Control of *Heracleum sosnowskyi* in Lithuania

*Beckämpfung von Heracleum sosnowskyi in Litauen*

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**Abstract**

Sosnovsky’s hogweed (*Heracleum sosnowskyi*) is a dangerous perennial, invasive alien plant in Lithuania. Control of this plant is complicated due to well-developed biological properties. To achieve efficient control of the species, it is crucial to choose highly efficient herbicides and their combinations.

Field experiments, designed to compare the efficacy of different herbicides and their mixtures used to control *Heracleum sosnowskyi*, were conducted in 2016 and 2017 in Lithuania, Varnupiai (54° 29' 19.54", 23° 30' 45.9"), Marijampolė distr. The efficacy of the herbicides and their mixtures applied for Sosnovsky’s hogweed control was different. The use of both lower and higher rates of glyphosate did not have the expected result, as 4-6 weeks after application new plants started to emerge. A mixture of glyphosate with triasulfuron showed better effect. The efficacy of dicamba and its mixtures with fluroxypyr and triasulfuron, fluroxypyr, triasulfuron and their mixture, fluroxypyr + clopyralid + MCPA mixture depended on the experimental years’ meteorological conditions. In 2017, the effect of the above mentioned herbicides and their mixtures on Sosnovsky’s hogweed stood out 4-6 weeks after application. Both the smaller and higher rates of tribenuron-methyl + metsulfuron-methyl mixture gave effective control of Sosnovsky’s hogweed. The effect of fluroxypyr + metsulfuron-methyl mixture was more rapid, and 6 weeks after application only single plants remained in the plots.

**Keywords**: Control, efficacy, *Heracleum sosnowskyi*, herbicides

**Zusammenfassung**


**Stichwörter**: Bekämpfung, Effizienz, *Heracleum sosnowskyi*, Herbizide, Pflanzendichte

**Introduction**

Sosnovsky’s hogweed (*Heracleum sosnowskyi*) is a dangerous, highly invasive alien plant species of the family Apiaceae. Around 1950, the species was introduced to Europe from the Caucasus and was recommended to be grown for silage production. Before long it started to spread spontaneously in a wide range of habitats, including roadsides, areas alongside footpaths and riverbanks, scrublands, abandoned land, and rarely mowed grasslands. The species it now invading woods and arable fields (Stravinskiene, 2016). As an alien species it is most widely distributed in the countries of Central and Eastern Europe – Poland, Belarus, Lithuania, Latvia, Estonia, Russia, Ukraine, may be it also occurs in Germany (Gudzinskas et al., 2014). It is estimated that in Lithuania the total area covered by this species is more than 10 thousand hectares (Rašomavičius, 2008).
One plant of *Heracleum sosnowskyi* is capable of producing up to 100,000 seeds, which remain viable for several years (from 5–6 to up to 15 years) (Nielsen et al., 2007; Gužinskas et al., 2014). Researchers have documented that under Lithuanian climate conditions, one plant of this species can produce from 15.4 to 16.1 thousand seeds, and the seed viability reaches 78% (Balezentienė and Bartkevičius, 2013; Balezentienė et al., 2013). The largest number of Sosnovsky’s hogweed seeds (95%) is concentrated within the top 5 cm of the soil layer (Nielsen et al., 2005; Denness et al., 2013).

Since 2001, *Heracleum sosnowskyi* has been included in the list of harmful species of wild plants and fungi that have to be controlled in Lithuania (Gazette, 2001, No. 4-106). Therefore, an effective strategy for the control of this species has to be worked out.

The key objective of *Heracleum sosnowskyi* control is to minimize the abundance and density of the species and to prevent its further multiplication and spread. Various control methods are known and are presently being applied, including burning, hot water treatment, multiple cutting, herbicide application (Kraus, 2013). The plants are recommended to be cut 3–4 times per season. Sosnovsky’s hogweed can be exterminated by cutting roots from at least 10 cm depth early in spring when the first leaves start to emerge; however, this practice can be repeated in the middle of summer (Nielsen et al., 2005; Gužinskas et al., 2014). Another practice used to control Sosnovsky’s hogweed is deep ploughing up to 25 cm, from which the seeds are not able to emerge. To prevent the invasion and spread of the species in arable fields, it is vital to apply crop rotation (Gužinskas et al., 2014).

To achieve efficient control of the species, it is crucial to choose highly efficient herbicides and their combinations. Herbicidal control of Sosnovsky’s hogweed has to be commenced early in spring until the plants are still short (up to 20–30 cm in height), or the plants have to be cut, and after regrowth when they have reached the above indicated height, they have to be sprayed with herbicides. It has been documented that after the plants have reached a height of about 50, herbicides may be ineffective. The most commonly recommended herbicides for the control of Sosnovsky’s hogweed are glyphosate and triclopyr as they provide high efficacy and cost effectiveness. These herbicides are intended for use on individual plants and on the overgrowth of plants. Through leaves, the herbicides travel to roots and inhibit the growth of sprouts (Olukans et al., 2005; Domarexki and Badowski, 2010; Kraus, 2013). It should be noted that, as a non-selective herbicide, glyphosate kills all vegetation, while the active ingredient of triclopyr has not been registered in Lithuania. For this reason, it is necessary to look for other, selective-type herbicides that would target specifically Sosnovsky’s hogweed but not the entire vegetation. The current study was aimed to compare the efficacy of herbicides and their mixtures used for the control of *Heracleum sosnowskyi*.

**Materials and Methods**

**Experimental design**

Field experiments, designed to compare the efficacy of different herbicides and their mixtures used to control *Heracleum sosnowskyi*, Sosnovsky’s hogweed, were conducted in 2016 and 2017 in Lithuania, Varnupiai (54° 29’ 19.54”, 23° 30’ 45.9”), Marijampole distr.

In 2016, the experiment included the following 15 treatments:

1. glyphosate 1440 g ha⁻¹,
2. glyphosate 2160 g ha⁻¹,
3. glyphosate 2880 g ha⁻¹,
4. glyphosate 3600 g ha⁻¹,
5. glyphosate 720 g ha⁻¹ + dicamba 480 g ha⁻¹,
6. glyphosate 720 g ha⁻¹ + fluroxypyr 60 g ha⁻¹ + clopyralid 30 g ha⁻¹ + MCPA 300 g ha⁻¹,
7. glyphosate 720 g ha⁻¹ + fluroxypyr 180 g ha⁻¹,
8. glyphosate 720 g ha⁻¹ + triasulfuron 4 g ha⁻¹,
9. dicamba 960 g ha\(^{-1}\),
10. dicamba 480 g ha\(^{-1}\) + fluroxypyr 180 g ha\(^{-1}\),
11. dicamba 480 g ha\(^{-1}\) + triasulfuron 4 g ha\(^{-1}\),
12. fluroxypyr 360 g ha\(^{-1}\),
13. triasulfuron 8 g ha\(^{-1}\),
14. fluroxypyr 120 g ha\(^{-1}\) + clopyralid 60 g ha\(^{-1}\) + MCPA 600 g ha\(^{-1}\),
15. triasulfuron 4 g ha\(^{-1}\) + fluroxypyr 180 g ha\(^{-1}\).

In 2017, the number of treatments was increased to 18 by adding to the ones tested in 2016 another 3 treatments:
16. tribenuron-methyl 2 g ha\(^{-1}\) + metsulfuron-methyl 4 g ha\(^{-1}\),
17. tribenuron-methyl 3 g ha\(^{-1}\) + metsulfuron-methyl 6 g ha\(^{-1}\),
18. fluroxypyr 360 g ha\(^{-1}\) + metsulfuron-methyl 4 g ha\(^{-1}\).

The experimental plot size was 18 m\(^2\); the experimental treatments were replicated 4 times. Plant density, height and chlorophyll index, which indicates the intensity of photosynthesis and at the same time plant viability, were estimated and measured before herbicide application and every two weeks after application, 5 times per vegetation season in 2016 and 6 times in 2017. The paper presents the variation of plant densities.

**Statistical analysis**

The data were estimated according to t criterion, using the statistical programme STAT from the software package STATISTICA 10. At the time of experiment establishment, the experimental plots significantly differed in plant density, therefore we did not compare herbicides and their mixtures but plant densities before herbicide application and 2, 4, 6, 8 and 10 weeks after application.

**Results**

The number of plants in the plots before herbicide application differed and ranged from 76.7 to 91.7 m\(^{-2}\) in 2016 and from 56.7 to 80.0 m\(^{-2}\) in 2017 (Tab. 1). Having sprayed the plots with different rates (1440-3600 g ha\(^{-1}\)) of glyphosate, the number of plants within 2 weeks after application decreased by 3.7-63.7% in 2016 and by 12.2-48.8% in 2017; however, significant differences were established only having applied glyphosate at a rate of 2160 g ha\(^{-1}\) in 2016 and at a rate of 3600 g ha\(^{-1}\) in 2017.

**Tab. 1** Influence of different glyphosate doses on *Heracleum sosnowskyi* density.

<table>
<thead>
<tr>
<th>Herbicides</th>
<th>Year</th>
<th>Weed density (number m(^{-2}))</th>
<th>before spraying</th>
<th>after 2 weeks</th>
<th>after 4 weeks</th>
<th>after 6 weeks</th>
<th>after 8 weeks</th>
<th>after 10 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate 1440 g ha(^{-1})</td>
<td>2016</td>
<td>76.7a</td>
<td>63.3a</td>
<td>146.7a</td>
<td>168.3a</td>
<td>133.3a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>68.3ab</td>
<td>60.0ab</td>
<td>78.3ab</td>
<td>85.0ab</td>
<td>90.0a</td>
<td>51.7b</td>
<td></td>
</tr>
<tr>
<td>Glyphosate 2160 g ha(^{-1})</td>
<td>2016</td>
<td>91.7cd</td>
<td>88.3d</td>
<td>210.0ab</td>
<td>258.3a</td>
<td>183.3bc</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>80.0a</td>
<td>46.7b</td>
<td>46.7b</td>
<td>83.3a</td>
<td>115.0a</td>
<td>68.3ab</td>
<td></td>
</tr>
<tr>
<td>Glyphosate 2880 g ha(^{-1})</td>
<td>2016</td>
<td>88.3a</td>
<td>53.3a</td>
<td>121.7a</td>
<td>146.7a</td>
<td>101.7a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>56.7ab</td>
<td>46.7ab</td>
<td>36.7b</td>
<td>61.7ab</td>
<td>81.7a</td>
<td>50.0ab</td>
<td></td>
</tr>
<tr>
<td>Glyphosate 3600 g ha(^{-1})</td>
<td>2016</td>
<td>91.7ab</td>
<td>33.3c</td>
<td>86.7bc</td>
<td>110.0ab</td>
<td>130.0a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>65.0a</td>
<td>33.3ab</td>
<td>20.0b</td>
<td>61.7a</td>
<td>53.3ab</td>
<td>51.7ab</td>
<td></td>
</tr>
</tbody>
</table>

In 2016, when the plant density was assessed 4 weeks after application, it was noticed that in the plots, particularly those applied with lower glyphosate rates, new plants started to grow.

A similar trend was established in 2017, only new plants started to emerge slightly later, i.e. 4-6 weeks after application. In 2017, plant density 10 weeks after application was found to be lower...
than 8 weeks after application. This can be explained by the fact that the plants of Sosnovsky's hogweed started to compete and smother one another.

Glyphosate mixtures with other herbicides had different effects on the Sosnovsky's hogweed plant density (Tab. 2). The best efficacy was exhibited by a glyphosate mixture with triasulfuron. The number of plants consistently decreased. A significant reduction (3.5–4.7 times) in the number of plants was recorded 8 weeks after application compared with the number before application. Other mixtures demonstrated weaker efficacy.

Tab. 2 Influence of different glyphosate mixtures on *Heracleum sosnowskyi* density.

<table>
<thead>
<tr>
<th>Herbicides and their mixtures</th>
<th>Year</th>
<th>Weed density (number m⁻²)</th>
<th>before spraying</th>
<th>after 2 weeks</th>
<th>after 4 weeks</th>
<th>after 6 weeks</th>
<th>after 8 weeks</th>
<th>after 10 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate 720 + dicamba 480 g ha⁻¹</td>
<td>2016</td>
<td>83.3a</td>
<td>73.3a</td>
<td>98.3a</td>
<td>121.7a</td>
<td>161.7a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>58.3a</td>
<td>40.0a</td>
<td>61.7a</td>
<td>66.7a</td>
<td>81.7a</td>
<td>70.0a</td>
<td></td>
</tr>
<tr>
<td>Glyphosate 720 + fluroxypyr 60 + clopyralid 30 + MCPA 300 g ha⁻¹</td>
<td>2016</td>
<td>95.0ab</td>
<td>86.7b</td>
<td>176.7a</td>
<td>178.3a</td>
<td>193.3a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>63.3ab</td>
<td>53.3ab</td>
<td>28.3b</td>
<td>68.3a</td>
<td>86.7a</td>
<td>46.7ab</td>
<td></td>
</tr>
</tbody>
</table>

The effect of dicamba differed between the experimental years (Tab. 3). In 2016, the number of plants did not change within 4 weeks after application, and later new plants started to emerge.

Tab. 3 Influence of different dicamba mixtures on *Heracleum sosnowskyi* density.

<table>
<thead>
<tr>
<th>Herbicides and their mixtures</th>
<th>Year</th>
<th>Weed density (number m⁻²)</th>
<th>before spraying</th>
<th>after 2 weeks</th>
<th>after 4 weeks</th>
<th>after 6 weeks</th>
<th>after 8 weeks</th>
<th>after 10 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dicamba 960 g ha⁻¹</td>
<td>2016</td>
<td>56.7b</td>
<td>56.7b</td>
<td>56.7b</td>
<td>75.0b</td>
<td>116.7a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>51.7a</td>
<td>48.3a</td>
<td>28.3a</td>
<td>30.0a</td>
<td>48.3a</td>
<td>38.3a</td>
<td></td>
</tr>
<tr>
<td>Dicamba 480 + fluroxypyr 180 g ha⁻¹</td>
<td>2016</td>
<td>90.0b</td>
<td>90.0b</td>
<td>95.0b</td>
<td>145.0b</td>
<td>201.7a</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>63.3a</td>
<td>56.7a</td>
<td>21.7ab</td>
<td>15.0b</td>
<td>13.3b</td>
<td>16.7b</td>
<td></td>
</tr>
</tbody>
</table>

For this reason, a higher number of plants was recorded: after 6 weeks 1.3 times, after 8 weeks 2.1 times, compared with the number before application. In 2017, 4 weeks after application were 1.8 times fewer plants. Later, even though new plants emerged, their number was lower than before herbicide application. The efficacy of the dicamba + fluroxypyr and dicamba + triasulfuron mixtures also differed between the experimental years – it was higher in 2017. Within 8 weeks after application, the number of Sosnovsky's hogweed plants decreased significantly by 4.8 times in the plots applied with dicamba 480 + fluroxypyr 180 g ha⁻¹ mixture and in the plots applied with dicamba 480 + triasulfuron 4 g ha⁻¹ mixture it decreased by 2.8 times.

When the plants had been sprayed with fluroxypyr, its effect became most distinct 4-6 weeks after application (Tab. 4). In 2016, the effect of triasulfuron was insignificant; however, in 2017, 4 weeks after application the number of plants was significantly (2.8 times) lower than before application. This difference remained until the end of experiments. 10 weeks after application, the number of Sosnovsky's hogweed plants was as low as 1.7 m⁻², i.e. 27.5 times lower than before the herbicide application.
In 2016, mixtures of fluroxypyr + triasulfuron and fluroxypyr + clopyralid + MCPA did not exert significant effect on Sosnovsky's hogweed, while in 2017 they significantly reduced the number of plants within 4 weeks after application.

Based on the Latvian researchers’ experience of controlling the spread of *Heracleum sosnowskyi*, in 2017 we tested the efficacy of tribenuron-methyl 3 + metsulfuron-methyl 6 g ha⁻¹ mixture. In Lithuania, these active ingredients are registered at 1.5 lower rates than in Latvia. Our findings suggest that both rates of these herbicide mixtures gave good control of Sosnovsky's hogweed (Tab. 5). Application of the tribenuron-methyl 2 + metsulfuron-methyl 4 g ha⁻¹ mixture significantly reduced the number of plants within the first 2 weeks after application. 10 weeks after application, there were 33.1 times fewer plants than before the application. Similar control was given by the higher rate of these active ingredients (tribenuron-methyl 3 + metsulfuron-methyl 6 g ha⁻¹); however, significant differences stood out only after 6 weeks.

**Tab. 4** Influence of different herbicides and their mixtures on *Heracleum sosnowskyi* density.

<table>
<thead>
<tr>
<th>Herbicides and their mixtures</th>
<th>Weed density (number m⁻²)</th>
<th>Year</th>
<th>before spraying</th>
<th>after 2 weeks</th>
<th>after 4 weeks</th>
<th>after 6 weeks</th>
<th>after 8 weeks</th>
<th>after 10 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluroxypyr 360 g ha⁻¹</td>
<td></td>
<td>2016</td>
<td>73.3a</td>
<td>75.0a</td>
<td>60.0a</td>
<td>56.7a</td>
<td>100.0a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2017</td>
<td>73.3a</td>
<td>78.3a</td>
<td>30.0b</td>
<td>13.3c</td>
<td>16.7c</td>
<td>13.3c</td>
</tr>
<tr>
<td>Triasulfuron 8 g ha⁻¹</td>
<td></td>
<td>2016</td>
<td>96.7a</td>
<td>75.0a</td>
<td>93.3a</td>
<td>60.0a</td>
<td>81.7a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2017</td>
<td>46.7a</td>
<td>55.0a</td>
<td>16.7b</td>
<td>5.0c</td>
<td>2.9c</td>
<td>1.7c</td>
</tr>
<tr>
<td>Triasulfuron 4 + fluroxypyr 180 g ha⁻¹</td>
<td></td>
<td>2016</td>
<td>81.7a</td>
<td>76.7a</td>
<td>66.7a</td>
<td>118.3a</td>
<td>113.3a</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2017</td>
<td>88.3a</td>
<td>86.7a</td>
<td>26.7b</td>
<td>11.7b</td>
<td>15.0b</td>
<td>15.0b</td>
</tr>
<tr>
<td>Fluroxypyr 120 + clopyralid 60 + MCPA 600 g ha⁻¹</td>
<td></td>
<td>2016</td>
<td>143.3ab</td>
<td>143.3ab</td>
<td>128.3b</td>
<td>160.0a</td>
<td>141.7ab</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2017</td>
<td>93.3a</td>
<td>81.7a</td>
<td>56.7b</td>
<td>11.7c</td>
<td>11.7c</td>
<td>10.0c</td>
</tr>
</tbody>
</table>

Even better results were obtained in the treatments applied with the fluroxypyr + metsulfuron-methyl mixture. A significantly lower number (4.8 times) of plants was recorded 4 weeks after application. 6 weeks after application, the plots contained only single plants, whose density totalled 0.25 m⁻².

**Discussion**

Our experimental findings suggest that the efficacy of the herbicides and their mixtures applied for *Heracleum sosnowskyi* control was different. The use of both lower and higher rates of glyphosate did not yield the expected result, as 4-6 weeks after application new plants started to emerge. A mixture of glyphosate with triasulfuron showed better effect. The efficacy of dicamba and its mixtures with fluroxypyr and triasulfuron, fluroxypyr, triasulfuron and their mixture, fluroxypyr + clopyralid + MCPA mixture depended on the experimental years’ meteorological
In 2017, the effect of the above mentioned herbicides and their mixtures on Sosnovsky’s hogweed stood out 4-6 weeks after application. Polish researchers have reported that the best result was achieved (90–95% control) by using mixtures of triclopyr and other herbicides: triclopyr + fluroxypyr + clopyralid, propoxycarbazone sodium + iodosulfuron methylsodium + amidosulfuron and triclopyr + fluroxypyr + clopyralid + propoxycarbazone sodium + iodosulfuron methylsodium + amidosulfuron (DOMARADZKI and BADOWSKI, 2010). Belarus researchers (YAKIMOVICH and IVASHKEVICH, 2013) have indicated that the highest efficacy in controlling Sosnovsky’s hogweed was achieved by using sulfometuron-methyl acid, imazapyr and their mixtures with glyphosate. The USA researchers recommend controlling Sosnovsky’s hogweed with a mixture of triclopyr and chlorothalonil or 2,3,6-trichlorobenzoic acid and MCPA in April–June (BROWNIK and CHANDRAN, 2015). Latvian researchers suggest controlling it by applying glyphosate, triclopyr and imazapyr in March–May (OLUKANS et al., 2005). Many authors point out that integrated approach provides the most effective control of Sosnovsky’s hogweed. Our study evidenced that both the smaller and higher rates of the tribenuron-methyl + metsulfuron-methyl mixture gave effective control of Sosnovsky’s hogweed. The effect of the fluroxypyr + metsulfuron-methyl mixture was more rapid, and 6 weeks after application only single plants remained in the plots.

References


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