NON-CHEMICAL CONTROL MEASURES OF *Senecio vulgaris* L.

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Abstract
Environmental constraints of crop production systems have stimulated interest in alternative weed management strategies, as the continued use of synthetic herbicides has resulted in serious ecological problems, such as weeds resistance to important herbicides and increased environmental pollution and health hazards. The aim of this study was to test the bioherbicidal activity of the essential oil of *Rosmarinus officinalis* L. on weed species *Senecio vulgaris* L., in 2019, at the Faculty of Agriculture, University of Novi Sad. In order to examine a phytotoxic effect, plants were treated with 1 and 5% (v/v) concentration of rosemary essential oil, kitchen salt NaCl (1:8), wine vinegar solution (1:10), and glyphosate, while the control variants remained untreated. The evaluation was carried out 1, 24, 48, 72, 96, 120 and 144 hours after application. Essential oils of rosemary in both concentrations and wine vinegar solution (1:10) had good efficacy compared to the control. High efficacy was in the treatment with NaCl solution and glyphosate, and complete decay of *S. vulgaris* plants occurred 144h after application. Phytotoxic changes in the form of turgor loss, chlorotic, then necrotic spots, were determined on the tested weed species 24h from the application of NaCl and glyphosate, while from essential oil first symptoms have appeared after 48h.

Introduction
Potential damage to human health and to the environment from herbicides is considered a real problem which has stimulated interest in using plant-derived compounds as a natural herbicide. The use of chemical herbicides besides their ecotoxicological effect could induce the emergence of resistant weed populations [1], such as continuous use of glyphosate has made certain populations become glyphosate-resistant (*Lolium rigidum* L., *Echinochloa crus-galli* (L.) Beauv.) [2]. During the last 40 years, a number of researchers have highlighted the potential importance of natural plant products as herbicides [3]. Among natural plant products, volatile essential oil and their constituents have attracted much attention because their phytotoxicity has shown strong activity against weeds [4]. Essential oils are complex of volatile compounds, naturally synthesized in different plant parts during the process of secondary metabolism [1]. Terpenoids, especially monoterpenes and sesquiterpenes, are the main components of essential oil and are often responsible for their inhibitory activity in plants. Tworkoski (2002) [5] demonstrated that essential oils from red thyme, summer savory, cinnamon, and clove were the most phytotoxic to *Chenopodium album*, *Sorghum halepense* and *Ambrosia artemisiifolia*. Herbicides based on plant essential oil have been demonstrated to be effective against a wide range of weeds and are potentially a natural alternative to non-selective herbicides [4]. Essential oils from species such as oregano, thyme, rosemary, sage and mint are reported to be particularly strong bioherbicide candidates [6]. Many recent studies have investigated the phytotoxicity of *Rosmarinus officinalis* L. extracts to weeds, and in this respect, significant results were obtained on a number of important weed species, such as *Amaranthus retroflexus* L., *Bromus tectorum* L., *Cynodon dactylon* L., *Digitaria sanguinalis* L. and *Lolium perenne* [7]. The aim of this study was to determine the influence of chemical and alternatives measures in the control of common groundsel (*Senecio vulgaris* L.).

Experimental

The plants of *Senecio vulgaris* L. were collected from an old vineyard and transplanted into containers. The experiment was set in six repetitions, and plants were grown in controlled conditions at the Faculty of Agriculture, University of Novi Sad during 2019. Treatments were done in the phase of 4-6 leaves, with a solution of rosemary essential oil in a concentration of 1% (v/v) and 5% (v/v), solution of wine vinegar (1:10) and kitchen salt NaCl (1:8). Plants were also treated with the non-selective herbicide glyphosate (3 l/ha), with the addition of 0.1% surfactant Trend 90. Untreated plants were also included in the experiment. The solutions were applied with hand sprayer Einhell BG-PS 1.5/1, after which the plants were placed in an air chamber with an average daily temperature of 25 °C. Evaluation of the effects of the examined treatments on whole plants was done by visual assessment according to EWRC (European Weed Research Council) scale from 1 (0% damage) to 9 (100% plant decay) [8], while for leaf damage a visual assessment was used according to a scale from 1 (0% damage) to 5 (100% plant decay) [9].

Results and discussion

The effects of rosemary essential oil in the tested concentrations (1 and 5% v/v), kitchen salt NaCl (1: 8), wine vinegar (1:10) and glyphosate on the weed species *S.vulgaris* L. are presented in Tables 1 and 2. The evaluation was carried out 1, 24, 48, 72, 96, 120 and 144 hours after application.

Table 1. Assessment of plant injury, EWRC scale

Time of assessment	Concentration of essental oil of rosemary		NaCl (1:8)	Wine vinegar (1:10)	Glyphosate	Control
	1%	5%				
1h	1	1	4	1	1	1
24h	2	4	7	4	4	1
48h	3	4	8	6	6	1
72h	5	6	8	6	6	1
96h	6	7	9	7	7	1
120h	6	7	9	7	8	1
144h	7	7	9	7	9	1

Table 2. Assessment of leaf injury, Gar scale

Time of assessment	Concentration of essental oil of rosemary		NaCl (1:8)	Wine vinegar (1:10)	Glyphosate	Control
	1%	5%				
1h	0	0	1	0	0	0
24h	2	2	3	2	3	0
48h	2	2	4	2	3	0
72h	2	3	4	3	4	0
96h	2	3	4	3	4	0
120h	3	4	5	3	4	0
144h	4	4	5	3	5	0

One hour after treatment there were no signs of damage on plants from the applied concentrations (1 and 5%) of rosemary essential oil. After 24h and 48h at a concentration of

1% the plants were partial lodgings down (categories 2 and 3 on EWRC scale), while at a concentration of 5% they lay down (category 4 on EWRC scale), and chlorotic and necrotic spots were observed (category 2 on Gar scale). In the treatment with both concentrations of essential oil, after 72 and 96 hours there was the lodging of plants and color loss (category 5-7 on EWRC scale, 2 and 3 on Gar scale), while after 144h a more pronounced lodging was observed (7 on the EWRC scale), plants reacted by loss of turgor and color, chlorosis and necrosis (4 on Gar scale). Atak et al. (2016) [10] showed that concentrations of rosemary essental oil from 2 to 16 µl/Petri dish caused a decrease in germination from 61 to 12% for *Avena sterilis* L. seeds, while at least 2 µl/Petri dish inhibited germination of *Sinapis arvensis* L. by 89%. High efficacy was observed in the treatment with NaCl after 48 and 72h (8 on EWRC scale), where seedlings lay down, and strong chlorosis and color loss occurred (4 on Gar scale). Later, treatment with NaCl caused complete decay of *S. vulgaris* (category 9 on EWRC and 5 on Gar scale), which was manifested by turgor loss and necrosis. In the treatment with wine vinegar (1:10) the damage was tolerable to strong (6 and 7 on EWRC scale), with the appearance of chlorosis (3 of Gar scale). After 24 and 48h from the glyphosate application, there was the lodging of plants (4 and 6 on EWRC scale) and color loss (3 on Gar scale). Glyphosate achieved high efficacy after 144h, where the plants were completely dead (9 on EWRC scale), the leaves were chlorotic, necrotic, or fallen off (5 on Gar scale).

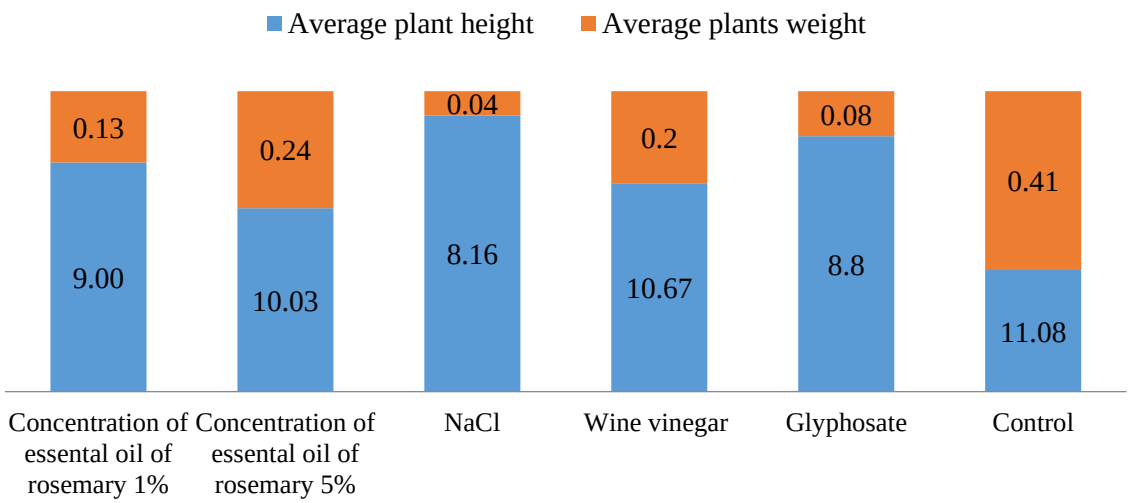

Figure 1. Average height and weight of *S.vulgaris* plants (after treatment and in control)

Six days after treatments, the average height and weight of S. *vulgaris* L. were measured. All treatments had an effect on the height and weight of the plants. The lowest average plant height was after the application of NaCl and glyphosate (fig. 1). According to the data obtained from Figure 1, it can be seen that rosemary essential oil of 1 and 5% (v/v), NaCl, wine vinegar and glyphosate had an effect on plant weight compared to control. The major effect on plant weight was observed with NaCl solution and glyphosate.
Benvenuti et al. (2017) [4] showed that the essential oil of *Xanthium strumarium* has an effect on reducing plant fresh weight of *Amaranthus retroflexus* and *Setaria viridis*, as well as on chlorophyll content, which confirms the total and rapid effectiveness of essential oil.

Conclusion

Essential oil of *Rosmarinus officinalis* L. at concentrations of 1 and 5% (v/v) showed efficacy in controlling Senecio vulgaris L. Good efficacy of essential oil was achieved 144 hours after

treatment, and it was manifested by turgor loss, color loss, chlorosis and plant necrosis. High efficiency of NaCl (1:8) was achieved after 48 hours, while complete decay of plants occurred 96 hours after application. Slightly lower efficacy was observed with wine vinegar (1:10), where the damage was tolerable to strong. Glyphosate showed high efficacy after 72h, and complete decay of *S. vulgaris* plants occurred 144h after application. Of all applied treatments, the highest efficacy was observed with NaCl and glyphosate, but the applied essential oil also had good efficacy in controlling *S. vulgaris*. After application, all treatments affected the height and weight of the plants. Due to the risk of possible resistance and questionable authorization of glyphosate after 2022, some possible alternatives should be considered for weed control.

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