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No detrimental effects of delayed mowing or uncut grass refuges on plant and bryophyte community structure and phytomass production in low-intensity hay meadows

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Abstract

To maintain European semi-natural grasslands, agri-environment schemes (AES) have been established in many countries but their biodiversity benefits have remained limited. We tested the effects of three new mowing regimes designed to benefit biodiversity in extensively managed meadows across the Swiss lowlands. Our experimental treatments mimicked easily implementable farming practices. We previously showed that invertebrates benefit from delayed mowing and leaving an uncut grass refuge. Here we focus on the effects on plant and bryophyte communities.

We compared the standard AES practice (earliest mowing on June 15, no fertilizer input, but no restriction on number of cuts) to three alternative mowing regimes: (i) earliest mowing delayed by one month, (ii) maximum of two cuts per year with at least eight weeks in between, and (iii) leaving an uncut refuge on 10–20% of the meadow area in 12 study areas in the Swiss lowlands. We also tested for the interactive effects of ambient temperature, precipitation, elevation, meadow size, local forest cover, time since AES registration, and phytomass production.

After five years of application, we found no difference in the effects of mowing regimes on vascular plant or bryophyte species richness, community composition, phytomass, flowering phenology or average plant height (the latter two indices were derived from the literature). However, cutting frequency and hay nutritional quality (C:N and Ca:P ratios) were lower under delayed mowing. Vascular plant and bryophyte species richness as well as forage quality were negatively related to phytomass, while the latter was positively related to mean summer temperature and negatively to time since AES registration.

We conclude that supporting invertebrate biodiversity with alternative mowing regimes has no detrimental effects on the vascular plants and mosses, while the reduced forage quality calls for additional financial compensation of the farmers adopting these agri-environment schemes.

Zusammenfassung

In Europa wurden Agrarumweltprogramme zur Förderung und zum Erhalt von Dauergrünländern etabliert. In den grundsätzlichen Richtlinien des Vertragsnaturschutzes fehlen jedoch meist konkrete Bewirtschaftungsempfehlungen. Auch die Wirkung

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der nutzungsgebundenen Instrumente zur Erreichung von Umweltzielen und dem Biodiversitätsschutz bleiben weitgehend unerforscht. Am Beispiel von extensiv genutzten Wiesen des Schweizer Mittellandes untersuchten wir deshalb drei alternative Mahdregime, die zur Förderung der Biodiversität konzipiert wurden und in der landwirtschaftlichen Praxis einfach umsetzbar sind. Eine frühere Studie auf diesen Wiesen zeigte bereits positive Auswirkungen einer späten Mahd sowie von temporär ungemähten Streifen auf die Diversität von Invertebraten. In der vorliegenden Studie untersuchten wir Gefäßpflanzen und Moose auf extensiven Wiesen in 12 Regionen des Schweizer Mittellandes, die nach der Standard-Nutzungsauflage bewirtschaftet wurden (Mahd ab 15. Juni, keine Düngung, keine Beschränkung Anzahl Schnitte) mit jenen auf Wiesen, die (1) einen Monat später, (2) höchstens zweimal, jedoch zeitlich mindestens acht Wochen versetzt und (3) die auf einer Fläche von 10 bis 20% der Wiesen temporär nicht gemäht wurden. Fünf Jahre nach Beginn des Experiments unterschieden sich die Wiesen nicht bezüglich ihrer Gefäßpflanzen- und Moosvielfalt und – zusammenstzung, Biomasseproduktion, Phänologie und mittlerer Pflanzenhöhe. Die Biomassequalität (C:N- und Ca:P-Verhältnis) war jedoch signifikant niedriger in den einen Monat später gemähten, als in den übrigen Wiesen. Die Gefäßpflanzen- und Moosvielfalt, sowie die Biomassequalität zeigten eine negative Beziehung zur Produktivität. Unsere Ergebnisse zeigen, dass die alternativen, für Invertebraten förderlichen Mahdregime Gefäßpflanzen und Moose nicht beeinträchtigen. Aufgrund der reduzierten Biomassequalität von später gemähten Wiesen sollten Landwirte, die dieses Mahdregime anwenden, zusätzliche finanzielle Anreize erhalten.

Keywords: Agri-environment scheme; AES; Agronomy; Biodiversity promotion area; Cutting; Near-infrared spectroscopy; NIRS; Productivity–diversity relationship; Semi-natural grassland; Switzerland

Introduction

European semi-natural grasslands under traditional, low intensity management harbor an extremely high diversity of plants (Wilson, Peet, Dengler, & Pärtel 2012) and animals (Tucker & Evans 1997; WallisDeVries & Van Swaay 2009). Traditional mowing can maintain a high plant species richness by suppression of tall-statured plant species, thereby decreasing light competition, and allowing short-statured species to persist (Grime 1973; Hautier, Niklaus, & Hector 2009). Grassland biodiversity in Western Europe has strongly declined over the past century due to agricultural intensification (Benton, Bryant, Cole, & Crick 2002; Kleijn et al. 2009). To counteract this negative trend, agri-environment schemes (AES) have been implemented in many countries (see Kleijn & Sutherland 2003 for an historic overview), but their efficacy in protecting or enhancing biodiversity has, so far, been limited (e.g. Kleijn et al. 2006; Aviron et al. 2009). There is thus an urgent need for alternative management systems that not only enhance biodiversity within AES but are also easily implementable and accepted by local stakeholders.

In the Swiss lowlands, the most popular AES for grasslands is the so called 'extensively managed hay meadow'. This scheme allows an earliest cut on June 15 (without limiting the number and frequency of subsequent cuts) and prohibits the application of fertilizers and pesticides. It is currently implemented on 6.9% of the Swiss lowland agricultural area (BLW 2015). Generally, mowing here takes place on the earliest permitted date, or shortly thereafter, leading to a strong spatio-temporal homogenization of the grassland landscape throughout the Swiss Plateau.

To enhance the effectiveness of the AES for meadow biodiversity, several simple changes of management regime might be envisioned, such as delayed mowing, leaving an uncut grass refuge, or limiting the cutting frequency. Earlier it was shown that several invertebrate groups benefit from both delaying mowing (reviewed by Humbert, Pellet, Buri, & Arlettaz (2012)) and leaving an uncut refuge (Nentwig 1988; Humbert, Ghazoul, Richner, & Walter 2012; Buri, Arlettaz, & Humbert 2013), but impacts on vegetation are more ambiguous. A meta-analysis has established that plant species richness tends to increase when mowing is delayed from spring to summer, but decreases when mowing is delayed from spring or early summer to fall (Humbert, Pellet et al. 2012).

Delayed mowing can affect plant diversity through several mechanisms. On the one hand, more plant species can potentially reach reproductive maturity before mowing (Jantunen, Saarinen, Valtonen, & Saarnio 2007; Smith & Jones 1991), leading to increases in plant species richness (Humbert, Pellet et al. 2012). On the other hand, tall-statured plant species could gain dominance with negative consequences for short-statured vascular plant species and bryophytes, leading to an overall decline in species numbers (Bobbink & Willems 1991; Aude & Ejrnaes 2005). Hence, the effects of delayed mowing, as well as leaving an uncut refuge, may critically depend on competition for light and the timing of seed set. Delayed mowing can thus be expected to cause a shift in community composition, where tall-statured species and/or species with a later phenology would increase in abundance.

However, the effects of agricultural management practices on plant communities are not independent of the local and regional environmental context, and may thus also depend on differences in local biotic and abiotic site conditions (Socher et al. 2012), landscape context (e.g. Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies 2005) or climate