Little effect of species richness and vegetation composition on herbage production and quality in a permanent temperate grassland

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Keywords: Temperate grasslands, biodiversity, production, herbage nutritive value.

Introduction

Phytodiversity of grasslands has been shown to support production and other ecosystem services (*e.g.* Weigel *et al.* 2009, Tilman *et al.* 2012). However, in many of these studies, species richness was controlled by sowing and weeding and it was questionable to what extent the findings would also be applicable to permanent 'real world' grasslands where the species number is dependent on site and management conditions. In addition there is uncertainty about the effect of diversity on the herbage value for ruminants (Wrage *et al.* 2011). In a new approach to biodiversity experiments, we combined experimental and observational measures and modified the vegetation of a permanent grassland by the use of herbicides (Petersen *et al.* 2012). We measured herbage production and quality over two full harvest years.

Methods

A grassland management experiment (GrassMan) was set up in 2008 on an old agriculturally managed permanent grassland in the Solling Uplands, Germany (51°44'53''; 9°32'42''E, 490 m a.s.l., haplic Cambisol). The vegetation is a moderately species-rich *Lolio-Cynosuretum* with high abundances of *Festuca rubra* and *Agrostis capillaris*. The experiment comprised of the three factors (1) sward type, (2) utilization (either one or three cuttings per year), and (3) fertilization (either no or NPK 180/30/100 kg/ha/year). Each plot was 15 x 15 m and the treatments were replicated six times. The sward type was either the undisturbed control sward (Co) or a sward that was sprayed with a herbicide against dicots (-Dic) (Fluoroxipyr, Triclopyr, Mecoprop-P) or a sward that was sprayed against monocots (-Mon) (Clethodim). Herbicides were applied in summer 2008. This treatment led to distinct sward types in 2009, with species numbers varying from 7-16 per m² among variants and to grass:forb:legume ratios of 76:22:2 (control), 93:7:0 (-Dic) and 39:52:9 (-Mon). Plots were cut with a forage combine harvester in May, July and September in the three cutting system, and in July in the one cutting system. Herbage production was measured on a subplot of 22.5 m² per each plot. A subsample of the harvested herbage was dried at 60°C and dry matter yield calculated. Herbage quality was assessed employing near-infrared reflectance spectroscopy (NIRS). The analysis is based on a large calibration dataset provided by the Institute VDLUFA Qualitätssicherung GmbH, Germany (Tillmann 2010).

Annual yield data from the years 2009 and 2010, and herbage quality data from July 2009 were used in this analysis. ANOVA models with sward type, utilization and fertilization as fixed factors and block (replication) as random spatial factor were calculated. Plant species number (per 15 x 15 m²-plot) and Shannon evenness were used as phytodiversity measures. Linear regressions were calculated with the species number and evenness as independent variables and herbage yield, CP- and ADF-concentration as response variables.

Results

Herbage dry matter yield as well as CP- and ADF-concentrations were significantly affected by grassland management, *i.e.* utilisation and fertilisation. However, the sward type was of minor importance; a significant sward effect on the dry matter yield was found in 2010, the variation explained by this factor was only three percent. CP was slightly higher and ADF slightly lower in -Mon compared to -Dic swards. When comparing all sward types and management treatments there was no relationship between plant species number and either yield, CP or ADF. However, species evenness was significantly positively related with herbage yield and CP-concentration. In addition there was a tendency for lower ADF with increasing evenness (Fig. 1).

Conclusion

In contrast to experiments where species number is established by sowing and maintained through weeding, phytodiversity of the investigated permanent grassland had a minor effect on herbage production and quality. We assume that in our experiment even in low diversity plots the species number was still above those values at which diversity effects on productivity are saturating. This is, however, a typical situation for many permanent temperate grasslands. The effect of species evenness on the target variables indicates the importance of species identity and composition compared to that of the mere species number.

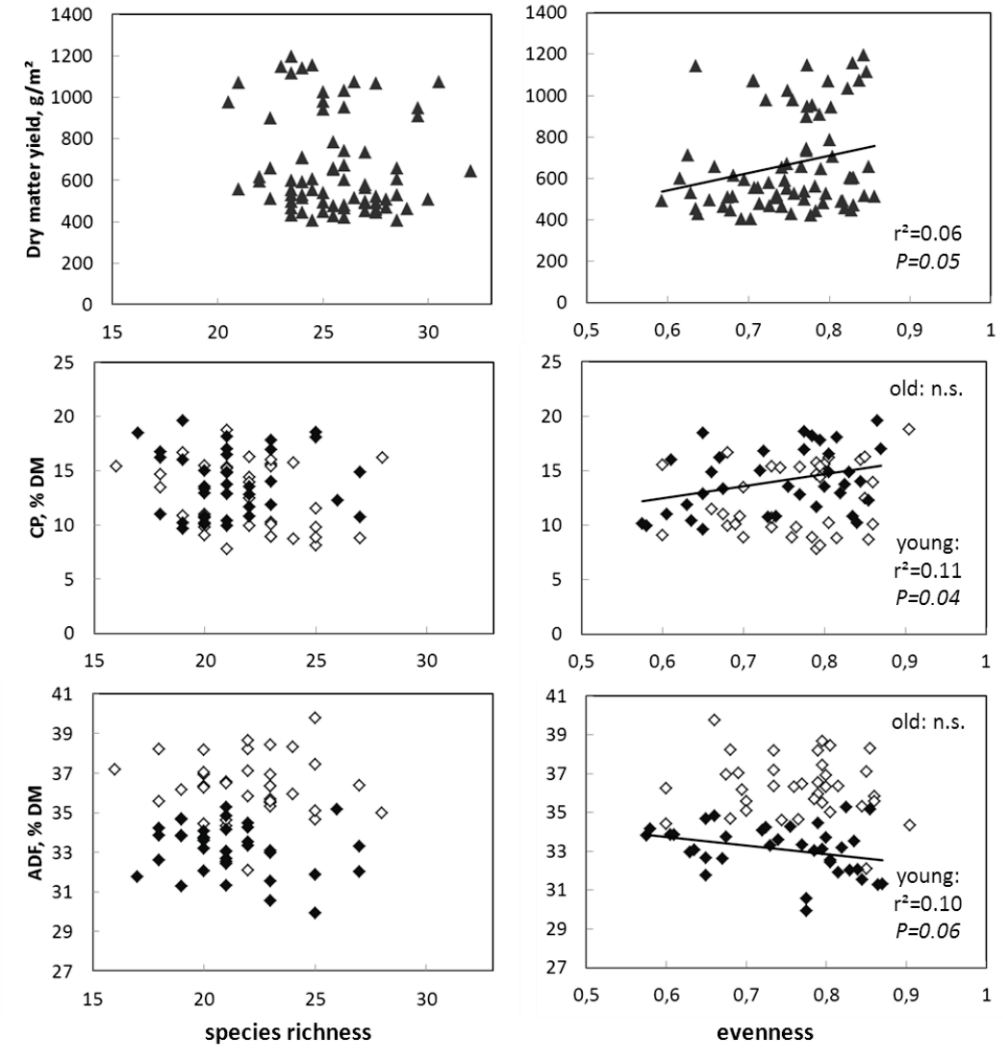

Figure 1. Effect of species richness (number of plant species per 15x15 m plot) and evenness on the annual herbage dry matter yield (mean of years 2009/2010) and the crude protein- (CP) and acid detergent fibre- (ADF) concentration of the herbage. CP and ADF were measured on herbage harvested in July 2009 with either young (♦ second cut of the three cutting system per year) or old (◊, first cut of the one cutting system per year) herbage.

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