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Effect of Silver willow "Russian olive" (*Elaeagnus angustifolia*) on extensive sheep management

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SUMMARY

We carried out a study in the Karcag Research Institute, which affected the areas of narrow-leaved silver willow. In the framework of this research, we performed Balázs's coenology, and thus established the degree of Borhidi degradation, which resulted in the fact that the areas of the silver willow were degraded practically irreversibly, the diversity of the grassland has decreased. We consider it very important to study these grassland areas of silver willows, as they can provide an additional fodder base for sheep grazing, which will also increase the sustainability of the grassland. The obtained soil analysis results show that the soil samples of the silver willow areas are richer in nitrogen (p-value: 0.006) and phosphorus (p-value: 0.003) than the examined control area.

Keywords: *Elaeagnus angustifolia; grassland diversity; soil analysis; Balázs's coenology; Borhidi's degree of degradation*

INTRODUCTION

Elaeagnus angustifolia is indigenous at the warm, continental parts of Asia. The most massive stocks of the species are found in the Caspian Depression and in the area of Lake Aral, where it is a typical species of the vegetation accompanying the water-courses of the semi deserts. Neither massively saline soil, nor polluted city environment can impede its spread. It is capable of surviving between minus 45 and plus 46 degrees. As an invasive species, it conquers mostly at plain areas. Its lifespan could even be about 100 years (Bartha and Csiszár, 2012). Its first occurrence at the Carpathian Basin is from the age of Turkish occupation; the Ottomans planted it for its aromatic flowers, and later it simply stayed with us (Gencsi and Vancsura, 1992). In the 18^{th}–19^{th} Centuries it is referred as an ornamental tree, under the names of "tomato tree" or "hairy cat". Its Hungarian name – Silver Tree – was created by Diószegi (1813). Its rural names are Hungarian oil tree, oil willow, and silver willow. It soon became popular among foresters, as Kiss (1897) writes: "in places, where locust could hardly take roots, and its growth is almost unnoticeable, this tree species grows merrily, easily overcoming the vicissitudes of weather." The same statement is reflected in the writings of Binder (1901), Mágocsi and Dietz (1906), as well as Bernátsky (1913). The antecedent of its large-scale forestry patronization is the Forestry Act of 1923, concerning the afforestation of the Great Plain. Magyar (1929) declared that "it is a species of almost indispensable importance at saline forest establishments". The ideology was, that the Russian olive could be an afforestation "outpost" during the establishment of forests on saline soils, before the plantation of other, more valuable tree species. Anon (1927, 1928), Rapaics (1928), Dorschner (1931), and Pászthory (1935) all took stand for the preference of Russian olive. Thus, until the Millennium, it was planted massively in our native environments as woodland fringe or hedge, utilizing its frugal nature, and its really relevant bee-feeder role (Binder, 1901; Lády, 1952). Tóth (2012) mentions that in the 50's, a massive spread of Russian olives planted in dry grasslands could be observed; an example for this is the achievement of the 10% forestation of Szolnok County by so called no-woodland tree establishments. As the VI. Act of 1961 about the protection of the lands in agricultural utilisation declares: „On our cohesive soils, the emphasis has been put on the mixed plantation of pedunculate oak, domestic cottonwood and Russian olive in the course of no-woodland afforestation efforts." During the 1970's and 80's – emphasizing its role in wildlife management as well as its "urban" characteristics – the targeted plantation of Russian olive continued steadfastly, although for example Kárpáti (1982) also wrote about its massive spontaneous spread. The essay of Bartha and Mátyás (1995) already reflects nature conservation interests, stating that "…in the recent years an aggressive spread [of Russian olive] can also be observed". At the same time, according to the National Forestry Sapling Inventory, 931.100 Russian olive saplings were still raised in 2002. In the classification of native neophytons of invasive aspects (Balogh et al., 2004), Russian olive is a transformative invasive species, which is the most adverse category concerning nature conservation interests. More and more advertisements drew attention to the invasive spread of Russian olive (Botta-Dukát and Balogh, 2008; Bölöni et al., 2011; Dancza, 2012; Csiszár and Korda, 2015; Korda, 2019). According to Korda (2019) its settlement has to be taken into consideration even in massively saline biotopes, thus the prevention of its spread could be possible by the elimination of propagulum sources. Recently, there are also legislations to control its plantation and spread. The 269/2007 (X.18) government decree stipulates the necessity of the confinement of Russian olive at the grassy areas of Natura 2000. In 2009, the invasive nature of Russian olive also became legally established.

Thus, at our native pastures, Russian olive is a feral, transformative invasive species. However, for a

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correct, complete image, we have to mention two, recently "hyped" subject concerning the silver willow, which could transcend this species into a hidden treasure. On the one hand, intensive international research has started due to the remarkable anti-oxidant content (Cansev et al., 2011; Okmen and Turkcan, 2013; Che et al., 2014) as well as the antibacterial effects (Deghan et al., 2014; Yridim et al., 2015) of Russian olive.

Since Russian olive is a cognate of sea-buckthorn, its effects against cancer cells receive more and more confirmation (Abizov et al., 2008; Ya et al., 2015; Sahan et al., 2015; Hamidpour et al., 2017).

Another subject concerning Russian olive is the N-fixation by the use of ray fungus (Khamzina et al., 2009; Bittsanszky et al., 2014). The research of these latter authors have inspired us to conduct soil examinations concerning pasture-Russian olive relations. Regarding the structure of Russian olive vs. grass associations, it is known for long that due to its nitrogen-fixing characteristics, the species promotes the proliferation of nitrophile vegetation, e.g. stinging nettle (*Urtica dioica*), white goosefoot (*Chenopodium album*) (www.kertlap.hu). Beyond that, it can affect the phitomass of the area by the impedance of mechanical mowing and stem-chopping on the pastures where it is allowed to settle (remark: these pastures are usually under continuous grazing utilisation), thus the rate of unutilised pastures increases while the succession processes and the starting of afforestation processes could accelerate (Hansson and Fogelfors, 2000; Kozák, 2011; Bajor et al., 2016). The advancement of the succession processes on the pasture could endanger the existence and subsistence of the existing grass components Penksza et al., 2015; 2016; Pápay, 2016). According to Perevolotsky and Seligman (1988), the transformation of the pasture into an impenetrable scrubland generates a so-called "green desert" condition, thus reducing the diversity of the area and increasing the frequency of wildfires.

Our research objective on the one hand was a review of international specialized literature dealing with Russian olive vs. pasture management, and on the other hand, the clarification of the effects that this invasive species have upon the plant structure of the grass association, and on the soil layer that is important for pasture management, by the use of specific coenology and soil examinations.

MATERIALS AND METHODS

We conducted our research at a pasture bearing the lot number 01712/1, which be-longs to the Karcag Research Institute. The altitude of the experiment area was 83 m above sea level. The average precipitation of 50 years is 503.4 mm. The type of the soil was medium grassland solonetz. The grass association at the area is *Artemisio-Festucetum pseudovinae*, and as such, subject to the "Natura 2000" nature conservation regulations; it is utilised in extensive pasture management (one mowing per year, sheep grazing on the second harvest) since 1987. Before 1987, as far as records go back, the area that was completely free of woody vegetation, and was utilised in extensive sheep grazing. In 1990, for the purpose of wind protection, coppices were planted, whose underbrush fringes consisted of Russian olives. In the last 30 years, Russian olives have started to conquer the grass-covered areas.

We have conducted our investigations on open grass, as well as on the areas limited by the canopy edges of quarter-of-a-century-old Russian olive witness trees, that are lo-cated sporadically in the grass association. We selected 2 by 2 metre square areas (EF1-EF5) under five Russian olive giants, where we implemented coenological records using the quadrat method of Balázs (1949). The botanical recording was also implemented on five representative grassy areas (EK1-EK5 – further on: control area). The scientific nomenclature of the identified plant species was recorded according to Király (2009). Following the coenological records, according to their ecologic conditions, we have classified each species into the categories of Social Behaviour Types by Borhidi (further on: SBT) (1993). In the course of the observations, the degree of degradation (degree of degradation – Dʃ) was determined on the basis of the coverage rates of the species that connote degradation and the species that connote naturalness, according to the SBT categories of Borhidi. The species that connote naturalness are classified into the groups of specialists (S), competitors (C), generalists (G), natural pioneers (NP), while the species connoting degradation belong to the groups of disturbance tolerant (DT), natural weed species (W), introduced foreign species (I), alien species (A), ruderal competitors (RC), and aggressive, adventitious invasive species (AC). The uncovered area was excluded from the calculations. According to Borhidi [45] the degree of degradation was calculated by the following formulae:

$$\text{Degree of degradation } (D\int) = (\Sigma DT + \Sigma W + \Sigma I + \Sigma A + \Sigma RC + \Sigma AC) / (\Sigma S + \Sigma C + \Sigma G + \Sigma NP). \quad (1)$$

At each recording location, we took samples from the 0-10 cm thick soil layers, which were analysed by so-called extended soil analysis in the accredited laboratory of the Karcag Research Institute (number of research schedule: T-45/20). The general analysis of soil samples was conducted according to Kalocsai et al. (2002). The comparison of the areas was done by Microsoft® Excel, by the additional use of variance analysis.

RESULTS AND DISCUSSION

On the basis of Balázs's coenological recordings we have established that the diversity of vegetation was higher on the control area (*Table 1*). The most dominant

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species of the areas under the canopy of Russian olives was *Bromus tectorum*, whose coverage on these areas fluctuated between 31.25-84.375%. Contrary to that, on the control area, the main component of the association was *Festuca pseudovina*, whose coverage varied between 37.5-53.125%. Upon the evaluation of Borhidi's degree of degradation, we came to the conclusion that the vegetation coverage under the Russian olives (EF1-5) has been a subject of strong degradation; the original association transformed, just as Balogh et al. [18] concluded upon their investigations. The EF1, EF2, EF3, EF5 areas almost exclusively consisted plant species that connote degradation, thus the calculation of the exact degree of degradation became unnecessary. The degradation degree of EF4 area was 5.4. The degree of degradation concerning the control area stayed under the critical 1.0 value: EK1: 0.164; EK2: 0.085; EK3: 0.085; EK4: 0.123; EK5: 0.231.

Table 1. **Balázs's coenological survey results and a Borhidi's Social Behavior Types (Karcag, 2020)**

Treatment	Species	Covering (%)	Borhidi's SBT	
			Sign	Value
EF1	*Bromus tectorum*	81.25	DT	2
	Hordeum murinum	9.375	W	1
	Elymus repens	6.25	RC	2
	Conium maculatum	3.125	RC	-2
EF2	*Bromus tectorum*	78.125	DT	2
	Hordeum murinum	15.625	W	1
	Elymus repens	6.25	RC	-2
EF3	*Bromus tectorum*	84.375	DT	2
	Galium aparine	6.25	W	1
	Hordeum murinum	6.25	W	1
	Conium maculatum	3.125	RC	-2
EF4	*Bromus tectorum*	31.25	DT	2
	Capsella bursa-pastoris	28.125	W	1
	Vicia tetrasperma	15.625	DT	2
	Poa pratensis	12.5	G	4
	Elymus repens	6.25	RC	-2
	Hordeum murinum	3.125	W	1
	Podospermum canum	3.125	G	4
EF5	*Bromus tectorum*	75	DT	2
	Galium aparine	18.75	W	1
	Hordeum murinum	6.25	W	1
EK1	*Festuca pseudovina*	42.1875	C	5
	Trifolium angulatum	21.875	S	6
	Festuca rupicola	12.5	C	5
	Alopecurus pratensis	6.25	C	5
	Euphorbia cypriassias	6.25	DT	2
	Plantago lanceolata	6.25	DT	2
	Podospermum canum	3.125	G	4
	Artemisia absinthium	1.5625	W	1
EK2	*Festuca pseudovina*	53.125	C	5
	Trifolium angulatum	18.75	S	6
	Festuca rupicola	15.625	C	5
	Plantago lanceolata	3.125	DT	2
	Podospermum canum	3.125	G	4
	Alopecurus pratensis	1.5625	C	5
	Artemisia absinthium	1.5625	W	1
	Bromus hordaceaus	1.5625	DT	2
	Inula britannica	1.5625	DT	2

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Table 1. continued

Treatment	Species	Covering (%)	Borhidi's SBT	
			Sign	Value
EK3	*Festuca pseudovina*	40.625	C	5
	Trifolium angulatum	31.25	S	6
	Festuca rupicola	9.375	C	5
	Podospermum canum	6.25	G	4
	Alopecurus pratensis	3.125	C	5
	Plantago lanceolata	3.125	DT	2
	Artemisia absinthium	1.5625	W	1
	Convolvulus arvensis	1.5625	RC	-2
	Eryngium campestre	1.5625	DT	2
	Poa pratensis	1.5625	G	4
EK4	*Festuca pseudovina*	42.1875	C	5
	Trifolium angulatum	28.125	S	6
	Festuca rupicola	9.375	C	5
	Alopecurus pratensis	6.25	C	5
	Plantago lanceolata	3.125	DT	2
	Podospermum canum	3.125	G	4
	Achillea collina	1.5625	DT	2
	Artemisia absinthium	1.5625	W	1
	Bromus hordaceaus	1.5625	DT	2
	Eryngium campestre	1.5625	DT	2
	Euphorbia cypriassias	1.5625	DT	2
EK5	*Festuca pseudovina*	37.5	C	5
	Trifolium angulatum	15.625	S	6
	Poa pratensis	9.375	G	4
	Alopecurus pratensis	6.25	C	5
	Festuca rupicola	6.25	C	5
	Erodium cicutarium	3.125	W	1
	Euphorbia cypriassias	3.125	DT	2
	Plantago schwarzenbergiana	3.125	Sr	8
	Podospermum canum	3.125	G	4
	Artemisia absinthium	1.5625	W	1
	Bromus hordaceaus	1.5625	DT	2
	Convolvulus arvensis	1.5625	RC	-2
	Eryngium campestre	1.5625	DT	2
	Lathyrus tuberosus	1.5625	W	1
	Plantago lanceolata	1.5625	DT	2
	Sonchus arvensis	1.5625	W	1
	Vicia tetrasperma	1.5625	DT	2

According to the outcomes of soil analysis, we established that the investigated areas classify among heavy clay soils, further on, they contain slight amount of solonchak, and are slightly calcareous soils, whose humus content is quite good. *Table 2* contains the examination values of the average soil samples both from the areas under Russian olive canopies and the control area. By the use of variance analysis (*Table 2*) we have con-firmed that concerning the soil under the Russian olives, the pH values are (22.25%) higher, (NO_2+NO_3)-N content is (371.17%) higher, P_2O_5 content is (98.45%) higher, S-SO_4 content is (68.85%) higher, and Cu content is (59.11%) higher, thus we have received a significant outcome. The high content of N confirms the research outcomes of Khamzina et al. (2009). Also, the soil layers under the Russian olives have higher values of Soil plasticity of Arany (13.53%), salt content (72.73%), $CaCO_3$ content (34.90%), humus content (5.86%), and K2O content (27.03%); however this comparison could not present a significant outcome. However, Na content (310.98%), Mg content (9.63%), Zn content (40.16%), and Mn content (140.11%) was higher at the control area; we also could not present any confirmed correlations between these data. At the same time, upon the evaluation of our outcomes, one has to take into consideration that for comprehensive conclusions, a significantly higher volume of investigated elements would have been necessary.

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Table 2. **Mean results of soil testing measured in silver tree areas and control areas and p-values of variance analysis (Karcag, 2020)**

	Silver tree	Control area	p- value
pH	6.99	5.72	0.045
Soil plasticity of Arany	68.80	60.60	0.160
Salinity (m/m)%	0.04	0.02	0.088
$CaCO_3$ (m/m)%	3.49	2.59	0.310
Humus (m/m)%	6.50	6.14	0.270
(NO_2+NO_3)-N (mg kg^{-1})	15.36	3.26	0.006
P_2O_5 (mg kg^{-1})	153.6	77.40	0.003
K_2O (mg kg^{-1})	507.6	399.6	0.174
Na (mg kg^{-1})	52.80	217.00	0.053
Mg (mg kg^{-1})	471.60	517.00	0.545
SO_4-S (mg kg^{-1})	15.50	9.18	0.003
Zn (mg kg^{-1})	2.54	3.56	0.260
Cu (mg kg^{-1})	4.06	6.46	0.013
Mn (mg kg^{-1})	69.80	167.60	0.123

The emergence and rapid spread of the diverse, so called invasive plant species can be also considered as a chronic reflection about the situation of our native grassy biotopes. In our manuscript, we undertake the study of a plant species that originally served as a garden ornament for centuries, but later, in the 20th Century – when human negligence became paired with the outstanding adaptability of the species – our plant started its conquering journey. An axiom, that the soils with the poorest qualities are the first to be neglected, and we are right at our grasslands with saline soil characteristics, where the seemingly unstoppable decrease of livestock leads to under-, and later zero utilization. According to the ancient order of nature, at these locations, the flora tends to move towards closing succession, which – concerning domestic conditions – could be a forest association, but concerning our saline grasslands, all these occur with some additional features. Namely, the climax association at our native neglected, or abandoned meadows is often a Russian olive "forest".

The outcomes of the coenological examinations at the areas under the canopy of Russian olives confirmed the establishment of Stefan (2018), namely that the area can be declared as a subject of degradation, since according to the SBT, the degradation values present an outcome that is above 1. The compound of the vegetation structure at the areas under the canopy of Russian olives confirm the establishments of Balogh et al. (2004), and Csiszár and Korda (2015), namely that Russian olive is a transformative invasive species. The investigated shrub species is also capable of spreading on shallow "A" level worm-wood-grass pastures, thus confirming the statement of Korda (2019) concerning the spread of Russian olive at areas with the poorest soil conditions. In summary, we can establish that the invasion of Russian olive at our saline pastures is also a problem that cannot be ignored. That is because the prestige loss of our pasture management that appears prognostically at several places is beneficial to the spread of this invasive species.

CONCLUSIONS

The sustainability of plant diversity of grassland associations of steppe origin, an important element of the Pannonian flora, is of common European interest. The corner-stone of this task is, in addition to nature-friendly management, the reduction of the spread of invasive plant species.

The aim was to establish a database through the study of the Cenological and soil biotope of *the Eleaganus angustifolia*, which is widely distributed in the Solonetz soil conditions of the Transdanubian grasslands. During our experiment, we clearly demonstrated a high degree of degradation of the original *Artemisio-Festucetum pseudovinae* grassland structure in the area of the studied 30-year-old solitary invasive tree canopy, as well as the enrichment of several macro- and microelements in the upper 10 cm soil layer.

These results encourage us to set up further experiments to refine our database.

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