Influence of Fertilizers on the Biodiversity of Semi-natural Grassland in the Eastern Carpathians

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Abstract

This investigation examines the influence of fertilization with organic and mineral fertilizers on the biodiversity of grasslands containing Festuca rubra, Agrostis capillaris and Nardus stricta. Permanent meadows were studied in terms of production of food, and of biodiversity. The current strategy of using organic fertilizers has raised concerns about resource conservation and environmental protection. The increase in the number of species is due to the fertilizers that have been applied leading to changes in the soil fertility status. This change in soil fertility has allowed other mesotrophic and eutrophic species to become established in fertilized meadows. In Romania, meadows belonging to this category occupy an area of approximately 1,600,000 hectares and have relatively low production rates. The experiment was located at Pojorata, Suceava County (Romania), in two different natural grasslands that had different floristic compositions. Manure improved the growth of a number of species, especially in the ‘plants from other botanical families’ category, because of the pool of seeds that it contains. Using a management system based on fertilization with small amounts of organic and mineral fertilizers can help preserve the biodiversity of these meadows. The results of this study, in an area considered representative for large parts of the mountainous areas of Romania, indicated that fertilization treatments were able to maintain a high species diversity.

Keywords: Carpathians, fertilizers, grassland

Introduction

Semi-natural grasslands, which are traditionally used as forage for ruminants, are an important type of land use in Europe, covering more than a third of the European agricultural area (Pacurar et al., 2012). Fertilization with manure are considered an appropriate management technique to conserve biodiversity value (Assaf et al., 2011; Chapin et al., 2000; Kesting et al., 2009; Louault et al., 2005; Peeters et al., 2004). Several management factors may affect the biodiversity of these grasslands, including fertilization, overseeding, grazing and cutting management (Duru et al., 2010; Lehman et al., 2000; Mauz and Rémy 2004; Paine et al., 1999; Pasho et al., 2011; Samuil et al., 2012a; Sirbu et al., 2012). Grasslands are an important forage resource in Romania, but poor management during the last few years have led to their present state of degradation.

The greatest reduction in permanent grassland productivity has been caused by unfavorable weather conditions and poor management (Samuil et al., 2012b). An increase in the productive potential of these meadows can be achieved by fertilization with different rates and types of organic fertilizers (Hopkins et al., 1990). Research conducted to date has demonstrated the positive effects of organic fertilizers on lawns (Hacala and Pillimlin, 1994; Ziegler, 1997). If regularly and sensibly applied, organic fertilizers can fully substitute for chemical fertilizers (Jean-gros et al., 1994, 2002).

Comparative studies that investigated the effects of different management practices on grasslands have demonstrated shifts in species diversity and in the composition of plant functional groups (Baudry, 2004; Dale et al., 2012; Hopkins et al., 1999). Each permanent grassland sward is a unique mixture of species and growing stages and this complexity makes it difficult to characterize and understand their feed value (Duru et al., 1998). Floristic composition influences the nutritive value of permanent grasslands because of the differences in the chemical composition and digestibility of individual species and also because of variations in the growth rate of different species (Dale et al., 2012; Duru et al., 1998).

In this study, an experimental approach was used to evaluate the effects of management treatments on the biodiversity for two semi-natural grasslands in the Oriental Carpathian Mountains. The two following key questions were addressed: (i) are there any changes in plant species composition and in the functional groups of plants under the different fertilization treatments and (ii) what are the temporal trends over a period of six consecutive years?

Materials and methods

Study area

This paper presents the results of two experiments located at Pojorata, Suceava County (Romania), on two different natural grasslands with different floristic compositions. The first experiment took place on a meadow com-
Experimental treatments

The experiments were subdivided into plots and were replicated four times. Each plot was 4 m × 5 m in size. They were subjected to the fertilizer treatments shown in Table 1.

The chemical composition of 1000 kg of manure was 5.19 kg N, 2.83 kg P and 6.72 kg K. The manure was applied during the autumn season, but the mineral nitrogen was applied in spring before vegetative growth began.

The Used Apparent Coefficient (UAC) was calculated so that the effects of the different types and combinations of organic and mineral nitrogen fertilizers could be compared. The UAC gives an indication of the effective use of organic nitrogen on a short-term basis. The UAC coefficient varies depending on the time of application and the type of vegetation cover and ranges in value from 0 to 70%. The UAC of the nitrogen equivalent for mineral fertilizer is the amount of nitrogen used by the plant. The results obtained in this experiment were based on a UAC value of 0.4 for manure applied annually, 0.45 for manure applied every 2 years and 0.55 for manure applied every 3 years (Bodet et al., 2001).

Analyses and statistical interpretation

The mean indicator values for light (L), temperature (T), soil moisture (W), soil reaction (R) and soil trophicity (Tr) were calculated based on the number of species from a given category. Species indicator values followed the scales of Ellenberg et al. (1992). In order to calculate the biodiversity indicators, surveys were conducted at

Fig. 1 Natural conditions of the permanent grassland research areas used in this study
Results and discussion

Botanical composition was very weak and was represented by species with low forage values (Tab. 2, Fig. 2). A total of 35 species were identified at the beginning of the experiments, of which 12 belonged to the Poaceae family, seven belonged to the Fabaceae family and 16 plant species belonged to other families. For each of these species, the ecological indicators were specified.

In the first experiment, 65.8% of the species had a high percentage tolerance to temperature and 63.2% had a high tolerance to soil acidity. In the second experiment, 61.9% of the species had a high percentage tolerance to temperature and 57.1% to soil acidity.

Constancy is an expression of a species relative to the area taken up by each species depending on the experimental variants assessed and provides information on the degree of fidelity. It can be seen that over 60% of the species had a high and a very high constancy, (classes IV and V; Fig. 3).

The application of mineral and organic fertilizers to the Agrostis capillaris L. with Festuca rubra L. grassland and the Nardus stricta L. grassland produced significant changes within the sward, depending on the applied treatments. However, the floristic composition in both experiments was quite similar. Analysis of the biodiversity parameters highlighted the fact that the number of species increased across all the variants compared to the control when fertilizers were applied (Tab. 3).

In experiment 1, the number of species increased from 15, in the control plots, to 17-26 in the fertilized plots. The Shannon index increased from 2.504 in the A_b plots to 2.611-2.855 in the fertilized plots. Shannon evenness values were 0.884 in the A_b plots and 0.875-0.932 in the fertilized plots. The Simpson index was

![Fig. 2. Distribution of the Ellenberg indicators (1-9 Ellenberg scale) for both experiments](image)
0.715 in the A\textsubscript{0}b\textsubscript{0} plots and 0.849 in the fertilized plots. The Simpson index was 0.097 in the A\textsubscript{0}b\textsubscript{0} plots and between 0.149 and 0.253 in the fertilized plots (Fig. 4).

Numerous studies have revealed positive relationships between biodiversity and ecosystem function (Chytrý et al., 2009; Ganatsas et al., 2012; Reiss et al., 2011). Grassland species richness was linked to the type of fertilizers in experiment 2, the number of species increased from 14 in the control plots to between 15 and 19 in the fertilized plots. The Shannon index was 2.534 in the A\textsubscript{0}b\textsubscript{0} plots and between 1.936 and 2.355 in the fertilized plots. The Shannon Evenness values were 0.914 in the A\textsubscript{0}b\textsubscript{0} plots and 0.875-0.98 in the fertilized plots. The Simpson index was 0.097 in the A\textsubscript{0}b\textsubscript{0} plots and between 0.149 and 0.253 in the fertilized plots (Fig. 4).

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Tab. 2. Plant composition and ecological characteristics of the identified species (after Ellenberg et al., 1992; Kovács, 1979)

<table>
<thead>
<tr>
<th>Species</th>
<th>Ecological indicators\textsuperscript{a,b}</th>
<th>Species</th>
<th>Ecological indicators\textsuperscript{a,b}</th>
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<tbody>
<tr>
<td></td>
<td>L</td>
<td>T</td>
<td>W</td>
</tr>
<tr>
<td>Agrostis capillaris</td>
<td>7</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Anthoxanthum odoratum</td>
<td>x</td>
<td>x</td>
<td>5</td>
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<tr>
<td>Arrhenatherum elatius</td>
<td>8</td>
<td>5</td>
<td>7</td>
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<tr>
<td>Brachypodium pinnatum</td>
<td>6</td>
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<td>4</td>
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<tr>
<td>Briza media</td>
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<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cynosurus cristatus</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Dactylis glomerata</td>
<td>7</td>
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<td>x</td>
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<tr>
<td>Festuca pratensis</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Festuca rubra</td>
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<td>5</td>
<td>x</td>
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<tr>
<td>Holcus lanatus</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Nardus stricta</td>
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<td>2</td>
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<tr>
<td>Poa pratensis</td>
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<td>5</td>
<td>x</td>
</tr>
<tr>
<td>Trisetum flavescens</td>
<td>7</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Anthyllis vulneraria</td>
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<td>4</td>
<td>8</td>
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<tr>
<td>Genista tinctoria</td>
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<td>5</td>
<td>4</td>
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<tr>
<td>Lathyrus pratensis</td>
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<td>6</td>
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<tr>
<td>Lotus corniculatus</td>
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<td>4</td>
<td>7</td>
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<tr>
<td>Medicago lupulina</td>
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<td>4</td>
</tr>
<tr>
<td>Trifolium alpestre</td>
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<td>3</td>
</tr>
<tr>
<td>Trifolium campestre</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Trifolium montanum</td>
<td>7</td>
<td>3</td>
<td>8</td>
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<tr>
<td>Trifolium pratense</td>
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<td>x</td>
<td>x</td>
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<tr>
<td>Average</td>
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<td>5.2</td>
<td>4.6</td>
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</table>

\textsuperscript{a,b} – Experiment 1, b – Experiment 2; \textsuperscript{a} Ecological indicators according to Ellenberg et al., 1992 and Kovács, 1979: L = light value; T = temperature value; W = soil moisture value; R = soil (water) acidity (pH) value; Tr = trophicity value.
Conclusions

The results showed that there were changes in the number of plant species and in the functional groups of plants under the different fertilization treatments. The increase in the number of species could have been caused by improved soil nutrient content after fertilizer application and/or by the species brought in with the applied manure. Using a fertilization management program based on small amounts of organic and mineral fertilizers could contribute to the conservation of biodiversity in these grasslands. The results of this study, in an area considered to be regionally representative of large parts of the mountain areas of Romania, indicated that fertilization treatments could maintain high levels of species diversity.
References


