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EVALUATION OF QUANTITATIVE AND QUALITATIVE TRAITS OF WILD ECOTYPES OF FORAGE GRASSES

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Wild ecotypes of *Festuca rubra* L. (four accessions), *Poa pratensis* L. (three accessions) and *Phleum pratense* L. (three accessions) originating from Central Slovakia were investigated. Dry matter production, qualitative traits as well as mineral content were studied under identical soil-climatic conditions in a three-cut system. Yield potential of wild ecotypes of *Festuca rubra* L. coming from mountain regions was significantly lower ($P < 0.01$) when compared to *Festuca rubra* L. cultivar Levočská. In contrast, as a consequence of low variability, the dry matter yield of *Phleum pratense* L. wild ecotypes originating from higher altitudes was comparable to the dry matter yields of *Festuca rubra* L. cultivar Levočská. There were not noted any considerable differences found in the content of crude protein, fibre or mineral substances between the wild ecotypes and the cultivars. All accessions showed consistent patterns in seasonal distribution with the highest dry matter yield at the first cut and with the lowest one at the third cut. In general, concentration of crude protein and fibre did not vary considerably among cultivars and wild ecotypes at all species under uniform growing conditions.

Key words: wild ecotypes; *Festuca rubra* L.; *Poa pratensis* L.; *Phleum pratense* L.; dry matter yield; mineral content

As crop improvement through plant breeding critically depends on crop genetic resources, knowledge of potential of natural populations is an essential starting point. Detections of qualitative and production traits of wild populations originating from various environmental conditions can identify the strength and the weakness of these populations and indicate a possibility to use them for breeding new improved varieties. Moreover, evaluation of indigenous wild genetic resources improves a basis of information on their specific characteristics and contributes to sustainable use of domestic natural resources.

Improved fodder quality and adaptation to changing climate has been recognized as important goals for breeding of fodder grasses (Wilkins & Humphreys, 2003). Crude protein and fibre has been recognised as critical parameters of nutritive value (Bonesmo & Bèlanger, 2002). Besides these important parameters influencing the amount of energy for maintenance and performance of ruminants, an increasing interest in the content of mineral nutrients is well documented (Steinshamn *et al*. 2004; Fulkerson *et al*. 2007). It is useful for plant breeders, conventional and organic farmers as well, to know the range of mineral concentration. Those genotypes that utilize soil nutrients more efficiently are of value to livestock producers who depend on forages to meet the energy and nutrient requirements of livestock. Genetic variation of mineral elements within the grass species has been studied in tall fescue (Sleper *et al*. 1977; Reeder *et al*. 1986), orchard grass (Míka 1982; Stratton & Sleper 1979).

In Slovakia, grassland management and environmental conditions affect utilisation of grass species and consequently their breeding. The Slovak culti-

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vars of fodder grasses were developed from the plant material originating from the Czech Republic (*Phlem pratense* L. cultivar Levočská, *Festuca rubra* L. cultivar Levočská) or from Slovakia (*Poa pratensis* L. cultivar Lea). *Phleum pratense* L. is naturally found at lowland hay meadows in Slovakia (Viceníková & Polák 2003). However it is the most productive under cool and humid conditions of mountain and upland regions (Jančovič *et al*. 2005).

Festuca rubra L. is found from wet to dry soil conditions with exception to very dry soils. It tolerates short-term drought and short-term wet soil conditions as well. *Festuca rubra* L. is most frequently found in long-term or permanent meadows and pastures with low and medium level of fertilisation.

Poa pratensis L. is hardy, persistent and attractive grass adapted to a wide range of environmental conditions with very good forage quality. It can colonize the gaps in the sward and its re-growth rate is very fast, so it produces a very thick sward. Along with *Festuca rubra* L., it is one of the best grasses for mountain regions (Peeters 2004).

Although assessment of nutritive value and nutrient content of monocultures of grass species grown in Slovakia has been reported (Hanzes *et al*. 2005), only few studies have evaluated the nutritive value and nutrient content of wild ecotypes of fodder grasses (Martincová 2009).

The aim of the presented research was to assess dry matter production, qualitative traits and content of mineral nutrients of *Festuca rubra* L., *Poa pratensis* L. and *Phleum pratense* L. accessions originating from the Central Slovakia.

MATERIAL AND METHODS

The initial material for the study comprised three accessions of *Festuca rubra* L., two accessions of *Poa pratensis* L. and two accessions of *Phleum pratense* L. (Table 1). All ecotype populations were collected in Central Slovakia in 2001. Altitudes of the sites ranged from 214 to 1533 m a.s.l. The "Hontianske Nemce" site was located in the southern part of the Central Slovakia and the other sites ("Nižná Boca", Liptovská Lužná", "Heľpa", "Čierny Balog", "Čertovica") were located in the Low Tatras mountains range. Within each species the following cultivars were used as the controls: *Festuca rubra* L. cv. Levočská, *Poa pratensis* L. cv. Lea and *Phleum pratense* L. cv. Levočská. These cultivars were obtained from the "Plant Breeding Station Levočské Lúky" in Slovakia.

In 2004, the research trial was established at the site of Grassland and Mountain Agriculture Research Institute in Banská Bystrica (48°39´ N, 19°08´ E) altitude 420 m a.s.l. on sandy loam soil with higher content of gravel and rich in plant-available minerals.

At the site the mean annual rainfall is 795.5 mm and mean annual temperature is 8.1°C (data recorded by the Department of Meteorological Service in Banská Bystrica). In 2005, the total annual rainfall and the sum of rainfall over growing season were 856 and 403 mm, respectively. Mean annual and seasonal temperatures did not show any particular difference from average values. By contrast, the year 2006 was a dry ones. Rainfall during growing season was 35% lower than the long-term average seasonal precipitation. The months of June, July and September were particularly dry. Compared to long-term monthly averages, the sum of rainfall during June (92.8 mm), July (80.9 mm), September (55.0 mm) were lower by 39, 68 and 90%, respectively.

The trial was arranged in a randomized complete block design with two replications. Precultivated plants were planted in the experimental plots (2 × 0.5 m size). Plant spacing was 500 × 250 mm. The fertiliser rates were applied as follows: 60 kg/ha of nitrogen was split into two dressings (65% in spring and 35% after the first cut), 70 kg P_2O_5/ha and 100 kg K_2O/ha was applied in spring. Plants were cut three times a year: the first cut at the ear emergence; the second cut – approximately 6 to 8 weeks later; the third cut approximately 8 to 10 weeks after the second cut.

The dry mater (DM) yield was determined by drying to a constant weight at 60°C in an electric drier. The crude protein (CP) was determined by the Kjeldahl method (N × 6.25). Phosphorus (P) analysis was carried out colorimetrically using a Skalar autoanalyzer. The determination of potassium (K) and calcium (Ca) was carried out using flame photometer FLAPHO 4 and that of magnesium (Mg) determination was carried out by atomic absorp-

T a b l e 1

Site information for the accessions of ecotypes of *Festuca rubra* L., *Poa pratensis* L. and *Phleum pratense* L. used in the field trial. Temperature (T) and rainfall (R) represent values of annual long-term averages (source: Slovak Hydrometeorological Institute). Accession designation responds to the Genebank Piešťany code for collected material (SVK NTAT 01– 454 i.e. acronym of the collecting expedition in the Slovakia to the Low Tatras Mountains and year – collecting number)

Wild ecotype collection site /cultivar	Accession designation /information on cultivar	Site altitude (m a.s.l.)	T [°C]	R [mm]
Festuca rubra L.				
Liptovská Lužná	SVK NTAT 01–454	880	4.8	950
Heľpa	SVK NTAT 01–371	799	4.7	850
Nižná Boca	SVK NTAT 01–198	892	4.1	967
Levočská	forage cultivar, registered in 1949	–	–	–
Poa pratensis L.				
Hontianske Nemce	SVK	214	8.2	592
Čierny Balog	SVK	550	6.6	758
Lea	turf cultivar, registered in 2000	–	–	–
Phleum pratense L.				
Čertovica	SVK NTAT 01–433	1533	3.9	1,086
Nižná Boca	SVK NTAT 01–193	892	4.1	967
Levočská	forage cultivar, registered in 1950	–	–	–

T a b l e 2

Total dry mater (DM) yield and mean content of CP, fibre, P, K, Ca, Mg and the ratios of Ca / P and K / (Ca + Mg) in *Festuca rubra* L. accessions

Traits	*P* value	Accession				
		Liptovská Lužná	Heľpa	Nižná Boca	Mean of ecotypes	Cultivar Levočská
DM [t/ha]	0.004^{++}	3.99	3.91	3.21	3.70^{a}	7.77^{b}
CP [g/kg]	0.328	141.49	166.46	156.35	154.77	134.35
Fibre [g/kg]	0.645	188.98	187.02	191.46	189.15	196.74
P [g/kg]	0.472	2.71	2.83	2.68	2.74	2.56
K [g/kg]	0.669	21.05	22.91	21.36	21.77	21.22
Ca [g/kg]	0.661	7.81	8.25	8.35	8.14	8.96
Mg [g/kg]	0.182	2.79	2.92	3.14	2.95	4.05
Ca / P	0.590	2.99	2.97	3.24	3.07	3.48
K / (Ca + Mg)	0.932	2.27	2.33	2.24	2.28	2.24

$^{++}$ Significant ($P < 0.01$) differences between mean of ecotypes and cultivar Levočská

tion spectrophotometer GBC 908AA. The ratios of P / Ca and K / (Ca + Mg) were calculated.

Dry mater yield and nutrient concentrations were subjected to analysis of variance followed by *post hoc* comparison using the Tukey´s HSD test (Statit). Analysis of variance was performed for the research years 2005 and 2006 .

RESULTS

Festuca rubra L.

Four accessions of *Festuca rubra* L. were evaluated. Mean values of quantitative and qualitative parameters are given in Table 2. The total DM production of wild ecotypes ranged from 3.21 (Nižná

T a b l e 3

Dry mater (DM) yield, the content of CP, fibre, P, K, Ca, Mg and the ratios of Ca / P and K / (Ca + Mg) in *Festuca rubra* L. accessions in the 1st, 2nd and 3rd cuts

Traits	*P* value	Accession				
		Liptovská Lužná	Heľpa	Nižná Boca	Mean of ecotypes	Cultivar Levočská
1st cut						
DM [t/ha]	0.001++	2.30	2.30	1.84	2.15a	4.19b
CP [g/kg]	0.095	91.80	118.88	107.70	106.13	85.50
Fibre [g/kg]	0.226	232.42	227.20	211.74	223.79	145.38
P [g/kg]	0.936	2.24	2.49	2.38	2.37	2.39
K [g/kg]	0.824	18.03	21.05	20.39	19.82	19.41
Ca [g/kg]	0.880	4.07	3.99	3.99	4.21	4.12
Mg [g/kg]	0.360	1.73	1.72	1.72	1.83	1.56
Ca / P	0.368	1.88	1.90	1.69	1.83	1.74
K / (Ca + Mg)	0.781	3.17	3.32	3.57	3.35	3.53
2nd cut						
DM [t/ha]	0.269	1.00	0.92	0.86	0.93	1.53
CP [g/kg]	0.550	180.19	204.21	188.30	190.90	179.92
Fibre [g/kg]	0.940	176.10	189.47	199.98	190.90	187.72
P [g/kg]	0.616	3.02	3.01	2.85	2.96	2.80
K [g/kg]	0.793	24.10	23.54	21.71	23.12	22.34
Ca [g/kg]	0.273	9.83	10.17	10.86	10.29	13.28
Mg [g/kg]	0.100	3.42	3.34	3.91	3.56	6.47
Ca / P	0.256	3.29	3.43	3.95	3.56	4.61
K / (Ca + Mg)	0.460	1.87	1.78	1.51	1.72	1.37
3rd cut						
DM [t/ha]	0.133	0.68	0.70	0.51	0.63	1.33
CP [g/kg]	0.272	152.46	176.29	173.05	167.27	137.63
Fibre [g/kg]	0.830	158.44	144.39	162.67	155.16	157.12
P [g/kg]	0.510	2.86	2.99	2.82	2.89	2.50
K [g/kg]	0.737	21.03	24.16	21.97	22.39	21.91
Ca [g/kg]	0.873	9.53	9.59	10.21	9.91	9.48
Mg [g/kg]	0.480	3.23	3.40	3.80	3.48	4.13
Ca / P	0.873	3.81	3.57	4.08	3.82	4.10
K / (Ca + Mg)	0.907	1.77	1.89	1.64	1.77	1.82

++ Significant ($P < 0.01$) differences between mean of ecotypes and cultivar Levočská

Boca site) to 3.99 t/ha (Liptovská Lužná site). Cultivar Levočská showed the highest production potential in comparison with the wild ecotype accessions (7.77 t/ha of DM; $P = 0.004$). In the first cut, there was the significant difference in the mean DM production between the wild ecotypes and the cultivar (Table 3). In the second and the third cut, the highest DM production was recorded at the cultivar Levočská, nevertheless, the differences between the wild ecotypes and the cultivar were not significant.

The higher mean content of CP was recorded at the wild ecotypes than at cultivar Levočská (Table 2). In the fist cut, CP content ranged from 85.50 to 118.88 g/kg both in the cultivar Levočská and the wild ecotype from Heľpa site (Table 3). For all accessions, the highest content of CP was observed in the second cut. Among the wild ecotype accessions, the lowest CP content was found at the wild ecotype from Liptovská Lužná site in all the cuts.

At fibre content the opposite trend was observed. The highest mean content of fibre was recorded at cultivar Levočská (196.74 g/kg) and the lowest one in the wild ecotype from Heľpa site (187.02 g/kg). Only in the second cut, the fibre content was lower in cultivar Levočská comparing to the mean values at the wild ecotype accessions (Table 3).

As to the content of minerals, it did not show any significant differences between the wild ecotypes and the cultivar. The mean content of P and K was higher in wild ecotypes than in the cultivar (Table 2). In the first cut, the lowest content of P and K was found at the wild ecotype from Liptovská Lužná site (Table 5). In the second and third cut, the lowest content of P was recorded in cultivar Levočská.

The lowest mean content of Ca and Mg had the wild ecotype from Liptovská Lužná site (Table 2). Except for the first cut, the cultivar Levočská showed the highest content of P and Mg in comparison to the wild ecotypes. The highest Ca / P ratio was found at cultivar Levočská, resulting from the highest mean Ca. On the other hand, higher mean values of K / (Ca + Mg) ratio were recorded in the wild ecotype accessions (Table 2).

Poa pratensis L.

Two wild ecotypes of *Poa pratensis* L. showed a contrast in DM yield, where the wild ecotype from the low-land Hontianske Nemce site reached significantly higher DM yield (4.74 t/ha) than the second other one from the mountainous site of Čierny Balog (3.85 t/ha). The distribution of DM yield to the cuts was similar for all accessions, with the highest

T a b l e 4

Total dry mater (DM) yield and the mean content of CP, fibre, P, K, Ca, Mg and the ratios of Ca / P and K / (Ca + Mg) in *Poa praensis* L. accessions

Traits	*P value*	Accession			
		Hontianske Nemce	Čierny Balogh	Mean of ecotypes	Cultivar Lea
DM [t/ha]	0.663	4.74	3.85	4.29	4.49
CP [g/kg]	0.988	160.12	166.80	163.46	163.11
Fibre [g/kg]	0.724	226.47	196.34	211.41	204.54
P [g/kg]	0.473	2.63	2.69	2.66	2.85
K [g/kg]	0.587	23.54	21.95	22.74	22.00
Ca [g/kg]	0.515	7.98	7.71	7.84	6.79
Mg [g/kg]	0.607	2.91	3.17	3.04	2.78
Ca / P	0.476	3.23	2.99	3.11	2.52
K / (Ca + Mg)	0.775	2.38	2.45	2.42	2.55

yield in the first cut and the lowest in the third one. In the first and the second cut, the highest DM production was observed in the ecotype from Hontianske Nemce site, whereas in the third cut the significantly higher DM yield was recorded at the cultivar Lea (Table 5).

Qualitative traits were better at the wild ecotype from the mountainous Čierny Balog site. The lowest mean CP content and the highest mean content of fibre were found in the wild ecotype from the lowland Hontianske Nemce site (Table 4). The highest

T a b l e 5

Dry mater (DM) yield, the content of CP, fibre, P, K, Ca, Mg and the ratios of Ca / P and K / (Ca + Mg) in Poa pratensis L. accessions in the 1st, 2nd and 3rd cuts

Traits	*P* value	Accession			
		Hontianske Nemce	Čierny Balog	Mean of ecotypes	Cultivar Lea
1st cut					
DM [t/ha]	0.414	2.63	2.54	2.59	2.42
CP [g/kg]	0.643	107.72	107.68	107.70	99.54
Fibre [g/kg]	0.735	267.60	226.28	246.94	238.48
P [g/kg]	0.670	2.46	2.54	2.50	2.67
K [g/kg]	0.283	21.20	20.97	21.09	18.98
Ca [g/kg]	0.540	4.71	3.85	4.28	3.81
Mg [g/kg]	0.380	2.06	1.79	1.93	1.68
Ca / P	0.570	1.92	1.56	1.74	1.46
K / (Ca + Mg)	0.960	3.14	3.84	3.46	3.47
2nd cut					
DM [t/ha]	0.959	1.35	0.78	1.06	1.04
CP [g/kg]	0.455	194.65	212.10	203.38	219.25
Fibre [g/kg]	0.336	210.11	203.59	206.25	197.29
P [g/kg]	0.190	2.75	2.87	2.81	3.14
K [g/kg]	0.335	24.33	22.47	23.40	25.38
Ca [g/kg]	0.242	9.48	10.28	9.88	8.63
Mg [g/kg]	0.644	3.33	4.26	3.79	3.46
Ca / P	0.008++	3.45	3.58	3.52b	2.74a
K / (Ca + Mg)	0.149	1.91	1.54	1.73	2.12
3rd cut					
DM [t/ha]	0.049+	0.76	0.54	0.65a	1.02b
CP [g/kg]	0.539	177.98	180.62	179.30	170.53
Fibre [g/kg]	0.948	201.71	159.15	180.43	177.86
P [g/kg]	0.922	2.69	2.66	2.67	2.75
K [g/kg]	0.369	25.07	22.40	23.74	21.65
Ca [g/kg]	0.659	9.75	9.00	9.37	7.94
Mg [g/kg]	0.762	3.35	3.47	3.41	3.19
Ca / P	0.748	4.32	3.82	4.07	3.32
K / (Ca + Mg)	0.969	2.10	1.97	2.03	2.06

+ Significant ($P < 0.05$) differences between mean of ecotypes and cultivar Lea
++ Significant ($P < 0.01$) differences between mean of ecotypes and cultivar Lea

content of CP was recorded at cultivar Lea the in the second cut (219.25 g/kg).

The content of minerals did not show any significant differences between the wild ecotypes and the cultivar. Mean content of P ranged from 2.63 (wild ecotype Hontianske Nemce site) to 2.85 g/kg (cultivar Lea). The highest content of P was observed at cultivar Lea in all the cuts, when compared to the wild ecotypes. As to the content of K, there was variability found at the wild ecotypes and the cultivar in all the cuts. In the second cut, the K content was lower at the wild ecotypes, whereas in the first and the third cut the lowest content of K was recorded in cultivar Lea (Table 5). The content of Ca and Mg was higher in both the wild ecotypes than in cultivar Lea at all the cuts. The mean value of Ca / P ratio ranged from 2.52 at cultivar Lea to 3.23 at the wild ecotype from Hontianske Nemce site. In the second cut, cultivar Lea showed significantly lower value of Ca / P ratio comparing to the mean value found for the wild ecotypes (Table 5). By contrast, the mean values of K / (Ca + Mg) were lower at the wild ecotypes than those at the cultivar Lea (Table 4).

Phleum pratense L.

There were differences in DM production between the two ecotypes and the cultivar of *Phleum pratense* L. ranging from 4.82 (wild ecotype, Nižná Boca site) to 5.25 t/ha at cultivar Levočská. In the first cut, the highest DM yield was recorded at the wild ecotype from Čertovica site. In the second and the third cut, cultivar Levočská showed higher DM production in comparison to wild ecotypes (Table 7).

Similarly to the situation with *Festuca rubra* L. and *Poa pratensis* L., any significant variability of the qualitative parameters and the content of minerals was not found in the ecotypes of *Phleum pratense* L. (Table 6).

The wild ecotypes showed better qualitative traits than those found in cultivar Levočská. The highest CP content was found at the wild ecotype from Čertovica site in the second cut (Table 7). The lowest content of fibre was recorded at all the accessions in the third cut.

Mean content of P ranged from 2.41 (cultivar Levočská) to 2.62 g/kg (wild ecotype Čertovica site). The wild ecotype from Čertovica site showed the highest mean content of all mineral nutrients when compared to the wild ecotype from Nižná Boca site and cultivar Levočská (Table 6). Contrary to that, the wild ecotype from Nižná Boca site showed the lowest mean content of Ca and Mg. Subsequently, this manifested in the lowest mean values of Ca / P and K / (Ca + Mg) ratios at the wild ecotype from Nižná Boca site as well.

T a b l e 6

Total dry mater (DM) yield, the mean content of CP, fibre, P, K, Ca, Mg and the ratios of Ca/P and K/(Ca+Mg) in *Phleum pratense* L. accessions

Traits	*P* value	Accession			
		Čertovica	Nižná Boca	Mean of ecotypes	Cultivar Levočská
DM [t/ha]	0.900	5.22	4.82	5.02	5.25
CP [g/kg]	0.684	144.83	144.61	144.72	136.53
Fibre [g/kg]	0.287	182.89	176.90	179.89	197.40
P [g/kg]	0.203	2.62	2.59	2.61	2.41
K [g/kg]	0.694	23.30	23.03	23.16	22.48
Ca [g/kg]	0.924	7.92	7.38	7.55	7.81
Mg [g/kg]	0.928	3.58	3.09	3.34	3.40
Ca / P	0.675	3.04	2.94	2.99	3.31
K / (Ca + Mg)	0.966	2.49	2.46	2.47	2.50

DISCUSSION

According to Cristea *et al.* (2010), DM yield of a cultivar of *Festuca rubra* L. grown as monoculture varied according to nitrogen fertilisation and it ranged from 2.82 t/ha for untreated control up to 4.31 t/ha for the rate of 100 kg/ha. Similar studies conducted with several alternative grasses in Austria showed that DM yield of monocultures of cultivar *Festuca rubra* L. were 12.3 t/ha and 13.6 t/ha, respectively (Grais *et al*. 2011). Dürr *et al*. (2005) observed differences in yield potential of *Poa pratensis* L. cultivars between two sites in Canada. The DM yields of *Poa pratensis* L. cultivar grown under

T a b l e 7

Dry mater (DM) yield, the content of CP, fibre, P, K, Ca, Mg and the ratios of Ca / P and K / (Ca + Mg) in *Phleum pratense* L. accessions in the 1st, 2nd and 3rd cuts

Traits	*P* value	Accession			
		Čertovica	Nižná Boca	Mean of ecotypes	Cultivar Levočská
1st cut					
DM [t/ha]	0.974	3.99	3.67	3.83	3.79
CP [g/kg]	0.373	102.83	117.96	110.41	97.15
Fibre [g/kg]	0.231	211.47	202.15	206.81	235.63
P [g/kg]	0.531	2.62	2.74	2.68	2.47
K [g/kg]	0.979	25.14	24.29	24.71	24.59
Ca [g/kg]	0.797	4.61	4.45	4.53	2.39
Mg [g/kg]	0.675	2.09	1.98	2.03	1.88
Ca / P	0.761	1.76	1.65	1.71	1.80
K / (Ca + Mg)	0.942	4.00	3.77	3.88	3.96
2nd cut					
DM [t/ha]	0.472	0.70	0.52	0.61	0.85
CP [g/kg]	0.849	177.00	173.33	175.17	167.97
Fibre [g/kg]	0.347	186.08	174.37	180.23	199.29
P [g/kg]	0.128	2.65	2.88	2.76	2.53
K [g/kg]	0.243	22.33	23.47	23.05	20.53
Ca [g/kg]	0.708	9.80	9.16	9.48	10.75
Mg [g/kg]	0.714	4.57	2.94	3.75	4.27
Ca / P	0.521	3.65	3.18	3.42	4.30
K / (Ca + Mg)	0.559	1.79	1.96	1.88	1.53
3rd cut					
DM [t/ha]	0.859	0.53	0.65	0.59	0.64
CP [g/kg]	0.881	154.63	142.52	148.57	144.47
Fibre [g/kg]	0.526	151.13	154.16	152.65	157.28
P [g/kg]	0.615	2.59	2.17	2.38	2.23
K [g/kg]	0.839	22.43	21.03	21.73	22.30
Ca [g/kg]	0.774	9.36	8.53	8.95	8.29
Mg [g/kg]	0.871	4.10	4.36	4.23	4.06
Ca / P	0.988	3.72	3.98	3.85	3.83
K / (Ca + Mg)	0.388	1.67	1.64	1.65	2.00

warm and dry conditions in Normandin site ranged from 4.16 to 4.54 t/ha, whereas *Poa pratensis* L. cultivars grown in Charlottetown sites with better soil and climate conditions yielded from 7.70 to 10.10 t/ha. To the contrary Grais *et al*. (2011) reported higher DM yields at *Poa pratensis* L. under drier conditions (13.0 t/ha) comparing to humid conditions (8.8 t/ha). Relatively lower DM yield at *Festuca rubra* L. and *Poa pratensis* L. observed in this study was associated with abiotic stress caused by the drought during the growing season in 2006. For *Phleum pratense* L., as reported by Bertrand *et al*. (2008), higher day and night temperatures resulted in low DM yield (5.41 t/ha) comparing to cooler temperature regime with long photoperiod. Low DM yield of all accessions of *Phleum pratense* L. in this study are consistent with findings of Jančovič *et al*. (2005) who noted that timothy (*Phleum pratense* L.) is not suitable to dry and warm conditions.

We found that yield potential of wild ecotypes differed within each grass species. The DM yield of wild ecotypes of *Festuca rubra* L. originating from mountain regions with low temperatures was significantly lower when compared to *Festuca rubra* L. cultivar Levočská. By contrast, yield production of the wild ecotypes of *Phleum pratense* L. was comparable with that of its cultivar. Similarly, Lemežiene and Kanapeckas (2008) found that the wild ecotypes of timothy differed in production only negligibly. As the cultivar Levočská of *Phleum pratense* L. was developed from the wild ecotypes coming from the Czech Republic where climate is more humid and with higher temperatures during winter comparing to Slovakia, the wild ecotypes originating from higher altitude of Central Slovakia with lower mean annual temperature seem to be adaptive to unfavourable weather conditions during winter season.

Wild ecotype of *Poa pratensis* L. originating from Hontianske Nemce – the site in the south of Central Slovakia with higher mean annual temperature and lower precipitation – showed significantly higher DM yield comparing to the wild ecotype originating from the humid conditions at Čierny Balog site. These results are consistent with findings of Weißhuhn *et al*. (2011) who reported that native perennial grassland plant species of the British provenance with the lower precipitation showed the weakest response to drought, whereas those of Swiss provenance with the higher summer precipitation showed the strongest response.

At all accessions, DM yield was affected by the growing season of the year. The DM yield decreased significantly from the first cut to the third one (not shown). We found that cultivars gave higher DM yield in the third cut comparing to wild ecotypes. However, each species differed in DM production in the first and the second cut. Whereas *Festuca rubra* L. cv. Levočská was superior in DM yield comparing to the wild ecotypes in all the cuts, the wild ecotype of *Poa pratensis* L. originating from Hontianske Nemce site in the south of Central Slovakia, showed the highest DM production in the first and the second cut. By contrast, *Phleum pratense* L. did not show any clear difference in DM production between cultivars and wild ecotypes at the cuts. Similar seasonal distribution of DM yield among wild ecotypes and cultivar within each species (*Festuca rubra* L., *Poa pratensis* L. and *Phleum pratense* L.) indicated that the wild ecotypes were dependent on the environmental conditions at the same degree as the cultivars.

In general, the content of CP and fibre did not vary considerably among cultivars and wild ecotypes at all species. In accordance with our results, Bovolenta *et al*. (2008) found only limited variation in mean CP content at eight grass species of alpine pastures. The highest CP content was recorded in *Poa pratensis* L., comparing to *Festuca rubra* L. and *Phleum pratense* L. Similarly, Dürr *et al*. (2005) found *Poa pratensis* L. as having the highest total N content. In our study, the mean CP content was 144.72 and 136.53 g/kg in the wild ecotypes and the cultivar of *Phleum pratense* L., respectively, which contrasts to Nordheim-Viken *et al.* (2009) who reported that *Phleum pratense* L. is rich in CP. Nevertheless, Kunelius *et al*. (2003) found differences in the CP content between early and late grazed cultivars of *Phleum pratense* L., where the content of CP was lower in the late grazed cultivars than in the early ones.

For all grass species, there were not any differences in mean nutrient content between wild ecotypes and cultivars. Our results are consistent with Dürr *et al*. (2005) who did not find any clear distinction among cultivars for being “high” or “low” in minerals. Similarly, mean values of Ca / P and

K / (Ca + Mg) ratio did not show any significant differences between the wild ecotypes and the cultivars.

It is well established that forages mineral profiles varies with the harvest during growing season (Whitehead 2000; Pelletier *et al*. 2008). For all accessions, the content of Ca and Mg increased as a season advances towards the autumn. Our findings are in agreement with Poland and Manske (2004) who reported that mineral concentrations in cool-season grasses were significantly influenced by advancing season. According to Hopkins *et al*. (1994) changes in the content of Ca and Mg in forage could be a consequence of differential uptake associated with seasonal factors such as temperature, water availability and light intensity. Seasonal variation in K concentration showed difference among *Festuca rubra* L., *Poa pratensis* L. and *Phleum pratense* L. At *Festuca rubra* L. and *Poa pratensis* L. the lowest content of K was found in the first cut, whereas K concentration in *Phleum pratense* L. non- significantly decreased with advancing growing season. Similarly Cherney and Cherney (1997) reported that the K content of *Phleum pratense* L. is lower in its regrowth. The differences among the species should be explained by a very high environmental effect and large genotype × environmental interactions for the K concentration (Sleper *et al*. 1989). Nevertheless, mineral profiles at the cuts did not show differences between the cultivars and the wild ecotypes within the species. These results are consistent with the results of Míka (1982) who did not found variability in Ca and K concentration among twelve cultivars of *Dactylis glomerata* L. under uniform soil and environmental conditions.

Seasonal changes in mineral concentrations in all accessions resulted in variation of Ca / P and K / (Ca + Mg) ratios during the growing season. Wild ecotypes of *Festuca rubra* and *Phleum pratense* L. obtained higher concentration of P in the cuts what resulted in lower Ca / P ratio in comparison to the cultivars. By contrast, cultivar Lea of *Poa pratensis* L. accumulated more P during the growing season comparing to the wild ecotypes and had significantly lower Ca / P ratio in the second cut.

The highest K / (Ca + Mg) ratio was observed for all accessions in the first cut, where wild ecotypes of *Festuca rubra* L. showed lower values in comparison to *Festuca rubra* L. cultivar Levočská and the other accessions of *Poa pratensis* L. and *Phleum pratense* L. as well. With advancing season, the increasing content of Ca and Mg in the wild ecotypes and the cultivars of *Festuca rubra* L., *Poa pratensis* L. and *Phleum pratense* L. resulted in K / (Ca + Mg) ratio decreasing to the value recommended for cattle diets (Whitehead 2000). These results are consistent with those of Pelletier *et al.* (2007) who reported that Ca and Mg concentrations have a great impact on the K / (Ca + Mg) ratio of *Phleum pratense* L. and the higher concentration of Ca and Mg in timothy harvested in summer resulted in reduced K / (Ca + Mg) ratio when compared with timothy harvested in spring. The differences in K / (Ca + Mg) ratio between the wild ecotypes and the cultivars of all the grass species were not statistically significant, but the ratio was higher at the wild ecotypes of *Festuca rubra* L. and *Phleum pratense* L. than at the cultivars.

The yield potential of *Poa pratensis* L. wild ecotype (from Hontianske Nemce site at the south of Central Slovakia) and the wild ecotypes of *Phleum pratense* L. (from the higher altitude sites of Central Slovakia) seems interesting for a future breeding programme aimed at upland environmental conditions of Central Slovakia. However, it was found that the cultivar Levočská of *Festuca rubra* L. showed significantly higher DM yield than the wild ecotypes, probably due to its genetic improvement.

As a consequence of uniform soil and environmental conditions, there were no considerable differences in the content of CP or mineral profiles between the wild ecotypes and the cultivars within the species.

CONCLUSIONS

The results of our study showed that the wild ecotypes *Festuca rubra* L., *Poa pratensis* L. and *Phleum pratense* L. differed from each other in their yield potential. While the DM yield of *Festuca rubra* L. cultivar Levočská was superior to that of *Festuca rubra* L. wild ecotypes, the wild ecotypes of *Phleum pratense* L., originating from the higher altitude sites provided the DM yields comparable to those recorded with *Phleum pratense* L. cultivar

Levočská. Nevertheless, all the ecotype accessions showed consistent patterns in the seasonal distribution of DM yield. Analyses of qualitative traits and mineral content confirmed limited genetic variability among wild ecotypes and cultivars within the species under uniform environmental conditions.

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