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Allelopathic effects of some medicinal plants on the germination and growth of *Chenopodium album* L.

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Abstract

This study was conducted at the Laboratory of Medicinal Plants, Payamenoor University of west Azerbaijan-Nagadeh, Iran, in 2012. The water extract was prepared by soaking 15, 30, 45 and 60 gram of plant materials of Moldavian balm (*Dracocephalum moldavica* L), Lemon balm (*Melissa officinalis* L.), Cumin (*Cuminum cyminum*) and Black cumin (*Nigella sativa* L.) in 1 litter distilled water and shaking for 24 hours. Results of analysis of variance showed the significant effect of extract concentration and on the germination percent, germination rate, shoot length and radicle length. Interaction effect between concentration and plant species was significant on the ratio of radicle/shoot length and seedling dry weight. The highest germination percent (65.1 %) and germination rate (6.90 % per day) were obtained from water extract of cumin plant material. The maximum germination percent (79 %), germination rate (8.48 % per day) were obtained from control treatment. The highest ratio of radicle/shoot length (1.72) belonged to 15 g/l of cumin extract, as same as by water extract of 30 g/l Moldavian balm and 15 g/l black cumin extracts. The maximum seedling dry weight (0.065 g) was obtained from 15 g/l Moldavian balm.

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Introduction

Allelopathy refers to the beneficial or harmful effects of one plant on another plant; both crop and weed species, by the release of secondary plant metabolites (such as alkaloids, isoprenoids, phenolics, flavonoids, terpanoids and gluconolates) from plant parts by leaching, root exudation, volatilization, residue decomposition, and other processes in both natural and agricultural systems (Gibson and Liebman, 2003) as one of the most controversial of ecological interactions. In addition, environmental conditions and genetic characteristics are the most effective agents in enhancing synthesis and exudation of allelochemicals. It is interesting to note that many of the weed species demonstrated to have powerful allelopathic effects as well. If some of those compounds are released to the environment, from leaching, litter decomposition, root exudation, or direct volatilization, they could affect germination and growth of other species (Ebana *et al.,* 2001). Allelopathy can influence the species composition of phytoplankton assemblages (Fistarol *et al.,* 2003; Fistarol *et al.,* 2004).

Moldavian Balm (*Dracocephalum moldavica*) is an annual herbaceous aromatic plant belonging to Lamiaceae family, and it is native to Central Asia and in Eastern and Central Europe (El-Baky and El-Baroty, 2008). Black Cumin (*Nigella sativa*) belongs to the Ranunculaceae family, is a spice that grows in Mediterranean region and in Western Asian countries including, India and Pakistan (Padhye *et al.,* 2008). Cumin (*Cuminum cyminum*) is native to Mediterranean regions, belongs to Apiaceae family that has grown by people of Egypt and India since ancient time (Rostami-Ahmadvandi *et al.,* 2013). Lemon balm (*Melissa officinalis* L.) is a perennial plant that belongs to the family of Lamiaceae and it is very important medicinal plant due to its medicinal value and high antioxidant and anticancer compounds (Saglam *et al.,* 2004). The shoot powder of lemon balm inhibited the germination and growth of roots and shoots of *Amaranthus caudatus, Digitaria sanguinalis* and *Lactuca sativa* (Kato Noguchi, 2003).

Weed management during growing season has been a serious problem for many years. Worldwide, a 10% loss of agricultural products can be attributed to competitive effect of weeds, despite their intensive control. The application of herbicides has been a major factor enabling the intensification of agriculture in past decades. There has been increasing herbicide resistance in weeds and widespread concern about adverse environmental effects from herbicide use (Stephenson, 2000). For this reason, the use of allelopathic varieties may provide an alternative to minimize the risk towards agroecosystems by serving in a complementary way with herbicides (Alam *et al.*, 2001).

Germination is an important stage in plant growth that is affected by allopathic compound. These compounds can regulate such interactions within and between species in plant communities (Fernandez *et al.*,2008). This stage includes several phases, which is included water imbibitions, catabolic and anabolic phases. Irregularities in the respiration rate reduced metabolic energy (ATP) and resulted in seed germination and growth reduction. Allopathic compound not only reduced germination, but also delayed germination that affect seedling (Escudero *et al.*, 2000). The leaves of *Chenopodium album* belonging to Chenopodiaceae family, use in traditional medicines. This plant is a common weed during summer and winter (Dai *et al.,* 2002).

But, the probable alleloptahic effects of these mentioned plants have not been study yet, especially on the *Chenopodium album*. Thus, the main objective of present study was to determine the probable allelopathic effect of four (Moldavian Balm, Balm, Black Cumin and Cumin) medicinal plants on the germination and seedling growth of *Chenopodium album* as an important weed.

Materials and methods

This study was conducted at the Laboratory of Medicinal Plants, Payamenoor University of west Azerbaijan-Nagadeh, Iran, in 2012. Moldavian balm (*Dracocephalum moldavica* L.), Lemon balm

(*Melissa officinalis* L.), Cumin (*Cuminum cyminum*) and Black cumin (*Nigella sativa* L.) were collected freshly and dried at room temperature (22-25 °C) in dark condition for 20 days. The dried material was chopped into 2 cm with an electric cutter. The water extract was prepared by soaking 15, 30, 45 and 60 grams of powdered plant materials in one litter distilled water and allowed for 24 hours on the shaker 200 rpm. The mixture was filtered through a double-layered muslin cloth to remove debris and then through the Whatman No. 1 filter paper. Seeds of *Chenopodium album* L. were sterilized with 1% sodium hypochlorite for 30 minutes and rinsed with distilled water (Yamamoto *et al.,* 1999; Higashinakasu *et al.,* 2004). *Petri* dishes and filter paper were sterilized in temperature 130 ċ for 2 hours. Fifty seeds of *Chenopodium album* L. was placed in *Petri* dishes (9 cm in diameter) lined with filter paper and 7 ml of the aqueous extracts were added. The distilled water treatment was used as a control. *Petri* dishes were placed in the growth chamber, darkness at 25°C. The germinated seeds were recorded intervals day for a period of 14 days. A seed was considered as germinated when radicle protrusion was more than 2 mm length. Germination percent, germination rate, shoot and radicle length and seedling dry weights after 14 days were measured for all treatments. Final Germination Percent (GP) and Rate of Germination (RG) were calculated using the formulas:

Germination Percent (GP) = $(a/b) \times 100$

Where "*a*" is the proportion of germinant and "*b*" the total number of seeds germinated.

Germination rate (GR) = $\Sigma Xn / Yn$

Where Xn is the total number of seeds germinated and Yn days that experiment was done.

After measuring the radicle and shoot lengths, the dry weights of seedlings were determined by drying the plant material in an oven at 72° C for 24 h prior to weighing. Treatments were arranged in a factorial experiment based on completely randomized design with three replications. The mean differences were adjudged using Duncan Multiple Range Test ($P \leq 0.05$). The data were analysis of variance with SAS software 9.1.

Results

Results of analysis of variance (ANOVA) showed the significant effect of extract concentration on the germination percent, germination rate, shoot length and radicle length ($P \leq 0.01$), significant effect of plant species on the germination percent, germination rate, shoot length and radicle length ($P \leq 0.01$). Interaction effect between concentration and plant species were significant on the ratio of radicle/shoot length and seedling dry weight ($P \leq 0.01$), too (Table 1).

Table 1. Effect of extract concentration of four medicinal plants on the seed germination and seedling growth of *Chenopodium album* L.

Source of Variation	df	Means Squares (MS)					
		Germination percent	Germination rate	Shoot length	Radicle length	Radicle/shoot ratio (length)	Seedling dry weight
Replication	4	7328.06	78.88	385.77	329.35	0.044	90.21
Extract concentrations (A)	2	2638.37**	28.78**	172.72**	617.23**	6.29**	7.74**
Plant species (B)	4	248.40**	2.22**	29.93**	12.12**	0.11**	3.10**
A×B	8	12.01ns	0.17 ns	1.73 ns	0.71 ns	0.002**	0.87**
Error	56	10.73	0.08	5.32	3.70	0.03	0.38
Coefficient of variation (%)		7.06	5.65	20.65	15.55	15.64	19.90

ns,* and ** non significant, Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

Extract concentration effect

Means comparison revealed that the maximum germination percent (79%), germination rate (8.48 % per day) and shoot length (19.16 cm) were obtained from control treatment. Increasing the extract concentration caused in descending trends of germination percent, germination rate, shoot length and seedling dry weight. So, the minimum germination percent (17.5 %), germination rate (2.03 % per day) and shoot length (4.39 cm) were obtained from 60 g/l of extract concentration (Figures 1-A, 1-B, 1-C). The longest (9.50 cm) and shortest (2.70 cm) radicle were obtained from control treatment and 60 g/l of extract as same as radicle length obtained from 45 g/l extract concentration (Figure 1-D). Extract concentration resulted significant reduction of germination percent, germination rate, shoot length and radicle length of *Chenopodium album* L.

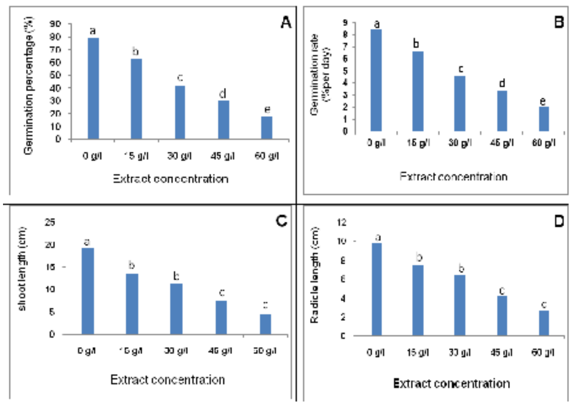


Fig. 1. Effect of extract concentration on germination percentage (A), germination rate (B), shoot length (C) and radicle length (D) of *Chenopodium album* L. The same letters show non significant differences at $P \leq 0.05$.

Effect of Plant Species

Means comparison revealed that the highest germination percent (65.1 %) and germination rate (6.90 % per day) were obtained from cumin extract treatment. The lowest germination percent (29.2 %) and germination rate (3.1 % per day) were obtained from black cumin extract (Figure 2-A, 2-B). The longest shoot (15.46 cm) was observed in Moldavian Balm extract, as same as cumin and balm extracts. The shortest shoot (6.02 cm) was observed in black cumin extract (Figure 2-C). The longest radicle (18.73 cm) was obtained from balm extract, as same as radicle length obtained from cumin extract treatment. While, the shortest radicle (4 cm) was obtained from black cumin extract (Fig. 2-D).

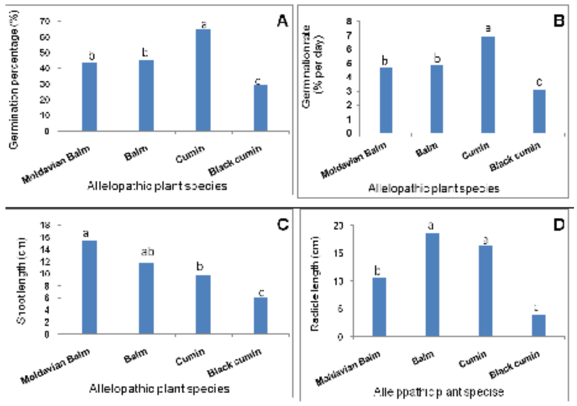
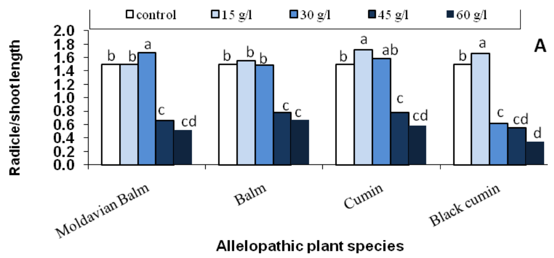


Fig. 2. Effect of plant species extracts on the germination percentage (A), germination rate (B), shoot length (C) and radicle length of (D) *Chenopodium album* L. The same letters show non significant differences at $P \leq 0.05$.

Interaction between species and concentration

The highest ratio of radicle/shoot length (1.72) belonged to cumin extract in 15 g/l concentration, as same as this ratio of Moldavian Balm and black cumin extracts in 30 and 15 g/l concentrations, respectively. The lowest ratio of radicle/shoot length (0.34) was obtained from black cumin extract in 60 g/l concentration. The maximum seedling dry weight (0.065 g) was obtained from Moldavian Balm extract in 15 g/l, as same as balm extract in 15 g/l concentration and control treatment. But the minimum seedling dry weight (0.001 g) belonged to black cumin extract in 60 g/l concentration, same with seedling dry weight of this concentration of Moldavian balm, balm and cumin extract (Figure 3-A, 3-B).



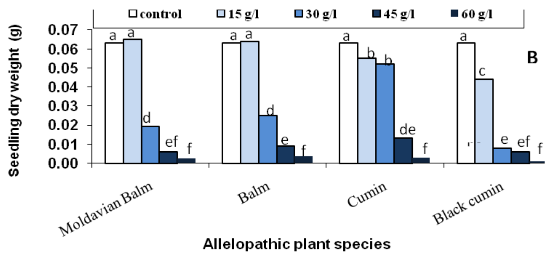


Fig. 3. Interaction effect between plant species and concentration on radicle/shoot length (A) and seedling dry weight (B). The same letters show non significant differences at $P \leq 0.05$.

Discussion

Our research showed the different affects of the plant species (Figures 2) in varying amount of extract concentration (Figure 1) on the germination and seedling growth of *Chenopodium album* L. In addition to temporal and seasonal variation in allelochemical production, differences may exist among genotypes, populations, or plants with differing ages. Age has been shown to affect allelopathic potential in *Pinus halepensis* (Fernandez *et al.,* 2006). Pirzad *et al.* (2012) indicated significant effect of extract concentration of Russian Knapweed (*Acroptilon repens* L.) on all the germination and seedling growth indices of Purslane (*Portulaca oleracea* L.). In conclusion seedling growth reduced by higher concentrations of all extract types.

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 (Gibson and Liebman, 2003). Inhibition of seed germination of crop plants was reported also due to disturbance in the activities of peroxidase, alpha-amylase and acid phosphates of nettleleaf goosefoot (Alam and Islam, 2002).

Allelopathic effects not only lead to reduced germination (Figure 1-A, 1-B) but also delayed in germination that can impact a lot the result of competition and seedling plants which may have acquired larger size (Figure 1-D) under incompatible conditions such as low soil moisture or food restriction may compete better with adjacent plant. Delayed in germination of seeds can have osmotic effects on the rate of water absorption, delayed at the beginning of germination and especially cell elongation (Chon *et al.,* 2005). Abiotic and biotic factors differ with location and these may have strong influences on the production of allelopathic compounds (Einhellig, 1999). Körner and Nicklisch (2002) found that the allelopathic algal growth inhibition was dependent on biomass of *Myriophyllum spicatum*.

Conclusion

In conclusion, increasing of extract concentration of all plant species led to reduce seed germination and seedling growth of *Chenopodium album*. But the Black cumin extract showed the highest decrease of all seed germination and seedling growth indices, followed by Moldavian balm for seed germination (percent and rate) and radicle length. Moldavian balm extract caused to produce the longest shoot than other three plant species.

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