SZENT ISTVÁN UNIVERSITY
ENVIRONMENTAL SCIENCES PhD SCHOOL

IMPACT OF BIOMASS UTILISATION BY GOATS ON SOME NATURAL AND REPLANTED GRASSLANDS

PHD THESIS

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1. BACKGROUND AND OBJECTIVES

There are new challenges for global agriculture due to the changing circumstances in natural and economical world. Many professionals mentioned that our current agricultural methods not suitable to produce proper amount and quality foods. We have to change from the conventional farming to a sustainable agriculture to reach a well performing global agriculture what consist local viable agro systems. The organic farming as one type of sustainable agriculture, is a developing sector where the market and economical competition is growing. There is an opportunity to produce high quality food without additives in Hungary based on the climate, good quality soil as well traditional plant and animal species. The hungarian government set better balance between animal husbandry and arable farming as target and focusing on family farming and organic farming.

The sustainable animal production systems has to have two pillars (Thomson és Nardonne, 1999.):

enough local resources,

secure long term operation.

The most important local resources are the water source and the good quality feed production capacity (Horn et al., 2001). Our ruminant species were born and selected on grasslands so it is obvious to the best production place and best feed to them is the pasture (Vinceffy, 1993) additionally the mandatory conditions of organic farming ask acces to open spaces or pasture. Easy to see that the grazing is stimulates metabolism, give better digestion and the herbaceous vegetation rich in vitamins and amino acids which have a beneficial effect on milk production (Csukás, 1952). By planting high diversity grasslands, these grasslands provide good quality forage in areas that are not well utilised by other forms of farming.

Grassland management systems play an important role both economically and in terms of nature conservation among extensive agricultural systems in Hungary because about one third of our protected animal and plant species and many endangered community connected to them. Approx. 11% of Hungray, about 1 million hectares of land is under grassland the majority of which can be used as pasture and a smaller part as meadow (meadow and pature mixed). Almost 70% of our grassland have low productivity and only the 5% have good productivity. The reason for this is that they have survived mainly in areas with unfavorable site conditions, where environmental conditions, especially poor soil conditions, are characteristic.

The situation is further aggravated by the high fragmentation of our grasslands. It is estimated that more than 50% of the Hungarian grasslands, some 500 thousand hectares, are extensively managed and thus potentially valuable from a conservation point of view.

The government’s goal is to develop family and small famrs in Hungary. In the case of small farms, keeping small ruminants, especially goats, with a narrow range of material and technological options can be a good solution. Few farms in Hungary produce goat-based animal products based solely on goats within the framework of organic farming, so the market opportunities are still open. In the European Union, for example, there is no quota for goat milk production, unlike cow's milk, which can also provide export opportunities.

The aim of my research is to investigate, through natural and sown grasslands, how to provide alternative utilization of areas unsuitable for arable production, and to prove that other native plants, previously considered as weeds, can be introduced into grassland production based on ecological needs, thus helping to create and maintain larger livestock. It may be particularly interesting to gain experience not only in the use of certain invasive species as feed, but that this scientific result can help in the ecologically and economically regeneration of weedy grasslands, and the re-use of abandoned agricultural land.

Objectives:

To sowing grasslands:

- Plantability and cultivation of grass and fodder plant seeds mixed with dicotyledonous plants in different mixtures, with special emphasis on replanting secondary grasslands formed in loess.
- Selecting the technology for the replanting (using low mechanization or animal power).
- Testing the success and efficiency of planting in untreated grasslands.
- Changes and examination of the coenological conditions of the re-sowing grasslands

To natural grasslands:

- Botanical investigations of domestic goat pastures.
- Assessing the vegetation of the studied areas.
- Establishing the state of naturalness on the basis of the ecological needs of plant species.
- Analysis of habitat and habitat spectra of areas.

To animal feeding:

- The ability to be as feed for goats of the invasive bushgrass (*Calamagrostis epigeios*) and the giant goldenrod (*Solidago gigantea*)?
- What are the nutritional values of these species?

2. MATERIALS AND METHODS

I processed the data of three independent experiments in this dissertation. The first is investigation of pasture type grassland planted with several species rich seed mixtures of ours in Bakonycsernye. Here I analyzed the effect of the planting methods and the applied seed mixture on the settling of the grassland and on the possibilities of utilization according to the organic goat keeping aspects. Investigation, evaluation and comparison of the results of the re-seeding with the grass seed mixture for the improvement of the pasture area of a small goat farm in Nagyréde.

The second is to study the species composition of grasslands grazed by goats in several parts of the country to analyze and evaluate the effect of grazing goats on changes in the species composition of grasslands.

Part three is a feeding study of two important invasive plants, the Bushgrass (*Calamagrostis epigeios*) and the Giant goldenrod (*Solidago gigantea*).

In first part we tested a total of three grass seed mixtures of different compositions in four replicates in Bakonycsernye: a traditional legume-grass (K1), a complete mix with legumes, grass and herb species (K2) and a mixture of legumes and herbs only (K3). Species included in the experiment were selected from indigenous grassland creators that matched the area's habitat.

The vegetation of the following goat pastures was examined as second part:

1. in Kaposzerdahely where grazing is carried out on abandoned arable land. The area has been abandoned for 3 and 5 years and has a lawn that. In addition, a wet reed area was grazed.

2. in Kaposdada, where owner is keeping goats on "pristine grass", a natural grassland close to nature. The sample area is sloping, so the upper (LFH) and the lower third (LAH) of the slope were recorded, as well as the most intensively used terrain of the pasture, as a part of the paddock.

3. In Nagyréde, where the grassland created on abandoned arable land, on the control areas of the pasture not affected by the inoculation experiment.

The coenological samples were taken in Kaposdada and Kaposszerdahely in June 2014, Nagyréde in July 2019 using Braun-Blanquet (1964) method using 2 × 2 m squares, but% cover of each species was recorded in 10-10 reeds with 3 quadrates. The species names follow the nomenclature of Király (2009).

The studied areas were evaluated on the basis of Borhidi's relative plant ecological indicators (Borhidi 1995) according to NB (relative values of nitrogen demand) and WB (relative indicators of groundwater and soil moisture). The distribution of conservation value categories (TVK) was done according to Simon (2000), and the evaluation based on social behavior types (SZMT) was done according to the work of Borhidi (1995).

To analyse the complete data structure, we included different ordination procedures in our study. These help us to interpret the original (multivariate) data structure using variables derived from the original variables, which cover as much of the variance of the original data structure as possible. Of the indirect ordination methods, principal component analysis (PCA) and detector correlation analysis (DCA) are the most common methods. The former attempts to describe the linear relationship of variables (species) along a hypothetical background gradient, while the other assumes a unimodal (ie, maximum) response curve. With DCA, it is possible to represent objects and species in the same coordinate system using an interactive method, which is why we chose this method for data analysis. The ordination space is determined by the number of ordination axes scaled to scatter units for DCA. The first version was produced by Ross Ihaka and Robert Gentleman (1996).

3. RESULTS

3.1.The results of seed mixture sowing experiment

The first year results of the Bakonycsernye plant surveys show that despite the extremely dry and hot weather, a significant proportion of the germinating seeds in the spring hatched and successfully settled in the experimental area. Among the perennial species of the mixture, some specimens of *Coronilla varia*, *Vicia sativa* and *Lotus corniculatus* had flowered in the first year and spread later in the study.

Due to the lack of rainfall, only a few specimens of *Festuca rupicola* were observed in the first year, which also settled in the following years. It may also be suitable for the appearance of species of K1 and K2 mixtures containing grasses and herbs and thus for its suppressive effect on weeds. Typical autumn germinating species are *Festuca rupicola, Achillea cf. millefolium*, *Centaurea jacea*, and plants sprouting in summer but with low growth in the first year: *Linum perenne, Galium verum* multiplied in subsequent years of the study.

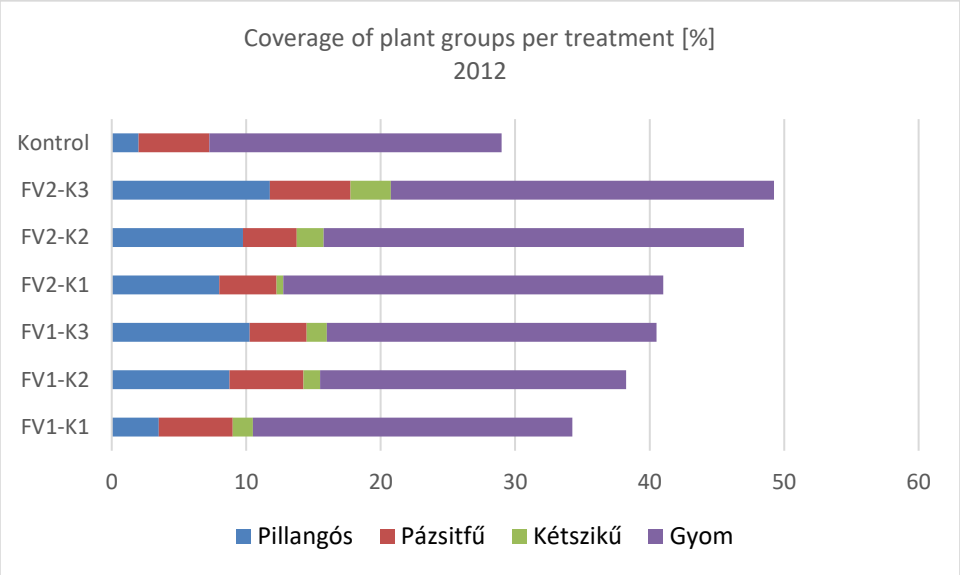
The treatments and mixtures resulted in a significant positive change in the species composition of the experimental plots in the first year compared to the control plots. The number of non-sown (weed) species varied between 5 and 10 species in the treated plots, which was equal to the average number of weed species in the control plots. The species composition of the weeds was also the same. At the same time, the total number of species increased by more than 40% in both treatments, as a result of sowing and successful colonization of grassland species. With respect to the total number of species (sum of the number of species determined in each plot), about 5% more useful species were found in the unprepared plots compared to the prepared one, which also suggests that more effective in increasing the number of species.

3.2.Changes in the number of sown species during the experimental period

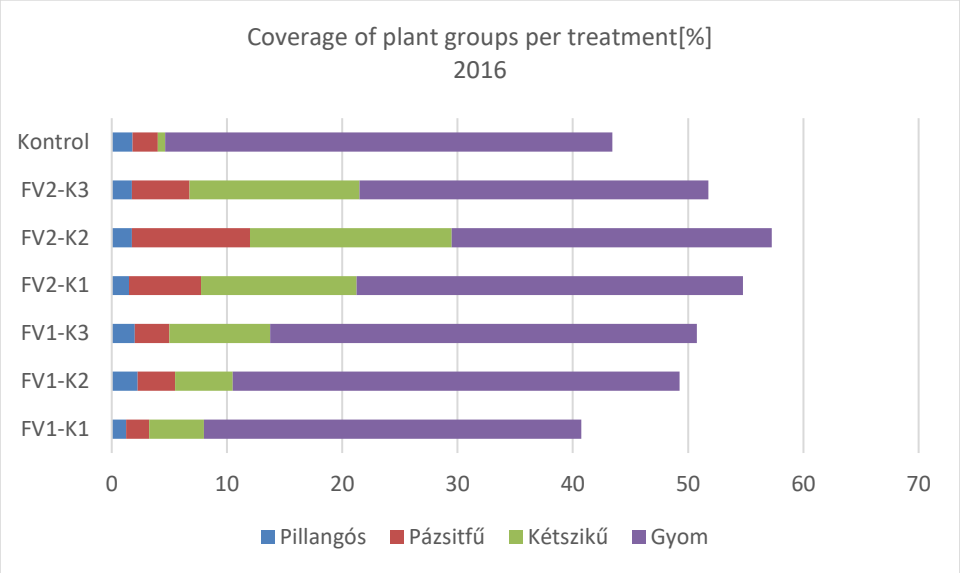
We examined the number of species of grasslands on the plots, including the number of species sown and those not distributed by us, and their relation to each other during the five years of experimentation. In the sowing year, most species appeared in the K3 mixture of 14 legumes and dicotyledonous species, regardless of treatment, and 38-60% (49.3% on average) of grassland species were sown. The most important result is that by the fifth year of the experiment practically both treatments and the use of all three mixtures resulted in the introduction of half of the grassland species, which can be considered as a significant change in the species composition of the grassland. This is particularly interesting in that both the number of colonized species and their species composition showed poorer results in the second, third and fourth year of the experiment. Thus, on the basis of these data, these species were able to establish permanent populations without human intervention.

The test plots changed as a result of the treatments, but during the five-year study period not only the species sown by us increased the initial species stock (Figure 1-2). As our aim was to evaluate the vegetation from the point of view of feeding, we also examined the dynamics of the cover of the individual plant groups. The presence of most useful grassland species in the post-mowing re-cultivated treatment (FV2) was produced by a mixture of K2 and K3 except for the year of sowing. The weed cover on these plots ranged from 48% to 71% over the five years. The sowing and the following year show a high level of legumes cover, but after that it drastically decreases. In parallel, the coverage of grasses and useful dicotyledons gradually increased. Grass species cover only exceeded 10% (10.25%) in the final year of the experiment for post-mowing and K2 mix. During the experimental period, regardless of treatment and mixture, the average ranged from 5-6%, where the plowed areas after mowing showed better results.

Based on these, pre-emergence mowing is more advantageous with regard to the coverage of sown grass species than non-mowing, which is justified by the lack of biomass that was removed during mowing and thus cannot produce a shading effect. The coverage of the dicotyledon from the initial low level to the third year of the experiment was already significant and remained. Again, the K2 blend on mowed plots performed best (17% in 5th year). Their cover also benefited from the removal of some of the litter after mowing, which indicates that by the fifth year of the experiment, the coverage of dicotyledons in the mowed and tilled plots was more than three times that of the unmown plots. We studied the ability of the introduced species to reduce the cover of the *Calamagrostis epigeios*, but found that in the first four years of the experimental period the coverage of the sown and control plots was practically the same, and by the fifth year it decreased by only three percent relative to the control.



1. Figure, Coverage of sown plant groups in the year of sowing

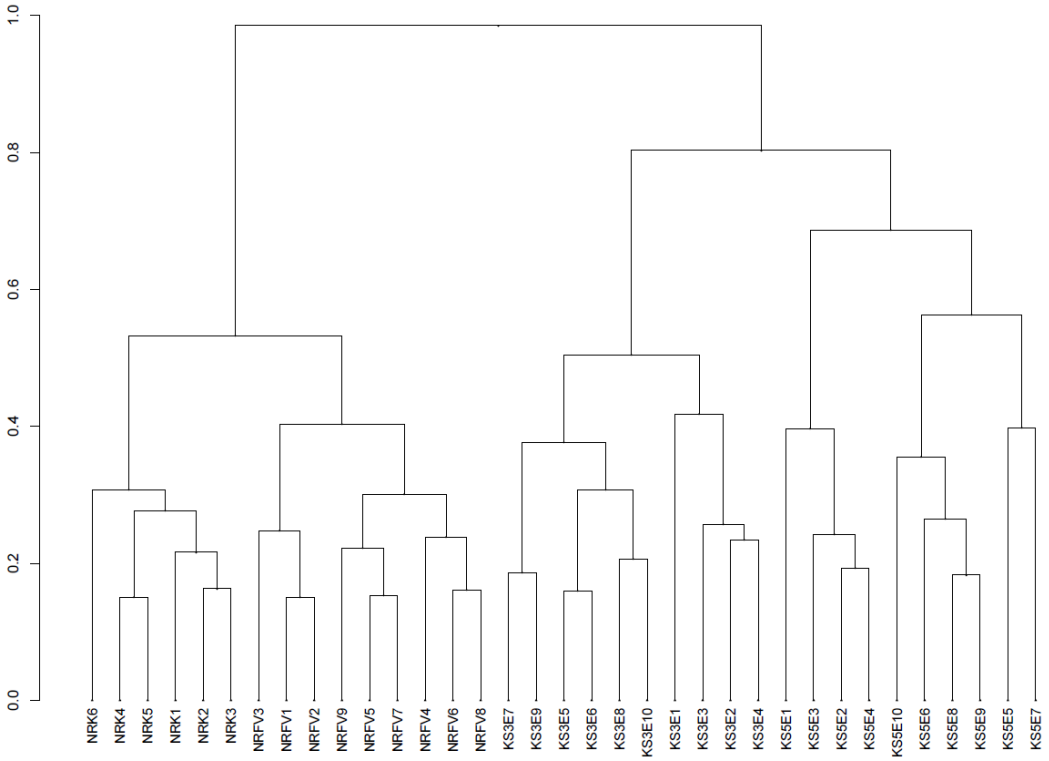


2. Figure, Coverage of sown plant groups in the fifth year after sowing

I could evaluate the negative effect of *Calamagrostis epigeios* on the establishment of sown species due to compare the data from sowing experiments in Bakonycsernye with data from experiment of Nagyréde. The coverage of *Calamagrostis epigeios* was between 20 and 50% in an experimental plots in Bakonycsernye while in Nagyréde no such aggressive species was not present. The composition of the Nagyréde seed mixture is most comparable to that of a K1 mixture in Bakonycsernye. The high coverage of *Calamagrostis epigeios* had not negative effect on the number of species settled in the first year but if you look at the average coverage values of the sown species, it is lower in Bakonycsernye - BCSÁ:28,3%; Nagyréde average NRÁ: 37,6%.

3.3.Evaluation of goat pasture vegetation

The results from 5 year abandoned Kaposszerdahely and from the close-to-the-natural plots of Kaposdada were separated as results from Nagyréde (sown and control) on the basis of the examined goat pastures (Figure 3). The upper third of the slope (LFH) recordings of Kaposdada are closest to the Kaposszerdahely recordings, including those that have been abandoned for 5 years. We could find legumes with high cover values, the *Trifolium repens*, in the plot abandoned 5 years ago.



3. Figure Dendrogram of the coenological study of pastures on Nagyréde and Kaposszerdahely (*Ksz: Kaposszerdahely, KS3: 3 years abandoned, KS5: 5 years abandoned, NRK: Nagyréde control, NRFV: Nagyréde re-sown*)

There is a clear distinction between the upper third of the slope (LFH) from the Kaposdada recordings. The data from next to corral are closer to the quadrats in the lower third of the slope (LAH). The coverage of *Plantago lanceolata* and *Hieracium pilosella* are large in both of the quadrants, as a result of more intense trampling. Based on the DCA analysis of the sample plots, the relationship between the images is better illustrated. The data form Nagyréde shown that the plots been planted and the control lawns are separated. The re-sown area was richer in this case too.

3.4.Evaluation of goat pasture vegetation according to relative ecological indicator

The grazing area was dominated by plants of moderately oligotrophic production sites. It showed a very similar pattern to species relative nitrogen requirements. Plants of nutrient-rich habitats were primarily found in more demanding areas or in nutrient-rich plots. These species occur in quadrats in the upper third of the slope in Kaposdada.
The most disturbed habitat spots will be found in areas close to the corral according to Simon Nature Conservation rate. These species occur in quadrants in the upper third of the slope. Although the amount of disturbance tolerant species was lower in the upper third of the slope, the proportion of weeds was higher. In the lower third and in areas close to the paddock, the coverage of disturbance tolerant plants will be greater.
The distribution of species by type of social behavior is similar to the one drawn by nature conservation categories. Between areas abandoned 3 years ago and 5 years ago, previously abandoned plots have less disturbance-indicating species (DT), so the pasture is becoming closer to natural state. On the Kaposdada recordings show the most disturbed habitat areas near the corral. These species occur in quadrants in the upper third of the slope. Although the amount of disturbance tolerant species was lower in the upper third of the slope, the proportion of weeds (W) was higher in the Kaposdada sample plots. In the lower third and in areas close to the paddock, the coverage of disturbance tolerant plants will be greater.
The most heavily used areas close to the corral, both in the Kaposdada and Nagyréde test areas, were most distinguished among the vegetation of the sample plots. Here vegetation is degraded by many weeds and disturbance-resistant species. During the Kaposszerdahely recordings, the vegetation of the grassland used for 5 years as grassland is already approaching that of the natural grassland, which confirms that the grazing of the goats also helped the regeneration and maintenance of the grassland. Goats were also suitable for maintaining the natural vegetation of the natural grassland.
Life form spectrum of species appeared as a good indicator. The amount of species with stolon and rosette became more significant in the intensively used spaces.

3.5.Results of a feeding study on Solidago gigantea and Calamagrostis epigeios

For the application of the two test plants as green fodder, the following contents per 1000g of dry matter were determined:

	Solidago gigantea	*Calamagrostis epigeios*
crude protein	119,3	85,8
ether extract	46,8	31,8
crude fiber	222,4	317,2
ash	88,7	118,1
N-free extract	522,8	447,1

The dry matter content of the *Calamagrostis epigeios* is significantly higher than that of the other plants - nearly double that of the pre-budding alfalfa - which supports our thesis that the goat that utilizes high dry matter content is the most suitable for grazing the *Calamagrostis epigeios*. By the same token, we can also look at the amount of crude fiber that is also outstanding, nearly three times the amount of crude fiber and nitrogen-free extractables in pre-budding alfalfa. Other dicotyledonous species, and the group of grasses and legumes, do not approximate the values of *Solidago gigantea* or *Calamagrostis epigeios* in terms of nitrogen-free extracts and ether extract. The high ether extract content provides a good basis for supplementary feeding with high protein feeds to the test species and can facilitate good utilization of this protein content .

The need for supplementary feeding is also supported by the fact that the crude protein content of both investigated plant species is only about two thirds of the total crude protein content of grasses and legumes in grasslands. The crude fiber content of the *Solidago gigantea* is close to that of the flowering alfalfa, since in the phenophase examined the *Solidago gigantea*'s stem is still soft, not woody and its leaf mass is also large, easy to consume.

The apparent digestibility of the *Solidago gigantea*'s crude protein content is favorable (71%) compared to crude fiber which is only 23%. Among the apparent digestibility values of *Calamagrostis epigeios,* crude protein is considered to be medium (53%) and crude fiber is considered good (61%). Compared with these values, the apparent digestibility of the *Solidago gigantea's* crude protein is only slightly lower than that of the alfalfa before flowering (76%), and is similarly favorable for the apparent digestibility of N-free extracts, digestibility value also for alfalfa before budding (76%). The aapparent digestibility of *Calamagrostis epigeios*'s crude fiber is outstanding, exceeding that of alfalfa before budding (55%) and, in terms of digestibility of N-free extractable materials, is closer to that of alfalfa before flowering (64%). *Solidago gigantea* shows unfavorable values for the apparent digestibility of crude fiber (23%) and *Calamagrostis epigeios* for ether extract (24%). Although the two evaluated plant species are far behind the other mass feeds in terms of energy content, this difference is not significant for all values. The values were as follows for the net energy of plants (MJ / kg dry matter):

	*NEm	NEl	NEg
alfalfa before budding	5,58	5,71	3,17
alfalfa before flowering	4,71	5,02	2,37
grasses, legumes	2,83	5,28	5,23
other dicotyledonous plants	2,69	5,06	4,97
Solidago gigantea	4,90	5,16	2,54
Calamagrostis epigeios	4,54	4,91	2,22

*(NEm-net energy for maintenance, NEg-net energy for meat production, NEl-net energy for lactation

The net energy (MJ / kg feed) per kg feed for the two tested plant species is as follows:

	*NEm	NEl	NEg
Solidago gigantea	1,31	1,37	0,68
Calamagrostis epigeios	1,79	1,93	0,87

*(NEm-net energy for maintenance, NEg-net energy for meat production, NEl-net energy for lactation

The energy values (NEm), it can be estimated as medium (*Solidago gigantea*: 4.90 MJ / Dry matter kg, *Calamagrostis epigeos*: 4.54 MJ / Dry matter kg) compared to other forage plants. The data clearly show that the *Solidago gigantea* and *Calamagrostis epigeos* are lagging behind grasslands in terms of net energy production. Among the indicators of alfalfa (Várhegyiné, 2000), the *Solidago gigantea* exceeds that of the *Calamagrostis epigeos* canopy (2.37MJ / kg feed) NEg. In contrast, both species have significantly better life maintenance energy content than any group of pasture plants, and the values of pre-flowering alfalfa (4.71MJ / kg feed) are exceeded by the *Solidago gigantea* and *Calamagrostis epigeos*. In calculating the net energy requirement of lactation, the *Solidago gigantea* shows an order of magnitude similar to grassland values (5.28MJ / kg of feed) and exceeds the value of alfalfa before flowering (5.02MJ / kg of feed), while the *Calamagrostis epigeos* is almost 10% below .

3.6.New and novel scientific results

- I examined and evaluated the planted vegetation in two different landscape units where goats are grazing. I found that the re-cultivation was suitable in both places for the improvement of the pasture, which also takes into account economic aspects. Goat grazing also has a positive impact on nature conservation and management.
- I carried out and evaluated the results of a 5-year seeding experiment in the Bakonycsernye area. I found that the planting was suitable for the improvement of the lawn, the selected sown plants were suitable for the establishment and development, and the majority of the selected species met the expectations.
- I carried out coenology studies of goat pastures in different Hungarian territories. For lifestyle analysis I also used Pignatti's lifestyle, which is a much better indicator of grazing effect.
- Relative ecological analysis of goat pasture vegetation was also carried out. I found that grazing of these areas is shifting in a favorable direction from a nature conservation point of view.
- The apparent digestibility and nutrient content of *Solidago gigantea* and *Calamagrostis epigeios* plants were determined for the first time in Hungary.
- I found that the apparent digestibility of Solidago gigantea crude protein is favorable (71%), while the apparent digestibility of crude fiber is low (23%). In contrast, from the epigaminal digestibility values of *Calamagrostis epigeios,* crude protein is considered to be medium (53%) and crude fiber is considered good (61%). Their energy values (NEm) can also be estimated as moderate (S. gigantea: 4.90 MJ / kg kg, C. epigeos: 4.54 MJ / kg kg).
- I found that the *Solidago gigantea* and *Calamagrostis epigeios* plants are consumed by the goats and can be used to feed the goats based on their nutrient content.

4. CONCLUSIONS AND RECOMMENDATIONS

The heavily used part of the slope in Kaposdada, the younger pasture in Kaposszerdahely and in Nagyréde, are close to grasslands were created on abandoned arable land among the studied grasslands. These trends are similar to those of other publications (Kiss et al., 2008). The vegetation of young fallow is often rich in degradation and weed species in other studies (Albert et al., 2014; Csecserits et al., 2011; Kelemen et al., 2010; Török et al., 2011; Valkó et al., 2010). Based on the relative ecological values of the species, the slopes of Kaposdada are the closest to the natural ones, among them the pastures formed in the lower third of the pasture. During the Kaposszerdahely recordings, the vegetation of the grassland used for pasture for 5 years is closer to nature, so grazing with goats does not prevent it, but rather facilitates it (Deák & Valkó, 2013; Valkó & Deák 2013). According to the data of the examined areas, grazing by goats had a positive role in maintaining the vegetation. Life form spectrum of species in the areas appeared as a good indicator. The amount of species with stolon and rosette became more significant in the intensively used spaces, which shows similar data to several publications (Török et al. 2016).

The *Calamagrostis epigeos* and the *Solidago gigantea*, can be used primarily to satisfy the net life maintenance energy based on the nutritional studies, while the *Solidago gigantea* can also be used to provide the net energy for lactation. In addition, any of them may be recommended for the mass feed of meat-producing herds. An average (dairy, 50 kg liveweight) goat has a dry matter requirement of 2900 g and an energy requirement of NEl (2 kg daily milk production) 11MJ (Bedő, 2001). In order to cover the dry matter requirement with

the *Solidago gigantea*, it would be necessary to consume 10,88 kg and the lactating net energy requirement would be 8,03 kg. The same values require a consumption of 7.36 kg of dry matter and 5.7 kg of net lactation requirements for *Calamagrostis epigeos*. Regarding the grazing ability of the two studied plant species, the four-leafed *Calamagrostis epigeos* optimal condition makes it suitable for utilization with sheep, however, except for the very early phenophases of the *Solidago gigantea*, it can be grazed almost exclusively with goats. This is also related to the literature that supports the different digestibility of crude fiber, and that goat can absorb more crude fiber (based on organic or dry matter content) than sheep (Hadjigeorgiou et al., 2003). Comparison of Molnár's (2014) data with our present results shows the optimal grazing time of the *Calamagrostis epigeos*. Taking the crude protein: crude fiber 1: 2 ratio as the crude protein digestion efficiency, we used the crude fiber level we defined (31.72%). This level of crude fiber is higher because the phenophase is more advanced, and the crude fiber value is lower in the younger spring phenological state of plants. The content analysis, including the determination of the crude fiber level, was carried out from the post-mowing series, which is phenologically close to the four-leaf condition of the plant in April. To this end, we sought the optimal time for the crude protein level derived from the nitrogen content data provided by Molnár (2014).

5. SCIENTIFIC PUBLICATIONS COVERING THE TOPIC OF THE THESIS

Journal article

Journal article with IF

Dobay G, Dobay B, S-Falusi E, **Hajnáczki S,** Penksza K, Bajor Z, Lampert R, Bakó G, Wichmann B, Szerdahelyi T. Effects of sport tourism on temperate grassland communities (Duna-Ipoly National Park, Hungary) (2017): Applied Ecology and Environmental Research 15(1): 457-472. (IF: 0.59)

Proofread journal articles without impact factor In foreign language

Zs. Fehér, **S. Hajnáczki,** P. Penksza, P. Szőke, K. Penksza, B. Wichmann (2015): Correlation between the Diversity and Land Use in Cleared Grassland Areas in the Pannon Mountains. Journal of Earth Science and Engineering. 2015 (5.) doi: 10.17265/2159-581X/2015. 01. 001

Proofread journal articles without impact factor In Hungarian

Hajnáczki S, Illyés E, Donkó Á, Szabó G, Zimmermann Z, Penksza K. (2014): Magas biológiai értékű tömegtakarmányt biztosító gyep kialakítása az ökológiai gazdálkodás keretei között: előzetes eredmények. GYEPGAZDÁLKODÁSI KÖZLEMÉNYEK 2014:(1-2) pp. 11-16. **(5 pont)**

Hajnáczki S, Stilling F T, Zimmermann Z, Szabó G, Póti P, Házi J, Szentes Sz, Sutyinszki Zs, Kerényi-Nagy V, Wichmann B, Penksza K. (2014): Kecskelegelők botanikai és természetvédelmi vizsgálatai és értékelése. GYEPGAZDÁLKODÁSI KÖZLEMÉNYEK 2014:(1-2) pp. 17-28. (2014)

Conference publications

Conference publications, in foreign language, abstract

Hajnáczki S., Házi J., Fehér Zs., Wichmann B., Sutyinszki Zs., Balogh Á., Szőke P., Centeri Cs., Szentes Sz. (2014): Effect of disturbance on species richness on different sandy grasslands in the center of Carpathian Basin. (Fajgazdagság és a környezeti hatások kapcsolata a Kárpát-medence központi homoki területein.);"II. Sustainable development in the Carpathian Basin"; international conference – Book of Abstracts (II. Fenntartható fejlődés a Kárpát-medencében"; nemzetközi konferencia absztraktkötete) Budapest, 2014.12.11-2014.11.12. pp. 77–78. (ISBN: 978-963- 269-455- 9)

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