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Possibilities of the management of *Helianthus tuberosus* species in Poodri PLA (Czech Republic)

H Svehlakova[1], A Janikova[1], J Kupka[1], N Sotkova[1] and T Rajdus[1]

[1]Institute of environmental engineering, Faculty of mining and geology, VSB – TU Ostrava, 17.listopadu 15, 708 33 Ostrava – Poruba, Czech Republic

E-mail: hana.svehlakova@vsb.cz

Abstract. This article deals with the possibilities of population management of invasive and in Czech Republic no - native species *Helianthus tuberosus*. We have chosen study areas in Poodri PLA, it is located near the industrial city Ostrava (Moravian-Silesian region). Invasive *Helianthus tuberosus* forms monodominant vegetation,excludes the original and often rare plant species and reduces biodiversity. It is a risk for the further development of the landscape of Poodri PLA. There is no known effective way to dispose of invasive *Helianthus tuberosus* so far. We have applied the proposed management works on 15 monitoring areas and then evaluated their effectiveness. We have used chemical (herbicides) and mechanical (mowing, digging up) methods and their combinations. The most effective was the combination of 3 interventions: manual mowing - spraying – mowing by mechanization, just mowing itself rather promotes the spread of the population. We can say this is a pilot study from a long-term project dealing with the effectiveness of different ways of invasive plants management.

1. Introduction

The Poodri Protected Landscape Area (PLA) is located in Czech Republic in the Moravian-Silesian Region close to the Ostrava agglomeration. It is exceptional especially due to the preservation of the natural water regime of the Odra river [1]. Most parts of the area is formed by floodplains, there are biotopes closely related to water: alluvial meadows, floodplain forests and permanent or periodic pools [2]. Also relatively dense system of ponds and drainage channels is typical for this area [1,2]. A major problem in Poodri PLA is the spread of invasive plant species. One of the non-native introduced species is Jerusalem artichoke (*Helianthus tuberosus*), a perennial tuberous herb of the *Asteraceae* family, originally from North America. Jerusalem artichoke belongs to an unpretentious plants capable of forming a dense, monodominant, successful phytocoenosis, which suppresses other species and can reduces biodiversity of territory [3]. *Helianthus tuberosus* is capable of rapid and successful vegetative reproduction, using especially tubers, rhizomes, but can spread also seeds [4,5,6].

The dynamics of the Ondrejnice watercourse contribute significantly to *Helianthus tuberosus* distribution, tubers and rhizomes being transported by annual floods. Litoral and alluvial meadows are the most threatened biotopes from this point of view. The most invaded communities by *Helianthus tuberosus* belong to the phytocoenological associations *Arhenatherion, Bidention tripartitae, Salicion albae* and *Alnion glutinosae*. For this reason, we proposed in cooperation with experts of Nature Conservation Agency of the Czech Republic (NCA CR) experimental management on selected areas with Jerusalem artichoke. Management of experimental areas with the occurrence of Jerusalem artichoke includes mechanical methods (mowing and digging up), chemical methods (application of herbicides), or combinations thereof.

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2. Materials and methods

The selected areas are located in the Poodri PLA, cadastral territory Proskovice (see figure1). It is an alluvial meadow, which the river Ondrejnice flows through the and which, due to the floods, is heavily invaded by *Helianthus tuberosus*. These invasive plants are located mainly along the banks of Ondrejnice, in the adjacent meadow, in the remains of floodplain forests and in new forest planting.

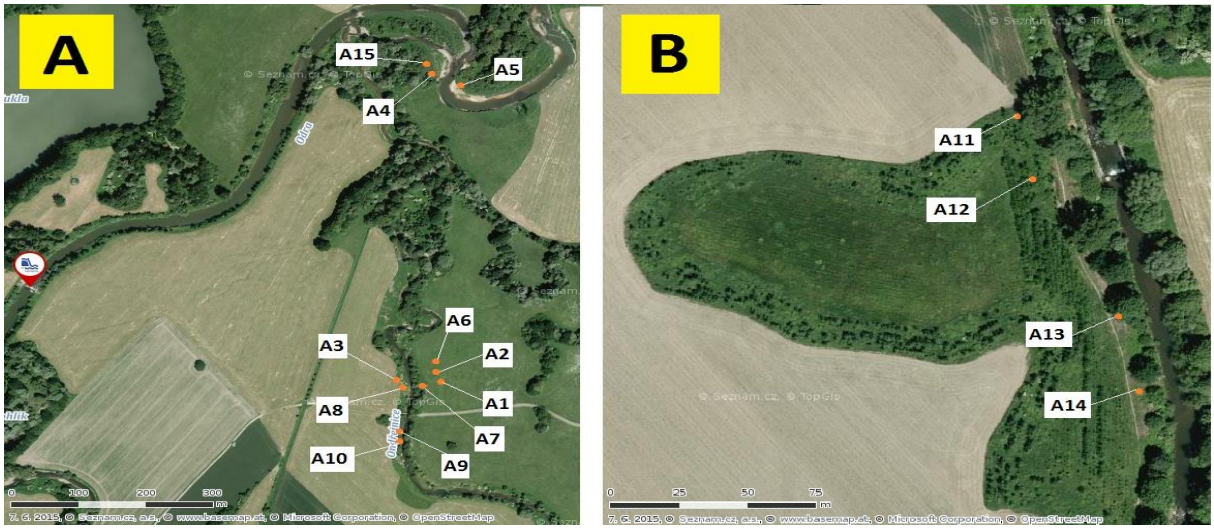


Figure 1. Selected monitoring areas of *Helianthus tuberosus.*

In 2014, we selected 4 experimental areas (A1-A4) with various managements and 1 control area (A5) where no intervention has taken place and serves to observing standard lifecycle and development of Jerusalem artichoke. It also serves to compare the effectiveness of the methods used.
In 2016, we have expanded number of study areas with *Helianthus tuberosus* by another 9 experimental areas (A6-A14) and 1 new control area (A15). Thus, we have monitored population of *Helianthus tuberosus* on a total of 13 experimental and 2 control areas. Areas have about 100 m^2 and are square in shape. The location of areas corresponds to the typical habitats of *Helianthus tuberosus* - sunny banks (A1, A2, A9, A14), shaded banks (A3, A5, A7, A8, A10, A13, A14), meadow (A4)), tree planting (A11, A12). Control areas are located in shaded banks (A5) and in the shaded meander (A15).

The following interventions were performed on the individual monitoring areas:

- the mowing - mechanical mowing in the regular management of meadows twice per season, supplemented by manual mowing or brush cutting in places where regular mowing did not take place;
- digging tubers up - removal of *Helianthus tuberosus* tubers by spade at the end of the growing season;
- application of herbicides - spraying plants by herbicides ROUNDAP, GARLON NEW, BOFIX, HERBISTOP. ROUNDAP is a systemic non-selective herbicide that belongs to the so-called total herbicides that destroy weeds from leaves to roots [7]. The active ingredient of the herbicide is glyphosate. GARLON NEW - a selective herbicide, it is intended for the control of unwanted tree species and dicotyledonous plants on meadows, pastures, temporarily uncultivated soils. The active substances are fluroxypyr and triclopyr [8]. HERBISTOP is a total natural herbicide based on pelargonic acid, intended for the disposal of monocotyledonous and dicotyledonous weeds. Pelargonic acid is a naturally occurring fatty acid that leaves no residue and is environmentally friendly [9]. BOFIX is a selective herbicide able to kill resistant dicotyledonous weeds in lawns. The active substances are clopyralid, fluroxypyr and MCPA [10].

- Management combinations - mowing + digging up, mowing + spraying, spraying and digging up, mowing, spraying and digging up.

3. Results and discussion

We have performed management interventions of *Helianthus tuberosus* on 5 monitoring areas (A1-A4) in 2014 - 2016, one area was control (A5). The management ran from June 2014 to October 2015, and in the 2016 season, we have conducted a field survey to determine the state of populations *Helianthus tuberosus* after interventions. The meadows were mowed always twice in June and August 2014 and 2015. The application of herbicides was at the turn of August and September 2014 (ROUNDUP) and 2015 (GARLON NEW). Tuber harvesting was performed in October 2015. In the autumn months of 2016, we have supplemented the network of experimental areas (A6-A14) and control areas (A15). We have expanded also a range of interventions. At the end of June and July 2017, and in August 2017 we have performed mowing, in early August 2017 application of herbicides (BOFIX, HERBISTOP) was carried out. Digging tubers up is scheduled for October 2017.

Mowing. Areas A2, A6. We also include the area A14 here, which is mowed and after this season we plan digging up of tubers. We can say plant compensates removing of terminal buds after mowing by their doubling and also rapid regeneration from roots. So it optically and actually increases the population. This increase is evident in the spring aspect of the following season and only slightly declines in autumn. Due the mowing weakening of plants occurs, which is evident in the size of the tubers. They are very small compared to the area without mowing. We can say exclusive mowing in *Helianthus tuberosus* does not cause the decreasing of population of *Helianthus tuberosus*; however, it negatively affects the height of the plant, which does not exceed 30-40 cm on the area of A2 and A6. The area of A14 was massively rejuvenated by young individuals and the plants reached a height of 60 cm in 2017. Since none of areas has created flowers, mowing also negatively affects generative reproduction.

Digging tubers up. Area A8. It will be done in autumn 2017.

Mowing and digging up. Areas A1, A14. Combination of mowing and harvesting of tubers is more effective in the elimination of the Jerusalem artichoke. Mowing weakens plants and harvesting of tubers removes the source of vegetative propagation. The abundance of plants on area A1 decreased by about 40%. We have to note that mowing took place twice in 2014 and twice in 2015 by mechanization, and in September 2016 it was supplemented by manual mowing. Area A14 was mowed in 2017 (but young plants quickly regenerate), digging of tubers up will be done in October.

Application of herbicide. Area A4 (GARLON NEW), A11 (HERBISTOP), A9, A12 (BOFIX).The application of GARLON NEW is ideal at the time of flowering. Jerusalem artichoke´s flowering on A4 began in a very dense vegetation formation, when defoliation of plants´stems has reached the height 1.4 m as a result of competition for light. This herbicide acts through the leaf, so it was not effective. We can say that its application is not suitable for dense plant stands, or it is necessary to apply it early spring before flowering. The application of HERBISTOP on A11 was not easy due to the high growing of the Jerusalem artichoke individuals. It was not possible to hit top of stems of all individuals. After application of the herbicide, assimilation organs of plants have been damaged (wilting, necrotisation). Lower individuals were completely destroyed and did not come into flower. Higher individuals over 2.5 m show leaf damage up to 2/3 height, but tops of stems remain undamaged, some had flowers. So we recommend using herbicide earlier, preferably at the turn of spring and summer. The BOFIX application to *Helianthus tuberosus* on areas A9 and A12 was successful. There was damage of most of plants assimilation organs (wilting, necrotisation), tops of stems were deformed and without flowers also in individuals over 2.5 m. On A9, the tubers will be dig up in October.

The application of herbicide and digging up. Area A3 (ROUNDUP). An interesting result was the application of the ROUNDAP herbicide to area A3 followed by digging tubers of survive individuals up. The spraying was carried out in the autumn months and, after its application, the invasive population almost did not recover. From the original abundance about 90%, *Helianthus tuberosus* was

eliminated for a spot occurrence - in the following season we found only 6 individuals. Plants that survived, however, reached a height of 2.8 m and a diameter of stem up to 7 cm and were very dominant in the stand. In August, they created up to tens of flowers per one plant. In October 2015, these individuals were harvested, their tubers were dig up and we have found that the root system of the plants was more potent and the tubers were 5 times larger than on other areas. Digging tubers up after application of ROUNDAP, we consider it very important, because of the high viability of individuals that survived the spraying.

Mowing and herbicide application. Areas A7 (BOFIX), A10 (HERBISTOP), A13 (HERBISTOP). Area A7 was manual mowed (July 2017) and treated with the BOFIX (August 2017), then it was mechanically mowed (August 2017). We have checked area A7 in September 2017 and have found the area is completely free of rejuvenated individuals. Plants of *Helianthus tuberosus* on the border of area, which have not been affected by mowing, were very damaged, without functional photosynthethic organs. The A10 area was mowed once and then HERBISTOP was applied to the regenerated plants. After the herbicide application, most of *Helianthus tuberosus* died, but lot of young individuals appeared in September. As a result of receiving more light, also the *Colchicum autumnale* bloomed on this habitat. A13 area was manually mowed in July 2017, the HERBISTOP was applied on gradually regenerating individuals. The herbicide-affected individuals are completely destroyed, but the new ones are again being rejuvenalised. In the autumn 2017, digging tubers up is planned. We terminated the use of herbicides ROUNDAP and GARLON NEW in 2015. We excluded the ROUNDAP because of the high toxicity of glyphosate and GARLON NEW was inappropriate for much closed plant formations with defoliation of stalks up to 1m.

HARTMANN et al [11] recommends mechanical methods twice a season (June, August). Our results show that the most effective method to the elimination of *Helianthus tuberosus* from alluvial meadow is the combination of manual mowing → application of BOFIX herbicide → mowing by mechanization (area A7). With this intervention, *Helianthus tuberosus* was completely removed without regeneration. Only BOFIX spraying (areas A9, A12) is also effective and also affects plants over 2.5 m high, but a part of plants survives and is able to be regenerated. BOFIX can be used even in mild winds and temperatures up to max. 25°C. Rain can reduce efficiency within 2 hours after application. The price for spraying of 100 m^2 is 80 CZK, which is favourable. It is also very effective to spraying the ROUNDUP herbicide and subsequently digging tubers and surviving plants up (A3). These individuals are generally very high, stable and viable and could become the basis of a rapidly spreading invasive population. The application of ROUNDAP was, however, stopped in the meadows of Poodri PLA due to glyphosate toxicity. Using herbicide HERBISTOP, the plant assimilation organs were very damaged. Generative organs were damaged in lower individuals (up to 2m), higher individuals were able to form flowers and expand populations. HERBISTOP is therefore not suitable for high vegetation, or it is necessary to apply it early in the spring, but in the sunny, windless weather, which is rare in the alluvial meadows of Poodri PLA in the spring months. An advantage is the degradation of the herbicide without residue in soil and water. The least suitable herbicide is GARLON NEW (A4), which can be applied to stem leaves. However leafs often absent in densely-growing formations of *Helianthus tuberosus* or are too high (above 1 m). The application can be done optimally early in the spring in sunny weather without rain. Mowing (A2, A6, A14) is less effective if it is not followed by another intervention of management. FEHÉR and KONČEKOVÁ [12] came to similar conclusion. They recorded decreasing of *Helianthus tuberosus* population of about 44 % after 3 years mowing. However, it can be said that mowing negatively affects the development of the plant's generative organs and the size of the tubers and it is extremely effective in combination with other interventions (especially herbicides). The digging tubers up themselves (area A8) will be carried out in autumn 2017, but results show that, like mowing, it will be more efficient combined with other management methods.

4. Conclusions

The article focuses on the effectiveness of various landscape management methods for the removal of invasive species *Helianthus tuberosus* from the alluvial communities of Poodri PLA. It summarizes results of the pilot research launched at the instigation of the NCA Czech Republic in 2014. We have chosen 4 basic management methods - mowing, digging tubers up, application of herbicides ROUNDUP, GARLON NEW, BOFIX, HERBISTOP and their combination - mowing and digging up, mowing and application of herbicide, application of herbicide and digging up. We can say that the most effective management method is a combination of twice to mow and in the meantime to apply a suitable herbicide. The most suitable herbicide is BOFIX. ROUNDUP also has excellent results, but its use with respect to glyphosate content is not possible in the long term. Relatively effective and environmentally friendly is HERBISTOP, but it is necessary to use it in the spring before the first mowing, higher plants survive the spraying and they flourish. So it is not possible to follow the optimal scheme of mowing - spraying - mowing. The research will be supplemented by the digging tubers up, because we can say on example ROUNDAP application, that surviving individuals have strong viability and removing of tubers from the soil can be prevent them from expanding.

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