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Influence of competition by sown grass, disturbance and litter on recruitment of rare flood-meadow species

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A B S T R A C T

As a response to the sharp decline in species-rich flood-meadows along the northern Upper Rhine during the past decades, large-scaled restoration projects have been started recently. For the implementation of restoration measures knowledge about the effects of topsoil disturbance, litter and simultaneously sown grasses on seedling recruitment are of special interest. This applies in particular to the role of sown of grasses that may accelerate sward development and ease the incorporation of newly created meadows into local farming systems. As study species we selected six typical, but rare or declining flood-meadow species which differed in seed size, since this may influence the impact of the applied treatments. We studied effects of simultaneously sown grasses on germination and recruitment success of these flood-meadow species in two former arable fields situated in the functional and fossil floodplain along the northern Upper Rhine. The effects of litter and topsoil disturbance in an existing grass sward on the recruitment of the six flood-meadow species were experimentally assessed in a species-poor grassland in the functional floodplain. The individual fate of emerging seedlings was followed over two years. The effects of the applied treatments were species-specific and rather inconsistent. Responses towards disturbance and litter application corresponded to differences in seed size, with large-seeded species showing a lower susceptibility to the influence of treatments. In addition, simultaneous sowing of grass did not hamper seedling recruitment in most cases, and thus seems to be a feasible measure to accelerate the integration of newly created flood-meadows into farming systems.

1. Introduction

Limited seed dispersal has been identified as a major constraint in the restoration of species-rich plant communities (Bakker and Berendse, 1999). Consequently, much recent research on restoration has focused on active seed introduction of target species (Jones and Hayes, 1999; Hölzel and Otte, 2003). However, even after bridging dispersal limitation by sowing, many species require specific regeneration conditions that may considerably differ from those of adult plants (Grubb, 1977). In this early life stage coexistent living and dead biomass can have quite diametrical impacts. In this context an established, closed sward was identified as one major obstacle for the successful establishment of less competitive herbaceous species whereas the impact of simultaneously sown grass is less clear (Bosshard, 1999).

On ex-arable fields, sowing grass simultaneously with target species may enhance the utilization of newly created meadows by hay-making or pasture. Thus grass sowing may be desirable practice since the integration of restoration sites

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into local, non-intensive farming systems (i.e. no fertilisation, first cut for hay production mid June or later) is a crucial factor for their long-term preservation (Donath et al., 2004). If the effects of sown grasses on seedling emergence of rare target-species were neutral (or even positive) the divergent interests of farmers and conservationists in flood-meadow restoration could be reconciled.

Facilitation by surrounding vegetation, dead or alive, seems to be more important under harsh site conditions, while under favourable conditions inhibition through interception of light and water often outweighs these positive effects (Xiong and Nilsson, 1999; Eckstein and Donath, 2005). These negative effects seem to be attenuated by gaps in closed swards created by disturbance, which are essential for changes in species composition through introduced seeds (Bullock et al., 1995). Seed size seems to be one important specific trait that may influence the impact of living and dead biomass on seedling recruitment: Large-seeded species are usually much more tolerant towards competition through surrounding vegetation or litter coverage than small-seeded ones (Krenová and Lepš, 1996).

In two field experiments we analysed the main effects of sown grass on (i) germination, (ii) survival and (iii) establishment of six rare herbaceous grassland species under contrasting hydrological regimes (functional vs. fossil floodplain, i.e. direct flooding vs. indirect flooding). Additionally, we assessed the effects of litter application and topsoil disturbance on the same variables in an alluvial meadow. Beyond general effects of the treatments we were also interested in species-specific reactions of the introduced herbaceous species. To draw conclusions about the effects of the treatments beyond the phase of germination we followed the individual fate of the seedlings over a period of two years.

2. Methods

2.1. Study area

The study area is situated in the Hessian portion of the Holocene floodplain of the River Rhine about 30 km south-west of Frankfurt, Germany. This region represents one of the last and most important strongholds of many rare and endangered alluvial grassland species in Central Europe (Donath et al., 2003).

A winter dyke divides the area into two hydrological compartments: functional and fossil floodplain. Although direct flooding of the fossil floodplain by river water is prevented by winter dykes, depressions are submerged by clear ascending ground water. The functional floodplain riverwards of the dyke is directly exposed to flooding by river water of up to 3 m above terrain. In contrast, ground water tables are often more than 3 m below the soil surface during low water levels of the River Rhine. The climatic conditions in the region are relatively warm and dry, i.e. mean temperature of 10.3 °C and mean annual precipitation of 580 mm (Müller-Westermeier, 1990). In conjunction with the hydrological and edaphic conditions, i.e. extremely fine-grained soils (clay content >60%), this results in highly variable soil water potentials.

2.2. Study species

The study species (Table 1) are typical of flood-meadows along the northern Upper Rhine. A strong long-term decline of these species has taken place since the 1920s in the course of intensified grassland management, drainage and conversion into arable land (Böger, 1991). Despite the restoration of suitable site conditions, the current occurrence of these species is restricted by dispersal limitation to remnant stands along ditches, paths and old meadows (Donath et al., 2003). While *Silaum silaus* is still relatively widespread, all other species are red-listed in Germany (Jedicke, 1997) and in case of *Arabis nemorensis*, *Iris spuria* and *Viola pumila* even considered threatened on a Central European scale (Schnittler and Günther, 1999). None of the species occurred in the above-ground vegetation, the seed bank or in the close surroundings of the study sites.

Seeds of the species were collected in bulk from populations in flood-meadows along the northern Upper Rhine in autumn 2001 and subsequently dry-stored in darkness at room temperature until sowing on February 5, 2002. This sowing date left enough time for cold stratification in the field, which enhances germination in several of the study species (Hölzel and Otte, 2004a). Germination potential was tested with two replicates of 400 seeds from each species. These seeds were sown into sterile garden soil under outdoor conditions at the same time as the field experiment started. Seeds were watered regularly during dry periods and germination was followed for two years with seedlings counted and removed once every week. This showed that we had viable seeds from all species with germination rates well above 70% (see Table 1).

2.3. Experimental design

We carried out seed addition experiments with seeds of six flood-meadow species at three sites, two ex-arable fields (one in functional and fossil floodplain, respectively) and one grassland site (functional floodplain). Both ex-arable sites were under cultivation until autumn prior to the start of the experiments. Consequently, species that co-emerged during the experiment were predominantly annuals and short-lived arable weeds such as *Plantago intermedia*, *Persicaria spec*, *Veronica catenata*, etc. To test for the effects of sown grass on

Table 1 – Study species (nomenclature according to Wisskirchen and Haeupler, 1998)

Species	RL	CG (%)	SM (mg)	SBT
Arabis nemorensis	2	85.8	0.06	3
Iris spuria	2	72.9	14.62	2
Serratula tinctoria	3	87.1	1.26	2
Silaum silaus	–	76.9	2.43	2
Pseudolysimachion longifolium	3	92.0	0.05	3
Viola pumila	2	83.9	1.08	3

Listed are their Red List (RL) status of vascular plants in Germany (RL; Jedicke, 1997), percentage germination for germination in a common garden (CG), seed mass (SM; Hölzel and Otte, 2004a) and seed bank type (SBT; 2, short-term persistent; 3, long-term persistent; derived from Hölzel and Otte, 2004b).