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EFFECTS OF NON-FERTILISED GRASSLAND MANAGEMENT INTENSITY ON HERBAGE QUALITY AND QUANTITY

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Over 2006–2009, an optimum cutting frequency was investigated at non-fertilised grassland. The research was carried out at the Suchý vrch site (near Banská Bystrica), altitude 460 m. The research sward was utilised by cutting with different intensity: high (4 cuts), medium (3 cuts), low (2 cuts) and by 1 cut under extensive exploitation. Herbage yield, organic and mineral substances and nutritive value were determined. The intensity of sward exploitation influenced the dry matter (DM) production which was higher when utilised by two cuts than by four and three cuts, respectively. The research parameters showed the best DM quality at the highest cutting frequency (the high and the medium intensity). Crude protein (CP) content increased at higher cutting frequency, but dropped at extensive utilisation. The content of fibre was higher at less intensive cutting. The highest content of phosphorus (P) and potassium (K) was found under more intensive cutting. Towards the end of growing season, calcium (Ca) content was rising while that of K was decreasing. The sodium (Na) content was low at all the research treatments.

Key words: cutting frequency, dry matter production, herbage quality, herbage quantity, sward utilisation

Grassland is an available resource providing large areas of land as well as producing a lot of good quality forage. Improved grassland management should lead to better yields while maintaining the cultural landscape. Looking for an optimum agreement between the conservation of biodiversity and the economic use of permanent grassland is currently topical. When a particular method and intensity of sward management is chosen, it is then reflected in the forage production and quality as well as in changed botanical composition and overall character of sward (Gaisler & Fiala 2003; Nilsdotter-Linde *et al*. 2002). It is necessary to adjust the intensity of sward utilisation to the required quality parameters in order to ensure adequate nutritive value and digestibility of feeds. Timeliness and frequency of cutting or grassland utilisation are closely related to the quality of forage (Turner *et al*. 2006). An early date of the first cut or an early start of grazing has a notable effect on the frequency of grassland utilisation and on the possible stocking rate (Nerušil *et al*. 2007). The number of cuts is dependent on an optimum harvesting, which is such that provides high yields of dry matter having adequate quality. In the first cut, the maximum yield is obtained at the growing stage of seed ripeness (Jančovič *et al*. 2006). The time for optimum utilisation is shorter at the beginning of growing season than at its end, when the time period becomes more flexible (Holúbek *et al*. 2007). Cutting grass early at an appropriate height of sward ensures the intensive production of tillers and enhanced yield at the second cut. The date of the second cut is less influential in terms of quality. Hejcman *et al*. (2010) reported that late cutting management, decreases forage quality in highly productive more than in low pro-

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ductive plant communities. According to Míka (2010), the date of the first cut should be chosen for mild and warm regions in early May, for the regions with conditions more difficult for growing grasses and legumes in late May and for the mountain regions even later. In terms of the parameters studied (crude protein, fibre and nutrient content), the quality of forage was better under high and medium intensity of utilisation, namely with three cuts than with two cuts. Crude protein (CP) content decreases and fibre content rises when the date of the first cut is postponed (Gaisler & Fiala 2003).

The objective of this work was to determine optimum cutting frequency at permanent grassland from the viewpoint of quality and quantity of production.

MATERIAL AND METHODS

The research was performed at productive grassland ("Suchý vrch" site – near Banská Bystrica; altitude 460 m; the mountain ranges of "Kremnické vrchy" and "Starohorské vrchy"; warm to medium-warm agro-climatic region; dry sub-region) over 2006–2009. During this research period, mean annual temperature was 9.28°C and it was 15.86°C over the growing season; mean annual rainfall was 843 mm and it was 401 mm over the growing season. The soil at the research site (geological substratum) was Cambisol; the soil texture sandy-loamy to loamy, medium deep to shallow; the initial pH (KCl) = 6.68; available nutrients: P = 13.08 mg/kg and K = 215.63 mg/kg. The original sward was represented by *Trifolio–Festucetum rubrae* association in which the dominant grasses were *Festuca arundinacea* Schreb. (16%), *Festuca rubra* L. (15%), *Trisetum flavescens* (L.) P. Beauv. (10%) and *Poa pratensis* L. (9%); the dominant legumes were *Medicago falcata* L. (8%) and *Trifolium repens* L. (4%) and other herbs were dominated by *Achillea millefolium* L. (3%) and *Taraxacum officinale* auct. non Web. (4%).

The research trial studying the sward utilisation was established as randomised blocks with four replicates, plot size 1.5 × 10 m (15 m^2). Four trial treatments were as follows:

Treatment 1 **high intensity** of utilisation – 4 cuts (the 1^{st} cut before 15 May, the following cuts 45 days later); Treatment 2 **medium intensity** of utilisation – 3 cuts (the 1^{st} cut between 16–31 May, the following 2 cuts 60 days later); Treatment 3 **low intensity** of utilisation – 2 cuts (the 1^{st} cut between 1–15 June, the 2^{nd} cut 90 days later); Treatment 4 **extensive** utilisation – 1 cut (plus the 2^{nd} cut if and when necessary). The production was defined as fresh herbage weight at the research site. Chemical analysis was made of herbage oven-dried at 65°C and the production was determined as dry matter (DM) content. The sward quality was analysed in the samples taken at all the treatments and cuts. The following organic and mineral substances were determined: crude protein by the Kjeldahl method (N × 6.25); fibre by the Henneberg–Stohmann method; the contents of P, K, Mg, Na and Ca were determined

Table 1

The nutrient content in soil as recorded before and after the trial period

Years	Treatments[1)]	pH/KCl	C_{ox} [g/kg]	N [g/kg]	P [mg/kg]	K [mg/kg]	Mg [mg/kg]
2006	1	6.65	51.9	4.6	73.9	152.9	1418.8
	2	6.70	52.8	5.7	48.5	179.6	1549.3
	3	6.77	51.3	4.6	87.1	143.4	1315.8
	4	6.76	47.8	4.7	23.2	141.5	1463.9
2009	1	6.80	40.9	3.2	42.1	114.7	1112.1
	2	6.83	37.5	2.8	20.8	111.1	1179.5
	3	6.83	36.5	1.7	30.8	147.3	1237.2
	4	6.74	37.1	1.6	12.0	140.1	1238.7

[1)]Treatment 1:intensive; Treatment 2:medium intensive; Treatment 3:low intensity; Treatment 4:extensive in accordance with the Slovak technical standard STN 46 7093). The obtained data were subjected to analysis of variance (ANOVA) followed by *post hoc* comparison using the Tukey´s HSD test (Statit Custom QC for Windows).

RESULTS AND DISCUSSION

In 2009, mean air temperature increased to 16.5°C which was more by 0.9°C when compared with that of 15.6°C in 2006. The lowest temperature over the growing season (15.4) was recorded in 2008. Over the growing seasons of 2006–2008, the total monthly rainfall was rising from 376 mm to 466 mm (Table 2). By comparison with the other research years, 2008 was the year when above-average rainfall was recorded over the growing season and the highest monthly amount of rainfall (159 mm) was received in July of 2008. The year 2009 was an exception when the rainfall over the growing season was only 328 mm. This was the lowest rainfall recorded throughout the research period, the decrease by 138 mm in comparison with the previous year. In 2009, the air temperature was above-average, but markedly below-average rainfall was recorded, similarly to the other research years.

In 2006, the soil reaction was neutral (pH 6.65–6.77), but the pH increased to 6.74–6.83 in 2009. The highest increase in pH (by 0.15) was recorded at Treatment 1 (high intensity of utilisation). The pH value was 0.13 higher (from the initial 6.70 to 6.83) also at Treatment 2 (medium intensity of utilisation). Only a low increase in pH (by 0.06) was found at Treatment 3 (low intensity of utilisation). An exception was found at Treatment 4 (extensive utilisation) where the pH decreased slightly. The soil agrochemical parameters recorded before and after the trial period are given in Table 1.

The dry matter production was influenced by the intensity of grassland utilisation, which was given by a different number and different time distribution of the cuts. Table 3 presents the DM yields when differentiated sward management was applied at "Suchý vrch" site over the four research years.

The highest total DM yield (2.82 t/ha) was recorded at the most intensive Treatment 1 (four cuts) in 2008. By comparison with the other treatments, the highest total yield (2.66 t/ha) was recorded in 2009. Every year, DM production was gradually rising due to the intensity of utilisation, but decreased slightly in 2009. In this year, there was the lowest total rainfall (328 mm) during the growing season and DM yield decreased at all the research treatments. Treatment 2 (medium intensity, three cuts) was characterized by low DM production (1.65–1.80 t/ha) in the first two research years. At this treatment, the lowest production was recorded throughout the research years. The data in Table 7 show significant effects of the years on DM production ($P < 0.05$). A comparison of Treatment 3 (low intensity, two cuts) with the rest of the research treatments showed that the highest DM yield of them

T a b l e 2

Mean monthly temperature [°C] and total monthly rainfall [mm] – "Suchý vrch" site

Mean monthly temperature [°C]													
Years	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Apr.–Sep.	Jan.–Dec.
2006	–5.7	–3.0	1.2	10.0	13.1	17.4	21.3	16.3	15.4	10.1	6.2	1.2	15.6	8.6
2007	2.9	2.7	6.4	11.5	15.3	18.2	19.7	19.1	11.8	8.5	2.3	–2.5	15.9	9.6
2008	0.2	2.2	3.7	9.9	14.6	18.1	18.7	18.3	13.0	10.0	5.3	1.5	15.4	9.6
2009	–3.4	–0.6	3.0	13.0	14.7	16.2	19.9	19.6	15.8	8.4	5.2	–0.7	16.5	9.2
Total monthly rainfall [mm]														
Years	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Apr.–Sep.	Jan.–Dec.
2006	68	53	53	51	93	65	56	106	5	34	56	19	376	659
2007	162	65	74	0	139	108	44	82	64	23	58	50	437	869
2008	71	30	97	63	62	106	159	38	38	65	71	116	466	916
2009	66	63	94	12	66	105	58	39	48	103	105	170	328	929

all (3.92 t/ha) was recorded in 2006, but also the lowest DM yields were recorded here, namely 1.79 t/ha in 2007 and 1.56 t/ha in 2009 (Table 3).

The extensive Treatment 4 with one or two cuts during the growing season also yielded more than the treatments utilised by more frequent cutting. The DM production kept rising, but dropped dramatically to 1.80 t/ha as a result of low total rainfall in 2009. At Treatment 4, the highest DM yield (3.46 t/ha) was recorded in 2008.

The results clearly show that the sward utilised by two cuts yielded more DM than that mowed several times a year (four cuts), as shown by the significant effects of the cutting frequency ($P < 0.05$) on DM production (Table 7). Similar results of methodically comparable trials were reported by Buchgraber and Pötsch (1994), Strežo (1997), Gaisler and Fiala (2003), Kašparová and Šrámek (2007) as well as by Štýbnarová *et al*. (2010).

The research results are similar to those reported from other sites (Kohoutek *et al*. 2005; Skládanka & Hrabě 2008; Pozdíšek *et al*. 2002) and testify that the volume of DM produced from grassland is influenced not only by the specific meteorological conditions in different years, but also by the sward management techniques. Similarly, as based on long-term experiments, Gruber *et al*. (2003) pointed out that there is a decline in the productivity of grassland when the cutting frequency increases, especially in the four-cut regime.

Crude protein ranks among the decisive parameters of nutritive value of herbage. Table 4 shows that an increase in CP content was recorded at the 2nd cut of Treatment 3 (low utilisation intensity; two cuts a year). In 2008 however, the CP content was very low (79.26–83.31 g/kg). At the extensively utilised Treatment 4, the highest CP content was also found at the 2nd cut. The year 2007 was an exception, because the CP content decreased to 109.36 g/kg.

T a b l e 3

Dry matter yields at the cuts [t/ha]

Treatments	Cuts	Years			
		2006	2007	2008	2009
1	1st	0.23	0.46	0.82	0.88
	2nd	0.91	1.32	0.98	1.25
	3rd	0.16	0.29	0.92	0.50
	4th	0.76	0.25	0.10	0.03
	Σ	2.06	2.32	2.82	2.66
2	1st	0.77	0.77	1.24	1.28
	2nd	0.23	0.70	1.56	1.10
	3rd	0.65	0.33	0.18	0.07
	Σ	1.65	1.80	2.98	2.45
3	1st	2.26	1.50	2.43	1.42
	2nd	1.66	0.29	1.32	0.14
	Σ	3.92	1.79	3.75	1.56
4	1st	1.52	2.20	2.32	1.65
	2nd	0.91	0.76	1.14	0.15
	Σ	2.43	2.96	3.46	1.80

Treatments	Σ of 4 years	Averaged over years
Treatment 1:intensive	9.86	2.46
Treatment 2:medium intensive	8.88	2.22
Treatment 3:low intensity	11.02	2.75
Treatment 4:extensive	10.65	2.66

The data in Table 4 show that the investigated parameters of DM quality (CP, fibre) were better at the very intensive and medium-intensive Treatments 1 and 2, respectively. The content of CP was higher at the treatments with more frequent cutting than at the two-cut ones. This agrees with Gaisler and Fiala (2003) and Hrabě *et al*. (2005), Pontes *et al*. (2009) and Pozdíšek *et al*. (2010) who came to identical conclusions. Nilsdotter-Linde *et al*. (2002) found better DM quality at the three-cut treatments than at the two-cut ones. The content of CP was decreasing and the fibre content was rising when the date of the 1st cut was postponed, as shown by the significant effects of different utilisation intensity ($P < 0.05$) on the crude protein content (Table 8). Similar conclusions were reported also by Razec *et al*. (2002) and Gruber *et al*. (2003).

It was found that the fibre content in DM of herbage was rising at the lower intensity of sward management (Table 5). This agrees also with Kašparová and Šrámek (2007) who reported that depending on the intensity of utilisation, the fibre content at their two-cut (extensive) treatment (315 g/kg) increased to 145% in comparison with the four-cut treatment, which is related to increased aging of sward under such management. In our research, the highest mean fibre content was found at Treatment 3. When the utilisation was rising, the content of fibre was decreasing and that of crude protein was increasing. This is in agreement with the conclusions reported by Novák (2008).

A range of nutrient content in forage is very large, as a result of site conditions and species composition of sward. Klapp (1971) defines that the content of P in herbage DM is about 2.8 g/kg, and according to Hopkins (2000) it ranges from 2 to 4 g/kg. The highest P content was recorded at the treatments with high frequency of cutting (Table 6), as reported also by Ržonca *et al*. (2006). In the presented research, the lowest values were recorded in sward under the extensive utilisation. The phosphorus content kept rising from the first to the last cutting except for the extensive Treatment 4 where the P content decreased to 3.28 g/kg at the 2nd cut. This agreed with conclusions by Míka (2010). Similar results were reported by Britaňák *et al*. (2009), but the experiment investigated only two-cut utilisation. The later dates of the 1st cut resulted in decreasing P content at the research treatments. In the 1st cut, the

T a b l e 4

Mean crude protein content in herbage DM [g/kg]

Treatments	Cuts	Years			
		2006	2007	2008	2009
1	1st	109.31	148.44	131.77	127.62
	2nd	134.03	167.19	125.76	111.27
	3rd	191.76	109.96	121.44	118.31
	4th	139.71	138.78	113.96	115.70
2	1st	90.72	122.10	96.73	122.83
	2nd	112.98	125.37	113.35	112.95
	3rd	197.86	120.95	102.09	120.95
3	1st	101.97	98.32	79.26	89.41
	2nd	134.44	121.48	83.31	110.82
4	1st	90.12	141.58	93.51	99.79
	2nd	154.92	109.36	107.02	109.87

Treatments	Mean
Treatment 1:intensive	131.59
Treatment 2:medium intensive	119.90
Treatment 3:low intensity	102.37
Treatment 4:extensive	113.27

T a b l e 5

Mean fibre content in herbage DM [g/kg]

Treatments	Cuts	Years			
		2006	2007	2008	2009
1	1st	166.63	166.57	198.56	211.11
	2nd	211.31	212.61	205.05	248.04
	3rd	176.92	220.66	189.80	194.24
	4th	191.92	189.19	226.33	186.73
2	1st	214.90	220.10	256.32	227.72
	2nd	221.42	233.92	262.57	216.89
	3rd	151.47	192.20	218.01	237.96
3	1st	201.44	233.63	288.11	248.90
	2nd	190.65	207.69	236.75	227.64
4	1st	203.69	242.04	264.09	263.24
	2nd	175.10	197.87	207.14	227.21

Treatment	Mean
Treatment 1: intensive	199.73
Treatment 2: medium intensive	221.12
Treatment 3: low intensity	229.35
Treatment 4: extensive	222.55

T a b l e 6

Average content of minerals at the cuts [g/kg]

Treatments[1)]	Cuts	P	K	Na	Ca	Mg
1	1st	3.49	19.30	0.31	7.84	3.00
	2nd	3.28	16.61	0.36	10.57	3.64
	3rd	3.54	16.14	0.40	10.84	4.99
	4th	3.94	15.25	0.47	12.43	4.96
2	1st	3.00	16.47	0.32	7.82	3.40
	2nd	3.45	16.66	0.37	10.66	4.93
	3rd	3.45	18.02	0.43	12.32	4.28
3	1st	2.94	14.33	0.38	7.47	2.84
	2nd	3.34	13.77	0.41	11.44	4.53
4	1st	2.81	16.53	0.36	9.96	3.15
	2nd	3.37	14.47	0.42	12.37	5.20

[1)] Treatment 1:intensive; Treatment 2:medium intensive; Treatment 3:low intensity; Treatment 4:extensive

T a b l e 7

Effects of the cutting frequency and the years on dry matter production [t/ha]

Effects	Factors	Dry matter [t/ha]	SEM
Treatment[1)]	1	2.46^{ab}	0.24
	2	2.22^{a}	0.24
	3	2.75^{b}	0.28
	4	2.66^{ab}	0.22
Year	2006	2.52^{a}	0.22
	2007	2.22^{a}	0.22
	2008	3.26^{b}	0.22
	2009	2.12^{a}	0.22

The values in the same row with different superscript letters are significantly different at $P < 0.05$ for each variable (Tuckey´s HSD test);
SEM – standard error of the mean
[1)] Treatment 1:intensive; Treatment 2:medium intensive; Treatment 3:low intensity; Treatment 4:extensive.

T a b l e 8

Effects of the cutting frequency and the years on nutrient content [g/kg]

Factor	Crude protein	Fibre	P	K	Na	Ca	Mg
Treatment[1)]							
1	131.56^{b}	199.73^{a}	3.56^{b}	16.83^{ab}	0.39^{a}	10.46^{a}	4.15^{a}
2	119.91^{ab}	221.12^{b}	3.32^{ab}	17.29^{b}	0.38^{a}	10.12^{a}	4.32^{ab}
3	102.37^{a}	229.35^{b}	3.14^{a}	14.05^{a}	0.40^{a}	9.46^{a}	3.69^{a}
4	113.27^{a}	222.55^{b}	3.10^{a}	15.50^{a}	0.40^{a}	11.17^{ab}	4.18^{a}
SEM	3.980	3.314	3.096	0.782	0.375	0.330	0.186
Year							
2006	132.53^{b}	191.40^{a}	3.48^{a}	21.64^{a}	0.36^{a}	11.12^{b}	3.74^{a}
2007	127.59^{ab}	210.59^{b}	3.31^{b}	14.09^{b}	0.42^{a}	10.61^{b}	4.68^{b}
2008	106.20^{a}	232.07^{c}	3.37^{a}	13.87^{a}	0.38^{a}	8.82^{a}	3.92^{a}
2009	112.68^{a}	226.33^{bc}	3.18^{a}	15.24^{a}	0.40^{a}	10.70^{b}	4.13^{a}
SEM	3.389	3.675	3.184	0.492	0.356	0.407	0.153

The values in the same row with different superscript letters are significantly different at $P < 0.05$ for each variable (Tuckey´s HSD test)
SEM – standard error of the mean
[1)] Treatment 1:intensive; Treatment 2:medium intensive; Treatment 3:low intensity; Treatment 4:extensive

P content was 3.49 g/kg at the four-cut Treatment 1, but it was only 2.81 g/kg at the two-cut Treatment 4. Holúbek *et al*. (2007) defined the acceptable range of P content in 1 kg of DM between 2.8 and 3.3 g/kg.

The highest potassium content was always recorded at the 1st cut and it kept decreasing by the end of growing season. Similar conclusions were drawn by Fiala (2005) as well as by Novák (2008). On the contrary, the three-cut Treatment 3 was an exception where the content of K was rising toward the 3rd cut, namely from 16.47 to 18.02 g/kg. However, Ržonca *et al*. (2006) reported more favourable K content at extensively utilised grassland. While the K content decreased at the end of growing season, the content of Ca had the opposite course and was increasing at all the research treatments. The content of Na was low at all the research treatments; however, it was rising from the first to the last cutting. From the viewpoint of animal nutrition, Na content was deficient, which is true of most grassland. Therefore, animal feeding rations are supplemented with mineral licks, as noted by Míka (2010) or Jančovič *et al*. (2008). The content of Mg was increasing at the two-cut treatments, however, any significant effects of the intensity of utilisation on Mg content were not found. There was an increase in Mg content also at multiple cutting (three- and four-cut treatments), but decreased slightly at the last cutting. The lowest content of Mg and Ca was recorded with the low intensity of utilisation (Treatment 3). The highest content of mineral nutrients was found at Treatment 1 (four cuts) and was decreasing towards the two-cut treatment. Similar results were reported by Lichner *et al*. (1983), Kohoutek *et al*. (2005) and also by Nerušil *et al*. (2007).

CONCLUSIONS

The research into grassland utilisation without fertiliser application from the viewpoint of the quality and quantity of production was carried out over 2006–2009 and the following simple conclusions can be drawn:

The intensity of utilisation influenced the DM production which was higher at the two-cut frequency than with more cuts (three or four) applied per year.

The highest content of mineral elements was recorded at the four-cut treatment, but this content was decreasing in the treatments applying the utilisation by two cuts.

The crude protein content was higher under more frequent cutting (high and medium utilisation intensity) than at the two-cut treatments. The content of CP was decreasing when the extensive utilisation was rising. The fibre content was rising when the intensity of sward utilisation was decreasing.

The highest content of P and K was found at the multiple-cut treatments. As the growing season was coming to its end, the K content was decreasing, but the content of Ca had the opposite tendency. The content of Na was low at all the research treatments.

Considering the parameters of quality (crude protein, fibre, minerals) and quantity, the high cutting frequency (four cuts per year) appears to be an optimum utilisation regime for the grassland without fertiliser application.

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