University of West-Hungary

PhD Thesis

Distribution, Biology and Control of Bush Grass (*Calamagrostis epigeios* /L./ Roth) in Hungary

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1. Introduction

Invasion of perennial weeds is one of the most serious problems during the reforestation especially in the case of clear-cut forest management. The most problematic weed of these is bush grass, forming large stands at several sites 2 to 3 years after tree harvesting. Its root system densely interweaves the upper layer of the soil. In invaded areas, acorns falling to the ground cannot germinate normally and the surviving seedlings are outcompeted by the unbroken canopy formed by the often 1.5-m tall weed plants. Dying culms with panicles are pressed down by the snow onto seedlings, hampering their budding and early development in the spring. The weed species has a significant impact on game populations, too. Its rough leaves are not eaten by big game species; however, its dense stands provide excellent hiding places, this is why woody regrowth is more exposed to game damage at locations severely infested by bush grass.

In agriculture, bush grass only forms large stands in fruit orchards; its importance in arable cultures is negligible. However, on abandoned fields it easily becomes dominant, regardless of the previous culture. It may invade pastures once grazing has stopped and, suppressing other species, spreads aggressively. The most significant problems are caused by bush grass in reforestation. Bush grass was listed by several botanical surveys performed in forests, yet its significance in forestry is not thoroughly known.

Bush grass may be controlled both mechanically and by herbicides in reforestation. Mechanical control is easily mechanised in artificially renewed forests; however, such control may only be performed by tiresome manual work in naturally renewed ones. Today’s conditions regarding human resources and forestry practices call for the use of herbicides. The chemical control method widely used earlier was based on Nabu S. However, as Hungary is now a member of the European Union, the registration of Nabu S has been withdrawn thus chemical control options are now limited.

2. Objective

In my thesis I tackled the following issues:

- distribution of bush grass in Hungarian forests, economic significance of the damage caused by the species and potential control options,
- site specific conditions affecting distribution,
- differences between the growth of populations from locations with different conditions,
- role of bush grass in the competition for nutrients,
- expanding chemical control options by means of recommendations for new technologies.

3. Material and method

The distribution of the species in Hungary and the economic significance of the damage caused by it were assessed by questionnaires. Questions were related to the local significance of bush grass, site specific conditions at the locations most often infested by it, control technologies, applied herbicides and control costs. I invited every forestry units belonging to the 22 state-owned forestlands to participate in my survey. Questionnaires were sent out in January and February 2012, hence the data collected applied to the year 2011.

To collect information on the site specific conditions affecting distribution, I performed surveys in forests in the vicinity of Sopron, Hungary (Soproni-hegység (Sopron Hills), Szárhalmi-erdő (Szárhalom Wood) and Dudlesz-erdő (Dudlesz Wood). Average height of plants and the number of flowering shoots as per square meter were assessed in 59 forest compartments infested by bush grass. Forest compartments were compared by analysis of variance according to average plant height, plant density and site specific parameters.

I collected soil samples from the root zone of the examined populations. By laboratory soil analysis, physical and chemical properties of the samples were measured. The relationship between the height and density of bush grass and soil parameters was determined by linear correlation analysis.

When examining growth rate, four different bush grass populations were compared. Populations differed in site specific conditions (climate and soil factors) and the severity of competition. Measurements were performed between 26 March and

24 June 2011. Every 8-10 days, the entire system of leaves and shoots above the ground from 10 average specimens were collected. Shoots were digitised by a flatbed scanner and leaf areas were determined. Later on, measured shoots were dried at 105 °C to constant weight and their dry weight was measured. Relying on leaf areas, dry weight values and the growth rate indexes calculated from the former, the growth rates of the sampled populations were compared.

Changes in the amounts of macro nutrients and micro nutrients were measured between 26 March and 24 June 2011. For the measurements, above ground shoots were collected every 8-10 days. The nutrient contents of shoots were determined by the ICP method.

To develop new control strategies against bush grass, I performed experiments with every gramicide registered and commercially available in Hungary. These experiments took 6 years. Herbicides and doses deemed efficient were also tested at a commercial scale. Experiments were aimed at finding the lowest efficient dose that reduces competition by the plant yet does not kill it, in accordance with the weed management practice of forestry. To reduce doses, experiments were also carried out with surfactants and additives promoting uptake by plants.

4. Results

The questionnaire was filled in by 81 forestry units. According to their replies, we may conclude that bush grass is the most problematic weed species in reforested areas of Hungary. Its significance varies according to location. Bush grass caused the most significant problems in Kisalföld (a plain in North West Hungary) and in the western and southern areas of Dunántúl (Transdanubia) that is in the western and south-western parts of Hungary.

Respondents described the control methods applied against bush grass on altogether 7428 hectares colonised by the species. In the total area covered by the answers, manual control, mechanical control by means of prime movers and chemical control were applied in 46%, 19% and 35%, respectively. Herbicides were used in the form of helicopter application, application by prime movers and manually on 50%, 30% and 20%, respectively. The significance of herbicide control varies according to location; however, herbicides are applied all over Hungary to battle the species.

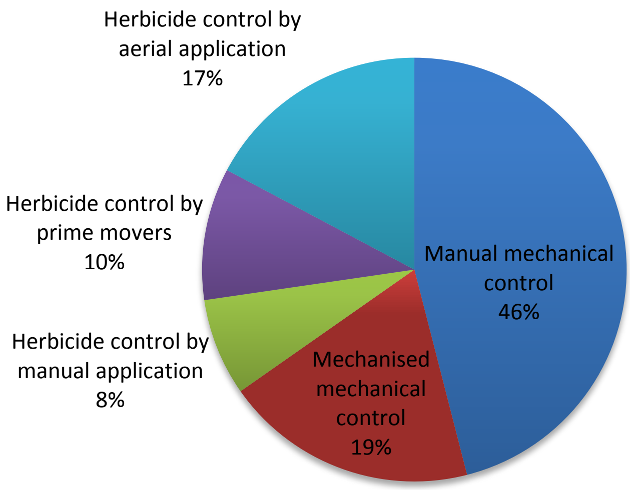

Figure 1. Control methods applied against bush grass in Hungary (2011)

In 2011, the highest costs were associated with manual mechanical control in national comparison (39 200 Ft/ha). The cost of control activities performed by means of prime movers was less than half as much (19 200 Ft/ha). Herbicide application costs more or less the same whether the chemicals are applied manually or in a mech-anised way. From control technologies, the lowest costs are associated with aerial application (18 900 Ft/ha). The total cost of chemical control is strongly influenced by the cost of applied herbicide and their dosage. The cost of herbicide could come to 30-50 % of total cost of chemical control (Figure 2.).

The specific costs of control methods varied significantly between locations. Average costs of bush grass control were the lowest in the Kisalföld region and the highest in southern Dunántúl.

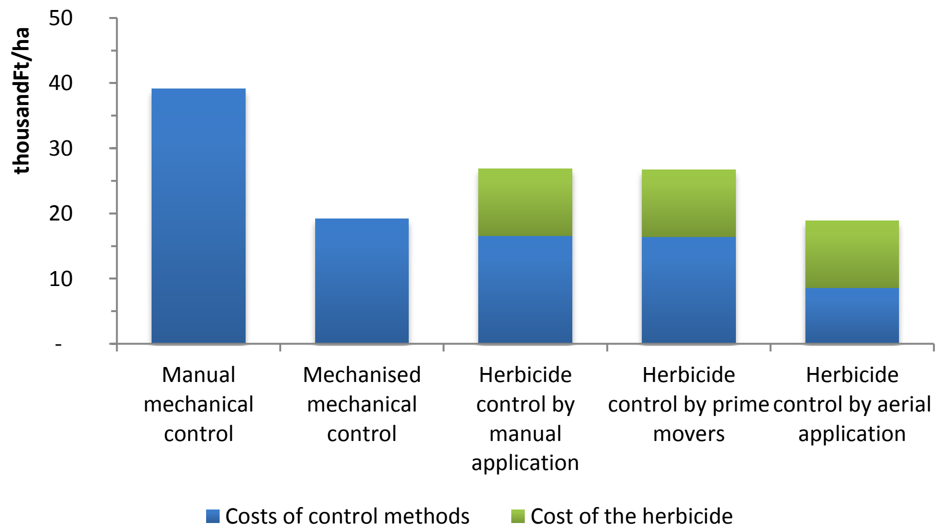

Figure 1 Specific costs of control methods applied against bush grass

In 2011, the use of 5 ones of the 8 gramicides registered in Hungary was permitted in forests. Respondents most often mentioned Fusilade Forte and Select Super, these two herbicides being applied most frequently for chemical weed control. Only few experts had professional experiences with the other herbicides available for the purpose. The two most widely used herbicides were often applied in higher doses than those in the permits and with unnecessary additives.

According to the results of my own experiments, I recommend Fusilade Forte, Select Super and Focus Ultra for the control of bush grass. For all three herbicides, dosage should be defined according to local conditions with special regard to stage of development of bush grass, its density and the height of saplings. Application is recommended to be scheduled for the spring, when bush grass has 2 or 3 leaves. The lowest doses still efficient in my experiments were as follows:

- Fusilade Forte 1.3 l/ha
- Select Super 1.8 l/ha + Bio-Film 0.5 l/ha
- Focus Ultra 1.5 l/ha + Dash HC 1.0 l/ha.

According to the answers received in the questionnaire survey, the sites most preferred by bush grass are characterised by dry or semi dry brown forest soils and an arid, warm macroclimate. Bush grass is a particularly problematic weed species in reforestation of sessile oak, English oak and Turkey oak forest stands where it is usually controlled by some means. It may also develop massive populations in renewed beech, Scots pine, black pine and northern red oak stands. Artificially renewed stands on clearcuttings southern slopes are particularly prone to infestations.

In the surrounding forest stands of Sopron, the highest coverage by the weed was observed in reforested areas of spruce, pine and oak forests. From the 3 climate zones corresponding to the sampled regions, the highest coverage by bush grass was measured in the sessile oak – hornbeam forest zone, on medium deep or deep luvisols, at 450-550 m a.s.l. However, none of the site specific or soil-related characteristics is able to significantly impact colonisation by itself. These factors probably affect each other as well, their interaction resulting in favourable or less favourable conditions for plants.

Within bush grass populations, individuals show significant variation in growth. However, according to the growth rate of average specimens best characterising populations, significant differences could be shown between populations growing under different site specific conditions.

Intensity of growth showed similar trends over populations. Until the middle of April, plants developed intensively. In the second half of April, leaf area values did not change much; then another intensive growth period followed in May. Growth slowed down again at the end of the month, then accelerated once more in June, until flowering.

The highest leaf area ratios (LAR) were calculated for young plants, with values steadily decreasing afterwards. Net assimilation rate (NAR) intensified only after 23 May. Relative growth rate values (RGR) were the highest at the beginning of the examination period for young plants and at the end of the period for flowering shoots. Relative leaf area growth rate (RLGR) varied, showing the highest values in the case of young plants at the beginning of May and at flowering.

Populations living under different climatic conditions but growing without interruption showed the largest differences in the spring. Under wet and cool conditions, bush grass buds later. Differences level off by May and stay within the 5% level of significance until the ripening of fruits.

The adverse impact by the closing canopy and thick layer of dead leaves can be detected in growth. Stands disturbed by such circumstances grow slower than undisturbed ones until the impacts are overcome; then in turn they grow more intensively. Because of the closing branches of young trees, bush grass develops less flowering shoots; however, the assimilation surface of such plants did not differ significantly from that of plants growing under similar site specific conditions but undisturbed. It means that even those individuals whose development is hampered by the developing trees and the thick layer of dead leaves accumulated in the previous year can exploit the potentials of the site and reach the same size as plants growing undisturbed.

The leaf area of the average specimen representing the population growing on a shallow, dry soil was smaller than that of the average specimen of the population growing on a soil with better water retention. While this difference levelled off in the period of intensive growing in May, the difference between the two populations became significant again in June.

The average leaf area of the population growing on the poorer soil lagged behind that of the plants growing on the better one.

Lower leaves died and gradually peeled off from flowering shoots in both populations. The reason behind this is probably the combined shadowing effect of the thick layer of dead grass and the continuously growing plants. Leaf loss was particularly significant in the population hampered in growth where it resulted in a temporary decrease of the assimilation surface.

The nitrogen demand of bush grass was the highest at the beginning of the examination period, showing a constantly decreasing trend afterwards. The amounts of potassium needed for intensive metabolism and magnesium catalysing synthetic processes were the highest in April, too, per unit weight of bush grass biomass. The amount of potassium decreased by the time of flowering while that of magnesium showed a relatively steady value. The phosphorus content of flowering shoots was the highest again in April in the period of intensive growth and decreased by the time of flowering. Microelement contents varied and showed little dependence on the pace of growth. From the examined heavy metals and toxic substances, chrome should be mentioned, where the highest value (4.5 mg/kg) was found in samples collected at the end of May. The natural chrome content of plants is 1-2 mg/kg; while higher amounts usually result in toxic symptoms in many plants, bush grass stayed healthy.

In the competition for nutrients, herbaceous plants only have a minor impact on woody regrowth. Forest soils are typically rich enough in nutrients; also, the root systems of tree seedlings develop more intensively than their above ground parts, soon outgrowing the upper soil layer interwoven by roots of herbaceous species. Regarding the uptake of nutrients, bush grass is considered a competitor for germinating oak acorns, seedlings or saplings planted as replacement. Bush grass is only able to outcompete older samplings for nutrients on poor, shallow soils. At such sites, bush grass's uptake of copper and manganese has the most significant adverse impact on the micro element stocks essential for tree seedlings.

5. Summary

Relying on my results, I described the significance of bush grass in forestry, the control methods applied against it and their costs according to various locations in Hungary. Regarding the replies to questions related to herbicide use we may conclude that weed control experts are not aware of the complete scale of herbicides available for the control of bush grass.

I assessed bush grass infestation levels in the renewed forests of Soproni-hegység, Szárhalmi-erdő and Dudlesz-erdő. I found no correlation between the height and density of bush grass stands and the site conditions of colonised locations.

However, the effect of the macroclimate, the soil water regime and competition of older tree on growth rate could be proved.

A detailed analysis was carried out for the nutrition uptake by flowering shoots. Results were compared to those of similar surveys and the role of bush grass in the interspecific competition for nutrients was established.

I performed experiments with every registered gramicide commercially available in Hungary and compared their efficiency against bush grass. The efficiency of recommendable technologies was tested at a commercial scale. According to the results of this series of experiments, I prepared recommendations for new technologies for forestry application.

6. Theses

1. Bush grass is one of the most problematic weeds species in Hungarian reforestations. Its significance is established as 3.27 on a 5-grade scale, the actual value varying according to location. The most severe problems are caused by the species in Kisalföld and the western and southern parts of Dunántúl. Bush grass is a particularly problematic weed species in reforested areas forests of sessile oak, English oak and Turkey oak forest stands where it is usually controlled by some means. It may also develop massive populations in renewed beech, Scots pine, black pine and northern red oak stands. During artificial reforestation clearcuttings on southern slopes are particularly prone to infestations.

2. In Hungary, bush grass is typically controlled mechanically. In 2011, manual control, chemical control and mechanical control by means of prime movers were applied in 46%, 35 % and 19% of the infested areas, respectively. Aerial application is often applied for chemical control; on half of the chemically treated areas, aerial application was preferred.

3. In 2011, the highest costs were associated with manual mechanical control in national comparison. The cost of control activities performed by means of prime movers was less than half as much. Herbicide application costs more or less the same whether the chemicals are applied manually or in a mechanised way. From control technologies, the lowest costs are associated with aerial application. The total cost of chemical control is strongly influenced by the cost of applied herbicide and their dosage. The cost of herbicide could come to 30-50 % of total cost of chemical control.

4. The specific costs of control methods varied significantly between locations. Average costs of bush grass control were the lowest in Kisalföld and the highest in the southern part of Dunántúl.

5. In 2011, chemical treatment in Hungary was based on herbicides selective for monocots and occasionally on those with the active ingredient glyphosate. The most often used herbicides were Select Super (active ingredient: clethodim) and Fusilade Forte (active ingredient: fluazifop-P). Forestry managers do not possess complete knowledge regarding available herbicides. From the respondents, nobody had practical experiences with Focus Ultra (active ingredient: cycloxydim). Doses and additives different from those in the permits of herbicides are often used for technologies which would also be efficient without additives.

6. I assessed bush grass infestation levels in reforestations of 59 forest compartments in Soproni hegység, Szárhalmi erdő and Dudlesz erdő. The height and density of bush grass populations were not strongly correlated to site specific or soil characteristics. At the examined locations, differences between site specific characteristics are not expressed enough to enable the determination of those having the most significant impact on the distribution of the species.

7. In the examined populations, the development of individual plants varied widely. According to the growth rate of average individuals taken from each population, significant differences could be demonstrated between populations being or not being subject to interspecific competition as well as those growing under different site specific conditions.

8. According to the results of 17 nutrients uptake analysis and comparison my data to similar experiments, I concluded that bush grass belongs to species with relative low nutrient requirement of the Hungarian flora. Its role in the competition for nutrients may be significant regarding the uptake of copper and manganese. It also uses relatively large amounts of chrome to build up its shoot system above ground without any damage.

9. From the results of 5 years of herbicide trials both at the scale of small plots and commercial production, I conclude that Select Super, Fusilade Forte and Focus Ultra could control bush grass effectively from the herbicides selective for monocots and registered for commercial use in Hungary. Through my experiments I proved that herbicides generally used in forestry are efficient at doses lower than

those in the permit. If my results are widely applied, the herbicide load on forestry and the costs of control may be reduced compared to respective current values.

7. The list of publications related with thesis:

Scientific papers:

- Varga Sz. – Molnár M. – Novák R. (2009): Gyomkorlátozási kísérletek szelektív egyszikűirtókkal erdősítésekben a siska nádtippan (*Calamagrostis epigeios* /L./ Roth) ellen – Növényvédelem 45. (4): 219-225.
- Molnár M. (2012): A siska nádtippan (*Calamagrostis epigeios* (L.) Roth) jelentősége Magyarországon, és az ellene való védekezés lehetőségei. Gyomnövények, gyomirtás, 13 (1): 24-38.
- Molnár M. (2014): A siska nádtippan (*Calamagrostis epigeios*) erdőgazdasági jelentőségégének vizsgálata kérdőíves módszerrel. Erdészettudományi Közlemények, 4 (1): (*in press*).

Presentations, posters:

- Varga Sz. – Molnár M. (2006): Erdészeti gyomkorlátozás – egyszikűirtó kísérletek az ERFARET kutatási program keretében, Alföldi Erdőkért Egyesület Kutatói Nap. Szeged, 2006. november 14.
- Varga Sz. – Molnár M. (2007): Környezetkímélő erdővédelmi technológiák fejlesztése: Gyakorlatban alkalmazható technológiák a gyapjaslepke (*Lymantria dispar*) és a siska nádtippan (*Calamagrostis epigeios*) ellen, NYME Erdőmérnöki Kar, Tudományos Konferencia. Sopron, 2007. december 11.
- Molnár M. – Novák R. (2008): Gyomkorlátozási kísérletek a siska nádtippan (*Calamagrostis epigeios*) ellen, XIV Nemzetközi Környezetvédelmi és Vidékfejlesztési Diákkonferencia. Mezőtúr, 2008. július 02-04.
- Varga Sz. – Molnár M. – Novák R. (2009): Gyomkorlátozási kísérletek erdősítésekben a siska nádtippan ellen, Tavaszi Szél 2009 (Doktoranduszok Országos Szövetsége). Szeged, 2009. május 21-24.

- Varga Sz. – Molnár M. (2009): Erdőfelújítások növényvédelme, alkalmazott technológiák, vegyszerek – Alföldi Erdőkért Egyesület, Erdőművelési és Környezetvédelmi Szakbizottsági ülés, Szeged-Dóc, 2009. október 1.
- Varga Sz. – Molnár M. – Novák R. (2009): Gyomkorlátozási kísérletek tölgy erdősítésekben szelektív egyszikűirtókkal a siska nádtippan ellen, NYME Erdőmérnöki Kar, Kari Tudományos Konferencia. Sopron, 2009. október 12.
- Molnár M. (2011): A siskanád (*Calamagrostis epigeios* [L.] Roth.) elleni védekezési kísérletek eredményei. NYME Erdőmérnöki Kar, Tudományos Doktorandusz Konferencia. Sopron, 2011. április 13.
- Molnár M. (2013): Erdőfelújításokban megjelenő gyomnövények jelentősége Magyarországon. NYME Erdőmérnöki Kar, Kari Tudományos Konferencia. Sopron, 2013. december 10.

Proceedings and Book of Abstracts:

- Varga Sz. – Molnár M. (2006): Erdészeti gyomkorlátozás – egyszikűirtó kísérletek az ERFARET kutatási program keretében In. Szulcsán G. (szerk.): Alföldi Erdőkért Egyesület Kutatói Nap: 110-121.
- Varga Sz. – Molnár M. (2007): Környezetkímélő erdővédelmi technológiák fejlesztése: Gyakorlatban alkalmazható technológiák a gyapjaslepke (Lymantria dispar) és a siska nádtippan (*Calamagrostis epigeios*) ellen In. Lakatos F. és Varga D. (szerk.): Erdészeti, környezettudományi, Természetvédelmi és Vadgazdálkodási Tudományos Konferencia (EKTV-TK): 180-181.
- Molnár M. – Novák R. (2008): Gyomkorlátozási kísérletek a siska nádtippan (Calamagrostis epigeios) ellen. In: Krizsán J. (szerk.): XIV. Nemzetközi Környezetvédelmi és Vidékfejlesztési Diákkonferencia, Szolnoki Főiskola Műszaki és Mezőgazdasági Fakultás: 93.
- Varga Sz. – Molnár M. – Novák R. (2009): Gyomkorlátozási kísérletek erdősítésekben a siska nádtippan ellen In. Tavaszi Szél 2009 Konferencia-kiadvány: 533.
- Varga Sz. – Molnár M. – Novák R. (2009): Gyomkorlátozási kísérletek tölgy erdősítésekben szelektív egyszikűirtókkal a siska nádtippan ellen In. Lakatos F. – Kui B. (szerk.): Kari tudományos konferencia: 103-105.
- Molnár M. (2011): A siskanád (*Calamagrostis epigeios* [L.] Roth.) elleni védekezési kísérletek eredményei. In. Lakatos F. – Polgár A. – Kerényi N.V. (szerk.): Tudományos Doktorandusz Konferencia: 181-184.

- Molnár M. (2013): Erdőfelújításokban megjelenő gyomnövények jelentősége Magyarországon. In. Bidlo A. – Szabó Z. (szerk): Kari Tudományos Konferencia – a konferencia előadásainak és posztereinek kivonata. 119.