



Flowering cover crops in winter increase pest control but not trophic link diversity



Maxime Damien^{a,b,*}, Cécile Le Lann^a, Nicolas Desneux^b, Lucy Alford^c, Diab Al Hassan^a, Romain Georges^a, Joan Van Baaren^a

^a Université Rennes 1, UMR 6553, ECOBIO, F-35042 Rennes, France

^b INRA (French National Institute for Agricultural Research), Université Côte d'Azur, CNRS, UMR 1355-7254, Institut Sophia Agrobiotech, 06903 Sophia Antipolis, France

^c Institute of Molecular, Cell and Systems Biology, College of Medical, Veterinary and Life Sciences, University of Glasgow, Davidson Building, G12 8QQ Glasgow, UK

ARTICLE INFO

Keywords:

Aphid-parasitoids trophic system
Biological control
Sown flowering cover crops
Synapis alba
Winter

ABSTRACT

In agrosystems, the increase in non-crop plant diversity by habitat management in or around arable fields contributes to improved Conservation Biological Control. During winter, plant flowers are often used as monospecific ground cover and are expected to die before flowering as a result of recurrent frost events. Decreases in minimal temperature due to climate change offers new possibilities for plants used in such sown cover crops to mature and flower. Changes in plant phenology thus constitute an important environmental change with expected consequences for ecosystem functioning, such as biological control. In Brittany, where winter agricultural landscape is dominated by a mosaic of cereal and sown cover crops, we assessed the consequences of mustard (*Synapis alba*) flowering cover crops (MFCC) on aphid parasitism and food web structure in plots adjoining cereal crops, in contrast to plots close to spontaneous non-crop plants (SNCP) of the same field. Overall, aphid parasitism rate at the field scale was strong (60–70%), being 13% higher adjacent to the MFCC than closer to SNCP. In addition, there was no change in food web structure between the two distinct zones, enabling us to hypothesize that MFCC mostly constituted an alimentary patch. The positive effect on parasitism rate was significant but weak, as floral nectar of mustard is known to be of poor quality for parasitoids. Results highlight the potential advantages of adapting practices in response to actual changes in agrosystems. Increase floral diversity in sown cover crops could constitute a complementary method in management programs, by providing more alternative food resources, alternative hosts, and climatic refuge to enhance the Conservation Biological Control of parasitoid populations.

1. Introduction

The adoption of wide scale agriculture and associated practices by farmers over recent decades has led to drastic changes in both landscape structure and biotic interactions (Redclift, 1989; Singh, 2000; Stoate et al., 2001; Tsiafouli et al., 2015), e.g. through the overall decrease in landscape complexity and biodiversity (Flynn et al., 2009; Matson, 1997; Tschardt et al., 2005). The increase of cultivated areas over semi-natural habitats (e.g. edges, meadows or woods) has resulted in small fragmented non-cropped habitats showing reduced biodiversity, notably across plant communities (Krause et al., 2015; Van Meerbeek et al., 2014; Wesche et al., 2012). This led to low arthropod diversity with modification of trophic interactions between plants and arthropods and/or within arthropod communities (Altieri, 1999;

Haddad et al., 2009; Scherber et al., 2010). Such changes have altered, what is referred to as the ‘pest complex system’ (Matson, 1997) and the biocontrol services provided by natural enemies, with an increase in specialist phytophagous agricultural pests, but a reduction in the abundance and diversity of predators and parasitoids (Cardinale et al., 2011; Meehan et al., 2011; Scherber et al., 2010).

To counterbalance this trend, habitat management programs in Conservation Biological Control (CBC) aim to enhance natural biodiversity by adaptive management promoting indigenous plant diversity and habitat complexity (Landis et al., 2000; Perović et al., 2017; Tschardt et al., 2007). The increase of non-crop plants surrounding arable fields contributes to improved pest regulation by natural enemies at the field scale (Balzan and Moonen, 2014; Tschardt et al., 2005; Tschumi et al., 2016a; Wratten et al., 2012). This practice induces an

* Corresponding author at: UMR Ecobio, Université de Rennes 1, 263 Avenue du Général Leclerc, 35042, Rennes Cedex, France.

E-mail addresses: maxime.damien@univ-rennes1.fr (M. Damien), cecile.lelann@univ-rennes1.fr (C. Le Lann), nicolas.desneux@inra.fr (N. Desneux), l.alford.02@cantabgold.net (L. Alford), diab.alhassan@univ-rennes1.fr (D. Al Hassan), romain.georges@univ-rennes1.fr (R. Georges), joan.van-baaren@univ-rennes1.fr (J. Van Baaren).

<http://dx.doi.org/10.1016/j.agee.2017.07.015>

Received 22 March 2017; Received in revised form 6 July 2017; Accepted 10 July 2017
0167-8809/ © 2017 Elsevier B.V. All rights reserved.

enhanced trophic system stability which reduces the intensity of pest outbreaks (Haddad et al., 2011). Grassy margin vegetation or flowering strips surrounding crops act to support natural enemy communities by constituting complementary patches with additional plants and habitat diversity. Natural enemies then migrate from these semi-natural habitats to the crops. First, these patches can improve natural enemy survival by providing alternative habitats against anthropic crop disturbances (Alignier et al., 2014; Ramsden et al., 2015; Thies et al., 2005). In addition, they can provide additional resources such as pollen, carbohydrates, or alternative prey for predators and hosts for parasitoids, thus improving trophic system complexity and population dynamics in adjoining crops (Wäckers and van Rijn, 2012). Regional spatial scales may also be considered, since increases in the proportion of these patches within the agricultural landscape can act to increase biological control efficiency, notably because they constitute refuges and as a consequence, sources from which natural enemies may emigrate (Alignier et al., 2014).

Changes to plant phenology during winter as a result of climate change have been highlighted (Menzel et al., 2006; Parmesan, 2006) at the local and regional scale (Nordli et al., 2008), for example, with advances in bud burst (Badeck et al., 2004) or first flowering date (Fitter, 2002). In their study, Uelmen et al. (2016) demonstrated changes in the phenological synchrony between caterpillars and trees in response to warming temperatures during winter. Such changes are likely to produce cascading effects on higher trophic levels and alteration of ecosystem functioning may be expected. However, few studies have focused on plant-arthropod interactions during winter and none in the context of climate change. Therefore, there is a need to unravel the use of semi-natural and cultivated habitats by arthropods during formerly considered unfavorable seasons, such as winter in temperate areas (Gurr et al., 2017), for which warmer temperatures are already observed or predicted (Räisänen et al., 2004). In this context, modifications of plant-insect interactions in agroecosystems may become a new challenge for CBC over seasons.

In Brittany (Western Europe), the intensive agricultural landscape during the autumn/winter season is dominated by a mosaic of cereal crops and flowering cover crops. The later are used to prevent soil erosion and to fertilize the soil prior to the planting of corn cultures. Theoretically, these winter sown-cover crops are destroyed by freezing during the winter. However, during the past two decades, winter temperatures have increased and there has been a reduction in the number of days in which temperatures have dropped below 0 °C (see Fig1 Andrade et al., 2016). Benefits from sown-cover crops are not documented compared to the benefits of grassy margin vegetation or sown flowering strips (Holland et al., 2016). In addition, the phenology of flower species used in winter sown-cover is impacted by rising temperatures and some species are flowering during the winter, as early as December when there is no frost. Considering the benefits provided by floral resources to natural enemies (Tschumi et al., 2016a,b), such environmental changes may favour their activity and population dynamics resulting in increased early pest regulation.

During winter, three aphid species are predominant on cereal crops in the cereal fields of North-Western France (Rabasse et al., 1983): *Rhopalosiphum padi* (Linnaeus), *Sitobion avenae* (Fabricius) and *Metopolophium dirhodum* (Walker). The natural enemy guild of aphid pests in cereal crops is composed mainly of Aphidiine parasitoids belonging to the *Aphidius* genus (Krespi et al., 1997), with other aphid predators being in a state of diapause. Oceanic temperate climate allows species involved in this trophic system to remain active during autumn/winter, even at lower activity levels (Andrade et al., 2016, 2015; Dedryver, 1981; Polgar, 1995). Parasitoid communities may benefit from changes in sown-cover plants phenology during this harsh period. Compartmentalization in aphid-parasitoid networks have been shown to be high between crop and non-crop habitats (Derocles et al., 2014; Vialatte et al., 2005), although parasitoids are more prone to foraging in neighbouring crops as opposed to in margin vegetation later in winter

(Macfadyen et al., 2015). Sown flowering cover crops may provide carbohydrate, alternative hosts, better climatic refuges for cereal parasitoids, and increase parasitoid activity and/or survival. In addition, according to the diversity-trophic structure hypothesis (Hutchinson, 1959; Knops et al., 1999), each crop, with its own arthropod community, may increase trophic system complexity and improve pest regulation (Haddad et al., 2009). This is due to functional redundancy resulting from greater parasitoid diversity (Peralta et al., 2014; Vos et al., 2001) or as a result of changes to the intra-guild interactions with the presence of alternative hosts and modification of apparent competition (Raymond et al., 2016).

Aphid-Parasitoid trophic systems have been used largely as a model system to assess biodiversity change owing to their ecology (Gagic et al., 2011; Roschewitz et al., 2005; Tylianakis et al., 2007). In particular, they are used to evaluate the influence of neighbouring crop habitats (Alignier et al., 2014; Macfadyen et al., 2015; Plečaš et al., 2014). In the current study, we used such pest-enemy complex to assess potential benefits of change in sown covers plant phenology on the biological control service under wintering conditions. In order to evaluate the effects of the earlier flowering time of mustard (*Synapis alba*) flowering cover crops (MFCC hereafter) on aphid pest control by parasitoids, the aphid-parasitoid food web, relative aphid and parasitoid abundances and parasitoid sex ratio were compared between cereal crop plots close to MFCC and close to spontaneous non-crop plants from grassy margins (SNCP hereafter). The following hypotheses were explored to explain change in aphid parasitism: (i) The increase of trophic system complexity positively impacts aphid regulation close to MFCC due to functional redundancy or changes in intra-guild interactions. (ii) MFCC may result in higher parasitoid relative abundances (higher parasitism rates) and female biased sex ratios (more favorable population dynamics) by providing more favorable environmental conditions than SNCP: two mechanisms are possible, firstly a higher vegetation cover may lead to buffered micro-climatic conditions, or more plants may offer increased floral food, host honeydew and/or host access.

2. Materials and methods

2.1. Study area and experimental design

The study was carried out in three different locations near Rennes, France, in the “Zone Atelier Armorique” (Long Term Ecological Research site, see Table 1 for GPS coordinates and crop sizes). Among fifteen cereals crop fields selected in a first approach, only six were retained (five wheat and one barley crops) as the others were not infested by aphids. Sampling was performed on three dates during February 2016 as no aphids were found before the end of January. Cereal crops were sown between September and October 2015 and had reached approximately 20 cm in height (ranging from 10 to 30 cm) at the sampling time. MFCC were sown in October or November in one side of the cereal crop and had reached approximately 1–1.20 m in height and had been flowering since the beginning of December. SNCP were composed of spontaneous non-crop grassy plants (without shrub or tree) in one of the three remaining sides of the cereal crop.

To compare MFCC or SNCP effects on the pest complex system, we compared the community composition and biocontrol services provided by aphid parasitoids using a paired experimental design. For each cereal field and for each date, two plots of 15 m² were delimited in the cereal crop when the first aphid was found, respectively near MFCC and near SNCP. New plots were delimited for each sampling and for each date. Samples near SNCP were conducted more than thirty meters away to the MFCC as it has been demonstrated that margins or flowering strips do not affect pest regulation at the field scale above a 20 m distance (Lavandero et al., 2005). Since the length of the field is commonly greater than this distance, the comparison of both field margins represents the better compromise. Cereal fields lacking neighbouring

Download English Version:

<https://daneshyari.com/en/article/5538017>

Download Persian Version:

<https://daneshyari.com/article/5538017>

[Daneshyari.com](https://daneshyari.com)