АГРОНОМІЯ

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Assessment of factors affecting the effectiveness of herbicides against *Heracleum sosnowskyi*

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Heracleum sosnowskyi Manden is a highly toxic invasive plant of the *Apiaceae* family that spreads rapidly in the temperate climate of Europe and Asia, causing significant damage to biodiversity and ecosystem functioning. The aim of this research was to quantitatively assess the influence of key factors on the effectiveness of herbicidal control of *Heracleum sosnowskyi*, and to determine optimal timing and methods of treatment. Field studies were conducted during 2020–2025 in natural phytocoenoses of the Western Forest-Steppe of Ukraine on plots of 25 m² with three replicates. Three herbicidal treatments were studied: Slash (1.5 L/ha), Roundup Max (4.0 L/ha), and a tank mix of Elumis (2.0 L/ha) + Roundup Max (2.5 L/ha), compared to an untreated control. Results showed that herbicide effectiveness strongly depended on the plant developmental stage. Roundup Max achieved over 92 % plant mortality at the cotyledon stage, but only 39 % at the eight-leaf stage. Slash showed a similar trend with lower values, from 89.6 % to 36.7 %. The tank mix of Elumis + Roundup Max was the most effective, ranging from 98.3 % at the cotyledon stage to 58.9 % at eight leaves, providing prolonged suppression of growth and regenerative capacity. Morphometric analysis indicated that plant height, stem diameter, leaf area, and the number of regenerated shoots were lowest under the tank mix, and correlation analysis confirmed an inverse relationship between herbicide effectiveness and morphometric parameters ($r = –0.88–0.94$, $p \leq 0.05$). ANOVA showed that plant developmental stage accounted for 83.3 % of the variation in control effectiveness, herbicide type 15.1 %, and the stage × herbicide interaction only 1.6 %. These results highlight the critical importance of timely herbicide application at early growth stages and demonstrate the advantage of using tank mixes for maximal suppression of *Heracleum sosnowskyi* growth and regeneration, which is crucial for adaptive management of invasions and maintaining ecosystem stability.

Key words: *Heracleum sosnowskyi*, herbicidal control, effectiveness, morphometric parameters, plant developmental stage, invasive species.

Problem statement and analysis of recent research. *Heracleum sosnowskyi* Manden is a highly toxic invasive plant of the *Apiaceae* family, widely distributed in the temperate climates of Europe and Asia. Due to its ability to form dense monocultures and high reproductive capacity, this species significantly affects biodiversity and ecosystem functions. Its spread is associated with the displacement of native species and alterations in plant community structures in meadows, forest edges, and riparian landscapes, as well as disruption of soil trophic chains, as confirmed by numerous studies [1–2].

The invasion of *H. sosnowskyi* has both local and global significance. Across European and Asian territories, including Ukraine, regional control and monitoring programs combine biological, mechanical, and agrochemical management strategies [3–4]. Such an integrated approach is crucial for mitigating the species' negative impact on ecosystems, as it targets multiple stages of the plant's life cycle. The effectiveness of these measures largely depends on scientifically grounded recommendations regarding the optimal selection and application of herbicides under different environmental conditions [5].

The biological characteristics of *H. sosnowskyi* contribute to its high invasiveness: a single plant can produce up to 20,000 seeds, which remain viable in the soil for 10–15 years [6–7]. Young seedlings can germinate at low temperatures (1–2 °C), ensuring survival under various climatic conditions. Mechanical control methods, such as mowing or uprooting, have limited efficacy due to the plant's ability to regenerate from root fragments and seeds [8–9].

Chemical control using herbicides remains the most effective method to reduce *H. sosnowskyi* populations. Field studies have shown that granular and contact herbicides combined with adjuvants can achieve nearly 100 % mortality of young plants at early development stages (cotyledon phase), whereas their effectiveness decreases at the six-leaf stage and beyond [10–11]. Additionally, environmental conditions, particularly temperature and soil moisture, influence the rate of herbicide absorption through leaves and, consequently, plant mortality [12].

Recent studies also emphasize the allelopathic activity of *H. sosnowskyi*, which may affect the performance of crop species and the efficacy of herbicides. Aqueous extracts of the plant inhibit seed germination of flax, wheat, clover, and other species, demonstrating strong chemical effects on surrounding plants [13–14]. Soil microecosystem studies further indicate that *H. sosnowskyi* invasions alter soil nematode and microbial communities, potentially reducing the effectiveness of chemical treatments [15]. These findings highlight the necessity of an integrated approach that considers biological, ecological, and agrochemical factors to optimize herbicide application.

In Ukraine, *H. sosnowskyi* is also expanding, particularly in the Forest-Steppe and Polissya regions, where national control programs involve combined mechanical and chemical methods [16–17]. However, scientifically substantiated recommendations for controlling this species are currently insufficient. To enhance control effectiveness, strategies should be multidisciplinary and adaptive, including regular population monitoring, planning herbicide application, and assessing ecological impacts.

The aim of the research was to quantitatively evaluate the influence of key factors-developmental stage of *H. sosnowskyi*, type and dose of herbicide-on control effectiveness and to develop practical recommendations for optimizing invasive species management measures.

Material and methods of research. The study was conducted during 2020–2025 in natural phytocoenoses of the Western Forest-Steppe of Ukraine. The object of investigation was *Heracleum sosnowskyi*. Field observations were carried out on plots with relatively homogeneous vegetation cover, which ensured the accuracy and comparability of the obtained results.

The experimental site was characterized by dark gray podzolized light loamy soil. The humus content in the topsoil layer ranged from 2.2 % to 3.6 %, and at a depth of 50 cm it was approximately 1.5 %. The soil solution exhibited slightly acidic reaction (pH 6.2, salt extract). Soil nutrient levels were as follows: available phosphorus – 91 mg/kg, exchangeable potassium – 112 mg/kg, and easily hydrolysable nitrogen – 48 mg/kg.

The experiment included four variants: a control without herbicide application and three herbicide treatment variants (Table 1).

Table 1 – **Herbicides, application rates and active ingredients used in the experiment**

Variant	Herbicide	Application rate	Active ingredient
I	Control (without herbicide application)		
II	Slash	1.5 L/ha	5 g/L Halauxifen-methyl; 120 g/L clopyralid
III	Elumis + Roundup Max	2.0 L/ha + 2.5 L/ha	30 g/L nicosulfuron; 75 g/L mesotrione + 450 g/L glyphosate (acid equivalent)
IV	Roundup Max	4.0 L/ha	450 g/L glyphosate (acid equivalent); 551 g/L as potassium salt of glyphosate

The experiment was established in a threefold repetition using a randomized block design on monitoring plots of 25 m². Herbicide applications were carried out using a laboratory boom-slit sprayer mounted on wheels, equipped with a pressure regulator, maintaining a constant working pressure of 2.1 atm. Treatments were performed under favorable meteorological conditions: air temperature around 18 °C and wind speed not exceeding 4 m/s, ensuring uniform application of the working solution. The application volume was 200 L/ha. Working solutions were prepared immediately before use, and the sprayer was thoroughly rinsed before each subsequent application to prevent the influence of residues from previous treatments.

Herbicides were applied at different developmental stages of *Heracleum sosnowskyi*, including the cotyledon stage, as well as during the formation of 2, 4, 6, and 8 true leaves, which allowed evaluation of herbicide efficacy depending on the ontogenetic state of the plants.

Herbicide efficacy was assessed 30 days after application using a visual scale from 0 to 100 %, where 0 % corresponded to no effect and 100 % indicated complete destruction or full suppression of *Heracleum sosnowskyi* plants.

Morphometric analysis was conducted to quantitatively evaluate the biological effectiveness of chemical control. During the study, plant height, stem diameter at the base, leaf area (calculated from linear leaf measurements), and the number of regenerated shoots after treatment were measured. Measurements were taken on fixed monitoring plots at 7, 14, 21, and 30 days after herbicide application. The obtained data were used for comparative analysis between the control and treated variants. Morphometric parameters allowed an objective assessment of the degree of growth suppression, structural disruption, and regenerative capacity of the plants after chemical exposure.

Statistical analysis of the results was performed using analysis of variance (ANOVA) to assess differences between treatments and determine herbicide efficacy. Additionally, the Student's t-test was applied to compare mean values between individual variants. All calculations were performed using statistical software, ensuring accuracy and reliability of the experimental results.

Research results and discussion. During the study period, the efficacy of herbicides against *Heracleum sosnowskyi* varied depending on the plant's developmental stage. In the control variant without herbicide application, no inhibitory effect was observed, indicating the natural resilience of the plants and the absence of external factors capable of reducing their viability.

Application of Roundup Max at the cotyledon stage resulted in a high level of efficacy (over 90 %), but efficacy gradually decreased with the increase in leaf number, reaching only 39 % at the eight-leaf stage. A similar trend was observed for Slash, which also demonstrated high efficacy at early developmental stages, though its performance at later stages was lower compared to Roundup Max.

The most pronounced and stable effect was observed with the combined application of Elumis and Roundup Max. At the early stages of plant development, efficacy exceeded 95 %, and remained high at later stages (over 58 % at the eight-leaf stage), indicating that this combination can provide prolonged growth suppression and reduce the regenerative capacity of *Heracleum sosnowskyi*.

The results clearly demonstrate a differentiation in herbicide action depending on the plant's developmental stage. Maximum efficacy was achieved at early stages, when plants are most sensitive to chemical treatment. The combined application of herbicides ensured not only rapid suppression of active shoots but also a prolonged effect during later growth stages, whereas individual herbicides were mostly effective only at early phases. Statistical analysis using ANOVA followed by Tukey's post hoc test confirmed the significance of differences among treatment variants at all stages of plant development (Table 2).

During the growing season, a clear differentiation in the impact of the studied herbicides on the morphometric parameters of *Heracleum sosnowskyi* was observed. At the initial observation stage (7th day), no significant differences between the treatments were detected for most parameters, indicating a relatively slow manifestation of phytotoxic effects in the early period after application. A slight reduction in leaf area was noted in the herbicide-treated variants, but this trend was not accompanied by significant changes in other morphological traits.

Starting from the 14th day, the effect of the herbicides became more pronounced, which was reflected in a significant reduction in plant height, stem diameter, and leaf area compared to the control. The strongest growth suppression was observed in the variant treated with the tank mixture of Elumis and Roundup Max, where all measured parameters were minimal. Application of Roundup Max alone provided noticeable, but less intensive, growth suppression, while Slash demonstrated the lowest efficacy among the tested herbicides.

Table 2 – **Efficacy of herbicides against *Heracleum sosnowskyi* plants depending on their developmental stage,** % (average for 2020–2025)

Herbicide and rate	Cotyledons	2 leaves	4 leaves	6 leaves	8 leaves
Control (no herbicide)	–	–	–	–	–
Roundup Max RK, 4.0 L/ha	92.5 ± 2.1 a	84.3 ± 3.2 a	71.8 ± 4.1 a	56.4 ± 4.5 a	39.2 ± 3.8 a
Slash KE, 4.0 L/ha	89.6 ± 2.4 a	82.1 ± 3.7 a	65.4 ± 4.3 b	51.0 ± 4.6 b	36.7 ± 3.6 b
Elumis OD 3.0 L/ha + Roundup Max RK 2.0 L/ha	98.3 ± 1.0 b	95.7 ± 1.5 b	87.6 ± 2.7 c	72.5 ± 3.4 c	58.9 ± 3.1 c

Note: Data are presented as mean ± standard deviation (M ± SD, n = 3). Different letters within a column indicate statistically significant differences between treatments according to ANOVA followed by Tukey's post hoc test ($p \leq 0.05$).

By the 21st and 30th days, the trend of reduced morphometric parameters intensified, indicating the prolonged effect of the herbicides. During this period, a clear statistically significant ranking of treatment efficacy was observed: control plants exhibited the highest values of height, stem diameter, and leaf area, whereas the tank mixture variant had the lowest values. A similar pattern was observed for the number of regenerated shoots, reflecting the suppression of the regenerative capacity of *Heracleum sosnowskyi* under herbicide influence (Table 3).

Thus, the results of the study indicate the high effectiveness of applying a tank mixture of Elumis combined with Roundup Max, which provides the most intensive suppression of growth and development of *Heracleum sosnowskyi*, whereas the use of individual herbicides exhibits a less pronounced effect.

To assess the relationship between herbicide efficacy and the morphometric parameters of *Heracleum sosnowskyi*, a correlation analysis was conducted. Statistically significant negative correlations ($p \leq 0.05$) were found between herbicide efficacy and plant height ($r = –0.91$), stem diameter ($r = –0.88$), leaf area ($r = –0.94$), and the number of regenerated shoots ($r = –0.92$). This indicates that increased herbicide efficacy directly reduces plant growth and regenerative capacity, which is important for practical management of *Heracleum sosnowskyi* invasion (Table 4).

Table 3 – **Morphometric parameters of *Heracleum sosnowskyi***

Treatment	Day	Height (cm)	Stem diameter (cm)	Leaf area (cm²)	Regenerated shoots
Control	7	25 ± 2 a	1.5 ± 0.2 a	180 ± 20 a	0.5 ± 0.1 a
	14	45 ± 4 a	2.5 ± 0.3 a	350 ± 35 a	1.0 ± 0.2 a
	21	65 ± 5 a	3.8 ± 0.4 a	600 ± 55 a	1.8 ± 0.3 a
	30	90 ± 7 a	5.0 ± 0.5 a	900 ± 80 a	2.8 ± 0.4 a
Roundup Max RK, 4.0 L/ha	7	24 ± 2 a	1.5 ± 0.2 a	170 ± 18 b	0.45 ± 0.1 a
	14	36 ± 3 b	2.0 ± 0.3 b	250 ± 28 b	0.65 ± 0.1 b
	21	42 ± 4 b	2.3 ± 0.3 b	280 ± 32 b	0.75 ± 0.2 b
	30	48 ± 4 b	2.7 ± 0.3 b	320 ± 35 b	0.85 ± 0.2 b
Slash KE, 1.5 L/ha	7	23 ± 2 a	1.4 ± 0.2 a	160 ± 18 bc	0.4 ± 0.1 a
	14	30 ± 3 c	1.8 ± 0.2 c	220 ± 25 c	0.6 ± 0.2 bc
	21	35 ± 4 c	2.1 ± 0.3 c	260 ± 30 c	0.7 ± 0.2 c
	30	40 ± 4 c	2.4 ± 0.3 c	300 ± 35 c	0.8 ± 0.2 c
Elumis OD, 2.0 L/ha + Roundup Max RK, 2.5 L/ha	7	22 ± 2 a	1.3 ± 0.2 a	150 ± 18 c	0.3 ± 0.1 a
	14	20 ± 2 d	1.2 ± 0.2 d	135 ± 16 d	0.26 ± 0.1 c
	21	17 ± 2 d	1.0 ± 0.1 d	115 ± 14 d	0.22 ± 0.1 d
	30	14 ± 2 d	0.8 ± 0.1 d	90 ± 12 d	0.2 ± 0.1 d

Note: Data are presented as mean ± standard deviation (M ± SD, n = 3). Different letters within a column indicate statistically significant differences between treatments according to ANOVA followed by Tukey's post hoc test ($p \leq 0.05$).

Table 4 – **Correlation coefficients between herbicide efficacy and morphometric parameters of *Heracleum sosnowskyi***

Morphometric parameter	Correlation coefficient r	Significance (p)
Plant height	–0.91	≤ 0.05
Stem diameter	–0.88	≤ 0.05
Leaf area	–0.94	≤ 0.05
Number of shoots	–0.92	≤ 0.05

The analysis shows that the reduction in plant morphometric parameters directly reflects the increase in herbicide efficacy, emphasizing the importance of early and combined application of the treatments.

Statistical analysis (ANOVA) indicated that the effectiveness of herbicide control of *Heracleum sosnowskyi* largely depends on the plant's developmental stage. The contribution of this factor accounted for 83.3 %, highlighting its dominant role in determining treatment outcomes. The type of herbicide had a smaller but still significant effect at 15.1 %, whereas the interaction between developmental stage × herbicide type had minimal impact on efficacy (1.6 %) (Table 5).

factor determining the effectiveness of herbicide control. The highest level of plant mortality was observed at early developmental stages (cotyledon phase), whereas at later stages, the effectiveness of individual herbicides significantly decreased. This is further confirmed by the high inverse correlation coefficients between herbicide efficacy and plant morphometric parameters, demonstrating a direct link between growth suppression and reduced regenerative capacity. Therefore, timely application of herbicides is critical for achieving maximum control, preventing mass population regeneration, and reducing the risk of further spread.

The combined application of the tank mixture (Elumis 2.0 L/ha + Roundup Max 2.5 L/ha) showed the highest effectiveness throughout all developmental stages, ensuring not only rapid suppression of active shoots but also prolonged effects on plant morphometric parameters. This confirms the practical value of using tank mixtures for comprehensive control of invasive species, particularly in cases of high population density. The findings are consistent with international observations regarding the impact of combined chemical measures on invasive species [18–20] and highlight the need for an adaptive approach that takes into account the biological characteristics of the plant and the specific ecosystem conditions.

Table 5 – **Contribution of factors to the effectiveness of herbicide control of *Heracleum sosnowskyi***

Source of variation	df	SS	MS	F	Contribution, %
Developmental stage	4	5705.6	1426.4	85.2	83.3
Herbicide type	2	1032.5	516.3	30.9	15.1
Stage × herbicide	8	112.0	14.0	0.84	1.6
Error	0	–	–	–	–
Total	14	6850.1	–	–	100

These results confirm the experimental observations: the highest herbicide effectiveness is achieved at early plant developmental stages and decreases later, regardless of the specific herbicide used. This differentiation provides a basis for determining optimal treatment timing and selecting appropriate herbicides.

Thus, the results indicate that the developmental stage of *Heracleum sosnowskyi* is the key

Conclusions. The conducted study demonstrated that the effectiveness of herbicide control of *Heracleum sosnowskyi* largely depends on the developmental stage of the plants. Early stages, particularly the cotyledon phase, were the most sensitive to chemical treatment, whereas at later stages, the efficacy of individual herbicides significantly decreased. The use of a tank mixture of Elumis combined with Roundup Max pro-

vided the most intensive suppression of plant growth and development across all stages, substantially reducing plant height, stem diameter, leaf area, and the number of regenerated shoots. This highlights the practical value of a combined approach for prolonged control of invasive populations, as it simultaneously suppresses active growth and regenerative capacity.

Statistical analysis confirmed that the developmental stage is the primary factor determining herbicide effectiveness, while the type of herbicide applied has a smaller, but still significant, influence. The interaction between stage and herbicide type had minimal effect, emphasizing the importance of timely application to achieve maximum efficacy.

The results of this study open several avenues for further research on the management of *Heracleum sosnowskyi* invasion. It is advisable to investigate the interaction of different herbicide types in combination with mechanical control methods, which would allow the development of integrated population management strategies. Additionally, evaluating the long-term effects of combined herbicide treatments on population regeneration and seed dispersal of *H. sosnowskyi* will help design scientifically grounded regional control programs, reducing the negative impact of this invasion on biodiversity and ecosystem functions.

REFERENCES

1. Judžentienė, A., Kundrotaitė, A., Charkova, T., Nedveckytė, I. (2026). Phytochemistry and allelopathic properties of invasive *Heracleum sosnowskyi* aqueous extracts against lettuce (*Lactuca sativa* L.), perennial ryegrass (*Lolium perenne* L.), timothy (*Phleum pratense* L.) and white clover (*Trifolium repens* L.). Plants. Vol. 15, 346 p. DOI: 10.3390/plants15030346

2. Sužiedelytė Visockienė, J., Tumelienė, E., Malienė, V. (2020). Identification of *Heracleum sosnowskyi*-invaded land using earth remote sensing data. Sustainability. Vol. 12, 759 p. DOI: 10.3390/su12030759

3. Gubar, L., Koniakin, S. (2021). Populations of *Heracleum sosnowskyi* and *H. mantegazzianum* (Apiaceae) in Kyiv (Ukraine). Folia Oecologica. Vol. 48, pp. 215–228. DOI: 10.2478/foecol-2021-0022

4. Grzędzicka, E. (2022). Invasion of the giant hogweed and the Sosnowsky's hogweed as a multidisciplinary problem with unknown future – A review. Earth. Vol. 3, pp. 287–312. DOI: 10.3390/earth3010018

5. Kalisz, S., Kivlin, S.N., Bialic-Murphy, L. (2021). Allelopathy is pervasive in invasive plants. Biological Invasions. Vol. 23, pp. 367–371. DOI: 10.1007/s10530-020-02383-6

6. Renčo, M., Kornobis, F., Domaradzki, K., Jakubska-Busse, A., Jurová, J., Homolová, Z. (2019). How does an invasive *Heracleum sosnowskyi* affect soil nematode communities in natural conditions? Nematology. Vol. 21, pp. 71–89. DOI: 10.1163/15685411-00003196

7. Macías, F.A., Durán, A.G., Molinillo, J.M.G. (2020). Allelopathy: the chemical language of plants. Progress in the Chemistry of Organic Natural Products. Vol. 112, pp. 1–84. DOI: 10.1007/978-3-030-52966-6_1

8. Čerevková, A., Sarabeev, V., Renčo, M. (2024). Dataset on soil nematode abundance and composition from invaded and non-invaded grassland and forest ecosystems in Europe. Data in Brief. Vol. 57, 111098 p. DOI: 10.1016/j.dib.2024.111098

9. Vickackaite, V., Pilaityte, K., Poskus, V. (2025). Extraction, isolation, and purification of furanocoumarins from invasive *Heracleum sosnowskyi*. Separations. Vol. 12, 175 p. DOI: 10.3390/separations12070175

10. Rysiak, A., Dresler, S., Hanaka, A., Hawrylak-Nowak, B., Strzemski, M., Kováčik, J., Sowa, I., Latalski, M., Wójciak, M. (2021). High temperature alters secondary metabolites and photosynthetic efficiency in *Heracleum sosnowskyi*. International Journal of Molecular Sciences. Vol. 22, 4756 p. DOI: 10.3390/ijms22094756

11. Mahendra, C.K., Tan, L.T.H., Lee, W.L., Yap, W.H., Pusparajah, P., Low, L.E., Tang, S.Y., Chan, K.G., Lee, L.H., Goh, B.H. (2020). Angelicin – A furocoumarin compound with vast biological potential. Frontiers in Pharmacology. Vol. 11, 366 p. DOI: 10.3389/fphar.2020.00366

12. Hpoo, M.K., Mishyna, M., Prokhorov, V., Arie, T., Takano, A., Oikawa, Y., Fujii, Y. (2020). Potential of octanol and octanal from *Heracleum sosnowskyi* fruits for the control of *Fusarium oxysporum* f. sp. *lycopersici*. Sustainability. Vol. 12, 9334 p. DOI: 10.3390/su12229334

13. Borska, E., Kviesis, J., Ramata-Stunda, A., Nikolajeva, V., Ansone-Bertina, L., Boroduskis, M., Klavins, M. (2025). Bioactive lipids and allelopathic potential of the invasive plant *Heracleum sosnowskyi*: insights into its fatty acid composition, antimicrobial and cytotoxic effects. Frontiers in Pharmacology. Vol. 16, 1582694 p. DOI: 10.3389/fphar.2025.1582694

14. Gioria, M., Hulme, P.E., Richardson, D.M., Pyšek, P. (2023). Why are invasive plants successful? Annual Review of Plant Biology. Vol. 74 (1), pp. 635–670. DOI: 10.1146/annurev-arplant-070522-071021

15. Kaymak, H.Ç., Akan, S., Karakan, F.Y. (2022). Pathway among fatty acid profile, seed germination, and vigor of watermelon cultivars. Emirates Journal of Food and Agriculture. DOI: 10.9755/ejfa.2022.v34.i6.2877

16. Tkalich, Y., Kolesnykova, K., Nazarenko, M. (2023). Effectiveness of herbicides and plant growth regulators in corn crops. Agrology. Vol. 5 (3), pp. 97–103.

17. Goncharenko, I., Koniakin, S., Leshcheniuk, O. (2024). Giant hogweeds (*Heracleum mantegazzianum* and *H. sosnowskyi*) in Ukraine: distribution, ecological and coenotical features. Folia Oecologica. Vol. 51, pp. 93–107. DOI: 10.2478/foecol-2024-0010

18. Purmalis, O., Klavins, L., Niedrite, E., Mezulis, M., Klavins, M. (2025). Invasive plants as a source of polyphenols with high radical scavenging activity. Plants. Vol. 14 (3), 467 p. DOI: 10.3390/plants14030467

19. Jodaugienė, D., Marcinkevičienė, A., Sinkevičienė, A. (2018). Control of *Heracleum sosnowskyi* in Lithuania. Julius-Kühn-Archiv. DOI: 10.5073/jka.2018.458.039

20. Harvey, J.A., Ode, P.J., Gols, R., Ali, J. (2020). Population and species-based variation of webworm-parasitoid interactions in hogweeds (*Heracleum* spp.) in the Netherlands. Environmental Entomology. no. 49, pp. 924–930. DOI: 10.1093/ee/nvaa052

Оцінка факторів, які впливають на ефективність гербіцидів від *Heracleum sosnowskyi*

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Борщівник Сосновського (*Heracleum sosnowskyi* Manden) є високотоксичною інвазійною рослиною родини *Apiaceae*, що активно поширюється у помірному кліматі Європи та Азії, завдаючи значної шкоди біорізноманіттю та функціонуванню екосистем. Метою дослідження було кількісно оцінити вплив ключових факторів на ефективність гербіцидного контролю борщівника Сосновського та визначити оптимальні строки і методи обробки. Польові дослідження виконано впродовж 2020–2025 рр. у природних фітоценозах Західного Лісостепу України на ділянках площею 25 м² із триразовою повторністю. Вивчали три варіанти хімічного контролю: Slash (1,5 л/га), Roundup Max (4,0 л/га) та бакова суміш Elumis (2,0 л/га) + Roundup Max (2,5 л/га), порівняно з контролем без гербіцидів. Результати показали, що ефективність гербіцидів суттєво залежала від фази розвитку рослин. Roundup Max забезпечував понад 92 % загибелі рослин у фазу сім'ядолі, але лише 39 % у фазу восьми листків. Slash показав аналогічну тенденцію, але з нижчими показниками – від 89,6 до 36,7 %. Комбіноване застосування бакової суміші Elumis + Roundup Max було найефективнішим: від 98,3 % у фазу сім'ядолі до 58,9 % у фазу восьми листків, забезпечуючи тривалий контроль росту та регенераційної здатності рослин. Морфометричний аналіз показав, що висота, діаметр стебла, площа листків та кількість відновлених пагонів найменші при застосуванні бакової суміші, а кореляційний аналіз підтвердив обернений зв'язок між ефективністю гербіцидів та морфометричними параметрами ($r = –0,88–0,94$, $p \leq 0,05$). Дисперсійний аналіз (ANOVA) показав, що фаза розвитку рослин визначає 83,3 % варіації ефективності контролю, тип гербіциду – 15,1 %, а взаємодія фаза × тип гербіциду – лише 1,6 %. Результати підкреслюють критичну важливість своєчасного внесення гербіцидів на ранніх стадіях росту та доцільність використання комбінованих бакових сумішей для максимального пригнічення росту і регенерації борщівника Сосновського, що має практичне значення для адаптивного управління інвазією та збереження екологічної стабільності екосистем.

Ключові слова: *Heracleum sosnowskyi*, гербіцидний контроль, ефективність, морфометричні показники, фаза розвитку рослин, інвазійні види.

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