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Phytotoxicity of *Cedrus* and *Pelargonium* essential oils on selected weeds

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Abstract

The inhibitory effects of *Cedrus atlantica* and *Pelargonium graveolens* essential oils on seed germination and seedling growth of three weed species were investigated. The oils were applied in three different concentrations (10, 20 and 30 µg/mL) in laboratory conditions, with four replications. Applied oils demonstrate a strong inhibitory effect on *Taraxacum officinale* in the tested concentrations with a germination inhibition percentage ranging from 50-100%. The tested oils were considerably less effective on *Chenopodium album* and *Daucus carota* seeds, suggesting their usage as natural herbicidal products for some weed species.

Keywords: essential oils, pytotoxicity, *Cedrus atlantica*, *Pelargonium graveolens*

1. Introduction

Essential oils metabolism has been studied in numerous plants (Azirak and Karaman, 2008).One of the reasons is that essential oils and their main constituents, monoterpenoids, have allelopathic and phytotoxic effects that can affect seed germination and development (Mutlu, Atici and Esim, 2010; Krifa, Gharad and Haouala, 2011). Hence, they can be considered as promising candidates for replacing synthetic pesticides to protect the environment.

Today, weeds have become an enormous problem because they lead to great economic losses (Bouajaj et al., 2014). Synthetic herbicides are mainly used to control weeds, but since they are difficult to degrade in nature and can lead to weed resistance, attention has been redirected to biopesticides, including essential oils and their constituents (Das et al., 2019). There are efficient

examples of the use of essential oils and their components as commercial herbicides: clove oil which is the main component of the commercial herbicide Burnout II (Ahuja et al., 2015) and 1,4-cineole which is the active compound of the herbicide cinmethylene, that is an analog of eucalyptol (Grayson et al., 1987).

The uncontrolled usage of pesticides and herbicides in agricultural production, especially in developing countries, requires concrete solutions. One of the potential answers is organic products and alternative eco-friendly approaches due to their limited risk to the environment and humans. The use of natural herbicides in agricultural production has been known since ancient times. For example, small farmers in Bosnia and Herzegovina soaked nettle for days and then watered their raspberry plantations with this extract.

The aim of this research was to evaluate the inhibitory effect of essential oils of Cedar and Geranium on the germination and growth of seedlings of three weed species, *Taraxacum officinale* F. H. Wigg., *Chenopodium album* L. And *Daucus carota* L.

2. Material and Methods

2.1. Plant material and essential oils

Weed seeds of dandelion (*Taraxacum officinale*) and White goosefoot (*Chenopodium album*) have been collected in 2019. in the surrounding area of Sarajevo. The seed of a Wild carrot (*Daucus carota*) has been obtained from commercial production (Franchi Sementi, Italy). Essential oils were Atlas cedar (*Cedrus atlantica*) and Rose geranium (*Pelargonium graveolens*) both obtained from a commercial source (BMLogistic d.o.o. Vogošća). The solutions of tested oils were first prepared in methanol, and serial dilutions were prepared with distilled water to give the concentrations of 10, 20 and 30 μg/mL.

2.2.Cultivation of the seeds

The seeds were cultivated in sealed Petri dishes on two layers of filter paper (Whatman No. 1) inside a climate chamber (23°C and 16-hour photoperiod). Five milliliters of each concentration of essential oils, or water for control, were applied to Petri dishes. Each Petri dish contained 25 seeds. The experiment was performed in four replications. Data were collected each day, for 10 days and on the last day, the lengths of roots and shoots were determined. Seeds were

considered as germinated when coleoptiles were longer than 1 mm and with a visible root (Kolb, Pilon and Durigan, 2016).

2.3. Seed germination and allelopathic bioassay

During 10 days, measurements were made to estimate the allelopathic effect of essential oils on the seeds of three weed species. The following parameters were determined: index of germination (AOSA 1983), percentage of germination (Scott, Jones and Williams,1984), germination rate index, germination vigor index, mean germination time, an average rate of germination (Ranal and Santana, 2006), percentage of germination inhibition (Ali et al., 2015). Phytotoxicity was determined according to Mekki, Dhouib and Sayadi(2007), with the values ranging between (0) and (1), where a higher value indicates a negative (i.e. toxic) effect, and a lower value a positive (i.e. stimulating) effect.

1.4. Statistical analysis

Analysis of variance (ANOVA) was applied to calculate the significance of differences between experimental parameters. The difference in mean values between the analyzed factors was compared with the Newman-Keuls post hoc test for the significance level of $p<0.05$. These analyses were performed in the STATISTICA 12 (StatSoft, Inc. 2014).

3. Results

After the treatment of *Taraxacum officinale* seeds with different concentrations of *Cedrus* and *Pelargonium* oils, a statistically significant inhibition of the germination process was observed, compared to the control. For eight examined parameters, the differences were more pronounced with the increase in the concentration of applied oils (Table 1).

Table 1. Effect of essential oils on Taraxacum officinale seeds ten days after sowing

	Index of germination	Germination %	**Germination rate index**	Germination time	Germination rate	Vigor index	Germination inhibition %	**Phytotoxic** index
Control	1.69 (±0.59)^{a}	25.00 (±9.45)^{a}	6.75 (±2.36)^{a}	1.53 (±0.23)^{a}	4.13 (±0.82)^{a}	4.40 (±1.99)^{a}	-	0.00
Cedrus oil 10 μg/mL	0.86 (±0.50)^{b}	12.05 (±11.00)^{ab}	3.45 (±2.01)^{b}	1.92 (±0.33)^{a}	5.70 (±0.48)^{a}	2.24 (±1.25)^{a}	32.00 (±2.20)^{b}	0.264
Cedrus oil 20 μg/mL	0.63 (±0.13)^{b}	0.00^{b}	0.25 (±0.50)^{c}	0.25 (±0.50)^{b}	1.00 (±2.00)^{b}	0.10 (±0.19)^{b}	96.00 (±0.50)^{a}	0.96
Cedrus oil 30 μg/mL	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{b}	0.00b	0.00b	100 (±0.00)^{a}	1
Pelargonium oil 10 μg/mL	0.61 (±0.23)^{b}	12.00 (±5.66)^{ab}	2.43 (±0.94)^{b}	1.28 (±0.87)^{a}	5.32 (±0.55)^{a}	0.70 (±0.47)^{a}	52.00 (±1.41)^{b}	0.42
*Pelargonium*oil 20 μg/mL	0.05 (±0.1)^{b}	1.00 (±2.00)^{b}	0.20 (±0.40)^{c}	0.25 (±0.50)^{b}	1.25 (±2.50)^{b}	0.10 (±0.15)^{b}	96.00 (±0.50)^{a}	0.89
Pelargonium oil 30 μg/mL	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00b	100 (±0.00)^{a}	1

Data are expressed as means of four replicates (±sd). Means within a column sharing the same letter are not significantly different at the 0.05 probability level.

Following the treatment of *Chenopodium album*s eeds with different concentrations of *Cedrus* and *Pelargonium* oils, results were slightly different, compared to *Taraxacum officinale* seeds. Statistically significant inhibition of the germination process, compared to the control, was observed for six examined parameters. No differences were found in the average germination time and germination rate (Table 2).

Table 2. Effect of essential oils on Chenopodium album seeds ten days after sowing

	Index of germination	Germination %	**Germination rate index**	Germination time	Germination rate	Vigor index	Germination inhibition %	**Phytotoxic** index
Control	4.96 (±0.20)^{a}	99.00 (±2.00)^{a}	19.84 (±0.79)^{a}	2.23 (±0.36)^{a}	5.12 (±0.20)^{a}	33.89 (±2.52)^{a}	-	0.00
Cedrus oil 10 μg/mL	4.88 (±0.69)^{ab}	94.00 (±9.52)^{b}	19.50 (±2.77)^{a}	2.57 (±0.14)^{a}	5.05 (±0.27)^{a}	25.95 (±5.37)^{ab}	5.17 (±2.38)^{b}	0.14
Cedrus oil 20 μg/mL	4.45 (±0.64)^{ab}	95.00 (±5.03)^{ab}	17.82 (±1.85)^{a}	2.74 (±0.26)^{a}	5.64 (±0.31)^{a}	22.37 (±1.16)^{b}	4.10 (±1.26)^{b}	0.32
Cedrus oil 30 μg/mL	3.90 (±0.17)^{bc}	94.00 (±4.00)^{b}	15.61 (±0.69)^{b}	2.35 (±0.51)^{a}	6.21 (±0.12)^{a}	17.10 (±1.71)^{bc}	5.05 (±1.00)^{b}	0.54
Pelargonium oil 10 μg/mL	4.71 (±0.40)^{ab}	95.00 (±6.00)^{a}	18.85 (±1.61)^{a}	2.46 (±0.36)^{a}	5.20 (±0 .27)^{a}	19.21 (±13.04)^{bc}	4.04 (±1.50)^{b}	0.04
Pelargonium oil 20 μg/mL	4.28 (±0.32)^{abc}	96.00 (±4.62)^{a}	17.13 (±1.26)a	2.48 (±0.49)^{a}	5.79 (±0.25)^{a}	21.48 (±2.01)^{bc}	3.03 (±1.15)^{b}	0.21
Pelargonium oil 30 μg/mL	3.61 (±0.05)^{bc}	87.00 (±3.83)^{c}	14.44 (±0.19)^{b}	2.18 (±0.63)^{a}	6.15 (±0.21)a	12.99 (±2.26)^{c}	12.12 (±0.96)^{a}	0.64

Data are expressed as means of four replicates (±sd). Means within a column sharing the same letter are not significantly different at the 0.05 probability level

Treated *Daucus carota* seeds with different concentrations of *Cedrus* and *Pelargonium* oils showed statistically significant inhibition of the germination process for five parameters. No differences were found for germination percentage, average germination time and germination rate (Table 3).

Table 3. Effect of essential oils on Daucus carota*s eeds ten days after sowing*

	Index of germination	Germination %	**Germination rate index**	Germination time	Germination rate	Vigor index	Germination inhibition %	**Phytotoxic** index
Control	5.63 (±0.78)^{ab}	83.00 (±11.5)^{a}	22.52 (±3.14)^{ab}	1.63 (±0.36)^{a}	37.73 (±5.22)^{a}	49.70 (±7.49)^{a}	-	0.00
Cedrus oil 10 μg/mL	5.56 (±0.81)^{ab}	82.00 (±8.33)^{a}	22.25 (±3.23)^{ab}	1.71 (±0.28)^{a}	37.27 (±3.78)^{a}	41.05 (±3.72)^{b}	1.21 (±2.08)^{b}	0.16
Cedrus oil 20 μg/mL	5.72 (±0.44)^{a}	86.00 (±5.16)^{a}	22.87 (±1.76)^{a}	1.76 (±0.09)^{a}	39.09 (±2.35)a	27.84 (±2.79)^{c}	-3.61 (±1.29)^{a}	0.38
Cedrus oil 30 μg/mL	4.59 (±0.36)b	84.00 (±8.64)^{a}	18.35 (±1.43)^{b}	2.45 (±0.16)^{a}	38.18 (±3.93)^{a}	16.69 (±3.64)^{d}	-1.21 (±2.16)^{b}	0.68
Pelargonium oil 10 μg/mL	5.91 (±0.73)^{a}	87.00 (±7.57)^{a}	23.66 (±2.92)^{a}	1.64 (±0.16)^{a}	39.55 (±3.44)^{a}	45.51 (±4.78)^{ab}	-4.82 (±1.89)^{a}	0.01
Pelargonium oil 20 μg/mL	5.50 (±0.48)^{ab}	83.00 (±6.83)^{a}	21.99 (±1.92)^{a}	1.69 (±0.20)^{a}	37.73 (±3.11)^{a}	31.77 (±3.71)^{c}	0.00 (±1.71)^{b}	0.30
Pelargonium oil 30 μg/mL	4.62 (±0.41)^{b}	83.00 (±5.03)^{a}	18.47 (±1.63)^{b}	2.22 (±0.22)^{a}	37.73 (±2.29)^{a}	19.02 (±8.66)^{d}	0.00 (±1.26)^{b}	0.57

4. Discussion

Inhibitory effects of the essential oils were observed depending on oil concentrations. Thus, the most efficient outcome was detected after the application of essential oils to the dandelion.

It was noticeable (Table 1) that an increase in the concentration of essential oils led to a reduction in all analyzed parameters with the lethal outcome for the highest concentrations. Our results showed a significant herbicidal effect of both oils on *Taraxacum officinale*, which is in agreement with the findings of Carroll, Kaminski and Borger(2020), who observed equal effects of natural and synthetic herbicides on dandelion control in the field. *Pelargonium graveolens* oil at a concentration of 30 μg/mL completely inhibited the germination of dandelion seeds, while *Cedrus atlantica* oil showed maximum phytotoxicity already at 20 μg/mL.

However, this is not the case for the other two weed species (Tables 2 and 3). The *Chenopodium album* treatment with essential oils led to a weak inhibitory effect, except for the highest concentrations of *Cedrus* and *Pelargonium* oil. In addition, *Pelargonium* oil showed more significant phytotoxicity (Table 2). On

the contrary, applied essential oils on the seeds of *Daucus carota* didn't show a significant phytotoxic effect (Table 3).

Although the essential oils did not show a high phytotoxic effect on the species *Chenopodium album* and *Daucus carota*, the literature data are diverse. References related to the essential oil of *Cedrus atlantica* are scarce. A herbicidal effect on lettuce (Mirmostafaee, Azizi, and Fujii, 2020) and a larvicidal effect (Wagan et al., 2022) were observed. Unlike *Cedrus*, the herbicidal effect of *Pelargonium* essential oil has been more studied. *Pelargonium* oil showed herbicidal effect on lettuce and Barnyard Grass (Mirmostafaee, Azizi, and Fujii, 2020; Abdelgaleil, Saad and Hassan, 2014 respectively), larvicidal (Benelli et al., 2017), fungicidal (Naveenkumar et al., 2017), acaricidal and nematicidal effect (Fierascu et al. 2020). These studies resulted in the active use of pelargonic acid (nonanoic acid) as a herbicide. Pelargonic acid removes the cuticle from the leaf surface, leading to rapid, uncontrolled desiccation of the weed tissue (Lederer et al., 2004; Coleman and Penner, 2008).

5. Conclusions

Based on the results of this research, it can be concluded that the essential oils of *Pelargonium graveolens* and *Cedrus atlantica* had a pronounced herbicidal effect against *Taraxacum officinale*. Such results underline the possibility of further research of these oils as bioherbicides. Therefore, the expansion of the current range of commercial herbicides in agriculture, with new ones low-dose bioherbicides, enables safe, efficient and economical production.

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