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Allelophatic effect of sunflower parts extract in different growth stages on germination and seed production of redroot pigweed (*Amaranthus retroflexus*)

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Abstract

Because of prevalence and importance of redroot pigweed (*Amaranthus retroflexus*) in most fields, a factorial experiment in three replicates was conducted in greenhouse conditions. The examined factors were extracting of different parts of sunflower (leaf, stem, root and whole plant), different extract concentration in 5 levels (extract as 1:20, 1:15, 1:10, 1:5 and control) from different growth stages as vegetative, inflorescence and seed filling. Results showed that leaf extract in inflorescence stage had the most reduction effect on radicle and plumule length, germination percent and germination time spread. Greenhouse results indicate that the effect of extract of different parts of sunflower decreased significantly plant height, root length and dry weight, leaf area, shoot dry weight, 1000 kernel weight and seed production of redroot pigweed. Leaf extract in vegetative stage of sunflower had the most reduction effect. Decreasing germination percent was 87% and seed production was to 74% by sunflower extract. Therefore, the sunflower allelopathic potential can reduce pigweed in the field.

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Introduction

Allelopathic properties in crop residues can control weeds population in the field. Sunflower is one of the crops that have been approved its allelopathic properties on weeds. The first report on sunflower allelopathic properties was published in 1931 (Kasas, 2009). Ohno *et al.*, (2001) isolated sunflower seeds allelopathic compounds as the sesqueiterpenes. This allelochemicals can prevent seed germination during germination of seeds. In an experiment, allelopathic extracts of sunflower were significantly affected *Chenopodium album* L., *Coronopis didymus* L., *Medicago polymorpha* L., *Rumex dentatus* L. and *Pharlaris minor***.**

Newman (2002) reported that pigweed germination reduced by sunflower extract and this property enhanced dramaticaly by increasing phenolics. Alam *et al.*, (2001a) reported that sunflower extract reduced germination of pigweed in greenhouse conditions. In another experiment sunflower extract destroyed all the sorrel plant population in field (Anjum and Bajwa, 2007)**.** Reports showed that overall extract of sunflower reduced canopy of weeds in field to 33 % (Alam *et al.*, 2001b).

The aim of this experiment were effects of allelopathic extracts from different organs of sunflower at different growth stages on the germination and growth and seed production of red root pigweed.

Materials and method

The study was conducted in Agriculture Department of Islamic Azad University, Tabriz branch, Iran, at 2011. The experiments were carried out in 3 distinct stages:

I. Preparing the extracts in the different stages of the sunflower growth,
II. Conducting the seed germination test in the laboratory,
III. Carrying out greenhouse experiment using sunflower extracts,

The germination and greenhouse experiments were conducted on the basis of Randomize Complete Design. All two experiments were done on the basis of factorial experiment with 3 replications. The first factor included the extracts of different parts of sunflower at 4 levels obtained from leaf, stem, root and the whole plant. The second factor included the sunflower harvesting at 3 stages of vegetative growth, prior to flowering, the beginning of the flowering and seed filling and the third factor included the concentration of the extracts obtained from the different parts of sunflower at 5 levels of pure water with no extracts (control), extracts with 1:5, 1:10, 1:15 and 1:20 concentration (James *et al.*, 1982).

Laboratory experiment

The experiment was conducted on the basis of ISTA rules and in Petri dish environment inside a germinator. 50 red-root pigweed seeds were placed inside Petri dish and then different extracts were added. The osmotic potential of solutes was measured using $log\Psi o = 1.016+1.065\ log$ EC formula and calibrated by Gupta (2002) method. The germination in this experiment was defined as the sticking out of at least 2 mm of the radical. The test was finished after 10 days. The germination percentage, radicale and plumle length, and germination spread time were measured.

Greenhouse experiment

In an atmospherically controlled greenhouse, (temperature 20-15, Humidity 50-75%) nine-litter pots were selected and with field by 1/3 sand and 2/3 soil mixture. Red-root pigweed (*Amaranthus retroflexus*) seeds were planted at the depth of 1.5 cm. Altogether, 50 seeds were sowed in each pot. Every 3 days, the pots were irrigated until plantlet establishment. Then the number of plantlet was reduced to 5 plantlets in a pot and irrigation began with sunflower extract. Each plant was measured attributes like plant height, root length, leaf area, root and shoot dry weight, 1000 kernel weight and seed production in red-root pigweed.

Statistical analysis

ANOVA was done by MSTATC. The comparison of means was made using Duncan Multi Range test at 5%, and the graphs were drawn using Excel 2007 software.

Results and discussion

Different concentrations of extracts from various organs and growth stages of sunflower had a significant effect on all traits (Table 1).

Table 1. Variance analysis of sunflower effect in laboratory on pigweed characteristics.

SOV	df	Germination Percent	Plumel Length	Radicle Length	Time Spread	Height	Root Length	Leaf Area	Shoot Dry Weight	Root Dry Weight	1000 Kernel Weight	Seed Production
Replication	2	60.3 n.s	1.5n.s	0.08*	303.2n.s	60/284n.s	0/091n.s	2321.6n.s	0.26*	0.05n.s	0.003n.s	0.001n.s
Organ Extrct (A)	3	9299.9**	22.3**	1.28**	1327.7**	181/077**	0/479**	340.1**	1.54**	0.81**	0.01**	0.038**
Growth stage (B)	2	1949.1**	0.1n.s	0.02n.s	313.1**	372/999**	0/018n.s	2922.4**	2.223**	0.05n.s	0.001n.s	0.007**
A×B	6	1170.8**	1.2n.s	0.03n.s	142.4**	49/721*	0/017n.s	220.3*	0.16**	0.02n.s	0.001n.s	0.001*
Concentration C)	4	12625.9**	13.4**	1.85**	907.7**	1348/34**	1/029**	3614.1**	5.98**	1.74**	0.028**	0.106**
A×C	12	1966.4**	4.7**	0.22**	241.8**	256/334**	0/041n.s	910.2**	2.26**	0.11**	0.002*	0.003**
B×C	8	357.9**	0.6n.s	0.02n.s	116.6*	122/757**	0/058**	494.1**	0.63**	0.09**	0.001n.s	0.002**
A×B×C	24	272.2**	0.7n.s	0.04**	73.1n.s	47/416**	0/011n.s	271.9**	0.12**	0.02n.s	0.001n.s	0.001n.s
Error	118	33.1	0.5	0.02	56.2	21/960	0/024	98.9	0.06	0.03	0.001n.s	0.001
CV (%)		7.77	27.40	22.74	29.16	16/33	14/52	7.22	8.72	26.05	10.81	11.62

* and**: significant at 5% and 1% levels, respectively, ns: non -significant

Table 2. Effect of sunflower extract on growth and seed production of pigweed in greenhouse.

	Height (cm)	Root Length (cm)	Leaf Area (cm^2)	Root Dry Weight (g)	Shoot Dry Weight (g)	1000 Kernel Weight (g)	Seed Production (g)
Organ Extract							
Root	30.78 a	1.139 a	141.7 a	0.7862 a	3.002 a	0.3413 a	0.1460 a
Stem	29.65 ab	1.147 a	135.8 b	0.6824 b	2.929 ab	0.3299 ab	0.1301 b
Leaf	26.13 c	0.9250 c	137.4 b	0.4658 c	2.578 c	0.3049 c	0.07838 d
Whole plant	28.21 b	1.050 b	136.0 b	0.6242 b	2.835 b	0.3249 b	0.1142 c
Control	37.74 a	1.294 a	151.1 a	0.9282 a	3.321 a	0.3677 a	0.1865 a
Growth Stage							
Vegetative	26.88 b	1.048	137.3 b	0.617	2.619 b	0.323	0.1071 b
Inflorsence	27.66 b	1.064	131.0 c	0.629	2.902 a	0.323	0.1154 b
Seed Filling	31.53 a	1.083	144.9 a	0.674	2.986 a	0.330	0.1291 a
Extract Concentration							
1:5	21.52 c	0.8531 d	128.5 b	0.3612 d	2.262 d	0.2934 c	0.04876 d
1:10	25.62 b	0.9675 c	127.2 b	0.5100 c	2.680 c	0.3094 b	0.08346 c
1:15	27.50 b	1.061 b	142.3 a	0.6352 b	2.806 b	0.3220 ab	0.1155 b
1:20	31.08 a	1.150 a	139.6 a	0.7635 a	3.110 a	0.3338 a	0.1517

Laboratoryexperiment

Different concentrations of sunflower extracts decreased significantly germination and growth components of pigweed seeds in compare with control. Pigweed seeds germination percent in control was 92.97 % but for every unit increase in the concentration of the extract obtained from roots, stems, leaves and whole organs of sunflower, pigweed seed germination percentage decreased, 10.37, 6.92, 27.72 and 12.39 %, respectively. Highest

inhibitory effect on pigweed seed germination obtained by Sunflower extracts from leaves at all stages (vegetative, flowering and grain filling), flowering stage, had more inhibitory effect especially (Fig. 1).

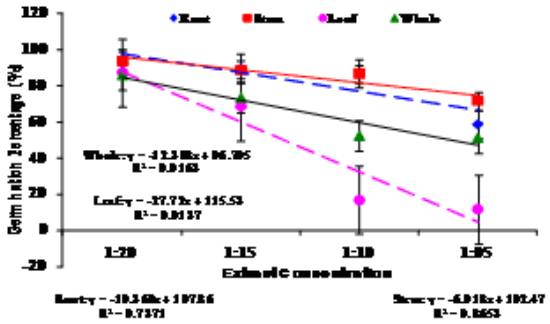

Fig. 1. effect of different part of sunflower leaf extract at different concentration on pigweed germination %.

The least effect obtained from shoot extracts, especially vegetative stage. In vegetative, flowering and grain filling stages inhibitory effect of sunflower leaf extract on germination percent was 40.4, 47.7 and 34.2 % and inhibitory effect of extracts from stems was 5.2, 8.1 and 6.9%, respectively (Fig. 2).

The lowest pigweed seed germination spread time was 3.74 days in the control treatment. Treated with extracts from different parts of sunflower, increased the period required for germination in pigweed. Increasing extract concentration decreased germination rate. With each unit increase in the concentration of extracts from leaves, stems, roots and whole plant, the range of weed germination rate increased 1.15, 0.39, 0.74 and 0.92%, respectively. The influence of extracts from the leaves of this extract on germination is consistent (Fig. 3).

Highest germination spread time was effect of leaf extract in grain filling stage (Fig. 4). Decreasing seedling components with each unit increase in extract concentration from root extract was, 0.18 unit root and leaves 0.79 units to shoot, respectively (Fig. 5 and 6).

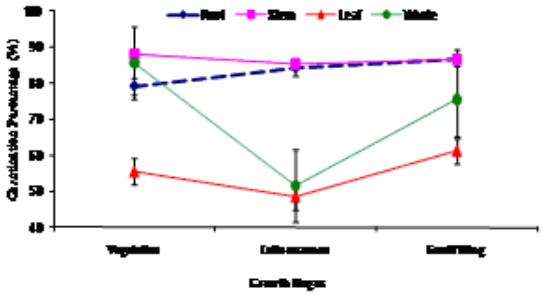

Fig. 2. effect of different part of sunflower leaf extract at different growth stages on pigweed germination %.

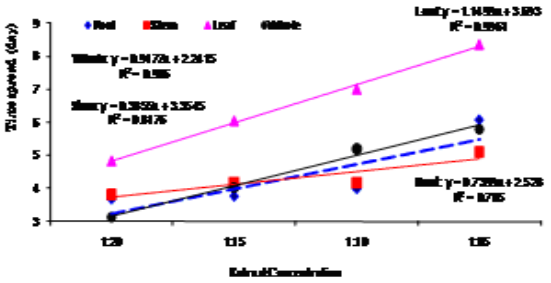

Fig. 3. effect of sunflower concentrations and extracts from the organs on pigweed germination spread time.

Stop germination may change in the enzyme activity on the transfer of storage compounds during germination affect (Noguchi, 2009). Small seeds are more sensitive to environmental stress such as allelopathic compounds (Schabes and Sigstad, 2007). Because they had less stored carbohydrates to overcome stress and they occur tend to germination on soil surface. Where allelopathic compounds are more and more influence on seeds (Song *et al.*, 2008). Thus, pigweed seedlings in the field appear later. Their competition power reduced compared and thus the balance will change in favor of crop.

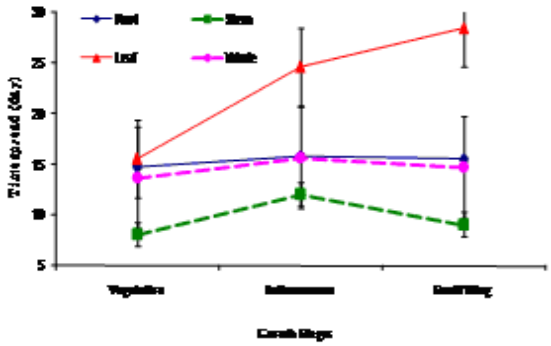

Fig. 4. Effect of growth stage and part extracts of sunflower on pigweed germination spread time

Greenhouse experiment

Extracts from sunflower leaves in greenhouse had more negative effect than other treatments on growth and production of pigweed. Highest height was 37.74 cm in control condition. Treatment by root, shoot and total sunflower organs reduced plant height as 18.44, 21.44, 30.76 and 25.25 %, respectively and treatment by 1:20, 1:15, 1:10 and 1:5 decreased 17.65, 27.13, 32.14, and 42.98 %, respectively (Table2).

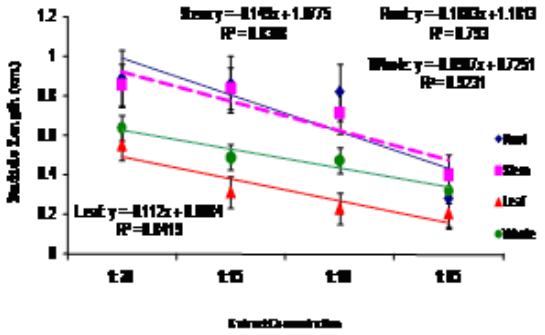

Fig. 5. Effect of sunflower extract part and concentration on pigweed Radicle length

The effect of vegetative and flowering stages extract was than grain filling stage**.** Leaves and the whole organs of sunflower extracts reduced pigweed root length significantly. The rate of decrease in concentrations of 1:20 and 1:5 treatments was 11.13 and 34.07 percent**.** Reduction in root length can be by changing water balance in root**.** Effects of extracts from flowering stages on root length were more than the other developmental stages**.** Treatment by sunflower roots extract had not significant effect on pigweed root dry weight but Extracts of stems, leaves and whole organs of sunflower decreased t root dry weight of pigweed as 26.48, 49.82 and 32.75 percent, respectively. Increasing extract concentration from 1:20 to 1:5 decreased significantly dry weight of pigweed root (Table 2).

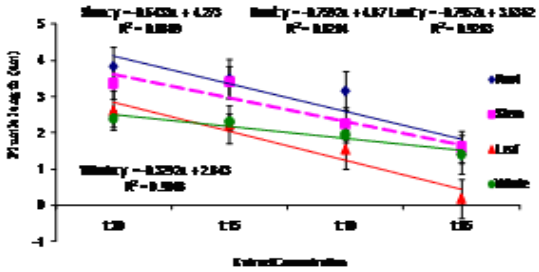

Fig. 6. Effect of extract part and concentration on pigweed panicle length.

Allochimicals prevents water potential changes in capillary roots and water and nutrients absorption reduced (Bogatek *et al.*, 2005). This will lead reduce growth of shoots. Maximum leaf area per plant of redroot pigweed was equal 151.1 cm² and obtained in control conditions.

Leaf area reduction by sunflower stem, leaves and whole organs extract was 10.13, 9.07 and 10% and by extract concentration 1:20, 1:15, 1:10 and 1:5 was 7.61, 5.82, 15.82 and 14.96 %, respectively (Table 2). Maximum pigweed 1000 kernel weight was equal 0.3677 g. in control condition. Treatment by sunflower leaves and whole organ decreased 11.40 and 17.08 %, respectively and treatment with 1:20, 1:15, 1:10 and 1:5 extract concentration decreased 9.22, 12.43, 15.86 and 20.21 %, respectively. Shoot dry weight decreased by treatments with extract of sunflower roots, stems, leaves and whole organs as 58.9, 78.11, 35.22 and 61.14 percent, respectively. Decreasing redroot pigweed shoot dry weight in treatments with extracts from the vegetative stage of sunflower was at least 10 percent more than other developmental stages. Increasing extract concentration reduced stem dry weight. Redroot pigweed Dry weight was 32/3 g under control condition, treatment with extract concentration of 1:20, 1:15, 1:10 and 1:5 leading to a reduction as 6.33, 15.48, 19.28 and 31.93 %, respectively (Table 2).

Important reason for biomass decline was sunflower allelopathic properties that can reduce pigweed photosynthesis (Yu *et al.*, 2003; Macias *et al.*, 2008).

Maximum seed production per plant was 0.187 gr in control condition.

Reducing rate of seed production in compare to control treatment at concentrations of 1:20, 1:15, 1:10 and 1:5 was 18.88, 38.24, 55.37 and 73.93 percent, respectively and the loss caused by treatment with the extract obtained from roots, stems, leaves and whole organs of sunflower was 21.93, 30.48, 58.08 and 38.93 percent, respectively (Table 2). The reduction rate in seed production in vegetative stage was more about 5 percent than flowering stage and more than about 12% in grain filling stage. Reduction in seed production will affect the extent of pigweed interference in the next year**.** The activity of allelopathic plants may reduce the number and extents of other species with reduce their competitiveness.

Conclusion

The results of this study demonstrated that the production of roots and shoots of sunflower at different growth stages of germination, growth and seed production could affect pigweed. Sunflower leaf extracts had highest reduction on Pigweed seed germination and seedling growth. Reducing germination components by sunflower extracts was from 5.2 to 87 percent depending on concentration of extracts, organs and different growth stage**.** In Greenhouse condition extracts from sunflower leaves and roots had maximum and minimum effect on growth and seed production, respectively. Reduction in seed production was at least 6 percent up to 74 percent in greenhouse. Thus, using sunflower extract not only reduced germination and growth and establishment of pigweed but also it will be led to decrease in weed seed bank in the soil.

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