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RESPONSE OF WHEAT VARIETIES AGAINST THE ALLELOPATHIC POTENTIAL OF PARTHENIUM WEED

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Abstract
This study examined the allelopathic effects of aqueous extracts from different Parthenium hysterophorus parts on wheat seed germination and seedling growth. Significant variations were observed across treatments and wheat varieties for seed germination, shoot length, biomass, and seed vigor index (SVI). Control treatments yielded maximum germination (100%), while Mardan leaf extract had the lowest (79.33%). Pak-81 exhibited the highest germination (99.04%), and Faisalabad 2008 the lowest (93.81%). Similar trends were seen for shoot length and biomass. The highest SVI (1000) was observed in control and Peshawar root extract treatments, and the lowest (651.3) in Mardan leaf extract. Pak-81 showed the highest SVI, and Shahkar 2013 the lowest. Significant interactions were observed, with control/Pak-81 generally exhibiting the highest values, and Mardan leaf extract/Shahkar 2013 the lowest. These findings highlight the potent allelopathic effects of parthenium on wheat, emphasizing the need for effective management strategies and the potential for developing parthenium-tolerant wheat cultivars.
Key words: *Allelopathy, Parthenium hysterophorus, Seedling growth, Wheat germination*

INTRODUCTION

Weeds are a significant threat to crop productivity and food security worldwide. Among various weeds, Parthenium hysterophorus, a noxious invasive weed, has been reported to cause substantial yield losses in various crops, including wheat (Triticum aestivum). Parthenium weed's allelopathic potential, which involves the release of phytotoxic chemicals, plays a crucial role in its invasive success and crop suppression.

Wheat, being a staple food crop, is vulnerable to Parthenium weed's allelopathic effects. Recent studies have shown that Parthenium weed's allelochemicals can inhibit wheat seed germination, seedling growth, and root development (1-2). Furthermore, Parthenium weed's allelopathic potential has been reported to alter wheat's physiological and biochemical processes, leading to reduced crop yields (3). Despite the growing concern about Parthenium weed's allelopathic effects on wheat, there is a lack of comprehensive research on the response of different wheat varieties to Parthenium weed's allelochemicals. Understanding the variability in wheat varieties' response to Parthenium weed's allelopathic potential is essential for developing effective weed management strategies and improving wheat productivity.

Parthenium hysterophorus is a highly invasive weed causing significant economic, environmental, and social impacts globally. Its allelopathic potential plays a crucial role in its invasive success.
Recent studies have revealed the need for effective management strategies against Parthenium. For instance, a 2022 study found that Parthenium's allelochemicals can inhibit crop growth and development (4). Another study published in 2023 reported that integrated management approaches can effectively control Parthenium infestations (5). Weeds are a significant threat to crop productivity and ecosystem balance, with allelopathy being a key mechanism underlying their invasive success. Allelopathic effects of weeds can inhibit crop growth, alter soil microbial communities, and disrupt ecosystem processes.

Recent studies have concluded the allelopathic potential of various weed species. For example, a study by (6) found that the allelochemicals released by invasive weed, Ageratum conyzoides, can inhibit the growth of soybean and maize. Another study by (7) reported that the allelopathic effects of weed, Chromolaena odorata, can alter the soil microbial community structure and function.

Despite the growing body of research on allelopathic effects of weeds, there is still a need for comprehensive studies on the mechanisms underlying these effects and their implications for ecosystem management. This study aims to investigate the allelopathic effects of weeds on crop growth and ecosystem processes, providing insights into the development of effective weed management strategies. (8-10)

Taking the ideas from the previous researches we focused in the instant research to screen out different wheat varieties against the allelopathic effects of common invasive weed Parthenium collected from different districts of KPK with the following objectives.

MATERIALS AND METHODS

A laboratory trial was laid out at the laboratory of Agriculture department, The Bacha Khan University Charsadda Pakistan to check out the allelopathic potential of invasive weed parthenium (*Parthenium hysterophorus*) extracts from leaf, stem and root from two locations (Peshawar and Mardan, Khyber Pakhtunkhwa), against the germination and seedling growth of five wheat varieties including Pirsabak 2005, Faisalabad 2008, Shahkar 2013, Durabi 11 and Pak 81.

PARTHENIUM COLLECTION

Mature and healthy plants of *Parthenium hysterophorus* L. were collected from the farmer's field of district Charsadda and Mardan by pulling along with the roots before flowering and shifting to the Agriculture laboratory, The Bacha Khan University Charsadda.

EXTRACT PREPARATION

The collected weeds species were cleaned from dust and other impurities and were then put in paper bags. In order to remove moister from weeds all the samples were then kept in oven at 65°C for 48 hours. After drying, the different plant parts (roots, stems, leaves) were separated and chopped and then ground with the help of grinder individually. The dried powder of the weed species parts were weighed and mixed in tap water at the rate of 120g L^{-1} to make concentrated extract at room temperature for 24 h. The final water extracts of the weeds were obtained by filtering process through 10 and 60-mesh sieves. All the prepared weed extracts were individually bottled and tagged for further process.

TRAIL SETUP AND PARAMETERS

Ten seeds of each wheat variety were positioned in Petri dish having 9 cm diameter with Watman No. 1 base. 3 ml of each prepared extract were applied as a first dose and later on the extract were applied according to the need. A distilled water treatment was also settled against three extract for comparison. The experiment was examined for 15 days.

The data were recorded on the following procedure:

GERMINATION (%)

Germinated seeds were counted daily. The seeds were considered as germinated when the radical size was 2 mm. The number of germinated seeds were recorded every 24 h. Six days after sowing the percentage germination data and other seedling parameters data were calculated using the formula,

$$\text{Germination \%} = \frac{\text{Germinated seed}}{\text{Total seed}} \times 100$$

SHOOT LENGTH (CM)

Shoot length was measured with a ruler in cm, for all the germinated plants in each treatment and then means were recorded at the final day of experiment.

SHOOT BIOMASS (G)

The fresh biomass of all plants was taken on an electric balance in grams (g) and subsequently means plant^{-1} were calculated for each treatment.

ROOT BIOMASS (G)

The roots were separated and the fresh root biomass of all plants was taken on an electric balance in grams (g) and subsequently means plant^{-1} were calculated for each treatment.

STATISTICAL ANALYSIS

The recorded data were statistically analyzed and least significant difference (LSD) was computed through the procedure mentioned by Steel and Torrie (1997).

RESULTS AND DISCUSSION

GERMINATION (%)

Statistical analysis of data showed significant effects of the aqueous extracts of different plant parts of Parthenium, collected from different district of Khyber Pakhtunkhwa province on the seed germination of different wheat Varieties (Table I). The treatment means showed that maximum (100%) seed germination was recorded for the control treatment, while the minimum (79.33%) germination was found for Mardan parthenium leaves extract. (11-12). In case of tested wheat varieties, the highest germination (99.04%) was recorded for wheat variety Pak-81 while, the minimum (93.810 %) seed germination was noted for wheat variety Faisalabad 2008. In case of interaction the results showed significant difference by recording the highest (100%) germination under several treatment combination like Peshawar Parthenium stem x Pak-81 and also with other wheat varieties. However, the minimum (90.00 %) germination were recorded for Mardan Parthenium Leaves under all studied wheat varieties.(14) The weeds extracts possess the capability to hinder the germination of other weeds (15). Therefore, the presence of such weeds can reduce the grain quality and quantity of different crops so they could be properly controlled in order to avoid the yields losses in economic important crops.

Table I. Effect of different plant parts of parthenium leaf, stem and root extracts on seed germination (%) of wheat varieties

Weeds Extracts	**Wheat Varieties**					
	Pirsabak 2005	**Faisalabad 2008**	**Shahkar 2013**	**Durabi 11**	**Pak 81**	**Mean**
Peshawar Parthenium Leaves	96.67 a	96.67 a	96.67 a	100.00 a	96.67 a	97.33 b
Peshawar Parthenium Stem	100.00 a	100.00 a	100.00 a	96.67 a	100.00 a	99.33 ab
Peshawar Parthenium Root	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a
Mardan Parthenium Leaves	90.00 b	90.00 b	90.00 b	90.00 b	100.00 a	79.33 c
Mardan Parthenium Stem	100.00 a	100.00 a	100.00 a	96.67 a	100.00 a	99.33 ab
Mardan Parthenium Root	100.00 a	10.000 a	100.00 a	100.00 a	96.67 a	99.33 ab
Control	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a
Extract means	94.76 c	93.81 c	96.66 b	97.61 ab	99.048 a	

SHOOT LENGTH (CM)

The results for shoot length revealed significant effects of the aqueous extracts of different plant parts of Parthenium, collected from different district of Khyber Pakhtunkhwa province on the shoot length of different wheat varieties (Table II). The treatment means showed that maximum (8.624 cm) shoot length was recorded for the control treatment; while the minimum (0.262 cm) shoot length was found for Mardan Parthenium Leaves (Table II). Like the seed germination the varietal response of wheat was again significant in case of shoot length. However, the highest (4.288 cm) shoot length was noted for wheat variety Shahkar 2013 that was statistically at par with the wheat variety Pak 81. While the minimum (3.170 cm) shoot length was recorded for wheat variety Pirsabak 2005. In the interaction the maximum (9.493 cm) shoot length found under the treatment Pak 81 x control, while the minimum (0.240 cm) shoot length noted for

Faisalabad 2008 x Mardan Parthenium Leaves (16-17). The production of allelochemicals by plants and their exudation through volatilization and leaching into the environment manipulate the seed germination, growth and shoot length of neighbor plant (18).

Table II. Effect of different plant parts of parthenium leaf, stem and root extracts on shoot length (cm) of wheat varieties

Weeds Extracts	Wheat Varieties					
	Pirsabak 2005	Faisalabad 2008	Shahkar 2013	Durabi 11	Pak 81	Means
Peshawar Parthenium Leaves	0.520 lmn	0.386 mn	0.313 mn	0.440 lmn	0.343 mn	0.400 f
Peshawar Parthenium Stem	3.853 ghi	5.073 efg	6.730 cde	4.193 gh	5.380 efg	5.046 c
Peshawar Parthenium Root	6.070 def	5.253 efg	6.900 b-e	9.403 a	5.100 efg	6.545 b
Mardan Parthenium Leaves	0.250 n	0.240 mn	0.250 mn	0.310 mn	0.256 mn	0.262 f
Mardan Parthenium Stem	0.836 lmn	0.940 lmn	1.866 j-n	1.756 k-n	2.110 i-m	1.502 e
Mardan Parthenium Root	2.260 ijkl	3.730 ghij	5.196 efg	2.930 h-k	4.673 fgh	3.758 d
Control	8.413 abc	7.763 abcd	8.763 ab	8.686 ab	9.493 a	8.624 a
Extract means	3.170 c	3.342 bc	4.288 a	3.960 ab	3.908 ab	

FRESH SHOOT BIOMASS (G)

The perusal of the data revealed that Parthenium all parts extracts pose significant effects on fresh shoot biomass of the wheat varieties (Table III). The treatment means showed that maximum (0.509 g) fresh shoot biomass was recorded for the control treatment, while the minimum (0.030 g) fresh shoot biomass was found for Mardan Parthenium Leaves (Table III). Like the previous parameters the response of the wheat varieties were also found significant for fresh shoot biomass. The highest (0.272 g) fresh shoot biomass was noted for wheat variety Pak 81 and the minimum (0.204 g) recorded for wheat variety Faisalabad 2008. In case of interaction the maximum (0.588 g) fresh shoot biomass was recorded for Pak 81 x control and the minimum (0.026 g) fresh shoot biomass achieved for Faisalabad 2008 x Peshawar parthenium leaves. Kadıoğlu 2005 (18) reported that among the other pests weeds are the most destructive pest that responsible for the yield reduction in different crops not only by competing with crop resources but also restrict the seed germination of crop and growth retardation through the release of allelochemicals in crop environment that weaken the crop plants by reducing their biomass (19, 20).

Table III. Effect of different plant parts of parthenium leaf, stem and root extracts on fresh shoot biomass (g) of wheat varieties

Weeds Extracts	Wheat varieties					
	Pirsabak 2005	Faisalabad 2008	Shahkar 2013	Durabi 11	Pak 81	Means
Peshawar Parthenium Leaves	0.175 g-l	0.026 l	0.038 kl	0.038 kl	0.055 jkl	0.066 de
Peshawar Parthenium Stem	0.233 e-j	0.295 c-g	0.105 hijkl	0.449 abc	0.419 abcd	0.300 bc
Peshawar Parthenium Root	0.355 b-f	0.359 b-f	0.444 abc	0.286 c-g	0.304 c-g	0.349 b
Mardan Parthenium Leaves	0.163 l	0.030 kl	0.019 l	0.038 kl	0.045 kl	0.030 e
Mardan Parthenium Stem	0.058 jkl	0.084 ijkl	0.139 g-l	0.365 b-f	0.084 ijkl	0.146 d
Mardan Parthenium Root	0.165 g-l	0.248 d-i	0.271 c-h	0.206 f-k	0.306 c-g	0.239 c
Control	0.528 ab	0.387 bcde	0.518 ab	0.523 ab	0.588 a	0.509 a
Extract means	0.218 a	0.204 b	0.219 ab	0.257 ab	0.272 a	

FRESH ROOT BIOMASS (G)

Like the fresh shoot biomass the root biomass was also significantly affected by the weeds extracts prepared from different plant parts of parthenium, By describing the treatment means the maximum (0.305 g) fresh root biomass was recorded for the control treatment, while the minimum (0.078 g) fresh root biomass was recorded for Mardan Parthenium leaves (Table IV). The response of the wheat varieties was also found significant for fresh root biomass. The highest (0.215 g) fresh root biomass was noted for wheat variety Pak 81 and the minimum (0.132 g) noticed for wheat variety Faisalabad 2008. In case of interaction the minimum (0.005 g) fresh root biomass was recorded for Pirsabak 2005 x Mardan Parthenium leaves and the maximum (0.381 g) fresh root biomass noticed for Pak 81 x control (21). The presence of allelochemicals proved many times and by many scientists that different allelochemicals release from different parts of donor plant affects the receiving plant by different ways including their fresh biomass (22). Effects of leaf extracts of various weeds on germination, radicle and plumule extension of field crops have also been reported earlier by Singh *et al.,* 2019 & Macías *et al.,* 2006 (23, 24).

Table IV. Effect of different plant parts of parthenium leaf, stem and root extracts on fresh root biomass (g) of wheat varieties

Weeds Extracts	Wheat varieties					
	Pirsabak 2005	Faisalabad 2008	Shahkar 2013	Durabi 11	Pak 81	Mean
Peshawar Parthenium Leaves	0.246 a-f	0.022 fgh	0.043 efgh	0.095 c-h	0.303 abcd	0.141 bc
Peshawar Parthenium Stem	0.137 b-h	0.144 b-h	0.223 a-h	0.193 b-h	0.229 a-h	0.185 b
Peshawar Parthenium Root	0.150 b-h	0.157 b-h	0.268 a-e	0.176 b-h	0.217 a-h	0.193 b
Mardan Parthenium Leaves	0.005 h	0.011 gh	0.025 fgh	0.108 b-h	0.243 a-g	0.078 c
Mardan Parthenium Stem	0.053 efgh	0.262 a-e	0.084 d-h	0.067 efgh	0.069 efgh	0.107 bc
Mardan Parthenium Root	0.086 c-h	0.135 b-h	0.161 b-h	0.101 c-h	0.125 b-h	0.122 bc
Control	0.336 ab	0.192 b-h	0.431 a	0.249 a-f	0.318 abc	0.305 a
Extract means	0.145 a	0.132 a	0.176 a	0.141 a	0.215 a	

SEED VIGOR INDEX (SVI)

The data for SVI revealed that different weed extracts and wheat varieties both posed significant result. The means values for weed extract in Table V presented that the highest seed vigor index (1000) was noted in both control treatment and Peshawar parthenium root extract while, the least SVI (651.3) was observed in case of Mardan Parthenium Leaves extract. Similarly, the wheat varieties mean also showed significant data for SVI. The maximum (981.90) SVI was noticed for wheat variety "Pak 81" and the minimum SVI (899.12) was calculated for wheat variety "Shahkar 2013" (Table V). In case of interaction means the higher (1000.0) SVI value observed in control treatment x all studied wheat varieties and the lower (360) SVI investigated for Mardan Parthenium Leaves x wheat variety "Shahkar 2013". In other studies, (25) also noted that the water extract of *Trianthema portulacastrum* remarkably decreased the seed vigor index (SVI) of rice seeds. The instant data has a great analogy with the results of (26) who observed retardation in shoot and root length of wheat varieties after exposing to the water extract of invasive weed *Parthenium hysterophorus*. Negative effects of water extracts of different weeds on radicle and plumule expansion of different field crops have also been stated earlier by Chaudhary *et al.,* 1980 & Singh *et al.,* 2022 (27, 28).

Table V. Effect of different plant parts of parthenium leaf, stem and root extracts on Seed vigor index (SVI) of wheat varieties

Weeds Extracts	Wheat varieties					
	Pirsabak 2005	Faisalabad 2008	Shahkar 2013	Durabi 11	Pak 81	Mean
Peshawar Parthenium Leaves	936.7 a	936.7 a	936.7 a	1000.0 a	936.7 a	949.3 b
Peshawar Parthenium Stem	1000.0 a	1000.0 a	1000.0 a	936.7 a	1000.0 a	987.3 a
Peshawar Parthenium Root	1000.0 a	1000.0 a	1000.0 a	1000.0 a	1000.0 a	1000.0 a
Mardan Parthenium Leaves	446.7 d	640.0 c	360.0 e	810.0 b	1000.0 a	651.3 c
Mardan Parthenium Stem	1000.0 a	1000.0 a	1000.0 a	936.7 a	1000.0 a	987.3 a
Mardan Parthenium Root	1000.0 a	1000.0 a	1000.0 a	1000.0 a	936.7 a	987.3 a
Control	1000.0 a	1000.0 a	1000.0 a	1000.0 a	1000.0 a	1000.0 a
Extract means	911.90 cd	939.52 bc	899.52 d	954.76 ab	981.90 a	

CONCLUSION

The findings of this study highlight the strong allelopathic effects of parthenium weed on wheat seeds, emphasizing the need for farmers to **actively control its growth** in their fields. Notably, among the tested wheat varieties, Pak-81 exhibited exceptional resistance to these harmful effects, making it the best choice for cultivation.

To further explore the potential of parthenium weed, additional studies are recommended to investigate its allelopathic impact on other crops and weeds. If proven to have strong phytotoxic effects on problematic weeds, this could open the door to the development of eco-friendly bio-herbicides, offering a sustainable and natural solution for weed management in the future.

Ethical statement:

No ethical issues were raised during the course of study.

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Authors` contribution:

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

Conflict of interest:

Authors have no conflict of interest.

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