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ALLELOPATHIC EFFECT OF PARSLEY (*Petroselinum crispum* Mill.) COGERMINATION, WATER EXTRACTS AND RESIDUES ON HOARY CRESS (*Lepidium draba* (L.) Desv.)

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SUMMARY

The aim of the study was to examine allelopathic effect of parsley (*Petroselinum crispum* Mill.) on germination and growth parameters of weed species hoary cress (*Lepidium draba* (L.) Desv.). Cogeneration of hoary cress with parsley seeds, water extracts from fresh and dry parsley biomass in concentrations of 5 and 10% (50 and 100 g per litre of distilled water) were evaluated in Petri dishes. Effect of water extracts from fresh parsley biomass in aforementioned concentrations as well as effects of fresh and dry parsley residues in two rates (10 and 20 g/kg of soil) were examined in pots with soil. Cogeneration of seeds stimulated root length, but decreased shoot length and fresh weight of hoary cress seedlings. In the Petri dish assay, extracts from fresh and dry parsley biomass reduced germination of hoary cress, but had both stimulatory as well as inhibitory effect on other parameters. The highest concentration of dry biomass extract completely reduced germination rate of hoary cress (by 100%). In the pot experiment, extracts from fresh parsley biomass had stimulatory effect on weed growth parameters except for root length which was inhibited with higher concentration by 4.2%. Fresh parsley residues reduced germination, root and shoot length of hoary cress, while dry parsley residues promoted measured parameters, with the exception of root length.

Key-words: allelopathy, cogeneration, water extracts, plant residues, parsley (*Petroselinum crispum* Mill.), hoary cress (*Lepidium draba* (L.) Desv.)

INTRODUCTION

Since excessive application of chemical herbicides in weed control leads to various problems such as weed resistance, herbicide residues, environmental pollution and adverse effects on human and animal health (Macías et al., 2003, Singh et al., 2003, Barreto et al., 2000), reduction of chemicals replaced by the use of alternative non-chemical and environmentally friendly methods, such as allelopathy, is recommended. Allelopathy represents the influence of one organism on the other, whether it is harmful or beneficial, through production of allelochemicals (Rice, 1984). Application of allelopathic interactions in crop protection for controlling populations of weeds, but also pests and phytopathogens is undeniable (Valcheva and Popov, 2013).

Weed control with allelopathic crops can be achieved in different ways i.e. as water extracts or surface mulch, incorporated in the soil, as cover crops in crop rotation (Singh et al., 2003, Reigosa et al., 2001).

Medicinal and aromatic plants have been increasingly explored for their potential use as allelopathically active crops (Đikić et al., 2005b, Dhima et al., 2009).

Parsley (*Petroselinum crispum* Mill.) is a biennial plant belonging to the Apiaceae family. It is grown for root and leaves and used as vegetable and spice (Parađiković, 2009). Parsley seed extract showed allelopathic potential against *Fusarium oxysporum* f.sp. *cucumeris* (Jia et al., 2011), while parsley vegetative biomass extract showed allelopathic effect on pepper seedlings growth (Valcheva and Popov, 2013). Dhima et al. (2009) reported inhibitory effect of parsley extracts and as green manure on various weed species.

The aim of the study was to determine the allelopathic effect of parsley (*P. crispum*) on hoary cress (*Lep-*

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idium draba (L.) Desv.) through cogermination, use of water extracts and plant residues.

MATERIAL AND METHODS

The experiments were conducted in 2013 in the Laboratory of Phytopharmacy at the Faculty of Agriculture in Osijek.

Seeds of parsley (*P. crispum*) were purchased from seed company (Sjemenarna Zagreb d.o.o.), while weed seeds of hoary cress (*L. draba*) were collected during 2013 from agricultural fields in Osijek-Baranya County. Weed seeds were surface-sterilized for 20 min with 1% NaOCl (4% NaOCl commercial bleach), then rinsed three times with distilled water (Siddiqui et al., 2009). Parsley vegetative biomass (leaves and petioles), fresh and dry, were used in the experiments. Fresh parsley biomass was air dried under shade, cut into small pieces and ground with electronic grinder into fine powder. Water extracts were prepared according to Norsworthy (2003) from fresh and dry parsley biomass. One hundred gram of fresh or dry biomass was mixed with 1000 ml of distilled water and kept for 24 h at room temperature. The mixtures were filtered through muslin cloth to remove debris and after that through filter paper. Obtained extracts were diluted with distilled water to give final concentrations of 5 and 10% (50 and 100 g of biomass per litre). Commercial soil substrate was used in the experiments with pots.

In total, four experiments were conducted using Petri dishes with filter paper and pots with soil.

The effect of cogermination of parsley and hoary cress seeds was investigated according to Đikić (2005a) in the first experiment. The treatment consisted of thirty seeds of both parsley and hoary cress germinating together in Petri dishes (9 cm diameter) on top of filter paper soaked in distilled water. Control treatment included 30 weed seeds per dish.

In the second experiment the effect of parsley water extracts from fresh and dry biomass on hoary cress was evaluated. Thirty weed seeds were placed in sterilized Petri dishes (9 cm in diameter) on top of filter paper. In each Petri dish the equal amount of certain extract was added, while distilled water was used in the control.

The effect of water extracts from parsley fresh biomass in soil medium was evaluated in the third experiment. Thirty weed seeds were sown in pots filled with commercial horticultural substrate and treated with 30 ml of extract or water in the control treatment. Thereafter all treatments were equally watered.

In the fourth experiment the effect of incorporated fresh and dry parsley residues was determined, according to Norsworthy (2003), with some modification. Fresh or dry plant residues in rates of 10 and 20 g per kg of soil were mixed with commercial substrate. Thirty weed seeds sown in pots filled with soil. The control treatment consisted of thirty weed seeds sown in the soil without residues.

In the first and second experiment Petri dishes were kept at room temperature ($22^{\circ}\text{C} \pm 2$) for 9 days, while the third and fourth experiment with pots lasted for 14 days ($22^{\circ}\text{C} \pm 2$). All treatments had four replications and all the experiments were conducted twice.

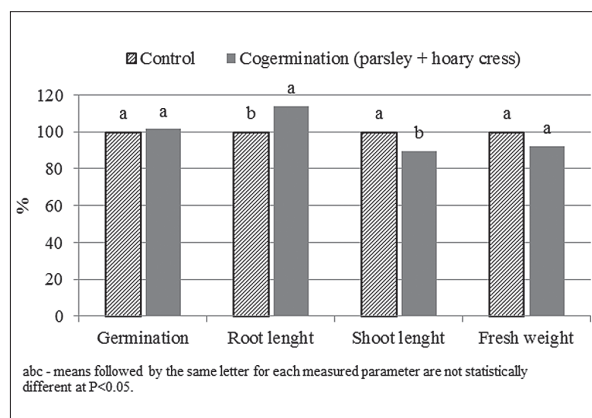
Germination percentage was calculated for each replication using the formula: $G = (\text{Germinated seed} / \text{Total seed}) \times 100$. At the end of each experiment, seedling root length (cm), shoot length (cm) and fresh weight (g) were determined. The collected data were statistically analysed using ANOVA while differences between treatments were compared using the LSD-test at probability level of 0.05 (software package Statistica 12).

RESULTS AND DISCUSSION

Cogermination of parsley with hoary cress seeds showed no significant effect on germination and fresh weight of weed seedlings although fresh weight was slightly reduced (Figure 1). Root length of hoary cress was significantly stimulated by 14.1% compared to the control, while shoot length was inhibited by 10.2%.

Figure 1. Effect of cogermination of parsley and hoary cress seeds on germination, root and shoot length of hoary cress (% of control)

Grafikon 1. Utjecaj zajedničkog klijanja sjemena peršina i strjelica grbice na klijavost, duljinu korijena i izdanka strjelica grbice (% u odnosu na kontrolu)



Other species from Apiaceae family also show allelopathic effects on hoary cress. According to Ravlić et al. (2013b) coriander and lovage reduced germination of hoary cress by 22.3 and 27%, respectively, but coriander promoted shoot length, while Đikić (2005a) found that caraway, dill and coriander have inhibitory effect on germination and fresh weight of hoary cress up to 65%. Cogermination of weed and crop seeds can variously affect weed germination and growth.

Water extracts from fresh and dry parsley biomass in Petri dish assay showed negative effect on germination of hoary cress (Table 1). Both concentrations of fresh biomass extract reduced germination around 18.2% compared to the control. Extracts from dry parsley biomass had greater effect and germination

was inhibited by 98.2 and 100%, respectively. Extracts from fresh biomass stimulated fresh weight and shoot length of weed seedlings, but reduced root length by 39.4% with application of the higher extract concen-

tration. Root and shoot length and fresh weight were inhibited by both concentrations of parsley and dry biomass extract. Higher concentration inhibited germination totally.

Table 1. Effect of parsley water extracts on germination and seedling growth of hoary cress on filter paper

Tablica 1. Utjecaj vodenih ekstrakata peršina na klijavost i rast klijanaca strjelicašte grbice na filter papiru

Parsley biomass in water, g/l <i>Biomasa peršina u vodi, g/l</i>	Germination – <i>Klijavost</i> (%)		Fresh weight – <i>Svježa masa</i> (g)	
	Fresh biomass <i>Svježa biomasa</i>	Dry biomass <i>Suha biomasa</i>	Fresh biomass <i>Svježa biomasa</i>	Dry biomass <i>Suha biomasa</i>
0	89.6 a	89.6 a	0.011 b	0.011 a
50	73.3 b	1.6 b	0.013 a	0.001 b
100	73.4 b	0.0 b	0.014 a	0.0 b
Average - <i>Prosjek</i>	78.7 A	30.4 B	0.013 A	0.004 B
Parsley biomass in water, g/l <i>Biomasa peršina u vodi, g/l</i>	Root length - <i>Duljina korijena</i> (cm)		Shoot length - <i>Duljina izdanka</i> (cm)	
	Fresh biomass <i>Svježa biomasa</i>	Dry biomass <i>Suha biomasa</i>	Fresh biomass <i>Svježa biomasa</i>	Dry biomass <i>Suha biomasa</i>
0	2.82 a	2.82 a	2.34 b	2.34 a
50	2.09 b	0.06 b	2.43 b	0.05 b
100	1.71 c	0.0 b	2.62 a	0.0 b
Average - <i>Prosjek</i>	2.03 A	0.78 B	2.47 A	0.79 B

Means followed by the same letter within the column (lower case letters) or in rows (capital letters) are not significantly different at $P \leq 0.05$

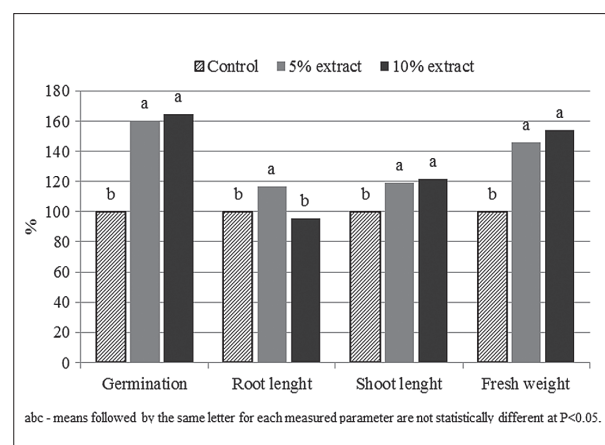
Dhima et al. (2009) showed that parsley extracts (20 and 40 g per litre) have inhibitory effect on germination, root elongation and fresh weight of barnyardgrass (up to 80%). According to Valcheva and Popov (2013) extracts from fresh parsley biomass showed inhibitory effect on fresh weight, and stimulatory effect on shoot length of pepper seedlings in Petri dish assay.

In general, extracts from fresh parsley biomass had lower inhibitory effect on germination and growth of weed seedlings than extracts from dry biomass. Differences among extracts prepared from fresh or dry biomass were also observed by Marinov-Serafimov (2010) and Ravlić et al. (2013a) and may be due to the different concentration of active substances extracted from the fresh and dry biomass.

Treatment with both concentrations of fresh parsley biomass extracts showed stimulatory effect on germination, shoot length and fresh weight of hoary cress sown in soil (Figure 2). Germination was stimulated over 64%, while shoot length and fresh weight by up to 21.8 and 53.9%, respectively. Root length of hoary cress seedlings was significantly stimulated in the treatment with lower (by 16.6%), and inhibited with higher concentration (by 4.2%), but there were no significant differences compared with the control. The obtained results are considered with results of Baličević et al. (2014) who reported that marigold extracts from fresh biomass stimulated all measured parameters of hoary cress, except root length. According to Valcheva and Popov (2013) extracts from fresh parsley biomass had a positive effect on shoot length of pepper seedlings sown in pots.

Figure 2. Effect of water extracts from fresh parsley biomass on germination, root and shoot length of hoary cress in soil (% of control)

Grafikon 2. Utjecaj vodenih ekstrakata od svježe mase peršina na klijavost, duljinu korijena i izdanka strjelicašte grbice u tlu (% u odnosu na kontrolu)



Water extracts from fresh parsley biomass both in Petri dish and pot experiment showed a positive effect on hoary cress shoot length and fresh weight, while root length was negatively affected in the aforementioned treatments. However, germination in Petri dish assay was inhibited, while in pot experiment it was stimulated. Differences in germination could be due to higher amount of extract applied to soil (30 ml) or direct contact of seed with extract on filter paper.

Fresh and dry parsley residues incorporated into the soil had different effect on germination and seedling growth of hoary cress (Table 2). Fresh parsley residues in both rates had no significant effect on weed germination, although higher rate slightly reduced germination by 8.1%. Oppositely, dry parsley residues stimulated hoary cress germination by 18.5 and 42.3%. Root length decreased with an increase of parsley residues rate, and fresh residues showed higher inhibitory effect reducing root length up to 51.6%, compared to the control. Shoot length of hoary cress was reduced by fresh but stimulated by dry parsley leaf residues. Except for fresh pars-

ley residues in 10 g/kg rate, in all other treatments fresh weight of weed seedlings was not affected compared to the control. Fresh residues had higher impact on germination and growth parameters than dry residues.

Incorporation of plant residues in soil can be both stimulatory and inhibitory. Dhima et al. (2009) reported that parsley incorporated as green manure reduced plant number of barnyardgrass (25%), common purslane (35%), and common lambsquarters (58%), while promoted plant number and fresh weight of puncturevine by 3 and 27%, respectively.

Table 2. Effect of parsley residues on germination and seedling growth of hoary cress

Tablica 2. Utjecaj biljnih ostataka peršina na klijavost i rast klijanaca strjeličaste grbice

Parsley residues, g/kg Ostatci peršina, g/kg	Germination - Klijavost (%)		Fresh weight - Svježa masa (g)	
	Fresh biomass Svježa biomasa	Dry biomass Suha biomasa	Fresh biomass Svježa biomasa	Dry biomass Suha biomasa
0	42.1 a	42.1 b	0.016 a	0.016 a
10	45.8 a	49.9 ab	0.013 b	0.017 a
20	38.7 a	59.9 a	0.017 a	0.017 a
Average - Prosjek	42.2 A	50.7 A	0.015 B	0.017 A
Parsley residues, g/kg Ostatci peršina, g/kg	Root length - Duljina korijena (cm)		Shoot length - Duljina izdanka (cm)	
	Fresh biomass Svježa biomasa	Dry biomass Suha biomasa	Fresh biomass Svježa biomasa	Dry biomass Suha biomasa
0	2.89 a	2.89 a	3.59 a	3.59 a
10	1.64 b	2.78 a	3.02 b	3.81 a
20	1.40 b	2.63 a	2.72 b	3.65 a
Average - Prosjek	1.97 B	2.76 A	3.11 B	3.68 A

Means followed by the same letter within the column (lower case letters) or in rows (capital letters) are not significantly different at $P \leq 0.05$

CONCLUSION

Results of experiments showed that parsley fresh and dry biomass has allelopathic effect on hoary cress. Cogeneration of seeds exhibited stimulation of root length, but inhibited shoots in length and fresh weight of hoary cress. Effect of extracts from fresh parsley biomass applied in Petri dishes and pots with soil differed only in percentage of germination. In Petri dish assay extracts from dry parsley biomass had inhibitory effect on hoary cress, especially higher concentration which almost completely reduced germination and growth. But since this experiment was not conducted in pots with soil, we assume that the strong inhibitory effect of the dry biomass extract could be due to high osmotic value. Fresh parsley residues showed greater negative effect on hoary cress, while treatment with dry residues negatively affected only the root length. Parsley could be used as allelopathically active crop to suppress susceptible weeds. In order to minimize herbicide usage, further experiments on inhibitory effect of water extracts and residues in different concentrations and rates as well as on different weed species need to be conducted, both in laboratory and field experiments.

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ALELOPATSKI UTJECAJ ZAJEDNIČKOG KLIJANJA, VODENIH EKSTRAKATA I BILJNIH OSTATAKA PERŠINA (*Petroselinum crispum* Mill.) NA STRJELIČASTU GRBICU (*Lepidium draba* (L.) Desv.)

SAŽETAK

Cilj istraživanja bio je utvrditi alelopatijski učinak peršina (*Petroselinum crispum* Mill.) na klijavost i rast korovne vrste strjeličaste grbice (*Lepidium draba* (L.) Desv.). U petrijevim zdjelicama istraživao je učinak zajedničkog klijanja sjemena peršina i strjeličaste grbice te utjecaj vodenih ekstrakata u koncentracijama od 5 i 10% (50 i 100 g na litru destilirane vode). U posudama s tlom ispitan je utjecaj vodenih ekstrakata od svježe mase peršina u istim koncentracijama te utjecaj svježih i suhih ostataka peršina u dozama od 10 i 20 g/kg tla. Zajedničko klijanje sjemena imalo je stimulativni utjecaj na duljinu korijena, ali je smanjilo duljinu izdanka i svježu masu klijanaca strjeličaste grbice. U pokusima u petrijevim zdjelicama, vodeni ekstrakti od svježe i suhe mase peršina smanjili su klijavost strjeličaste grbice, ali su pokazali i pozitivni i negativni utjecaj na ostale parametre. Najviša koncentracija ekstrakta suhe mase potpuno je inhibirala klijavost grbice (100%). U pokusima s posudama, ekstrakti od svježe mase peršina djelovali su pozitivno na rast korovne vrste, osim na duljinu korijena, koja je bila inhibirana s višom koncentracijom za 4,2%. Svježi biljni ostatci peršina smanjili su klijavost i duljinu izdanka grbice. Suhi ostatci promovirali su klijavost i rast grbice, ali su imali negativan učinak na duljinu korijena.

Ključne riječi: alelopatija, zajedničko klijanje, vodeni ekstrakti, biljni ostatci, peršin (*Petroselinum crispum* Mill.), strjeličasta grbica (*Lepidium draba* (L.) Desv.)

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