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Chemical control of Sosnowsky's hogweed (*Heracleum sosnowskyi* Manden.) in Ukraine

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Abstract

Sosnowsky's hogweed (*Heracleum sosnowskyi* Manden.) is known as an invasive, ineligible, harmful to human health, and hardly controlled plant. The purpose of this study was to evaluate the efficiency of chemical control when different herbicides were applied at various development stages of *H. sosnowskyi* plants. The experiment was carried out in Ukraine over the period of 2013–2020. Two field experiments on the first-year and second-year *H. sosnowskyi* plants were conducted. All the selected herbicides were applied at the rates registered in Ukraine. The first-year plants of *H. sosnowskyi* were the most sensitive to the herbicides at the cotyledon stage – the efficacy of herbicides ranged from 97.3% to 100%. Postponing the herbicide application up to a six-leaf stage, the efficacy ranged from 43.2% to 60.7%. The most effective were the following herbicides: Task Extra 66.5 WG (rimsulfuron 23 g kg^{-1}, nicosulfuron 92 g kg^{-1}, dicamba 550 g kg^{-1}) + Trend 90 at application rates of 385 g ha^{-1} + 0.2 L ha^{-1} and MaisTer Power OD (foramsulfuron 31.5 g L^{-1} + iodosulfuron 1.0 g L^{-1} + thiencarbazone-methyl 10 g L^{-1} + cyprosulfamide (antidote) 15 g L^{-1}) at an application rate of 1.5 L ha^{-1}. The second-year plants of *H. sosnowskyi* were effectively controlled by the following herbicides: Elumis 105 OD (mesotrione 75 g L^{-1}, nicosulfuron 30 g L^{-1}) at an application rate of 2.0 L ha^{-1} and the tank composition Elumis 105 OD + Roundup Max (glyphosate potassium salt 551 g L^{-1}) at application rates of 2.0 + 6.0 L ha^{-1}.

The results of the experiment clearly showed that the sensitivity of *H. sosnowskyi* plants to herbicides decreased with increasing the stages of plant development of the first-year of *H. sosnowskyi*. The results suggest that the combination of mesotrione, nicosulfuron, and glyphosate might be a suitable solution for the chemical control of second-year plants of Sosnowsky's hogweed.

Keywords: invasive alien species, Apiaceae, Sosnowsky's hogweed, chemical weed control, herbicides.

Introduction

Sosnowsky's hogweed (*Heracleum sosnowskyi* Manden.) is a biennial or perennial plant. Its height is usually 100–300 cm (Stojanović et al., 2017). Hogweed occupies a specific place among weeds in crops and the environment (Baležentienė et al., 2013; Dalke et al., 2015; 2018; Čerevková et al., 2020). Sosnowsky's hogweed, which was introduced and established as a promising crop for a forage, became an aggressive invasive adventitious object that poses a danger to both natural phytocenoses and humans (Grzedzicka, 2022). The most important features of *H. sosnowskyi* plants for monostand formation in invaded areas are the early commencement of growth, the rapid formation of a dense canopy, the high efficiency of light and water use during photosynthesis, the ability of young plants to survive in low light conditions, the rapid recovery of above-ground plant parts after damage, and the high density of the soil seed bank. *H. sosnowskyi* plants begin to germinate from both seeds and underground shoot buds immediately after snowmelt as early as spring ephemeral plant species do. The plants form 100% monostand cover earlier than most of the other plants (Dalke et al., 2015).

There are 69 species of *Heracleum* L. worldwide, mainly in the temperate zone of Eurasia (Pyšek et al., 2007; Gubar, Koniakin, 2021; Grzedzicka, 2022). There are over 20 species of plants of the genus *Heracleum* known in Europe. In Europe, invasive alien species are three species of this genus, the so-called giant hogweeds, i.e., *H. sosnowskyi* (Manden.), *H. mantegazzianum* (Sommier & Levier), and *H. persicum* (Desf. ex Fischer),

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from the Central and Eastern Caucasus, Trans-Caucasus, and Turkey (Sužiedelytė Visockienė et al., 2020). In the European Union, giant hogweeds are included in the List of Invasive Alien Species of Union Concern (EU, 2017), which obliges the EU countries to limit their spread or eliminate them.

H. sosnowskyi was introduced to Middle and Eastern Europe during the 1950s as a pasture plant for cattle, reflecting the high biomass production and good nutritional value of this plant (Jahodová et al., 2007). The active distribution of giant hogweed as an invasive alien species began around the mid-1980s and occurred almost simultaneously in different parts of Ukraine as well as in Russia and the Baltic countries (Pyšek et al., 2007; Mežaka et al., 2016; Gudžinskas, Žalneravičius, 2018). *H. sosnowskyi*, as an invasive alien species, is also present in Germany, Hungary, Denmark, and Poland (Jahodová et al., 2007; Gołos, 2018).

H. sosnowskyi plants are hardly controlled because of their high seed productivity and biological peculiarities, the potential danger posed by the plants themselves (Chernyak, 2018). Plants of *H. sosnowskyi* produce furanocoumarins, which cause severe injuries to human and animal skin (Jakubowicz et al., 2012; Klimaszyk et al., 2014). Therefore, one of the most common methods is chemical control (Jodaugienė et al., 2018; Postnikov et al., 2021; Grzedzicka, 2022). The optimal stages of spraying are from the beginning of regrowth in spring to the beginning of flowering; spraying with herbicides at later stages is less effective (Klima, Synowiec, 2016).

According to the studies in Ukraine and Lithuania (Vykhor, Prots, 2015; Jodaugienė et al., 2018), the fastest results can be obtained using the active substance glyphosate (N-(phosphonomethyl)-glycine, $C_3H_8NO_5P$) in the form of ammonium, isopropylamine, and potassium salt. However, the regrowth of plants is usually quite high and requires more applications. Therefore, to avoid the resistance of weeds, it is important to choose herbicides of different chemical groups (Peterson et al., 2018; Auškalnienė et al., 2020).

In Ukraine, chemical methods of controlling *H. sosnowskyi* plants are insufficiently studied. According to the latest data (Vykhor, Prots, 2015), to control *H. sosnowskyi* plants, for spraying weed plants of 30–50 cm in height (late April – first half of May), Roundup at an application rate of 6.0 L ha^{-1} or its analogues at an application rate of 6–8 L ha^{-1} can be used. At the same time, the available method is successive double mowing of plants during the flowering of the main (central) inflorescence and after weed regeneration.

The purpose of the experiment was to study the chemical control for both first-year and second-year plants of *H. sosnowskyi* in the conditions of Ukraine.

Material and methods

The investigations were carried out in 2013–2020 in the Bila Tserkva Research and Breeding Station located in the Central Forest-Steppe of Ukraine. The field experiments were established in the typical coarse leached medium-loam chernozem (WRB, 2015) with a depth of humus horizon from 100 to 120 cm. The humus content in the arable (0–30 cm) layer was 3.9%.

During the years of the experiment, weather conditions showed some deviations from the average long-term indicators, but in general, it was favourable for the growth and development of most species of crops and weeds including Sosnowsky's hogweed (*Heracleum sosnowskyi* Manden.). During the year, rainfall distribution was not even: mostly in the warm season, especially in mid-summer (July). In some years, the summer was dry, which negatively affected the growth and development of plants. The sum of active temperatures (the sum of temperatures above 10°C for the growing season) varied from 2500°C to 2800°C, and the amount of precipitation per year was 521 mm.

Chemical control of H. sosnowskyi. Two experiments of chemical control were carried out against the first-year (in 2015–2020) and the second-year (in 2013–2015) plants of *H. sosnowskyi*. The experiment was carried out in four replications at the randomised complete block design. The size of each assessed plot was 25 m². Herbicides were applied with a special laboratory slit-type gas sprayer on wheels with a reducer, a rod, at a constant working pressure of 2.1 atm. The amount of water was 200 L ha^{-1}. The herbicides were applied at about 18°C air temperature when the wind speed was below 4 m s^{-1}. The tank mix of the selected herbicides was prepared immediately before the application. All the tested herbicides were applied at registered rates. The sprayer was truly washed with water before each treatment.

Experimental design of the first-year H. sosnowskyi: 1) control plot without the use of herbicides; 2) Betanal Max Pro 209 OD (phenmedipham 60 g L^{-1} + desmedipham 47 g L^{-1} + ethofumesate 75 g L^{-1} + lenacil (activator) 27 g L^{-1}) (Bayer CS) at a rate of 1.0 L ha^{-1}; 3) Gesagard 500 FW (prometryn 500 g L^{-1}) (Syngenta) at a rate of 3.0 L ha^{-1}; 4) Granstar Gold 75 WG (tribenuron-methyl 562.5 g kg^{-1}, thifensulfuron-methyl 187.5 g kg^{-1}) (FMC) at a rate of 35 g ha^{-1}; 5) Esteron 600 EC (905 g L^{-1} of 2-ethylhexyl ether; 2,4-dichlorophenoxyacetic acid, in acid equivalent 600 g L^{-1}) (Corteva) at a rate of 0.8 L ha^{-1}; 6) Task Extra 66.5 WG (rimsulfuron 23 g kg^{-1}, nicosulfuron 92 g kg^{-1}, dicamba 550 g kg^{-1}) (FMC) + Trend 90 at a rate of 385 g ha^{-1} + 0.2 L ha^{-1}; 7) MaisTer Power OD (foramsulfuron 31.5 g L^{-1} + iodosulfuron 1.0 g L^{-1} + thiencarbazone-methyl, 10 g L^{-1} + cyprosulfamide (antidote) 15 g L^{-1}) (Bayer SC) at a rate of 1.5 L ha^{-1}. The herbicides were applied at the following development stages of *H. sosnowskyi*: cotyledon, two-leaf, four-leaf, six-leaf, and eight-leaf ones.

Experimental design of the second-year H. sosnowskyi: 1) control plot without the use of herbicides; 2) Roundup Max (glyphosate potassium salt 551 g L^{-1}) (Monsanto SC) at a rate of 6.0 L ha^{-1}; 3) Banvel 4S 480 SL (dicamba 480 g L^{-1}) (Syngenta) at a rate of 0.8 L ha^{-1}; 4) Elumis 105 OD (mesotrione 75 g L^{-1}, nicosulfuron 30 g L^{-1}) (Syngenta) at a rate of 2.0 L ha^{-1}; 5) Banvel 4S 480 SL at a rate of 0.8 L ha^{-1} + Roundup Max at a rate of 6.0 L ha^{-1}; 6) Elumis 105 OD at a rate of 2.0 L ha^{-1} + Roundup Max at a rate of 6.0 L ha^{-1}. The herbicides were applied in spring after the beginning of the regrowth of second-year plants at the formation of three true leaves stage.

The evaluations of the efficiency of various herbicide tank combinations against *H. sosnowskyi* plants were carried out 30 days after each application for the first-year plant and 60 days after the application for the second-year plants according to the experimental design.

Statistical analysis. Averages were calculated for each plot and used in the calculation of mean. The average data were used as input in the general linear model for testing treatment effects. The assessment data were processed by analysis of variation (ANOVA) with Fisher's least significant difference (LSD) test. The treatment effects were considered significant at $P < 0.05$. Statistical analysis was performed using the software SAS, version 7.1 (SAS Institute Inc., USA).

Results and discussion

To obtain an effective control method of *H. sosnowskyi*, several studies were performed: plant shading, mechanical cutting, digging, and thermal (Ivashchenko et al., 2022), as well as chemical control and others (Klima, Synowiec, 2016; Jodaugienė et al., 2018; Grzedzicka, 2022). Non-chemical control methods are very important, especially in places where herbicide use is not allowed, but they are time-consuming and require more human and other resources. Also, such methods might be dangerous due to a close human contact with *H. sosnowskyi* plants. Chemical control of *H. sosnowskyi* is much faster and simpler and it can be repeated several times with rather low inputs. Chemical control has been recommended as the most efficient method (EPPO, 2009). As an effective herbicide for *H. mantegazzianum* control, many authors have indicated glyphosate (Caffrey, Madsen, 2001; Nielsen et al., 2005). However, some studies have also demonstrated poor control of *H. sosnowskyi* treated with this herbicide alone (Hairullina, Pavlyuchenkova, 2012; Jodaugienė et al., 2018). Against this weed, herbicide mixtures are more effective (Klima, Synowiec, 2016).

Efficacy of herbicides on the first-year H. sosnowskyi. The results of the experiment on the first-year *H. sosnowskyi* plants showed that Task Extra 66.5 WG (385 g ha^{-1}) and MaisTer Power OD (1.5 L ha^{-1}) can effectively control the plants in the cotyledon and at two-leaf stages, when the efficacy reached 100% and 99.7%, and 99.4%, respectively, as well as Betanal Max Pro 209 OD (1.0 L ha^{-1}) at the cotyledon stage, when the efficacy was 97.3%; *H. sosnowskyi* to other herbicides was less sensitive (Table). At the later development stages (four-, six-, and eight-leaf stages) of *H. sosnowskyi* plants, the efficacy of herbicides significantly decreased.

Table. Efficiency of herbicides (%) against the first-year *Heracleum sosnowskyi* plants applied at different development stages (2015–2020)

Herbicide and application rate	Development stage at herbicide application				
	cotyledon	two-leaf	four-leaf	six-leaf	eight-leaf
Control (without herbicides)	–	–	–	–	–
Betanal Max Pro 209 OD 1.0 L ha^{-1}	97.3 a ± 2.6	85.4 b ± 4.4	62.1 b ± 4.8	43.2 b ± 4.5	23.3 b ± 3.9
Gesagard 500 FW 3.0 L ha^{-1}	80.1 b ± 2.9	73.2 d ± 8.5	61.1 b ± 4.9	38.4 b ± 5.4	21.4 b ± 4.1
Granstar Gold 75 WG 35 g ha^{-1}	87.3 b ± 3.6	79.4 c ± 4.5	61.3 b ± 4.7	39.7 b ± 4.3	22.6 b ± 3.9
Esteron 600 EC 0.8 L ha^{-1}	87.2 b ± 3.3	77.9 cd ± 5.0	62.2 b ± 4.9	40.1 b ± 4.6	24.5 b ± 3.3
Task Extra 66.5 WG + Trend 90 385 g ha^{-1} + 0.2 L ha^{-1}	100 a ± 0.0	99.7 a ± 0.3	85.7 a ± 5.0	63.2 a ± 4.4	38.7 a ± 3.5
MaisTer Power OD 1.5 kg ha^{-1}	100 a ± 0.1	99.4 a ± 0.7	84.2 a ± 4.8	60.7 a ± 4.6	43.2 a ± 4.0
LSD_{05}	5.42	5.62	8.58	6.74	6.17

Note. Different letters indicate significant differences between the treatments ($P \leq 0.05$); data in the columns are the mean ± standard deviation between years.

In the process of their ontogenesis, *H. sosnowskyi* plants change the level of sensitivity to any damage (Ivashchenko et al., 2022) as well as to herbicides. The results of the experiment also showed that postponing of the application timing of herbicides negatively correlated with the sensitivity of *H. sosnowskyi* (Figure 1). The higher the development stage of *H. sosnowskyi*, the less the sensitivity of the plants.

According to the results of one of the prerequisites, a successful control of *H. sosnowskyi* seedlings by treated herbicides is timely spraying plants during the cotyledon and two-leaf stages. This confirms and complements the research of Klima and Synoviec (2016), who found that the majority of seedlings emerged in the spring of the first year. However, the longevity of *H. sosnowskyi* seeds is approximately five years. Emerged seedlings of *H. sosnowskyi* plants could be successfully

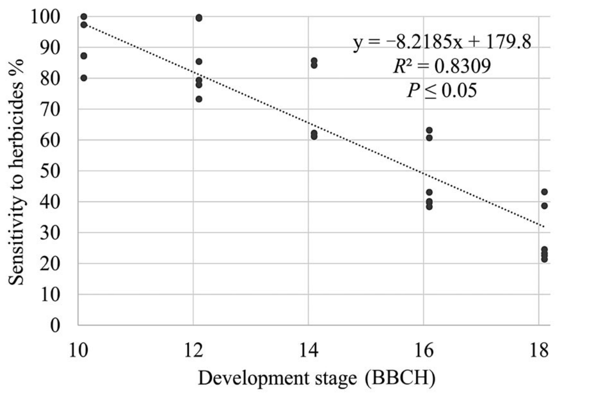
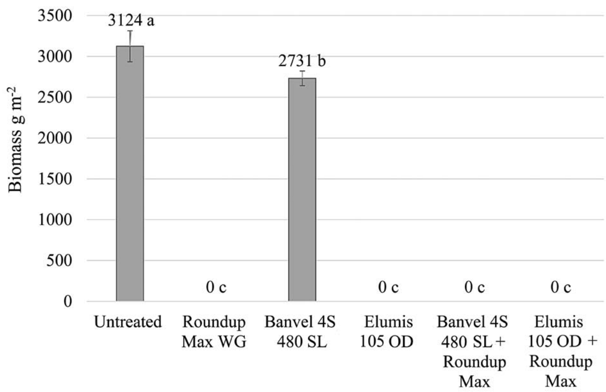


Figure 1. Sensitivity (herbicide efficacy %) of the first-year *Heracleum sosnowskyi* plants to herbicides applied at different development stages

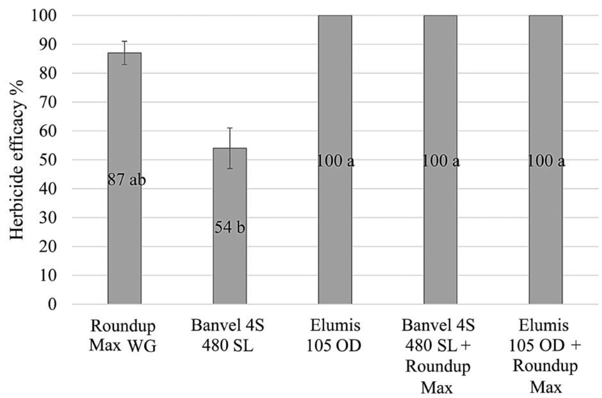
controlled by herbicides Task Extra 66.5 WG as well as by MaisTer Power OD. It could be mentioned that the time of application should be at early growth stages of *H. sosnowskyi* – from cotyledon to two-leaf stages of weed. Later application of herbicides significantly decreased their efficacy.

Efficacy of herbicides on the second-year H. sosnowskyi. The reproductive abilities of *H. sosnowskyi* are extremely high (Perglová et al., 2006; Chernyak, 2018; Gudžinskas, Žalneravičius, 2018); therefore, it is very important not only to control the seedlings, but also to stop seed propagating by controlling the second-year plants. The results of the experiment on the second-year plants of *H. sosnowskyi* are given in Figures 2 and 3.



Note. Different letters indicate significant differences between the treatments ($P \leq 0.05$); the bars on the columns indicate the standard error.

Figure 2. Biomass of the second-year *Heracleum sosnowskyi* plants 30 days after application of different herbicides (2013–2015)



Note. Different letters indicate significant differences between the treatments ($P \leq 0.05$); the bars on the columns indicate the standard error.

Figure 3. Efficiency of different herbicides on the second-year *Heracleum sosnowskyi* plants 60 days after application (2013–2015)

In the untreated plots, 30 days after the application of second-year plants, *H. sosnowskyi* successfully passed the stages of their ontogenesis and began flowering. In the treatment with Roundup Max (6.0 L ha^{-1}), the above-ground part of the plants completely died off (Figure 2), but a part of the plants continued their vegetation and formed the above-ground mass; therefore, in 60 days after the application, the efficacy of herbicide was incomplete – 87% (Figure 3). Similar results of the efficacy of glyphosate on *H. sosnowskyi* were also obtained by Jodaugienė et al. (2018) when 4–6 weeks after the application *H. sosnowskyi* started to regrow. After 30 days of application of Banvel 4S 480 SL (0.8 L ha^{-1}), *H. sosnowskyi* plants looked suppressed and the leaves were twisted, but the aboveground parts of the plants were alive and continued to grow; after 60 days of application, the efficacy of herbicide was only 54%. In the plots treated with the herbicide Elumis 105 OD (2.0 L ha^{-1}), the complete extinction of weed plants was observed 30 and 60 days after the application (herbicide efficacy 100%). Similar results were obtained by using tank mixes of herbicides. In the treatment with the tank mix of Banvel 4S 480 SL + Roundup Max (0.8 + 6.0 L ha^{-1}), *H. sosnowskyi* plants did not grow and the extinction was complete (herbicide efficacy 100%). After the use of Elumis 105 OD + Roundup Max (2.0 + 6.0 L ha^{-1}), both aboveground and belowground parts died off and the efficacy reached 100%. Such tank compositions of herbicides for controlling the second-year plants of *H. sosnowskyi* can also be used on arable land after harvesting cultivated crops.

It could be said that chemical control could be effective against *H. sosnowskyi*. The results of our experiment slightly differ from those of Klima and Synoviec (2016), who found that continuous (5 years long) herbicide spraying three times during the vegetative season could perform a high control efficacy of *H. sosnowskyi*. In our experiment, the herbicide Elumis 105 OD and Elumis 105 OD with Roundup Max one time during the growing season performed a sufficient control of *H. sosnowskyi*.

Conclusions

1. The sensitivity of weed plants to herbicides decreased with increasing stages of plant development. *Heracleum sosnowskyi* plants were most sensitive at the cotyledon stage: the level of efficiency varied from 97.3% to 100%. By the six-leaf stage, the sensitivity of weed seedlings decreased from 43.2% to 60.7%.

2. The highest level of efficiency on the first-year *H. sosnowskyi* was recorded for Task Extra 66.5 WG (rimsulfuron 23 g kg^{-1}, nicosulfuron 92 g kg^{-1}, dicamba 550 g kg^{-1}) + Trend 90 at application rates of 385 g ha^{-1} + 0.2 L ha^{-1} and MaisTer Power OD (foramsulfuron 31.5 g L^{-1} + iodosulfuron 1.0 g L^{-1} + thiencarbazone-methyl 10 g L^{-1} + cyprosulfamide 15 g L^{-1}) at an application rate of 1.5 L ha^{-1}.

3. Studies of the herbicide efficiency on the second-year plants of *H. sosnowskyi* showed that the most powerful were the effect of herbicide Elumis 105 OD (mesotrione 75 g L^{-1}, nicosulfuron 30 g L^{-1}) at an application rate of 2.0 L ha^{-1} and Elumis 105 OD + Roundup Max (glyphosate potassium salt 551 g L^{-1}) at application rates of 2.0 + 6.0 L ha^{-1}.

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References

Auškalnienė O., Kadžienė G., Stefanovičienė R., Jomantaitė B. 2020. Development of herbicides resistance in *Apera spica-venti* in Lithuania. Zemdirbyste-Agriculture, 107 (2): 99–104. https://doi.org/10.13080/z-a.2020.107.013

Baležentienė L., Stankevičienė A., Snieškienė V. 2013. *Heracleum sosnowskyi* (Apiaceae) seed productivity and establishment in different habitats of central Lithuania. Ekologija, 59 (3): 123–133. https://doi.org/10.6001/ekologija.v59i3.2795

Caffrey J. M., Madsen J. D. 2001. The management of giant hogweed in an Irish river catchment. Journal of Aquatic Plant Management, 39: 28–33.

Čerevková A., Ivashchenko K., Miklisová D., Ananyeva N., Renčo M. 2020. Influence of invasion by Sosnowsky's hogweed on nematode communities and microbial activity in forest and grassland ecosystems. Global Ecology and Conservation, 21: e00851. https://doi.org/10.1016/j.gecco.2019.e00851

Chernyak D. M. 2018. Study of seed productivity of *Heracleum sosnowskyi* Manden. in the conditions of the south of the Primorsky Krai. Biology, 8 (74): 92–95 (in Russian). https://doi.org/10.23670/irj.2018.74.8.019

Dalke I. V., Chadin I. F., Zakhozhiy I. G., Malyshev R. V., Maslova S. P., Tabalenkova G. N., Golovko T. K. 2015. Traits of *Heracleum sosnowskyi* plants in monostand on invaded area. PLoS ONE, 10 (11): e0142833. https://doi.org/10.1371/journal.pone.0142833

Dalke I. V., Chadin I. F., Zakhozhiy I. G. 2018. Control of Sosnowskyi's hogweed (*Heracleum sosnowskyi* Manden.) invasion on the territory of the Russian Federation. Russian Journal of Biological Invasions, 9 (4): 331–344. https://doi.org/10.1134/S2075111718040045

EPPO. 2009. *Heracleum mantegazzianum*, *Heracleum sosnowskyi* and *Heracleum persicum*. EPPO Bulletin, 39 (3): 489–499. https://doi.org/10.1111/j.1365-2338.2009.02313.x

EU. 2017. Commission Implementing Regulation (EU) 2017/1263 of 12 July 2017 updating the list of invasive alien species of Union concern established by implementing Regulation (EU) 2016/1141 pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council. http://data.europa.eu/eli/reg_impl/2017/1263/oj

Gołos J. 2018. Barszcz Sosnowskiego (*Heracleum sosnowskyi* Manden.) is a threat to the ecosystem. Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series Economical Sciences, 20 (86): 175–181 (in Polish). https://doi.org/10.15421/nvlvet8633

Grzedzicka E. 2022. Invasion of the giant hogweed and the Sosnowsky's hogweed as a multidisciplinary problem with unknown future – A review. Earth, 3 (1): 287–312. https://doi.org/10.3390/earth3010018

Gubar L., Koniakin S. 2021. Populations of *Heracleum sosnowskyi* and *H. mantegazzianum* (Apiaceae) in Kyiv (Ukraine). Folia Oecologica, 48 (2): 215–228. https://doi.org/10.2478/foecol-2021-0022

Gudžinskas Z., Žalneravičius E. 2018. Seedling dynamics and population structure of invasive *Heracleum sosnowskyi* (Apiaceae) in Lithuania. Annales Botanici Fennici, 55: 309–320. https://doi.org/10.5735/085.055.0412

Hairullina V. I., Pavlyuchenkova L. N. 2012. Perfection of technology of application of herbicides against cow parsnip Sosnovsky (*Heracleum sosnovskyi* Manden). Proceedings of the 2nd international conference Innovations and Technologies in Forestry. Saint-Petersburg Forestry Research Institute, Russia, p. 23–27 (in Russian). https://www.spb-niilh.ru/pdf/innovations/innovations_2012_2.pdf

Ivashchenko O., Makukh Y., Remeniuk S., Moshkivska S., Riznyk V., Auškalnienė O., Kadžienė G. 2022. Non-chemical control methods of Sosnowsky's hogweed (*Heracleum sosnovskyi* Manden.). Zemdirbyste-Agriculture, 109 (3): 269–276. https://doi.org/10.13080/z-a.2022.109.034

Jahodová Š., Trybush S., Pyšek P., Wade M., Karp A. 2007. Invasive species of *Heracleum* in Europe: An insight into genetic relationships and invasion history. Diversity and Distributions, 13 (1): 99–114. https://doi.org/10.1111/j.1366-9516.2006.00305.x

Jakubowicz O., Żaba C., Nowak G., Jarmuda S., Żaba R., Marcinkowski J. T. 2012. *Heracleum sosnowskyi* Manden. Annals of Agricultural and Environmental Medicine, 19 (2): 327–328. https://www.aaem.pl/pdf-71782-9008?filename=Heracleum%20sosnowskyi.pdf

Jodaugienė D., Marcinkevičienė A., Sinkevičienė A. 2018. Control of *Heracleum sosnowskyi* in Lithuania. Proceedings of the 28th German Conference on Weed Biology and Weed Control. Julius Kühn-Institut, vol. 458, p. 275–280. https://doi.org/10.5073/jka.2018.458.039

Klima K., Synowiec A. 2016. Field emergence and the long-term efficacy of control of *Heracleum sosnowskyi* plants of different ages in southern Poland. Weed Research, 56 (5): 377–385. https://doi.org/10.1111/wre.12214

Klimaszyk P., Klimaszyk D., Piotrowiak M., Popiołek A. 2014. Unusual complications after occupational exposure to giant hogweed (*Heracleum mantegazzianum*): a case report. International Journal of Occupational Medicine and Environmental Health, 27: 141–144. https://doi.org/10.2478/s13382-014-0238-z

Mežaka A., Zvaigzne A., Tripāne E. 2016. *Heracleum sosnowskyi* Manden. monitoring in protected areas – A case study in Rezekne Municipality, Latvia. Acta Biologica Universitatis Daugavpiliensis, 16 (2): 181–189. https://du.lv/wp-content/uploads/2022/02/8_Mezaka.pdf

Nielsen C., Ravn H. P., Nentwig W., Wade M. 2005. The giant hogweed best practice manual. Guidelines for the management and control of an invasive weed in Europe. Forest and Landscape Denmark, 44 p.

Perglová J., Pergl J., Pyšek P. 2006. Flowering phenology and reproductive effort of the invasive alien plant *Heracleum mantegazzianum*. Preslia, 78: 265–285. https://www.preslia.cz/article/310

Peterson M. A., Collavo A., Ovejero R., Shivraindand V., Walsh M. J. 2018. The challenge of herbicide resistance around the world: a current summary. Pest Management Science, 74 (10): 2246–2259. https://doi.org/10.1002/ps.4821

Postnikov A, Partolina A., Jegorov A., Pavlyuchenkova L., Bubnov A. 2021. Selective herbicides to control Sosnowsky's hogweed (*Heracleum sosnowskyi* Manden.) in pine and spruce plantations. IOP Conference Series: Earth and Environmental Science: 876. https://doi.org/10.1088/1755-1315/876/1/012062

Pyšek P., Cock M. J. W., Nentwig W., Ravn H. P. 2007. Ecology and management of giant hogweed (*Heracleum mantegazzianum*). CABI, 324 p. https://doi.org/10.1079/9781845932060.0000

Stojanović V., Stojanović S., Kovačević J., Stojanović D., Bjedov I. 2017. *Heracleum sosnowskyi* Manden. (Apiaceae) – a new invasive species in the flora of Serbia. Glasnik Sumarskog fakulteta [Bulletin of the Faculty of Forestry, University of Belgrade], 116: 215–220. https://doi.org/10.2298/GSF1716215S

Sužiedelytė Visockienė J., Tumelienė E., Maliene V. 2020. Identification of *Heracleum sosnowskyi*-invaded land using earth remote sensing data. Sustainability, 12 (3): 2–13. https://doi.org/10.3390/su12030759

Vykhor B. I., Prots B. H. 2015. Control of the number of populations of hogweed Sosnowski – *Heracleum Sosnowskyi* Manden. Youth and the progress of biology: A collection of abstracts of the XI International Scientific Conference of Students and Postgraduates. Lviv, Ukraine, p. 55–56 (in Ukrainian).

WRB. 2015. World reference base for soil resources. World Soil Resources Reports, vol. 106. https://www.fao.org/3/i3794en/I3794en.pdf

Sosnovskio barščio (*Heracleum sosnowskyi* Manden.) cheminė kontrolė Ukrainoje

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Santrauka

Sosnovskio barštis (*Heracleum sosnowskyi* Manden.) yra žinomas kaip invazinis, kenksmingas žmonėms ir sunkiai kontroliuojamas augalas. Tyrimo tikslas – įvertinti cheminės kontrolės efektyvumą, kai skirtingi herbicidai naudojami įvairiais *H. sosnowskyi* augalų vystymosi tarpsniais. Tyrimai buvo atlikti Ukrainoje 2013–2020 m. Buvo vykdyti du lauko eksperimentai su pirmųjų ir antrųjų metų *H. sosnowskyi* augalais. Augalai herbicidams jautriausi buvo skilčialapių tarpsniu. Herbicidų efektyvumas svyravo nuo 97,3 iki 100 %. Purškiant šešių lapelių tarpsniu, herbicidų efektyvumas sumažėjo ir siekė 43,2–60,7 %. Sosnovskio barščių kontrolei buvo efektyviausi šie herbicidai: Task Extra 66,5 WG (rimsulfuronas 23 g kg^{-1}, nikosulfuronas 92 g kg^{-1}, dikamba 550 g kg^{-1}) + Trend 90, naudojant 385 g ha^{-1} + 0,2 L ha^{-1} ir MaisTer Power OD (foramsulfuronas 31.5 g L^{-1} + jodosulfuronas 1,0 g L^{-1} + tienkarbazono metilas 10 g L^{-1} + ciprosulfamidas (priešnuodis) 15 g L^{-1}), naudojant 1,5 L ha^{-1}. Antrųjų metų *H. sosnowskyi* augalai buvo efektyviai kontroliuojami šiais herbicidais: Elumis 105 OD (mezotrionas 75 g L^{-1}, nikosulfuronas 30 g L^{-1}), naudojant 2,0 L ha^{-1} ir herbicidų mišinį Elumis 105 OD + Roundup Max (glifosato kalio druska 551 g L^{-1}), kai purkšta 2,0 + 6,0 L ha^{-1}.

Sosnovskio barščių jautrumas herbicidams antraisiais metais buvo mažesnis nei pirmaisiais. Tyrimo rezultatai rodo, kad mezotriono, nikosulfurono ir glifosato derinys yra tinkama priemonė siekiant išnaikinti antrųjų augimo metų Sosnovskio barščius.

Reikšminiai žodžiai: invazinės svetimžemės rūšys, salieriniai augalai, Sosnovskio barštis, piktžolių cheminė kontrolė, herbicidai.