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# Effect of Aqueous Extracts from Weed Species on Germination and Initial Growth in *Raphanus sativus* L.

Anişoara STRATU*, Zenovia OLTEANU, Andrei LOBIUC

*"Alexandru Ioan Cuza" University, Faculty of Biology, 20 A Carol I Bd, Iaşi, Romania; anisoara_stratu@yahoo.com (*corresponding author); zenovia.olteanu@uaic.ro; alobiuc@yahoo.com*

**Abstract**

The current paper presents the results of a study on the effects of aqueous extracts from five weed species (*Amaranthus retroflexus, Cirsium arvense, Convolvulus arvensis, Echinochloa crus-galii, Setaria verticillata*) on germination and initial growth in *Raphanus sativus* L. The following indicators have been analyzed: indices of germination (the germination percentage; the speed of germination; the speed of accumulated germination and the coefficient of germination rate), the length of the root and hypocotyls, the pH of aqueous extracts, the UV-Vis absorption spectra of aqueous extracts. The results of the investigations showed the following aspects: the aqueous extracts reduced the values of calculated germination indices and root growth in the first ontogenetic stages of the test species; the pH of the extracts was slightly acid to neutral. Qualitative spectrophotometric analysis indicated the possible presence of phenolic and organic compounds in the extracts. *C. arvense, S. verticillata* and *E. crus-galii* presented the most pronounced effect on germination and growth processes.

***Keywords:*** allelopathic potential, growth reduction, plant extracts, radish

## Introduction

Weeds compete with cultivated plants for different environment factors (water, mineral elements, soil, light) and also may favour the spreading of some pathogen agents and harmful animal (because they are host plants for them). This affects the growth and the development of cultivated plants, the good carry out of the agro-technical works and determines the quantitative and qualitative reduction of the vegetal production (Chirilă, 2001; Slonovschi *et al*., 2001).

It is known the fact that between weeds and the neighbouring plants (cultivated or spontaneous plants) there is a certain influence (which can be negative or positive) caused by chemical substances eliminated in the environment, phenomenon called allelopathy. The chemical substances with allelopathic potential are represented by secondary metabolites (phenolic compounds, terpenoids, lactones, cyanogenic glycosides, alkaloids etc.) that are synthesized in various plant organs and tissues (Rice, 1974; Kremer and Ben Hammouda, 2009). The substances with allelopathic potential (in soluble or volatile state) are released from plants in the environment by several ways: exudates from root wash during precipitations or with irrigation water, decomposition, volatilisation (Rice, 1974). It has been proved that these substances influence other plants or communities of plants (affect the germination of seeds, the growth of plants, respiration, photosynthesis, mineral nutrition and other physiological processes) (Makoi and Ndakidemi, 2007; Kremer and Ben Hammouda, 2009).

The in-depth knowledge of some aspects regarding the allelopathy phenomenon can have implications/applications in agriculture and ecology: in the control of weeds, of harmful animals, and of some phytopathogenic agents (Kalid *et al*., 2002; Makoi and Ndakidemi, 2007). Some substances synthesized by plants could represent the alternative potential to synthetic classical herbicides and possibly other pesticides, fact that can contribute to the reduction of pollution of soil/environment (Faravani *et al*., 2008).

In this paper, five weed species (*A. retroflexus, C. arvense, C. arvensis, E. crus-galii, S. verticillata*) were taken into study. These species are segetal (in almost all crops), but they are also considered ruderal species. In Romania, these species are included in the segetal species list and are considered as problematic weeds (Chirilă, 2001). Some species with a broader ecological adaptability such as *A. retroflexus* (Shahrokhi *et al*., 2011), *C. arvense*, *C. arvensis* (Golubinova and Ilieva, 2014) are considered among the most damaging weeds in the entire world; *E. crus-galii* is considered the most damaging weed in rice crops in the world (Heidarzade *et al*., 2012), but is also present in other crops with known resistance to various herbicides. According to Kostov and Pacanoski (2007), *C. arvense* causes damages of up to 15-60% in crops, depending on weed density and crop species.

Different authors have studied the allelopathic effect of aqueous extracts from *A. retroflexus, C. arvense*, *C. arvensis, E. crus-galii* species on crop species - *Oryza sativa* (Esmaeili *et al*.,

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2012; Heidarzade *et al*., 2012), *Triticum aestivum* (Hegab and Ghareib, 2010), *Pisum sativum, Medicago sativa, Glycine max* (Marinov-Serafimov, 2010; Golubinova and Ilieva, 2014), *Lepidium sativum, Lactuca sativa* (Son *et al*., 2010), *Zea mays* (Aktar *et al*., 2001) and other spontaneous species (Aktar *et al*., 2001; Khan *et al*., 2011).

In the available literature few data was found regarding the possible allelopathic interactions between *Setaria verticillata* and other species (Kremer and Ben Hammouda, 2009). However, there are efforts made to counteract this species due to the major damages caused in crops, especially in the case of maize (James and Rahman, 2009) and alfalfa (Oster, 2012). In some of the mentioned species (*A. retroflexus, C. arvense, C. arvensis, E. crus-galii*) some compounds with allelopathic potential were identified (Son *et al*., 2010; Khan *et al*., 2011; Golubinova and Ilieva, 2014).

The current paper aimed to outline the effect of aqueous extracts from the five weed species on germination and initial ontogenetic stages growth in *R. sativus* L. (*Brassicaceae* family).

## Materials and Methods

*Biological material*

The plant material was represented by individuals of five weed species: three dicotyledonous species (*A. retroflexus* L.- fam. Amaranthaceae*; Cirsium arvense* (L.) Scop. - fam. Asteraceae; *Convolvulus arvensis* L. - fam. Convolvulaceae) and two monocotyledonous species (*Echinochloa crus-galii* (L.) P. B and *Setaria verticillata* (L.) P. B - fam. Poaceae). The identity of the species was established by Prof. Dr. Stefan N. of the Faculty of Biology, "Alexandru Ioan Cuza" University, Iaşi.

Plants were collected from crops from the surrounding rural areas of Iasi city (*A. retroflexus, C. arvense, C. arvensis* and *S. verticillata*) and from degraded fields within Iasi city (*E. crus-galii*). Plants were in different phenophases: vegetative (*C. arvensis* and *C. arvense)*, flowering (*A. retroflexus*), early fruiting (*E. crus-galii, S. verticillata)*.

*Experimental procedures*

Extracts were prepared using fresh plant material, from underground storage organs (root of *A. retroflexus, E. crus-galii, S. verticillata*; rhizome and root of *C. arvense* and *C. arvensis*), from leaves (all species) and immature fruits (*E. crus-galii, S. verticillata*). The weighed plant material was grounded and a corresponding volume of water was used to achieve a 10% (w/v) concentration mixture. Extraction was performed at room temperature, for 4 h, using a magnetic stirrer. The resulting extract was filtered using filter paper and was considered as the stock solution, which also served to prepare by dilution a solution corresponding to 2% (w/v) initial mixture concentration. Filtered extracts were kept refrigerated. For each of the three dicotyledonous species, two extracts were prepared: one using parts of underground storage organs and one using leaves. For each of the monocotyledonous species, an extract using immature fruits was further prepared.

The effects of prepared extracts were tested on *R. sativus* L. ('Rodica' cultivar) seeds, purchased from SC Unisem SA, a species with a high germination percentage. The species is also considered to have a high sensibility when exposed to the action of allelopathic compounds, even in low concentrations (Faravani *et al*., 2008).

Seeds were placed to germinate in Petri dishes, on filter paper moistened with distilled water (in case of control plates) or extracts (treatment variants). Plates were kept at room temperature (26-28.5 °C), a photoperiod corresponding to the months of July and August, 2014. The initial water volume and extracts, used to moisten the filter paper was 4 ml. During the experiments, the germination substrate was kept moist adding, when needed, distilled water (controls) and extracts (treatment variants). Each variant was replicated in three repetitions; for each replication 25 seeds were used.

Germinated seeds were counted in every 24 hours for three days. During this experiment the following indicators have been analyzed: indices of germination (the germination percentage at 72 h - GP; the speed of germination - S; the speed of accumulated germination - AS and the coefficient of the rate of germination - CRG); the length of the root and hypocotyl at 72 h. The four germination indices were calculated using the equations described by Chiapusio *et al*. (1997).

The pH of the extracts was measured using a CONSORT C532 pH-meter. UV-Vis absorption spectra of aqueous extracts were recorded using a Beckman spectrophotometer in 1 cm light path length plastic cuvettes.

*Statistical procedures*

The measurements (the length of the root and hypocotyl) were performed on 30 seedlings for each experimental variant. All the results presented in tables were expressed as mean value ± standard error (for germination indices n = 3; for the length of root and hypocotyl n = 30). The one-way Anova test and the Tukey test were performed in order to test the difference between averages of all the analyzed indices (Zamfirescu and Zamfirescu, 2008).

## Results and Discussion

*Effect on germination indices*

The aqueous extracts (with some exceptions: 2% *A. retroflexus* root extract; 10% immature fruits and 2% leaves *S. verticillata* extracts) delayed the germination percentage (GP) of radish seeds. From a statistic point of view, the reduction of GP was significant in *C. arvense* (10% concentration) and *E. crus-galii* (2% and 10% concentration) leaf extracts (Table 1 and Table 2).

Comparing to control, in the treatment variants, the average values obtained for speed of germination (S), speed of accumulated germination (AS) and coefficient of the rate of germination (CRG) was lower (Table 1 and Table 2). A significant reduction of germinating speed was noticed in the case of: leaves extracts (10% concentration) for two dicotyledonous species (*A. retroflexus* and *C. arvense*); leaves and immature fruit (concentrations 2% and 10 %) for the monocotyledonous species (Table 1 and Table 2). Speed of germination (S) is a more sensible indicator than the germination percentage and it can be used to appreciate the allelopathic effects on the germination (Chiapusio *et al*., 1997).

In this study, the speed of accumulated germination (AS) index was more sensitive compared to S index. A significant reduction of AS index was observed for all extracts mentioned for the S index, but also for the extract obtained from underground organs of *E. crus-galii* (2% concentration), *S. verticillata* (10% concentration) and leaves of *C. arvensis* (2% and 10% concentration) (Tables 1 and 2).

The coefficient of the rate of germination (CRG) index presented a lower sensitivity compared to AS index, indicating significant differences in the analysed cases (Tables 1 and 2).

The extracts prepared from leaves presented a more pronounced retardant effect compared to the ones obtained from underground storage organs. Among the species considered in the study, *C. arvense, E. crus-galii* and *S. verticillata* presented the most pronounced effect on the germination indices.

The obtained results are, generally, similar to those described in the available literature concerning effects of delay of the germination induced by extracts obtained from different organs from the species chosen by us in the study.

In *C. arvense* the 5%, 10% and 15% root, stem and leaves aqueous extracts reduced the germination in *Poa annua* and *Phalaris minor* (Aktar *et al*., 2001); the leaf extracts significantly delayed the germination in *C. arvensis* and inhibited the germination in the species *Avena fatua, Ammi visnaga, Rumex crispus, Asphodelus tenuifolius* (Khan *et al*., 2011). The aqueous extracts from the aerial parts (mixture of leaves and stems) from *C. arvense* and *C. arvensis* reduced the relative germination and the speed of germination in *Pisum sativum, Vicia sativa, Medicago sativa* (Golubinova and Ilieva, 2014). In the species *A. retroflexus,* the 10% root, stem and leaves aqueous extracts reduced significantly the germination of seeds in barley cultivars (Shahrokhi *et al*., 2011); the aqueous extracts in leaves, according to the concentration, reduced, respectively inhibited $G_T$ (total or final germination), S and AS indices in *Lepidium sativum* (Mlakar *et al*., 2012). According to Marinov-Serafimov (2010), the aqueous extracts of *A. retroflexus* presented inhibitory effect on the germination of *Glycine max, Pisum sativum, Vicia sativa.*

*Effect on root and hypocotyl growth*

Comparing to the controls, the tested extracts reduced/inhibited root elongation in radish, except for *A. retroflexus* 2% and 10% root extracts. The negative effect was significant for 14 extracts (most of them having a concentration of 10% from monocotyledonous species, respectively). Leaves extract with a 10% concentration, from all species, significantly reduced root elongation in radish, in the following descending order: *C. arvensis*, *E. crus-galii*, *A. retroflexus*, *C. arvensis*, *S. verticillata* (Tables 1 and 2).

Concerning hypocotyl growth, the effects varied according to the species, extract type and tested concentration (Tables 1 and 2). *C. arvense* (10% concentration) leaves extract recorded a statistically significant inhibitory effect and *A. retroflexus* (2% and 10% concentration) root extracts had a statistically significant stimulatory effect.

The elongation of root is more affected than hypocotyl elongation and germination (Tables 1 and 2). This situation can be explained by the fact that the root is the first organ to develop and it is in permanent contact with the extracts during the experiments.

The results obtained hereby are in accordance to the ones obtained by other authors with the same weed species. For *E. crus-galii,* Li *et al*. (1992) indicated that the exudates of the weed

Table 1. Effect of aqueous extracts of dicotyledonous weeds on the analyzed indicators

| Species | Extract/ concentration (%) | Mean value ± SE | | | | | |
|---|---|---|---|---|---|---|---|
| | | GP (%) | S | AS | CRG | LR (mm) | LH (mm) |
| | Control | 93.33±2.22 (100) | 20.21±2.25 | 36.61±0.3 | 47.88±0.46 | 37.96±2.07 (100) | 16.33±0.88 |
| *A. retroflexus* | Underground organs 2% | 93.33±3.51 (100) | 18.49±1.3 | 32.94±2.91 | 46.18±0.63 | 42.66±2.29 (112,38) | 23.66±1.06* |
| | Underground organs 10% | 86.66±5.81 (92,85) | 17.94±1.92 | 31.72±3.52 | 46.84±0.7 | 38.06±2.14 (100,26) | 21.73±1.05* |
| | Leaves 2% | 92±2.31 (98,57) | 16.55±0.52 | 28.83±1.01 | 45.02±0.25 | 30.8±1.98 (81,13) | 18.23±0.98 |
| | Leaves 10% | 88±0 (94,28) | 14.16±0.66* | 25.49±0.66* | 44.13±0.38 | 23.36±1.55* (61,53) | 18.73±0.87 |
| *C. arvense* | Underground organs 2% | 92±2.31 (98,57) | 16.77±1.59 | 29.38±3.22 | 45.05±1.23 | 32.1±1.94 (84,56) | 15.16±0.93 |
| | Underground organs 10% | 82.66±1.66 (88,56) | 15.88±1.69 | 25.72±1.61 | 44.79±0.91 | 27.7±1.8* (72,97) | 14.96±0.93 |
| | Leaves 2% | 88±2.31 (94,28) | 16.44±0.64 | 28.66±1.51 | 45.65±0.92 | 31.97±2.36 (84,22) | 15.8±1.1 |
| | Leaves 10% | 56±6.43* (60) | 7.49±2.12* | 12.49±3.53* | 41.47±1.77* | 17.76±1.14* (46,78) | 11.03±0.84* |
| *C. arvensis* | Underground organs 2% | 89.33±8.75 (95,71) | 15.83±2.75 | 25.33±3.08 | 44.57±1.36 | 37.93±2.17 (99,92) | 15.76±0.91 |
| | Underground organs 10% | 85.33±5.33 (91,42) | 15.49±1.51 | 26.38±3.66 | 44.41±0.87 | 33.80±2.56 (89,04) | 19.33±1.37 |
| | Leaves 2% | 84±2.31 (90) | 15.6±1.54 | 24.16±3.6* | 45.31±1.29 | 29.06±2.49* (76,55) | 17±3.93 |
| | Leaves 10% | 86.66±4.8 (92,85) | 15.22±1.4 | 26.38±2.64* | 44.3±0.58 | 23.63±1.59* (62,24) | 17.4±1.02 |

Note:* indicates significant differences (Tukey test, $p<0.05$); S - speed of germination; AS - the speed of accumulated germination; CRG - the coefficient of the rate of germination; LR - the length of root; LH - the length of hypocotyl; the number in brackets represent the percentage relative to the control.

Table 2. Effect of aqueous extracts of monocotyledonous weeds on the analyzed indicators

| Species | Extract/ Concentration (%) | Mean value±SE | | | | | |
|---|---|---|---|---|---|---|---|
| | | GP (%) | S | AS | CRG | LR (mm) | LH (mm) |
| | Control | 93.33±2.22 (100) | 20.21±2.25 | 36.61±0.3 | 47.88±0.46 | 37.96±2.07 (100) | 16.33±0.88 |
| *E. crus-galii* | Underground organs 2% | 82.66±1.32 (88.56) | 12.55±0.97 | 21.05±1.97* | 42.56±0.94 | 27.56±1.79* (72.60) | 17.13±1.02 |
| | Underground organs 10% | 84±2.31 (90) | 15.1±1.31 | 26.33±2.52 | 44.98±1.26 | 30.13±1.87 (79.37) | 16.86±1.06 |
| | Leaves 2% | 78.66±2.31* (84.28) | 13.33±1.04* | 22.88±2.22* | 43.56±0.79* | 19.9±1.41* (52.42) | 14±0.74 |
| | Leaves 10% | 68±6.11* (72.85) | 10±1.15* | 16.16±1.35* | 42.1±0.38* | 19.06±1.08* (50.21) | 14.23±1.14 |
| | Immature fruits 2% | 85.33±2.66 (91.42) | 15.27±1.15* | 26.77±2.22* | 44.83±0.84* | 22.66±1.58* (59.69) | 13.8±0.71 |
| | Immature fruits 10% | 88±4.62 (94.28) | 15.16±1.6* | 26.33±3.1* | 44.41±1.13* | 22.4±1.49* (59) | 15.76±1.14 |
| *S. verticillata* | Underground organs 2% | 89.33±3.51 (95.71) | 16.55±1.83 | 29.11±3.5 | 45.37±1.54 | 29.33±1.54* (77.26) | 13.13±0.78 |
| | Underground organs 10% | 85.33±3.51 (91.42) | 14.22±0.56 | 24.27±0.94* | 43.96±0.18* | 28.8±1.65* (75.86) | 14.86±0.99 |
| | Leaves 2% | 96±2.31 (102.86) | 13.1±1.1* | 21.83±2.06* | 41.11±1.02* | 32.76±2.19 (86.30) | 15±0.79 |
| | Leaves 10% | 85.33±2.33 (91.42) | 10.83±0.72* | 17.6±1.35* | 40.16±0.51* | 26.5±1.39* (69.81) | 17.06±1 |
| | Immature fruits 2% | 89.33±3.66 (95.71) | 10.88±0.62* | 17.6±1.36* | 39.67±0.44* | 33.06±1.8 (87.09) | 14.93±0.79 |
| | Immature fruits 10% | 94.66±1.32 (101.42) | 12.49±0.43* | 20.05±1.55* | 40.3±0.59* | 28.66±1.49* (75.50) | 16.46±0.93 |

Note:* indicates significant differences (Tukey test, $p<0.05$); S - speed of germination; AS - the speed of accumulated germination; CRG - the coefficient of the rate of germination; LR - the length of root; LH - the length of hypocotyls; the number in brackets represent the percentage relative to the control.

Table 3. The pH of the extracts

| Plant part | Concentration (%) | Species/pH value | | | | |
|---|---|---|---|---|---|---|
| | | *A. retroflexus* | *C. arvense* | *C. arvensis* | *E. crus-galii* | *S. verticillata* |
| Underground organs | 2% | 6.29 | 5.87 | 5.59 | 7.01 | 7.19 |
| | 10% | 5.77 | 5.71 | 5.21 | 6.92 | 7.16 |
| Leaves | 2% | 6.04 | 5.62 | 5.89 | 5.81 | 6.28 |
| | 10% | 5.87 | 5.24 | 5.67 | 5.60 | 6.02 |
| Immature fruits | 2% | - | - | - | 6.47 | 6.09 |
| | 10% | - | - | - | 6.18 | 6.16 |

inhibit the growth of lettuce and bean seedlings. The 0.1 g $l^{-1}$ *E. crus-galii* methanolic extracts (mixture of root, stem, seeds and leaves) completely inhibited the growth of the root and stem in lettuce (Son *et al*., 2010).

For *C. arvense*, researches underlined that the root, stem and leaves (5%, 10% and 15 %) aqueous extracts significantly reduced the root length of *Phalaris minor,* while 5%, 10% root extracts significantly reduced the root length of *Poa annua* (Aktar *et al*., 2001); the leaves extract significantly delayed the growth of the seedlings of *Convolvulus arvensis* (Khan *et al*., 2011).

According to Hegab and Ghareib (2010), the 600 ppm stems extract of *C. arvensis* significantly reduced the root elongation of wheat, while lower (75, 150, 300 ppm) concentrations presented a stimulating effect on the growth in the same species, a similar effect being recorded in the present research in radish hypocotyl.

*The pH of the extracts*

The extracts used for the current experiment had a pH between 5.21 and 7.19 (Table 3). Variations were noticed according to species, organ and the concentration of the extract. Slightly higher pH values were registered in the case of monocots and underground storage part extracts. The 10% aqueous extracts compared to 2% aqueous extracts had lower pH values. The lower pH values of extracts corresponded, generally, to lower values of the final germination, speed of germination and root length. A similar aspect was observed by Golubinova and Ilieva (2014) in the case of the *Cirsium arvense* and *Convolvulus arvensis* aqueous extracts.

The physical and chemical properties of the extracts are considered to influence the effect of the extracts on the germination and growth of the seedlings. Wardle *et al*. (1992), underlines the fact that the extreme pH and the osmotic potential of test solutions used in the studies of allelopathy, inhibited the germination, root and stem growth in different species.

*The absorption spectra of the extracts*

The absorption spectra of the prepared extracts registered maximum values in the UV range, with variations according to the species and organ (Figs. 1 and 2). The monocot weeds extracts compared with dicotyledonous weed extracts recorded higher values of absorbance. There was a correspondence between the extracts spectra of 10% concentration from leaves of *E. crus-galii* and *S. verticillata* and the germination indices

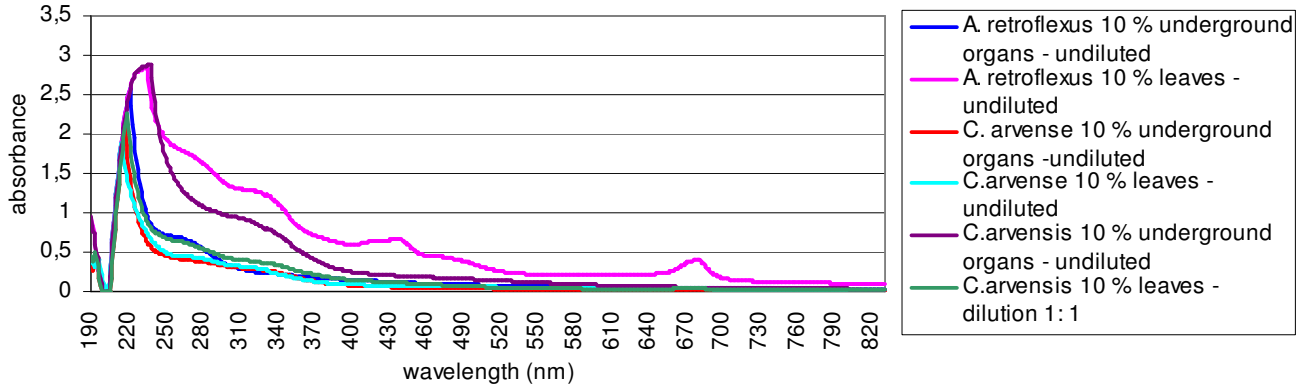


Fig. 1. Absorption spectra for tested extracts of dicotyledonous weeds

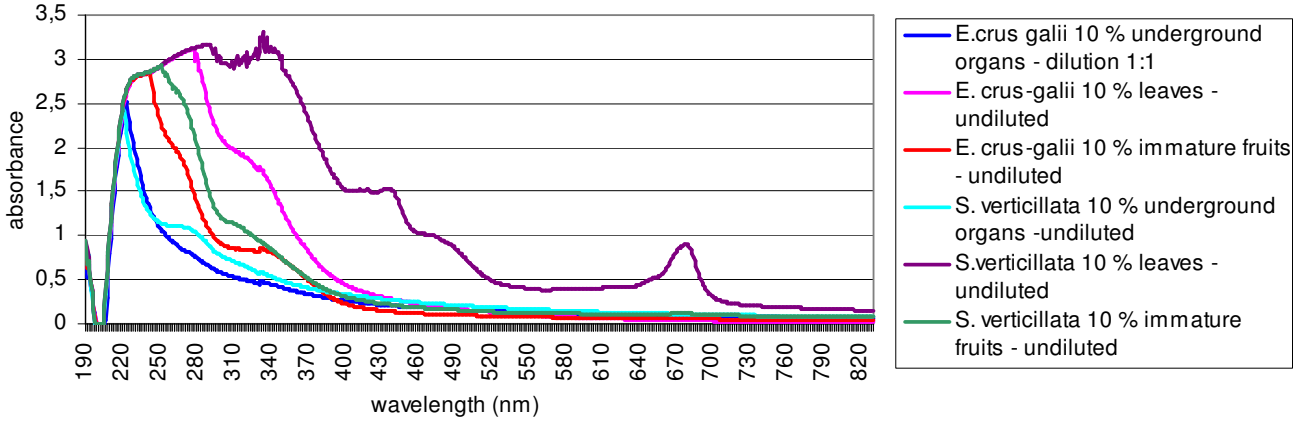


Fig. 2. Absorption spectra for tested extracts of monocotyledonous weeds

and the root length, respectively: higher values of absorbance corresponded to lower values of germination indices and root length.

The obtained results show the possible presence of some phenol compounds in extracts, but also of other classes of organic compounds (ketones, aldehydes, etc.).

According to Lattanzio *et al.* (2006), the phenolic compounds constitute the most prevalent group of compounds in plants. These organic compounds absorb intensely the radiations in the UV area of the spectrum, but each class of phenolic compounds has specific absorption wavelengths: maximum absorption at 250-290 nm for phenolic acids (p-hydroxybenzoic, syringic, vanillic acids, etc.); the main absorption range is between 290-330 nm for cinnamic acid derivatives (caffeic, ferulic, p-coumaric acids, etc.). Flavones present two ranges of absorption (310-350; 250-280 nm), flavonols present a range of absorption between 350-385 nm and a second band common with the one of the flavones (Bohm, 1998). We must also take into account the fact that polar solvents cause displacements of the electronic spectra because of the action of the intermolecular forces manifested in solutions (Strat and Spulber, 1981); water determines the displacement towards left of the spectrum of absorption (Kumar, 2006).

The effect of delay of the germination and the incipient growth of the root in the radish caused by the aqueous extracts can be due to the presence of some water soluble substances, with allelopathic potential.

Substances of phenolic nature are considered to represent a group of compounds involved in the regulation of growth and development of the plants (Harborne, 1980). According to Li *et al.* (2010), the phenolic compounds can inhibit the cell division, root elongation, can induce modifications in the cell ultra-structure and thus interfere with the normal growth and development of the whole plant. Some phenolic compounds in high concentrations ($10^{-2}$ -$10^{-3}$ M $l^{-1}$) have inhibitory action, and in lower concentrations ($10^{-5}$-$10^{-6}$ M $l^{-1}$) act as stimulators of growth processes (Neamțu and Irimie, 1991).

In some of the considered species of weeds, some authors identified substances with allelopathic potential. Thus, *E. crus-galii* phenolic compounds were identified both in root exudates: p-hydroxybenzoic acid, 3,4-dihydroxybenzoic acid, p-coumaric acid, m-coumaric acid, cinnamic and vanillic acid (Li *et al.*, 1992; Heidarzade *et al.*, 2012) and in leaf extracts: p-hydroxybenzoic acid, m-coumaric acid, ferulic acid, p-coumaric acid, cinnamic acid (Esmaeili *et al.*, 2012). An allelopathic potential is assigned to these compounds, especially to the p-hydroxybenzoic acid detected in the highest quantities. Golubinova and Ilieva (2014) identified polyphenols and cyanogenic glycosides in *C. arvense* leaves and stems with allelopathic potential on the germination seedlings growth of *Pisum sativum, Vicia sativa* and *Medicago sativa.* In *C. arvensis,* Shahrokhi *et al.* (2011), quoted the presence in the aqueous extracts of compounds such as

aldehydes, flavonoids, chlorogenic acid, alkaloids, saponins, etc.; Hegab and Ghareib (2010) identified phenolic compounds (p-hydroxybenzoic acid, p-coumaric acid, syringic acid, ferulic acid, cinnamic acid, etc.) in methanolic extracts prepared from the stem.

Radu *et al.* (2012) identified in *C. arvense* dry leaves and stems ethanolic extracts several phenolic compounds (cafeic acid, cis-ferulic acid, 3,4 dimetoxy cinnamic acid, quercetin-3-O-glucoside, etc.) used in medicine and phytopharmacy; some of these compounds also present allelopathic activity. The trans-cinnamic acid and the ferulic acid in 500 and 750 μM concentration inhibited the total germination in *Arabidopsis thaliana* (Reigosa and Pazos-Malvido, 2007). The trans-cinnamic acid in concentration of 0.001 μM inhibited the speed of germination in *Rumex acetosa.* The ferulic, p-hydroxybenzoic and trans-cinnamic acids, in concentration of 0.001 μM inhibited AS index in *Rumex acetosa* (Iftikhar Hussain *et al.,* 2008). According to Razavi *et al.* (2009), quercetin 3-O-glucoside has phytotoxic potential; it reduced the germination of the seeds of lettuce, progressively with the growth of the concentration (100-500 μg/ml). The ferulic, m-cumaric, p-cumaric, vanilic acids presented strong inhibitory effect on the germination in *E. crus-galii,* and the cinnamic acid strongly inhibited root and stem elongation in the same species (Heidarzade *et al.,* 2012). Also, the derivatives of the cinnamic acid affected the formation of radicular hairs and induced modifications in the structure of the vascular system in beans (Jitareanu *et al*., 2013).

## Conclusions

The extracts obtained from the five analysed species reduced the values of calculated germination indices and reduced/inhibited the root growth in the first ontogenetic stages of the test species *Raphanus sativus*. Root growth was more affected than hypocotyl growth and germination. *C. arvense, E. crus-galii* and *S. verticillata* species extracts presented a more pronounced adverse effect on germination and growth, while *Amaranthus* extracts recorded lower effects. The leaf extracts had a more inhibitory effect than underground storage organs extracts, with qualitative spectrophotometric analysis indicating the possible presence of various classes of organic compounds (including phenolic compounds) that could explain the observed effects. It can be recommended that subsequent research is necessary for elucidation of the potential interactions established between the segetal species investigated and different test species, considering the negative impact of the former on species cultivated for different purposes.

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