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ASSESSMENT OF ALLELOPATHIC EFFECTS OF PARTHENIUM (*Parthenium hysterophorus* L.) PLANT PARTS ON SEED GERMINATION AND SEEDLING GROWTH OF WHEAT (*Triticum aestivum* L.) CULTIVARS

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ABSTRACT

A twice repeated experiment was undertaken at the Weed Science Laboratory Khyber Pakhtunkhwa Agricultural University Peshawar investigating the allelopathic effects of root, stem and leaf aqueous extracts of parthenium (Parthenium hysterophorus L.) on the germination and seedling growth of four wheat cultivars (viz. Siran, Ata Habib, Sahar and Lasani). All the four experimental treatments; [viz. control (distilled water), parthenium root, stem and leaf aqueous extracts were replicated three times using a completely randomized design (CRD). The results revealed significant inhibitory effects (P<0.05) of the root, stem and leaf aqueous extracts of parthenium upon the seed germination and seedling growth of the four wheat cultivars tested in comparison to the control. The leaf treatment was superior among all other treatments in germination inhibition, root/shoot length, seedling root/shoot weight. In addition, the seed germination of wheat cultivar (Siran) was comparatively less inhibited by the parthenium extracts than the other wheat cultivars. Similarly, the seedling of wheat cultivar (Sim) has also shown better resistance to the parthenium extracts of root, stem and leaf than the other cultivars. The seed germination as well as the seedling growth of wheat cultivar (Lasani) was the most inhibited one by the parthenium root, stem and leaf extracts.

Key words: Allelochemicals, parthenium, seed germination and seedling growth, wheat cultivars.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most significant annual self-pollinated winter grain crop. Wheat was sown on an area of 9046 thousands ha during 2008-2009 which produced 24032.9 thousand tons grain yield with an average grain yield of 2657 kg ha^{-1} while in Khyber Pakhtunkhwa Province (KPK), it was grown on 769.5

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thousand ha area which produced 1204.5 thousand tons grain yield with an average grain yield of 1565 kg ha^{-1} (MINFAL, 2008-2009). This crop gives 14.4% to the value added in agriculture and also 3.0% to the GDP. A number of high yielding wheat cultivars are available in Pakistan including NARC-2011, Millat-11, AARI-11, Pirsabak-08 and Rskoh-05 etc. if sown properly in time, these cultivars can give higher yield per unit area, however, several production constraints (viz. shortage or unavailability of quality registered seed for sowing, high prices of various inputs, insect pests and disease and many weeds) are all causing yield losses in this crop (Hassan *et al.*, 2003; Mujahid, 2011). Weeds can cause up to Rs.28 billion losses in wheat crop in Pakistan and 2 billion in KPK Province (Hassan and Marat, 2001). Among the weeds, parthenium weed (*Parthenium hysterophorus* L.) which is although not a major weed of wheat crop currently, but it is suspected to become a major weed and may cause great production losses to the crop in the near future due to its high invasive nature.

Parthenium is an annual invasive broadleaf herbaceous plant of family Asteraceae. Its life cycle can range from 4 to 8 months under sufficient moisture conditions (Navie *et al.*, 1998; Doley, 1977). Parthenium can grow up to 30-150 cm tall and produce up to 26,000 filled seeds per plant (Nguyen *et al.*, 2010). It is native to tropical and sub-tropical Americas, and was undeliberately introduced into many countries (Parsons & Cuthbertson, 1992). Parthenium is thought to have introduced into sub-continent in 1955 through the import of food grains (Rao, 1956) and initially reported by Zeenat *et al*. (1994) in Pakistan, but its exact source of introduction into Pakistan has not been found yet, however it is suspected to have come through livestock, food commodities and or vehicles transport from India contaminated with the weed seed.

Parthenium is seen to be infesting various crops and is able to cause significant yield losses in crops such as wheat (Agarwal & Anand, 1992), maize (*Zea mays* L.) (Bhatt *et al*., 1994) and sorghum (*Sorghum bicolor* L.; Tamado & Milberg, 2004). More than 40% yield losses have been reported in crops by parthenium (Khosla & Sobti, 1981). Dense infestations of parthenium have also been recorded in various field crops in Pakistan (Shabbir & Bajwa, 2006). The weed has also been found to deteriorate quality and decline market price of crop products and cause significant economic losses to the producers (Chippendale & Panetta, 1994). It can reduce up to 90% carrying capacity of pastures (Rezene *et al*., 2005) and biodiversity of pastures and other native plants in many countries (Frew *et al*., 1996) including Pakistan (Shabbir & Bajwa, 2006). Parthenium can also act as alternative host to several crops pests [e.g. tobacco streak virus (*Ilarvirus TSV*) of sunflower and mung bean] (Sharman *et al*., 2009). Ahmad *et al*. (2003) have reported this virus from Pakistan being

present in parthenium. Parthenium is also found to be causing human and animal health issues in many countries including Pakistan (Nadeem *et al*., 2005). A number of growth characteristics of parthenium (viz. its rapid seed germination, faster growth, greater seed production, large soil seed banks and allelopathic ability) are all considered to be responsible for its invasiveness (Baker, 1974). The release of allelopathic chemicals by parthenium may be involved in the decline of plant biodiversity (Adkins & Sowerby, 1996b). Its allelopathic effects may happen through leaching, volatilization, root exudations and by its decaying plant parts (Adkins and Sowerby, 1996b; Khan *et al.*, 2011). Seed germination and seedling growth inhibition of many crops have been reported by parthenium extracts e.g. barley (*Hordeum volgare* L.) and maize (Rashid *et al*., 2008). Sesquiterpene lactones and phenolics, particularly parthenium are found to be inhibitory to seed germination and growth in many plants (Swaminathan *et al*., 1990). These allelochemicals possibly making the weed to strongly suppress crop plants growth (Singh *et al*., 2003). Oudhia (2001) have reported a significant allelopathic effect of parthenium extracts upon the seed germination and growth of wheat. Parthenium is found to be rapidly spreading in many areas of Pakistan and has become a serious weed of many habitats (Javaid & Anjum, 2006). Keeping in mind importance of allelopathic activity of parthenium that may cause greater yield losses to wheat crop in case the crop comes under its heavy infestations, the present research study was designed to investigate allelopathic effects of parthenium root, stem and leaves aqueous extracts upon seed germination and seedling growth of wheat cultivars under laboratory conditions. This could provide a base for further investigation of parthenium allelopathy under field condition upon wheat crop.

MATERIALS AND METHODS

Twice repeated laboratory experiments were conducted during winter season in November, 2011 in the Weed Science Laboratory KPK Agricultural University Peshawar (AUP) to study the allelopathic effects of parthenium root, stem and leaf aqueous extracts upon the seed germination and seedling growth of four wheat cultivars (cvs.). Mature plants of parthenium were harvested from New developmental Research Farm, KPK, AUP and their roots, stems and leaves were separately cut using a pair of shears and dried under shade for 25 days until all the moisture present in the parthenium plant parts was removed. The completely dried roots, stems and leaves were then grinded using a grinder into fine powder form. The powder of parthenium roots, stem and leaves (each 75 g) were separately soaked at room temperature (21 ± 2^{o}C) in one liter distilled water, dissolved and left for 24 hours, and then filtered through two layers of

muslin cloth to obtain their aqueous extracts. The experiment was laid out using a Completely Randomized Design (CRD) and each treatment replicated three times. The experiment was repeated two times. Forty eight plastic made Petri dishes (9 cm diameter in size) were randomly arranged inside the Weed Science Laboratory and lined with three layers of tissue paper (Triple Horse Tissue Ltd. Hayatabad, Peshawar). Seed of four wheat cvs. (viz. Siran, Ata Habib, Sahar and Lasani) were thoroughly cleaned manually and 10 seeds of each cv. were carefully placed into each Petri dish using a forceps. The 3 mL aqueous extract obtained previously each from the roots, stems and leaves of parthenium was applied on each Petri dish and 3 mL quantity of distilled water was applied on the control Petri dishes using disposable syringes. All Petri dishes were covered with their respective lids and kept at room temperature (25 ± 2^{o}C). This action was continued throughout the course of the experiments. After noticing seed germination, the lids were carefully removed as to record seed germination as well as allow the seedlings to grow up. The experiment was looked after regularly for its entire duration of 12 days. Those seeds inside all Petri dishes were considered germinated whose radicals were appeared and counted visually. This activity was undertaken for two weeks time until all the seeds were either germinated and/or expired. The roots and shoots length of all the seedlings was measured using a plastic measurement rod while their fresh weight was measured using an electrical balance at the 12th day growth stage. The second run of the experiment was undertaken immediately after completion of its first run using similar experimental protocols. Data recorded during both the runs of the experiment was added and means were taken. The data means were then accordingly subjected to Analysis of Variance (ANOVA) individually using MSTATC statistical analysis package and means were separated by least significance test (LSD; Steel and Torrie, 1980) to identify significant differences.

Treatments applied	**Rate of application (g L^{-1})**
T1.Control	0
T2. Parthenium (root aqueous extract)	75
T3. Parthenium (stem aqueous extract)	75
T4. Parthenium (leaf aqueous extract)	75

Parameters recorded

1. All wheat cultivars seed germination (%).
2. All wheat cultivars shoot length per plant (cm).
3. All wheat cultivars root length per plant (cm).
4. All wheat cultivars fresh shoot weight per plant (g).
5. All wheat cultivars fresh root weight per plant (g).

RESULTS AND DISCUSSION

Seed Germination

Statistical analysis of the data showed significant ($p<0.05$) affect of aqueous extracts of parthenium root, stem and leaf on the seed germination of all wheat cultivars (Table-1). The maximum seed germination (98%) was achieved for the control treatment and the minimum (20%) was found for the leaf extract of parthenium (Table-1). Visual observations have also shown a great effect of the parthenium root, stem and leaf extracts on the seed germination of the wheat (Plate 1). This indicates that parthenium leaf extract was most inhibitory to the seed germination of all the used wheat cvs. Our results are in line with those of Oudhia (2001) and Scrivanti (2010) both of them have observed root, stem and leaf extracts of parthenium highly inhibitory on the seedling growth of native bluestem (*Andropogon gerardii*), lettuce seeds (*Lactuca sativa*), maize, winter green paspalum (*Paspalum guenoarum*) and lovegrass (*Eragrostis curvula*), however, they have also found that parthenium extracts had less inhibitory effect upon seed germination of these species which may be due to their tolerance to the allelochemicals that may have been released by parthenium. Similarly, Maharjan *et al*. (2007) have also found leaf extract of parthenium the most inhibitory to the seed germination of wheat and other crops. In this present study, seed germination of wheat was greatly reduced by the weed aqueous extracts applied which shows low tolerance to the weed allelopathic activity. As overall, the data revealed that the extracts of parthenium plant parts had lowest inhibitory effect upon the seed germination of wheat cv. Siran by achieving highest seed germination (76%) while cv. Lasani was found to be greatly affected and achieved lowest seed germination (66%; Table-1). This indicates that some wheat cvs. may possess tolerance against the allelopathic activity of parthenium and could be used to minimize production losses due to this weed.

Shoot length

The ANOVA showed a significant inhibitory effect of the parthenium root, stem and leaf aqueous extracts upon the shoot length of all the four wheat Cvs. ($p<0.05$). The shorted shoot length (0.4 cm) was seen in Petri dishes that received the leaf aqueous extract of the weed plant parts while the longest shoot length (8.4cm) was noticed in Petri dishes applied with the distilled water (control; Table-2). Visual observations have also shown a great effect of the parthenium root, stem and leaf extracts on the seedling growth of the wheat (Plate 1). Similar results have also been recorded in earlier studies (Singh & Sangeeta, 1991) in which the root, stem and leaf extracts of parthenium had significantly inhibited the roots and shoots elongation of wheat and other cereal crops.

Table-1. Seed germination (%) of the four wheat cultivars tested against the root, stem and leaf aqueous extracts obtained from the parthenium.

Wheat Cultivars	Treatments applied				Means
	Control (distilled water)	Root aqueous extract	Stem aqueous extract	Leaf aqueous extract	
Siran	100.0a	98.3a	93.3ab	15.0f	76.6a
Ata Habib	100.0a	96.7ab	83.3c	18.3ef	74.5a
Sahar	98.3a	90.0bc	71.7d	21.7ef	70.4b
Lasani	96.7ab	71.7d	71.7d	25.0e	66.2c
Means	98.7a	89.1b	80.0c	20.0d	-

LSD for parthenium root, stem and leaf extract= 3.813 and LSD for wheat Cvs.= 3.76. Different letters alongside the numbers indicate significant differences.

In addition, the higher concentration of parthenium leaf extracts have greatly reduced the seed germination, shoot length, shoot weight, root length and root weight of soybean (*Glycine max* L.), mungbean (*Vigna radiata* L.) and maize (Khan *et al*., 2011). The highest inhibitory effect of parthenium leaf is thought to be due the presence of high quantity of photochemical in its leaf (Kanchan, 1975; Kanchan and Jayachandra, 1980). On the other hand, wheat cv. Siran had produced the longest shoot length (4.3cm) while *cv*. Lasani of wheat had yielded the shortest shoot length (2.4 cm) when treated with the aqueous extracts of parthenium root, stem and leaf (Table-2).

Root length

Statistical analysis has shown significant ($P<0.05$) effect of the root, stem and leaf aqueous extracts of parthenium upon the seedlings root length of the four wheat cultivars. (Table-3). The maximum seedlings root length (4.2cm) was observed in Petri dishes which received the distilled water (i.e. the control) treatment while the minimum (0.2cm) seedlings root length for Petri dishes applied with the parthenium leaf extracts (Table-3). These observations showed that parthenium leaf may possess higher concentration of the phytochemicals that are strongly inhibitory to the root growth of wheat after it comes in contact to the seedlings root of the wheat as has been previously described for various crops and weeds (Bhowmik and Doll, 1984; Quasem, 1995). Our results are in also analogy to those presented by Tefera (2002) and Maharjan *et al*. (2007) who reported parthenium leaf extract strongly inhibitory to the root growth of several cereal crops. Wheat *cv*. Scrivanti gave the least seedlings root length (1.4cm) while the wheat cv. (Ata Habib) had produced the highest shoot length (2.2cm) when these cultivars seed was applied the root, stem and leaf extracts of parthenium (Table-3).

Table-2. Shoot length per plant of the four wheat cultivars tested against the root, stem and leaf aqueous extracts obtained from parthenium.

Wheat Cultivars	Treatments applied				Means
	Control (distilled water)	Root aqueous extract	Stem aqueous extract	Leaf aqueous extract	
Siran	9.7a	4.2d	1.6f	0.9hi	4.3a
Ata Habib	8.2b	2.6e	1.0gh	0.4i	3.0b
Sahar	6.9c	1.4fg	0.8hi	0.4i	2.7c
Lasani	8.6b	1.5fg	0.3i	0.2i	2.4d
Means	8.4a	2.4b	0.9c	0.4d	-

LSD for parthenium root, stem and leaf extract= 0.4436 and LSD for wheat cvs.= 0.2353. Different letters alongside the numbers indicate significant differences.

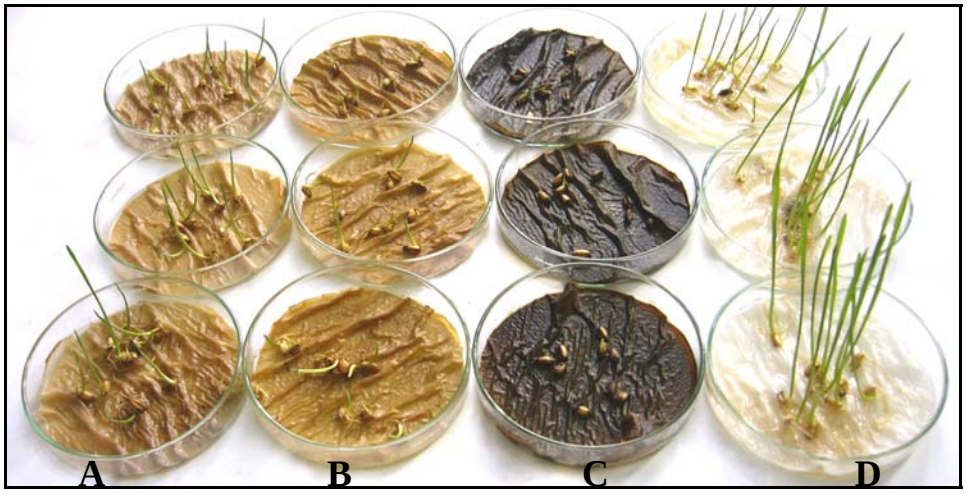

Plate 1. One replicate pots of the 12-day old wheat cv. Siran seedlings as effected by the parthenium root (A), stem (B), leaf (C) aqueous extracts and the control (D). Note the greatly inhibitory effect of parthenium aqueous extracts upon the wheat cultivars seedlings shoot growth.

Seedlings Fresh Root Mass

Analysis of the data showed significant inhibitory effect of the root, stem and leaf extracts upon the fresh root mass of the four wheat cultivars. ($p<0.05$; Table- 4) The leaf extract of the weed had shown the highest inhibition and the wheat cultivars. had produced the lowest root mass per plant (0.02g) in case of the leaf extract application in comparison to the control treatment where the maximum per plant root mass (0.1 g) was recorded.

Table-3. Root length per plant (cm) of four the wheat cultivars tested against the root, stem and leaf aqueous extracts obtained from the parthenium.

Wheat Cultivars	Treatments applied				Means
	Control (distilled water)	Root aqueous extract	Stem aqueous extract	Leaf aqueous extract	
Siran	4.3b	2.3e	1.3f	0.2hij	2.0b
Ata Habib	5.1b	2.1e	1.3f	0.3ghi	2.2a
Sahar	3.6d	1.3f	0.6g	0.1j	1.4c
Lasani	4.0c	1.2f	0.5gh	0.1ij	1.4c
Means	4.2a	1.7b	0.9c	0.2d	-

LSD for parthenium root, stem and leaf extract= 0.1637 and LSD for wheat cvs.= 0.1331. Different letters alongside the numbers indicate significant differences.

Tefera (2002) and Maharjan *et al*. (2007) have also presented similar findings. They recorded significant reduction in the biomass of wheat and other cereal crops seedlings when treated with the vegetative parts of parthenium. This growth inhibitory effect of the weed extracts upon the seedlings growth of wheat may have had occurred due to presence of parthenin in parthenium plant, as has been demonstrated earlier (Patil and Hedge, 1988). The four wheat cvs. seedlings gave statistically similar fresh root mass against the parthenium root, stem and leaf aqueous extracts (Table-4). This indicates that the wheat cvs. have similar tolerance to the weed allelopathic inhibition effect.

Table-4. The fresh root mass per plant (g) of the four wheat cultivars tested against the root, stem and leaf aqueous extracts obtained from the parthenium.

Wheat Cultivars	Treatments				Means
	Control (distilled water)	Root aqueous extract	Stem aqueous extract	Leaf aqueous extract	
Siran	0.10a	0.02bc	0.02bc	0.002c	0.04a
Ata Habib	0.10a	0.02bc	0.01bc	0.002c	0.04a
Sahar	0.10a	0.01c	0.01bc	0.001c	0.04a
Lasani	0.10a	0.03b	0.02bc	0.002c	0.04a
Means	0.10a	0.02b	0.01b	0.002c	-

LSD for parthenium root, stem and leaf extract= 0.0145 and LSD for wheat cvs.= 0.0108. Different letters alongside the numbers indicate significant differences.

Seedlings Fresh Shoot Mass

Significant inhibitory effect of the root, stem and leaf aqueous extracts of parthenium was found upon the fresh root mass of the four

wheat cultivars ($p<0.05$) as in Table-5). The lightest fresh shoot mass per seedling (0.002g) was noted for the parthenium leaf extract while the heaviest (0.1g) shoot mass was recorded in the control treatment (Table-5). This shows higher concentration of parthenium (i.e. the growth inhibitory chemicals) in the leaves of the weed than in its stem and roots as has been demonstrated in earlier studies (Kanchan & Jayachandra, 1980). These results can be supported by the work of Maharjan *et al*. (2007) who found significant allelopathic inhibition of parthenium plant extracts on shoot growth of wheat and other crop species. However, Wakjira *et al*. (2006) have reported that the wheat plant is itself allelopathic upon the growth of parthenium because the application of wheat straw extract had reduced growth performance of the weed. All the wheat cvs. have shown statistically same seedlings shoot mass per plant under the parthenium root, stem and leaf aqueous extracts activity (Table-5).

Table-5. Seedlings fresh shoot mass per plant (g) of four wheat cultivars tested against the root, stem and leaf aqueous extracts obtained from the parthenium.

Wheat Cultivars	Treatments applied				Means
	Control (distilled water)	Root aqueous extract	Stem aqueous extract	Leaf aqueous extract	
Siran	0.10a	0.02bc	0.02bc	0.002c	0.04a
Ata Habib	0.11a	0.02bc	0.01bc	0.002c	0.04a
Sahar	0.11a	0.01c	0.01c	0.001c	0.04a
Lasani	0.10a	0.03b	0.02bc	0.002c	0.04a
Means	0.10a	0.02b	0.01b	0.002c	-

LSD for parthenium root, stem and leaf extract= 0.0145 and LSD for wheat cvs. = 0.0108. Different letters alongside the numbers indicate significant differences.

CONCLUSION

The current study suggests that parthenium possesses strong inhibitory effects on the seed germination and seedling growth of wheat. Further, the wheat cultivar Siran seed germination and seedling growth showed highest tolerance against parthenium extracts while the wheat *cv*. Lasani showed susceptibility to the weed extracts. The allelopathic effect of parthenium leaf extract was significantly greater inhibitory on the seedling growth of wheat cultivars, compared to its stem and root extracts. However, this allelopathic activity of the weed may be different in field conditions due to the large difference of environmental conditions. Therefore, further studies are suggested to confirm this activity under field conditions.

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