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EXAMINING THE TOXIC EFFECTS OF PLANT PARTS OF INVASIVE PARTHENIUM WEED (*PARTHENIUM HYSTEROPHORUS* L.) AGAINST WHEAT AND ITS WEEDS

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Abstract

A laboratory experiment was conducted to assess the allelopathic potential of aqueous extracts from different parts of the invasive weed Parthenium hysterophorus L. on winter wheat (Triticum aestivum L.) and associated weeds (Silybum marianum, Avena fatua, and Phalaris minor). The results indicated significant inhibitory effects of all Parthenium plant parts (root, stem, and leaf aqueous extracts) on the seed germination and seedling growth of the test species compared to the distilled water/control. Among the plant part extracts, the leaf extract of Parthenium exhibited superior germination inhibition, shoot length restriction, and shoot weight reduction, while the root extract was less toxic to all test species. Furthermore, the seed germination of wheat was less suppressed by Parthenium extracts compared to the other tested species. Wheat seedling growth and weight also showed better resistance to the leaf, stem, and root extracts of Parthenium than the other species. Additionally, Phalaris minor failed to germinate against the leaf and stem extracts of Parthenium, suggesting the potential of Parthenium as a bioherbicide for controlling this problematic weed in wheat crops.

Keywords: *Cereals, herbicides, Integrated weed management, Parthenuim, Plant extracts*

INTRODUCTION

The invasive weed *Parthenium hysterophorus* L. is an annual herbaceous broadleaf plant that belongs to the family Asteraceae. A single plant of parthenium can produce up to 26,000 viable seeds and can reach a height of 30-150 cm (1-2) his longevity of the life cycle of this weed is soil moisture-dependent. When the soil is well-moisture, its life cycle ranges from 4 to 8 months, while at low soil moisture, it completes its life cycle in only 28-35 days (3-4).

Parthenium hysterophorus L. is native to North and South America and was accidentally introduced to the subcontinent (5). The introduction of this weed into Pakistan was first reported by (6), but the exact method of introduction is still unknown. Parthenium weed is known to infest various cultivated crops and can cause significant production losses in crops such as wheat (7), maize (*Zea mays*) (9), and Sorghum (*Sorghum bicolor* L.; (8-9) **re**ported up to a 40% decline in crop production due to the weed. Dense infestations of Parthenium weed have been observed in various field crops in Pakistan. The weed can also reduce the carrying capacity of pastures by up to 90% **(**10) and decrease biodiversity in these pastures (11). Parthenium weed has been found to reduce the biodiversity of native plants in many countries, including Pakistan **(12**).

In addition to its impact on crops and biodiversity, parthenium weed can act as an alternative host to several crop pests, such as the tobacco streak virus (Ilarvirus TSV) of sunflower and mung bean, which can harbor on parthenium weed (13. The weed has also been reported to cause health issues in both humans and animals in many countries, including Pakistan **(**14-15).

One of the major negative characteristics of Parthenium weed is the release of allelopathic chemicals that can inhibit seed germination and growth in other plants, contributing to a decline in plant biodiversity (15). These allelochemicals are released through various means, such as volatilization, leaching, root

exudations, and decomposition of dead plant parts (2). Sesquiterpene lactones and phenolics, particularly parthenin, have been found to inhibit seed germination and growth in many plants (16-17).

Given the bioherbicidal potential of *Parthenium hysterophorus* L. against weeds and its impact on wheat yield, this research aims to determine the tolerance of wheat to root, shoot, and leaf extracts of parthenium weed and evaluate the bioherbicidal potential of parthenium plant parts in suppressing associated weeds in wheat crops. Further this study also aims to identify the most phytotoxic plant part of parthenium in terms of weed seed suppression.

MATERIALS AND METHODS

A laboratory trial was conducted at the Agriculture Research Laboratory, Bacha Khan University, Charsadda in 2024 to assess the phytotoxicity of parthenium (*Parthenium hysterophorus* L.) plant parts on wheat (*Triticum aestivum* L.) and its associated weeds. Aqueous extracts of Parthenium leaf, stem, and roots were tested on the seed germination and seedling growth of winter wheat and its associated weeds (*Silybum marianum, Avena fatua, and Phalaris minor*).

Mature and healthy Parthenium plants with roots were collected from the New Developmental Farm of Bacha Khan University, Charsadda, cleaned, and separated into leaves, stems, and roots. The plant parts were dried, powdered, and soaked in tap water to obtain the aqueous extracts. The extracts were then filtered and used to treat seeds of the test species in petri-dishes.

The experiment was conducted in a completely randomized design with four replicates and monitored for 20 days. Data on seed germination, shoot length, and shoot weight were recorded and analyzed using ANOVA and LSD test.

RESULTS AND DISCUSSION

SEED GERMINATION (%)

The statistically analyzed data showed a significant ($p<0.05$) effect of parthenium aqueous extracts from all parts (root, stem, and leaf) on the seed germination (%) of all test species (Table I). The mean data of the test species indicated that the highest seed germination (90.03%) was observed for wheat, while the lowest (22.62%) was noted for *Phalaris minor*. This suggests that wheat seeds may have tolerance against the phytotoxic effects of Parthenium weed. When discussing parthenium plant parts extract, the maximum suppression of seed germination was found for parthenium leaf extract, with only 32.71% germination recorded on average compared to distilled water, where a maximum of 82.62% seed germination was noted. This indicates that among the parthenium parts, leaf extract was more toxic, while root extract was less toxic in terms of seed germination inhibition in all the test species. These results are supported by previous findings of Shikha & Jha (2016) and Forcella *et al.*, 2000, who reported that the root, stem, and leaf extracts of parthenium weed were highly inhibitory against seed germination and seedling growth of various plant species (18-19). Additionally, the current study found that Parthenium plant parts extract exhibited high phytotoxicity towards weed species, but less towards wheat crops, suggesting potential for developing bioherbicides for weed control in wheat crops in the future.

Table I. Effects of Parthenium weed plant parts extracts on the germination (%) of tested weed species

Test weeds	Parthenium weed plant parts extracts				Mean
	Leaf extract	Stem extract	Root extract	Distil water/ Control	
Triticum aestivum	80.14 c	90.00 b	90.01 b	100.00 a	90.04 a
Avena fatua	30.50 g	40.20 f	60.25 e	90.00 b	55.24 b
Silybum marianum	20.22 h	40.25 f	20.25 h	70.24 d	37.73 c
Phalaris minor	00.00 i	00.00 i	20.23 h	70.25 d	22.63 d
Mean	32.79 c	42.61 b	47.68 b	82.62 a	

*LSD for Parthenium plant parts= 5.17, LSD for test species= 11.56, LSD for Interaction= 7.15

Similarly, the data on the interaction between parthenium plant parts and test species showed that the maximum germination (100%) was observed in wheat x control, while the minimum (0.00%) germination was recorded for P. minor against both leaf and stem extracts of parthenium weed.

SHOOT LENGTH (CM)

The data in Table II clearly demonstrate a significant inhibitory effect of parthenium weed leaf, stem, and root aqueous extracts on the shoot length of the test species ($p< 0.05$). The mean shoot length of the test species showed that *Silybum marianum* had the shortest shoot length (1.98 cm), while wheat had the longest shoot length (7.05 cm). The mean shoot lengths of the Parthenium plant parts extracts also revealed significant results, with the minimum shoot length (0.76 cm) recorded in Petri dishes treated with the aqueous extract of Parthenium, and the maximum shoot length (7.26 cm) observed in Petri dishes treated with distilled water (20).

Furthermore, the interaction data indicated that the longest shoot length (12.60 cm) was recorded for wheat treated with distilled water, while the shortest shoot length (0.00 cm) was calculated for P. minor in both the aqueous extract of leaf and stem of Parthenium weed. These findings are consistent with previous studies which also reported suppressive effects of parthenium weed stem and leaf extracts on the root and shoots elongation of wheat and other cereal crops. Additionally, (20**)** claimed that higher concentrations of parthenium weed leaf extracts significantly inhibit seed germination, shoot length, shoot weight, root length, and root weight of soybean, mungbean, and maize **(**21).

Table II. Effects of Parthenium weed plant parts extracts on shoot length (cm) of tested weed species

	Parthenium weed plant parts extracts				
Test weeds	Leaf extract	Stem extract	Root extract	Distil water/ Control	Mean
Triticum aestivum	1.36 i	3.40 f	10.85 ab	12.60 a	7.05 a
Avena fatua	0.66 l	2.81 h	0.85 k	6.36 c	2.67 b
Silybum marianum	1.05 ij	1.00 jk	1.06 ij	4.83de	1.98 d
Phalaris minor	0.00 m	0.00 m	3.05 fg	5.26 cd	2.07 bc
Mean	0.76 d	1.80 c	3.95 b	7.26 a	

*LSD for Parthenium plant parts= 0.09, LSD for test species= 0.07, LSd for Interaction= 0.05

SHOOT WEIGHT (G)

The analysis of variance conducted on the data indicated that extracts from various parts of the Parthenium plant significantly influenced the shoot weight of the species under examination (refer to Table III). The mean values for the species demonstrated that wheat exhibited the highest shoot weight at 0.376 g, whereas the lowest shoot weight of 0.010 g was observed in *P. minor*. Similarly, the mean results for the extracts of parthenium plant parts also showed significant effects on shoot weight. Notably, the leaf extract of parthenium yielded the minimum shoot weight of 0.037 g, while distilled water resulted in the maximum shoot weight of 0.443 g **(**22-23).The interaction between the test species and the extracts from parthenium plant parts was also found to be highly significant concerning the shoot weight parameter. The highest recorded shoot weight of 1.093 g occurred with the combination of *S. marianum* and distilled water, while the lowest shoot weight of 0.00 g was noted for *P. minor* when combined with both the leaf and stem extracts of parthenium weed. These findings provide clear evidence of the presence of phytotoxic compounds in the invasive parthenium weed. Similar studies conducted by Ahmad *et al.,* 2003 and Bhatt *et al.,* 1994 **(**24-25) have reported analogous results, indicating a significant reduction in the shoot weight of wheat and other crops when exposed to the aerial parts of parthenium weed (26-27). The growth-inhibitory effect of the extracts from Parthenium weed on shoot weight may be attributed to the presence of phenolic compounds, such as parthenin, as previously noted by Nadeem *et al.,* 2005 and Patil *et al.,* 1988 (28-29).

Table III. Effect of Parthenium plant parts extracts on shoot weight (g) of test species

Test weeds	Parthenium weed plant parts extracts				Mean
	Leaf extract	Stem extract	Root extract	Distil water/ Control	
Triticum aestivum	0.082 g	0.288 d	0.638 b	0.494 c	0.376 a
Avena fatua	0.008 j	0.002 lm	0.004 l	0.148 f	0.041 c
Silybum marianum	0.058 i	0.211 de	0.067 h	1.093 a	0.357 b
Phalaris minor	0.000 n	0.000 n	0.003 lm	0.037 j	0.010 d
Mean	0.037 d	0.125 c	0.178 b	0.443 a	

*LSD for Parthenium plant parts= 0.031, LSD for test species= 0.021, LSD for Interaction= 0.006

CONCLUSION AND RECOMMENDATIONS

Parthenium poses a significant threat to the biodiversity of Pakistan due to its rapid and vigorous spread, which not only devastates native plant species but also leads to health issues. Given its pronounced phytotoxic effects on various weeds, this plant has the potential to be developed as a bioherbicide for controlling numerous weed species, thereby offering a promising avenue for future bioherbicide production. Additionally, the prevalence of weeds throughout the country could be diminished through this approach. By harnessing the potential of Parthenium, it may serve a beneficial purpose, as it currently lacks any other recognized utility within our nation.

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Ethical Statement:

No ethical issues were raised during the course of study.

Authors` Contribution:

Concept: ZH, RK. Plan: ZH, RK. Data analysis: RA, RK,. Writing, review and editing: RK, WAS, MA.M.F All authors have reviewed and consented to the final version of the manuscript for publication.

Conflict of Interest:

The authors have no conflict of interest.

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