The effect of different grazing systems on botanical composition, diversity and productivity of permanent pasture

Kobes M., Suchý K., Voženílková B. and Frelich J.
University of South Bohemia, Faculty of Agriculture, *Dept of Plant Production and Agroecology, Czech Republic*
Corresponding author: kobes@zf.jcu.cz

Abstract

Two types of grazing systems are common in the Czech Republic: continuous grazing and rotational grazing with 2 – 4 grazing cycles from May to October. The effect of the two grazing systems on botanical composition, sward type, plant species diversity and production of a *Festuceto-Trisetetum* (*Cynosurion* alliance) pasture sward was examined at an altitude of 650 m a.s.l. from 2000 – 2008 in South Bohemia. A differentiation of *Festuceto-Trisetetum* to *Festuceto-Dactylidetum*, *Dactylideto-Agrostidetum* and *Poaetum* swards was observed for rotational and continuous grazing. Rotational grazing with a lower frequency (2 grazing cycles) increased the dominance of grasses, while the higher grazing frequency (4 grazing cycles) as well as continuous grazing increased the dominance of herbs. The highest species diversity (Simpson´s index – D) was observed under rotational grazing with three grazing cycles (D > 12.80). Higher biomass production ($P < 0.01$) was recorded for rotational than for continuous grazing.

Keywords: pasture systems; continuous grazing; rotational grazing; botanical composition; species diversity; biomass production

Introduction

Two types of grazing systems prevail in the use of grasslands for grazing in the Czech Republic – continuous grazing, and rotational grazing with 2 – 4 grazing cycles per year. The botanical composition of the pasture swards, the species richness, species diversity and productivity are affected by the grazing system and the intensity of grazing. Extensive grazing in a rotational system leads to a greater proportion of tall grass species, foliage area and crop yield as compared to continuous grazing with a high stocking rate. An optimal stocking rate and pasture exploitation increase the rate of non-climbing legumes (Klimeš *et al.*, 2006) and herbs with a high feeding value. A high intensity of pasture exploitation is associated with lower species diversity (Hofmann *et al.*, 2006). The sward species richness can increase with increasing altitude, where tall grasses (Pappas and Koukoura, 2006) and herbs represent stable parts of the communities. The aim of this study is to assess the effect of various grazing systems on the species richness, the diversity and productivity of the pasture sward.

Material and methods

The influence of different pasture systems on species richness, species diversity and productivity was studied from 2000 – 2008 in a permanent pasture in the Šumava foothills (South Bohemia, Kaplice – Velký Chuchelec, 650 m a.s.l.). At the beginning of the study in 1999 the vegetation appertained to the *Cynosurion* alliance with dominant species of *Dactylis glomerata* L., *Trisetum flavescens* L. and *Festuca pratensis* Huds. The site was originally grazed by a rotational strip grazing system 2-3 times per year. Since 2000 three grazing systems have been applied: Rotational strip grazing with either 2, 3, or 4 grazing cycles per year (stocking rates 0.6, 1.2 and 1.8 LU ha^{-1}), combined exploitation – mowing 1x and

grazing 1x, and continuous grazing throughout the grazing period (2.5 LU ha^{-1}, May – October). The single plot area was 30 m^2 and each treatment had four replications (i.e. 120 m^2 per treatment). Fixed and mobile fences were used to arrange the rotational strip grazing and combined exploitation treatments. The area surrounding the strip rotational system was used for the continuous grazing treatment where the referring plots were located. A cattle herd of Charolais breed was used for the grazing trial. For the rotational strip grazing and the combined exploitation treatments several grazing animals were separated from the herd for the time of grazing on the plots. The botanical composition, the sward type, the number of species (species richness – S), species diversity (Simpson index – D; $D = 1/\Sigma p_i^2$) and biomass (dry matter) production were measured in each grazing cycle before grazing. In continuously grazed plots herbage yield was measured by the use of exclosure cages (2 m²). Data were statistically analysed using ANOVA and LSD test for *post-hoc* comparison of mean values applying the STATISTICA software package.

Table 1. Experimental treatments (grazing system and intensity – number of grazing cycles) and total numbers of vascular plant species (S - alpha diversity, per 30 m^2).

Variant of grazing	Year, total number of species (S)					
	2000	2002	2004	2006	2008	$Mean_{00-08}$
Rotational strip, 2x	26	28	30	29	26	27.0^b
Rotational strip, 3x	26	26	24	29	25	26.0^b
Rotational strip, 4x	25	28	27	25	24	25.3^b
Continuous grazing	26	24	21	20	20	22.1^c
Mowing 1x + grazing 1x	27	32	29	28	28	29.2^a

Treatments: F = 16.59***, $P < 0.001$; Years: F = 1.08 ns, $P > 0.05$

Results and discussion

In response to the different pasture systems and grazing intensities, the sward composition developed from two stand associations originally (*Festuceto-Trisetetum* and *Dactylidetum*) to three associations: *Festuceto-Dactylidetum* (rotational grazing 2x per year and mowing 1x + grazing 1x), *Dactylideto-Agrostidetum* (rotational grazing 3x) and *Poaetum* (rotational grazing 4x and continuous grazing). When a combined system of mowing and grazing was used as well as under lower grazing intensities (rotational grazing 2x per year), the swards contained tall, tussock forming/tall loosely clumped grasses (*Festuca pratensis*, *Dactylis glomerata*, *Trisetum flavescens*, *Phleum pratense* L.). Higher grazing intensity (rotational grazing 3x and 4x per year) and continuous grazing increased the abundance of *Lolium perenne* L., *Poa pratensis* L., *Agrostis capillaris* L. and of the herbs (*Plantago lanceolata* L., *Leontodon autumnale* L. and *Taraxacum* sect. *Ruderalia* Kirschner). The number of vascular plant species (S) increased under lower management intensities (mowing 1x + grazing 1x, rotational strip grazing 2x) but decreased under continuous grazing (Table 1). Simpson's index of species diversity was lower under continuous grazing (D = 10.3; Table 2) than under rotational strip grazing. Preferred (more palatable) plant species and species non-resistant to trampling (*Trisetum flavescens*, *Agrostis stolonifera* L., *Ranunculus acris* L., *Lathyrus pratensis* L., *Vicia cracca* L. etc.) disappeared from the sward under continuous grazing. High management intensity favoured the development of short swards with a high proportion of herbs with leaf rosettes, whereas the lower intensity of pasture exploitation (rotational system 2x per year, combined system mowing and grazing) had a significantly higher biomass production ($P < 0.01$) (Table 3). A higher species richness of non-fertilized pastures compared to unfertilized mown grasslands was also reported by Farruggia *et al.* (2008) in the French Massif Central. At stocking rates of 1.0 and 0.7 LU ha^{-1} the authors found an increased potential for a medium-to-high species richness of the pasture swards.

Table 2. Simpson's index of species diversity (D) in relation to grazing treatment and time.

Grazing treatment	Simpson's index (D) in different years					
	2000	2002	2004	2006	2008	$Mean_{00-08}$
Rotational strip, 2x	9.3	9.9	12.3	12.3	11.7	11.1^{bc}
Rotational strip, 3x	9.9	12.9	13.6	13.1	13.0	12.8^{a}
Rotational strip, 4x	9.9	10.3	13.7	11.6	11.8	11.4^{b}
Continuous grazing	9.2	11.9	11.8	10.5	9.1	10.3^{c}
Mowing 1x + grazing 1x	9.3	8.9	11.1	12.6	11.6	10.9^{bc}

Treatments: F = 8.02***, $P < 0.001$; Years: F = 3.54**, $P < 0.01$

Table 3. Dry matter production in relation to grazing treatment and time. Values indicated by the same character are not significantly different ($P_{0.05}$).

Variant of Grazing	Dry matter yield (t ha^{-1}) in different years									
	00	01	02	03	04	05	06	07	08	$\bar{x}_{00-08}$
Rotational 2x	6.91	6.45	5.12	6.76	9.87	7.65	7.24	7.12	7.03	7.13^{a}
Rotational 3x	6.85	5.72	5.22	4.22	6.70	6.75	6.59	5.61	5.46	5.90^{b}
Rotational 4x	8.10	5.85	4.38	3.75	7.01	7.15	5.91	4.43	4.51	5.68^{b}
Continuous	6.91	5.65	4.45	3.81	7.20	6.61	5.98	4.21	3.98	5.42^{b}
Mow. 1x grazing 1x	7.72	7.04	5.66	6.37	9.09	7.99	10.11	8.56	8.43	7.89^{a}
Mean	7.30	6.14	4.97	4.98	7.97	7.23	7.17	5.99	5.88	6.40

Treatments: F = 12.35**, $P < 0.01$; Years: F = 9.78***, $P < 0.001$

Conclusion

The results of this investigation confirm that rotational grazing with three grazing cycles per year proved to be a suitable pasture system to improve the species richness and diversity of *Lolio-Cynosuretum* grasslands under organic farming conditions in central Europe at altitudes of 450 – 800 m a.s.l. Considerably high values of species richness, together with a high biomass production, are achieved under exploitation combining mowing once a year with one cycle of grazing. In contrast, continuous grazing appeared to be a less suitable management system as it leads to decreased species richness and diversity, as well as decreased biomass production.

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