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PHYTOREGULATORY EFFECTS OF FOLIAR APPLIED AQUEOUS EXTRACTS OF THREE WEED SPECIES ON SEEDLING GROWTH OF BARLEY, MUSTARD AND SESAME

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ABSTRACT

Background Weeds exude allelochemicals into the immediate environment which may have the ability either to promote or inhibit the germination and seedling growth of surrounding crops. It is, therefore, imperative to identify weed species manifesting phytoregulatory effects on growth of crops occupying the same niche.

Methodology A wire house study was conducted following completely randomized design with four replications and two repeats to investigate the suppressive or stimulatory effects of foliar applied aqueous extracts of three problematic arable weed species namely *Adiantum capillus-veneris, Parthenium hysterophorus* and *Sisymbrium orientale* on seedling growth of barley, mustard and sesame.

Results Weed extracts exerted inconsistent and differential allelopathic effects on growth and physiological parameters of test crop seedlings. Foliar application of aqueous extract of *Sisymbrium orientale, Adiantum capillus-veneris* and *Parthenium hysterophorus* caused 171.79, 100.27 and 111.62% increase in leaf area and 41.25, 60.61 and 29.77% decrease in electrolyte leakage of barley seedlings over control. Root, shoot length and fresh biomass of barley seedlings were not significantly ($p \leq 0.05$) influenced by these extracts. Contrastingly *Sisymbrium orientale* extract caused maximum reduction in leaf area, chlorophyll content, root and shoot length of mustard seedling, while highest reduction in its fresh and dry weight was recorded with the application aqueous extract of *Adiantum capillus-veneris.* The exposure of sesame seedlings to aqueous extract of *Parthenium hysterophorus* resulted in minimum leaf area (15.71 mm^2) while, minimum chlorophyll content and fresh weights were recorded with the application of *Adiantum capillus-veneris* aqueous extract.

Conclusion This study demonstrated that chemical interference of these weed extracts (most likely involving phenolic) in establishment of barley seedlings was stimulatory whereas it is detrimental for mustard and sesame seedlings.

INTRODUCTION

In agricultural crop production system, crop quality and yield is compromised by many abiotic and biotic factors (Valiki et al. 2015). Among them, weeds are the most important biotic factor responsible for deteriorating the quality and quantity of crop produce. They are present everywhere in arable fields and hinder The germination, growth, development and hence yield of nearby growing economic crops. They mostly interfere with crops seedling growth and establishment by discharging various allelochemicals (Hayyat et al. 2020). They are known as the threat to natural and agro ecosystems (Shabbir et al. 2018). Extensive invasion of weeds has been recognized as the most important reason for more than one-third of the losses in yield of crops that are cultivated all over the world (Jabran et al. 2015). Weed infestation causes production losses

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up to 15-40% in cotton, 58-85% in soya bean, 35-69% in mung bean, 10-60% in wheat, 10 to 100% in rice and 25-93% in maize (Kolhe et al. 1998; Yadav and Singh 2005; Yaduraju et al. 2015).

The secretions of weeds have great ability either to inhibit or promote germination of seeds and seedling growth of the surrounding weeds and crops, this is known as allelopathy (Nadeem et al. 2020). They are released into surrounding environment by the exudation of roots, leaching from upper ground parts and volatilization or by plant material decomposition (Dutta and Devi 2012). Allelopathic interactions between crops and weeds gained key consideration of the scientists which are involved in the research of allelopathy (Singh et al. 2007). For first time, De Candolle (1932) reported the injurious impact of Canada thistle (*Cirsium arvense*) root exudates on growth of surrounding oat plants. After that numerous species of weeds are documented to have some allelochemicals that influence the nearly grown crops (Mulatu et al. 2009). Previous research (Nasrine et al. 2011) has confirmed that *Melilotus indica* aqueous extract reduces germination, shoot and root length of maize. Reinhardt et al. (1994) documented the negative influence of *Chenopodium album* on germination and growth stages of onion. Aqueous extracts of *Parthenium* spp. retarded the germination of teff (*Eragrostis teff*) seeds (Tefera 2002). Chaghtai et al. (1988) found that *Fumaria indica* allelo-chemicals halted *Triticum aestivum* germination and seedling. Iqbal et al. (2006) reported the inhibitory impact of *Lycoris radiate* on the alfalfa crop. Moreover, *Melilotus indica* extract inhibited the germination and growth of maize (Nasira and Ahmed 2009).

Adiantum capillus-veneris, P. hysterophorus and Sisymbrium orientale weed species are important component of the weed flora invading field crops in Pakistan. They grow profusely in uncultivated as well as cultivated fields, waste lands, lawns, canal banks and roadside areas. The available information about the possible allelopathic effects of these weeds on barley, mustard and sesame growth is scanty and non-systemic. The present study was undertaken to evaluate the allelopathic effects of aqueous extracts of three noxious arable weed species i.e. *Adiantum capillus-veneris*, *P. hysterophorus* and *Sisymbrium orientale* on early seedling growth and physiological attributes of three economically important crops namely barley (*Hordeum vulgare*), mustard (*Brasicca compestris*) and sesame (*Sesamum indicum*).

MATERIALS AND METHODS

Plant extract preparation

The naturally growing plants of three weed species namely, *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* were uprooted from Soan valley during their flowering stage. The plant samples were cleaned twice with the distilled water to eliminate any kind of contamination. These samples were placed separately at room temperature for shade drying with zero periods of sunlight. After shade drying, electric blender was used for individually grinding these samples to make fine powder. After grinding, fine powder of each specie was preserved separately in tightly sealed plastic zipped bags to avoid moisture contact.

A 5 g ground powder of all these weed species was soaked separately in 100 ml of the distilled water for 24 hours and filtered by muslin cloth (Rice 1984; Qasem and Foy 2001). These weed extracts were used to evaluate their phytoregulatory effects on physiological and growth parameters of barley, mustard and sesame seedling under wire house conditions.

Experimental site, design and treatments

To evaluate the allelopathic effects of aqueous extracts of *Adiantum capillus-veneris*, *Parthenium hysterophorus and Sisymbrium orientale* on early seedling growth of barley, mustard and sesame a wire house experiment was conducted at College of Agriculture, University of Sargodha in completely randomized design with four replications and repeated twice.

Experimental procedure and data recorded

Firstly, pots having 9 cm depth were filled with the 500 g fine soil and ten seeds of barley, mustard and sesame were planted uniformly in pots. After germination of crops at three leave stage, foliar application of aqueous extracts of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* was done according to the treatment plan. The distilled water treatment was included as control. The data regarding seedling fresh biomass (mg), seedling dry biomass (mg), root length (cm), shoot length (cm), electrolyte leakage (%), leaf area (mm^2) and chlorophyll content (SPAD value) were recorded. Seedling fresh biomass was recorded 10 days after application of extract with the help of weight balance. The seedlings were dried in the oven for 48 hours at 64°C and then weighed to record dry biomass with the help of weight balance. Ten seedlings from every treatment and replication were selected at random and their root and shoot lengths were measured in cm. Then average root and shoot lengths were worked out by using standard formulae. To determine electrolyte leakage (%), leaf samples of each crop was taken from all treatments and replications separately. Each sample was placed in 20 ml distilled water for 24 hours and

EC was taken by EC meter and denoted as EC_1. Then these plant mixtures were autoclaved for 15 minutes and again EC was measured as EC_2. Electrolyte leakage was calculated by the equation (Whitlow et al. 1992)

$$\text{Electrolyte leakage (\%)} = EC_1 / EC_2 \times 100$$

Five plants were selected from every pot and their leaf areas were noted by using leaf area meter (CI-202, Portable Laser Leaf Area Meter). To measure leaf chlorophyll contents, five plants of each crop were selected from each pot at random. The SPAD (Soil Plant Analysis Development) chlorophyll values of 3 top most fully opened leaves of these plants were recorded by chlorophyll meter (Yaxin 1260). The mean SPAD values were calculated by using standard procedure (Peng et al. 1993).

Statistical analysis

The data collected were analyzed by using Fisher's analysis of variance technique and means were equated at 5% significance level by using Honestly Significant Difference Test (Steel et al. 1997).

RESULTS AND DISCUSSION

Barley growth and physiological characteristics

Leaf area

Leaf area of barley was significantly ($p \leq 0.05$) influenced by aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* plants (Table 1). The barley plants subjected to the distilled water control treatment produced the lowest leaf area (16.79 mm^2) while maximum leaf area (45.62 mm^2) of barley crop seedling was noted when treated with aqueous extract of *Sisymbrium orientale*. This study depicted that leaf area of barley seedling was significantly increased with application of aqueous extracts of *Sisymbrium orientale, Adiantum capillus-veneris* and *Parthenium hysterophorus* as compared to control treatment. It was probably due to stimulatory effect of allelochemicals in aqueous extracts of these species. These results were confirmed by Ilori et al. (2007), who also observed the promotive impact of *Tithonia diversifolia* aqueous extract on growth and germination of *Oryza sativa*.

Chlorophyll contents

Chlorophyll contents of barley seedlings were not significantly influenced by foliar application of aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* plants (Table 1). The aqueous extract of *Sisymbrium orientale* limited the chlorophyll content (22.81) of barley crop, however it was not significantly lower than other treatments. These observations were supported by the findings of Murimwa et al. (2019) who reported that the post emergence sprays of sorgaab herbicide did not significantly ($p \leq 0.05$) affect chlorophyll contents of goose grass.

Electrolyte leakage

Aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* significantly influenced the electrolyte leakage of barley leaves (Table 1). The data indicated that lowest value of electrolyte leakage (14.31%) of barley crop was observed when aqueous extract of *Adianthum capillus* was applied while distilled water (control treatment) resulted in maximum electrolyte leakage (36.32%). These findings are contradictory to the results of Joanna et al. (2016) who found that the aqueous extract of *Galium aparine* L. increased the electrolyte leakage of corn seedlings at higher concentration (5%) as compared to control and lower concentrations. This variation in our results may be due to low concentration of phenolics in aqueous extracts which stabilized the barley leaf membranes.

Fresh weight

Barley seedling fresh weight was significantly influenced by aqueous extract of the whole plant of *Adiantum capillus-veneris, Parthenium hysterophorus* and *Sisymbrium orientale* is presented in Table 2. The data indicated that *Adianthum capillus* produced lowest barley seedling fresh weight (0.12 mg) which was followed by aqueous extract of whole plants of *Sisymbrium orientale* and *Parthenium hysterophorus* whereas maximum seedling fresh weight (0.20 mg) of barley crop was achieved when treated with distilled water. Above findings are supported by Gulzar and Siddiqui (2017), who found that root exudates of *Asphodelus microcarpus*, significantly decreased dry and fresh weights of *Portulaca oleracea*.

Shoot length

Shoot length (cm) of barley seedlings were not significantly influenced by the application of aqueous extracts of *A. capillus-veneris*, *P. hysterophorus* and *Sisymbrium orientale* plants (Table 2). The data indicated that *A. capillus-veneris* resulted in smallest shoot length (18.12 cm) of barley crop while maximum shoot length (20.68 cm) of barley was observed when *P. hysterophorus* extract was applied. These outcomes were different from the reports of Jiang et al. (2015), who found that application of water extract of onion bulbs at 60 g L^{-1} content significantly decreased the cotton root and shoot height.

Root length

Root length of barley was not significantly influenced

Table 1 Phytoregulatory effect of different weed extracts on leaf area, chlorophyll content and electrolyte leakage of barley (*Hordeum vulgare*) seedlings

Treatments	Leaf area (mm^2)	Chlorophyll content (SPAD)	Electrolyte leakage (%)
Control	16.78b	24.57	36.31a
Adianthum capillus extract	35.51a	24.55	14.30d
Parthenium hysterophorus extract	33.61a	25.29	25.47b
Sisymbrium orientale extract	45.62a	22.81	21.33c
HSD (0.05)	14.06	NS	3.88

HSD = Honestly Significant Difference; NS = Non-significant. Means sharing same letter in a column do not differ significantly at 5% probability level.

Table 2 Phytoregulatory effect of different weed extracts on shoot, root length, fresh and dry weight of barley (*Hordeum vulgare*) seedlings

Treatments	Shoot length (cm)	Root length (cm)	Fresh weight $seedling^{-1}$ (mg)	Dry weight $seedling^{-1}$ (mg)
Control	17.28	12.62	0.20 a	0.026a
Adianthum capillus extract	18.11	12.61	0.12 c	0.012c
Parthenium hysterophorus extract	20.67	12.99	0.16 b	0.020b
Sisymbrium orientale extract	18.88	11.78	0.13 c	0.014c
HSD (0.05)	NS	NS	0.03	0.00341

Means sharing same letter in a column do not differ significantly at 5% probability level

by foliar application of aqueous extracts of *Adiantum capillus-veneris*, *P. hysterophorus* and *Sisymbrium orientale* plants (Table 2). Data depicted that aqueous extract of *S. orientale* resulted in lowest root length (11.79 cm) of barley seedlings which was non-significantly followed by aqueous extract of whole plants of *A. capillus-veneris*, distilled water and *P. hysterophorus*. Our findings are contrary to the remarks of Jiang (2015) who reported that the onion bulb water extract sprayed at 60 g L^{-1} significantly reduced the length of cotton root and shoot.

Dry weight

Dry weight of barley seedling was significantly influenced by the application of aqueous extracts of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* weeds (Table 2). Data indicated that application of *Adianthum capillus* caused lowest seedling dry weight (0.01 mg) of barley and maximum seedling dry weight (0.026 mg) of barley crop was noted when they were treated with distilled water (control treatment). Our findings were in line with findings of Gulzar and Siddiqi (2017) who found that dry weights of *Portulaca oleracea* plants were significantly reduced by the application of *Asphodelus microcarpus* root exudates.

Mustard growth and physiological characteristics

Leaf area

In response to foliar spray of aqueous extracts of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale*, the leaf area of mustard was significantly influenced (Table 3). The application of *Sisymbrium orientale* aqueous extract produced the lowest leaf area (32.43 mm^2) of mustard seedlings and maximum leaf area (99.48 mm^2) of mustard seedlings was noted when these were sprayed with distilled water (control). Our results were in accordance with the findings of Mushtaq et al. (2010) who reported that foliar spray of water extract mixture of sunflower + brassica + sorghum + mulberry significantly reduced leaf area of *Trianthema portulacastrum* L.

Leaf chlorophyll content

Leaf chlorophyll content of mustard seedlings were significantly influenced by aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* weeds (Table 3). Data indicated that chlorophyll content of mustard crop were minimum when they were simply sprayed with distilled water and maximum (25.30) mustard chlorophyll content were recorded with the application of *Parthenium hysterophorus* water extract. An increase in chlorophyll content of mustard examined with the spray of aqueous extract of *Parthenium hysterophorus* might be due to stimulatory effects of allelochemicals present in its composition. These results were opposite to Khaliq et al. (2010) who reported that aqueous leaf extract of *Coronopus didymus* decreased the chlorophyll content of horse purslane and increased phenolics of targeted plants.

Electrolyte leakage

Data regarding the impact of aqueous extracts *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* on electrolyte leakage of mustard is presented in the Table 3. Aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* expressively reduced electrolyte leakage from mustard leaves. Among all the treatments, the *Adianthum capillus* caused lowest electrolyte leakage (41.43%) of mustard crop which was followed by aqueous extract of whole plants of *Parthenium hysterophorus* and *Sisymbrium orientale*. The maximum electrolyte leakage (87.45%) of mustard crop was recorded, when these received controlled treatment. Our findings were contradicted with Skrzypek et al. (2015) who noted that electrolyte leakage of sunflower seedling increased with the application of higher concentration (15%) of an aquatic extract of peppermint leaves.

Fresh weight

Mustard seedling fresh weight in response to the foliar application of aqueous extracts of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* is given in the Table 4. *Adianthum capillus* extract resulted in lowest seedling fresh weight (0.21 mg) of mustard crop while maximum mustard seedling fresh weight (0.37 mg) was observed when they were raised under controlled treatment. Our results were in line with Javaid et al. (2008) who found that aqueous extract of rice plants significantly reduced dry and fresh biomass of *P. hysterophorus*.

Shoot length

The shoot length of mustard seedling was not significantly influenced by aqueous extract of weeds (Table 4). Data demonstrated that aqueous extract of *Adiantum capillus-veneris* produced lowest shoot length (9.10 cm) of mustard crop which was non-significantly followed by application of aqueous extracts of whole plants of *Parthenium hysterophorus* and *Sisymbrium orientale.* Highest shoot length (10.75 cm) of the mustard crop was noted when seedlings were grown with distilled water control. Our results were contrary to the observations of Khaliq et al. (2013) who reported that aqueous leaf extract of *Coronopus didymus* decreased shoot and root length of wheat.

Root length

Effect of foliar spray of aqueous extracts of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* on root length of mustard is shown in Table 4 and it was found non-significant. The non-significant effect of aqueous extract of these species was probably due to better tolerance of mustard roots to the phenolics present in these extracts. These observations were opposite to the findings of Skrzypek et al. (2015) who reported that foliar spray of *Parthenium hysterophorus* L. at higher concentrations significantly increased the seedling length of *Triticum aestivum* and *Avena fatua*.

Dry weight

Data regarding dry weight of mustard seedling as influenced by the foliar spray of aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* is presented in the Table 4. The perusal of data indicated that dry weights of seedling were reduced by the application aqueous extract of these weeds. The *Adianthum capillus* extract produced lowest seedling dry weight (0.004 mg) of mustard crop while maximum dry weight was found in control treatment (0.012 mg). Our findings were in line with findings of Gulzar and Siddiqui (2017) who found that dry weights of *Portulaca oleracea* plants were significantly reduced by the application of *Asphodelus microcarpus* root exudates.

Sesame growth and physiological characteristics

Leaf area

Data regarding leaf area of sesame as influenced by the application of aqueous extract of whole plant of *Parthenium hysterophorus, Adiantum capillus-veneris* and *Sisymbrium orientale* is presented in Table 5. The data indicated that *Parthenium hysterophorus* extract produced lowest leaf area (15.71 mm^2) of sesame crop while *Sisymbrium orientale* and *Adiantum capillus-veneris* extract produced maximum leaf area of sesame crop seedling. Our results were supported by the findings of Dadkhah and Rassam (2016) who reported that foliar application of water extract of sugar beet caused 43.2% reduction in the leaf area of *Convolvulus arvensis* over control treatment.

Leaf chlorophyll contents

Data regarding leaf chlorophyll content of sesame as influenced by the application of aqueous extract of whole plant of *Parthenium hysterophorus, Adiantum capillus-veneris* and *Sisymbrium orientale* is presented in Table 5. Data indicated that maximum (27.43) chlorophyll contents were observed when sesame seedlings were treated with *Parthenium hysterophorus* extract while *Adianthum capillus* and *Sisymbrium orientale* extracts produced significantly lower chlorophyll contents. An inhibition of chlorophyll contents perceived with the use of aqueous extract of *Sisymbrium orientale* and *A. capillus* might be due to more phytotoxicity of allelochemicals existing in their extracts. According to Khaliq et al. (2013) foliar applied aqueous extracts of *Helianthus annuus*, *Sorghum bicolor*, *Brassica compestris*, *Eucalyptus*

Table 3 Phytoregulatory effect of different weed extracts on leaf area, chlorophyll contents and electrolyte leakage of mustard (*Brasicca compestris*) seedling

Treatments	Leaf area (mm^2)	Chlorophyll content (SPAD)	Electrolyte leakage (%)
Control	99.47a	20.92b	87.44a
Adianthum capillus extract	47.25b	24.51ab	41.43d
Parthenium hysterophorus extract	45.54b	24.97a	66.81b
Sisymbrium orientale extract	32.43b	21.53ab	52.31c
HSD (0.05)	15.51	3.89	5.51

Means sharing same letter in a column do not differ significantly at 5% probability level.

Table 4 Phytoregulatory effect of different weed extracts on shoot, root length, fresh and dry weight of mustard (*Brasicca compestris*) seedling

Treatments	Shoot length (cm)	Root length (cm)	Fresh weight $seedling^{-1}$ (mg)	Dry weight $ssedling^{-1}$ (mg)
Control	10.755	3.3575	0.3748a	0.0125a
Adianthum capillus extract	9.1075	4.3475	0.2075c	0.0045b
Parthenium hysterophorus extract	10.205	3.4675	0.2965b	0.0095ab
Sisymbrium orientale extract	9.7550	4.1375	0.2635b	0.0065b
HSD (0.05)	NS	NS	0.041	0.00535

Means sharing same letter in a column do not differ significantly at 5% probability level

Table 5 Phytoregulatory effect of different weed extracts on leaf area, chlorophyll contents and electrolyte leakage of sesame (*Sesamum indicum)* seedling

Treatments	Leaf area (mm^2)	Chlorophyll contents (SPAD)	Electrolyte leakage (%)
Control	22.75b	27.225a	49.86a
Adianthum capillus extract	33.22a	24.005b	55.46b
Parthenium hysterophorus extract	15.71c	27.435a	92.40b
Sisymbrium orientale extract	34.15a	25.195b	74.81b
HSD (0.05)	3.39	1.87	41.72

Means sharing same letter in a column do not differ significantly at 5% probability level

Table 6 Phyto-regulatory effect of different weed extracts on shoot, root length, fresh and dry weight of sesame (*Sesamum indicum)* seedling

Treatments	Shoot length (cm)	Root length (cm)	Fresh weight $seedling^{-1}$ (mg)	Dry weight $seedling^{-1}$ (mg)
Control	6.16b	2.75b	0.3468	0.0070
Adianthum capillus extract	6.81a	4.03a	0.3175	0.0055
Parthenium hysterophorus extract	6.59ab	2.99ab	0.3260	0.0055
Sisymbrium orientale extract	6.40ab	2.55b	0.3388	0.0042
HSD (0.05)	0.65	1.18	NS	NS

Means sharing same letter in a column do not differ significantly at 5% probability level

camaldunensis, *Morris alba* and *Withania somnifera* inhibited the chlorophyll contents, biomass accumulation, lateral plant spread and root shoot length of rice.

Electrolyte leakage

Data regarding electrolyte leakage of sesame as influenced by the application of aqueous extract of whole plant of *Parthenium hysterophorus*, *Adiantum capillus-veneris* and *Sisymbrium orientale* is presented in Table 5. The data indicated that distilled water (control) caused lowest electrolyte leakage (49.86%) of sesame crop while maximum electrolyte leakage (92.40%) was recorded in *P.hysterophorus* extract. Our results were contradicted with the findings of Hassan et al. (2018) who reported that foliar spray with higher concentrations of *Parthenium hysterophorus* significantly inhibited the electrolyte leakage of all tested species (*Triticum aestivum*, *Avena fatua*, and *Lepidium* sp.).

Fresh weight

Data regarding fresh weight of sesame seedling as influenced by the application of aqueous extract of whole plant of *Parthenium hysterophorus, Adiantum capillus-veneris* and *Sisymbrium orientale* is presented in Table 6. Data indicated that *Adianthum capillus* application produced lowest sesame seedling fresh weight (0.32 mg) while maximum (0.35 mg) was recorded in control. Our results were contradictory from the findings of Hassan et al. (2018) who reported that foliar spray of higher concentrations of *Parthenium hysterophorus* extract significantly inhibited the seedling weight and seedling length of all tested species (*Triticum aestivum*, *Avena fatua*, and *Lepidium* sp.).

Shoot length

Data regarding shoot length (cm) of sesame as influenced by the application of aqueous extract of whole plant of *Parthenium hysterophorus, Adiantum capillus-veneris* and *Sisymbrium orientale* is presented in Table 6. The perusal of data indicated that control treatment exhibited lowest shoot length (6.16 cm) of sesame crop, while maximum shoot length (6.81 cm) was observed with the application of *Adianthum capillus.* Our observations were similar to the findings of Oyerinde et al. (2009) who reported that application of fresh shoot aqueous extract of *T. diversifolia* significantly increased shoot length of maize plants.

Root length

Data regarding root length (cm) of sesame as influenced by the application of aqueous extract of whole plant of *Parthenium hysterophorus*, *Adiantum capillus-veneris* and *Sisymbrium orientale* is presented in Table 6. Data indicated that maximum root length (4.03 cm) of sesame seedling was produced by the application of aqueous extract of *Adianthum capillus* whereas aqueous extract of *Sisymbrium orientale* produced lowest root length (2.55 cm) of sesame crop. Our results were supported by Mushtaq et al. (2010) who found significant increase in rice root length as a result of parthenium extract application.

Dry weight

The foliar application of aqueous extract of *Adiantum capillus-veneris*, *Parthenium hysterophorus* and *Sisymbrium orientale* did not significantly affect sesame seedling dry weight (Table 6). The *Sisymbrium orientale* extract produced sesame seedling with lowest dry weight (0.004 mg) which was not significantly different from other treatments. Our findings were opposite to the observations of Mushtaq et al. (2010) who reported that two foliar sprays of water extract mixture of sunflower + brassica + sorghum + mulberry significantly reduced dry matter production of *Trianthema portulacastrum* L.

CONCLUSION

The allelopathic activity of *Sisymbrium orientale*, *Adiantum capillus-veneris* and *Parthenium hysterophorus* weeds largely varied with the target crop species. Foliar application of aqueous extracts of all these weeds stabilized barley seedling growth by causing significant increase in leaf area and decrease in electrolyte leakage; however, mustard and sesame seedling growth was adversely affected with concomitant decrease in leaf area, chlorophyll content, root and shoot length. It is therefore recommended that these weeds must be removed from mustard and sesame crops to avoid their detrimental effects on early seedling establishment. Moreover, barley seedling growth stabilizing potential of these weeds needs to be explored further.

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