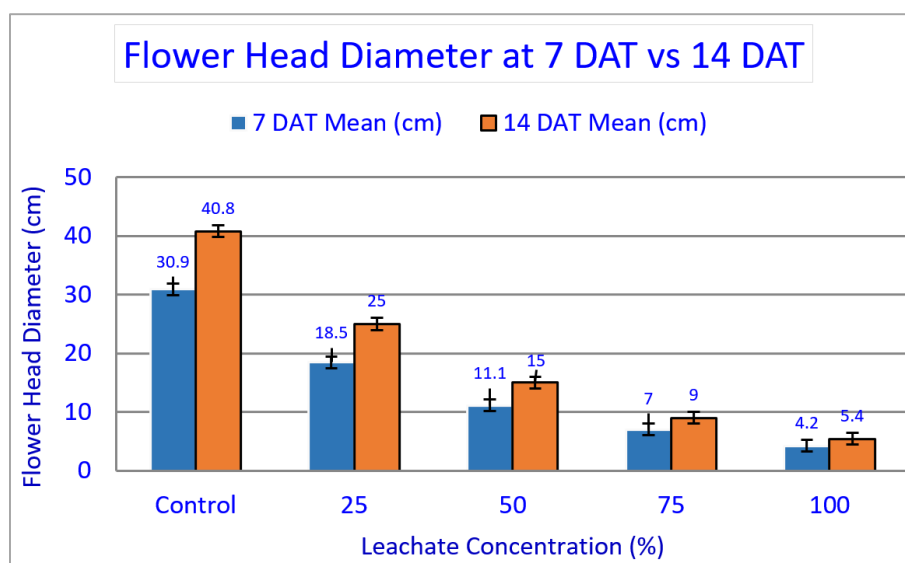


Figure 1. Sudan black B staining under microscope.

The effect of different concentrations of leaf leachate from *Chromolaena odorata* on the floral characteristics of sunflower (*Helianthus annuus*) is shown in Table 3. The values, given as mean $\pm$ SEM of three replicates, revealed a significant decline in flower head development with increasing leachate concentrations. Parameters such as flower head diameter, fresh weight, and overall floral biomass showed a consistent reduction compared to the control. The highest concentration had the most noticeable inhibitory effect, indicating that reproductive growth is highly sensitive to allelopathic

stress [13]. The decrease in flower head size and biomass suggests that allelochemicals released from *C. odorata* negatively affect not only vegetative growth but also reproductive development. These phytotoxic compounds, including phenolics and terpenoids, may disrupt hormonal regulation, especially auxins and gibberellins, which are essential for floral initiation and development [14]. Additionally, impaired nutrient uptake and decreased photosynthetic efficiency could limit the supply of resources for flower formation.

4. Conclusions

This study highlights the strong allelopathic effects of *Chromolaena odorata* on the growth and development of important crop species, including rice (*Oryza sativa*), moong dal (*Vigna radiata*), and sunflower (*Helianthus annuus*). The results consistently show that leaf leachates of *C. odorata* have a concentration-dependent inhibitory effect on seed germination, seedling Vigor, and reproductive traits. Growth parameters such as root length, shoot length, and biomass were significantly reduced, with inhibition levels reaching 18–20% at higher concentrations. Additionally, reproductive traits such as flower head diameter and biomass in sunflowers were negatively affected, indicating that allelopathic stress affects both vegetative growth and reproductive performance. The phytotoxicity observed in this study is caused by allelochemicals, including phenolic compounds, flavonoids, and terpenoids, released by *C. odorata*. These bioactive substances are known to disrupt vital physiological and biochemical processes, such as enzymatic activity, nutrient uptake, membrane integrity, and hormonal regulation. The increasing level of inhibition over time suggests that these compounds accumulate in the growth medium, intensifying their negative effects as exposure continues. This interference ultimately leads to decreased plant vigor and lower productivity. Therefore, *C. odorata* poses a serious ecological and agricultural threat due to its potent allelopathic effects and invasive nature. Its ability to suppress both early growth and reproductive success of neighboring crops highlights the need for timely and effective management strategies. Integrated approaches, including mechanical removal, biological control, and sustainable weed management practices, are essential to mitigate its impact. Addressing the spread and influence of this invasive species is crucial for protecting crop productivity, maintaining ecosystem balance, and ensuring long-term agricultural sustainability.

Abbreviations

DAT	Days After Treatment
CRD	Completely Randomized Design
SEM	Standard Error of Mean

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Author Contributions

Aishwarya Mohanty: Conceptualization, Resources
Manoja Das: Data curation, Methodology
Prasanna Kumar Gantayat: Formal Analysis, Investigation

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Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Aishwarya Mohanty is a dedicated Ph.D. researcher scholar in Botany at GIET University. Her work explores the allelopathic effects of *Chromolaena odorata* and its impact on plant growth and ecological interactions. During her doctoral research, she studies the plant's bioactive compounds and phytochemicals to evaluate their potential for use in agriculture and environmental management. Her research aims to contribute to sustainable weed control and to natural, plant based methods of growth regulation. Mrs. Mohanty is actively involved in both laboratory and field research, dedicated to advancing botanical science through innovative and impactful studies. Her academic focus and scientific approach highlight her strong interest in plant physiology, ecology, and applied biotechnology.



Manoj Das is a prominent academic and researcher, currently leading the Department of Biotechnology at Gandhi Institute of Engineering and Technology University, Odisha, Gunupur. With extensive experience in biotech research, teaching, and administration, he has made significant contributions to nanobiotechnology, microbial biotechnology, natural products, and plant biotechnology. His research primarily focuses on green nanoparticle synthesis, probiotics, phytochemical analysis, and the development of bio-functional materials for healthcare and agriculture. Dr. Das has published extensively in reputable national and international journals and mentors' students at all levels. He has led numerous projects funded by DBT, BIRAC, MSME, and AICTE.



Prasanna Kumar Gantayat, PhD, D.Sc, is a distinguished academician and educationist celebrated for his dedicated service to higher education in Odisha. He served as the Principal of Rayagada Autonomous College, where he contributed significantly to academic growth, institutional management, and student support. With decades of experience in teaching and educational leadership, Dr. Gantayat has been instrumental in enhancing the academic environment and fostering quality education in the region. Under his leadership, the college advanced in academics, infrastructure, and extracurricular activities. He is highly regarded by colleagues, students, and the academic community for his disciplined nature, visionary guidance, and unwavering commitment to education. Dr. Gantayat continues to motivate

young scholars and educators through his scholarly work and social engagement. He has authored numerous research articles in various journals and magazines. His lifelong dedication to education has earned him widespread recognition and respect within Odisha's academic circles.

Research Field

Aishwarya Mohanty: Microbiology, Plant physiology

Manoj Das: Plant Biotechnology, Microbiology, Plant physiology

Prasanna Kumar Gantayat: Microbiology, Biotechnology, Plant physiology