Landscape Management for Functional Biodiversity
IOBC-WPRS Bulletin Vol. 100, 2014
pp. 95-99

Farming intensity and field margin complexity affected post-dispersal weed seed predation by arthropods in sunflower crops

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Abstract: Farming intensity and complexity of field margins adjoining crop fields are expected to affect seed predation levels in annually cropped fields. The impact of both factors was determined in six sunflower fields in the Pisa Plain (Italy). Arthropod seed predation was measured above- and below-ground by comparing the seed removal of two common weeds differing in seed size (small: *Amaranthus retroflexus* L.; large: *Lolium multiflorum* Lam.). Seeds were covered with metal grids to exclude rodents, birds, from predation. Farming system intensity defined the largest difference in weed seed predation for both species. The presence of a complex, undisturbed margin adjoining fields increased seed predation only when conventionally managed. Seed predation was higher in field centres than close to field margins. In organic fields, seed predation for both weed species was lower below-ground than above-ground, whereas the opposite was observed in the other farming systems. Results showed that arthropod predation levels of weed seeds can be encouraged within cropped fields by adopting low-input or organic farming systems or by improving field margin complexity.

Key words: biodiversity, ecosystem services, semi-natural habitat

Introduction

There is a growing interest in the provisioning of ecosystem services for sustainable agriculture by semi-natural habitat (SNH). In theory, less disturbed and more complex non-cropped habitats are believed to sustain populations of beneficial insects providing services to agriculture, such as crop pollination and biological pest control (Bianchi *et al.*, 2006). Seed predation can be seen as a special type of biological weed control, namely exhaustion of weed seed banks by granivores, thus reducing the weed density in the following cropping seasons (Menalled *et al.*, 2000; Westerman *et al.*, 2003). The level of seed predation will depend on the types of seed predators, their food preferences and foraging ranges. Moreover, fields are repeatedly disturbed each year, with ploughing having a more detrimental effect on soil arthropods than on birds and rodents. However, mobile arthropods could re-colonize crop fields from adjoining undisturbed SNH during the crop growing season or fallow periods (Tscharntke *et al.*, 2005). In this study, we assumed that abundance and diversity of granivorous arthropods would increase with decreasing levels of chemical inputs in the farming systems (Fischer *et al.*, 2011). We hypothesized that weed seed bank depletion would be higher in organically managed fields. We predicted higher predation levels close to more complex field margins. Moreover, we also expected that the proportion of seed predated within sunflower fields would be affected by the distance to the non-cropped margins and the seed depth in the soil profile (above- and below-ground).

Material and methods

Study area

This study was carried out in six sunflower (*Helianthus annuus* L.) fields belonging to three different farming systems (FS); organic (ORG), low-input (LI), and conventional (CONV). All fields were located in the Pisa Plain (43°41′N, 10°23′E; Italy) which has a typical Mediterranean climate. Fields were selected to have one large, complex field margin composed of combinations of hedges, ditches, and herbaceous vegetation strips, and one narrow herbaceous margin of up to 1 m wide. Fields were at least 2 km apart. Seed predation was evaluated just before sunflower harvest (15 to 25 September 2013), when there are naturally more seeds available for granivores. We expected arthropod seed predation rate to be high, because the last soil disturbance occurred at least two months prior to sampling,

Weed seed predation

Seed predation was evaluated using two common weed species, which have contrasting seed sizes [small: *Amaranthus retroflexus* L., 0.4 mg (Ar), and large: *Lolium multiflorum* Lam., 3.1 mg (Lm)]. Seeds were glued in a random pattern on sandpaper cards (15 x 25 cm, SAITA sand paper AW-D H.115 P-40) with Spray Mount 3M. Seeds on cards could be all the same species (Lm and Ar) or a uniform mixture of 50% of each species (Lm + Ar), but the total would always be 50 seeds. Cylindrical cages (30 cm high by 30 cm in diameter) were constructed of 1.5-cm mesh metal grid. Cages were dug 20 cm into the ground. Two seed cards for each weed species were placed at two levels inside the cage: on the soil surface (AG) and 15 cm below the ground level (BG). Seeds above the ground remained covered with 1-cm metal grid to exclude rodents, birds from predation. Two sets of three cages were placed at 2 m (edge) and 25 m (centre) from each complex and simple margins. A total of 48 seed cards were placed at each field. Seeds were exposed to arthropod predation for four days, then removed from the field and stored in plastic bags. Remaining seeds were counted in the lab. Control cards were also included (data not shown), but seed loss from control cards was extremely low and therefore omitted.

Statistical analysis

Because percentage of predation did not differ between single species and mixed species seed cards, data were pooled and the number replicates consequently doubled. Thus, there were eight replicates for each treatment. Data were analyzed with linear mixed-effect models using the *nlme package* (Pinheiro *et al*., 2009) of the R software (http://www.R-project.org). Factors were hierarchically nested according to the sampling design (margin type in FS, position in margin type, and depth in position). Models were calculated separately for each weed species in order to detect specific differences in treatment effects on seed predation rates (Fischer *et al*., 2011).

Results and discussion

Seed predation of L. multiflorum

Predation of Lm was mainly affected by FS, depth and margin type and their interactions (Table 1). Predation rate was generally lower in CONV (24%) than in LI (56%) and ORG (52%). Predation BG was lower than AG in ORG. This effect was stronger near simple margins. Opposite trends were observed in LI and CONV fields, with higher BG predation regardless of field margin complexity. Soil conditions may explain the low overall level of

BG seed predation in ORG. Clay soils prevailing in these fields become very dry and hot in summer, which may restrict arthropod activity (Villani & Wright, 1990). There was no effect of position within fields (Table 1). In CONV, the low seed predation above-ground at harvest time is remarkable (Figure 1), but complex field margins increased predation rate slightly.

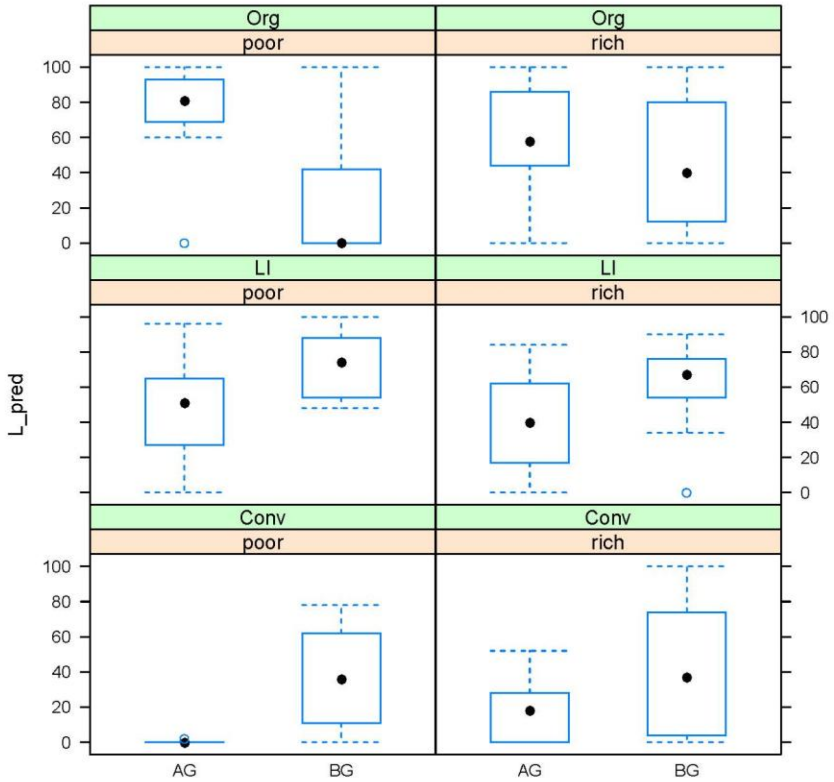
Table 1. P- and F-values for different models from GLMM for predation rate of *L. multiflorum* and *A. retroflexus* in relation to three farming systems (FS), two field margin types, two soil depth and two distances into the cropped field (position), each treatment combination having 8 replicates.

		L. multiflorum		*A. retroflexus*	
Treatment	*df*	F value	*p* value	F value	*p* value
Intercept	1	169.62	**0.00**	103.53	**0.00**
FS	2	7.10	**0.07**	12.68	**0.03**
Position	1	0.88	0.35	7.15	**0.01**
Depth	1	14.54	**0.00**	0.11	0.74
Margin type	1	0.22	0.64	0.78	0.38
FS x Position	2	0.08	0.92	1.52	0.22
FS x Depth	2	26.09	**0.00**	6.18	**0.00**
Position x Depth	1	0.18	0.67	0.05	0.83
FS x Margin type	2	4.36	**0.01**	0.19	0.83
Position x Margin type	1	0.22	0.64	0.91	0.34
Depth x Margin type	1	0.05	0.83	0.32	0.58
FS x Position x Depth	2	0.03	0.97	2.98	**0.05**
FS x Position x Margin type	2	0.11	0.90	2.70	**0.07**
FS x Depth x Margin type	2	5.26	**0.01**	1.98	0.14
Position x Depth x Margin type	1	0.10	0.75	0.07	0.79
FS x Position x Depth x Margin type	2	2.20	0.11	1.10	0.33

Seed predation of A. retroflexus

Seed predation of Ar was lower in CONV (9%) than in LI (39%) and ORG (30%), which was in turn lower than in Lm. Predation rate was mostly affected by FS and position, and some interactions with depth and margin type (Table 1). Seed predation BG was lower than AG in ORG (20 and 42%, resp.), probably due to dry clay soils, whereas predation levels were similar in LI (37 and 42%, resp.) and higher AG than BG in CONV (12 and 6%, resp.).

Unexpectedly, in those cases where a difference was found, predation rate was higher at field centres than at edges, for both margin types, but only for Ar (Figure 1). This could be due to predation of granivorous arthropods by carnivores, also attracted by the favourable conditions at complex field margins (Fischer *et al*., 2011). In addition, recurrent ploughing and pesticide applications may also create harsher conditions for arthropods at field edges. Alignier *et al.* (2008) reported no effect of distance from the field margin on predation levels.



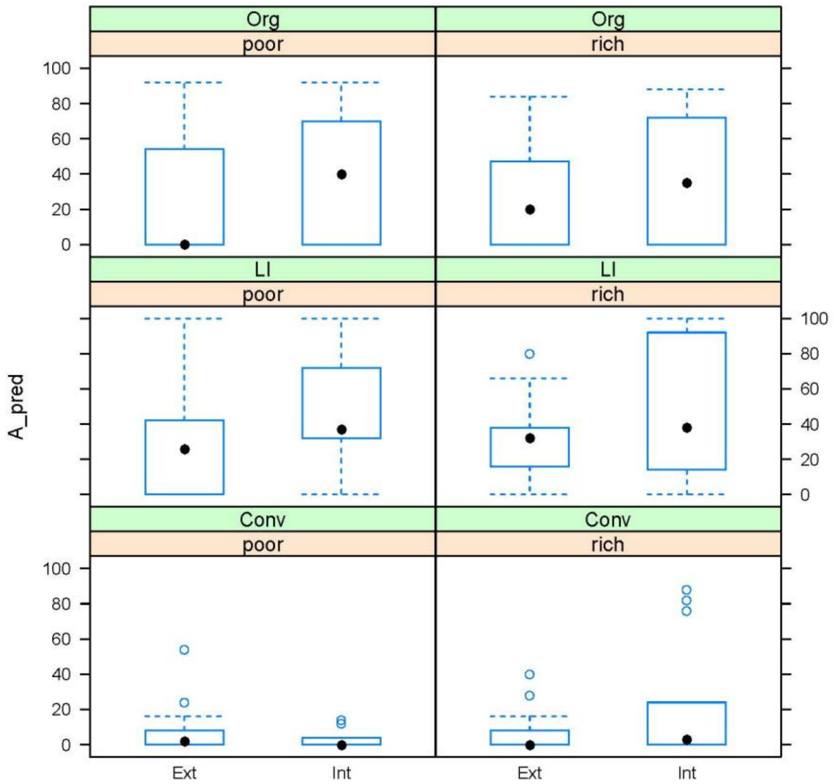


Figure 1. Predation rate (%) of *L. multiflorum* (L_pred) and *A. retroflexus* (A_pred) for the interactions FS x Margin_type x Depth, and FS x Margin_type x Position, respectively.

Farming intensity, along with proximity and complexity of non-cropped habitats, closely interacted to determine seed predation within-fields. Our findings suggest that managing farming intensity and field margin complexity may contribute to effectively manage the levels of seed predation to regulate the density of common weeds. Results also suggest that reduced-input systems have a stronger effect on seed predation than SNH management, and SNH management is more important in conventional farming systems. This will require taking in account the landscape perspective, which recognises the key role of semi-natural habitats in agro-ecosystems to sustain biodiversity and provide ecosystem services.

Acknowledgements

GARM has received a study and travel grant funded by the Italian Ministry of Foreign Affairs 2012/2013. We thank the farmers and personnel of CIRAA for their help. This work was funded by the European FP7-KBBE project QuESSA (www.quessa.eu).

References

Alignier, A., Meiss, H., Petit, S. Reboud, X. 2008: Variation of post-dispersal weed seed predation according to weed species, space and time. J. Plant. Disease Prot. Sp. I. XXI: 221-226.

Bianchi, F. J. J. A., Booij, C. J. H., Tscharntke, T. 2006: Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. P. Roy. Soc. B-Biol. Sci. 273: 1715-1727.

Fischer, C., Thies, C. Tscharntke, T. 2011: Mixed effects of landscape complexity and farming practice on weed seed removal. Perspect. Plant. Ecol. 13: 297-303.

Menalled, F. D., Marino, P. C., Renner, K. A., Landis, D. A. 2000: Post-dispersal weed seed predation in Michigan crop fields as a function of agricultural landscape structure. Agric. Ecos. Environ. 77: 193-202.

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D. the R Core Team 2009: nlme: Linear and Nonlinear Mixed Effects Models. R Package Version 3.1-96.

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., Thies, C. 2005: Landscape perspectives on agricultural intensification and biodiversity–ecosystem service management. Ecol. Lett. 8: 857-874.

Villani, M. G., Wright, R. J. 1990: Environmental Influences on soil macroarthropod behavior in agricultural systems. Annu. Rev. Entomol. 35:249-269.

Westerman, P. R., Hofman, A., Vet, L. E. M., Van Der Werf, W. 2003: Relative importance of vertebrates and invertebrates in epigaeic weed seed predation in organic cereal fields. Agric. Ecos. Environ. 95: 417-425.