

Allelopathic Effect of Aqueous Leaves Extract of Some Plants on Seed Germination of *Parthenium hysterophorus* L.

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ABSTRACT

The weed *Parthenium hysterophorus* is an invasive, ubiquitous and significantly threatens agricultural productivity and biodiversity. This study explored the potential of allelopathy for its impact by investigating the effects of aqueous extracts from 31 plant species on seed germination of parthenium. The study revealed that all the 31 plant species adversely affected the germination of Parthenium seed. Leaf extract of *Azadirachta indica*, *Cassia tora*, *Mentha arvensis*, and *Xanthium strumarium* caused 100% inhibition of seed germination within 7 days and did not allow further seed germination. Inhibitory effect of some plant species were persistent on germination of parthenium seed upto 15 days. Minimum inhibition in seed germination was recorded in extract of *Achyranthes aspera* i.e. 24.13%.

Keywords- Parthenium, Aqueous extract, Allelopathy, Germination inhibition.

I. INTRODUCTION

Parthenium hysterophorus L., commonly referred to as congress grass, carrot grass, gajar ghas, feverfew, ragweed, parthenium, chatak chandani, and white head, is an invasive herbaceous annual belonging to the Asteraceae family. This species has proliferated across more than 40 Nations (Bajwa et al., 2018). In India, parthenium has emerged as a significant issue in all states, further disseminating to neighbouring countries via vehicles or as a contaminant in transported seeds (Adkins and Shabir, 2014). The successful establishment of parthenium in agricultural fields is facilitated by various factors, including its prolific seed production, genetic variability, stress tolerance, and allelopathic properties (Bajwa et al., 2016). This weed competes with essential crops in Australia, the Indian subcontinent, and Africa (Bajwa et al., 2016). It exhibits continuous growth and flowering throughout the year, lacking a dormancy phase; however, under adverse conditions, it demonstrates phenotypic plasticity by forming low-growing rosettes that only bolt and flower when conditions become favorable (Kohli and Rani,

1994; Adkins et al., 2019). The presence of parthenium adversely affects natural ecosystems, as its pollen can hinder fruit set in various crops. Furthermore, its allelopathic properties suppress the germination and development of indigenous plant species. In humans, exposure to parthenium pollen, airborne fragments of dried plant material, and its roots can trigger allergic reactions such as hay fever, asthma, and eczema. In animals, the plant may lead to external symptoms including pruritus, alopecia, and loss of skin pigmentation, dermatitis, erythematous eruptions, and anorexia. Furthermore, the milk of cattle, buffalo, and sheep may become contaminated with parthenin (Towers and Subba Rao, 1992).

The most economical approach to controlling the proliferation of parthenium is through prevention. The risk of parthenium dissemination is significantly heightened through the movement of vehicles, livestock, and agricultural products. Globally, various approaches, including mechanical, chemical, biological, and integrated weed management techniques, are employed to control weeds (Shahzad et al., 2016; Farooq et al., 2017). The eradication of *P. hysterophorus* has been

attempted through manual, chemical, and biological control methods, such as the use of leaf-feeding beetles and fungi, with varying degrees of success. The most effective method for controlling parthenium involves manual uprooting prior to flowering and seed set, provided that appropriate precautions are taken. Foliar applications of certain herbicides have been reported to manage parthenium effectively (Javaid et al., 2006). While herbicides offer a rapid solution to many weed issues, their excessive and indiscriminate application has led to the development of resistance and a resurgence of pest populations. Over the past two decades, there has been a dramatic increase in resistance to specific synthetic herbicides, resulting in diminished land values and leaving farmers with fewer options for weed control. Consequently, it is crucial to focus research efforts on identifying natural extracts that can mitigate this problem, thereby reducing or eliminating the reliance on herbicides in the future. Additionally, the growing public concern regarding environmental issues necessitates the development of alternative weed management systems that are environmentally friendly, less reliant on pesticides, or based on naturally occurring compounds (Singh et al., 2003). In this context, the allelopathic effects of various plants have garnered significant interest among researchers recently. Therefore, it is essential to conduct studies aimed at evaluating the efficacy of specific plant extracts on the seed germination of parthenium.

Allelochemicals primarily consist of secondary metabolites generated by plants, which are the byproducts of primary metabolic activities. Allelopathy can be viewed as a facet of biological control, wherein plants are utilized to diminish the growth and vigour of competing plant species. Numerous allelochemicals exhibit phytotoxic properties and hold promise as herbicides or as foundational elements for the development of new classes of herbicides. These compounds present significant potential for use in pesticides, as they circumvent the issues commonly associated with current pesticide formulations. The significance of allelochemicals in the development and advancement of novel herbicides is remarkable. The capacity of certain natural plant compounds to effectively inhibit the growth of other plants indicates their applicability as herbicides. Allelopathy represents a natural and environmentally sustainable strategy that could serve as a distinctive method for weed management, enhance crop productivity, reduce dependence on synthetic pesticides, and contribute positively to ecological health. The aim of the current

study was to evaluate the efficacy of aqueous leaf extracts from 31 plant species, including *Acacia nilotica*, *Achyranthes aspera*, *Amaranthus spinosus*, *Anethum sowa*, *Acalypha indica*, *Azadirachta indica*, *Boerhaavia diffusa*, *Argemone mexicana*, *Brassica campestris*, *Calotropis procera*, *Cassia fistula*, *Cassia tora*, *Chenopodium album*, *Coriandrum sativum*, *Cannabis sativa*, *Croton bonplandianum*, *Datura metel*, *Lantana camara*, *Mentha arvensis*, *Nerium indicum*, *Nepeta cataria*, *Ocimum sanctum*, *Ricinus communis*, *Sida acuta*, *Solanum nigrum*, *Spinacia oleracea*, *Tagetes erecta*, *Trigonella foenum-graecum*, *Tephrosia purpurea*, *Lochnera rosea*, and *Xanthium strumarium*, in controlling the germination of Parthenium

II. MATERIALS AND METHOD

Fresh leaves from 31 different plants species were collected and washed with sterilized distilled water and dried at room temperature. To prepare stock solution leaves were separately crushed with pestle and mortar in sterilized distilled water (w/v 50gm/100ml) and filtered with muslin cloth and then with filter with Whatman No. 1 and filtrate were applied for seed germination bioassay.

III. SEED GERMINATION BIOASSAY

Seeds of *Parthenium hysterophorus* were collected, air dried and stored in sterilized bottles. Healthy seeds were dipped in 0.2% Sodium Hypochloride solution for 1 minute and washed with sterilized and distilled water. Seeds were soaked in 10 ml of each plant extracts of different concentration (10, 25, and 50%) for 24 hrs. 20 seeds of each were arranged equidistantly in sterilized petridishes containing sterilized moist sand and incubated at 25 ± 2 degrees Celsius. From preliminary screening it was found that out of 10%, 25%, 50% concentration of plant extracts 50% concentration had the strongest allelopathic effect on seed germination. Thus 50% concentration was selected for the experiment. Three replicates of each set were used. After 07 days and 15 days germinated normal seedlings were counted and % germination inhibition was calculated by the following formula.

$$\% \text{ Inhibition} = \frac{\% \text{ of germination in control} - \% \text{ of germination in treated}}{\% \text{ of germination in control}} \times 100$$

IV. RESULT

Table-1. Inhibitory effect of different extract on seed germination of *Parthenium hysterophorus*

S.no	Plant Extracts	Effect on Seed Germination			
		7 Days		15 Days	
		% Germination	% Inhibition	% Germination	% Inhibition
1	<i>Acacia nilotica</i> (Mimosaceae)	3.33	96.15	41.66	56.50
2	<i>Achyranthes aspera</i> (Amaranthaceae)	25.00	71.15	73.33	24.13

3	<i>Amaranthus spinosus</i> (Amaranthaceae)	11.66	86.54	11.66	87.93
4	<i>Anethum sowa</i> (Apiaceae)	25.00	71.15	45.00	53.44
5	<i>Acalypha indica</i> (Euphorbiaceae)	0	100	5.00	94.82
6	<i>Azadirachta indica</i> (Meliaceae)	0	100	0	100
7	<i>Argemone mexicana</i> (Papaveraceae)	20.00	76.92	23.33	75.86
8	<i>Boerhaavia diffusa</i> (Nyctaginaceae)	23.33	73.07	26.66	72.41
9	<i>Brassica campestris</i> (Brassicaceae)	23.33	73.07	30.00	68.96
10	<i>Calotropis procera</i> (Asclepiadaceae)	1.66	98.08	1.66	98.28
11	<i>Cassia fistula</i> (Caesalpiniaceae)	10.00	88.46	10.00	89.65
12	<i>Cassia tora</i> (Caesalpiniaceae)	0	100	0	100
13	<i>Chenopodium album</i> (Chenopodiaceae)	33.33	61.53	51.66	47.07
14	<i>Coriandrum sativum</i> (Apiaceae)	33.33	61.53	43.33	55.17
15	<i>Cannabis sativa</i> (Cannabinaceae)	20.00	76.92	20.00	79.30
16	<i>Croton bonplandianum</i> (Euphorbiaceae)	10.00	88.66	16.66	82.76
17	<i>Datura metel</i> (Solanaceae)	6.66	92.31	13.33	86.20
18	<i>Lantana camara</i> (Verbenaceae)	26.66	69.22	28.33	67.24
19	<i>Mentha arvensis</i> (Lamiaceae)	0	100	0	100
20	<i>Nepeta cataria</i> (Lamiaceae)	33.33	61.53	63.33	34.48
21	<i>Nerium indicum</i> (Apocynaceae)	5.00	94.23	6.66	93.10
22	<i>Ocimum sanctum</i> (Lamiaceae)	10.00	88.46	10.00	89.65
23	<i>Ricinus communis</i> (Euphorbiaceae)	20.00	76.92	25.00	74.13
24	<i>Sida acuta</i> (Malvaceae)	23.33	73.07	23.50	75.86
25	<i>Spinacia oleracea</i> (Chenopodiaceae)	6.66	92.31	10.00	89.65
26	<i>Tagetes erecta</i> (Asteraceae)	13.33	84.61	16.66	82.76
27	<i>Solanum nigrum</i> (Solanaceae)	1.66	98.08	1.66	98.28
28	<i>Trigonella foenum graecum</i> (Papilionaceae)	33.33	61.53	38.33	60.34
29	<i>Tephrosia purpurea</i> (Papilionaceae)	1.66	98.08	3.33	96.53
30	<i>Lochnera rosea</i> (Apocynaceae)	11.66	86.54	11.66	87.93
31	<i>Xanthium strumarium</i> (Asteraceae)	0	100	0	100
	Control	86.66		96.66	

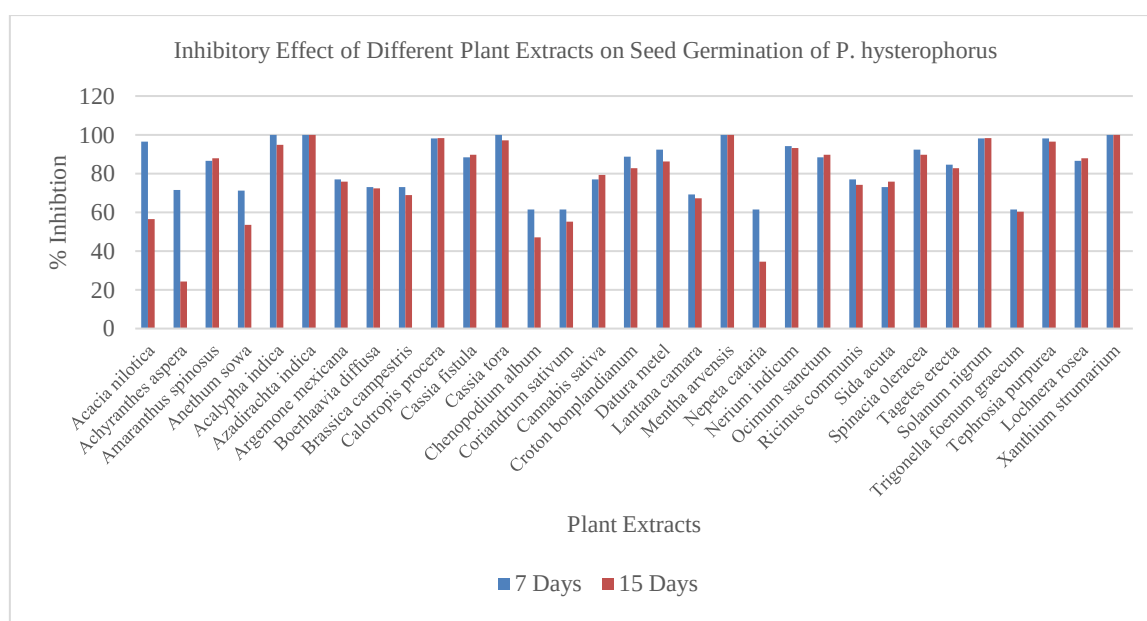


Figure-1

It is evident from the table-1, figure-1 that aqueous leaf extract of different plant species differ in their efficiency in controlling the germination of

parthenium. Almost all the extracts have inhibitory effect on seed germination within 7 days as compared to 15 days. Aqueous extracts of *Azadirachta indica* *Cassia*

tora, *Mentha arvensis*, and *Xanthium strumarium* proved very effective, completely restricting the germination of seed within 7 days.

Effect of aqueous leaf extract of *Amaranthus spinosus*, *Azadirachta indica*, *Cassia tora*, *cassia fistula*, *Canabis sativa*, *Mentha arvensis*, *Ocimum sanctum*, *Sida acuta*, *Solanum nigrum*, *Lochnera rosea*, and *Xanthium strumarium* were persistent up to 15 days and did not allow further seed germination.

Effects of aqueous extract of *Amaranthus spinosus*, *Azadirachta indica*, *Cassia tora*, *Cassia fistula*, *Cannabis sativa*, *Mentha arvensis*, *Ocimum sanctum*, *Sida acuta*, *Solanum nigrum*, *Lochnera rosea* and *Xanthium strumarium* were persistent up to 15 days and did not allow further seed germination.

Impact of *Acalypha indica*, *Argemon mexicana*, *Boerhaavia diffusa*, *Brassica compestris*, *Croton bonplandianum*, *Datura metel*, *Lantana camara*, *Nerium indicum*, *Ricinus communis*, *Spinacia oleracea*, *Tagetes erecta*, *Trigonella foenum-graecum* and *Tephrosia purpurea* was almost persistent up to 15 days. Aqueous extracts of *Acacia nilotica*, *Anethum sowa*, *Achyranthes aspera*, *Chenopodium album*, *Coriandrum sativum* and *Nepeta cataria* delayed the germination of parthenium seeds. *Achyranthes aspera* was least effective in inhibiting the seed germination.

Aqueous extracts of all the Test plants adversely affected the growth of seedlings, reduction of shoot length and root length of seedling were also observed. Effectiveness of different aqueous plant extracts on inhibition of seed germination of parthenium are as follows:

Azadirachta indica (100%), *Cassia tora* (100%), *Mentha arvensis* (100%), *Xanthium strumarium* (100%) > *Calotropis procera* (98.28%), *Solanum nigrum* (98.28%) > *Tephrosia purpurea* (96.55%) > *Acalypha indica* (94.82%) > *Nerium indicum* (93.10%) > *Cassia fistula* (89.65%), *Ocimum sanctum* (89.65%) > *Spinacia oleracea* (88.97%) > *Amaranthus spinosus* (87.93%) > *Datura metel* (86.20%) > *Croton bonplandianum* (82.76%) > *Cannabis sativa* (79.30%) > *Argemone mexicana* (75.86%) > *Ricinus communis* (74.13%) > *Boerhaavia diffusa* (72.41%) > *Lantana camara* (70.66%) > *Brassica compestris* (68.96%) > *Trigonella foenum-graecum* (60.33%) > *Acacia nilotica* (56.50%) > *Coriandrum sativum* (55.17%) > *Anethum sowa* (53.44%) > *Chenopodium album* (47.07%) > *Nepeta cataria* (34.48%) > *Achyranthes aspera* (24.13%).

V. DISCUSSION AND CONCLUSION

The aqueous leaf extracts from all tested plant species, including *Azadirachta indica*, *Cassia tora*, *Mentha arvensis*, and *Xanthium strumarium*, achieved complete inhibition of seed germination within a week, preventing any further germination. This phenomenon may be attributed to the presence of potent allelochemicals in the leaves of these species.

Additionally, aqueous leaf extracts from various other plants such as *Amaranthus spinosus*, *Azadirachta indica*, *Mentha arvensis*, *Cassia fistula*, *C. tora*, *Cannabis sativa*, *Ocimum sanctum*, *Sida acuta*, *Solanum nigrum*, *Lochnera rosea*, and *Xanthium strumarium* demonstrated significant effectiveness in inhibiting seed germination, with effects lasting up to 15 days.

The inhibitory effects of aqueous extracts of 50% concentration of 31 selected plant species not only caused a delay in germination of seed but also completely inhibited the germination. This might be due to presence of growth inhibitory substances i.e. allelochemicals in the extracts that were released during extraction.

Seed germination denotes the process of reinitiating growth in the dormant embryonic plant encapsulated within the seed. This process encompasses several distinct phases, including imbibition, catabolic, and ultimately anabolic phases, culminating in the emergence of the radicle. Thus, the appearance of the radicle is considered the end of the germination process and the beginning of seedling growth. In the initial phase, water is absorbed through imbibition and osmosis, leading to the activation of enzymes and an increase in metabolic activity. The expansion of cells results in the elongation of the radicle, which breaks through the seed coat, while the protoplasm becomes hydrated and respiratory enzymes are reactivated following hydrolysis. Stored nutrients such as carbohydrates, proteins, and lipids are utilized in anabolic processes, with soluble reserves being mobilized and transported to the embryonal axis (Van Overbeek, 1966). The embryonal axis produces gibberellic acid, which may stimulate the synthesis of amylase, protease, lipase, and the amino acid tryptophan, a precursor to indole-3-acetic acid (IAA) (Van Overbeek, 1966).

Investigations into the allelopathic characteristics of the grasses *Imperata cylindrica* and *Desmostachya bipinnata* have revealed their capacity to suppress the proliferation of *P. hysterophorus*, aqueous extracts derived from these grasses demonstrated notable inhibitory effects on the germination and development of this invasive species (Javaid et al., 2005; Anjum et al., 2000). Additionally, another study indicated that aqueous leaf extracts from allelopathic trees such as *Azadirachta indica*, *Ficus bengalensis*, *Melia azadarach*, *Mangifera indica* L., and *Syzygium cumini* can effectively reduce the germination and seedling development of Parthenium (Shafique et al., 2005). Subsequent studies indicated that the greatest inhibition of germination occurred with all concentrations of *Azadirachta indica* seed oil, succeeded by 10% aqueous extracts of *Brassica carinata* seeds and *A. indica* leaves, leading to reductions in germination rates of 89.3%, 67%, and 51%, respectively (Zehara, 2022). The research demonstrated that extract concentrations of 2%, 5%, 10%, and 20% derived from *Syzygium aromaticum*

significantly inhibited the germination of *Parthenium* (Sanghmitra and Kavita, 2024). Furthermore in the present study impact of *Acalypha indica*, *Argemone mexicana*, *Boerhaavia diffusa*, *Brassica campestris*, *Croton bonplandianum*, *Datura metel*, *Lantana camara*, *Nerium indicum*, *Ricinus communis*, *Spinacia oleracea*, *Tagetes erecta*, *Trigonella foenum-graecum*, and *Tephrosia purpurea*, on the germination of parthenium seeds were observed to persist for nearly 15 days. Aqueous extracts from *Acacia nilotica*, *Anethum sowa*, *Achyranthes aspera*, *Chenopodium album*, *Coriandrum sativum*, and *Nepeta cataria* were found to delay the germination process of parthenium seeds. The least inhibition in seed germination was noted with *Achyranthes aspera*, which exhibited a mere 24.13% reduction. Consequently, the allelopathic effects of different plant aqueous extracts varied according to the species involved, potentially due to the unique allelopathic compounds produced by each species (Chon et al., 2003). These allelochemicals may interfere with metabolic processes that are crucial for the biosynthesis of gibberellic acid and indole-3-acetic acid (IAA), ultimately leading to the inhibition of seed germination. It is well-documented that allelochemicals can impede the synthesis of proteins, including enzymes (Kohli, 1992). Furthermore, leaves are recognized as the plant organs with the highest concentration of allelochemicals compared to other parts (Kil and Yun, 1992; Qasem, 2002).

The current research indicates that *Azadirachta indica*, *Cassia tora*, *Mentha arvensis*, and *Xanthium strumarium* are effective plant species with the potential to suppress weeds and contain inhibitors that affect the germination and growth of *Parthenium* weed. Additional research is necessary to isolate and characterize their herbicidal components, particularly from the leaves. These natural substances could serve as a foundational basis for developing herbicides derived from natural products to manage one of the most detrimental weeds to the environment.

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