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Allelopathic Effect of Aqueous Extracts of Pigweed, *Amaranthus retroflexus* L. Organs on Germination and Growth of Five Barley Cultivars

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Abstract. In order to evaluate the allelopathic effects of aqueous extract of pigweed, *Amaranthus retroflexus,* different organs on germination and growth of five barley cultivars, an experiment was conducted as factorial based on completely randomized design with three replications. Experimental factors were barley cultivars at five levels including Fajr 30, Nosrat, Valfajr, Reyhan and Kavir and extract of pigweed organs (leaf, stem and root) in 10 percent concentration and distilled water was considered as control. Traits including germination rate, radicle length, plumule length, fresh weight and dry weight of seedlings were measured. The results of variance analysis showed different significant effects of pigweed organs' extracts on most measured traits in five studied barley cultivars. According to the results, Reyhan, Valfajr and Kavir were more tolerant to pigweed allelochemicals in germination rate than Fajr and Nosrat. Except Fajr, all cultivars showed some levels of tolerance to allelopathic effects of pigweed organs' extracts in most traits measured. Besides germination rate, Fajr was also very susceptible to extract of all three weed organs in other traits, including radicle length, plumule length, fresh weight and dry weight of seedlings. It was concluded that farming Fajr barley cultivar most probably may result in an increased yield loss duo to allopathic effects of pigweed. In the other hand, Reyhan and Kavir were more tolerant than other cultivars to pigweed allelochemicals, and so their planting may cause reduced pigweed damage.

Key words: allelopathy, weed organs, tolerance, pigweed, *Amaranthus retroflexus,* barley.

1. Introduction

About 250 weed species cause problems in agricultural crops production (1). Weeds seriously compete with crops due to their high adaptatitive potential with the environment, and so they are considered as one of the most important crop yield reducing factors. Besides competition with crops, weeds reduce crops' growth and yield by releasing allelopathic substances (4). Economic damage of weeds has been reported more than 100 billion dollars in the world (6).

Red-root pigweed, *Amaranthus retroflexus* is considered as one of the most hazardous weeds in all over the world and its allelopathic effects is well known. Pigweed extracts contains allelochemicals such as Aldehydes, Alkaloids, Apocarotenoids, Flavonoids, Steroids, Xyloids, Clerogenic acid and Saponyns (2). Allelochemical substances is secreted by aerial organs of pigweed and released through washing by rain or irrigation water to the soil (3, 5).

Weeds may disrupt germination and growth of agricultural crops by chemicals production leading to lower yield production (10). Allelopathy is an important mechanism in which plants disperse toxic substances in the environment as their competitive strategies (7, 8). Allelochemicals were released in different ways such as leaching from plant tissues by rain and dew and excretion from plant roots (9). Allelopathy is an important environmental friendly approach to weeds control, to yield increase and herbicide application reduction (10, 11).

Many researchers evaluated the allelopathic effects of pigweed on different crops. Pigweed extracts reduced soybean and corn growth (2). Reduced seed germination rate, stem length, root length and seedling dry weight has also been reported by extracts from pigweed stems and roots (5). Letournea *et al.* (1956)

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reported that the extract derived from pigweed in 2 grams dry matter in 100 ml water reduced seed germination and seedlings root length in wheat (11).

The present study was carried out for evaluation the allelopathic effects of different pigweed organs' extracts on germination and growth of barley cultivars to determine sensitive and tolerant cultivars to chemicals produced by pigweed.

2. Material and methods

2.1 Treatments

The research was carried out in Miyaneh Branch, Islamic Azad University as factorial based on completely randomized design with three replications in 2010. Experimental factors were barley cultivars at five levels (Fajr30, Nosrat, Valfajr, Reyhan and Kavir) and extract of pigweed organs in 10% concentration at three levels (leaf, stem and root), and distilled water was considered as control.

2.2 Sampling and plant extract preparation

Pigweed was collected from fields of different crops in Miyaneh region and the weed leaves, stems and roots were blended separately after drying in an oven with 50˚C for 72 hours. For extract preparation, 10 grams of powdered plant material were suspended in 100 ml distilled water and mixed for 24 hours by a horizontal rotary shaker for producing uniform extract. Finally, centrifugation was performed using a Mikro-22R centrifuge (Hettich, Germany) at 6000 rpm for 30 minutes at 10˚C and the obtained extract was considered as 10% concentration.

2.3 Bioassay tests

To investigate the allelopathic effect of weed extracts on germination and initial growth of sorghum cultivars in the laboratory, sorghum seeds were disinfected superficially by 70% ethanol for 1 minute and by 2.5% sodium hypochlorite solution for 3 minutes and then were washed four times by sterile distilled water. Twenty sorghum seeds were placed in Petri dishes with sterile filter paper inside and 5 ml extract were added on and incubated in 25 ± 1 ˚C in dark condition. Petri dishes were sealed with Parafilm for reducing evaporation. Seed germination percentage, radicle and plumule length and seedling fresh and dry weight were recorded after 15 days incubation.

2.4 Experimental design and data analysis

The experiment was conducted as factorial based on completely randomized design with three replications. The data were analyzed using GLM procedure by SAS software and Duncan's multiple rRange test was used for mean comparisons at 1% probability level.

3. Results and discussion

According to results of analysis of variance (table 1), the effect of different pigweed organs' extracts and the interaction of pigweed organs with barley cultivars was significant in seed germination percent, radicle and plumule length and fresh and dry weight of barley seedlings at 1% probability level. The significant interaction of the studied factors means that the effect of extracts from different pigweed organs was different on germination and growth of barley cultivars studied.

Table 1. Mean squares of pigweed organs' extracts effect on germination and growth related characteristics of barley cultivars

Source of variation	df	Germination percentage	Radical length	Coleoptile length	Seedling fresh weight	Seedling dry weight
Weed organ	2	27.56^{**}	56.95^{**}	110.01^{**}	43.46^{**}	43.72^{**}
Cultivar	4	1.55^{ns}	3.58^{ns}	2.60^{ns}	3.05^{ns}	3.44^{ns}

Organ * Cultivar	8	5.48**	9.62**	6.28**	7.19**	9.06**
Error	30	0.58	2.37	5.03	1.57	2.47
Coefficient of variation (%)		9.27	22.56	38.60	15.46	19.71

**: significant at 1% probability level (Duncan's multiple range test)

3.1 Seed germination

Seed germination percentage of Fajr and Nosrat cultivars was decreased substantially by all pigweed organs' extracts (Fig.1) In Valfajr and Kavir cultivars, the hazardous effect of weed's stem extract on barley seed germination was more than two other pigweed organs studied, while germination of Reyhan was influenced by weed's leaf extract. The least allelopathic effect of pigweed on barley germination was belong to weed's root extract in Kavir, Reyhan and Valfajr and pigweed stem extract in Reyhan cultivars. On the whole, Kavir and Valfajr were more tolerant to pigweed root extract. Reyhan was also more tolerant to weed root and stem extracts than others in germination. However, Fajr and Nosrat were susceptible to extract from all weed organs tested

3.2 Radicle length

Fajr cultivar was susceptible to all pigweed organs' extracts studied. The results revealed that Nosrat and Reyhan were susceptible to weeds' leaf extract and Nosrat and Kavir were susceptible to weeds' stem extract. In conclusion, Reyhan showed good tolerance to extracts from stems and roots and Valfajr was tolerant to all pigweed organs' extract. Nosrat had also tolerance to root and leaf extracts (Figure 2).

3.3 Plumule length

According to Figure (3), pigweed leaf extracts was more allelopathic than stem's extract. Stem extract had also more allelopathic effect than root extract in plumule length. It is concluded that allelopathic substances in pigweed leaves were more than roots and stems.

3.4 Seedling fresh weight

According to Figure (4), Fajr was the most sensitive cultivar to all extracts from pigweed different organs in seedling fresh weight. The extracts from all three organs significantly reduced fresh weight of Fajr seedlings. The most tolerance to pigweed leaf extract was observed in Reyhan and Kavir. Reyhan had also good tolerance to root and stem extracts, while Kavir was susceptible to the last mentioned organs' extracts.

3.5 Seedling dry weight

Figure (5) shows the effect of different pigweed organs' extracts on the reduction of pigweed seedlings dry weight compared to control. Based on the results, tolerance of Kavir to pigweed leaf extract and tolerance of Valfajr and Nosrat to root extract was more than other cultivars studied. Based on the results of present study, Fajr was susceptible to all three pigweed organs' extracts. Reyhan, Kavir and Valfajr were more tolerant than Fajr and Nosrat cultivars in terms of germination percentage. All cultivars, except Fajr, showed some levels of tolerance to extracts from pigweed organs.

This study demonstrated that allepathic substances derived from pigweed organs such as Saponins, Phenolic and Benzoic acid compounds significantly reduced germination and growth of barley cultivars. In the present study, extracts from different pigweed organs caused 33.17-100 percent reduction in barley seed germination compared to the control. Considerable reduction of barley seeds germination by pigweed extracts have also been reported by other researchers (2). Extracts derived from different organs of pigweed have reduced corn and sugar beet seeds germination up to 60.8 and 53.4 percent, respectively (2). According to Mirshekari (2003), pigweed roots and stems' extracts reduced germination and growth of sorghum plants. Significant inhibition of pigweed extracts on root growth of corn, beans and squash have also been reported (8). Seedling fresh weight of wheat, barley, canola, sugar beet and corn was reduced by pigweed extracts, too (2).

Growing susceptible barley cultivars to allelopathic substances of pigweed may results in an increased herbicides application rate duo to decreasing weed economic injury level (EIL). Based on the results, it seems that planting Fajr cultivar may increase allelopathic induced damage of pigweed to barley. In the other hand, Reyhan and Kavir were more tolerant than other cultivars to pigweed allelochemicals, and so their planting may cause reduced pigweed damage.

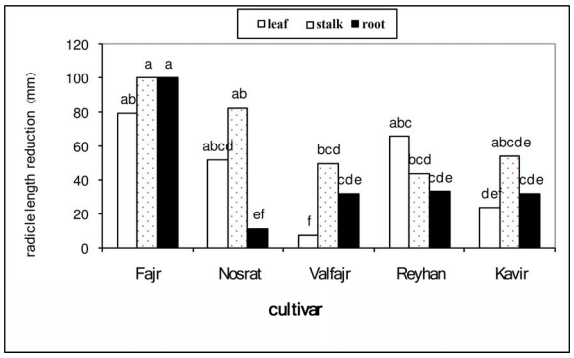

Fig. 2. Radical length reduction in barley cultivars compared to control by extracts from pigweed organs

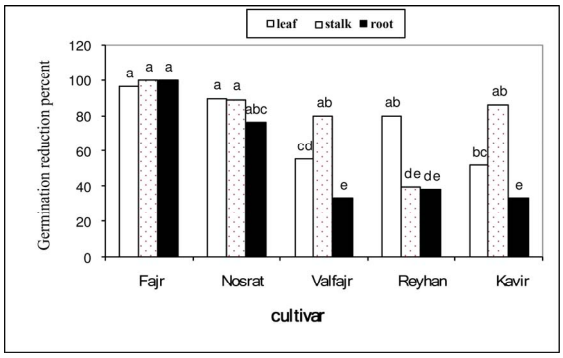

Fig. 1. Germination reduction in barley cultivars compared to control by extracts from pigweed organs

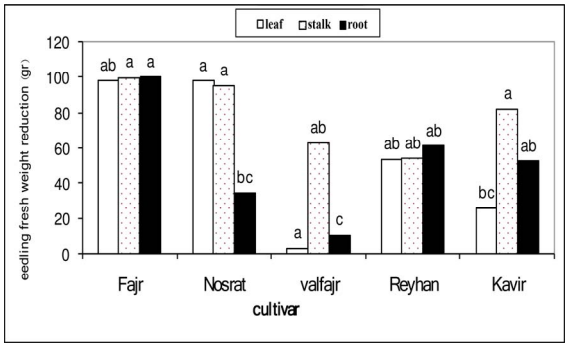

Fig. 5. Seedling dry weight reduction in barley cultivars compared to control by extracts from pigweed organs

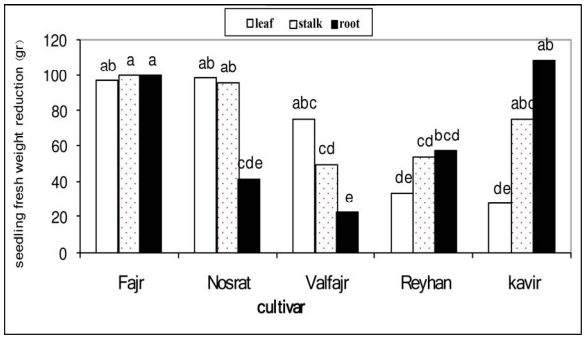

Fig. 4. Seedling fresh weight reduction in barley cultivars compared to control by extracts from pigweed organs

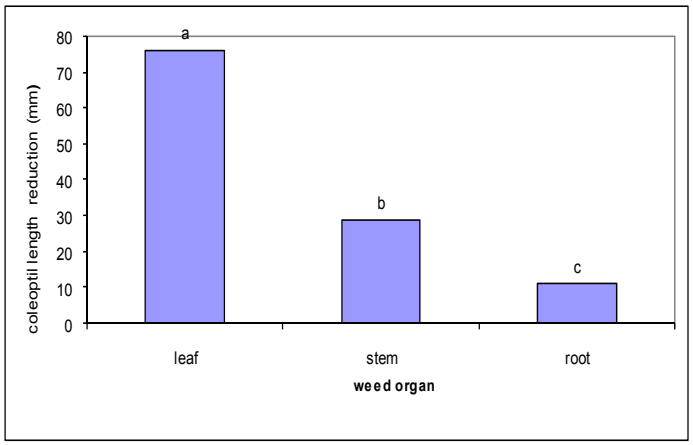

Fig. 3. Plumule length reduction in barley cultivars compared to control by extracts from pigweed organs

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