

ALLELOPATHIC POTENTIAL OF BIRTHWORT (*Aristolochia clematitis* L.) EXTRACTS ON CROPS AND WEEDS

Marija Ravlić*, Renata Baličević*, Jelena Ravlić*, Brankica Svitlica*

* Josip Juraj Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Osijek, Croatia

corresponding author: Marija Ravlić, e-mail: mravlic@fazos.hr



This work is licensed under a
[Creative Commons Attribution 4.0
International License](https://creativecommons.org/licenses/by/4.0/)

Original scientific paper
Received: May 16th, 2025
Accepted: July 22nd, 2025
HAE-2535

<https://doi.org/10.33765/thate.16.1.3>

ABSTRACT

Allelopathic plants and their chemical compounds offer promising possibilities for sustainable weed management. This study aimed to assess the phytotoxic potential of birthwort (*Aristolochia clematitis* L.) on the germination and early growth of crops (wheat, barley, basil) and the weed species redroot pigweed (*Amaranthus retroflexus* L.). Extracts from fresh and dry aboveground biomass of *A. clematitis*, in different concentrations, were evaluated using a Petri dish bioassay and a pot experiment with soil. The results indicated that allelopathic effects of *A. clematitis* extracts depended on extract concentration, biomass type, test species, and application method. Germination and growth of the test species generally decreased as the concentration of weed biomass in the water extracts increased. In the Petri dish bioassay, extracts from fresh biomass had both positive and negative effects, while higher concentrations of dry biomass extract suppressed germination and seedling growth by up to 90 %. In the pot experiment, the allelopathic impact was less pronounced, and inhibition was observed only with the application of extracts from dry biomass. Variability in species sensitivity was also noted, with barley and *A. retroflexus* being the most affected. *A. clematitis* shows great potential as a subject for further research.

Keywords: *Aristolochia clematitis*, germination, inhibition, phytotoxicity, seedling growth, biocontrol

INTRODUCTION

The pursuit of sustainable weed control methods and the need to reduce reliance on synthetic herbicides in order to minimize their negative impacts on the environment and human health have led to growing interest in alternative approaches to plant protection, such as allelopathy [1]. Allelopathy is a biological phenomenon in which plants release chemical

compounds, known as allelochemicals, into the environment to inhibit germination, growth, or development of neighbouring plants [2]. Allelopathically active plants and allelochemicals can be incorporated into integrated pest management systems - for example, through crop rotation, mulches, or plant extracts [3] - or as biostimulants to improve crop growth and productivity [4]. In addition to cultivated plants with substantial

allelopathic potential, such as cereals, brassicas [5], aromatic and medicinal species [6, 7], wild plant species are also recognized for their allelopathic properties, which can be utilized for effective weed control [7 - 9].

Birthwort (*Aristolochia clematitis* L.) is a perennial herbaceous plant in the Aristolochiaceae family, commonly found in central, eastern, and southern Europe. It typically grows in ruderal habitats such as roadsides, canals, and riverbanks, as well as in abandoned meadows, nitrogen-rich row crops, and vineyards. Recognizable by its heart-shaped leaves and pale-yellow tubular flowers, *A. clematitis* has been used in traditional medicine to treat various ailments [6, 10]. However, it contains aristolochic acids, which are linked to nephrotoxicity and carcinogenicity, particularly aristolochic acid nephropathy (AAN). As a result, its medicinal use is restricted or banned in many countries [11]. Phytotoxic potential of *A. clematitis* on germination and growth of other plant species has been previously documented in several studies [6, 12, 13].

Harmful effects of an allelopathic plant should be directed toward weeds, while at the same time the crops must remain unaffected or tolerant. Therefore, assessing its potential across a wide range of species, both crops and weeds, is essential [14]. Therefore, the aim of the study was to determine the allelopathic potential of water extracts from fresh and dry biomass of *A. clematitis* on the germination and growth of crops - wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), basil (*Ocimum basilicum* L.) - and weed species redroot pigweed (*Amaranthus retroflexus* L.), both in Petri dishes and pots with soil.

MATERIALS AND METHODS

Plant material and seed acquisition, and preparation of water extracts

The aerial biomass of *A. clematitis* was gathered in full flowering stage (BBCH 65

[15]) from ruderal habitats in Osijek-Baranja County, Croatia. A portion of fresh biomass was oven dried for 48 hours at 60 °C, then cut into small pieces and ground into a fine powder using an electronic grinder.

Seeds of barley (cv. 'Barun') and wheat (cv. 'Lucija') were obtained from Agricultural Institute Osijek, while basil seeds were commercially sourced from a seed company. Weed seeds of redroot pigweed (*A. retroflexus*) were collected from agricultural fields. Before each experiment, all seeds were surface-sterilized for 20 min with 1 % NaOCl and then rinsed three times with distilled water [16].

Water extracts were prepared according to Norsworthy [17], with slight modifications. A total amount of 100 grams of fresh or dry *A. clematitis* biomass was soaked with 1000 ml of distilled water and left to extract for 24 hours at room temperature. The mixtures were first strained through muslin cloth to remove coarse debris, and then filtered through filter paper. The obtained extracts were subsequently diluted with distilled water to obtain final concentrations of 1 %, 5 % and 10 % m/v (equivalent to 10, 50 and 100 g/L, respectively). All extracts were freshly prepared before bioassays and stored at 4 °C in a refrigerator throughout the experimental period.

Petri dish bioassay

The effect of three different concentrations (1 %, 5 % and 10 %) of extracts from fresh and dry *A. clematitis* biomass was assessed using a Petri dish bioassay. Twenty-five (barley, wheat) or thirty (basil, redroot pigweed) seeds were placed in sterilized Petri dishes (90 mm) lined with filter paper. In each Petri dish an equal amount of the respective extract was added (5 ml for barley and wheat, and 2 ml for basil and redroot pigweed), while distilled water was used in the control treatment. Equal amount of additional extract or water was added during experiment to prevent seedling desiccation. All Petri dishes were incubated at room temperature (22 °C ± 2) for seven days.

Pot bioassay

The effects of two concentrations (5 % and 10 %) of extracts from fresh and dry biomass of *A. clematitidis* were evaluated in a soil medium. Thirty seeds of crop or weed species were sown in pots (9 × 7 cm for barley and wheat; 9 × 4 cm for basil and redroot pigweed) filled with commercial substrate (NPK 210:120:260 mg/L, pH 5.6). Each pot was treated with 60 ml of extract per 100 g of soil, while distilled water was applied in the control treatment. All treatments were subsequently watered uniformly with distilled water. Both crops and weeds were grown for two weeks at room temperature (22 °C ± 2) on laboratory benches.

Data collection and statistical analysis

All experiments were conducted using a completely randomized design with four replications and repeated twice. Germination

and emergence percentages were calculated for each replication. At the end of each experiment, seedling root length (cm), shoot length (cm), and fresh weight (mg) were measured. The percentage of inhibition in germination, root length and shoot length, and fresh weight was calculated using Abbott's reduction coefficient (formula) [18]. The collected data were analysed statistically using ANOVA, and the treatment means were compared using the LSD test at a probability level of $p < 0.05$.

RESULTS AND DISCUSSION

Application of water extracts from fresh *A. clematitidis* biomass in concentrations of 1 %, 5 % and 10 % showed various effects on test species in the Petri dish experiment (Table 1).

Table 1. Effects of water extracts from fresh *Aristolochia clematitidis* biomass on germination and growth of test species in Petri dishes

<i>A. clematitidis</i> extract	Germination inhibition (%)	Root length inhibition (%)	Shoot length inhibition (%)	Fresh weight inhibition (%)
Wheat				
Control	0.0 a	0.0 b	0.0 a	0.0 a
1 %	1.5 a	-14.6 a	-3.8 a	-0.1 a
5 %	3.6 a	-7.3 ab	-2.5 a	8.2 a
10 %	1.0 a	-13.0 a	-1.3 a	-0.2 a
Barley				
Control	0.0 a	0.0 a	0.0 a	0.0 a
1 %	-2.2 a	33.3 b	0.2 a	14.0 b
5 %	5.5 a	54.8 c	0.7 a	22.5 c
10 %	24.7 b	65.6 d	16.6 b	40.9 d
Basil				
Control	0.0 a	0.0 a	0.0 b	0.0 ab
1 %	-4.0 a	7.7 a	-19.2 a	-3.6 a
5 %	-6.1 a	73.1 b	-26.9 a	14.4 bc
10 %	-1.0 a	76.9 b	-30.8 a	18.0 c
<i>Amaranthus retroflexus</i>				
Control	0.0 a	0.0 a	0.0 b	0.0 a
1 %	5.1 a	62.5 b	-42.1 a	3.9 a
5 %	9.5 a	82.5 c	5.3 b	35.3 b
10 %	7.1 a	92.5 d	52.6 c	62.7 c

Germination, shoot and root length, and fresh weight are expressed as % inhibition or stimulation relative to the control. Positive values (+) indicate inhibition, and negative values (-) indicate stimulation. Values followed by the same letter within a column for each crop or weed are not significantly different at $p < 0.05$.

A significant reduction in germination was observed only in barley with the highest extract concentration, with a decrease of 24.7 % compared to the control. The increase in extract concentrations led to a reduction in root length in both barley and basil, by up to 65.6 % and 76.9 %. Similarly, both shoot length and fresh seedling weight of barley were reduced, as well as fresh weight of basil. In *A. retroflexus*, root length, shoot length, and fresh weight declined with higher extract concentrations - by up to 92.5 %, 52.6 %, and 62.7 %, respectively. In contrast, stimulatory effects were observed on wheat root length, as well as on shoot length in both basil and *A. retroflexus*.

Germination of all tested crops in the Petri dish bioassay was decreased by extracts from dry *A. clematitidis* biomass, with barley being the most affected - showing up to 86.7 % reduction in germination compared to the control (Table 2). Furthermore, significant reductions in seedling length and fresh weight of crops were observed, with inhibitory

potential increasing as the biomass of *A. clematitidis* in extracts increased. Seed germination and seedling growth of *A. retroflexus* were inhibited at 5 % and 10 % extracts concentrations, by over 80 % and 90 %, respectively. Significant positive effects were recorded at the lowest extract concentration for the shoot length of wheat and *A. retroflexus* which were promoted by 8.7 % and 52.4 %, respectively.

The results of the allelopathic potential of water extracts from fresh *A. clematitidis* biomass in concentrations of 5 and 10 %, applied in pots, are presented in Table 3. None of the test species' emergence was affected, nor did the extracts exhibit inhibitory effects on seedlings length and fresh weight. However, both concentrations of the extract showed significant positive effect on growth of crops and *A. retroflexus*. The greatest stimulatory effects were recorded on fresh weight of basil and *A. retroflexus*, which were increased by up to 50.4 % and 41.2 %, respectively.

Table 2. Effects of water extracts from dry *Aristolochia clematitidis* biomass on germination and growth of test species in Petri dishes

<i>A. clematitidis</i> extract	Germination inhibition (%)	Root length inhibition (%)	Shoot length inhibition (%)	Fresh weight inhibition (%)
Wheat				
Control	0.0 a	0.0 a	0.0 b	0.0 a
1 %	-1.1 a	5.1 a	-8.7 a	-2.6 a
5 %	6.3 ab	75.7 b	28.3 c	36.8 b
10 %	10.1 b	98.5 c	84.8 d	84.2 c
Barley				
Control	0.0 a	0.0 a	0.0 a	0.0 a
1 %	8.3 a	27.5 b	4.2 a	13.6 a
5 %	53.3 b	77.1 c	43.7 b	52.5 b
10 %	86.7 c	98.2 d	84.4 c	89.8 c
Basil				
Control	0.0 a	0.0 a	0.0 a	0.0 a
1 %	-0.5 a	44.4 b	-12.5 a	-13.3 a
5 %	57.1 b	97.2 c	62.5 b	60.0 b
10 %	73.9 b	97.7 c	87.5 c	79.0 c
<i>Amaranthus retroflexus</i>				
Control	0.0 a	0.0 a	0.0 b	0.0 a
1 %	-21.3 a	70.3 b	-52.4 a	-7.7 a
5 %	34.2 b	89.2 c	81.0 c	65.4 b
10 %	83.8 c	97.3 c	90.5 c	90.4 c

Germination, shoot and root length, and fresh weight are expressed as % inhibition or stimulation relative to the control. Positive values (+) indicate inhibition, and negative values (-) indicate stimulation. Values followed by the same letter within a column for each crop or weed are not significantly different at $p < 0.05$.

Table 3. Effects of water extracts from fresh *Aristolochia clematitis* biomass on emergence and growth of test species in pot bioassay

<i>A. clematitis</i> extract	Emergence inhibition (%)	Root length inhibition (%)	Shoot length inhibition (%)	Fresh weight inhibition (%)
Wheat				
Control	0.0 a	0.0 b	0.0 a	0.0 b
5 %	1.0 a	-14.0 a	-0.1 a	-15.9 a
10 %	0.5 a	-15.0 a	-1.2 a	-6.8 b
Barley				
Control	0.0 a	0.0 b	0.0 b	0.0 b
5 %	-2.6 a	-8.9 a	-20.1 a	-13.9 a
10 %	0.0 a	-11.3 a	-25.9 a	-18.4 a
Basil				
Control	0.0 a	0.0 a	0.0 a	0.0 b
5 %	-1.2 a	-16.7 a	-3.5 a	-50.4 a
10 %	-5.2 a	-4.2 a	-6.1 a	-35.5 a
<i>Amaranthus retroflexus</i>				
Control	0.0 a	0.0 b	0.0 b	0.0 b
5 %	-7.0 a	-12.0 a	-9.1 a	-33.8 a
10 %	-18.8 a	-8.0 a	-13.6 a	-41.2 a

Germination, shoot and root length, and fresh weight are expressed as % inhibition or stimulation relative to the control. Positive values (+) indicate inhibition, and negative values (-) indicate stimulation. Values followed by the same letter within a column for each crop or weed are not significantly different at $p < 0.05$.

The application of extracts from dry *A. clematitis* biomass in pots significantly reduced the emergence of basil, but had no

effect on the emergence of wheat and barley (Table 4).

Table 4. Effects of water extracts from dry *Aristolochia clematitis* biomass on emergence and growth of test species in pot bioassay

<i>A. clematitis</i> extract	Emergence inhibition (%)	Root length inhibition (%)	Shoot length inhibition (%)	Fresh weight (inhibition) %
Wheat				
Control	0.0 a	0.0 a	0.0 ab	0.0 ab
5 %	-1.0 a	6.8 a	-0.9 a	-5.3 a
10 %	0.5 a	6.7 a	2.3 b	3.8 b
Barley				
Control	0.0 a	0.0 a	0.0 a	0.0 a
5 %	1.0 a	4.8 ab	-0.1 a	8.6 b
10 %	-1.5 a	8.9 b	1.4 a	12.3 b
Basil				
Control	0.0 a	0.0 a	0.0 a	0.0 a
5 %	13.6 b	5.0 a	12.7 a	7.5 ab
10 %	10.8 ab	35.0 b	10.0 a	23.3 b
<i>Amaranthus retroflexus</i>				
Control	0.0 a	0.0 a	0.0 a	0.0 a
5 %	16.1 a	17.4 b	9.4 a	16.4 b
10 %	55.9 b	47.8 c	31.2 b	35.8 c

Emergence, shoot and root length, and fresh weight are expressed as % inhibition or stimulation relative to the control. Positive values (+) indicate inhibition, and negative values (-) indicate stimulation. Values followed by the same letter within a column for each crop or weed are not significantly different at $p < 0.05$.

Furthermore, the root length and fresh weight of both barley and basil were substantially decreased, by up to 35 %. The extracts also significantly inhibited the emergence of *A. retroflexus*, with a higher extract concentration reducing it by 55.9 %. Similarly, *A. retroflexus* seedling growth was reduced by both extract concentrations, with decreases of over 30 % compared to the control.

The experimental results suggest that water extracts from both fresh and dried *A. clematidis* biomass showed inhibitory and stimulatory effects on the tested species. Allelopathic potential varied depending on the extract concentration, biomass type, test species, and the method of application - either in Petri dishes or in pots containing soil.

Generally, germination and growth of test species decreased proportionately as the concentration of weed biomass in water extracts increased. The highest inhibitory potential was observed with *A. clematidis* dry biomass extracts applied in the Petri dish assay. The results of Turker and Usta [6] showed that *A. clematidis* extracts at a concentration of 7.5 % decreased radish (*Raphanus sativus* L.) seed germination and seedling length to a greater extent compared to a lower concentration of 1 %. Similarly, Valcheva et al. [13] found that higher concentrations of *A. clematidis* biomass caused complete (100 %) inhibition of germination and seedling growth of lettuce (*Lactuca sativa* L.). However, positive effects were also recorded in this study, especially with extracts from fresh biomass at lower concentrations. A positive effect on germination, root elongation, and biomass accumulation of target species was also reported with *A. clematidis* [12] and other medicinal and weed species [6, 9, 19].

In both the Petri dish and pot experiments, extracts differed in their allelopathic effects depending on whether fresh or dry biomass was used, with extracts from dry biomass showing higher inhibitory potential. Furthermore, extracts from fresh biomass stimulated seedling growth. Extracts from fresh *A. clematidis* biomass were reported to reduce only the root length of the weed species

scentless mayweed (*Tripleurospermum inodorum* (L.) C.H. Schultz), while extracts from dry biomass inhibited both germination and growth by up to 100 % [12]. Differences among extracts may be due to the varying concentrations of active substances extracted from fresh and dry biomass [19]. Although extracts from dry biomass generally exhibit greater inhibitory potential [19, 20], some studies have found that extracts from fresh biomass are more inhibitory [21], possibly due to a reduction in allelochemical potency as a result of drying [22].

Test species differed in their sensitivity to *A. clematidis* water extracts (Figure 1). On average, *A. retroflexus* was the most susceptible species, followed by barley and basil, while wheat was the most tolerant. Sensitivity of crops and weeds to allelochemicals is different among species and genotypes within species [8, 9, 14, 19] due to morphological and physiological diversity among seeds, seed size or the ability of species to detoxify allelochemicals [17, 23, 24].

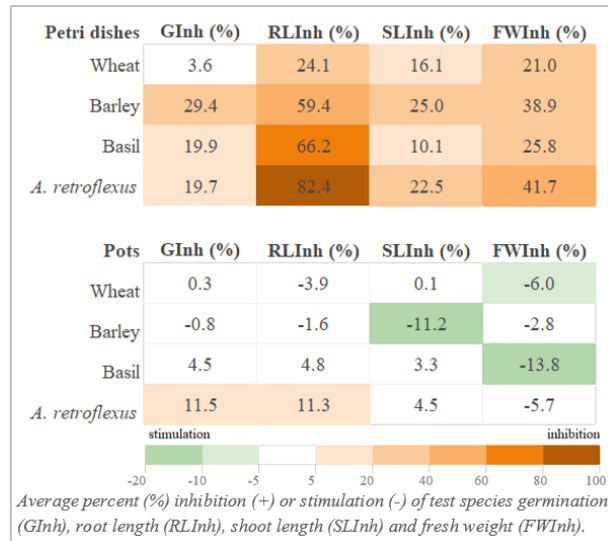


Figure 1. Color-coded heatmap illustrating the sensitivity of test species to *Aristolochia clematidis* extracts, with inhibition responses shown in orange (+) and stimulation responses in green (-)

The phytotoxic potential of *A. clematidis* extracts differed between the Petri dish assay and the pot experiment, with the inhibitory effect being more pronounced in the Petri

dishes (Figure 1). This difference between assays was most evident in root length and fresh weight of seedlings, which showed strong inhibition in Petri dishes but minimal effects or even stimulation in pots. Gatti et al. [25] also recorded a greater decrease in seedling growth of lettuce and radish when treated with *Aristolochia esperanzae* O. Kuntze extracts on filter paper, compared to seedlings grown in coconut fibre. Similarly, in a Petri dish assay, the application of *Aristolochia maurorum* L. water extracts completely (100 %) inhibited the germination, root and shoot dry weight of wheat [26], while foliar-applied extracts reduced plant height and shoot dry weight of *A. retroflexus* and nettle-leaved goosefoot (*Chenopodium murale* L.) by up to 48.7 % and 64.7 % [8]. The higher inhibitory effect of water extracts may be due to the direct contact between the seeds and the extract on the filter paper or the adsorption of allelochemicals to the soil. The physical, chemical, and biological properties of the soil, as well as the presence of microorganisms, can affect the transformation, degradation, and adsorption of allelochemicals to soil organic matter, which may reduce their effect and result in lower phytotoxicity [27, 28].

CONCLUSION

The experiments demonstrated that extracts from both fresh and dry biomass of *A. clematitis* exhibit allelopathic activity against crops and weeds. In Petri dish assays, all tested species showed growth inhibition when exposed to the extracts. However, in soil-based pot experiments, only the dry biomass extract significantly suppressed weed emergence and growth, while crop species were either unaffected or only mildly inhibited. The observed selectivity indicates a possible application in integrated weed management strategies, especially in systems that aim to reduce synthetic herbicide use. However, further research is needed to evaluate the consistency of these effects under field conditions, determine optimal application methods and rates, and assess potential

impacts on non-target organisms and soil health.

REFERENCES

- [1] G.F. Al-Samarai, W.M. Mahdi, B.M. Al-Hilali, Reducing environmental pollution by chemical herbicides using natural plant derivatives - allelopathy effect, *Annals of Agricultural and Environmental Medicine* 25(2018) 3, 449-452. <https://doi.org/10.26444/aaem/90888>
- [2] E.L. Rice, *Allelopathy*, 2nd ed., Academic Press, Orlando, Florida, 1984.
- [3] D. Soltys, U. Krasuska, R. Bogatek, A. Gniazdowska, Allelochemicals as Bioherbicides - Present and Perspectives, in: *Herbicides - Current Research and Case Studies in Use*, eds.: A.J. Price, J.A. Kelton, InTech, Rijeka, 2013, 517-542. <https://doi.org/10.5772/56185>
- [4] P. Findura, S. Kocira, P. Hara, A. Pawłowska, A. Szparaga, P. Kangalov, Extracts from *Artemisia vulgaris* L. in Potato Cultivation - Preliminary Research on Biostimulating Effect, *Agriculture* 10(2020) 8, Article 356. <https://doi.org/10.3390/agriculture10080356>
- [5] D.T. Hickman, D. Comont, A. Rasmussen, M.A. Birkett, Novel and holistic approaches are required to realize allelopathic potential for weed management, *Ecology and Evolution* 13(2023) 4, Article e10018. <https://doi.org/10.1002/ece3.10018>
- [6] A. Turker, C. Usta, Biological Activity of Some Medicinal Plants Sold in Turkish Health-Food Stores, *Biotechnology & Biotechnological Equipment* 20(2006) 3, 105-113. <https://doi.org/10.1080/13102818.2006.10817386>
- [7] T.G. Isin Ozkan, E. Akalin Urusak, K.S. Appiah, Y. Fujii, First Broad Screening of Allelopathic Potential of Wild and Cultivated Plants in Turkey, *Plants* 8(2019) 12, Article 532. <https://doi.org/10.3390/plants8120532>

- [8] L.J. Al-Batsh, J.R. Qasem, Phytotoxicity of wild plants extracts to redroot pigweed (*Amaranthus retroflexus* L.) and nettle-leaved goosefoot (*Chenopodium murale* L.), Pakistan Journal of Agricultural Sciences 57(2020) 6, 1441-1456.
- [9] M. Ravlić, R. Baličević, Ž. Vinković, B. Brozović, A. Sarajlić, D. Kranjac, The allelopathic potential of ruderal plant species on tomato and lettuce, Poljoprivreda 30(2024) 2, 3-9. <https://doi.org/10.18047/poljo.30.2.1>
- [10] M. Knežević, Atlas korovne, ruderalne i travnjačke flore, Sveučilište Josipa Jurja Strossmayera u Osijeku, Poljoprivredni fakultet u Osijeku, Osijek, Croatia, 2006.
- [11] J. Michl, M.J. Ingrouille, M.S.J. Simmonds, M. Heinrich, Naturally occurring aristolochic acid analogues and their toxicities, Natural Product Reports 31(2014) 5, 676-693. <https://doi.org/10.1039/C3NP70114J>
- [12] R. Baličević, M. Ravlić, M. Mišić, I. Mikić, Allelopathic effect of *Aristolochia clematitis* L., Proceedings of the 50th Croatian and 10th International Symposium on Agriculture, ed.: M. Pospišil, University of Zagreb, Faculty of Agriculture, Opatija, Croatia, February 16 - 20, 2015, 54-58.
- [13] E. Valcheva, V. Popov, P. Marinov-Serafimov, I. Golubinova, B. Nikolov, I. Velcheva, S. Petrova, Allelopathic effect of some weed species on germination and initial development of *Lactuca sativa*, Book of Proceedings VIII International Agriculture Symposium "Agrosym 2017", ed. D. Kovačević, University of East Sarajevo, Faculty of Agriculture, Jahorina, Bosnia and Herzegovina, October 5 - 8, 2017, 170-175.
- [14] R. Baličević, M. Ravlić, T. Živković, Allelopathic effect of invasive species giant goldenrod (*Solidago gigantea* Ait.) on crops and weeds, Herbologia 15(2015) 1, 19-29.
- [15] M. Hess, G. Barralis, H. Bleiholder, L. Buhr, TH. Eggers, H. Hack, R. Stauss, Use of the extended BBCH scale - general for the description of the growth stages of mono- and dicotyledonous species, Weed Research 37(1997) 6, 433-441. <https://doi.org/10.1046/j.1365-3180.1997.d01-70.x>
- [16] S. Siddiqui, S. Bhardwaj, S.S. Khan, M.K. Meghvanshi, Allelopathic effect of different concentration of water extract of *Prosopis juliflora* leaf on seed germination and radicle length of wheat (*Triticum aestivum* Var-Lok-1), American-Eurasian Journal of Scientific Research 4(2009) 2, 81-84.
- [17] J.K. Norsworthy, Allelopathic potential of wild radish (*Raphanus raphanistrum*), Weed Technology 17(2003) 2, 307-313. [https://doi.org/10.1614/0890-037X\(2003\)017\[0307:APOWRR\]2.0.CO;2](https://doi.org/10.1614/0890-037X(2003)017[0307:APOWRR]2.0.CO;2)
- [18] W.S. Abbott, A method of computing the effectiveness of an insecticide, Journal of Economic Entomology 18(1925) 2, 265-267. <https://doi.org/10.1093/jee/18.2.265a>
- [19] P. Marinov-Serafimov, I. Golubinova, D. Marinova, Allelopathic tolerance of alfalfa (*Medicago sativa* L.) varieties to dodder (*Cuscuta epithimum* L.), Pesticides and Phytomedicine 32(2017) 1, 51-59. <https://doi.org/10.2298/PIF1701051M>
- [20] P. Marinov-Serafimov, Determination of Allelopathic Effect of Some Invasive Weed Species on Germination and Initial Development of Grain Legume Crops, Pesticides and Phytomedicine 25(2010) 3, 251-259. <https://doi.org/10.2298/PIF1003251M>
- [21] J.R. Qasem, Allelopathic effect of white top (*Lepidium draba*) on wheat and barley, Allelopathy Journal 1(1994) 1, 29-40.
- [22] J.R. Qasem, Allelopathic effects of *Amaranthus retroflexus* and *Chenopodium murale* on vegetable crops, Allelopathy Journal 2(1995) 1, 49-66.
- [23] Inderjit, S.O. Duke, Ecophysiological aspects of allelopathy, Planta 217(2003) 4, 529-539. <https://doi.org/10.1007/s00425-003-1054-z>

- [24] A. Khaliq, A. Matloob, Z.A. Cheema, M. Farooq, Allelopathic activity of crop residue incorporation alone or mixed against rice and its associated grass weed jungle rice (*Echinochloa colona* [L.] Link), Chilean Journal of Agricultural Research 71(2011) 3, 418-423. <https://doi.org/10.4067/S0718-58392011000300012>
- [25] A.B. Gatti, S.C.J. Gualtieri de Andrade Perez, M.I.S. Lima, Atividade alelopática de extratos aquosos de *Aristolochia esperanzae* O. Kuntze na germinação e no crescimento de *Lactuca sativa* L. e *Raphanus sativus* L., Acta Botanica Brasilica 18(2004) 3, 459-472. <https://doi.org/10.1590/S0102-33062004000300006>
- [26] J.R. Qasem, A Survey on the phytotoxicity of common weeds, wild grown species and medicinal plants on wheat, Allelopathy Journal 42(2017), 179-194. <http://dx.doi.org/10.26651/allelo.j./2017-42-2-1115>
- [27] R.A. Vidal, M.V. Hickman, T.T. Bauman, Phenolics adsorption to soil reduces their allelochemical activity, Pesquisa Agropecuaria Gaúcha 4(1998) 2, 125-129.
- [28] P.B.S. Bhadoria, Allelopathy: A natural way towards weed management, American Journal of Experimental Agriculture 1(2011) 1, 7-20. <https://doi.org/10.9734/AJEA/2011/002>