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Weed seed predation increases with vegetation cover in perennial forage crops

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ABSTRACT

Vegetation cover may affect weed seed predation by modifying the habitat quality for predatory organisms. Post-dispersal weed seed predation was measured by placing 'seed cards' in two perennial crops (alfalfa, cocksfoot) with and without crop cutting and in plots with bare soil. Each treatment was repeated four times in a randomized complete block design. Vegetation cover was measured by canopy light interception. Predation trials lasted two weeks and were repeated three times. Seed predation rates varied among three weed species (highest for *Viola arvensis*, intermediate for *Alopecurus myosuroides*, lowest for *Sinapis arvensis*). Vertebrate exclusion cages (12 mm × 12 mm openings) strongly reduced seed predation rates. Positive relationships were observed between vegetation cover and seed predation rates by both vertebrates and invertebrates for all weed species and trials, except when overall predation rates were very low. Predation rates were highest in uncut alfalfa, lowest on bare soil, but 16–64% of this variation could equally be explained by vegetation cover. The factorial design indicated that cutting had a stronger impact than crop species (legume or grass). Results suggest that weed seed predation may be enhanced by maintaining a high and temporally extended vegetation cover.

1. Introduction

Weed seed predation may be considered a valuable ecosystem service for two reasons. First, weed seeds constitute an important part of the diet of animals including various invertebrates, small mammals and birds (Manson and Stiles, 1998; Wilson et al., 1999; Kollmann and Bassin, 2001). The reduced availability of this food resource is probably a major cause of the biodiversity loss observed in farmed landscapes during recent decades (Robinson and Sutherland, 2002). Second, seed predation may reduce the density of weed populations. Both experiments (Menalled et al., 2000; Davis and Liebman, 2003; Westerman et al., 2003b; Mauchline et al., 2005) and modelling studies (Jordan et al., 1995; Davis et al., 2004; Kauffman and Maron, 2006) suggest that seed predation may have a very strong impact on weed population demography. Westerman et al. (2005) showed that seed loss rates exceeding 40% per year would be sufficient to stabilize *Abutilon theophrasti* Medik. population densities in a low-herbicide system. Promoting weed seed predation may thus (1) be beneficial to farmland biodiversity and (2) contribute to preventive weed management and hence decrease the need for curative weed control.

Among the multitude of factors that may influence seed predation, vegetation cover and crop species could play a key role, because they may affect the quality of the foraging habitat for seed predators. Several studies compared the weed seed predation rates and/or the abundances of seed predators in different crop species (Andersson, 1998; Zhang et al., 1998; Cromar et al., 1999; Kromp, 1999; Macdonald et al., 2000; Westerman et al., 2005; Menalled et al., 2006; O'Rourke et al., 2006, 2008). In contrast, few studies have dealt explicitly with the vegetation cover, they vary in scope, geographical location, habitat, seed and predator group, yet most of them have found its impact to be positive as shown in the literature review made in Table 1.

In the study of Heggenstaller et al. (2006) weed seed predation rates roughly paralleled the development of biomass during the growing season of annual crops as well as the periodic cutting and regrowth dynamic in mown perennial forage crops. However, disentangling seasonal effects (e.g., variations in predator abundance/activity) from vegetation cover effects would require comparing simultaneously situations of contrasting degrees of vegetation cover of the same crop species.

In this paper, we report experimental results where weed seed predation was measured in different perennial forage crops with and without crop cutting, where cut and uncut plots of each crop

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Table 1
Studies investigating the impact of vegetation cover on seed predation.

Reference	Location	Habitat	Seeds	Main predators	Findings	Vegetation cover
Mittelbach and Gross (1984)	Michigan, USA	Old fields	Biennials	Ants, rodents	Seed removal higher in undisturbed vegetation than with disturbed soil.	+
Gill and Marks (1991)	New York, USA	Old fields	Trees	Mice	Predation higher under cover of herbs (85%) than without (6%).	+
Povey et al. (1993)	Oxford, UK	Field margin	Weeds	Small mammals	Higher predation in dense and uncut grass swards.	+
Hulme (1997)	Jaén, Spain	Shrubland	Trees	Rodents >birds >ants	Increased predation with increasing vegetation height, rodents avoided open areas while the reverse was true of ants.	+
Manson and Stiles (1998)	New Jersey, USA	Old fields	Trees	Mice	Ground cover explained most of the variation in seed predation.	+
Kollmann and Bassin (2001)	Klettgau, Switzerland	Field margin	Weeds	Rodents, slugs » insects, birds	Predation reduced by harrowing, not by cutting.	+,0
Davis and Liebman (2003)	Iowa, USA	Crops	Weeds	Crickets	Predation doubled in wheat underseeded with red clover compared to wheat alone (lower cover).	+
Gallandt et al. (2005)	Maine, USA	Crops	Weeds	Invertebrates	Harpalus rufipes density and predation higher in vegetated treatments and crops with higher LAI.	+
Heggenstaller et al. (2006)	Iowa, USA	Crops	Weeds	Crickets, beetles	Positive correlations between predation and canopy light interception for different crops.	+
Booman et al. (2009)	Pampas, Argentinia	Crop stubbles	Weeds	Small mammals	Predation increased with canopy height of wheat stubbles adjacent to annual crops, but decreased in stubbles adjacent to grasslands.	+,–
Navntoft et al. (2009)	Canterbury, New Zealand	Crops	Weeds	Mainly birds	Positive impact of plant cover until maximum at 54–75% cover, then sometimes decreasing.	+,∩

+, positive impact of vegetation cover on seed predation rates; –, negative impact; 0, no impact; ∩, highest predation rates at intermediate vegetation cover.

were present at the same time (treatments one to four). Bare soil plots (treatment five) were also included to increase the gradient of vegetation cover. We first studied the hypothetical impact of vegetation cover on weed seed predation. We then tested whether predation rates differed between the factors crop species and cutting. Finally, we assessed whether the variation between the treatments could be predicted by vegetation cover. As the impacts may vary between weed species and predator guilds, we used dif-

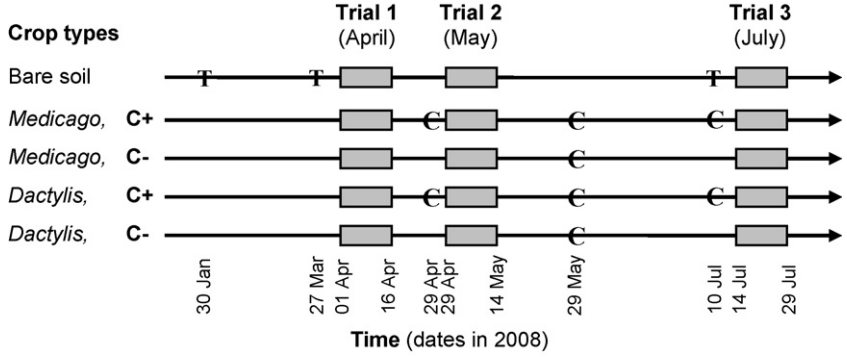

Fig. 1. Temporal overview of crop management in the five treatments. C, cutting dates; T, soil tillage dates; grey boxes, predation trials; C+, high cutting frequency; C–, low cutting frequency.