

RESEARCH ARTICLE

Allelopathic impact of *Chromolaena odorata* on the local crops in Mizoram, India

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ABSTRACT

Allelopathy is the major biological advantage of an invasive alien plant, often inhibitory to the germination and growth of other plants within their space. This study aimed to demonstrate the allelopathic effect of *Chromolaena odorata* extracts on seed germination and seedling growth of four commonly grown crops as test plants in Mizoram. *Chromolaena odorata* was observed as one of the dominant invasive alien plants in the natural forests of Mizoram with increased abundance and lower diversity in the invaded areas during frequent field visits. Petri plate and pot bioassay study revealed that the increasing concentrations (control, 2.5, 5, 7.5, 10 and 15 g per 100 ml) of aqueous extracts or leachates inhibited seed germination, root and shoot length, vigour index. Bioassay treatment of the test plants with a higher concentration of *C. odorata* extract exhibited a significant inhibition of germination and test plant growth. Preliminary phytochemical analysis exhibited the presence of Alkaloids, Tannins, Saponins, Terpenoids and Flavonoids. The inhibitory effects on seed germination confirmed the inhibitory allelopathic potential of *Chromolaena odorata* in cultivated lands of Mizoram which may be attributed to presence of the allelochemicals in the leaf and stem extracts of the IAPs

Keywords: Asteraceae; Indo-Burma biodiversity hotspot; Plant invasion; Shifting cultivation; Allelochemicals; Natural forests

1. Introduction

Invasive alien plants have caused significant environmental disbalance and economic setbacks

globally with a serious impact on the important cereal crops during the last centuries ^[1-3]. *Chromolaena odorata* (L.) R.M. King and H. Robinson, commonly known as the Siam weed,

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belonging to Asteraceae, is one such invasive alien plant listed among 100 worst invasives in the world ^[4,5]. However, the allelopathy exerted to favour proliferation potential of *C. odorata* to crops varies with particular geographical location ^[6] with increased invasion throughout Tropical and Sub-tropical areas.

Chromolaena odorata is a perennial shrub, growing to 2–3 m, sometimes scrambling up to 5–10 m. Ovate-triangular leaves are in opposite decussate phyllotaxy, usually sized at 6–14 cm × 4–7 cm and emit a characteristic odour when crushed. Capitula inflorescence remain in panicles terminally where a single capitulum contains 20–35 white to lilac-coloured florets ^[7]. Native range of *C. odorata* is northwestern Argentina to southern Florida covering the Caribbean islands ^[5].

In India, *C. odorata* was introduced as an ornamental plant in 1840s through the Calcutta and Srerampore Botanical Gardens ^[7-9]. The first record of naturalization of *C. odorata* was in the 1870s in Indo-Gangetic Plain. The species has since spread throughout Oceania, Africa and South East Asia due to anthropogenic activities, including tourism, transportation, land-use changes and international trade as well as natural phenomena like winds, surface runoff, animal movement and dispersal ^[10]. The probable cause of introduction of the invasive alien species to Mizoram may be attributed to escape from cultivation in Eastern India and subsequent spread in lower Burma and Assam along with the ship movement ^[4,7]. In Mizoram, it was probably introduced due to extensive movement of people, agriculture machinery, bulldozers and other heavy machinery during World War-II ^[7]. The earliest collection of this species in North–Eastern states of India is represented by a single herbarium specimen at ASSAM (Sibsagar, 3rd June 1913, *U. Kanjilal* 2035) while in Mizoram it was collected during 1927 from Lushai Hills [(Lushai Hills, Dec.1927, *N.E.Parry* 434 (CAL)] ^[7]. The species grow abundantly in open places between 1300–1700 m ^[9].

The species grows well at 18–37°C and well-drained soil, favouring open and sunny areas such as riverbanks, roadsides and fallow lands. In most cases, *C. odorata* outperform other native species for acquisition of nutrient and space resulting in

ecosystem deterioration and reduced quality as well as yields of crops. To achieve own habitat compatibility, *C. odorata* exert allelopathic properties on the neighbouring plants and support the production of allelochemicals ^[11]. However, the amount and composition of allelochemicals for *C. odorata* extracts varies with locality and soil composition and maturity stages ^[12]. Detrimental impact of *C. odorata* was reported from western Himalayan natural forests of India ^[13].

Our field observations revealed that communities dominated by *C. odorata* have reduced density of associated herbs or crops compared to adjacent natural uninvaded areas. Allelopathic effect of the aqueous extract of *C. odorata* was studied on *Zea mays* in Assam ^[14], *Mycrotyloma uniflorum* and *Vigna aconitifolia* in Maharashtra ^[15]. But little is known about phytotoxic impact of *C. odorata* or its residues to native plants or crops of Mizoram. Presence of *C. odorata* may influence growth of locally cultivated crops in Mizoram. Therefore, the present study was conducted to determine the allelopathic potential of *C. odorata* extracts on the seed germination and early seedling growth of the commonly grown crops in Mizoram.

2. Materials and methods

2.1. Study sites

The present study was conducted in Mizoram, a part of Indo-Burma biodiversity hotspot in India ^[7] (**Figure 1**) and carried out during July, 2018 to September, 2021 for floristic as well as ecological survey including protected areas. Only 6.75% of the geographical area of the state comes under protected area networks. Temperature range during the March–May (summer) stays around 18–29°C whereas during August–December (winter) low temperature range (11–24°C) persist. The rainfall profile exhibits annual rainfall of 2160 mm to 3500 mm. The experiments were conducted in laboratory and pot condition near Phawngpui national park (PNP, 50 km²) and Murlen national Park (MNP, 100 km²).

2.2. Collection of plant materials

Mature plant individuals of *Chromolaena odorata*

(L.) R.M. King and H. Rob. belonging to Asteraceae family was collected during their peak growth stage during July-September, 2018–2022 from the infested plots in two national parks i.e., PNP and MNP and their fringe villages in a random manner and used for allelopathic studies. The collected individual plant material was washed and shade dried followed by powdering with the help of mechanical grinder. The powdered plant materials were sieved and stored in plastic sterilized containers for further studies.

As per local perception, *Chromolaena odorata* grow near the cultivation fields of fringe villages and supposedly exert negative impact on growth of local crops. Four commonly cultivated crop species of the localities i.e., “*Cicer arietinum* (variety- IPC 97-67), *Lens culinaris* (variety- IC0635701), *Brassica nigra* (variety- IC 590587) and *Oryza sativa* (variety- CAUR1)” were chosen as test species after interviewing the local farmers. The seeds of four test crops were collected from Krishi Vigyan Kendra, Lawngtlai and Krishi Vigyan Kendra, Champhai in respective districts near the study areas.

2.3. Crop seed bioassay in laboratory and natural condition

Seeds of test crops were subjected to both laboratory

bioassay and pot assays in natural conditions. For the bioassay in laboratory condition, the test crop seeds were pre-soaked in individual treatment percentages namely 2.5, 5, 7.5, 10 and 15 g per 100 mL of *Chromolaena odorata* aqueous extracts. From each treatment, 20 soaked seeds were equidistantly placed in Whatman No. 1 filter paper beds in 15 cm diameter Tarson petri-dishes. The individual petri-dish for each concentration treatment was maintained with 10 mL aqueous extract of treatment percentage extract. Separately a control set was also maintained for Twenty uniform seeds in each petri dish soaked in water instead of the invasive alien plant (hereafter, IAP) extract. The petri dishes were covered to maintain the moisture preventing evaporation and kept in laboratory seed germinator maintaining the temperature at 25°C under 12h dark/light cycle and for each treatment as well as control set, three replicates were maintained simultaneously. The radicle length was measured accurately after 7 days of seed germination. To maintain uniformity among all the experimental setup, a crop seed was treated as germinated when its length of emergence attained 2 mm length. The experiment was replicated 10 times for each IAPs following completely randomized block design.

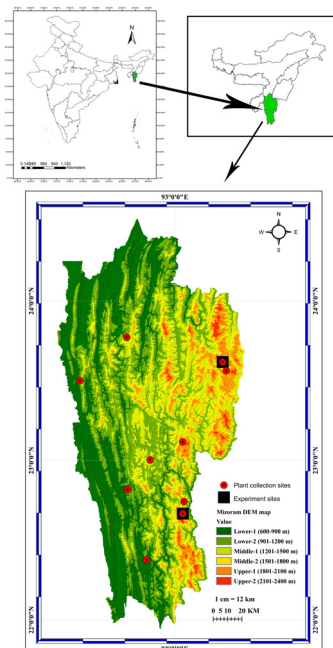


Figure 1. Map of Mizoram showing co-ordinates of plant collection and experimental sites.

Once the germination percentage experiments were done on petridish, further experiments were carried out in the natural conditions using the soil from the study area in pot condition at Sangau (fringe village of PNP) and Vapar (fringe village of MNP). The soil samples were collected locally from the shifting cultivated lands in Sangau and Vapar. To check the impact of the IAPs, twenty seeds of each selected crops were sown in a pot and subjected to treatment extracts of *Chromolaena odorata* in different percentages (2.5, 5, 7.5, 10 and 15 g per 100 ml). Five such replicates of twenty seeds in each pot were maintained in randomised manner and were moistened alternate day by using respective percentage extracts and tap water for control. The seedlings were allowed to grow for 25 days. The length of the seedlings was measured for both aboveground and belowground parts to understand allelopathic impact the selected IAPs on the crop species.

Important parameters like SVI (Seed vigour index), PTI (plant tolerance index) and Response index (allelopathic index) was measured for each crop plant. Germination percentage, seedling vigour index^[16], plant tolerance index^[17] and allelopathic response index^[18] were calculated as follows:

$$\text{Germination percentage (GP)} = \frac{\text{Final no. of seeds germinated}}{\text{Total no. of seeds incubated}} \times 100$$

$$\text{Seedling vigour index (SVI)} = \text{Germination percentage} \times \text{Radicle length}$$

$$\text{Allelopathic effect response index (RI)} = 1 - \frac{\text{Germination speed of control}}{\text{Germination speed of Treatment}}$$

$$\text{Plant tolerance index (PTI)} = \frac{\text{Radicle length of the treatment}}{\text{Radicle length of control}} \times 100$$

2.4. Phytochemical analysis

All the tests were performed by standard phytochemical methods for detection of various allelochemicals for their presence in *Chromolaena odorata*^[19,20].

2.5. Data analysis

All the resultant data were analysed using triplicate result tests. Test results were then calculated for univariate analysis of variance (ANOVA), trailed by Tukey's test ($P \leq 0.05$) utilising the statistical package for SIGMAPLOT 14.5 (Systat Software Inc., USA) and PAST v. 4.13 software^[21].

3. Results

3.1. Allelopathic effect of *Chromolaena odorata* on seed germination of local crops

Germination of the crop seeds were negatively correlated when treated with the increased concentration *Chromolaena odorata* extracts significantly reducing the germination capability of the crop plants. The *Chromolaena odorata* aqueous extract inhibited the growth rate (germination percentage, plumule and radicle length of the seedlings of the test crops.

Seeds of *Cicer arietinum* seeds were also significantly ($P < 0.05$) inhibited at 7.5% concentration of *Chromolaena odorata* extracts. Only ($53.50 \pm 0.43\%$) and ($26.76 \pm 0.50\%$) seeds of *Cicer arietinum* germinated at 7.5% and 10% concentration of *Chromolaena odorata* extracts, respectively. Complete inhibition was observed in response to 15% concentration of *Chromolaena odorata* extracts in comparison to control ($99.97 \pm 0.03\%$). Germination of *Lens culinaris* seeds were significantly ($P < 0.05$) inhibited at 7.5% – 10% concentrations of *Chromolaena odorata* extracts (Figure 2, Table 1).

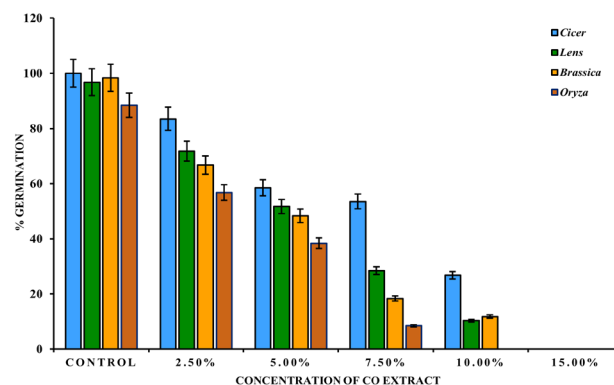


Figure 2. Impact of *Chromolaena odorata* on the germination of crop seeds.

Table 1. Allelopathic impact of *Chromolaena odorata* on germination of crop seeds.

Test Crops	Control	2.50%	5.00%	7.50%	10.00%	15.00%
<i>Cicer arietinum</i>	99.97±0.03 ^a	83.47±0.45 ^b	58.51±0.43 ^c	53.50±0.43 ^d	26.76±0.50 ^e	0
<i>Lens culinaris</i>	96.77±0.48	71.77±0.49	51.71±0.60	28.44±0.48	10.33±0.60	0
<i>Brassica nigra</i>	98.37±0.54 ^a	66.73±0.52 ^b	48.33±0.57 ^c	18.33±0.57 ^d	11.79±0.52 ^e	0
<i>Oryza sativa</i>	88.40±0.51 ^a	56.77±0.49 ^b	38.40±0.64 ^c	8.46±0.46 ^d	0	0

3.2. Allelopathic effect of *Chromolaena odorata* on plumule and radicle growth of the test crops

In *Cicer arietinum*, length of the plumule was recorded as 9.76 ± 0.16 cm, 7.86 ± 0.19 cm, 6.58 ± 0.15 and 4.43 ± 0.19 cm at the 2.5%, 5%, 7.5% and 10% concentration of aqueous extract of *Chromolaena odorata* respectively, as compared to the plumule length of 10.86 ± 0.07 cm in the control treatment (0%) (**Figure 3**). Similarly, for radicle length of *Cicer arietinum*, was 10.05 ± 0.11 cm, 8.16 ± 0.08 cm, 6.95 ± 0.10 cm and 4.65 ± 0.19 cm at the 2.5%, 5%, 7.5% and 10% concentration of aqueous extract of *Chromolaena odorata* respectively, as compared to the radicle length of 11.36 ± 0.24 cm in the control treatment (0%) (**Figure 3**).

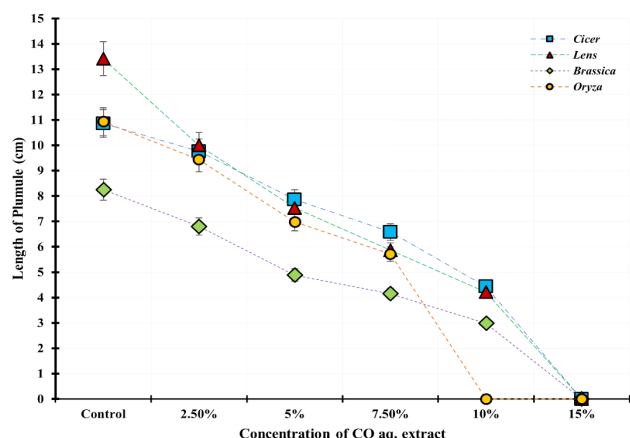


Figure 3. Allelopathic effect of *Chromolaena odorata* extract on plumule growth of test crops.

In *Lens culinaris*, recorded length of the plumule was 10 ± 0.3 cm, 7.53 ± 0.3 cm, 5.86 ± 0.24 cm and 4.21 ± 0.15 cm at the 2.5%, 5%, 7.5% and 10% concentration of aqueous extract of *Chromolaena odorata* respectively, as compared to the plumule length of 13.41 ± 0.31 cm in control treatment (0%) The radicle length of *Lens culinaris*, was 5.98 ± 0.08 cm, 4.2 ± 0.15 cm,

3.71 ± 0.11 cm and 2.91 ± 0.15 cm at the 2.5%, 5%, 7.5% and 10% concentration of aqueous extract of *Chromolaena odorata* respectively, as compared to the radicle length of 7.79 ± 0.15 cm in control treatment (0%) (**Table 2**). Seed germination and subsequent growth of plumule and radicle were not observed at 15% aqueous extract of *Chromolaena odorata*.

In *Brassica nigra*, recorded length of the plumule was 6.8 ± 0.03 cm, 4.88 ± 0.09 cm, 4.15 ± 0.06 cm and 2.98 ± 0.18 cm at the 2.5%, 5%, 7.5% and 10% concentration of aqueous extract of *Chromolaena odorata* respectively, as compared to the plumule length of (8.25 ± 0.16) cm in the control treatment (0%). Similarly, radicle length of *Brassica nigra*, was 5.01 ± 0.07 cm, 3.28 ± 0.23 cm, 2.71 ± 0.05 cm and 1.55 ± 0.01 cm at the 2.5%, 5%, 7.5%, 10% and 15% concentration of aqueous extract of *Chromolaena odorata* respectively, as compared to the radicle length of 6.3 ± 0.09 cm in the control treatment (0%) (**Figure 4, Table 2**).

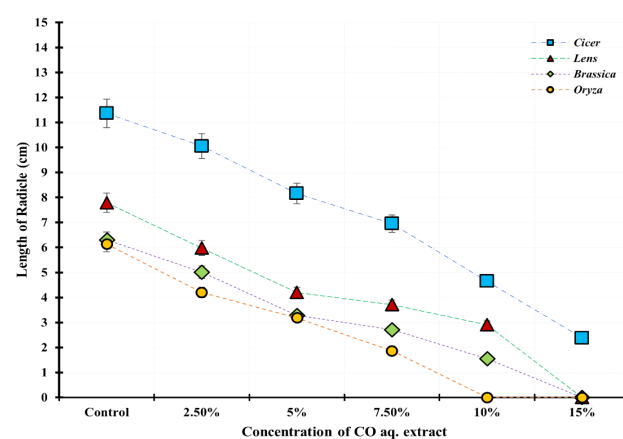


Figure 4. Allelopathic effect of *Chromolaena odorata* extract on radicle growth of test crops.

In *Oryza sativa*, recorded length of the plumule was 9.43 ± 0.27 cm, 6.98 ± 0.1 cm and 5.71 ± 0.18 cm at the 2.5%, 5% and 7.5% concentration

of aqueous extract of *Chromolaena odorata* respectively, as compared to the plumule length of 10.85 ± 0.07 cm in control treatment (0%). Similarly, for radicle length of *O. sativa*, was 4.2 ± 0.15 cm, 3.18 ± 0.27 cm and 1.86 ± 0.03 cm at the 2.5%, 5% and 7.5% concentration of aqueous extract

of *Chromolaena odorata* respectively, as compared to radicle length of 6.13 ± 0.06 cm in control treatment (0%). Seed germination and subsequent growth of plumule and radicle were not observed at 10% and 15% aqueous extract of *Chromolaena odorata* (Table 2).

Table 2. Effect of *Chromolaena odorata* aqueous extracts on Plumule and Radicle growth of the test crops.

PLUMULE	Control	2.50%	5%	7.50%	10%	15%
<i>Cicer arietinum</i>	10.86 ± 0.07^a	9.76 ± 0.16^b	7.86 ± 0.19^c	6.58 ± 0.15^d	4.43 ± 0.19^e	0
<i>Lens culinaris</i>	13.41 ± 0.31^a	10 ± 0.3^b	7.53 ± 0.3^b	5.86 ± 0.24^c	4.21 ± 0.15^d	0
<i>Brassica nigra</i>	8.25 ± 0.16^a	6.8 ± 0.03^b	4.88 ± 0.09^c	4.15 ± 0.06^d	2.98 ± 0.18^e	0
<i>Oryza sativa</i>	10.85 ± 0.07^a	9.43 ± 0.27^b	6.98 ± 0.1^c	5.71 ± 0.18^d	0	0
RADICLE	Control	2.50%	5%	7.50%	10%	15%
<i>Cicer arietinum</i>	11.36 ± 0.2^4a	10.05 ± 0.11^b	8.16 ± 0.08^c	6.95 ± 0.10^d	4.65 ± 0.19^e	0
<i>Lens culinaris</i>	7.79 ± 0.1^5a	5.98 ± 0.08^b	4.2 ± 0.15^b	3.71 ± 0.11^c	2.91 ± 0.15^d	0
<i>Brassica nigra</i>	6.3 ± 0.09^a	5.01 ± 0.07^b	3.28 ± 0.23^c	2.71 ± 0.05^d	1.55 ± 0.01^e	0
<i>Oryza sativa</i>	6.13 ± 0.06^a	4.2 ± 0.15^b	3.18 ± 0.27^c	1.86 ± 0.03^d	0	0

The response index (RI) of all the four test crops, viz. *Cicer arietinum*, *Lens culinaris*, *Brassica nigra* and *Oryza sativa* exhibited significant negative values with increasing percentage leachates (aqueous extracts) of *Chromolaena odorata*.

Aqueous extract treatment of *Chromolaena odorata* showed a negative value (Figure 5) of RI of indicating their inhibitory effect on the test crops.

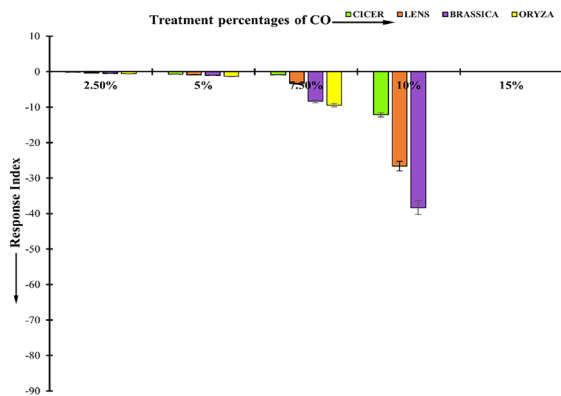


Figure 5. Response index of the crop plants against various percentages of *Chromolaena odorata* extract.

The outcome of seedling vigour index (SVI) analysis exhibited that *Cicer arietinum* and *Lens culinaris* was the most resistant to allelopathic impact of the aqueous extracts of *Chromolaena odorata*. On the contrary, *Oryza sativa* was most

vulnerable to the inhibitory allelopathic impact of the IAPs extracts (Figure 6).

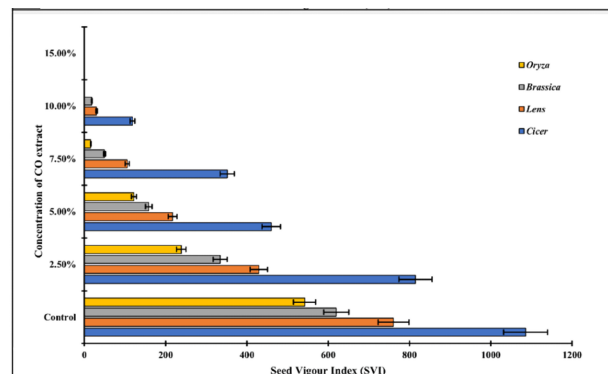


Figure 6. Seedling vigour index of the crop plants against various percentages of *Chromolaena odorata* extract.

Based on the plant tolerance index (PTI) results, aqueous extracts of the IAPs exhibited an inhibitory impact on the growth and germination of test crops. Among the four crop plants, *Cicer arietinum* showed maximum tolerance of $89.87 \pm 2.45\%$ and *Oryza sativa* showed lowest tolerance of $68.52 \pm 2.24\%$ against the against 2.5% extract of *Chromolaena odorata*. With increasing concentration (2.5% to 15% extract) of the IAPs, *Oryza sativa* exhibited low tolerance of $11.09 \pm 1.38\%$ against 15% extracts of IAPs was observed. *Cicer arietinum* with 33.61

± 1.65% PTI exhibited maximum tolerance against 15% extract of *Chromolaena odorata* followed by *Lens culinaris* (24.30 ± 3.15%) and *Brassica nigra* (13.49 ± 2.19%) (Table 3).

In the laboratory, the preliminary phytochemical

analysis was conducted on aqueous extracts of *Chromolaena odorata*. The results, detailed in Table 4, indicated the presence of Flavonoids, Alkaloids, Tannins, Terpenoids, Glycosides, Steroids and Saponins.

Table 3. Plant tolerance index of the test crops under *Chromolaena odorata* extracts.

Crop plant	2.50%	5%	7.50%	10%	15%
<i>Cicer arietinum</i>	89.87±2.45	72.38±2.95	60.59±1.86	40.79±3.12	33.61±1.65
<i>Lens culinaris</i>	76.08±1.38	53.44±1.86	47.20±1.75	37.02±1.58	24.30±3.15
<i>Brassica nigra</i>	79.52±3.95	52.06±2.15	43.02±2.64	24.60±1.67	13.49±2.19
<i>Oryza sativa</i>	68.52±2.24	51.88±3.2	30.34±1.88	23.82±2.32	11.09±1.38

Table 4. Qualitative phytochemical analysis of *Chromolaena odorata* extracts.

Samples	Phenols/ Tannins	Flavonoids	Saponins	Glycosides	Steroids	Terpenoids	Alkaloids
<i>Chromolaena odorata</i>	++	+++	+++	++	++	+++	++

Note: +++ indicates presence in high quantity; ++ indicates presence in moderate quantity; + indicates presence in low quantity;

4. Discussion

Germination of *Cicer arietinum*, *Lens culinaris*, *Brassica nigra*, *Oryza sativa* seeds were strongly inhibited by different concentrations of aquatic extracts of *Chromolaena odorata* and the inhibitory effect was significant at 7.5% concentration. The impact on inhibition of germination percentage by *Ageratina riparia* were in the order of *Oryza* > *Lens* > *Brassica* > *Cicer* (Figure 2; Table 1). The results of this study were in congruence to Hoque et al (2003) who observed that different concentrations of *Chromolaena odorata* leaf aqueous extract significantly inhibited the root and shoot elongation and development of lateral roots of *Brassica juncea*, *Cicer arietinum*, *Phaseolus mungo*, *Cucumis sativus*, *Vigna unguiculata* and *Raphanus sativus* in Bangladesh^[22]. Similarly, Madane & Patil (2017) reported the inhibitory mechanism of the extracts of *Chromolaena odorata* on the germination and growth of the seeds of *Cicer arietinum* and *Cajanus cajan* in Maharashtra, India^[23]. According to Karim et al. (2017), up to 4.0% aqueous extract of *Chromolaena odorata* was sufficient to inhibit the seed germination and for reducing the seedling

growth by 30-42% of four field crops viz. *Cicer arietinum*, *Oryza sativa*, *Arachis hypogea* and *Brassica campestris* in Bangladesh^[24] and these finding was similar to the outcome of inhibitory concentrations of *Chromolaena odorata* in our study on the test crops. Onwugbuta (2001) also observed that aqueous extract of *Chromolaena odorata* at the concentration of 2.5% exerted significant growth inhibition of *Lycopersicum esculentum* seed germination as well as growth of seedling^[25]. Allelopathic impact of *Chromolaena odorata* on the plumule length of test crops were in the order *Lens* > *Oryza* > *Brassica* > *Cicer* but for radicle length it was observed as *Oryza* > *Brassica* > *Lens* > *Cicer* (Figure 3, 4; Table 2). It was also reported that incorporation of *Chromolaena odorata* leaves in the soil of *Capsicum annum* and *Solanum melongena* field suppress their vegetative growth^[26] in Sri Lanka. Similarly, Popoola et al. (2020) also reported inhibitory effect of aqueous extract of *Chromolaena odorata* on seedling growth of *Vigna unguiculata* in Nigeria^[27]. Kato-Noguchi and Kato (2023) indicated that *Chromolaena odorata* exhibits potent allelopathic effect, with aqueous extract composed of inhibitory allelochemicals in higher concentrations,

hindering the growth of various plants in nurseries and cultivated lands^[11]. Results of our study also exhibited congruence to the allelopathic impact of *Chromolaena odorata* reported by Gao et al. (2009) showing different response behaviour of multiple crops in different manner in response to the aqueous extract of *Hemistepta lyrata*, indicating that allelopathic impact can be considered as a selective mechanism^[18]. Laxman et al. (2019) reported that different concentrations of aqueous extract and litter leachates of *Chromolaena odorata* exerted varying degrees inhibitory allelopathic impact on the growth and germination of *Salvadora persica*^[28]. From Assam, India, Nirgundikar et al. (2023) reported that aqueous extract of *Chromolaena odorata* in 16–20% concentration exerted high inhibition on germination and radicle-plumule growth of *Lens culinaris* and two other lentil crops in Kanhe, Maharashtra^[15]. The present study shows that 7.5–10% concentration of aqueous extract of *Chromolaena odorata* was inhibitory to all the four test crops. Analysis of the response index of the crop plants against the IAPs extract showed that all the crop plants were subjected to negative response value in respect to control.

Gradual reduction in the germination rate of the four test crops observed with increasing concentration aqueous extracts of noxious IAPs substantiate the direct allelopathic impact of IAPs on growth attributes of the test crops. All the concentrations i.e. 2.5, 5, 7.5, 10 and 15% of aqueous extracts exhibited adverse allelopathic impact on growth attributes (germination percentage, plumule growth and radicle growth) of test crops as compared to respective controls which is analogous to the study of Poonpaiboonpipat *et al.*^[29] on *Amaranthus viridis* and *Echinochloa crus-galli* in Thailand. Our test results revealed maximum inhibition in *Brassica nigra* and *Oryza sativa* along 10% and 15% noxious IAPs aqueous extracts of the three IAPs. Phytochemical analysis showed the presence of Flavonoids, Alkaloids, Tannins, Terpenoids, Glycosides, Steroids and Saponins (**Table 4**) considered as important allelochemicals responsible for the allelopathic impact of Asteraceae plants^[30,31].

The inhibitory impact of aqueous extracts of *Chromolaena odorata* could be attributed their strong meddling effects (competitive and allelopathic) through presence of different allelochemicals^[30,31]. The inhibitory allelopathic impact of the aqueous extract of *Chromolaena odorata* on the seed germination of the test crops could be attributed to the presence of allelochemicals like p- cymene, β -caryophyllene, α -cedrene, longipinene, Quercetin, Gallic acid, Stigmasterol, D-Limonene were reported by earlier workers^[32].

5. Conclusions

Results of this study exhibited the allelopathic impact of *Chromolaena odorata* on the four test commonly cultivated crops of Mizoram and these results suggested that allelopathy may contribute to the ability of *C. odorata* to become dominant in invaded ecosystems in Mizoram. The allelopathic studies revealed that *Chromolaena odorata* caused significant reduction in gemination rate, plumule and radicle growth of the studied local test crops, namely *Cicer arietinum*, *Lens culinaris*, *Brassica nigra* and *Oryza sativa* which interprets that crops in cultivated lands of villages in Mizoram get frequently replaced by the IAPs. This phenomenon could be explained by the rampant disturbance regime followed by irregular fallow period which allows the IAPs to expand further as a pioneer species.

The allelopathic impact of the aqueous leachates of *Chromolaena odorata* maybe attributed to the presence of different classes of allelochemicals but the quantification and evaluation of these allelochemicals and their isolation, identification under field conditions warrant further research. presence of different allelochemicals. Additionally, utilizing the invasive *Chromolaena odorata* for constructive socio-economic use avoiding manual eradication is recommended. Studies akin to this one are imperative for understanding the cultivation pattern and avoiding invasion of alien plants in Mizoram emphasizing the necessity of sustainable agriculture.

Author Contributions

R.S. (PhD student and first author) contributed in the plant sample collection, identification, field work and data analysis of the data and drafted the paper. S.S.D. contributed to validation of the data, methodology preparation and contributed to critical reading of the manuscript. All the authors have read the final manuscript and approved the submission.

Conflict of Interest

The authors express no conflict of interest.

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