View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Organic Eprints

RAHMANN G & AKSOY U (Eds.) (2014) Proceedings of the 4th ISOFAR Scientific Conference.
'Building Organic Bridges', at the Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey (eprint ID 24363)

Functional biodiversity to improve pest control in annual and perennial cropping systems

LUKAS PFIFFNER[1], HANS-JAKOB SCHÄRER[1], HENRYK LUKA[1/2]

Key words: functional agrobiodiversity, habitat management, natural enemies, pest control, flowering strips, companion plant

Abstract

A sustainable use of functional agrobiodiversity (FAB) providing habitats with suitable floral resources is needed to conserve and improve pest control by natural enemies in organic cropping and other low-input systems. We present an overview on our activities identifying appropriate flowering plants in relation to the antagonists-pest complex and quantifying benefits and limits in lab- and field tests. We have focussed on the control of apple-aphids and cabbage lepidopteran pests in two organic cropping systems. We can show that tailoring the flowering strips to the needs of specific natural enemies within a cropping system is a key issue for successful application of FAB. We found plants as Fagopyrum esculentum, Centaurea cyanus and Vicia sativa enhancing target parasitoids in cabbage, and we found Daucus carota, Carvum carvi, Pastinca sativa, Vicia sepium as promising plants in apple orchards. A successful on-farm application of FAB using flowering strips and companion plants is challenging and needs further analyses of its impact on pest control, considering different scales as plot, farm and landscape.

Introduction

There is a growing concern that declining biodiversity caused by intensive agriculture affects ecosystem services. Due to landscape fragmentation and loss of suitable habitats natural enemies have been reduced in species diversity and abundance. In consequence this leads to a substantial loss of biocontrol function. Therefore a sustainable use of FAB, providing habitats with suitable floral resources to conserve these functions, is needed (Bianchi et al. 2013). Herbivore populations are regulated by bottom-up control through food availability and quality and by top-down control by natural enemies. Land-use dominated by monocultures provides abundant food to specialized herbivores and simultaneously has a negative impact on natural enemies because lacking in adequate food sources (Balmer et al. 2013). We have found insufficient effects of 'unspecific' flowering strips, which were based on officially recommended plant mixtures, targeting to increase the overall biodiversity (Pfiffner et al. 2009). Therefore we have tailored the strips in relation to the requirements of the specific complex of natural enemies within a cropping system.

Here we focus on flowering plants as one promising approach to boost pest control within a four-step pest-control strategy (Zehnder et al. 2007). We present an overview on the activities in which we analysed this targeted approach in two cropping systems. The overall objective was (i) to identify appropriate plants in relation to the antagonist-pest complex, (ii) to quantify the benefits and assess the limits under field conditions.

Material and methods

We have focused our activities on two model crops as apple with multi-annual flowering strips and cabbage cropping system using annual strips and companion plant. Apple and cabbage were selected since perennial and annual crops differ greatly in biology and management and are highly productive and economically relevant.

The use of flowering strips was tested in organic apple and cabbage cropping systems on different farms in low-land of Switzerland. First, based on literature data, we conducted lab-trials to identify selective plant species that would improve the longevity and fecundity of natural enemies (parasitoids, predators) without benefiting the pests and are attractive to natural enemies (olfactory tests). Effects of floral and extra-floral nectar of the plants were analysed in the cabbage crop. Afterwards we investigated the impact of the flowering strips under field conditions, focussing on the control of aphids in apple and lepidopteran pests (*Mamestra brassicae: Noctuidae)* in cabbage. Weekly visual observations, monthly beating-tray samples and branch samples in winter on randomly chosen trees were performed to analyse the impact in a low-tree

[1] Research Institute of organic agriculture (FiBL), Ackerstrasse 21, Postfach 219, 5070 Frick, Switzerland, lukas.pfiffner@fibl.org; www.fibl.org
[2] University of Basel, Department of Environmental Sciences, NLU-Biogeography

orchard with and without flowering plants. To better understand the plant-parasitoid interaction, we have studied the olfactory attractiveness of five wildflowers (*Ammi majus*, *C. cyanus*, *F. esculentum*, *Iberis amara* and *Origanum vulgare*) to *Microplitis mediator* (Braconidae), a larval parasitoid of the cabbage moth *M. brassicae*. We conducted choice experiments in a Y-tube olfactometer to test the attractiveness of flowers against air and the relative attractiveness in paired choice tests.

Results and discussion

One of the most relevant pest species of cabbage in central Europe is *M. brassicae.* Its primary larval parasitoid is *M. mediator* and the main egg-parasitoids are *Trichogramma brassicae, T. evanescens (Trichogrammatidae*) and *Telenomus sp.* (*Scelionidae*).

Beneficial effects of *F. esculentum* (floral nectar), *C. cyanus* (floral and extrafloral nectar) and non-flowering *V. sativa* (Extrafloral nectar (EFN)) on parasitoids *M. mediator* have been found in lab-tests (Geneau et al. 2012). Longevity and fecundity of the pest (*M. brassicae*) were not increased by the plant species tested. Longevity of *M. mediator* as well as parasitism rates of *M. mediator* were significantly increased by the presence of *F. esculentum, C. cyanus* and non-flowering *V. sativa* (EFN only). The key parasitoid *M. mediator* parasitized 202.3±29.7 *M. brassicae* larvae during its lifetime when presented *F.esculentum*, compared to 14.4±3.4 larvae in the absence of floral resources (Geneau et al. 2012).

The olfactory test of plant attractiveness showed that *C. cyanus* and *I. amara* were greatly attractive to the target parasitoid *M. mediator*. This has shown innate preferences that can be effectively exploited in biological control (Belz et al. 2013).

Our field trials showed that the application cornflowers as companion non-crop flowering plant within the crop can significantly increase parasitism by larval parasitoids. Additionally, higher parasitism and predation of herbivore eggs finally reducing crop damage and may increase yield (Balmer et al. 2013). Companion plant presence lead to a significant increase in parasitation of *M. brassicae* by *M. mediator* and had a significant positive effect on cabbage head weight and the number of damaged leaves was also significantly lower in plots with companion plants (Balmer et al. submitted).

Furthermore, we found higher abundance and species richness of spiders and carabids in flowering strips compared to adjacent cabbage fields (Dittner et al. 2013). Intersown cornflowers had a positive effect on spider and carabid abundance. Other predators such as syrphids, chrysopids and coccinellids were also detected on these flowering plants. The species richness of spiders and carabids was only weakly affected by this companion plant.

Table 1: Impact of FAB using flowering strips on a key-pest and their natural enemies and pest-control function in a cabbage and apple cropping system (data sources in references 1, 2, 4, 5, 8 and 9)

	lab-trial		**field test**				
	Increased (parasitoids)		*Reduced*	*Increased*		*enhanced density of*	
	fecundity	*longevity*	*pest density*	*parasitism*	*predation*	*predator*	*parasitoids*
M. brassicae	+	+	+	++ (larvae)	+	+	o
in cabbage[1)]				+ (egg)			
D. plantaginea	o	o	+	-	++	++	-
A. pomi	o	o	+	-	+	++	-
in apple [2)]							

Legend: + +: high impact, +: moderate impact, o: not investigated, -: not found
Useful plants in [1)] *F. esculentum, C. cyanus, V. sativa* [2)] *D. carota, C. carvi, C. sepium, L. corniculatus, M. sativa*

Apple orchards are in general characterised by simplified plant and animal communities. The soil below the trees is often kept bare and has a uniform flora dominated by grass which is mulched regularly. Using flowering strips in organic apple orchards we found a positive impact in controlling apple key pests (Wyss et al. 2005). The higher numbers of all relevant predator groups (Coccinellids, Chrysopids, Syrphids, Cecidomyiids, Bugs, Spiders, Staphylinids) leads to a better pest control in the plots with flowering plants compared to the control plots without (Wyss 1995a). These predators were able to keep the aphids (*Dysaphis plantaginea, Aphis pomi*) under the commercially threshold In autumn, spiders (i.a. *Araniella sp.)*

were the dominant predators of aphids and they were significantly more reduced in the area with flowering strips compared to areas without flower strips. This was mainly due to higher abundance of spiders and more spider webs (Wyss et al. 1995b).

Conclusions

An accurate plant screening is essential to achieve plant selectivity and to maximize biological control. In cabbage crop, *Fagopyrum esculentum, Centaurea cyanus and Vicia sativa* can be recommended as selective plant species to enhance target parasitoids. In orchards it is challenging to establish a perennial flower strip. Plants of the family of Apiaceae (*Daucus carota, Carvum carvi, Pastinca sativa*) and others (*Vicia sepium, Lotus corniculatus, Medicago sativa*) are promising plants.

For a successful practice, the composition of the agro-biodiversity elements needs to be adapted to the crop, pest complex, pedo-climatic conditions, as well as to the farm structure and the farmer. Suitable tailored flowering plants can also improve the efficacy of commercially available biocontrol agents. The pest-damage reduction has to be substantial within the pest-control strategy and the management needs to be practically and economically feasible.

The implementation of FAB to effectively control pests in the practice of farming systems is a challenge and we are still at the beginning of the development of eco-intensification. We want to find the optimal use of specific biodiversity elements and further research is therefore needed to appropriately combine indirect-preventive measures and direct intervention strategies which are effective in controlling pests and finally pay off for farmers and the environment.

Acknowledgements

We thank PhD-workers E. Belz, C. Géneau. C. Daniel, O. Balmer and E. Wyss for their work, support and fruitful discussions. The project was funded by Bundesamt für Umwelt (BAFU) and foundations as Bristol, Ernst Göhner, Parrotia, Werner Steiger, Singenberg, Schöni Swissfresh AG, Stiftung zur internationalen Erhaltung der Pflanzenvielfalt, SWO, Gamil and Bank Vontobel.

References

Balmer, O., Pfiffner, L., Schied, J., Willareth, M., Leimgruber, A., Luka, H. & Traugott, M. (2013): Noncrop flowering plants restore top-down herbivore control in agricultural fields. Ecol and Evol 3(8): 2634-2646.

Balmer, O., Géneau, C. E., Belz, E., Weishaupt, B., Förderer, G., Moos, S., Ditner, N., Juric, I. & Luka, H. (submitted): Companion plants increase pest parasitism and yield in cabbage fields: experimental demonstration and call for caution.

Bianchi, F.J.J.A., Mikos, C., Brussaard, L., Delbaere, B., Pulleman, M.M. (2013) Opportunities and limitations for functional agrobiodiversity in the European context. Review. Environ Sci & Pol 223 – 231.

Belz, E., Kolliker, M. & Balmer, O. (2013): Olfactory attractiveness of flowering plants to the parasitoid Microplitis mediator: potential implications for biological control. BioControl 58: 163–173.

Géneau, C. E., Wäckers, F. L., Luka, H., Daniel, C. & Balmer, O. (2012). Selective flowers to enhance biological control of cabbage pests by parasitoids. Basic and Appl Ecol 13 (2012) 85–93.

Pfiffner L, Wyss E (2004) Use of sown wildflower strips to enhance natural enemies of agricultural pests; Gurr GM, Wratten SD, Altieri MA, editors. Collingwood VIC, Australia: CSIRO Publishing. 165-186 p.

Pfiffner, L., H. Luka, C. Schlatter, A. Juen, and M. Traugott (2009): Impact of wildflower strips on biological control of cabbage lepidopterans. Agri Ecosys & Environ 129: 310-314.

Wyss E, Luka H, Pfiffner L, Schlatter C, Uehlinger G, et al. (2005) Approaches to pest management in organic agriculture: a case study in European apple orchards. CABI Publishing, pp. 33-36.

Wyss E (1995a) The effects of weed strips on aphids and aphidophagous predators in an apple orchard. Entomol Exp Appl 75: 43-49.

Wyss, E., Niggli, U. and Nentwig,W. (1995b). The impact of spiders on aphid populations in a strip managed apple orchard. Appl Entomol 119: 473–478.

Zehnder G, Gurr GM, Kühne S, Wade MR, Wratten SD, Wyss, E. (2007) Arthropod Pest Management in Organic Crops. Ann Rev Entomo 52: 57-80.