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Short Communication

Allelopathic Effects of Wild Barley (*Hordeum spontaneum* Koch) Extracts on Growth of Five Wheat (*Triticum aestivum* L.) Cultivars

D. Hamidi*, H. Ghadiri, M.J. Bahrani, A. Moradshahi [1] , and R. Hamidi

Agronomy Department, College of Agriculture, Shiraz University, Shiraz, Iran.
[1] *Biology Department, College of Science, Shiraz University, Shiraz, Iran.*
*Author for Correspondence: *donyahm612001@yahoo.com*

ABSTRACT

Greenhouse studies were conducted to examine the effects of wild barley shoot and root extracts on five wheat cultivars including Shiraz, Chamran, Darab-2, Cross-Azadi, and Falat growth. After 12 weeks, plants were harvested and leaf area, dry weight, and stem length were determined. Shoot extracts significantly reduced dry weight in Darab-2 and Cross-Azadi cultivars. Plant height was significantly reduced at shoot extract concentrations of 6 and 9 g/L in Chamran and Cross-Azadi cultivars. All concentrations of root extract significantly reduced leaf area in Falat cultivar. Most severe inhibitory effects of root extract on dry weight and plant height were observed in Cross-Azadi and Falat cultivars, respectively. The results showed that wild barley has allelopathic potential to reduce wheat growth and that wild barley shoot extract exerted more allelopathic effects on wheat growth than that of root.

Key Words: Inhibitory Effects, Allelopathy, *Hordeum Spontaneum*, Shoot and Root Extracts, Growth Traits, Wild Barley.

INTRODUCTION

A number of weed and crop species have been reported to possess allelopathic activity on the growth of other plant species (Ashrafi et al. 2008). Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, by the release of chemicals from plant parts by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems. Different plant parts, including flowers, leaves, leaf litter and leaf mulch, stems, bark, roots, soil and soil leachates and their derived compounds, can have allelopathic activity that varies over a growing season (Asghari and Tewari 2007, Rizvi et al. 1992, Uludag et al. 2006). Several phytotoxic substances, causing germination and/or growth inhibitions, have been isolated from plant tissues and soils. These substances, collectively known as allelochemicals, are usually secondary plant products or waste products of main metabolic pathways of plants (Chon and Kim 2002). Barley is well known for its allelopathic compounds. Several phenols and terpenes have been reported in various cultivars of barley (Macias et al. 2004, Spring et al. 1992). Under certain conditions, these compounds are released in to the environment, either as exudates from living tissues or by decomposition of plant residues in sufficient quantities to affect neighboring or succesional plants (Einhelling 2008). This same cultivar of barley was also found to be phytotoxic to durum wheat (*Triticum durum* L.) and bread wheat (*T. aestivum* L.). Seedling growth bioassays demonstrated that the two wheat species responded differently to the allelopathic potential of barley with a greater sensitivity shown by the bread wheat (Ashrafi et al. 2007, Hamidi and Ghadiri 2011). Various plant parts may vary in their allelopathic potential (Chon and Kim 2002). Leaves and roots were the most phytotoxic barley plant parts for bread wheats (Narwal 1994). Hordenine, as a major component of barley root which released up to a maximum 2 μg plant^{-1} day^{-1} for up to 60 days in a hydrophonics system, is responsible for the growth retardation (Asghari and Tewari 2007). Consequently, barley should be considered a depressive prior crop for both durum wheat and bread wheat in a field cropping sequence. However, studies with other species have reported that the response to allelochemicals may be concentrationdependent (Asghari and Tewari 2007). The allelopathic potential of a barley plant on other plant varied according to the source of extracts as was found with sorghum and white mustard (Kolahi and Kolahi 2008, Moncef et al. 2001). The present study was conducted to determine the allelopathic potential of wild barley, a problematic weed in wheat fields in Iran. The main objective was to determine the effects of wild barley shoot and root extracts on the growth of wheat.

MATERIAL AND METHODS

Mature and green wild barley shoots and roots were collected from wheat field and dried in oven for 48 hours at 48 °C for shoot and 48 hours at 55 °C for roots. The wild barley shoots and roots were chopped to 1-2 cm long pieces and then, 1 to 9 g shoots and 3, 6, 9, 12, 15 g roots were soaked in 1000 mL distilled water for 24 hours at 24-25 °C. The extracts were collected and filtered through 2 layers of Whatman # 2 filter paper and used for conducting experiments.

Wheat Seed Bioassay

Seeds of Wheat 5 cultivars including Shiraz, Chamran, Darab-2, Cross Azadi, and Falat were soaked in 1% sodium hypochlorite solution and then thoroughly rinsed with deionized water. Twenty five centimeter diameter plastic pots were filled with 3 kg of soil. Then 25 seeds of each wheat cultivar were sown to each pot. After emergence, seedlings were thinned to 10 per pot. Then shoot and root extracts were added to each pot at rates of 3, 6, 9 g dried shoots of wild barley per 1 liter water and 5, 10, 15 g dried roots of wild barley per 1 liter water. Each pot received the related extracts in the rate of the field capacity (500 mL every two days). Tap water in the rate of FC was used for the control treatment. The experiment was continued for 12 weeks. After the period, plants were harvested from the above soil surface and leaf area, dry weight, and stem length were determined. Treatments (extracts from the various plant parts and tap water control) were arranged in a completely randomized design (CRD) with three replications. All experiments were repeated twice and pooled mean values were separated using Duncan`s new multiple range test at the 0.05 probability level following an analysis of variance.

RESULTS AND DISCUSSION

Shoot extracts reduced leaf area in all cultivars (Table 1). The reduction was the most severe at maximum concentration of extract (9 g/L). Inhibitory effects of shoot extract were the most in Darab-2 cultivar and the reduction at 3, 6, and 9g L^{-1} extract was 23.72, 31.00, and 40.31%, respectively, compared to check. Shoot dry weight of 5 wheat cultivars was reduced by all shoot extract concentrations, but the reduction was significant in Darab-2 and Cross-Azadi cultivars. Comparison between two these cultivars showed that the reduction was more severe in Darab-2 cultivar and was 42.85, 42.85, and 57.14, respectively, compared to check (Table 1). Plant height in all cultivars was reduced by wild barley shoot extract and the reduction was more severe at 6 and 9 g/L extract concentrations. The most severe reduction was observed in Cross-Azadi cultivar and was 10.41, 16.84, and 21.50% at 3, 6, and 9 g L^{-1} extract concentrations respectively compared to check (Table 1).

Root extracts of wild barley had allelopathic effects on wheat growth and reduced all variables. Leaf area reduced in all treatments. The reduction was significant at all extract concentrations (5, 10, and 15 g L^{-1}) only in Falat cultivar and it was 24.87, 53.60, and 68.01% respectively compared to check (Table 2). Root extract at 10 and 15 g L^{-1} concentrations reduced wheat dry weight significantly in all cultivars (Table 2). The reduction was more severe at 10 and 15 g L^{-1} extract concentrations in Cross-Azadi and Shiraz cultivars. The reduction was 45.36 and 68.57% for Cross-Azadi cultivar and 43.15 and 53.93% for Shiraz cultivar at 10 and 15 g L^{-1} root extract concentrations respectively compared to check (Table 2).

Plant height was affected significantly by root extract at 10 and 15 g L^{-1} extract concentrations. Plant height in Falat and Darab-2 cultivars was the lowest at 10 and 15 g L^{-1} root extract concentrations and the reduction was 24.34 and 34.81% for Falat cultivar and 21.83 and 40.71% for Darab-2 cultivar respectively compared to check (Table 2).

These results suggest that wild barley had a potential to reduce the growth of plants as well as other plant species (Chon and Kim 2002). When susceptible plants are exposed to allelochemicals, germination, growth, and development may be affected. The most frequent reported gross morphological effects on plants are inhibited or retarded seed germination and effects on shoot and root development (Kruse et al. 2000). Barley is known as a “smother” crop. This effect has both been

Table 1. Effects of wild barley shoot extracts on growth traits of 5 wheat cultivars.

Wheat cultivars	Wild barley shoot extract concentrations (g L^{-1})			
	0	3	6	9
Leaf area (cm^2)				
Shiraz	6.13 c*A**	5.93 bA	5.12 bAB	3.89 bB
Chamran	8.48 abA	6.75 abB	6.13 abB	5.70 aB
Darab-2	8.26 abA	6.30 abB	5.70 abB	4.93 abB
Cross Azadi	9.36 aA	7.69 aB	6.94 aB	6.45 aB
Falat	7.70 bA	6.14 bB	5.38 bBC	4.47 bC
Shoot dry weight (g)				
Shiraz	0.22 cA	0.20 aA	0.19 aA	0.18 aA
Chamran	0.30 abcA	0.26 aA	0.25 aA	0.23 aA
Darab-2	0.42 aA	0.24 aB	0.24 aB	0.18 aB
Cross Azadi	0.38 abA	0.23 aB	0.23 aB	0.19 aB
Falat	0.27 bcA	0.20 aA	0.19 aA	0.16 aA
Plant height (cm)				
Shiraz	38.07 bcA	34.90 abAB	31.87 bB	10.76 cC
Chamran	44.07 aA	39.93 aAB	37.78 aB	35.50 aB
Darab-2	36.37 cA	32.60 bAB	31.77 bAB	29.60 bB
Cross Azadi	42.27 abA	37.87 aAB	35.15 abB	33.18 abB
Falat	35.93 cA	34.67 aA	32.86 bA	31.37 abA

* Means within each column with the same letters (small letters) are not significantly different at 5% level according to Duncan's new multiple range test.
** Means within each row with the same letters (capital letters) are not significantly different at 5% level according to Duncan's new multiple range test.

Table 2. Effects of wild barley root extracts on growth traits of 5 wheat cultivars.

Wheat cultivars	Wild barley root extract concentrations (g L^{-1})			
	0	5	10	15
Leaf area (cm^2)				
Shiraz	41.06 a*A**	34.06 abA	23.89 aB	18.09 aB
Chamran	36.47 abA	29.78 abAB	22.58 aBC	15.19 abC
Darab-2	41.64 aA	35.52 aAB	27.07 aB	16.16 abC
Cross Azadi	31.20 bA	25.13 bAB	20.00 aB	12.71 bC
Falat	38.92 abA	29.24 abB	18.06 aC	12.45 bC
Shoot dry weight (g)				
Shiraz	0.89 aA	0.64 aAB	0.50 aB	0.41 aB
Chamran	0.80 aA	0.67 aAB	0.50 aBC	0.38 aC
Darab-2	0.72 aA	0.66 aAB	0.53 aB	0.39 aB
Cross Azadi	0.64 aA	0.46 aAB	0.35 aBC	0.20 aC
Falat	0.65 aA	0.55 aAB	0.38 aBC	0.23 aC
Plant height (cm)				
Shiraz	51.15 abcA	48.84 abA	44.84 aAB	39.16 aB
Chamran	53.19 abA	51.78 aA	43.11 aB	37.50 aB
Darab-2	56.72 aA	50.56 abAB	44.34 aB	33.63 abC
Cross Azadi	47.00 bcA	42.33 bcAB	37.93 abBC	32.24 abC
Falat	44.81 cA	38.58 cAB	33.89 bBC	29.21 bC

* Means within each column with the same letters (small letters) are not significantly different at 5% level according to Duncan's new multiple range test.
** Means within each row with the same letters (capital letters) are not significantly different at 5% level according to Duncan's new multiple range test.

attributed to the competitive ability for nutrients and water and to the indirect effects of allelochemicals released from the part of the plant. Also the residues of barley have been associated with phytotoxicity (Lovett and Houll 1995). Phytotoxic phenolic compounds, including ferulic, vanillic and phydroxybenzoic acids, have been identified in cold water extract of barley straw and in methanol extracts of living barley roots (Borner 1960). The two alkaloids, gramine (N, N-dimethyl-3-amino-methylindole) and hordenine (N,N-dimethyl-tyramine) have been confirmed to play an important role in the phytotoxic ability of barley (Lovett and Houll 1995). Hydroxamic acids are absent in cultivated barley, but DIBOA has been found in wild *Hordeum* species (Kruse et al. 2000). Hence, the production of DIBOA by cultivated barley could possibly be achieved by transferring genetic material from wild barley species (Gianoli and Niemayer 1998). Gramine is not present in seeds or roots of barley, but is a constituent of barley leaves. In the leaves, gramine is located in mesophyll parenchyma and in epidermis. Both the surface gramine and some inner gramine can be released by rain (Kruse et al. 2000). The content of gramine in barley shoots reaches a maximum during the first two weeks of growth of barley seedlings, decreasing afterwards to near zero for some genotypes. The effect on the release of gramine does not seem to have been investigated (Lovett and Houll 1995). The gramine content in wild barley was considerable higher both in the leaves and on their surface. Both gramine and hordenine has been reported to inhibit the growth of various plants (Deef and Abd EL-Fattah 2008).

The mode of action of allelochemicals can broadly be divided into a direct and indirect action (Rizvi et al. 1999). The direct action involves the biochemical/ physiological effects of allelochemicals on various important processes of plant growth and metabolism. Processes are influenced by allelochemicals involve.

Mineral uptake allelochemicals can alter the rate of which ions are absorbed by plants (Harper and Balk 1981). The results showed that wheat growth was reduced by wild barley extracts. The Comparison between shoot and root extract showed that shoot extract had more severe inhibitory effects on wheat growth. The reduction was increased with increasing the extract concentrations. Barley has the potential to be allelopathic, although the level of effects might differ. This indicates that allelochemicals produced by barley species have strong potential to be inhibit other plants. Barley varieties are widely known to have secondary chemicals that might act as allelopathic agents. It can be concluded that barley is potentially allelopathic (Yansen 2007).

The present study indicates that different parts of wild barley possess inhibitory effects on wheat growth. Aqueous root extracts of wild barley inhibit more than those of shoots. Ecofriendly extract formulations can be developed using allelochemicals as bioherbicides which could be safe to human and environment. However, more investigations are required under field conditions to establish them as commercial bioherbicides.

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