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Assessing the germination response of selected species to lavender hydrolate

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SUMMARY

The present study investigates the effect of lavender hydrolate on the germination of selected cultivated and weed species. Lavender hydrolate, known for its diverse biological activities, is a byproduct of the lavender essential oil distillation process. The study examined the effects of four different lavender hydrolate concentrations (10, 20, 50, and 100%) on the germination of sunflower (*Helianthus annuus*), wheat (*Triticum* sp.), lamb's quarters (*Chenopodium album*), and purslane (*Portulaca oleracea*). The findings indicate that lavender hydrolate significantly reduced the seed germination of *C. album*, with the germination rates being 37.25-50.98% in the case of lower concentrations. The most pronounced effects were observed for *P. oleracea*, in which all the concentrations significantly impaired the germination. Notably, by applying the 10, 20, 50, and 100% hydrolate solution, the germination was reduced by 78, 92, 88, and 100%, respectively. The results revealed that lavender hydrolate had a significant inhibitory effect on the germination of all the tested species, with the highest concentration showing the strongest inhibition. Statistically significant differences in the growth of the hypocotyl and epicotyl of the weed plants were observed for all the tested concentrations compared to the control. The hydrolate more effectively reduced the growth rates of the weeds than of the cultivated crops, indicating its potential as a bioherbicide, particularly at higher concentrations.

Keywords: bioherbicides, weed control, *Chenopodium album*, *Portulaca oleracea.*

INTRODUCTION

In agricultural production, weed species cause damage to cultivated crops and can lead to a significant reduction in yield. According to official FAO data, up to 40 percent of crops are lost due to plant pests and diseases every year (FAO, 2025). Therefore, the use of synthetic herbicides in agriculture has become almost indispensable. However, the intensive and long-term use of pesticides has resulted in a number of adverse consequences. One of them is the development of resistance, which is associated with the repeated application of herbicides with the same mode of action in the same crop, allowing the survival of the most resistant individuals within the treated weed populations that were previously susceptible (Holt, 1992). As a result of changes in the sensitivity of pest populations and the emergence of resistance, pesticide efficacy decreases. The use of alternative pesticides then becomes necessary to protect crops, leading to both economic losses and significant environmental pollution. Intensive pesticide use, along with improper application and failure to observe preharvest intervals, has caused the accumulation of pesticide residues in the environment and agricultural products, representing a major issue in modern agriculture (Vuković and Šunjka, 2021).

In order to reduce the use of synthetic herbicides, there is increasing emphasis on the implementation of alternative plant protection measures. This involves integrated pest management approaches that include the use of various biological control agents, i.e., biopesticides, which serve as substitutes for chemical synthetic compounds. Such agents may include beneficial microorganisms or their metabolic products, as well as plant extracts and essential oils (Ibanez and Blazquez, 2019). Their role is to ensure effective crop protection while minimizing toxicity to the environment. Biopesticides decompose rapidly, have shorter preharvest intervals, act selectively on target organisms, and may help in suppressing resistant populations due to their mechanisms of action differing from those of conventional pesticides. Since herbicides represent the most commonly used class of pesticides, there is an especially strong need to identify alternative weed control strategies. One such alternative is allelopathy (Pejić, 2013).

The term allelopathy was first introduced in 1937 by the Austrian botanist Molisch, and based on his concept, Rice (1984) defined allelopathy as the direct or indirect, positive or negative influence of one plant, fungus, or microorganism on another plant through the release of chemical substances (allelochemicals) into the environment. Allelochemicals are generally secondary metabolites or their derivatives that play little role in primary metabolism essential for plant survival (Swain, 1977). Hence, allelopathy plays a significant role in agriculture, particularly within integrated weed management. Certain aromatic plants and their essential oils have demonstrated allelopathic potential (Arminante, 2006). In recent years, interest in essential oils as potential substitutes for synthetic pesticides has been increasing (Koiou et. al., 2020). Hydrolates, which are by-products obtained during essential oil production, are also gaining attention as potential agents for use in plant protection (Aćimović et. al., 2020). In light of the above, this study analyzed the effects of different concentrations of hydrolate derived from the medicinal plant lavender (*Lavandula angustifolia*) under laboratory conditions on

the germination and initial growth of selected cultivated (*Helianthus annuus*, *Triticum* spp.) and weed species (*Chenopodium album, Portulaca oleracea*).

MATERIAL AND METHODS

In this experiment, seeds of the field crops sunflower (*Helianthus annuus*) and wheat (*Triticum* spp.) were obtained from the Institute of Field and Vegetable Crops in Novi Sad, while seeds of the weed species were collected from several locations in the vicinity of Novi Sad. A ready-to-use hydrolate provided by the Institute of Field and Vegetable Crops, Novi Sad, was used in the study.

The hydrolates were diluted with distilled water to obtain solutions of 10%, 20%, and 50% concentrations in addition to the undiluted (100%) hydrolate. Seeds of the test plants were surface-sterilized in a 2% sodium hypochlorite solution. Following sterilization, filter paper was placed in Petri dishes, and 25 seeds of each test species were placed in each dish, with four replications per treatment (ISTA, 1993). The control was treated with 5 mL of distilled water, while the other treatments received 5 mL of the respective hydrolate solutions. Four hydrolate concentrations (10%, 20%, 50%, and 100%) were tested.

The Petri dishes were placed in a growth chamber under alternating temperature and light conditions: 23°C during a 12-hour light period and 20°C during a 12-hour dark period, with an average relative humidity of 65%. The seeds were incubated for seven days (ISTA, 1993). The number of germinated seeds was recorded every other day. At the end of the experiment, the lengths of the hypocotyl and epicotyl were measured.

The analysis and statistical processing of the collected data were carried out at the Faculty of Agriculture in Novi Sad, Department of Phytomedicine and Environmental Protection. All data were presented and analyzed in the Statistica 10 and MS Excel programs.

RESULTS AND DISCUSSION

Figure 1 presents the effects of lavender hydrolate treatments at different concentrations on seed germination of the selected test plant species. It was observed that all hydrolate concentrations exerted an inhibitory effect on seed germination. The 10% lavender hydrolate reduced sunflower seed germination by 17.00% compared to the control, while the 100% hydrolate caused an 84% reduction in germination percentage. A similar concentration-dependent reduction in germination was observed in wheat, showing a pattern comparable to that of sunflower.

In *Portulaca oleracea*, a lower germination percentage was recorded compared to the control (up to 22.00% reduction), whereas in *Chenopodium album*, the lavender hydrolate exhibited a stimulatory effect, with higher hydrolate concentrations resulting in greater germination percentages, but overall germination was still inhibited relative to the control.

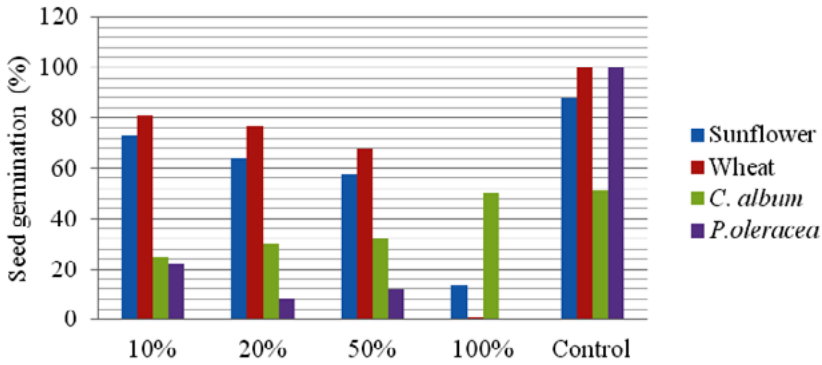

Figure 1. Effect of different concentrations of lavender hydrolate on seed germination (%) of sunflower, wheat, *Chenopodium album*, and *Portulaca oleracea*.

At the lowest hydrolate concentration (10%), germination of *P. oleracea* seeds was reduced by 78.00%, while *C. album* germination decreased by 50.98% compared with the control. At a concentration of 20.00%, the hydrolate reduced germination of *P. oleracea* by as much as 92.00% relative to the control, and of *C. album* by 41.18%. When treated with 50% hydrolate concentration, *P. oleracea* seed germination decreased by 88.00%, and *C. album* by 37.25% compared to the control.

Treatment with undiluted (100%) lavender hydrolate completely inhibited germination of *P. oleracea* seeds, whereas *C. album* was almost unaffected, showing only a 1.96% reduction in germination relative to the control.

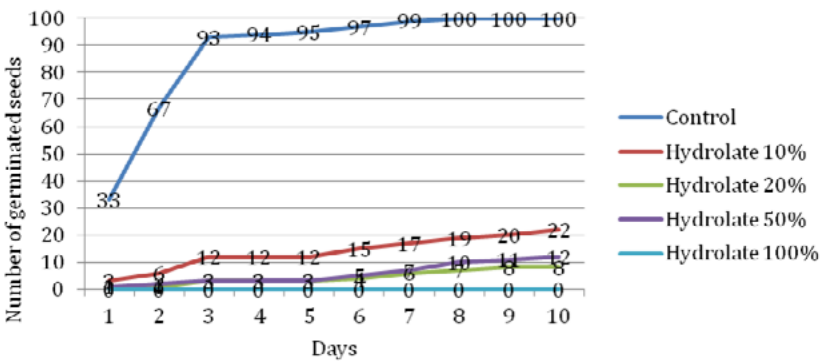

Figure 2. Effect of different concentrations of lavender hydrolate on the germination (%) of *Portulaca oleracea* seeds.

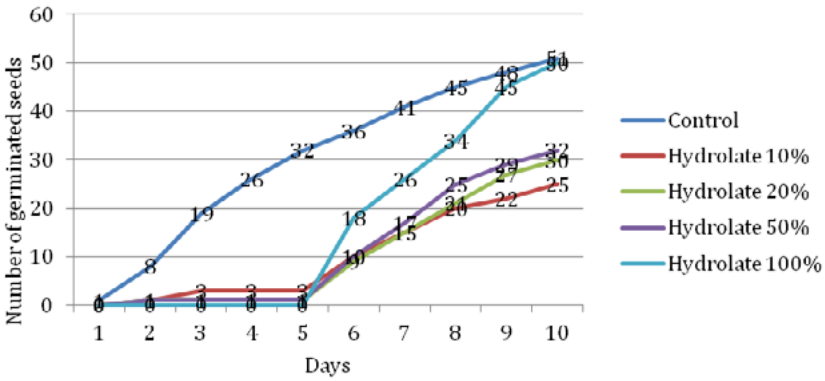

Figure 3. Effect of different concentrations of lavender hydrolate on the germination (%) of *Chenopodium album* seeds.

Based on the presented data, it can be observed that lavender hydrolate exhibited an inhibitory effect on the germination of the tested weed species, except in the case of the 100% concentration applied to *C. album* seeds, where inhibition was absent. In contrast, complete inhibition of *P. oleracea* germination occurred under the same treatment. It can therefore be concluded that lavender hydrolate exerted the strongest inhibitory effect on the germination of *P. oleracea* seeds.

Germination of sunflower (*Helianthus annuus*) seeds treated with lavender hydrolate at a concentration of 10.00% was reduced by 17.05% compared to the control. With increasing hydrolate concentration, the inhibitory effect on germination intensified: germination was reduced by 27.27% at the 20.00% concentration, by 34.09% at the 50.00% concentration, and by as much as 84.09% following treatment with undiluted (100%) hydrolate.

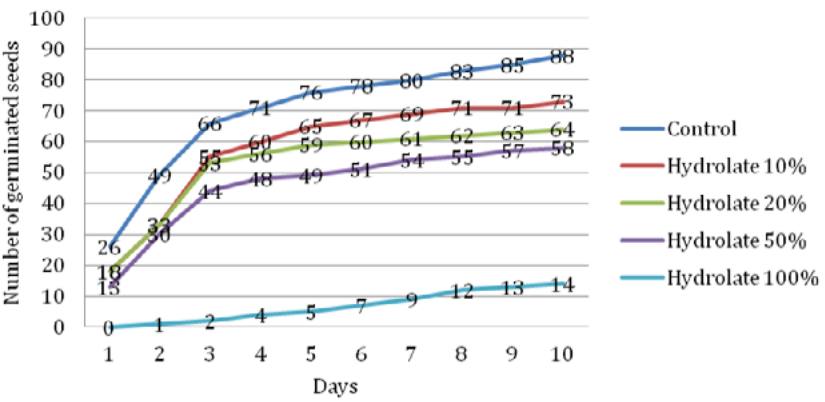

Figure 4. Effect of different concentrations of lavender hydrolate on the germination (%) of *Helianthus annuus* seeds.

In wheat (*Triticum* spp.), treatment with a 10.00% lavender hydrolate solution reduced germination by 19.00% relative to the control. Germination decreased by 23.00% at the 20.00% concentration and by 32.00% at the 50.00% concentration. Nearly complete inhibition of germination occurred following treatment with the 100% hydrolate, where germination was reduced by 99.00% compared with the control.

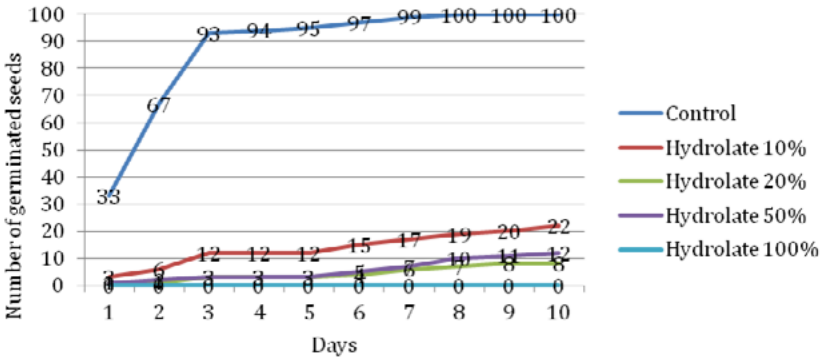

Figure 5. Effect of different concentrations of lavender hydrolate on the germination (%) of *Triticum* spp. seeds.

Examination of the effects of lavender hydrolate on the growth of seedlings of cultivated plant species revealed statistically significant differences (at the significance level of $p < 0.05$) in both shoot and root length of sunflower (*Helianthus annuus*) and wheat (*Triticum* spp.) seedlings across all applied hydrolate concentrations compared with the control (Table 1).

Table 1. Duncan's post-hoc test: significance of differences in shoot and root length of *Helianthus annuus* and *Triticum* spp. seedlings in relation to the applied concentrations of lavender (*L. angustifolia*) hydrolate.

Hydrolate (%)	Sunflower		Wheat	
	Shoot lenght (mm)	Root lenght (mm)	Shoot lenght (mm)	Root lenght (mm)
10%	30.41±26.16^{a}	19.04±18.68^{bw}	56.75±37.78^{b}	42.43±34.88^{b}
20%	26.99±28.02^{ab}	14.67±17.44^{bc}	46.63±40.70^{b}	43.45±37.76^{b}
50%	18.67±20.39^{b}	9.80±11.28^{c}	27.58±31.65^{c}	28.13±33.78^{c}
100%	1.51±4.56^{c}	0.76± 2.72^{d}	0.20±2.00^{d}	0.41±4.10^{d}
Control	34.41±21.64^{a}	50.01±38.16^{a}	114.12±19.17^{a}	114.11±19.14^{a}

*Values followed by the same letter are not significantly different at the 95% confidence level.

Analysis of the effects of hydrolate on the growth of weed seedlings showed statistically significant differences in shoot and root length of *C. album* and *P. oleracea* between the control and all tested concentrations of *L. angustifolia* hydrolate (Table 2).

Table 2. Duncan's post-hoc test: significance of differences in shoot and root length of *Chenopodium album* and *Portulaca oleracea* seedlings in relation to the applied concentrations of lavender (*L. angustifolia*) hydrolate.

Hydrolate (%)	*Chenopodium album*		*Portulaca oleracea*	
	Shoot lenght (mm)	Root lenght (mm)	Shoot lenght (mm)	Root lenght (mm)
10%	1.30±2.93^{b}	1.33± 3.14^{b}	1.13±2.17^{b}	1.82±3.68^{b}
20%	1.22±2.5^{b}	0.91± 2.06^{b}	0.19±0.72^{c}	0.24±0.94^{c}
50%	1.06±1.94^{b}	0.76± 1.4^{b}	0.23±0.72^{c}	0.23±0.63^{c}
100%	0.06±0.31^{b}	0.50± 0.3^{b}	0.00±0.00^{c}	0.00±0.00^{c}
Controle	5.62±6.77^{a}	8.65±11.79^{a}	10.47±2.56^{a}	19.76±4.53^{a}

*Values followed by the same letter are not significantly different at the 95% confidence level.

CONCLUSION

The hydrolate of *Lavandula angustifolia* had a significant inhibitory effect on sunflower seed germination at the highest concentration (100%), where germination was reduced by 84.09% compared with the untreated control. In wheat, nearly complete inhibition of seed germination was observed following treatment with the 100% hydrolate, resulting in a 99.00% reduction in germination relative to the control. The tested hydrolate caused moderate inhibition of *Chenopodium album* seed germination (ranging from 37.25-50.98%), except at the 100% concentration, where almost no effect was recorded—the reduction in germination was only 1.96% compared with the control. The most pronounced inhibitory effect of lavender hydrolate was observed in *Portulaca oleracea*, where all tested concentrations significantly reduced germination. The lowest concentration (10.00%) reduced germination by 78.00%, while the 20.00% and 50.00% hydrolates reduced germination by 92.00% and 88.00%, respectively, compared with the control. Complete inhibition of germination occurred at the 100% concentration. Analysis of seedling growth parameters in both cultivated and weed test species revealed statistically significant differences in shoot and root length between the control and all tested concentrations of *L. angustifolia* hydrolate ($p < 0.05$).

It can be concluded that hydrolate exhibited a weaker effect on the cultivated species, whereas in weed species it caused a more pronounced reduction in both seed germination and seedling growth of aerial and root parts. The strongest inhibitory effect of lavender hydrolate was observed in *P. oleracea*. Further research under field conditions is required, as well as the inclusion of a broader range of weed species, to allow for a comprehensive assessment of the potential of *L. angustifolia* hydrolate. The findings of this study indicate that this hydrolate shows promise for use in plant protection as a bio-based preparation for weed management.

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Uticaj hidrolata lavande na klijavost odabranih biljnih vrsta

REZIME

U ovom istraživanju ispitivan je uticaj hidrolata lavande (*Lavandula angustifolia*) na klijavost odabranih gajenih i korovskih vrsta. Hidrolat lavande, poznat po različitim biološkim svojstvima, nusproizvod je destilacije etarskog ulja lavande. Ispitane su četiri koncentracije hidrolata (10, 20, 50 i 100%) na klijavost semena suncokreta (*Helianthus annuus*), pšenice (*Triticum* spp.), pepeljuge (*Chenopodium album*) i tušta (*Portulaca oleracea*). Rezultati pokazuju da je hidrolat značajno smanjio klijavost semena *C. album*, sa vrednostima od 37,25-50,98% pri nižim koncentracijama. Najizraženiji efekat uočen je kod *P. oleracea*, gde su sve primenjene koncentracije značajno umanjile klijavost: 10, 20, 50 i 100% hidrolata smanjili su klijavost za 78, 92, 88 i 100%, respektivno. Hidrolat lavande je imao značajan inhibicioni efekat na klijavost svih ispitivanih vrsta, pri čemu je najveća koncentracija izazvala najjače suzbijanje. Statistički značajne razlike u rastu hipokotila i epikotila korovskih vrsta zabeležene su pri svim koncentracijama u odnosu na kontrolu. Hidrolat je efikasnije smanjivao rast korova nego ratarskih kultura, što ukazuje na njegov potencijal kao bioherbicida, posebno pri višim koncentracijama.

***Ključne reči*:** bioherbicidi, kontrola korova, *Chenopodium album*, *Portulaca oleracea*.