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Allelopathic effects of aqueous extracts of different organs of redroot pigweed (*Amaranthus retrofelexus* L.) on summer savory (*Satureja hortensis* L.)

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Abstract

In order to demonstrate the allelopathic effects of different organs (root, shoot and whole plant) of redroot pigweed (*Amaranthus retrofelexus* L.) on germination, emergence, growth and development of summer savory (*Satureja hortensis* L.) under laboratory and greenhouse conditionan experiment was carried out as CRD design with nine and five replications at laboratory and greenhouse of the Faculty of Agriculture, University of Tabriz, Iran, respectively. Results showed the significant effects of different organs aqueous extracts (AEs) of redroot pigweed on germination percentage, germination rate and normal seedlings percentage. Germination rate decreased by shoot, root and whole plant AEs compare with control. Shoot and whole plant AEs of redroot pigweed were able to reduce summer savory biomass more than the root aqueous extract.

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Introduction

Weeds are the most severe and widespread biological constraint to crop production and cause invisible damage till the crop is harvested. Weeds are undesirable plants which compete with main crops in the growth media for nutrients, moisture, space, light and hamper the healthy growth ultimately reducing the growth and yield both qualitatively and quantitatively. Allelopathy is defined as inhibitory/stimulatory the effect(s) of one plant on other plants through the release of chemical compounds in the environment (Rice, 1984). Allelopathy interactions are primarily based on the ability of certain species to produce secondary chemical compounds that exert some sort of biological effects on other organisms, many of which are unknown. The chemical causing the allelophatic effects are called allelochemicals. Allelopathy is characterized by a reduction in plant emergence or growth, reducing their performance in the association (Florentine *et al*., 2006).

Allelopathy provides a relatively cheaper and environmental friendly weed control alternative. This can be considered as a possible alternative weed management strategies (Cheema *et al*., 2000). The world consumption of medicinal plants as pharmaceuticals, cosmetics and as a food supplement for the improvement of human welfare is increasing day by day. One of the possible solutions is allelopathy, the utilization of the chemical interaction between plants by introducing modern biological and ecological methods. The various methods such as race, frequency control, chemical, mechanical and on chemical as properties of plants allelopathic weed control are applied in weed control management systems.

Allelochemicals emancipated as residues, exudates and leachates by many plants from leaves, stem, roots, fruit and seeds reported to interfere with growth of other plants (Asgharipour and Armin, 2010). These chemicals products mainly affect plants at seed emergence and seedling levels (Alam and Islam, 2002; Hussain *et al*., 2007; Naseem *et al*., 2009). The allelopathic potential of several weeds have been studied in the laboratory (Bhowmik and Doll, 1984). Batish *et al*., (2007) conducted experiment using residue of Chenopodium murale on the growth of chickpea and pea and found that their root and shoot length significantly decreased.

The present study was conducted to examine the allelopathic effects of aqueous extracts of different organs of redroot pigweed (*A. retrofelexus* L.) on germination, emergence, growth and development of summer savory (*S. hortensis* L.) in the University of Tabriz.

Materials and methods

Two experiments were conducted in the Medicinal Plants Laboratory and Research Greenhouse of Faculty of Agriculture, University of Tabriz, Iran in order to evaluate the phytotoxic effects of different organs of redroot pigweed (*Amaranthus retrofelexus* L.) on germination, emergence, growth and development of summer savory (*Satureja hortensis* L.). Treatments included the aqueous extracts (AEs) of whole plant, shoot and root of redroot pigweed and distilled water as control. Redroot pigweed plant materials were gathered during the late stages of growth from experimental fields of Agriculture Research Center of Tabriz University in Karkaj. Plant material were separated to whole plant, shoot and root, rinsed in shade at about 30-50°C and then, were grinded for extraction.

Preparation of aqueous extracts

Fifty grams of grinded material was soaked with 500 ml of distilled water (1:10 w/v) and then shacked for 24 hrs. Aliquots were filtered for separation of plant residues from AE. In the next step extracts were diluted as 2% w/v for greenhouse and laboratory experiments.

Laboratory experiment

This experiment was replicated 9 times in a CRD design. Germination tests were conducted in 10-cm diameter Petri dishes with 25 seeds laid on a double layer Watman N 2 paper supplemented with 5 ml of

AE at 20°C and 12 hrs light period. For evaluation of seed germination percentage plant sample were kept in the germinator for 10 days. Mean rate of seed germination was calculated by using the following equation Majnonhoseini (1994):

$$R = 100 \times \frac{\sum n}{\sum Dn}$$

In this equation, stands for mean rate of seed germination, n: number of germinated seeds per defined day and D: day from experiment commence.

Greenhouse experiment

This experiment was conducted as CRD with 5 replications. Greenhouse temperature and light period were set at 24±6°C and 16 hrs, respectively. Pots (21 cm diameter × 23 cm height) were filled with medium grade perlite. Fifty seeds were spread on the surface of pot and covered with fine grade perlite. Each pot was irrigated with 1.2 liters of AE as spray.

Statistical Analysis

Significant differences were determined using ANOVA and separation of means using Duncan's New Multiple Range Test (P≤0.05).

Results and Discussion

Germination test

The analysis of variance revealed significant effects of different organs AEs of redroot pigweed on germination percentage, germination rate and normal seedlings percentage (Table 1). All traits significant decreased by different organs AE compared with control (Table 2). Germination percentage and rate decreased by shoot, root and whole plant AEs compared with control, also were no significant difference among the redroot pigweed organs AEs and the highest germination rate was found in the control but normal seedlings percentage decreased by whole plant AE more than root AE (Table 2). Benyas *et al.* (2009) reported that shoot and whole plant AE of *Chenopodium album* and *Xanthium strumarium* had destructive effects on the seedling growth of summer savory compared root AE. Some researchers reported the allelochemicals exhibited inhibitory effects on physiological processes that translate to growth (Jefferson *et al.*, 2003). El-Rokiek and Eid (2009) reported that the inhibitory effects of eucalyptus on weeds correlated with accumulation internal contents of total phenols, compared to their respective controls. Sharokhi *et al.* (2012) reported that seed germination percentage of two wheat cultivars was significantly decreased by different organs AEs of redroot pigweed.

Table 1. Analysis of variance for aqueous extracts (AE) of redroot on germination characteristics in summer savory

S.O.V.	df	M.S.		
		Germination percentage	Germination rate	Normal seedlings percentage
Weeds aqueous extract	3	839.11**	0.0063**	4.59**
Error	32	125.33	0.00069	0.123
C.V. (%)	-	17.86	9.39	1.66

** indicate significant at 0.01 level of probability

The same result was found in other study showed that AEs of Eucalyptus leaves inhibited significantly the germination of *Brassica juncea* and *Brassica campestris*, the extract inhibited the growth of the roots and stems of four receptor plants, and the inhibition exhibited concentration dependence because of Malondialdehyde contents in leaves and remarkably reduced the root vigor (Zhu, 2011). Shoot, root and whole plant AEs were due to the abnormal of seedlings (Fig.1). Allelochemicals inhibits plant root growth through generation of reactive oxygen species (ROS) induced oxidative damage (Gholami *et al.*, 2011).

Table 2. Mean values for aqueous extracts (AE) of redroot pigweed on germination characteristics in summer savory.

Treatment	Germination percentage (%)	Germination rate	Normal seedlings percentage (%)
Shoot	55.56 b	0.275 b	4.44 bc
Whole plant	55.56 b	0.259 b	1.33 c
Root	63.56 b	0.266 b	5.33 b
Control	76 a	0.318 a	73.33 a

Amounts that have at least one similar letter are not significant difference.

Table 3. Analysis of variance for aqueous extracts (AE) of redroot pigweed on emergence and morphological traits.

S.O.V.	df	M.S.					
		Emergence percentage	Emergence rate	Plant height	Number of leaves	Shoot dry weight	Root dry Weight
Weeds aqueous extract	3	3897.47**	0.00085**	221.9**	2593.19**	0.0363**	0.00196**
Error	16	6.025	0.00008	0.915	14.106	0.00018	0.000026
C.V. (%)	-	8.95	8.1	4.55	10.65	8.47	18.18

** indicate significant at 0.01 level of probability

Greenhouse test

Analysis of variance for the w redroot ild pigweed organs AEs indicated that there was significant difference for emergence percentage, emergence rate, plant height, number of leaves, shoot and root dry weight (Table 3). Results showed that different organs AEs reduced all traits of summer savory compared with control. Among the treatments, shoot and whole plant AEs had higher reduction in plant height, number of leaves, shoot and root dry weight. Whole plant AE had higher reduction emergence percentage (Table 4). The effects of allelopathy on growth of plants may occur through a variety of mechanisms including reduced mitotic activity in roots and shoots, suppressed hormone activity, reduced rate of ion uptake, inhibited photosynthesis and respiration, protein formation, decreased permeability of cell membranes and/or inhibition of enzyme action (Rice, 1984).

Table 4. Mean values for aqueous extracts (AE) of redroot pigweed on emergence and morphological traits.

Treatment	Emergence percentage (%)	Emergence rate	Plant height (cm)	Number of leaves	Shoot dry weight (g)	Root dry weight (g)
Shoot	16.8 b	0.105 b	16.24 c	19.99 c	0.099 c	0.0165 c
Whole plant	6.6 c	0.1 b	15.59 c	17.76 c	0.09 c	0.0132 c
Root	17.6 b	0.107 b	22.14 b	36.19 b	0.171 b	0.0258 b
Control	68.6 a	0.129 a	29.95 a	67.13 a	0.274 a	0.0566 a

Amounts that have at least one similar letter are not significant difference.

Shoot and whole plant AEs of redroot pigweed were able to reduce summer savory biomass more than the root AE. The plant height of summer savory was significantly affected by the different organs AEs of redroot pigweed (Table 4). In emergence rate, plant height, number of leaves, shoot and root dry weight had no significant difference between shoot and whole plant AEs (Table 4).

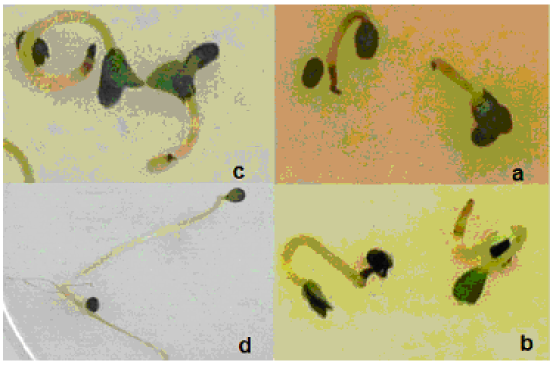

Fig. 1. a, b and c aqueous extracts (AE) of shoot, root and whole plant, respectively and d is control.

The same result was found in other study showed that the aqueous extract of *Xanthium strumarium* L. reduce dry weight of lentil seedlings (Benyas *et al.,* 2010). Dry matter accumulation might be reduced by a reduction in photosynthetic area or assimilation rate per unit leaf area. One possibility is that phytotoxic chemicals influenced stomatal aperture indirectly by modifying water status, hormone balances and ion uptake. It has been reported that phytotoxic chemicals may reduce chlorophyll accumulation in three ways (the inhibition of chlorophyll synthesis, or stimulation of chlorophyll degradation or both) (Yang *et al.,* 2002). Reduction of number of leaves can correlated with reduction of plant height under allelopathic effects of organs AEs of redroot pigweed.

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