RESTORATION OF PANNONIC SANDY GRASSLAND HABITAT ON ABANDONED AGRICUTURAL FIELDS

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Abstract: The area of the Pannonic inland dunes and sand steppes has considerably decreased in the past century in Hungary due to intensive agricultural production. The socio-economic transition in the 1990s induced the abandonment of cultivation on nutrient-poor soils, resulting in large areas of degraded old fields, especially in the sandy Kiskunság region. The natural regeneration of the grassland vegetation is often hindered by the limited dispersal of the specialist species from the surrounding landscape, thus the old field can remain at an intermediate state dominated by weeds for a long time. Therefore restoration measures should be applied to facilitate the natural secondary succession and to regain some of the former area of these Natura 2000 priority habitat types. Field experiment started in 2002 on three old fields of different ages to test the effectiveness of various treatments (ploughing as a basic treatment, carbon amendment, seeding with target species, mowing and their combinations) in plots of 1 m^2. Success of the applied restoration methods was evaluated by multivariate analysis and by the comparison of the share of different habitat preference categories in the 5th year of the experiment. We found that neither carbon addition nor mowing alone had no significant effect on the vegetation composition, but their combination had positive effect on the regeneration process. Seeding was very successful, and plots with the seeding plus mowing treatment became the most similar to the reference grassland.

Keywords: Pannonic sand steppes, land use change, reintroduction of species, reclamation of former agricultural land

Introduction

More and more agricultural fields have recently been abandoned due to socio-economic changes (Prach et al. 2007) after an intensive agricultural production period in Central Europe in the second half of the 20th century. Large areas of weedy abandoned fields can be found especially in the arid Kiskunság region in Hungary on sandy soils (Csecserits et al. 2007). Restoration measures can eliminate the limits of natural regeneration and shift succession towards the native open sandy grassland vegetation (subtype of Pannonic inland dunes and Pannonic sand steppes, Natura 2000 Annex I 2340 and 6260 habitat types).

Different restoration methods have been applied in previous experiments in order to decrease the competitiveness of non-target species established during the secondary succession. Mowing has been tested against shrub encroachment on clear-cut black-locust stands on the potential habitat of the open sandy grassland (Török et al. 2003). Carbon addition has been used to reduce nitrogen availability through bacterial immobilization in our previous experiment at an abandoned field in the same region (Török et al. 2000) and at other old-fields as well (Eschen 2007). Introduction of propagules is also a widely used method to test if dispersal is the limiting factor of regeneration (Turnbull et al. 2000), however, it has not been studied in details on sandy old-fields of the Kiskunság region. Results of a small-scale experiment at three abandoned fields are demonstrated in this paper where previously tested and new restoration methods are applied in combination with the aim to facilitate vegetation

recovery. The present study evaluates the effectiveness of single and combined restoration treatments applied through 5 years.

Materials and methods

The study area is located in the inland sand dune area of the Kiskunság National Park. The climate is temperate with continental and mediterranean features with a strong semiarid character during the summer. The soil is calcareous sandy soil with very low humus content and extreme soil moisture regime. The native grassland vegetation is the endemic open sand grassland (*Festucetum vaginatae)* and sandy steppe.
Three old-fields of different ages have been selected for the experiment: a rye-field (Fallow) freshly harvested, a former corn field (Maize) where the cultivation was ceased 3 years ago and an old-field abandoned approx. 12 years ago (Old) when the experiment started in September 2002.
Ploughing was applied as a pre-treatment in all sites to decrease the effect of the existing vegetation. 64 permanent plots of $1m^2$ within each site have been marked and selected for the following treatments and their combination: seeding with a mixture of sand grassland species (in September 2002, *Festuca vaginata, Stipa borysthenica, Koeleria glauca, Dianthus serotinus, Euphorbia seguieriana*), carbon amendment (every three weeks from April to October, 120 g m^{-2} in the first year, later 45 g m^{-2} each time), mowing (2 times in the first year, once in the first week of September afterwards) and control. Vegetation of the plots was sampled 2 times per year by visually estimating the cover of each vascular plant species. 1 m^2 plots were also surveyed in the nearby reference sandy grassland.
Data of the vegetation sampling at the end of May 2007, that is the 5th year of the experiment was used in the analysis. Principal Coordinate Analysis based on species abundance data was used to reveal the main differences among the treatments. Species groups were created according to the habitat preference of species typical in the Kiskunság region (categories were: species connected to open sandy grassland, species characteristic to dry grasslands in general, species charactersitic to closed grasslands, and species of anthropogenic habitats). Proportion of each category related to the total cover was calculated, and analysed by GLM and Tukey Posthoc test ($p < 0.05$).

Results and discussion

Sowing with target species often proves to be a useful tool in grassland restoration experiments (Lindborg 2005). Our result was similar, as the most expressed difference between the treatments was due to the application of seeding, that means that the seeded plots and the non-seeded appeared to be different in all analyses. The multivariate analysis (Fig. 1) showed that the seeded plots (full symbols) are at least partly separated from the non-seeded ones (empty symbols) based on species abundances. Although the samples of reference grassland create one detached group, the seeded plots are always closer to the reference (REF) along the first Axis than the non-seeded ones.

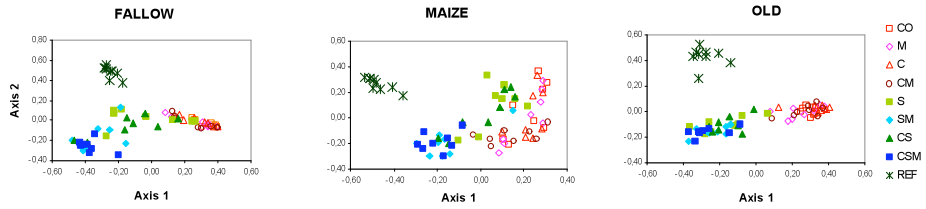

Figure 1. Ordination diagram of the Principal Coordinate Analysis (Ruzicka index). The eigenvalues for Axis 1 and 2 are: Fallow 27 and 14, Maize 19 and 13, Old 22 and 10, respectively. Abbreviations of treatments: control (CO), carbon addition (C), seeding (S) and mowing (M) and their combinations.

The success of the seeding treatment is also proven by examining the relative abundance of secies groups with different habitat preference (Fig. 2). Seeded plots (S) have lower proportion of species of anthropogenic habitats (An) and naturally higher proportion of sandy grassland (Sg = target) species, which is supported by the significant difference of all non-seeded and seeded plots (Table 1). However, the impact of other treatments can also be seen: the abundance of sandy species is the highest in the seeded and mowed (SM, CSM) plots at all sites, and the plots that received three combined treatments (CSM) do not differ significantly from the reference unlike the other treatments (Table 1).

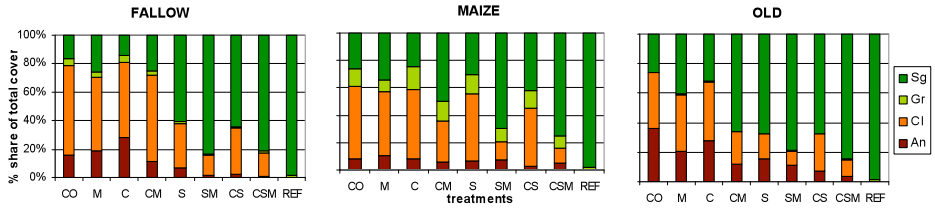

Figure 2. Percentage share of the species groups based on habitat preference. The treatments (x axis) are control (CO), carbon addition (C), seeding (S) and mowing (M) and their combination. Symbols: Sg means species connected to sandy grassland, Gr: to dry grasslands, Cl: closed grasslands, An: anthropogenic habitats.

Neither carbon amendment (C) nor mowing (M) have resulted significant effect when used as a single treatment (Table 1). Favourable effect of carbon addition alone has been found to be questionable in other grassland restoration experiments (Corbin and D'Antonio 2004).

Table 1. Significant differences among the treatments regarding the relative abundance of species connected to sandy grassland. Different letters mean significant differences.

	CO	M	C	CM	S	SM	CS	CSM	*REF*
Fallow	a	a	a	a	c	bc	c	bc	b
Maize	a	a	a	ab	a	b	a	bc	c
Old	a	a	a	b	b	bc	b	cd	d

However, combination of carbon treatment with mowing (CM) proved to be succesful in our case: abundance of sandy species became significantly higher than in the control plots (CO) at the Maize and Old sites. Mowing combined with seeding has also resulted in a considerable similarity to the reference grassland in the amount of sandy species, which also supports the importance of combined treatments in restoration experiments.

Conclusions

We have shown that carbon amendment in combination with mowing or seeding can be a useful tool in the restoration of open sandy grassland on abandoned fields. The most successful treatment was seeding, but combined with mowing and carbon addition the vegetation became more similar to the reference grassland.

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