

AN IMPACT OF MINERAL FERTILISATION ON THE STABILITY OF SEMI-NATURAL GRASSLAND AT EXCESSIVE OR DEFICIENT RAINFALL

VPLYV MINERÁLNEHO HNOJENIA NA STABILITU POLOPRÍRODNÉHO TRÁVNEHO PORASTU POČAS NADBYTKU A NEDOSTATKU ZRÁŽOK

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An influence of increasing mineral fertiliser rates on the temporal stability of semi-natural grassland (*Festuco-Cynosuratum* association) was investigated at a site in a mountain region (Liptovská Teplička, the Low Tatras mountain range, Slovakia). Based on the botanical composition of sward at the first cut, the temporal stability was assessed in the wet and the

dry years during a decade (1993–2002). This ten-year research supported a hypothesis of plant species loss caused by human-driven eutrophication through fertiliser loading. However, the temporal stability of sward was showing an ambiguous tendency throughout the research or the wet and the dry period, respectively.

Key words: fertilisation, temporal stability, semi-natural grassland, botanical composition

INTRODUCTION

Diversity is often discussed as a trait of a community, and stability as a community function (Ives 2007). One of the ecological tenets justifying conservation of biodiversity is that diversity begets stability. The preservation of biodiversity is essential for the maintenance of stable productivity in ecosystems (Tilman and Lehman 2001) and biodiversity reduces variability in ecosystem productivity through compensatory effects; that is, a species increases in its abundance in response to the reduction of another in a fluctuating environment. Undoubtedly, ecosystem stability depends not only on community composition but also on disturbance, nutrient supply and climatic condition (Bai et al. 2004). Stability has several meanings in ecology (Ives 2007; Lehman and Tilman 2000; Tilman et al. 2006).

For definitions of stability involving dynamics, species-species interactions (competition) tend to create negative diversity-stability relationships. Specifically, species-species interactions underlie the existence of alternative stable states and non-point attractors. Similarly, species-species interactions cause the decrease in return rates with increasing diversity. Conversely, species-environment interactions underlie the positive diversity-stability relationship for resistance; when species respond differently to environmental variation, the variation in their combined, ecosystem level response decrease with increasing diversity, because the decreases in abundance of some species are counterbalanced by increases in others (Ives and Carpenter 2007). Tilman et al. (2006) proposed that diversity has consistent stabilizing effects on ecosystem processes once timescales are sufficient to incorporate the aver-

age net effects of diversity on both resistance to and recovery from perturbations (resilience), because as Loreau and Behera (1999) stated, more diverse ecosystems are more likely to contain some species that can survive during a given environmental disturbance and thus compensate for reduced competitors.

Nitrogen is a key element controlling the species composition, diversity, dynamics, and the functioning of many terrestrial, freshwater, and marine ecosystems (Vitousek et al. 1997). The use of N and P fertilisers has revolutionised agriculture (Davidson and Howarth 2007), and the greatest changes in plant community biomass, composition, and diversity came from N addition in the grasslands (Tilman and Lehman 2001). Because human activities have increased nitrogen (N) availability dramatically in terrestrial and aquatic ecosystems, N deposition has two commonly hypothesized mechanisms driving the productivity – diversity relationship. First, as productivity is enhanced, the chance that a species is lost is proportional to its initial abundance, and therefore, diversity decline is driven primarily by the loss of rare species. Second, as productivity increases, species losses are a function of changes in the traits optimal for resource use. Specifically, species that are able to tolerate low levels of below-ground resources in unfertilised conditions, effectively obtain below-ground resources, or constrained in their use of above-ground resources should be more likely to be excluded in fertilised conditions (Suding et al. 2005).

After land use change, N deposition and climate change have been predicted to be major drivers of diversity loss (Sala et al. 2000). For example, under conditions of Northern-American prairie with manipulated diversity, Tilman and Downing (1994) have shown a decrease in species number by 35 per cent resulting from a severe drought occurrence. There was a connection between the species number decline and diminished dry matter production observed. However, under conditions of the Slovak Republic, Gáborčík (2005) has found positive correlation between increasing amounts of fertiliser and water use efficiency in cases of rainfall deficiency, but he has observed the reduced dry matter production as well. Silvertown et al. (1994) have showed that rainfall affected the floristic composition of plots in the Park Grass Experiment directly, but that the indirect effect was stronger. They showed that March-May rainfall affected composition

and that no time lag occurred (Silvertown et al. 1994).

In this paper, results are presented of a ten-year field experiment carried out on semi-natural grassland. In the experiment, we tried to find a connection between the natural fluctuation in rainfall and the temporal stability of botanical composition under the mineral fertiliser influence. The research objective was to study an influence of four mineral fertiliser application rates on botanical composition and consequently, to assess these ecological characteristics: the temporal stability of sward throughout the research period and the temporal stability as recorded in the wet and the dry years of the research period.

T a b l e 1

Soil properties before the experiment establishment

pH	Nt	SOM	P	K	Mg
	[g kg ⁻¹]		[mg kg ⁻¹]		
7.00	2.77	61.1	3.5	70.8	592.8

Nt – total nitrogen content; SOM – soil organic matter; P – phosphorus; K – potassium; Mg – magnesium

T a b l e 2

Total rainfall over the important months and the positive or negative deviations [%] from the long-term average in the April – May period

Years	January – May rainfall [mm]	April – May rainfall [mm]	Deviation +/- [%]
1993	144.2	96.3	-17*
1994	268.9	184.9	+59
1995	208.2	109.3	-6*
1996	254.4	190.8	+64
1997	111.6	58.7	-50
1998	150.4	91.7	-21
1999	241.0	100.0	-14
2000	267.9	128.5	+10
2001	207.9	120.0	+3
2002	144.2	84.9	-27
\bar{x}	199.7	116.5	-

An asterisk is placed next to the years excluded from the research analyses, because equivalence between the wet and dry periods was needed.

MATERIAL AND METHODS

The field trial was established at the site in a mountain region of northern Slovakia, at Liptovská Teplička, the village located in the Low Tatras mountain range. At this site the main meteorological factors were as follows (on average): long-term temperature 4.0°C, annually (during the growing period 9.0°C) and long-term sum of rainfall 900 mm, annually (during the growing period 500 mm).

The human colonisation of the area (since 17th century) had resulted in deforestation and created conditions for pastures and arable land. Later, the arable land naturally turned to grassland and created the plant community of *Festuco-Cynosuretum* association. This grassland was used by traditional management, that is, once-a-year mowed and grazed aftermath sparsely by cattle or sheep before the experiment was established. In 1992, this permanent grassland comprised 32 vascular plant species and four nutrition levels at the following fertiliser rates were applied (numbers in subscript denote kg per ha): Treatment 1: N₀ P₀ K₀ (control); Treatment 2: N₀ P₃₀ K₆₀; Treatment 3: N₉₀ P₃₀ K₆₀; and Treatment 4: N₁₈₀ P₃₀ K₆₀. Each of these treatments consisted of four randomized replications and was used by three-times-a-year mowing management. In Table 1, soil characteristics before the experiment establishment are given.

The results of ten research years (1993–2002) are presented here. Throughout this research period, botanical composition (Marhold and Hindák 1998) as well as dry matter production and quality were assessed. The method of reduced projective dominance was used to determine the species composition always before the 1st cut. Consequently, the list of vascular plant species was used to measure the temporal stability (S) by Tilman (1998) and Tilman et al. (2006) that defined S as μ/σ , where μ is the mean value for a time period and σ is its temporal standard deviation over the same interval. In this field trial, the wet periods (the years 1994, 1996, 2000 and 2001) as well as the dry ones (the years 1997, 1998, 1999 and 2002) were evaluated (Table 2). The excluded years were 1993 (the initial research year) and 1995, the year with minimum deviation from mean rainfall during the main months of growing season (April and May) throughout the research period.

Note: species only with one record was excluded from analysis, and species with the same coverage was excluded as well.

The annual instantaneous rate of change of species diversity (e.g., Knops and Tilman 2000 and Fonara and Tilman 2008 for accumulation of nitrogen and carbon in grassland soils) in relation to the control treatments for a time interval was calculated as follows:

$$r = \left(\log e \frac{S_t}{S_a} \right) \frac{1}{x}$$

T a b l e 3

Temporal stability and botanical composition's fluctuation (by number of species) within investigated periods

Treatments	Characteristics	Total research period	Wet periods	Dry periods
N ₀ P ₀ K ₀	Stability	50.102	44.277	35.259
	maximum species	32	24	23
	mean species	25.8	22	19.75
	minimum species	19	21	16
N ₀ P ₃₀ K ₆₀	Stability	46.123	39.597	29.989
	maximum species	30	20	23
	mean species	24.8	19	20
	minimum species	19	18	17
N ₉₀ P ₃₀ K ₆₀	Stability	34.865	25.350	32.951
	maximum species	27	17	19
	mean species	22.3	16.5	15.5
	minimum species	13	16	12
N ₁₈₀ P ₃₀ K ₆₀	Stability	37.045	27.183	19.292
	maximum species	28	19	19
	mean species	21.4	17	14.75
	minimum species	11	14	9

where S_1 is the number of species in the control treatment; S_a is the number of species in the Treatments 2, 3, and 4, respectively; and x is the number of years of investigation, i.e. 10 years for the whole research period and 4 for both the wet and the dry years.

Multiple linear regressions were applied to assess a relationship between the temporal stability of grassland and the increasing fertiliser rates.

The recorded and calculated data were processed by STATIT Professional QC Release 5.2.8.36 (STATWARE, Inc., Corvallis, Oregon, USA).

RESULTS AND DISCUSSION

There had been earlier reports on the effects of different rates of mineral fertilisers applied to permanent

T a b l e 4

Mean annual loss/increase rates of plant species in grassland influenced by mineral fertilisation as related to the control [%]

Treatments	Total research period	Wet periods	Dry periods
$N_0P_{30}K_{60}$	-0.40	-3.67	+0.31
$N_{90}P_{30}K_{60}$	-1.46	-7.19	-6.06
$N_{180}P_{30}K_{60}$	-1.87	-6.46	-7.30

grassland in relation to the herbage DM production by Ilavská et al. (1999) and Britaňák et al. (2004). In agreement with Sala et al. (2000), the rising fertiliser application rates resulted in reduced diversity of vascular plants throughout the decade-long period of investigation (Table 3). Annually, by comparison with the con-

T a b l e 5 a

Temporal stability of grassland species through the research period (1993–2002)

Species/Botanical groups	Treatment 1	Treatment 2	Treatment 3	Treatment 4	<i>r</i>	<i>P</i>
<i>Alopecurus pratensis</i> L.	1.888	2.643	2.636	1.767	-0.101	0.889
<i>Avenula pubescens</i> (L.) Dumort	1.862	1.203	1.139	1.552	-0.383	0.617
<i>Dactylis glomerata</i> L.	0.717	0.998	1.247	1.339	0.979	0.021+
<i>Festuca pratensis</i> Huds.	1.021	1.274	1.133	1.071	-0.784	0.216
<i>Festuca rubra</i> L.	0.872	–	–	–	–	–
<i>Poa pratensis</i> L.	1.607	2.273	2.285	1.314	-0.230	0.770
<i>Trisetum flavescens</i> (L.) P. Beauv	1.739	1.391	1.253	0.965	-0.988	0.012+
Grasses	2.720	2.436	2.834	3.093	0.719	0.707
<i>Lathyrus pratensis</i> L.	0.857	1.202	–	–	–	–
<i>Medicago lupulina</i> L.	1.440	1.434	–	–	–	–
<i>Trifolium pratense</i> L.	1.470	1.154	–	–	–	–
<i>Trifolium repens</i> L.	0.960	1.194	–	–	–	–
<i>Vicia cracca</i> L.	1.397	1.219	–	–	–	–
<i>Vicia tetrasperma</i> L.	–	–	0.818	2.192	–	–
Legumes	1.805	2.187	0.745	0.410	-0.860	0.175
<i>Acetosa pratensis</i> Mill.	–	–	–	0.690	–	–
<i>Achillea millefolium</i> L.	2.014	–	2.062	1.801	-0.632	0.565
<i>Alchemilla xanthochlora</i> Rothm.	1.888	1.298	1.716	–	-0.283	0.817
<i>Anthriscus sylvestris</i> (L.) Hoffm.	–	–	1.173	–	–	–
<i>Carum carvi</i> L.	0.781	–	0.728	0.613	-0.921	0.255
<i>Cerastium arvense</i> L.	1.449	1.149	–	–	–	–
<i>Galium verum</i> L.	1.465	1.050	1.083	1.044	-0.780	0.221
<i>Heracleum sphondylium</i> L.	–	–	0.583	–	–	–
<i>Ranunculus acris</i> L.	1.873	1.161	1.113	0.805	-0.929	0.071
<i>Stellaria graminea</i> L.	1.372	1.407	–	1.115	-0.903	0.282
<i>Taraxacum officinale</i> auct. non Weber	1.836	2.889	2.187	1.991	-0.066	0.934
<i>Veronica chamaedrys</i> L.	1.561	1.791	1.764	2.133	0.919	0.081
Herbs	13.384	3.618	3.055	2.850	-0.812	0.300

r – Pearson’s correlation coefficient; *P* – probability

trol, mean rates of species loss were –0.40, –1.46 and –1.87% at the Treatments 2, 3 and 4, respectively. The average annual plant diversity loss as recorded both in the wet and the dry years was ambiguous. In the wet years, the highest loss of plant diversity (–7.19%) was found at Treatment 3. In the dry years, to the contrary, a surprising increase was calculated at Treatment 2 and the maximum decline was found at Treatment 4 (Table 4). Both the periods are related to the control treatment (mean values).

Our results, however, have not agreed with an argument by Stevens et al. (2004) that a cumulative effect of every 100 kg N ha⁻¹ year⁻¹ brings a 3 to 4% decline of species richness in a vegetation cover. A decreased species richness related to the cumulative effect of nitrogen was found “only” on the level of 1.51 and 0.95% at Treatments 3 and 4, respectively. Stevens et

al. (2004) did their estimates for the primary vegetation cover, namely the peat-lands of England (3%) and the Northern-American prairie (4%). Our estimates, however, were done for the secondary vegetation of semi-natural grassland substituting the forest cover. A relationship between the temporal stability of grassland and the increasing fertiliser rates by multiple linear regression was not significant (total period: R² = 0.804; T = –2.867, P = 0.103; wet years: R² = 0.832; T = –3.142, P = 0.088; and dry years: R² = 0.648; T = –1.918, P = 0.195). The research values predicted for the temporal stability of semi-natural grassland (Table 3) were consistent with the theoretical considerations (Lehman and Tilman 2000) and also with the experimental results Tilman et al. (2006). However, this related only to a certain level of mineral fertilisation, because the observed levels of stability were ambiguous. The sec-

T a b l e 5 b

Temporal stability of grassland species in the wet years

Species/Botanical groups	Treatment 1	Treatment 2	Treatment 3	Treatment 4	<i>r</i>	<i>P</i>
<i>Alopecurus pratensis</i> L.	3.700	3.890	2.807	1.755	–0.914	0.086
<i>Avena pubescens</i> (L.) Dumort	1.855	1.353	1.871	2.326	0.627	0.373
<i>Dactylis glomerata</i> L.	2.308	1.787	1.906	1.859	–0.678	0.322
<i>Festuca pratensis</i> Huds.	1.629	2.211	1.155	1.040	–0.718	0.282
<i>Festuca rubra</i> L.	2.150	–	–	–	–	–
<i>Poa pratensis</i> L.	1.839	2.228	1.533	1.512	–0.646	0.354
<i>Trisetum flavescens</i> (L.) P. Beauv	1.994	1.192	1.053	1.017	–0.790	0.210
Grasses	5.950	3.410	6.927	13.798	0.787	0.105
<i>Lathyrus pratensis</i> L.	0.608	3.591	–	–	–	–
<i>Medicago lupulina</i> L.	0.707	0.707	–	–	–	–
<i>Trifolium pratense</i> L.	2.305	2.507	–	–	–	–
<i>Trifolium repens</i> L.	1.502	0.732	–	–	–	–
<i>Vicia cracca</i> L.	2.000	1.372	–	–	–	–
<i>Vicia tetrasperma</i> L.	–	–	1.154	–	–	–
Legumes	1.617	2.377	1.919	1.500	–0.267	0.398
<i>Acetosa pratensis</i> Mill.	–	–	–	0.781	–	–
<i>Achillea millefolium</i> L.	1.773	–	1.703	5.579	0.746	0.464
<i>Alchemilla xanthochlora</i> Rothm.	2.653	2.085	2.210	1.504	–0.906	0.094
<i>Anthriscus sylvestris</i> (L.) Hoffm.	–	–	0.707	–	–	–
<i>Carum carvi</i> L.	0.842	–	0.787	0.500	–0.845	0.359
<i>Cerastium arvense</i> L.	2.093	1.685	–	–	–	–
<i>Galium verum</i> L.	1.630	1.155	1.021	1.541	–0.176	0.824
<i>Heracleum sphondylium</i> L.	–	–	0.500	–	–	–
<i>Ranunculus acris</i> L.	1.689	0.865	1.006	0.709	–0.837	0.163
<i>Stellaria graminea</i> L.	1.870	2.383	–	2.150	0.377	0.754
<i>Taraxacum officinale</i> auct. non Weber	2.225	2.283	2.089	2.851	0.647	0.353
<i>Veronica chamaedrys</i> L.	3.221	1.754	1.185	2.471	–0.412	0.588
Herbs	15.798	3.127	2.156	2.808	–0.786	0.371

r – Pearson’s correlation coefficient; *P* – probability

ondary vegetation cover with the higher level of applied nitrogen was superior to the lower one throughout the period of investigation. To the contrary, shifting from excessive to deficient precipitation favoured the low nitrogen rate treatment, where the temporal stability exceeded not only the high N rate treatment, but also the one with only PK applied. The temporal stability of species throughout the research period as well as in the dry and the wet years is given in Tables 5a, 5b and 5c, respectively. During the experiment, *Dactylis glomerata* L. correlated with the increasing mineral nutrition of grassland and this relationship had positive effects on the temporal stability ($r = 0.979$; $P = 0.021$). On the other hand, *Trisetum flavescens* L. was the species representing the negative relationship between mineral fertilisation and temporal stability ($r = -0.988$; $P = 0.012$). The statistically significant relationships were

not found at any other species. The increasing fertiliser rates reduced the temporal stability of botanical groups, namely grasses ($r = 0.719$; $P = 0.707$), legumes ($r = -0.860$; $P = 0.175$) and herbs ($r = -0.812$; $P = 0.300$), but the decrease was not significant. In the wet years, the relationships between the temporal stability and the fertilisation were not significant at the species level. It was recorded a positive relationship at the level of group of grasses only ($r = 0.787$; $P = 0.105$). The relationship between stability and increased mineral fertilisation under excessive rainfall amounts ($P < 0.10$) was consistent with the results of Silvertown et al. (1994) that rainfall selectively favoured the grasses in plant communities. The legumes and herbs were without any statistical influence as well ($r = -0.267$; $P = 0.398$; $r = -0.786$; $P = 0.371$, respectively). Throughout the dry years, *Festuca pratensis* Huds., was

Table 5c

Temporal stability of grassland species in the dry years

Species/Botanical groups	Treatment 1	Treatment 2	Treatment 3	Treatment 4	r	P
<i>Alopecurus pratensis</i> L.	1.683	3.396	5.392	1.322	0.063	0.937
<i>Avenula pubescens</i> (L.) Dumort	2.309	1.114	0.786	1.108	-0.756	0.244
<i>Dactylis glomerata</i> L.	0.776	0.944	1.097	1.530	0.964	0.036 ⁺
<i>Festuca pratensis</i> Huds.	0.707	0.707	0.707	0.707	NA	NA
<i>Festuca rubra</i> L.	1.432	–	–	–	–	–
<i>Poa pratensis</i> L.	0.882	1.647	3.945	0.819	0.186	0.814
<i>Trisetum flavescens</i> (L.) P. Beauv	1.688	1.195	1.739	1.009	-0.533	0.467
Grasses	4.521	3.399	17.054	14.692	0.819	0.121
<i>Lathyrus pratensis</i> L.	0.927	1.271	–	–	–	–
<i>Medicago lupulina</i> L.	1.091	2.104	–	–	–	–
<i>Trifolium pratense</i> L.	1.177	0.801	–	–	–	–
<i>Trifolium repens</i> L.	1.032	1.373	–	–	–	–
<i>Vicia cracca</i> L.	1.225	1.594	–	–	–	–
<i>Vicia tetrasperma</i> L.	–	–	1.007	–	–	–
Legumes	1.688	2.426	1.241	0.500	-0.760	0.231
<i>Acetosa pratensis</i> Mill.	–	–	–	0.577	–	–
<i>Achillea millefolium</i> L.	2.663	–	3.837	2.309	-0.033	0.979
<i>Alchemilla xanthochlora</i> Rothm.	2.779	1.580	4.340	1.851	-0.187	0.881
<i>Anthriscus sylvestris</i> (L.) Hoffm.	–	–	0.707	–	–	–
<i>Carum carvi</i> L.	0.707	–	0.577	1.155	0.598	0.592
<i>Cerastium arvense</i> L.	3.921	0.707	–	–	–	–
<i>Galium verum</i> L.	1.111	1.000	1.007	1.155	0.130	0.934
<i>Heracleum sphondylium</i> L.	–	–	0.660	–	–	–
<i>Ranunculus acris</i> L.	2.461	0.865	0.866	0.577	-0.841	0.364
<i>Stellaria graminea</i> L.	2.784	2.122	–	1.155	-0.997	0.052
<i>Taraxacum officinale</i> auct. non Weber	2.036	2.001	2.577	1.781	-0.979	0.131
<i>Veronica chamaedrys</i> L.	1.162	3.279	3.034	1.851	0.134	0.914
Herbs	9.441	3.333	4.016	2.347	-0.836	0.255

r – Pearson's correlation coefficient; P – probability; NA – not analysed due to lack of variability

the species without any changes recorded at the fertiliser treatments (Table 5c). The temporal stability of *Dactylis glomerata* L. had a statistically positive reaction to the increasing amount of applied fertilisers ($r = 0.964$; $P = 0.036$). Any other individual plant species did not have statistically significant relationships. The botanical groups did not have any significant relationships as well (grasses: $r = 0.819$; $P = 0.121$; legumes: -0.760 ; $P = 0.231$; herbs: -0.836 ; $P = 0.255$).

CONCLUSIONS

The presented ten-year research supported a hypothesis of plant species loss caused by the human-driven eutrophication through fertiliser loadings. However, the research data recorded during the wet and the dry years showed ambiguous directions in the species richness development. Also, the application of different N fertiliser rates into semi-natural grassland suggested lower plant species loss than was recorded in the primary vegetation cover. The temporal stability of semi-natural grassland did not have a straightforward tendency in all the periods investigated. Among grasses, the significant relation to the increasing fertiliser application rates was positive at *Dactylis glomerata* L., but negative at *Trisetum flavescens* L. In the dry years, *Festuca pratensis* Huds. was the most stable grass species at each of the treatments with added nutrition. The temporal stability of plant botanical groups of semi-natural grassland decreased with the higher amount of applied fertilizers (inter alia functional group of grasses) in all the periods of research.

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SÚHRN

V horskej oblasti Slovenskej republiky (Liptovská Teplička, Nízke Tatry) sa sledoval vplyv zvyšujúcich sa dávok priemyselných hnojív ($N_0P_0K_0$, $N_0P_{30}K_{60}$, $N_{90} + PK$, $N_{180} + PK$) na dočasnú stabilitu (S) poloprirodného trávneho porastu (aso-

ciácia *Festuco-Cynosuretum*). Na základe botanického zloženia trávneho porastu v prvej kosbe sa stanovila dočasná stabilita pre obdobia s nadbytkom zrážok a aj ich nedostatok počas dekády od roku 1993 do 2002. Desaťročné sledovanie podporilo hypotézu straty rastlinných druhov človekom indukovanou eutrofizáciou prostredníctvom priemyselných hnojív. Počas celého obdobia a obdobia s nedostatkom zrážok sa relatívne priemerné ročné straty rastlín zvyšovali so stúpajúcim minerálnym hnojením. Iná situácia nastala počas obdobia s nadbytkom zrážok. Počas tohto obdobia sa na variante s nižšou dávkou dusíka zaznamenala najvyššia relatívna miera straty vyšších rastlín. Výsledky dočasnej stability trávneho porastu, ktorá bola rovnako ovplyvnená hnojením priemyselnými hnojivami, poskytli nejednoznačnú tendenciu či už počas celého výskumného obdobia, alebo počas jeho vlhkých alebo suchých rokov. Uvedené sa vzťahuje na celý ekosystém poloprirodného trávneho porastu, pretože na úrovni jednotlivých funkčných skupín sa zistilo koherentné správanie sa, t.j. podpora/rast dočasnej stability botanickej skupiny *Lipnicovité* a naopak pokles pri botanických skupinách *Bóbovité* a ostatné lúčne byliny.

Kľúčové slová: botanické zloženie, dočasná stabilita, hnojenie, poloprirodných trávny porast