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***Original scientific paper***

# ALLELOPATHIC EFFECTS OF RAGWEED ON CORN *(Zea mays* L.) AND WHEAT (*Triticum aestivum* L.)

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**Summary**

*Ambrosia artemisifolia* (ragweed) is an invasive plant species with severe allergenic effects which quickly detects favorable growth conditions and represents a threat to the quality of plant communities. There are still unanswered questions to the allelopathic effects of ragweed on other species, which further complicates the understanding of its compatibility with other plants in both natural and agricultural environment. The paper monitors the allelopathic effects of the aqueous extract isolated from dry ragweed leaves (10, 5, 2.5 and 1.25%) on the germination and growth of corn and wheat. The aquaeous ragweed extracts reduced the germination of corn and wheat down to 70%. The seedling length was inhibited, especially in high concentrations. Wheat appeared to be more tolerant to the extract effect. Corn suffered a larger inhibition effect in terms of root length and seedlings, which suggested that this species was more sensitive. The obtained results imply that the ragweed should be combated in a timely manner in order to avoid its inhibitory effects on the indicator crops.

**Key words**: allelopathy, ragweed, leaf extract, corn, wheat, germination.

## INTRODUCTION

Ragweed (*Ambrosia artemisifolia* L.) is an annual herbaceous plant native to North America and dominant in the abandoned fields of the USA and Canada. The species is a common weed in corn, wheat and soya fields and house gardens. It may grow thickly in fields which are cultivated in spring and then deserted. In addition, it may occupy the roads, empty city sites and other habitats. It was brought to Europe in 1900 and has been a subject of many studies ever since due to its intensive allergenic and allelopathic potential (Galzina *et al*., 2010; Greber *et al*., 2011; Viddotto *et al*., 2013; Buzhdygan and Baglei, 2016; Skálová *et al*., 2017).

Allelopathy is a biological phenomenon referring to either positive and negative or direct and indirect effects of a plant species, fungi or microorganisms on other species by creating chemical compounds (allelochemicals) released into the environment (Tesio *et al*., 2010; Lehoczky *et al*., 2011; Viddotto *et al*., 2013). Allelochemicals which combat or remove plant species are paid special attention for their agricultural application as selective natural herbicides (Vyvyan, 2002; Sangeetha and Bashar, 2015). Ragweed generates allelochemicals which can be found in all parts of plants, and most common compounds with the allelopathic potential are terpenes and phenols (Seigler, 2006).

Allelopathic effects of ragweed on other plant species should be further accounted for Buzhdygan and Baglei, 2016), although its inhibition effects on crops have been documented (Csiszár, 2009; Lehoczky *et al*., 2011; Sangeetha and Bashar, 2015; Bonea and sar., 2018). Vidotto *et al.* (2013) deduced that extracts isolated from ragweed roots and leaves inhibited the growth of tomato, lettuce and wheat. A lower germination percentage under the effects of the ragweed aqueous extract was registered in *Helianthus annus, Medicago sativa, Trifolium pratense, Prunella vulgaris* and *Plantago major* (Buzhdygan and Baglet, 2016), and the germination percentage was higher in *Hordeum vulgare.* Earlier studies (Bonea *et al*., 2018) suggest that the extract isolated from the ragweed leaves, stems and roots inhibited germination and growth in corn. Ragweed grows quickly with large ground biomass and strong roots, in which process it represses other crops. According to Buzhdygan and Baglei (2016), ragweed contains chlorogenic acid and the glucose and caffeic acid esters, which inhibit germination of many plant species.

Given the fact that ragweed has the potential to decrease plant and crop growth and to negatively affect human health, we found it crucial to test sensitivity of some cereals to ragweed. Hence, the paper investigates allelopathic effects of the ragweed aqueous extract on germination and growth of corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.).

## MATERIAL AND METHODS

*Ambrosia artemiisifolia* sprouts were collected from an abandoned field in the municipality of Doboj in July 2020. The leaves were removed on site and dried at 60 ºC. The obtained material was then ground, used for the preparation of the aqueous extract at 1:10 ratio (100 g of herbal material per 1000 ml of water) and left at the room temperature (22 ºC) for 24 hours. Afterwards, it was filtered through the filter paper. 24 hours later, the obtained extract was used for the preparation of the following solutions: 1/2 (5% extract), 1/4 (2.5% extract) and 1/8 (1.25% extract). The ragweed allelopathic activity was assessed via a modified method of biotesting on corn seeds (*Zea mays* L.) and wheat seeds (*Triticum aestivum* L.) (Lehoczky *et al*., 2011). The seeds' surface was sterilized with 1% NaOCl for five minutes, after which 15 corn seeds and 15 wheat seeds covered in filter paper moistened by distillated water (control) and prepared treatments were selected. Each treatment was repeated three times, and the experiment was repeated twice. Petri-dishes were incubated at 26 °C for seven days.

Once the experiment finished, we monitored the effects of different concentrations of the ragweed aqueous extract on germination percentage, mean germination time (MGT), speed of germination – germination index (GI) and parameters of sprout and root growth (root length and height) (Figure 1).

The ragweed allelopathic activity was assessed through the biotesting of pea seed (*Pisum sativum* L.) and bean seed (*Phaseolus vulgaris* L.).

The germination percentage was calculated in line with the following formula:

Germination % = No. of germinated seeds / the total No. of seeds at the beginning of experiment × 100

Mean germination time (MGT – *Mean Germination Time*) – was calculated in line with the formula designed by Elis and Roberts (1981):

$$MGT = \Sigma (Dn) / \Sigma n$$

In which n is the number of seeds germinated on D day, and D is the number of days since the beginning of germination.

Speed of germination – germination index (GI) – was calculated in line with the following formula (Khandakar and Bradbeer, 1983):

$$GI = n1 / d1 + n2 / d2 + n3 / d3 + Nn/n \times 100$$

In which n is the number of germinated seeds which germinate on 1,2,3…n days after the experiment started, and d is the number of days.

All data were statistically processed in the SPSS 20.0 program (Statistical Package for the Social Sciences). The analyses were performed in three independent replicates and the analyzed parameters were processed by the nonparametric Mann-Whitney U test, at the significance level $p<0.05$.

## RESULTS AND DISCUSSION

Allelopathy has drawn great attention from many scholars due to the inhibition effects of allelochemicals on the growth, germination and survival of other plant species in the direct surroundings (Galzina *et al*., 2010; Lehoczky *et al*., 2011; Buzhdygan and Baglei, 2016; Vidotto *et al*., 2013; Skálová *et al*., 2017). The most common mechanism of allelopathy in terms of plant interaction is the effect of secondary metabolites which might be toxic due to interrupted adsorption of organic matter or microbiological rhizosphere (Tessio and Ferrero, 2010). Our results suggest that the aqueous extract isolated from *Ambrosia artemiisifolia* leaves affects both target species (corn and wheat) via inhibition of germination percentage and sprout and root growth in comparison with the control group (Figure 1).

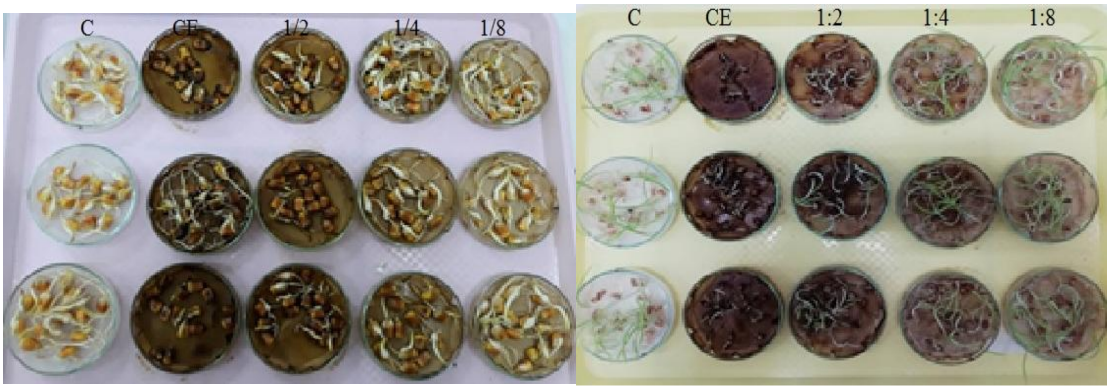


**Figure 1.** The effect of different concentrations of the ragweed aqueous extract on germination and growth of corn and wheat seeds after the experiment finished (C-Control (distilled water), CE- concentrated extract, diluted 1/2, diluted 1/4 and diluted 1/8)

The smallest germination percentage in corn was registered on the third day when the extract concentration was highest (26.63%), and the control group had the highest percentage on days five and seven (100%) (Figure 2). Inhibition effects of the ragweed aqueous extract were registered in first treatments, and germination decreased along with the decrease in extract concentration in a solution (concentrated extract <1/2 <1/4 <1/8). Our results matched the results of Lehoczky *et al*. (2011), who detected inhibition effects of ragweed on the germination of corn, wheat, rye and oat. Higher concentrations of the ragweed leaf aqueous extracts, especially concentrated ones and ½, caused the germination decrease in seeds and lower germination index, longer germination time and poorer initial growth of both target species.

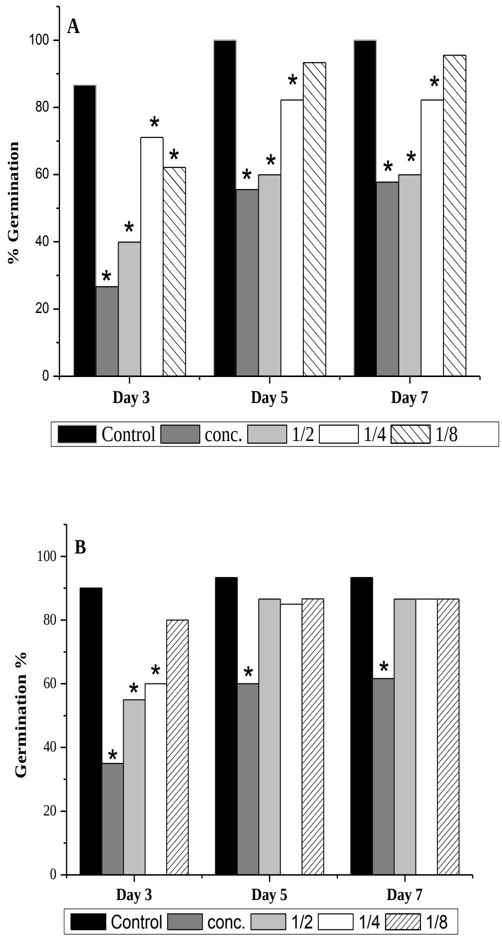


**Figure 2.** Germination (%) of corn (A) and wheat (B) seeds treated by different concentrations of the ragweed aqueous extract. The asterisk stands for the statistically significant difference between the control and the treatment for the same period ($p < 0.05$)

The obtained result indicate that germination of wheat seeds also decreased under the impact of the ragweed aqueous extract, but the average germination percentage was slightly larger in comparison with corn seeds (Figure 2). The wheat seed germination was lowest in the highest extract concentrations (concentrated and 1/2), and it was the highest in the control group (Figure 2). The average percentage of wheat seed germination in the control group was 92.20%, in concentrated extract it was 52.22%, and in groups with ½, 1/4 and 1/8 extracts it was similar with no evident difference. The results suggest that the inhibition effects of the ragweed aqueous extract significantly increased along with the increase of its concentration in the medium, which was also corroborated by other studies (Lehoczky *et al*., 2011; Buzhdygan and Baglei, 2016).

The mean germination time in corn was shortest in the control group and it was five days (Figure 3), and the longest time was in the highest extract concentration (5.33). MGT in low extract concentrations was similar to the one in the control group (Figure 3).

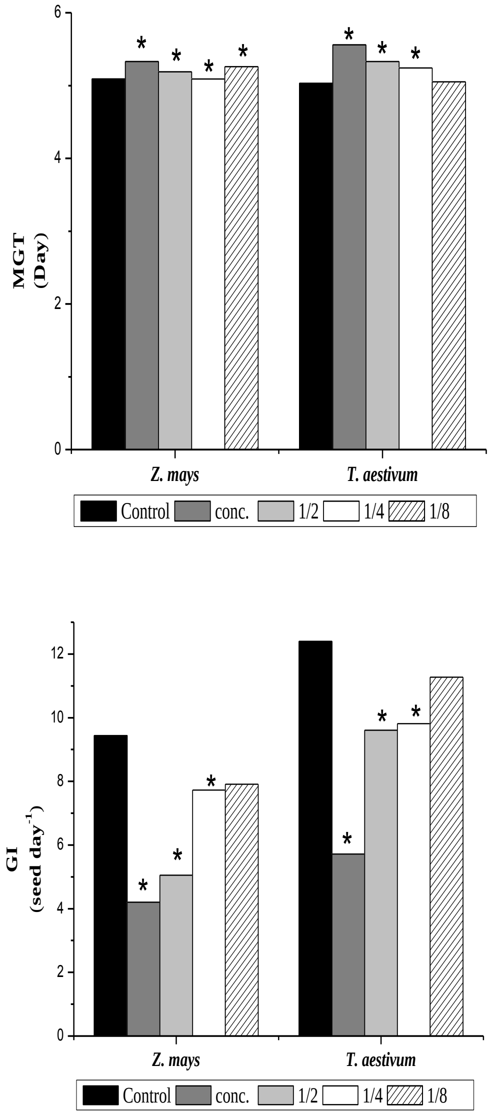


**Figure 3.** Mean germination time (MGT) and germination index (GI) of the observed crops under control and different extract concentrations. The asterisk stands for the statistically significant difference between the control and treatments applied to one treated species ($p<0.05$)

Mean germination time in wheat was shortest for the control group, 5.03 days (Figure 3). The highest inhibition effect was registered in the concentrated extract where mean germination time was 5.56 days, meaning the germination was 0.53 days longer. Results imply that there were significant statistical differences of MGT between the control group and applied concentrations in both target species. The concentrated ragweed extract prolonged MGT in wheat more than it did in corn. Some authors believe that allelopathic ragweed effects are conditioned not by the direct toxic impact but by the effect on the decrease in osmotic potential of the surrounding plant species (Kazinczi *et al*., 2008). They inferred that smaller concentrations of the ragweed aqueous extract could stimulate germination and growth of sunflower seeds. On the other hand, high extract concentrations had a negative impact on *Helianthus annuus* growth due to disturbed water potential and regime in mineral diet, especially NPK.

The applied concentrations of the ragweed aqueous extract largely decreased the germination index (GI) of seeds of both our plant species (Figure 3). Germination index of corn was highest in the control group and lowest in the highest concentration (concentrated ragweed extract and 1/2) (Figure 3). Islam *et al*. (2014) found that *Chenopodium murale* extracts had a negative allelopatic effect on germination index of different crops. The ragweed negative effect on GI might have been caused by the disturbed metabolism in meristematic cells which had been proved to have been extremely sensitive to allelochemicals from this species (Bonea *et al*., 2017). The same authors demonstrated that the ragweed leaf aqeous extract caused the reduction of mitotic index of meristematic cells in wheat roots during germination. It may be associated with the germination inhibition and sprout growth detected in our study.

Wheat had higher GI than corn, and GI was the highest in control groups of both plant species. Wheat GI was the highest in the lowest extract concentrations (1/4 and 1/8) and lowest in the highest extract concentrations (concentrated ragweed extract and 1/2) (Figure 3). The concentrated extract isolated from the *Ambrosia artemisiifolia* leaves had a largest impact on the decrease of GI, and it was more pronounced in corn than in wheat (Figure 3). Both target plant species registered significant statistical difference in the germination speed between control groups and applied treatments, with an exception of 1/8 concentration.

Allelochemicals (phenolic acids,terpenes) inhibit germination and growth of sprouts and probably affect the cell division and strain process or the increase of the proteolytic enzimes which participate in the mobilization of material crucial for germination (Kamal, 2020; Madhan Shankar *et al*., 2014). Our applied concentrations of the aqeous ragweed extract (concentrated extract, 1/2, 1/4 and 1/8) strongly limited the growth parameters (Figures 1 and 4). Both plant species registered a significant decrease in sprout growth in comparison with roots. The corn root length was highest in the control group and in 1/8 extract (4.27 cm), and it was largely reduced in the concentrated extract (1.99 cm). The sprout growth decreased as the concentration of the extract increased. Still, corn had a 50% decrease in the concentrated extract when compared to the control group. There was a significant statistical difference between the control group and the treatments (concentrated extract and 1/2), whereas 1/4 and 1/8 extracts registered no significant statistical difference. In wheat, roots were the longest in the control group (11.29 cm), and the shortest in the concentrated ragweed extract (1.76 cm). The sprout length in wheat was the biggest in the control group (7.60 cm), and the smallest in the concentrated extract (1.53 cm). There was a significant statistical difference between the control group and all applied treatments of the ragweed aqueous extract (except 1/8) (Figure 4).

Earlier studies (Csiszár, 2009) found that ragweed extracts inhibited germination and growth of corn, whereas a study by Wu *et al*. (2001) demonstrated that the ragweed aqueous extract in 2.5% concentration stimulated root elongation in wheat (*Triticum aestivum* L.), and that 5 to 10% concentrations inhitited it. Given that our plants which were treated with ragweed extracts had shorter sprout length in comparison with roots, we may conclude that initial growth phases demonstrated greater inhibition of sprout growth in comparison with roots. Similar results were obtained by Buzhdygan and Baglei (2016), who corroborated that ragweed aqueous extracts inhibited sprout growth some other wild and domestic plant species (*Medicago sativa, Hordeum vulgare, Plantago* sp.*, Trifolium pratense*).

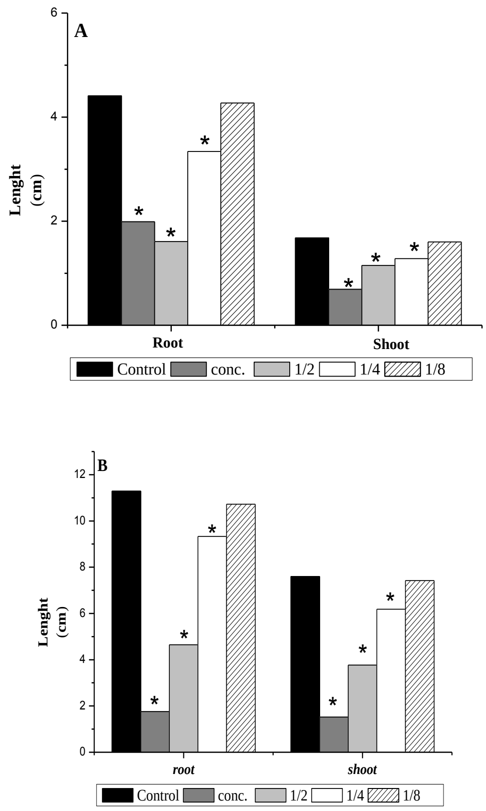


**Figure 4.** Effects of different concentrations of the extract of *Ambrosia artemisifolia* on the root length and sprout height in corn (A) and wheat (B). The asterisk stands for the statistically significant difference of the measured parameter betwwen the control and applied treatments in one treated species ($p< 0.05$)

## CONCLUSIONS

Results of the study suggest that the ragweed aqueous extract inhibited more germination in corn seeds than in wheat seeds. We also saw that the extracts had more effects on sprout growth than on root growth. The ragweed aqueous extracts prolonged the mean germination time and decreased the germination index in both target plant species.

The obtained results also suggest that *Ambrosia artemisiifolia* L. has the allelopathic potential due to its strong inhibition effects on target species, which is very likely to be caused by allelochemicals in the ragweed leaves. The study also demonstrated the pertinence of the control of ragweed considering its negative allelopathic effects.

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