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THE ALLELOPATHIC POTENTIAL OF *ERIGERON ANNUUS* (L.) DESF. SUBSP. *ANNUUS* EXTRACTS ON CROP SPECIES

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INTRODUCTION

Plants can release chemicals into the environment that suppresses the growth and establishment of other plants in their vicinity, a process known as allelopathy (Inderjit et al., 2011). Allelopathic compounds play an important role in determining nutrient dynamics, mycorrhizae, soil chemical characteristics, microbial ecology, plant diversity, dominance and invasion (Koocheki et al., 2013). Although allelopathy in the plant kingdom is well known, the ubiquity of allelopathy among invasive plants is unknown (Kalisz et al., 2021). Invasive plant species affect globally, human health and the economy, representing one of the greatest threats to biodiversity (Peter et al., 2021). According to Yuan et al. (2013), the question of why invasive plants are more competitive in the introduced area than native species is an unanswered question. Invasive species use numerous strategies to establish themselves in new ecosystems (Kalisz et al., 2021). Del Fabbro and Prati (2015) said that some invasive species can be superior to native species because they release allelochemical substances that affect native species. Allelopathic substances can affect plants immediately after they are released into the environment or can persist in the soil. Allelopathic invasive plants compounds can directly affect the tissues of surrounding plants, disrupting the germination and growth of shoots or adult plants (Zhang et al., 2020a).

Erigeron annuus, the annual fleabane, daisy fleabane, or eastern daisy fleabane, is an invasive species, native to North America, which was introduced in Europe (Tunaitienė et al., 2017) in the XVIIth century and in Romania is known since the late XIXth century (Goia, 2013). According to Anastasiu and Negrean (2005), eastern daisy fleabane is the most frequent invasive plant which is found both in semi-natural and artificial habitats in Romania.

This paper investigated the allelopathic effect induced by aqueous and hydroalcoholic extracts obtained from *Erigeron annuus* (L.) Desf. subsp. *annuus* on crop species. We used the seed of three of the most important crop plants: wheat (*Triticum aestivum* L.), cucumber (*Cucumis sativus* L.) and pea (*Pisum sativum* L.).

MATERIAL AND METHOD

Biological material collection

Mature individuals of *Erigeron annuus* subs. a*nnuus* (Fig.1) were collected in October 2020 from Vultureşti locality (Argeş county) (N 45.05126°; E 025.07318°) near an agricultural land cultivated with corn. The plants were transported in plastic bags in the laboratory and placed on sheets of paper for drying.

Fig. 1. Individuals of *Erigeron annuus* subs. a*nnuus* and dried plant material

Obtaining extracts of *Erigeron annuus*

The extracts were obtained using dried plant material from the aerial parts of the plant: stems, leaves, inflorescences. For both types of extracts (aqueous - EA and hydroalcoholic - EH) the ratio of plant material: solvent was 1:10 (1 gram of biological material per 10 ml of distilled water and 1 gram per 10 ml of 1: 1 hydroalcoholic solution). The obtained mixtures were placed in glass vessels and sealed with parafilm. The vessels were placed in the dark at room temperature (15^{o}C) for 5 days and then the extracts were filtered (Fig.2). After filtration, the extracts were placed in bottles with a ground-glass stopper, covered with parafilm and kept in the refrigerator.

Fig. 2. Obtaining the extracts

The experiment

To test the phytotoxicity of the two extracts, three species of crop plants were used: one species of monocotyledonous plant (*Triticum aestivum* L.) and two species of dicotyledonous plants (*Pisum sativum* L. and *Cucumis sativus* L.). Before being used, the seeds were sterilized by introducing them, for 5 minutes, in a solution of 75% ethanol and then rinsed with distilled water (Li et al., 2018). The seeds of the three species were hydrated in distilled water for one hour. After this period, the seeds were immersed for 60 minutes in the test solutions. For each type of extract, we used two dilutions: 1:10 and 1:100. For the control, distilled water was used in the case of the CA variant and hydroalcoholic solution (1: 1) for the CH variant (Tab.1).

Table 1. Tested variants

Variant	Contain	Dilution
CA	Distilled water	-
CH	Hydroalcoholic solution	-
EA 1:10	Aqueous extract of *Erigeron annuus* subsp. *annuus*	10
EA 1:100		100
EH 1:10	Hydroalcoholic extract of *Erigeron annuus* subsp. *annuus*	10
EH 1:100		100

Then, they were put in Petri dishes on filter paper and watered with distilled water. The Petri dishes were kept in the dark until measurements were made. The measurement of the root and stem of the seedlings was made with the help of graph paper. With the balance fresh and dry biomass were determined. The determination was performed after 4 days.

The data obtained were processed using the SPSS program - version 16 for Windows; thus, the mean and standard error were calculated, and by using the Duncan test, it was possible to make comparisons between means.

RESULTS AND DISCUSSIONS

The influence of *Erigeron annuus* subsp. *annuus* on the growth in length of the seedling root

The used extracts influenced the increase in root length (Fig. 3). Except for the variant EA 1:100, root growth in *Triticum aestivum* was inhibited by extract exposure. For the dicotyledonous the variant EH 1:10 significantly inhibited growth in length of root compared with the water control (CA). No root development was observed in hydroalcoholic Control (CH) for wheat and cucumber, while for pea the media the root did not exceed 1 mm.

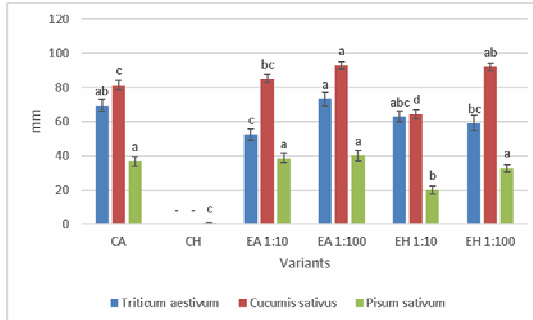

Fig. 3. The influence of extracts on root growth (a, b, c, d - Duncan's test results)

The influence of *Erigeron annuus* subsp. *annuus* on the growth in length of the seedling stem

The strong inhibition of growth observed at the root is also maintained in the case of stem in control with hydroalcoholic solution (CH) in the three species used (Fig.4). For *Triticum aestivum,* the inhibition of growth was bigger in roots than in the stem, while for the dicotyledonous the situation observed in the root it is maintained even in case of stem growth: the variant EH 1:10 inhibit significantly inhibited the growth.

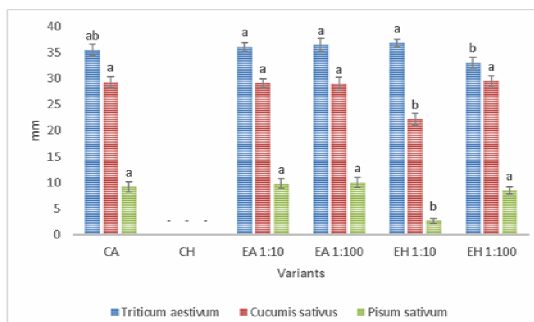

Fig. 4. The influence of extracts on stem growth (a, b, c, d – Duncan's test results)

The influence of *Erigeron annuus* subsp. *annuus* on biomass

In case of fresh biomass, the smallest values (0,79g wheat, 0,43g cucumber, 4,94g pea) were recorded, regardless of species at variant CH; between this variant and the Control with water (CA) the differences were significantly (Fig.5). For the pea, significant differences were observed also between the variants EA 1:100 and EH 1:10 and the variant with water Control (CA) (Fig.5).

In the case of wheat, exposure to extracts did not adversely affect fresh and dry biomass (Fig. 5-6) compared to water Control (CA). The dry biomass of the dicotyledonous was less influenced by extract exposure compared to fresh biomass.

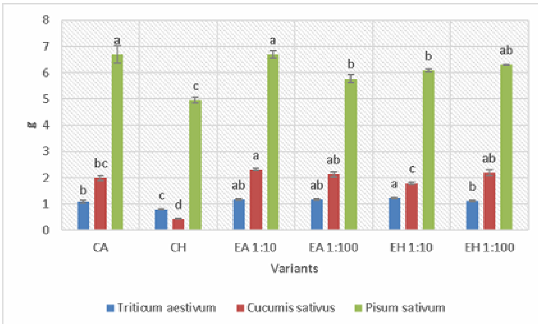

Fig. 5. The influence of extracts on fresh biomass (a, b, c, d - Duncan's test results)

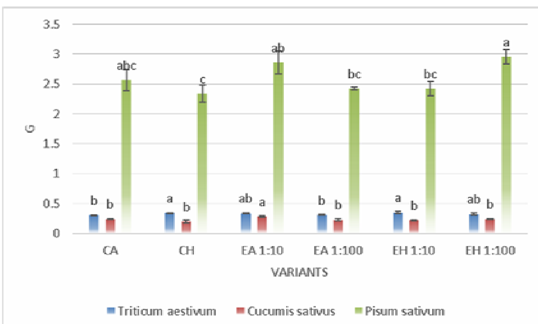

Fig. 6. The influence of extracts on dry biomass (a, b, c, d - Duncan's test results)

Park et al. (2011) studied the effects of aqueous extracts of *Erigeron annuus* on growth in *Lactuca sativa* and *Raphanus raphanistroides*. They found that the extracts inhibited the early growth of the individuals of the 2 species; the inhibitory effect was much stronger in lettuce.

Cheng et al. (2021) mentioned that *Erigeron annuus* produced visible allelopathic effects affecting germination performance in *Lactuca sativa*. The situation being similar to that reported by Balicevic et al. (2016); aqueous extracts of dried leaves of *Erigeron annuus* inhibited seed germination and development of lettuce seedlings.

Aqueous extracts from *Erigeron annuus* seeds did not inhibit *Trifolium pratense* seedlings (Kudryavtseva et al., 2020).

Various factors can influence allelopathic effects. For example, the allelopathy of *Erigeron annuus* leaf extracts on seed germination and growth of *Lactuca sativa* shoots has intensified under conditions of Cu and Pb pollution (Lu et al., 2020).

The impact of *Erigeron annuus* extracts in different concentrations on germination, root length and stem in *Sinapis alba* varied depending on the origin of the individuals. Thus, plant extracts from populations whose habitat is affected had a stronger inhibitory effect on germination, stem and root growth than those from stable habitats (Tunaitienė et al., 2017).

Wang et al. (2017) studied the allelopathic effects of *Erigeron canadensis* on germination index and vigor, on germination rate, height and biomass of seedling in *Lactuca sativa.* They reported a decrease of allelopathic effects with increasing degree if invasion and increase with increasing latitude (leaves of plants growing at high latitudes secrete a higher concentration of allelochemicals than leaves of plants growing at lower latitudes).

Different concentrations (25, 50, 75 and 100%) of aqueous extracts of *Erigeron canadensis* inhibited germination, root and stem growth in all six plant species used: tomato, radish, wheat, corn, millet and beans (Shaukat et al., 2003). The effects of aqueous and alcoholic extracts obtained from aerial and underground parts of *Erigeron philadelphicus* on *Brassica chinensis* var. *communis*, *Brassica campestris, Cucumis sativus* and *Lycoperiscum esculetum* were studied by Guan et al. (2009). They observed that all extracts significantly inhibited seed germination and root growth in the four crop species; the inhibition increased significantly with concentration. At low concentrations, the extracts had a stimulating effect on seedling growth. The main allelopathic components identified in the extracts are acids, ketones, esters and terpenes.

Zhang et al. (2020b) investigated the extraction yield of *Erigeron annuus* inflorescences in different solvents (chloroform, ethanol, methanol, water, etc.). The extraction yield in the case of aqueous extracts was high due to the compounds soluble in this solvent (polyphenol, polysaccharides, salts, proteins). Pyromeconic acid was the main component, being present in all extracts. The aqueous extracts had the highest total phenol content; methanolic and ethanolic extracts had high phenol content but were also rich in pyromeconic acid. Aqueous, methanolic and ethanolic extracts had high antioxidant activity. And in the extracts obtained from the seeds of *Erigeron acris* the total content of phenols and flavonoids had high values (İrtemKartal et al., 2020). Phenolic compounds are one of the first classes of secondary metabolites to have strong allelopathic activities (Yang et al., 2021).

CONCLUSIONS

Aqueous and hydroalcoholic extracts obtained from the above-ground part of the invasive species *Erigeron annuus* subsp. *annuus* influenced the growth of the root and stem and the biomass seedlings of *Triticum aestivum*, *Pisum sativum* and *Cucumis sativus.*

The influence of extracts was more pronounced at the roots than at the stems of the seedlings, regardless species. The effect varies upon the type of extract and upon the species. The hydroalcoholic extract diluted 10 times inhibited growth, especially in the case of dicotyledons.

The influence of the growth process and the biomass of the tested plants produced by the extracts obtained from the eastern daisy fleabane can explain, at least partially, the invasiveness of this species.

ABSTRACT

Invasive plants are one of the biggest threats to biodiversity. The invasive plant species have a high allelopathic potential, which helps them spread to new areas. The allelopathic effect of invasive species on different plants varies upon to the phenophase. *Erigeron annuus* is an annual invasive alien species, which we can find in Romania. This paper investigated the allelopathic effect induced by aqueous and hydroalcoholic extracts obtained from *Erigeron annuus* (L.) Desf. subsp. *annuus* on crop species. The extracts were obtained using dried plant material from the aerial parts of the plant: stems, leaves, inflorescences. For each type of extract, we used two dilutions: 1:10 and 1:100. We used the seed of three of the most important crop plants: wheat (*Triticum aestivum* L.), cucumber *(Cucumis sativus* L.) and pea (*Pisum sativum* L.). After hydration, the seeds were immersed for one hour in extracts, and then put in Petri dishes in the dark. The parameters which were determined after four days of the beginning of the experiment are the length of the root and stem, fresh and dry biomass. The influence of extracts was more pronounced at the roots than at the stems of the seedlings, regardless of species. The effect varies upon the type of extract and upon the species. The hydroalcoholic extract diluted 10 times inhibited growth, especially in the case of dicotyledons.

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