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ALLELOPATHIC POTENTIAL ASSESSMENT OF DIFFERENT VEGETAL EXTRACTS ON LETTUCE SEED GERMINATION

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Abstract

The aim of the present work was to evaluate the allelopathic influence of different vegetal extracts on the seed germination of lettuce (Lactuca sativa) as test plant. Eight experimental variants have been studied (including Control). The species used for aqueous extracts were: Amaranthus retroflexus, Aquilegia vulgaris, Atriplex hortensis, Chenopodium ficifolium, Cirsium avense, Echinochloa crus-galli, Elytrigia intermedia, Juglans regia, Lactuca serriola, Leucanthemum vulgare, Parthenocissus inserta, Phragmites australis, Poa pratensis, Polygonum aviculare, Portulaca oleracea, Sambuscus ebulus, Solidago gigantea, Xanthium strumarium, Convolvulus arvensis, Vicia sativa, Pinus sylvestris, Helianthus tuberosus. Aqueous extracts from fresh biomass were examined under laboratory bioassay in Petri dishes. The obtained results suggest that the extract from common vetch, canada thistle, red-root amaranth, common purslane and cockspur display more serious allelopathic effects on the seed germination of lettuce. Thus, the study of vegetal extracts with potentials allelopathic effect can lead to development of some new herbicides with low environmental impact.

***Key words**: aqueous extracts, allelopathic effects, new herbicides, environmental impact.*

INTRODUCTION

Allelopathy is a chemical interaction between plants, that could play an important role in natural ecosystems and agro-ecosystems (Molisch, 1937). Various crop species have shown allelopathic activity that can be useful to control weeds in field crops by using them as cover crops, mulch, crop rotation, intercropping, and crop extract (Jabran & Farooq, 2012). Many allelochemicals that can suppress the growth of other plant species have been identified in different weeds species (Siyar et al., 2019). Weed species have allelopathic properties, exactly like crops. Allelochemicals produced by weeds are supposed to be more toxic, because weeds usually grow under stress conditions (Om et al., 2002; Hamburdă et al., 2015). The effects of allelopathic compounds on germination and growth of plants may occur through a variety of mechanisms, including reduced mitotic activity in roots and hypocotyls, reduced rate of ion uptake, suppressed hormone activity, inhibited protein formation, inhibited photosynthesis and respiration, decreased permeability of cell membranes and/or inhibition of enzyme action (Rice, 1974; Corbu et al., 2007). Possibility to use weeds species as an ingredient for the production of herbicides can be an environment-friendly option to control weeds in crops. Herbicides with low environmental impact and new modes of actions are needed due to fast-increasing herbicide resistance in weeds against all the major herbicide groups (Heap, 2018). Weed management in organic production systems is a huge challenge (Munteanu & Stoleru, 2012; Melander et al., 2018). Numerous natural herbicidal substances have been identified from different microbes and crop species (Duke et al., 2000; Jabran, 2017). These herbicidal compounds can be classified in two main groups: terpenoids and phenolics (Anaya, 2006). These natural phytotoxins offer a huge opportunity to be directly used as natural herbicides and to develop new herbicide mode of actions (Dayan & Duke, 2014).

The goal of the present work was to evaluate the allelopathic influence of different species extracts: red-root amaranth (*Amaranthus retroflexus*), common columbine (*Aquilegia* *vulgaris*), orach (*Atriplex hortensis*), fig-leaved goosefoot (*Chenopodium ficifolium*), canada thistle (*Cirsium avense*), cockspur (*Echinochloa crus-galli*), intermediate wheatgrass (*Elytrigia intermedia*), common walnut (*Juglans regia*), prickly lettuce (*Lactuca serriola*), ox-eye daisy (*Leucanthemum vulgare*), thicket creeper (*Parthenocissus inserta*), common reed (*Phragmites australis*), blue grass (*Poa pratensis*), common knotgrass (*Polygonum aviculare*), common purslane (*Portulaca oleracea*), danewort (*Sambuscus ebulus*), giant goldenrod (*Solidago gigantea*), clotbur (*Xanthium strumarium*), field bindweed (*Convolvulus arvensis*), common vetch (*Vicia sativa*), scots pine (*Pinus sylvestris*) and Jerusalem artichoke (*Helianthus tuberosus*).

MATERIALS AND METHODS

Site description

The experiments were carried out at the Vegetable Research and Development Station of Bacau, during 2022 year.

Preparation of water extract

Plant samples for aqueous extracts were collected from SCDL Bacău research field. These samples were cut into small pieces of 1-2 cm. For V1, V2, V3, V4, V5 and V6 variants, the material was inserted into glass jars and the distilled boiled water was added to the samples (Călin, 2005). For V7 variant, fresh sample was grinded through mortar and pestle. Over the ground material was added distilled water and after that the extract was put in the glass jars. The extracts were made from the whole plant (root, stem, leaf and flower) except common walnut and scots pine, from which only leaves were used.

Experimental design

Eight experimental variants have been studied (including Control) (Table 1).

Table 1. Variants used in the experiment

Variants	Allelopathic species
V1	- fig-leaved goosefoot (7.0 g), prickly lettuce (10.0 g), clotbur (10.0 g), common knotgrass (3.0 g), common walnut (5.0 g)
V2	- common reed (8.0 g), danewort (10.0 g), thicket creeper (10 g), common columbine (6.5 g), field bindweed (6.5 g)
V3	- common vetch (4.0 g), canada thistle (10.0 g), red-root amaranth (8.0 g), common purslane (11.5), cockspur (9.0)
V4	- intermediate wheatgrass (5 g), blue grass (3.0 g), Jerusalem artichoke (8.0 g), giant goldenrod (7.0), scots pine (7.0)
V5	- prickly lettuce (4.0 g), clotbur (4.0 g), canada thistle (4.0 g), cockspur (4.0 g), common reed (4 g)
V6	- clotbur (9.0 g), cockspur (3.5 g), prickly lettuce (2.8 g), red-root amaranth (3.5 g), fig-leaved goosefoot (0.63 g)
V7	- common columbine (3.0 g), ox-eye daisy (3.0 g), canada thistle (4.0 g), clotbur (4.0 g), orach (4.0 g), prickly lettuce (4.0 g), common walnut (3.0 g)
VM	- distilled water (Control)

Aqueous extracts from fresh biomass were examined under laboratory bioassay in Petri dishes. Seeds of lettuce were sown on a filter paper in sterilized Petri dishes. The filter papers were moistened with aqueous extracts (7 ml of the extract was pipetted into each Petri-dish). Control was treated similarly with distilled water. There were three replicates of each treatment with 50 seeds per Petri plate. Plates were regularly checked for moisture.

In order to assess extract`s age efficiency, they were applied at two days - in fermentation (A), respectively, 22 days - fermented (B), after preparation, according to Călin (2005).

The research methods used

The parameters used to compare the germination data were:

1. Final Germination Percentage (FGP);
2. Mean Germination Time (MGT);
3. Germination Rate Index (GRI);
4. First Day of Germination (FDG);
5. Last Day of Germination (LDG),

The final germination percentage (FGP %) represents the total number of seedlings at the end of the test, calculated as follows:

FGP (%) = Final no. of seeds germinated in a seed lot × 100.

Mean Germination Time (MGT) was calculated according to the following formula of Orchard (1977):

$$\mathrm{MTG} = \sum f \cdot x / \sum f$$

Where, f is the number of seeds germinated on day x.

Germination Rate Index (GRI) was calculated according to the following formula of Esechie (1994):

$$\mathrm{GRI} = \frac{G1}{1} + \frac{G2}{2} + \cdots + \frac{Gx}{x}$$

Where, G1 represent germination percentage × 100 at the first day after sowing and G2, germination percentage × 100 at the second day after sowing.
FDG = Day on which the first germination event occurred.
LDG = Day on which the last germination event occurred.
The amount of germinated seeds was counted every day, and each lettuce seed was adjudged as germinated if the radicle has emerged (Wang et al., 2016).

Statistical analysis

Data related to germination were analysed statistically with ANOVA. Means were separated via a Tukey's HSD test at $P \leq 0.05$ in IMB SPSS Statistics 20.

RESULTS AND DISCUSSIONS

Germination percentage was analysed from day 2 to day 10 after imbibing, when no further germination occurred. Germination capacity for lettuce is between 65-85% (Stan et al., 2003).
According to ANOVA, results of final germination percentage for variants with aqueous extracts applied at two days after preparation, showed a significant difference ($p<.001$). Tukey post-hoc analysis indicated that the control variant has significantly more sprouted seeds than V1, V2 and V3. For variant V3, germination was completely inhibited (Figure 1).

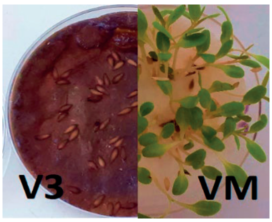

Figure 1. Germination of lettuce seeds, V3 variant and VM - Control variant

Instead, for variant V6, germination was stimulated. Results for aqueous extracts applied at 22 days after preparation highlighted a significant difference in terms of final germination percentage according to ANOVA ($p<.001$). The aqueous extracts exhibit a strong allelopathic activity on lettuce seed germination. Germination was completely inhibited for variants V1, V2, V3 and V4. Based on Tukey post-hoc analysis the control variant has significantly more sprouted seeds than all variants (Figure 2).

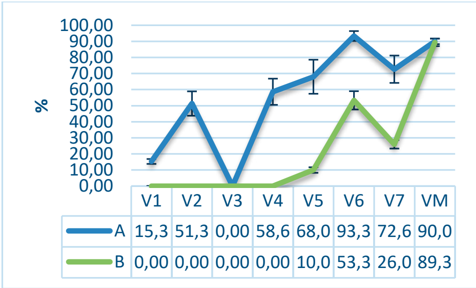

Figure 2. Final Germination Percentage (%): A - Aqueous extracts applied at two days after preparation; B - Aqueous extracts applied at 22 days after preparation

It is interesting that the extract from clotbur, cockspur, prickly lettuce, red-root amaranth and fig-leaved goosefoot have a stimulatory effect on seed germination of lettuce for variant applied at two days after preparation (Figure 3).

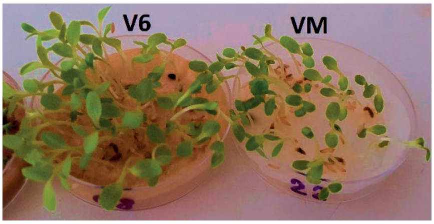

Figure 3. Germination of lettuce seeds, V6 variant and VM - Control variant

Seed germination and rapid germination are generally essential processes in seedling establishment, especially with plants that are endangered. According to Oseni et al. (2020), numerous studies evaluated the germination success only based on final percentage germination, however it is not enough due to the lack of ability to compare two sets of data (one lot of seed may have germinated well before the other, but both achieved the same final germination percentage) and this has led to the development of a number of germination parameters (Jeyavanan et al., 2016). Germination parameter is considered to be a qualitative developmental response of an individual seed that appears at a point in time within a treatment respond within different time

(Murungu, 2011). Initiation of germination is a useful parameter and lower FDG values indicate a faster initiation of germination. ANOVA results revealed a significant influence of the allelopathic extracts on the initiation of germination. The aqueous extracts in V4, V5 V6 applied at two days after preparation, have faster initiation of germination than control. In the case of extracts applied at 22 days after preparation the control variant has a faster initiation of germination (Figure 4).

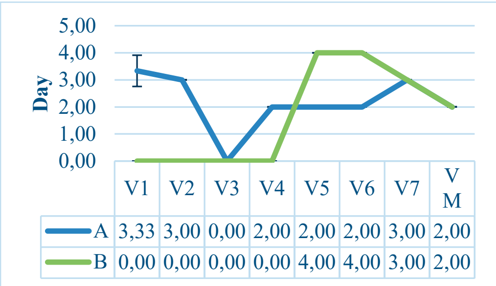

Figure 4. First Day of Germination (FDG) (day): A - Aqueous extracts applied at two days after preparation; B - Aqueous extracts applied at 22 days after preparation

Time at which the last germination event occurred was also considerably different among the treatments. A lower LDG values indicate a faster ending of germination (Kader, 2005). Regarding the LDG for the aqueous extracts applied at two days after preparation, the average value fluctuated between 0.00 and 5.00 days (Figure 5).

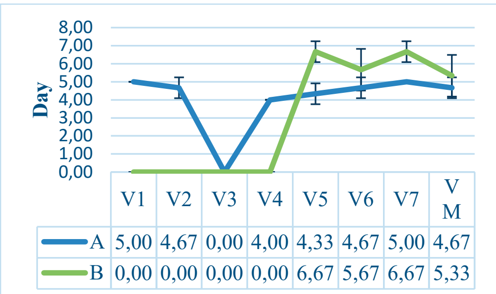

Figure 5. Last Day of Germination (LDG) (day): A - Aqueous extracts applied at two days after preparation; B - Aqueous extracts applied at 22 days after preparation

Value for LDG fluctuated between 0.00 and 0.67 days, with the highest value recorded in V5 and V7, in the case of extracts applied at 22 days after preparation average.

The analysis of variance for germination rate index confirmed that there were significant differences between variants (p<.001). Tukey post-hoc analysis indicated that the control variant has significantly a higher GRI than V1, V2, V3, V4 and V7 for extracts applied at two days after preparation. Tukey post-hoc analysis revealed that the control variant has significantly a higher GRI than all variants, for extracts applied at 22 days after preparation (Figure 6). The GRI indicates the percentage of germination on each day of the germination period. Higher GRI values suggest higher and faster germination.

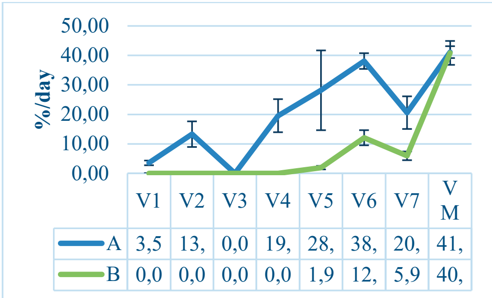

Figure 6. Germination Rate Index (GRI) (%/day): A - Aqueous extracts applied at two days after preparation; B - Aqueous extracts applied at 22 days after preparation

Average value for MTG fluctuated between 0.00 and 4.45, with the highest value recorded in V1, in the case of extracts applied at two days after preparation (Figure 7).

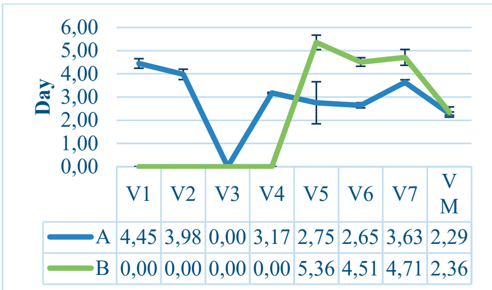

Figure 7. Mean Germination Time (MTG) (day): A - Aqueous extracts applied at two days after preparation; B - Aqueous extracts applied at 22 days after preparation

Instead, extracts applied at 22 days after preparation, average value for MTG fluctuated between 0.00 and 5.36, with the highest value recorded in V5. According to Orchard (1977), the lower the MGT means the faster a population of seeds has germinated.

Further investigation may be necessary to identify the specific compounds in the extracts that led to the inhibition of germination and to determine the potential implications for the practical use of these extracts in agriculture.

CONCLUSIONS

The obtained results suggest that the extract applied at 22 days after preparation display more serious allelopathic effects on the seed germination of lettuce.

The extract from common vetch, canada thistle, red-root amaranth, common purslane and cockspur exhibited a strong allelopathic activity on lettuce seed germination.

The extract from clotbur, cockspur, prickly lettuce, red-root amaranth and fig-leaved goosefoot applied at two days after preparation showed a stimulatory effect on seed germination of lettuce.

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