Experience gained from the control of giant goldenrod in the Őrség National Park

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Introduction

As agriculture has become industrialised, the methods of grassland management have greatly changed over the last century, not only in the territory of the Őrség National Park, but also in other regions of the country. Due to the changing socioeconomic circumstances, the majority of family farms disappeared, and these lands were afforested or became weedy. The most widespread weed of abandoned or ill-managed – sometimes very valuable – grasslands is giant goldenrod (*Solidago gigantea*), which is to some extent present in every mowed and unmowed mesic grassland in the area of the national park.

Although goldenrod has been causing problems especially in Transdanubia since the second half of the 19th century, there are only few publications (Hungarian or international) about experimental analysis or the reactions to control treatments. It is known that this plant can be treated effectively with mechanical methods, but our experience shows that the way and the speed it establishes and spreads in an area and its reaction to control treatments greatly depends on the history and water conditions of the given area, as well as on the intensity and timing of the control treatments. The following experiences and observations are based on a mowing experiment we have been doing for eight years.

Natural characteristics of the area

Our observations were made by surveying two sites (about 0.64 ha each) that were divided based on different control methods. Both sites are located along the Szentgyörgyvölgyi stream, 250 m away from each other, with a 100 m wide forest and some hayfields of average condition between them. The two sites are located between the stream and a parallel dirt road, and the area declines slightly (2–3%) towards the stream. The altitude is about 210 m.

The soil of the area is closed, moderately cold and slightly acidic. The average annual precipitation is between 750 and 850 mm.

In the second half of the last century, owing to some river engineering works, the Szentgyörgyvölgyi stream carved itself 1.5–2 m deep in its basin, this is why it often runs dry in the summer. However, this reduces the groundwater level of the surrounding grasslands. The water condition of Area No.1. is mesophilic, while Area No. 2 is more humid, in rainy periods surface water appears locally. These circumstances are further nuanced by terrain characteristics. Higher places are not influenced by excess water, but both areas are plain in the centre, where rainfall can remain close to the surface for longer periods. This is well indicated by the presence of slim sedge (*Carex acuta*) in Area No. 1 and tussock grass (*Deschampsia caespitosa*) populations in Area No. 2. Closer to the stream, soil water conditions are usually drier as the stream is deep in its basin and water flows in that direction. This is why drought-tolerant species characteristic of drier grasslands are common here.

The study sites are surrounded by riverine ash-alder forests that run along the stream, but there are also areas afforested with pines, as well as spontaneous forests, fen-meadows, bog meadows and hay meadows. There are small and large patches of giant goldenrods close to the experimental areas, but also in the trenches along the road, and on the forest edges.

The vegetation of the experimental areas is as follows: species of *Arrhenatherum* hay meadows are the most dominant, but – depending on the terrain and water conditions – there are elements characteristic of *Molinia* meadows, *Festuca rubra* hay meadows as well. Protected species occurring in high numbers in the area are western marsh orchid (*Dactylorhiza majalis*), adder's-tongue (*Ophioglossum vulgatum*), sneezeweed (*Achillea ptarmica*), and marsh gentian (*Gentiana pneumonanthe*). The former two species

are more common in Area No. 1, while the latter two occur more often in Area No. 2. In Area No. 1, we can also find some small tufted-sedge (*Carex caespitosa*) and umbrosa sedge (*Carex umbrosa*) plants, and there are small populations of lemon day-lily (*Hemerocallis lilio-asphodelus*) in Area No. 2.

An outstanding faunistical value of the study sites is the fact that three large blue butterfly species (*Maculinea teleius*, *M. nausithous*, *M. alcon*) are present together. The mowing experiment was initially started in order to observe the response of species to the treatments, and it was done by the staff of the national park lead by István Szentirmai (Kőrösi *et al.* 2009). Some individuals of the specially protected corncrakes (*Crex crex*) also appear in this area every year.

Initial conditions

What we know about the study sites and the surrounding meadows is that these were used as grasslands since the 1940s (probably earlier too). People mowed these areas twice a year, and the aftergrass was even grazed in autumn. The areas were mowed – depending on the weather – between May and June, then between August and September. Hedges and road edges were grazed, too. After the early 1960s, when farmers were forced to join farmer's cooperatives, there was no grazing, only mowing twice per year. When the amount of livestock started shrinking in the 1990s, people abandoned most of the lands.

After the end of the decade and until the beginning of the experiment, the area of the study sites was randomly treated by mowing once per year. Giant goldenrod was already present sporadically and in small patches. The former botanical relevés made in experimental area No. 1 in 2008 show that once early mown sampling units close to the road have 40%, 25% and 4% of goldenrod presence, but once late mown sampling units close to the road and the centre of twice mown treatment stripes also had a presence of 10% or above. Regarding Area No. 2, when we recorded the initial site conditions, all treatment unit types had a high presence of goldenrod, especially those in the centre and close to the road. In the rest of the units, however, there were hardly any goldenrods present. The alternating values suggest that the overall results of the experiment were only slightly influenced by the initial state of infestation. Area No. 2 had been untreated for some years before the start of the experiment. This was a great opportunity for goldenrod to establish and spread. 50 meters away from this area there is a gas well. The necessary earthworks to build this also enabled goldenrod to spread faster. Area No. 2 is not only more humid than Area No. 1, but it is also more severely infested by giant goldenrod.

Methods used

We examined the response of giant goldenrod populations to mowing, while we kept changing the timing and the intensity. For this purpose, in 2007 we established two study sites near Magyarszombatfa (Fig. 1).

The two study sites were both divided into 16 sampling units of 20 × 20 m in size, all marked with wood stakes. These units fell into four categories: single mowing in early June; single mowing in early September; mowing both in June and in September; unmowed. This results in 4 sampling units per treatment type in both areas. In Area No. 1, the sampling units are ordered according to sections perpendicular to the stream, while those of Area No. 2 are organised into two rows between the stream and the road – the sampling units are mixed here. Management of the study sites has been carried out by the Őrség National Park Directorate, used RK-165 type drum mowers, leaving a stubble height of 8–10 cm.

The first botanical survey of the study sites was conducted in August 2008 (Bodonczi 2008), and we repeated it in 2014. During this, we took cenological relevés in the NNW corner of each 20 × 20 m sampling unit in a 2 × 2 m quadrant. The quadrants are always in the corner of a sampling unit because it makes them easier to find. Our experiences and suggestions are based on the relevant data of these rel-

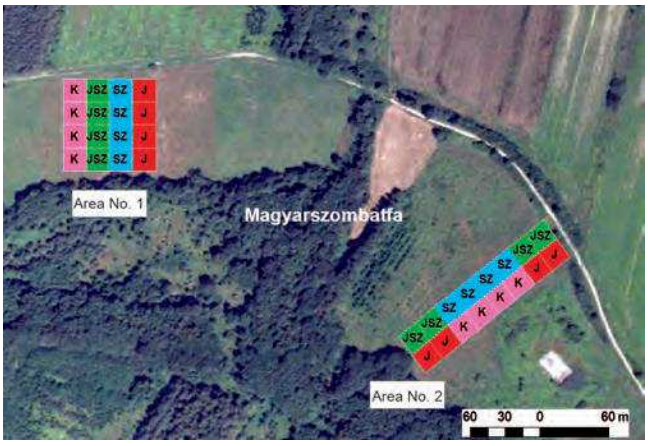

Fig. 1. Position of the study sites and the sampling units (K = untreated; JSZ = mowed in both early June and early September; SZ = mowed in early September; J = mowed in early June).

evés, but we also mention the response of protected plant and animal species present in the study sites. We also wanted to know if our experiences gained on these small-sized sample plots lots could be used on a larger scale under different circumstances, so we visited other areas infested by goldenrod within the territory of the national park in order to be able to provide suggestions based on more detailed observations.

We carried out interviews with the owner of the hayfield in order to reveal how the study sites were used in the past.

Experiences gained

Our experiment shows that after 8 years of treatment, giant goldenrod spread or thinned to different extents depending on the treatments used (Fig. 2). The chart represents the level of goldenrod cover in 8 sampling units per treatment types for both areas and both surveyed years. The most visible spread happened in the two unmowed areas: goldenrod became dominant in all but one abandoned sampling units. Experience shows that goldenrod prefers mesic grasslands in valleys that are not marshy. Without treatment, it can create stable, homogeneous populations in these areas, and it also hinders the growth of trees.

In general, we can conclude that a single early mowing is unable to stop the spread of goldenrod. The average cover increased in this type of treatment in both experimental areas. Although goldenrod does not able to bloom after early mowing, it starts a vigorous vegetative spread, displacing many native species. After mowing in May–June it has enough time to spread remaining in the growing season. Rangers of the area reported that sites mowed only once in June are in bad condition, and goldenrod is continuously spreading on them.

Single late mowing was, however, able to control or sometimes reduce the cover of goldenrod. This is not the case in the unit close to the road in Area No. 1. The reason is probably the high level of disturbance due to the maintenance works of the road and its ditch, or to the fact that the soil water conditions are the most balanced here. In September-mown plots stands of *S. gigantea* grow thinner, although remain permanent. These results suggest that it is more sensitive to mowing during the flowering period when most energy invested in sprout and florescence. Late mowing therefore weakens polycormons more efficiently. In addition, late mowing favours to the spread of native competitor species as well, which are more resistant to the colonisation of goldenrod.

It can be seen in both areas that approaching the stream – regardless of treatment – the cover of goldenrod decreased, and its populations are sparser, scattered in small patches (Fig. 3). This is because of the deep stream bed drains water from the area, thus creating unfavourable conditions for goldenrod. Under these circumstances, the species is more vulnerable to mechanical treatment. In case of treatment units close to the stream, there are smaller patches of goldenrod populations even in units of single early mowing. The reduced vitality level is also represented by their smaller size (Fig. 4).

Outstanding results were only achieved with twice mowing. This effectively prevented the spread of goldenrod, and it managed to eradicate it almost completely from areas that were severely infested in 2008. It has to be added, however, that goldenrod cover was not above 20% in any sample unit assigned for double mowing in 2008. Sometimes double mowing also has mixed results. In a visit near the village of Szőce, we found a small (200–300 m^2) hayfield – with mesic site characteristics – surrounded by forests that had been covered by a dense population of gold-

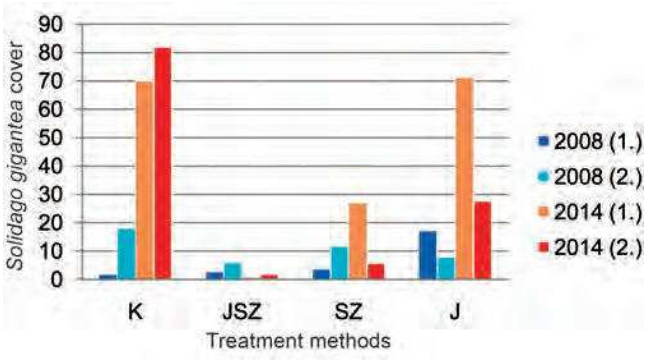

Fig. 2. Average cover of *Solidago gigantea* in pilot area No. 1 and 2 in 2008 and August 2014, based on the average of the 2 x 2 quadrants (U = untreated; JS = mowed in both early June and early September; S = mowed in early September; J = mowed in early June).

Fig. 3. In drier areas close to the stream, goldenrod populations are sparser, even in the untreated sampling units. (Photo: M. Szépligeti)

Fig. 4. In unfavourable conditions, giant goldenrod can be curbed with a single early mowing. (Photo: M. Szépligeti)

enrod before its treatment begun. It turned out that after 10 years of twice mowing, the invasive species is still dominant in the area (Fig. 5). Although there is a grassland patch with a good species composition less than 100 m away, it takes a lot of time for grassland species to appear on meadows surrounded by forests. Under wet and humid circumstances, exhausting the stolons of goldenrod is a very slow process. Again, the area close to the Szőce stream is less infested.

Regarding the most important protected species of the study sites, we can conclude that lemon day-lily, marsh gentian and sneezeweed spreads faster in wet areas that are mowed late. In treatment units mowed early or twice, these species are smaller, and they bloom rarely or not at all. Other researches revealed that ant species host to *Maculinea* larvae as well as corncrakes also prefer unmowed or late-mowed areas. The lack of treatment, however, quickly results in featureless vegetation and spreading weeds or trees. The hay mowed at the end of summer cannot be used as feed, thus its economic value is very low. In order to effectively control goldenrod and to restore the species pool of wet meadows, two times mowing per year should be considered.

There are no patterns for control planning, however. The first task in every case is to set the most important conservation goals. For this, the current state, the level of infestation and the distance of other potential seed sources has to be considered. For example, if we do not intend to utilise a bog meadow economically, and goldenrod is only sporadically present on it, a once, late mowing could be enough. In areas free of goldenrod it is not even necessary in every year. In other lands under agricultural use – and where the land is big enough –, it is suggested to leave a 5–20% patch of the area unmowed, but it has to be ensured that the rest of the land is free of goldenrod. In severely infested areas, significant results can only be achieved if the site is mowed twice (or even three times) per year. Cut material has to be disposed of immediately! Regeneration is slower in areas isolated from seed sources, but if the required resources are available and the area is important from the conservation aspect, small-scale mowing should be carried out several times a year in order to eliminate small goldenrod patches. In case of drying fen-meadows and mesic hayfields on hillsides, where there are no specially protected species, once early mowing is sufficient, but the spread of goldenrod has to be constantly monitored. Another mowing should be carried out if needed, at least in the infested patch.

It is advisable to change the timing and frequency of mowing from time to time, with leaving unmowed refuge areas. If goldenrod starts spreading in the habitat of valuable, protected species, twice mowing per year should be done for the next 3–4 years. If it is necessary, goldenrod-free refuge areas should be assigned for protected species.

Issues raised

We have no relevant experience of how goldenrod responds to grazing. This should be examined in the future.

So far, we only know that cattle, the most dominant grazing animals of the national park, do not eat old goldenrod individuals. However, they do eat young plants – especially when there is nothing else.

Cattle also cause damage to the plant as they trample on the stolons. There was a young, homogeneous goldenrod population covering a large area near the livestock farm of the national park directorate close to Őriszentpéter. When the animals were grazing the population for years, goldenrod completely disappeared in a short time. Based on this information, we consider grazing a viable temporal solution against homogeneous goldenrod populations on degraded sites, but in case of meadows in good condition (especially wet meadows), we recommend repeated mowing, as excessive grazing pressure can lead to infestation of other meadow-weeds.

Fig. 5. The area was previously covered by a homogeneous goldenrod population. However, after 10 years of mowing two times per year, the condition is still not satisfactory. (Photo: M. Szépligeti)

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