Herbicidal potential of meadow sage (Salvia pratensis L.) against velvetleaf (Abutilon theophrasti Med.) and common corn-cockle (Agrostemma githago L.)

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Original scientific paper

Herbicidal potential of meadow sage (*Salvia pratensis L.*) against velvetleaf (*Abutilon theophrasti Med.*) and common corn-cockle (*Agrostemma githago* L.)

Abstract
Medicinal and aromatic plants with allelopathic effect are a potential source of natural herbicides. The experiment was conducted in order to assess herbicidal potential of meadow sage (Salvia pratensis L.) on germination and growth of weed species velvetleaf (Abutilon theophrasti Med.) and common corn-cockle (Agrostemma githago L.). Water extracts from S. pratensis dry biomass in different concentrations were evaluated under controlled laboratory conditions in Petri dish bioassay. Herbicidal effect of S. pratensis extracts depended on the extract concentration and weed species. In general, higher concentrations of water extract showed greater negative effect on germination and growth parameters of weed seedlings. A. githago had greater sensitivity to S. pratensis extracts with reductions in germination and seedlings growth up to 100% in treatments with 7.5% and 10% extract concentrations. A. theophrasti germination was not affected by water extracts, however, substantial reductions of root and shoot length as well as fresh weight of seedlings were recorded. S. pratensis proved as promising plant species for further studies.
Keywords: *allelopathy, biological control, weeds, inhibition, Salvia*

Introduction

Weed management in modern-day agriculture heavily relies on the use of synthetic herbicides due to their high efficiency, simple application and cost-effectiveness. Nevertheless, their improper and excessive application leads to occurrence of weed resistant populations and raises environmental and health concerns (Macías et al., 2003, Singh et al., 2003). Additionally, ban on active ingredients and restrictions in application of synthetic herbicides in organic agricultural systems as well as in protected areas requires a different approach in weed control. Allelopathy, a biological phenomenon, is defined as any direct or indirect, harmful or beneficial effect of one plant on the germination and growth of other through the production of allelochemicals that are released into the environment (Rice, 1984). Allelopathic crops with strong herbicidal effect, implemented as cover crops, mulches and natural-based herbicides, have the potential as alternative and sustainable weed control tool (Singh et al., 2003, Scavo et al., 2022).

Medicinal and aromatic plants, both cultivated and wild, represent immense source of bioactive molecules (Bouajaj et al., 2013, Amini et al., 2016, Ravlić et al., 2016). Genus *Salvia*, the largest genus in the Lamiaceae family, contains over 900 species distributed all over the world (Lopresti, 2017). *Salvia* species are used as medicinal plants, as food and spices, honey and ornamental plants (Knežević, 2006, Lopresti, 2017). Researchers reported that extracts, powders, exudates as well as essential oils and hydrosols of various *Salvia* species possess allelopathic, herbicidal, antifungal, insecticidal and antibacterial properties (Bisio et al., 2010, Bouajaj et al., 2013, Erez and Fidan, 2015, Matković et al., 2018; Politi et al., 2022, Raveau et al., 2022). However, among them meadow sage (*Salvia pratensis* L.) is rarely included in the studies. The aim of this research was to evaluate herbicidal potential of meadow sage (*S. pratensis*) water extracts

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on seed germination and seedlings growth of weed species velvetleaf (*Abutilon theophrasti* Med.) and common corn-cockle (*Agrostemma githago* L.).

Materials and methods

Plant material and water extracts preparation

Aboveground biomass of *S. pratensis* was collected in full flowering stage (phenological stage 6/65 (Hess et al., 1997)) in Osijek-Baranja County. Fresh biomass was shade dried for 72 h and additionally oven dried at 40 °C for 72 h. Dry biomass was then cut into small pieces, ground with electronic grinder into fine powder and stored in paper bags in dry and cool place.

Preparation of *S. pratensis* water extracts followed the procedure of Norsworthy (2003) with some modifications. Dry plant biomass in the amount of 10 g was extracted in 100 ml of distilled water at room temperature 22 (±2) °C for 24 h. The mixture was after that filtered through filter paper and the obtained extract was further diluted with distilled water to give final concentrations of 1%, 2.5%, 5%, 7.5% and 10%.

Test species

Seeds of weed species *A. theophrasti* and *A. githago* were used in bioassay as test species. Mature weed seeds were collected in 2014 (*A. theophrasti*) and 2015 (*A. githago*) in Osijek-Baranja County. The seeds were cleaned and dried at room temperature, after which they were stored in cool and dry place. Prior to the experiment, weed seed germination was assessed and satisfactory germination percentage was determined.

Bioassay

The effect of *S. pratensis* extracts was evaluated in Petri dish bioassay under controlled laboratory conditions. The experiment was set up as completely randomized design with four replications. Twenty-five weed seeds were placed in sterilized Petri dishes lined with filter paper. The filter paper was moistened with 4 ml of extract in each concentration, while distilled water was used in control. Additional extract/water in the amount of 2 ml was added to each Petri dish on the fourth day of the experiment to prevent the seeds from drying. The seeds were incubated at 30/20 °C alternating temperatures (light/dark, 12/12 h) for 10 (*A. theophrasti*) and 9 (*A. githago*) days. Germination percentage was calculated for each replication using the formula: G (germination) = (germinated seeds/total seeds) × 100. Root and shoot length, and fresh weight of seedlings were determined on the last day of the experiment.

Statistical analysis

All collected data was analysed statistically with ANOVA and differences between treatment means of measured parameters for each weed species were tested with the LSD test at probability level of 0.05.

Results and discussion

The application of *S. pratensis* water extracts showed different effect on weed seed germination (Figure 1). *A. theophrasti* germination was not affected at any concentration of the water extracts. Contrary, all concentrations of water extract significantly decreased germination of *A. githago*. The lowest extract concentration reduced *A. githago* germination by 7.6% compared to the control, while the increase in extract concentration resulted in germination inhibition from 92.4 to 98.9%. Herbicidal and allelopathic effect of *Salvia* species on germination of weeds and crops was previously reported, and the degree of phytotoxic effect depended on various factors, such as *Salvia* species, test species, extract concentration and extraction method. Bisio et al. (2010) screened 13 *Salvia* species for their inhibitory potential on common poppy (*Papa-*

ver rhoeas L.) and oat and recorded significant reduction in germination of both test species in all treatments. Similarly, methanol extracts of *Salvia macrochlamys* Boiss. and Kotschy lowered germination of common purslane (*Portulaca oleracea* L.) according to Erez and Fidan (2015). Higher concentrations of *Salvia* extract generally result in greater inhibitory potential (Bisio et. al., 2010, Erez and Fidan, 2015, Ravlić et al., 2016) which is in accordance with results of our study. Ravlić et al. (2016) reported reduction in germination of hoary cress (*Lepidium draba* L.) up to 100% with common sage (*Salvia officinalis* L.) extracts from dry biomass compared to 25.7% with extracts from fresh biomass.

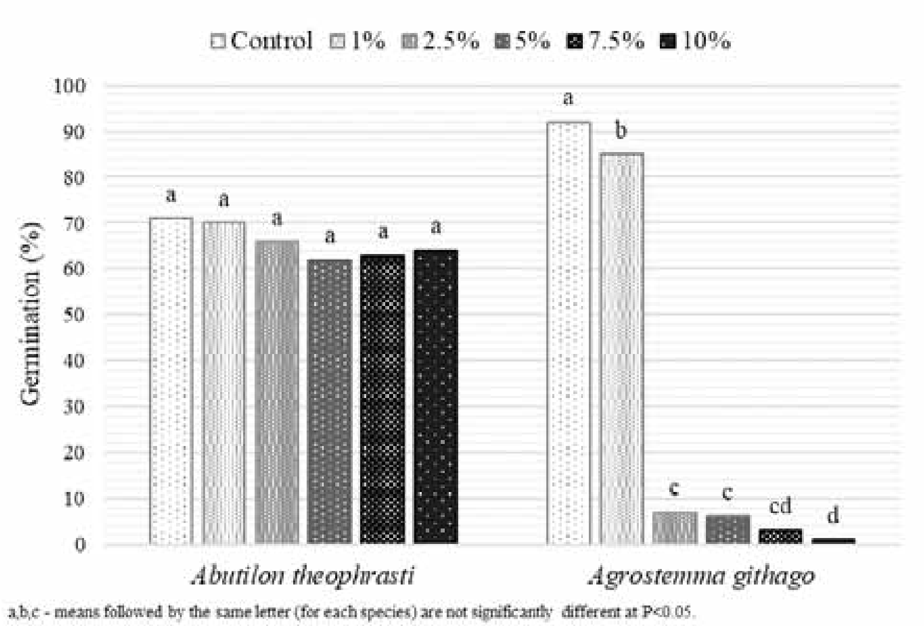

Figure 1. Effect of meadow sage (*Salvia pratensis*) water extracts on germination of weeds
Grafikon 1. Utjecaj vodenih ekstrakata livadne kadulje (*Salvia pratensis*) na klijavost korova

With the increase of extract concentration, the inhibitory effect on root and shoot length of weed seedlings increased (Table 1). Root length of *A. theophrasti* was significantly reduced in all treatments from 47.5% to 83.9% compared to control. Similarly, root length of *A. githago* was significantly decreased in all treatments, except for 1% concentration, up to 100%. Considerable inhibition of *A. theophrasti* shoot length was recorded for extract concentrations above the 2.5%, with the maximum reduction of 57.9%. Water extracts exhibited significant negative effect on *A. githago* shoot length with reductions ranging from 38.5% in treatment with 1% concentration to 100% in treatment with 10% concentration. According to Itani et al. (2013) leaves of meadow sage (*S. pratensis*) and autumn sage (*Salvia greggii* A.Gray) reduced root length of lettuce for over 50% compared to the control. Additionally, both *Salvia* species showed greater negative effect compared to majority of other species belonging to Lamiaceae family. Similarly, Bouajaj et al. (2013) reported negative effect of common sage (*S. officinalis*) essential oil on root length of lettuce. Inhibition of shoot length was also reported in other studies, as well as reductions in chlorophyll content in treatments with extracts from different *Salvia* species (Bisio et al., 2010, Ravlić et al., 2016). *Salvia* extracts are rich in phenolic compounds and flavonoids (Erez and Fidan, 2015; Grzegorczyk-Karolak and Kiss, 2018), while major components of *Salvia* essential oils and hydrosols include β-thujone, α-thujone, camphor and 1,8-cineole (Bouajaj et al., 2013, Matković et al., 2018, Politi et al., 2022). Qui et al. (2018) demonstrated significant phytotoxic potential of 1,8-cineole on germination and seedling growth of lettuce.

Table 1. Effect of meadow sage (*Salvia pratensis*) water extracts on root and shoot length of weed seedlings / **Tablica 1.** Utjecaj vodenih ekstrakata livadne kadulje (*Salvia pratensis*) na duljinu korijena i izdanka klijanaca korova

Water extract concentration (%)	Root length (cm)		Shoot length (cm)	
	Abutilon theophrasti	*Agrostemma githago*	*Abutilon theophrasti*	*Agrostemma githago*
Control	5.35 a	6.11 a	2.57 a	1.92 a
1 %	2.81 b	6.49 a	2.15 a	1.18 b
2.5 %	1.93 c	4.09 b	1.57 b	0.55 c
5 %	1.6 c	2.5 c	1.09 c	0.4 cd
7.5 %	1.32 cd	0.38 d	1.11 c	0.23 d
10 %	0.86 d	0.0 d	1.08 c	0.0 e

a,b,c - means followed by the same letter within column are not significantly different at P<0.05

The fresh weight of weed seedlings was significantly reduced in all treatments (Figure 2). For both weed species, *S. pratensis* water extracts in higher concentrations showed substantial inhibitory effect. The reduction of seedlings fresh weight ranged from 10.9% to 43.4% for *A. theophrasti*, and from 24.3 % to 100% for *A. githago*. The same was confirmed by Ravlić et al. (2016) where *S. officinalis* extracts inhibited fresh weight of *L. draba* seedlings from 3.7 to 100%.

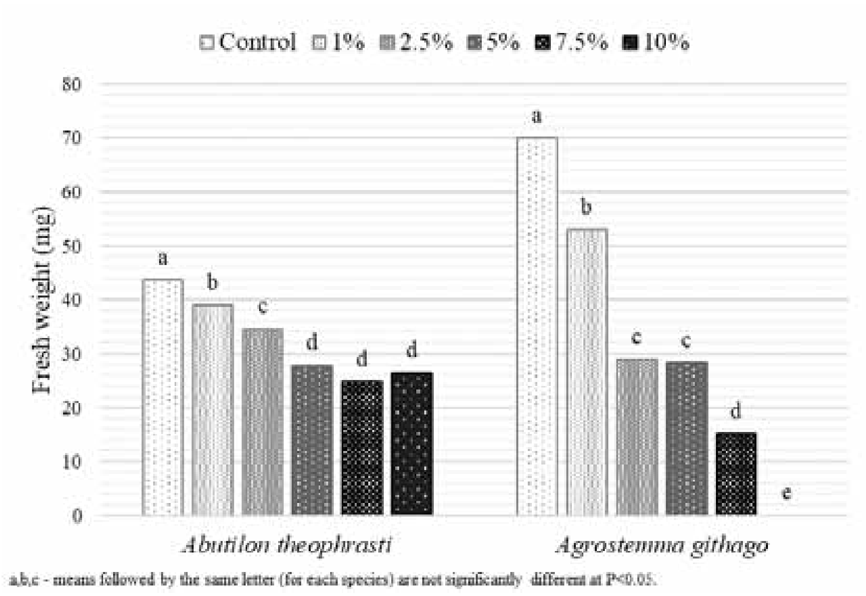

Figure 2. Effect of meadow sage (*Salvia pratensis*) water extracts on fresh weight of weed seedlings/ **Grafikon 2.** Utjecaj vodenih ekstrakata livadne kadulje (*Salvia pratensis*) na svježu masu klijanaca korova

Regardless of the extract concentration, average reduction of germination, shoot length and fresh weight of seedlings was greater for *A. githago* than for *A. theophrasti*. For example, average inhibition of *A. theophrasti* germination was 8.5%, while for *A. githago* 77.8%. Differences in sensitivity of tests species to phytotoxic potential of extracts is well documented. Kadioğlu and Yanar (2004) found that among nine weed test species *A. theophrasti* and curly dock (*Rumex crispus* L.) were the most sensitive to *S. officinalis* extracts. Similarly, Baličević et al. (2015) recorded greater susceptibility of redroot pigweed (*Amaranthus retroflexus* L.) compared to *A. theophrasti* when giant goldenrod (*Solidago gigantea* Ait.) water extracts were applied both in Petri dish bioassay and pot experiment.

Conclusion

S. pratensis water extracts in different concentrations showed significant herbicidal effect on the tested weed species. Differences in weed susceptibility were determined, and *A. githago* showed greater sensitivity to *S. pratensis* water extracts. *S. pratensis* represents a promising plant species for further studies in greenhouse experiments and phytochemical analysis.

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Izvorni znanstveni rad

Herbicidni potencijal livadne kadulje (Salvia pratensis L.) na Teofrastov mračnjak (Abutilon theophrasti Med.) i poljski kukolj (Agrostemma githago L.)

Sažetak

Ljekovite i aromatične biljke s alelopatskim djelovanjem potencijalni su izvor prirodnih herbicida. Pokus je proveden kako bi se utvrdio herbicidni potencijal livadne kadulje (Salvia pratensis L.) na klijanje i rast korovnih vrsta Teofrastov mračnjak (Abutilon theophrasti Med.) i poljski kukolj (Agrostemma githago L.). Vodeni ekstrakti od suhe biomase S. pratensis u različitim koncentracijama procijenjeni su u kontroliranim laboratorijskim uvjetima u pokusu u Petrijevim zdjelicama. Herbicidni utjecaj ekstrakata S. pratensis ovisio je o koncentraciji ekstrakta i vrsti korova. Općenito, više koncentracije vodenog ekstrakta pokazale su veći negativan učinak na klijavost i parametre rasta klijanaca korova. Vrsta A. githago pokazala je veću osjetljivost na ekstrakte S. pratensis sa smanjenjem klijavosti i rasta klijanaca do 100 % u tretmanima s koncentracijama ekstrakta od 7,5 % i 10 %. Vodeni ekstrakti nisu imali utjecaja na klijavost A. theophrasti, ali je zabilježeno značajno smanjenje duljine korijena i izdanaka kao i svježe mase klijanaca. S. pratensis pokazala se kao perspektivna biljna vrsta za daljnja istraživanja.

Ključne riječi: *alelopatija, biološka zaštita, korovi, inhibicija, Lamiaceae*