Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 1, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PRODUCTIVITY AND BOTANICAL COMPOSITION OF NATURAL GRASSLAND (*Chrysopogon gryllus*) IN PASTURE AND HAY-MAKING MODE OF USE

Minko ILIEV, Tatyana BOZHANSKA, Magdalena PETKOVA, Biser BOZHANSKI

Research Institute of Mountain Stockbreeding and Agriculture, 281 Vasil Levski Street, 5600, Troyan, Bulgaria

Corresponding author email: iliev_ved@abv.bg

Abstract

The experiment was conducted in the region of Central Balkan Mountain, on natural grassland of Chrysopogon gryllus type and covered a five-year study period. The grasslands in the studied variants were a pasture harvesting (PH1 - 31.05.-09.06.; PH2 - 10.06.-19.06. and PH3 - 20.06.-29.06.) and as hay-making harvesting (HH1 - 30.06.-09.07; HH2 - 10.07.-19.07. and HH3 - 20.07.-31.07.) in three periods. The grasslands harvested at pasture maturity stage in the third decade of June had the highest yield of fresh (833.3 kg/da) and dry (280.6 kg/da) mass. The values of the traits in the studied variants significantly exceeded (P <0.001) the control by 55.5% and 64.8%, respectively. At hay-making mode of use with the highest productivity of fresh (988.2 kg/da) and dry (130.5 kg/da) mass, the grasslands were harvested in the second decade of July. The amount of formed biomass exceeded (P <0.001) the control by 39.6% and 30.5%, respectively. The long-term pasture and hay-making harvest led to the elimination of Chrysopogon gryllus from the botanical composition in the observed grasslands, and Agrostis capillaris established itself as an edificator with a dominant impact in the formed aboveground mass. The studied modes of use favored an increase in the share of leguminous meadow grasses (Lotus corniculatus, Trifolium pratense, Trifolium repens, Medicago falcata, Vicia cracca, Vicia sativa) which presumed better quality and higher nutritional value of pasture and hay.

Key words: *natural meadows and pastures, productivity, botanical composition.*

INTRODUCTION

Meadows and pastures in the mountainous regions of Bulgaria are a major source for animal feeding. The species diversity in the composition of the above-ground mass is directly dependent on environmental factors, the type of use and the applied environmentally friendly measures (Mitev et al., 2010 a, b; Kulakov & Sedova, 2013; Georgiev et al., 2017). The balanced approach between them is the basis for a better distribution of components in plant communities and production of feed with high economic value (Fattahi & Ildoromi, 2011; Zziwa et al., 2012; Vasileva & Enchev, 2018). Unsystematic management of natural and semi-natural grasslands, as well as human activity lead to the emergence of aggressive and invasive grass species, shrubs and trees and the loss of valuable species affecting the yield and quality of grass mass (Suding et al., 2008; Gross et al., 2009). The optimal cutting period and the technology for utilization of the above-ground mass have a positive impact on the botanical composition, productivity and longevity of the meadow and pasture vegetation (Stevanovıć et al., 2008; Pellegrini et al., 2010).

Climate conditions in the mountain regions of Bulgaria allow the development of perrenial grass-forage species (*Festuca pseudovina* Hask., *Festuca rubra* L., *Chrysopogon gryllus* L., *Agrostis capilaris* L., *Poa bulbosa* L., *Poa silvicola* Guss., *Poa pratensis* L., *Deschampsia flexuosa* L. Trin., *Poa alpine* L., *Phleum boehmery* Wit., *Phleum pretense* L. etc.) with high resistance to the environmental factors and a high biological potential (Kirilov & Mihovski, 2014; Popescu & Churkova, 2015). In the pasture phase, they provide easily digestible biomass, which is readily accepted by ruminants, which is a prerequisite for improving the quality of animal production (Kulakov & Sedova, 2013; Dimitrova-Hristova, 2019). The selective and sharp reduction of the number and types of perennial meadow grasses requires a purposeful and regulated selection of agro-technical measures for maintenance and application of systems for the use of grass stands (Tanova et al., 2008). In pasture and hay-making, pasture and mowing times affect yield and variability in floristic composition of the grassland (Kemp & Michalk, 2005). Knowledge of these patterns aims to create favourable conditions for better recovery and development of valuable species in different botanical groups (Bovolenta et al., 2008) and obtaining feed with higher nutritional value. Grass communities respond to changes in the environment both through species turnover and through intraspecific biological and morphological changes (Volf et al., 2016). Local species (legumes and cereals) form highly productive and long-lasting grasslands (Naydenova & Mitev, 2008; Mitev et al., 2011). The mode of use can be associated with their limited distribution or create conditions for their more stable participation in the grassland. Pasture use favours low-growing species (Li et al., 2013), and hay use of grass cover stimulates high-growing grasses.

The aim of the present study was to determine the impact of the harvest period on the bioproductive indicators of fodder from natural meadows (*Chrysopogon gryllus* type) in the region of Central Balkan Mountain.

MATERIAL AND METHODS

The experiment was conducted on natural grasslands, a meadow of bunch grasses (*Chrysopogon gryllus* L. type), at the foot of Central Balkan Mountain (latitude_N - 42° 54' 37", longitude_E - 24° 41' 31" and 515 m above sea level) and covered a period of five years (2013-2017). The pasture and hay-making productivity of the grassland in the first regrowth was monitored. Two modes of use were applied for three harvest periods (early, medium-early and late), with respective dates of implementation, as indicated in Table 1.

Table 1. Variants according to the mode and dates of use of natural grassland of *Chrysopogon gryllus* L. type

Variants	Pasture harvesting (PH)	Variants	II. Hay-making harvesting (HH)
PH1	Pasture (Control) – from 31. May to 09. June	HH1	Mowing (Контрола) from 30. June to 09. July
PH2	Pasture from 10. June to 19. June	HH2	Mowing from 10. July to 19. July
PH3	Pasture from 20. June to 29. June	HH3	Mowing from 20. Юли to 31. July

The early terms of pasture harvesting in tasseling phenophase (PH1) as well as hay harvesting in flowering phenophase of bunch grasses (HH1) were used as control variants. The medium-early and late harvesting periods in both modes were determined after a 10-day and a 20-day period, respectively, compared to the control harvesting period.

The grass cover was used without management before the experiment. During the first three years (2013 and 2014) in the experimental variants, we applied stockpile fertilization with N6P6. Fertilization with triple superphosphate (containing 44–48% P2O5) was applied once in the autumn (September-October). Nitrogen fertilization (NH4NO3) was also used once in spring (April). Experimental data were statistically processed by analysis of variance (ANOVA).

Research indicators

Yield of fresh and dry mass (kg/da) - the yield of fresh and dry mass was determined by mowing the area of each harvest plot (in replications) followed by drying the plant samples (0.5 kg) in a laboratory dryer at 105ºC and recalculating for an area of 1 da, based on dry mass content.

Botanical analysis of grassland (%) - determined by weight analysis of grass green mass samples taken at each mowing of each variation. The percentage share of each species per year from the group of grasses and legumes, of motley grasses (total) in both modes of use and their total ratio in the main botanical groups (grasses, legumes and motley grasses) was established.

Agroclimatic characteristics in the experimental area

Climate conditions during the experimental years affect the development of plants (by species and groups), productivity and quality of grass cover (Andreeva et al., 2015).

In 2014, autumn-winter precipitation shown the highest amount (1164. 9 mm) compared to the other experimental years the vegetation and autumn-winter precipitation shown the highest amount (1164.9 mm) compared to the other experimental years (Table 2).

The relative difference in the precipitation amount in 2015 (922.7 mm) and 2017 (983.2 mm), as well as in 2013 (807.3 mm) and 2016 (837.0 mm) compared to the maximum value of the feature varied respectively from 18.5 to 26.2% and from 39.2 to 44.3%.

For the experimental period, the highest average air temperature (11.9°C) and the highest average temperature for the months of July, August and September (22.4°C) were measured in 2015.

The relative difference in the average air temperatures for 2013 (11.4°C), 2014 (11.0°C) and 2016 (11.1°C) year varied from 0.9 to 3.6%. The data on the temperature level show that the lowest average annual temperature (10.5°C) was measured in 2017. The interesting thing in this case is that in the fifth harvest year, the active vegetation of the plants in the grassland began at the highest average temperature in March (8.1°C) compared to the other experimental years.

Table 2. Average monthly temperatures (T°C) and monthly precipitation amounts (mm) of 2013-2017

Month \ Year	2013	2014	2015	2016	2017
	Precipitation				
I-III	155.6	145.6	179.5	207.2	151.9
IV-VI	457.0	322.3	312.2	333.6	336.7
VII-IX	98.8	498.1	282.0	151.2	238.7
X-XII	95.9	198.9	149.0	145.0	255.9
Total	**807.3**	**1164.9**	**922.7**	**837.0**	**983.2**
	Temperature				
I-III	3.4	4.6	2.9	4.6	1.6
IV-VI	16.1	14.6	14.7	15.8	14.8
VII-IX	19.2	18.7	22.4	19.1	19.1
X-XII	6.9	6.0	7.3	4.7	6.5
Average	**11.4**	**11.0**	**11.9**	**11.1**	**10.5**

RESULTS AND DISCUSSIONS

Productivity of natural grassland depending on the harvest period

On average for the five-year study period, the highest yield of fresh (833.3 kg/da) and dry mass (280.6 kg/da) was gathered from grasslands harvested at **pasture maturity** stage during the third decade of June (20.06.-29.06.) - Table 3. The values exceeded the control (31.05.-09.06) by 55.5% (fresh mass) and 64.8% (dry mass), respectively, with a high degree of proof ($P < 0.001$). This trend was also observed in the period 10.06.-19.06., where the amount of fresh and dry biomass was 47.4 and 49.9% ($P < 0.01$) higher than that of the control. The obtained data give grounds to assume that the most favorable period for pasture harvesting of grasslands of *Chrysopogon gryllus* type in the conditions of the Central Balkan Mountain was the second half of June.

Table 3. Yield of fresh and dry mass in kg/da at natural grassland of bunch grasses depending on the terms of harvesting, average for the period 2013-2017

Variants	Fresh mass		Dry mass	
	kg/da	% compared to PH1	kg/da	% compared to HH1
Pasture harvesting				
PH1	536.0	100.0	170.3	100.0 -
PH2	789.8	147.4	255.3	149.9
PH3	**833.3**	**155.5**	**280.6**	**164.8**
$LSD_{0.05}$	119.4	22.3	40.5	23.8
$LSD_{0.01}$	180.8	33.8	61.3	36.1
$LSD_{0.001}$	290.5	54.3	98.5	57.9

Hay-making harvesting				
HH1	707.8	100.0	259.1	100.0
HH2	**988.2**	**139.6**	**337.9**	**130.5**
HH3	756.2	106.8	268.6	103.7
$LSD_{0.05}$	100.8	14.2	30.8	11.9
$LSD_{0.01}$	152.7	21.5	46.7	18.0
$LSD_{0.001}$	245.3	34.5	75.0	29.0

In **hay-making mode**, the mowing period had a significant impact on plant development. The grasses harvested in the second ten days of July (10.07.-19.07.) ave the highest productivity. The amount of biomass exceeded (P <0.001) the control by 39.6% (fresh mass) and 30.5% (dry mass), respectively. With advancing age and development phase (insemination, flowering) of the grassland, the yield of aboveground biomass decreased. Statistical data processing shows an unproven and insignificant difference in the values of dry and fresh mass between the observed variants and the regulated controls.

Botanical composition of natural grassland of *Chrysopogon gryllus*

The sustainable development of phytocenoses is related to a system that includes the specific relationships between the vegetation factors of the environment and the requirements of the plants in the pasture-meadow biomass. In pasture and hay-making harvesting, only *Agrostis capillaris* is the species with relatively constant participation in all variants by years (Figures 1, 2, 3, 4 and 5).

In 2013, with pasture mode, the share of *Agrostis capillaris* at a later harvest date decreased from 8.8 (PH2) to 50.0% (PH3) compared to the control.

Festuca pseudovina participated in the composition of the grassland only during the first vegetation year, as in the period 10.06-19.06 (PH2), the presence of *Festuca pseudovina* in grass biomass was over 140% lower than in the control period. The participation of the species in the second variant was completely opposite, where it dominated by more than 120% compared to the control.

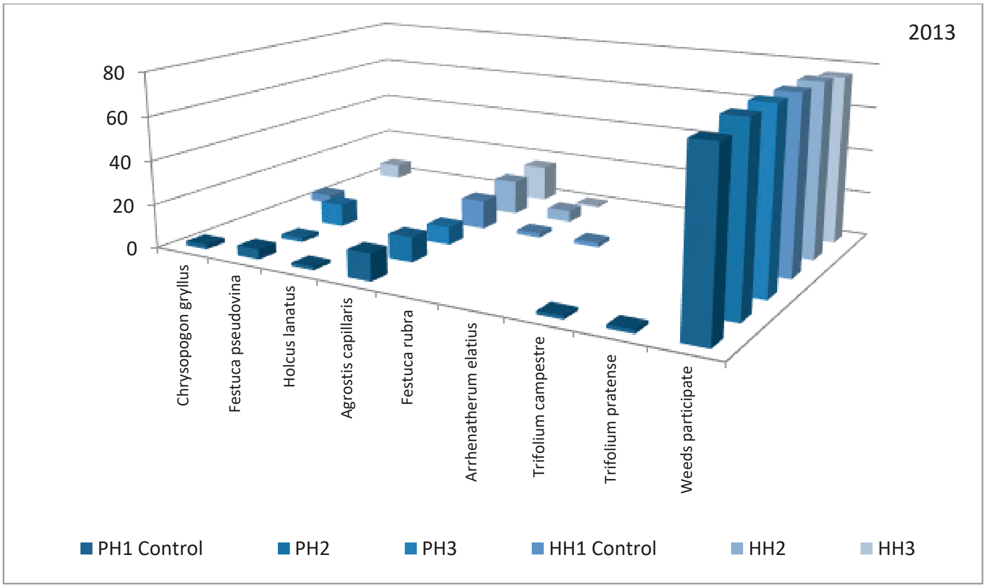

Figure 1. Botanical composition (%) of natural grassland of *Chrysopogon gryllus* L. type in 2013

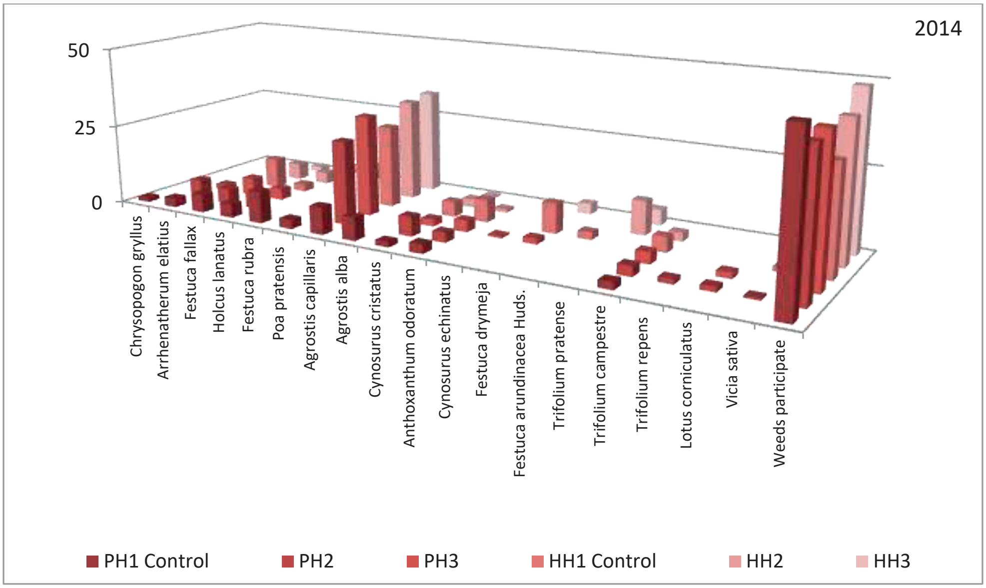

Figure 2. Botanical composition (%) of natural grassland of *Chrysopogon gryllus* L. type in 2014

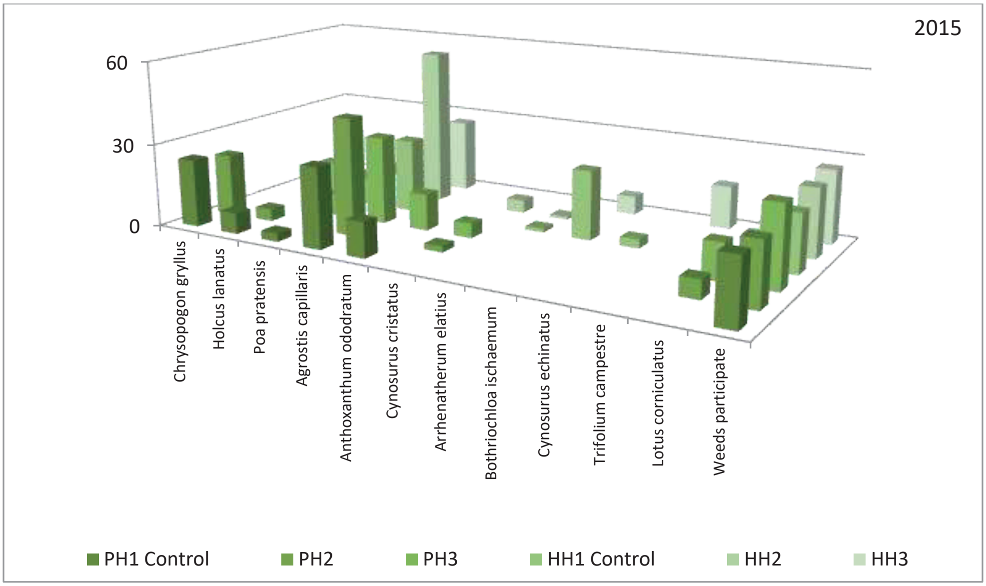

Figure 3. Botanical composition (%) of natural grassland of *Chrysopogon gryllus* L. type in 2015

The grasslands formed in the year, with the highest soil and air humidity (2014), are characterized by the richest floristic composition in pasture harvesting. Of the grass components, *Agrostis capillaris* occupied the largest share in the grassland in the variants in both modes of use. In percentage terms, the representatives of the species in the second and third variant occupied 26.0 and 31.4% respectively at 8.6% in the control variant in pasture mode, and 31.7 and 32.6% in 25.8% in the control variant in hay-making mode, followed by those of:

- *Festuca fallax*: 4.6 and 5.5% compared to 5.7% in the control variant in pasture mode, and 5.3 and 1.6% with 9.4% in the control variant in hay-making mode;

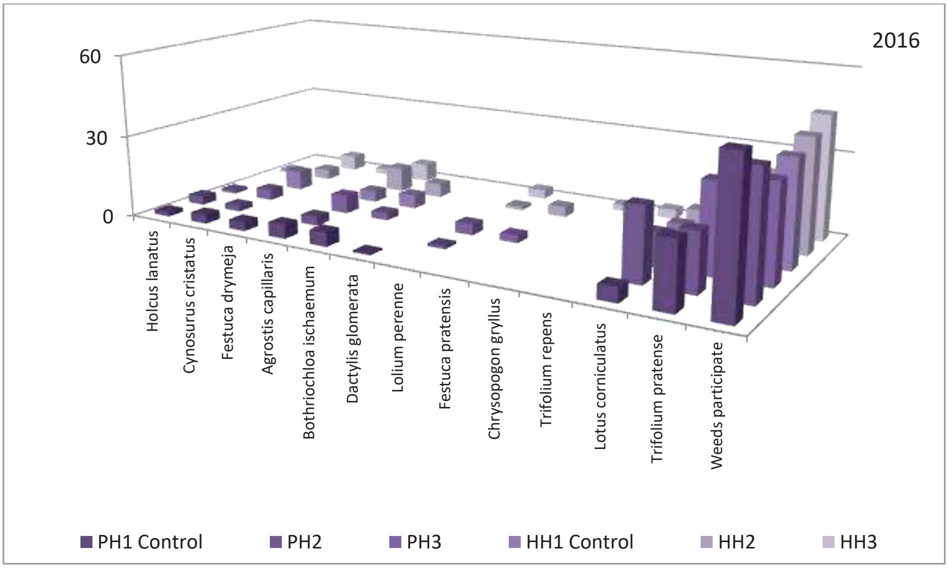

Figure 4. Botanical composition (%) of natural grassland of *Chrysopogon gryllus* L. type in 2016

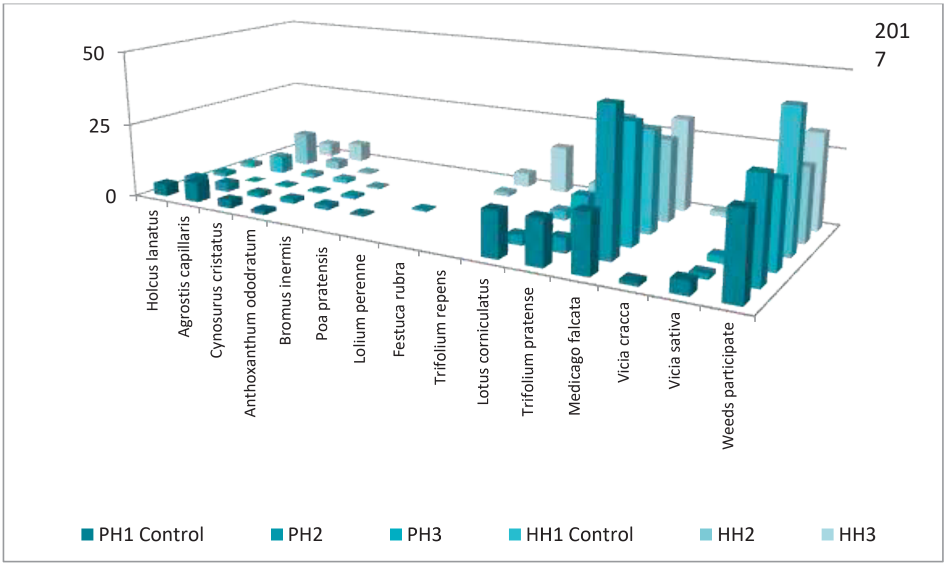

Figure 5. Botanical composition (%) of natural grassland of *Chrysopogon gryllus* L. type in 2017

- *Holcus lanatus*: 4.6 and 3.6% compared to 4.3% in the control variant in pasture mode, and 3.7 and 3.3% compared to 2.3% in the control variant in hay-making mode;
- *Cynosurus cristatus*: 6.1 and 2.2% compared to 1.7% in the control variant in pasture mode, and 2.6 and 0.7% compared to 4.7% in the control variant in hay-making mode.

In 2014, French ryegrass registered a share from 1.8 to 6.1% in pasture options alone.

Anthoxanthum odoratum is one of the grass species with an increased share during the spring and summer growth of the researched grassland in the second experimental year. Pasture harvest increased by 6.9-24.1% the share of *Anthoxanthum odoratum* in the second and third variants of the control. The hay-making use mode points to a declining trend (1.1% at 7.0% in control variant) regarding the share of this species in above-ground biomass at a later harvest date.

In pasture mode variants, *Festuca rubra* and *Poa pratensis* participated in the composition of observed grasslands only in the period 31.05.-09.06. (control variant) and in the last ten days of July (hay-making mode). Single plants of the species *Cynosurus echinatus* and *Festuca drymeja* were also found in later harvest dates.

The share of the representatives of the Family *Fabaceae* (*Trifolium campestre*, *Lotus corniculatus*, *Trifolium repens* and *Vicia sativa*) was 0.6 to 3.6% (in pasture mode) and from 1.4 to 4.7% (in the case of a hay-making mode). In 2014, the white clover and bird's-foot-trefoil did not have a share in the formed above-ground mass in July.

In the year with the highest average air temperature (2015), the percentage share of *Agrostis capillaris* followed a growing trend in grasslands of pasture and hay-making mode. In variants with an earlier (10.06.-19.06. and 10.07.-19.07.) and later harvest date (20.06.-29.06 and 20.07.-31.07), the species prevailed by 45.0-112.4% and 1.0-8.6% respectively relative to the controls. *Holcus lanatus* recorded the highest share in the grass cover formed in the period 31.05-09.06. (control - 7.6%) and 30.06-09.07. (control - 13.8%) in both types of harvesting. The species is also involved in the composition of the grass mass in PH2 variants (4.4%), HH2 (5.2%) and HH3 (4.4%). The annual share of *Anthoxanthum ododratum* ranged from 12.8% (PH1) to 13.2% (PH3). It was found only within the range of the marked parts of grassland in mode/period of pasture use.

A similar trend was observed in *Poa pratensis*, except in control variants (PH1 – 3.1% and HH1 – 9.2%), the species was mainly present (7.9%) in the grass cover formed in the 20-29th June *Cynosurus cristatus* is a tuft-like perennial grass common in high-mountain pastures, spread mainly on more moist to dry soils (Velev et al., 2011). High summer temperatures and low soil and air humidity during the year limited the share (PH2 – 2.2% and PH3 – 5.3%) of the species to the pasture harvesting modes in the grassland and its absence in the variants with hay harvesting.

In 2015, *Arrhenatherum elatius* (HH1 – 1.4% and HH2 – 1.0%), *Bothriochloa ischaemum* (HH1 – 24.9% and HH3 – 6.7%) and *Cynosurus echinatus* (HH1 – 3.2%) participated only in the marked hay-making parts of the grassland, the above-ground mass for the purpose of hay-making.

Of the legume representatives, *Lotus corniculatus* exhibited high plasticity in pasture (6.7-13.2%) and hay-making (5.2-6.7%) grasslands. *Trifolium campestre* participated by 15.6%, only in the grassland formed at the end of July (HH3).

In the fourth experimental year (2016), *Cynosurus cristatus* and *Agrostis capillaris* were continuously involved in the grasslands of all variants in both modes of use.

Grasses include the following species: *Holcus lanatus* (1.3-3.3%), *Festuca drymeja* (2.2-3.4%), *Bothriochloa ischaemum* (2.7-5.2%), *Dactylis glomerata* (0.7%), *Lolium perenne* (1.1-4.0) %) and *Festuca pratensis* (2.7-3.8%).

Compared to previous experimental years (2013, 2014 and 2015), the share of legume meadow grasses in the grassland during the vegatation period in the fourth attempt was higher. The share of *Lotus corniculatus* (PH1 – 5.2%, PH2 – 26.1%, PH3 – 12.0% and HH1 – 10.0%, HH2 – 10.3%, HH3 – 9.9%), *Trifolium pratense* (PH1 – 23.4%, PH2 – 20.7%, PH3 – 32.0% and HH1 – 36.0%, HH2 – 24.4% and HH3 – 22.0%) and *Trifolium repens* (HH3 – 3.3%) implies the formation of a grass mass of better nutritional value.

With an increase in the period of mode use, the quantitative and species composition of the representatives of the family *Fabaceae* increased. In the last experimental year (2017), during the vegetation period, the above-ground grass mass of the pasture and hay-making harvesting variants had the highest share of the following species:

- *Medicago sativa subsp. falcata* - (PH1 – 18.9%, PH2 – 46.6%, PH3 – 38.6% and HH1 – 33.1%, HH2 – 27.0%, HH3 – 30.8%);
- *Trifolium pratense* - (PH1 – 14.9%, PH2 – 4.7%, PH3 – 13.8% and HH1 – 7.5%, HH2 – 32.7%);
- *Lotus corniculatus* - (PH1 – 14.9%, PH2 – 3.1%, PH3 – 1.4% and HH1 – 3.0%, HH3 – 4.7%);
- *Vicia sativa* - (PH1 – 4.4%, PH2 – 1.6%, PH3 – 2.2%);
- *Vicia cracca* - (PH1 – 1.4%)
- *Trifolium repens* - (HH3 – 15.7%).

Cynosurus cristatus and *Agrostis capillaris* are typical representatives of grasses which participate in the grasslands of all variants in both modes of use. *Holcus lanatus* occupied 4.1% in the biomass of the control variant in pasture harvesting. In variants with later harvesting, the quantity of the species decreased to 1.4%. The composition of the natural grassland is also enriched by species such as:

- *Anthoxanthum ododratum* - (PH1 – 1.4%, PH2 – 1.6%, PH3 – 0.6% and HH1 – 1.5%, HH2 – 0.6%),
- *Bromus inermis* - (PH1 – 4.4%, PH2 – 1.6%, PH3 – 1.1% and HH1 – 0.6%),
- *Poa pratensis* - (PH2 - 0.6%),
- *Lolium perenne* - (PH3 – 0.6%)
- *Festuca rubra* - (HH2 – 1.4%, HH3 – 4.7%).

Impact of the period and mode of use on the botanical composition of natural grasslands

The interaction between environmental conditions and applied management practices (Pacurar & Rotar, 2004) have an impact on diversity in the composition of natural grasslands. In this experiment, **pasture harvesting** resulted in the gradual dropping of *Chrysopogon gryllus* from the botanical composition of the grasslands in the fourth and fifth experimental year. Earlier pasture harvesting decreased the percentage share of the valuable rhizome rare tufted plants such as: *Poa pratensis, Festuca pratensis, Festuca fallax, Cynosurus cristatus*, *Cynosurus echinatus* and *Agrostis alba*. On the other hand, the pasture use mode increased the share of species with creeping and low stems (genus *Trifolium*). Genotypic factor successfully determines abiotic restriction and specific adaptation of legumes to environmental conditions (Naydenova & Vasileva, 2019 a, b). The pasture of legumes in a later phase allowed the formation of generative organs and supported their natural reproduction. Between 20.06.-29.06, the percentage share of the dominant during the year - *Trifolium pratense* and *Lotus corniculatus* was increased by 36.8% and 8% and 130.0% (2016) compared to that in the control date in grassland in pasture mode of use (31.05.-09.06.). The mode of use supports better development of species such as: *Medicago falcata* and *Vicia sativa.* In contrast, survey data show that the grazing (pasture mode) of grasslands in the early, medium and late phases limits the development and spread of *Trifolium repens* and *Trifolium campestre*.

Mowing in an earlier phase inhibits the development of the so-called indicator plants and significantly affects the botanical composition and productivity of natural grasslands (Duru et al., 2010; Duru et al., 2014). Earlier mowing did not allow insemination and self-sowing of certain grasses (*Festuca pseudovina, Arrhenatherum elatius, Poa pratensis, Cynosurus echinatus, Dactylis glomerata* and *Lolium perenne*) and led to their removal from the grass cover. The use mode allowed the validation of rhizomes (of genus *Trifolium*) and long-lasting grasses (*Agrostis capillaris*, *Holcus lanatus*, *Anthoxanthum ododratum*) to improve the floristic composition, meadow and pasture grasslands in the conditions of the Central Balkan Mountains. The motley grasses group is a constant presence factor in the above-ground grass mass of the variants under both harvest modes. In later mowing (in a period with high atmospheric temperatures), soil drought and compaction inhibits the growth and development of motley grass species, as a result of which the share of economically significant grasses and legumes has increased.

CONCLUSIONS

In the conditions of the Central Balkan Mountains, the most favourable period for pasture harvesting of grassland of *Chrysopogon gryllus* type was the second half of June, when the yield of fresh (833.3 kg/da) and dry mass (280.6 kg/da) exceeded the control by 55.5 % and 64.8 %, respectively. At hay-making mode of use with the highest productivity of fresh (988.2 kg/da) and dry (130.5 kg/da) mass, the grasslands were harvested in the second decade of July. The excess over control was 39.6% and 30.5%, respectively. Pasture and hay-making harvesting enriched the spectrum of the typical grasses for the region (*Agrostis capillaris*, *Holcus lanatus*, *Festuca rubra*, *Lolium perenne*, *Cynosurus cristatus*, *Bromus inermis*, *Festuca fallax*) and legumes (*Trifolium pratense*, *Lotus corniculatus* and *Medicago sativa subsp. falcata*). The long-term pasture and hay-making harvesting led to the elimination of

Chrysopogon gryllus from the botanical composition in the observed grasslands, and *Agrostis capillaris* established itself as an edificator with a dominant impact in the formed aboveground mass.

REFERENCES

Andreeva, N., Georgiev, D., Popski, G., Mihova, T., & Georgieva, M. (2015). Physical-chemical indicators of soils in organic growing of small-fruit trees species in mountain conditions. *Plant Science*, *LII* (1), 48–53.

Bovolenta, S., Spanghero, M., Dovier, S., Orlandi D., & Clementel, F. (2008). Chemical composition and net energy content of alpine pasture species during the grazing season. *Animal Feed Science and Technology*, *140*(1–2), 164–177.

Dimitrova-Hristova, T. M. (2019). Characteristics of goat milk and cheese of bulgarian white dairy goat breed and its crossbreeds with Anglo-Nubian and Toggenburg breeds in the region of the Central Balkan Mountain. Dissertation, University Trakia University, Stara Zagora, Bulgaria, pp. 133.

Duru, M., Cruz, P., Jouany, C., & Theau, J. P. (2010). Herb'type©: Un nouvel outil pour évaluer les services de production fournis par les prairies permanentes. *INRA Production Animale*, *23*. 319–332.

Duru, M., Jouany, C., Theau, J. P., Granger, S., & Cruz, P. (2014). A plant-functional-type approach tailored for stakeholders involved in field studies to predict forage services and plant biodiversity provided by grasslands. *Grass and Forage Science*, *70*. 2–18.

Fattahi, B., & Ildoromi, A. R. (2011). Effect of some environmental factors on plant species diversity in the Mountainous Grasslands (Case Study: Hamedan - Iran). *International Journal of Natural Resources and Marine Sciences*, *1*. 45–52.

Georgiev, D., Mihova, T., Georgieva, M., Ivanova, P., Popski, G., Naydenova, G., & Mitev, D. (2017). Influence of grass establishment with some legume species on the biochemical composition of 'Black satin' blackberry fruits. *Proceedings of the VIII International Agricultural Symposium „AGROSYM 2017"*, 136–140.

Gross, N., Kunstler, G., Liancourt, P., Bello, F., Suding, K. N., & Lavorel, S. (2009). Linking individual response to biotic interactions with community structure: a trait-based framework. *Funct. Ecol.*, *23*. 1167–1178.

Kemp, D.R., Michalk, D.L. (2005). Grasslands for production and environment. *In: Grassland: a global resource, Ed. D.A. McGilloway. Proceedings of 20-th IGC*, Dublin, 26, 183–208.

Kirilov, A., Mihovski, T. (2014). Forage Sources For Ruminants In Bulgaria. *Turkish Journal of Agricultural and Natural Sciences*, *2*. 2040–2045.

Kulakov, V.A., Sedova, E.G. (2013). Kormoproizvodstvo, Moscow, Russia, Kormoproizvodstvo, 7, 8–10, 13 ref.

Li, W., Tian, F. P., Ren, Z. W., Huang, H. Z., & Zhang, Z. N. (2013). Effects of grazing and fertilization on the relationship between species abundance and functional traits in an alpine meadow community on the Tibetan Plateau. *Nordic Journal of Botany*, *31*(2), 247–255.

Mitev, D., Churkova, B., Lingorski, V., & Mihovski, T. (2011). Study on the coadaptive ability of some meadow grasses in the conditions of the Central Balkan Mountain. *Journal of Mountain Agricultural on the Balkans*, *14*(6), 1278–1291.

Mitev, D., Mihovski, T., & Churkova. B. (2010b). Persistence of artificial grasslands with the participation of red fescue, located on the slopes of the Central Balkan Mountain. 9. Condition of mixed grassland of red fescue, cock's-foot, red clover and bird's-foot-trefoil. *Journal of Mountain Agricultural on the Balkans*, *13*(6), 1594–1605.

Mitev, D., Lingorski, V., & Churkova, B. (2010a). Durability of artificial grasslands with the participation of red fescue, located on the slopes of the Central Balkan Mountain. 8. Condition of mixed grassland of red fescue, Kenthucky bluegrass and alfalfa. *Journal of Mountain Agricultural on the Balkans*, *13*(6), 1565–1577.

Naidenova, G., Mitev, D. (2008). Persistenceof artificial grasslands, with the participation of red fescue, located on the slopes of the Central Balkan Mountains. 4. Condition of mixed grassland of red fescue and Kenthucky bluegrass. *Journal of Mountain Agriculture on the Balkans*, *11*(6), 1124–1135.

Naydenova, G., Vasileva, V. (2019b). The potential breeding value of snow clover (*Trifolium pratense* ssp. *nivale* (W.D.J. Koch) Arcang.) and red clover (*Trifolium pratense* ssp. *sativum)* hybrids. *Thaiszia Journal of Botany, Kosice*, *29*(2), 217–224.

Naydenova, G., & Vasileva, V. (2019a). Comparative evaluation of diploid and tetraploid red clover genotypes in a flat area of Northern Bulgaria. *Journal of Central European Agriculture*, *20*(3), 919–927.

Pacurar, F., Rotar, I. (2004). Maintaining biodiversity and increasing the production of dry matter on mountain meadows. Land Use Systems in Grassland Dominated Regions. *Grassland Science in Europe*, *9*. 216–218.

Pellegrini, L. G. De, Nabinger, C., Neumann, M., Carvalho, P. C. de F., & Crancio, L. A. (2010). Sociedade Brasileira de Zootecnia, Viçosa, Brazil. *Revista Brasileira de Zootecnia*, *39*(11), 2380–2388.

Popescu, E., & Churkova, B. (2015). Banat's University of Agricultural Sciences and Veterinary Medicine, Timisoara, Romania. *Banat's Journal of Biotechnology*, *6*(12), 5–14.

Stevanovıć Dajıć, Z., Peeters, A., Vrbnıčanın, S., Šoštarıć, I., & Aćıć, S. (2008). Long term grassland vegetation changes: Case study NaturePark Stara Planina (Serbia). *Community Ecol.*, *9*. 23–31.

Suding, K.N., Lavorel, S., Chapin, F.S., Cornelissen, J.H.C., Diaz, S., Garnier, E., Goldberg, D., Hooper, D.U., Jackson, S. T., Navas, M. L. (2008). Scaling environmental change through the community-level: a trait-based response-and-effect framework for plants. *Global Change Biol.*, *14*. 1125–1140.

Tanova, K., Uchkunov, I., Slanev, K., Nikolov, P., Enchev, S. (2008). Study on the soil mycoflora and some pests in ecofield with forage crops in the region

of Shumen. *Journal of Mountain Agriculture on the Balkans*, *11*(4), 694–700.
Vasileva, V., Enchev, S. (2018). Self-seeding of subterranean clover in degraded birdsfoot trefoil seed production stands. *Bulg. J. Agric. Sci*., *24*(Suppl. 2), 104–108.
Velev, N., Apostolova, I., Fajmonová, Z. (2011). Cynosurus cristatus grasslands in West Bulgaria. *Phytologia Balcanica*, *17*(2), 221–236.
Volf, M., Redmond, C., Albert, Á.J., Le Bagousse-Pinguet, Y., Biella, P., Götzenberger, L., & Šebelíková, L. (2016). Effects of long-and short-term management on the functional structure of meadows through species turnover and intraspecific trait variability. *Oecologia*, *180*(4), 941–950.
Zziwa, E., Kironchi, G., Gachene, C., Mugerwa, S., & Mpairwe, D. (2012). Production systems, land cover change and soil factors affecting pasture production in semi-arid Nakasongola. *International Journal of Agronomy and Agricultural Research (IJAAR)*, *2*(5), 1–12.