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Density and richness of soil seed banks in loess grasslands

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Abstract

We studied the vegetation and seed banks in a *Salvio-Festucetum* loess grassland and in and formerly grazed and then abandoned *Cynodonti-Poëtum* loess pasture. We answered the following questions: (i) How dense are the local seed banks? (ii) Which species of the vegetation possess a seed bank? Soil samples were collected in early spring, 2010. Samples were concentrated and treated using the seedling emergence method. Percentage cover of vascular plants was recorded in twelve, 1-m^2-sized plots in June, 2009. We found that the mean densities of seed banks were similar in both grassland types (20,200 seeds/m^2 in *Salvio-Festucetum* and 22,800 seeds/m^2 in *Cynodonti-Poëtum*, respectively). Altogether, 94 species were detected both in vegetation and seed banks. In the pasture the species-poor loess vegetation (a mean of 10.2 species/m^2) was characterised by the high cover of *Festuca rupicola* (mean cover of 45%). Conversely, we detected significantly higher species richness in *Salvio-Festucetum* grassland (t-test; $p< 0.001$, mean, 27 species/m^2). The seed bank was characterised by common forbs (*Hypericum perforatum* 6,200 seeds/m^2, *Galium verum* 4,270 seeds/m^2, *Achillea collina* 2,100 seeds/m^2) and graminoid species (*Poa angustifolia* 1,060 seed/m^2, *Carex stenopylla* and *C. praecox* 2,480 seeds/m^2) in both grassland types. Dense seed banks were typical for *Conyza canadensis* (6,760 seeds/m^2) and *Veronica persica* (1,215 seeds/m^2). Most of the characteristic species of loess grasslands possessed only sparse seed banks (e.g. *Salvia austriaca*, *S. nemorosa*, *Pimpinella saxifraga*, *Medicago falcata*). Our results suggest that the seed bank can have only a limited role in maintaining species diversity in loess grasslands.

Keywords: biodiversity; grassland restoration; plant traits; secondary succession

Introduction

The maintenance and recovery of species diversity in grasslands can be supported by soil seed banks as local propagule sources (Valkó et al. 2011). To design and/or improve conservation measures in grasslands the analysis of the composition and density of soil seed banks is also necessary. Persistent soil seed banks of characteristic grassland species enable the fast recovery of former diversity after disturbances and degradation (Bossuyt and Honnay 2008). However, in most of the studies only low density seed banks of grassland species were proven; some promising results were already published for dry grasslands (Kalamees et al. 2011). The species composition and density of seed banks are specific to the studied grassland and region; thus, it is necessary to have a seed bank analysis and persistency records for each grassland type. In spite of the high

conservation value and species richness of loess grasslands, seed bank data only for a few characteristic species is available. The area of historically characteristic loess grasslands became fragmented in lowland areas in Central-Europe and elsewhere because of the agricultural intensification in the last century (Molnár and Botta-Dukát 1998). In most regions only species-poor degraded fragments of formerly species-rich grasslands remained, often surrounded by intensively managed agricultural lands. To preserve and restore loess grasslands it is necessary to understand how do soil seed banks contribute to the maintenance of species diversity. Vegetation and seed banks of (i) a traditionally managed loess grassland (*Salvio-Festucetum*) and (ii) a loess pasture (*Cynodonti-Poëtum*) were studied. We asked specifically the following questions: (i) How dense are the local seed banks? (ii) Which species of the vegetation possess seed banks?

Material and methods

The studied grasslands are situated near the town of Balmazújváros (Magdolna Puszta, traditionally managed loess grassland, N 47°35'01" E 21°17'54") and village of Hortobágy (Nyírőlapos, degraded loess pasture, N 47°34'47", E 21°15'30"). The climate of the region is moderately continental with an annual precipitation of 550mm and a mean temperature of 9.5°C. In each of the grasslands, twelve 1-m^2 plots were randomly marked, and the percentage cover of vascular plants was recorded in June, 2009. In the following spring, 2010, in each plot three soil cores (4-cm diameter and 10-cm depth, each 126 cm^3, in total 36 soil cores per grassland) were collected for seed bank analysis. The seedling emergence method of ter Heerdt et al. (1996) was used. Samples after bulk reduction were spread in a 3-4mm thick layer on the surface of trays filled with steam-sterilised potting soil. Germinated seedlings were identified and regularly counted and removed from the trays. Unidentified seedlings were transplanted and grew till identification. Spontaneous seed contamination was detected using sample-free trays filled with sterilised potting soil. Means of species richness of grasslands were compared using t-test (Zar 1999). Similarity between vegetation and seed banks was calculated by the Jaccard index. The vegetation and seed bank composition was compared using DCA ordination.

Results

Altogether 94 species were detected in the vegetation and seed banks. In the vegetation of the loess pasture 24 species, and in the loess grassland

52 species were found. For detailed species composition see Fig 1. The vegetation of the loess pasture was characterised by low species richness (a mean of 10.4 species/m^2) and the high cover of *Festuca rupicola* (a mean of 45%). In addition, only *Poa angustifolia* and *Galium verum* were present with higher mean cover than 5%. High species richness scores were typical in the loess grassland (a mean of 27 species/m^2, t-test - p<0.001). Species with higher cover than 5% were *Festuca rupicola*, *Cynodon dactylon*, *Thymus glabrescens*, *Poa angustifolia* and *Filipendula vulgaris*. In the seed bank of the degraded pasture 52 species, and in the loess grassland 44 species were found. In the degraded loess pasture, six species had higher mean seed bank density than 500 seeds/m^2: *Achillea collina* (2,100 seeds/m^2), *Carex praecox* and *C. stenophylla* (2,476), *Conyza canadensis* (6,764*), Epilobium tetragonum* (575), *Galium verum* (4,266), *Poa angustifolia* (951). In the seed bank of semi-natural loess grassland 11 species had higher seed density than 500 seeds/m^2; these were *Cynodon dactylon* (575 seeds/m^2), *Euphorbia cyparissias* (685), *Hypericum perforatum* (6,233), *Myosotis stricta* (1,967), *Plantago lanceolata* (1,017), *Poa angustifolia* (1,061), *Potentilla arenaria* (1,304), *Potentilla argentea* (1,326), *Stellaria graminea* (862), *Juncus compressus* (995), and *Veronica persica* (1,216). Some species characteristic to loess grasslands like *Knautia arvensis* (no seed bank), *Pimpinella saxifraga* (no seed bank), and *Salvia nemorosa* (66 seeds/m^2) had very sparse seed banks. No significant differences were obtained between the mean seed bank densities of the two grassland types (and 22,800 seeds/m^2 in the degraded loess pasture; 20,200 seeds/m^2 in the semi-natural loess grassland, respectively). Similarly, no significant differences were found in species numbers (means were 17.0 and 15.4 species/ m^2, respectively). The similarity of vegetation and seed banks were low in both grasslands (the Jaccard similarity ranged up to 0.35). In the degraded pasture 76% and in the semi-natural grassland 46% of the species detected in the vegetation possessed seed banks.

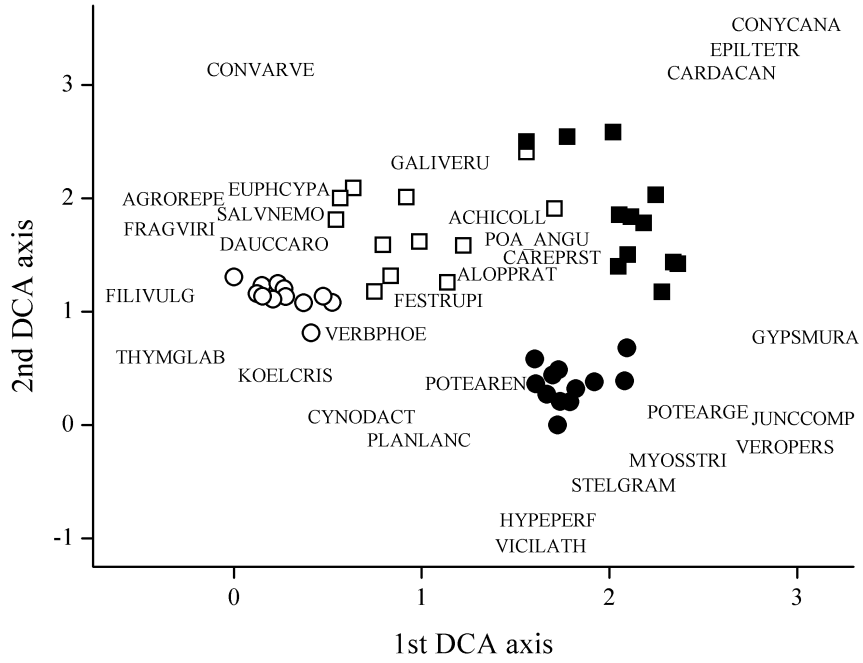

Figure 1. DCA ordination of vegetation and seed banks in the studied grasslands. Notations: loess grassland – circle, degraded loess pasture – rectangle; full symbols – seed banks, empty symbols – vegetation. The most frequent 30 species are shown using 4 letters of genus and 4 letters of their species names.

Discussion and conclusions

For most of the characteristic grass species in vegetation only sparse seed banks were detected, which corresponds with former findings (Bossuyt and Honnay 2008). According to another study of the authors in sandy grasslands (Török et al. 2009), dense seed banks were only found for *Poa angustifolia*. In the present study, the most characteristic species of the loess grasslands possessed sparse seed banks. This result corresponds with other findings from several grassland types (e.g. sandy grasslands, Török et al. 2009; mountain hay meadows, Valkó et al. 2011).

In most seed bank studies in grasslands low to medium similarity was found between vegetation and seed banks (Bakker et al. 1996; Bossuyt & Honnay 2008). This was also supported by the present study. There are several reasons for this phenomenon: (i) In case of several perennials the

seed production and seed bank formation are subordinated compared to vegetative reproduction (Bakker et al. 1996). (ii) The detection probability of rare species with aggregated seed banks is low (Thompson et al. 1997). (iii) There is a high chance of non detection of short-lived species with high fluctuations in cover (Török et al. 2009). (iv) The seed bank is mostly characterised by disturbance-tolerant and weedy species missing from aboveground vegetation in most native grasslands (Valkó et al. 2011).Our results suggest that local persistent seed banks have only a minor contribution to the maintenance of diversity in native loess grasslands.

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