Crop association to improve aphid biological control

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Introduction

Increasing plant diversity within crops can have several beneficial effects on pest control:

- ***Resource concentration hypothesis*** (Root, 1973): specialist herbivores are more likely to find and remain on host plants that are concentrated in dense or pure stands.
- ***Enemy hypothesis*** (Root, 1973): natural enemies (predators and parasitoids) are more abundant in complex environments, especially because they can benefit from alternative sources of prey, nectar and pollen (reviewed by Rodriguez-Saona *et al*. 2012).

Objective: determine the effect of two wheat-pea associations (mixed cropping with no specific row arrangement and strip cropping) on the populations of aphids and their adult natural enemies, and compare it with pure stands of wheat and pea.

Materials and methods

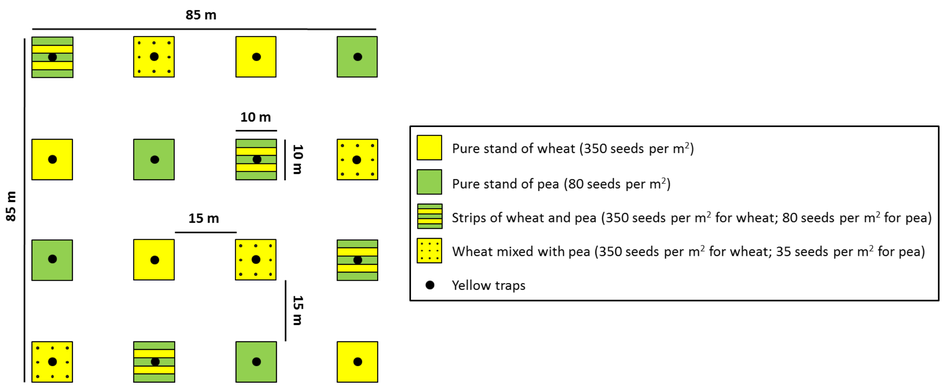

Fig 1 Experimental design.

Sampling method (each week)

Observation of aphids on pea and wheat plants

20 plants of each crop were randomly selected in each plot (20 plants in the pure stands and 40 plants in the mixing and strip cropping)

Insect trapping (Yellow pan traps)

Collection and identification of adult **predators** and **parasitoids**

Results

Observation of aphids on plants

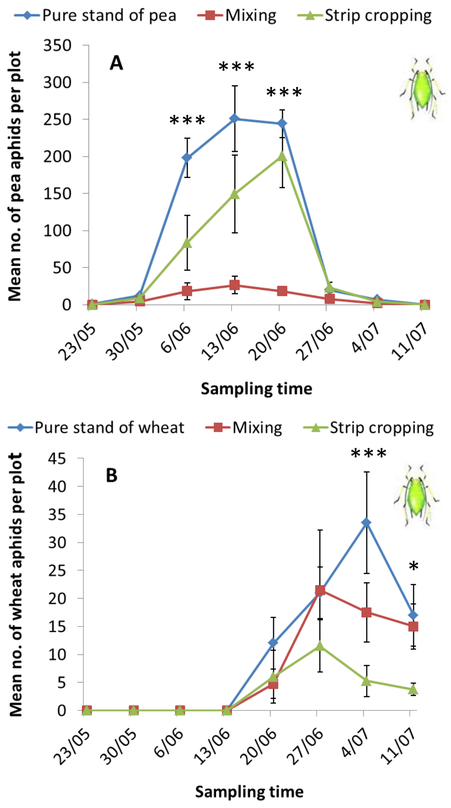

Fig 2 Seasonal occurrence and abundance (mean number per week ± SEM) of *A. pisum* (a) and wheat aphids (*S. avenae* + *M. dirhodum*) (b) observed on pea and wheat plots respectively, through 2012 growing season (*P<0.05; ***P<0.001). M, SC, mixing and strip cropping respectively; PSP, PSW, pure stand of pea and pure stand of wheat respectively.

Table 1 Diversity and abundance (total numbers) of beneficials trapped in the different treatments through 2012 growing season. A code is given for each species to indicate their identity in Fig 4. M, SC, mixing and strip cropping respectively; PSW, PSP, pure stand of wheat and pure stand of pea respectively.

Code	Species	Treatments M	SC	PSW	PSP	%[a]
	Ladybirds (Coccinellidae)		**50.3%[b]**			
1	*Adalia decempunctata* (Linnaeus)	0	0	1	1	**1.3**
2	*Coccinella septempunctata* Linnaeus	9	18	4	40	**47.3**
3	*Harmonia axyridis* (Pallas)	3	11	3	13	**20.0**
4	*Propylea 14-punctata* (Linnaeus)	6	13	7	21	**31.3**
	Hoverflies (Syrphidae)		**30.2%[b]**			
5	*Episyrphus balteatus* (De Geer)	2	2	6	4	**15.6**
6	*Eupeodes corollae* (Fabricius)	4	1	9	3	**18.9**
7	*Melanostoma mellinum* (Linnaeus)	4	0	3	0	**7.8**
8	*Melanostoma scalare* (Fabricius)	1	0	5	0	**6.7**
9	*Platycheirus manicatus* (Meigen)	0	1	0	0	**1.1**
10	*Platycheirus peltatus* (Meigen)	1	0	1	0	**2.2**
11	*Sphaerophoria scripta* (Linnaeus)	15	6	17	2	**44.4**
12	*Syrphus ribesii* (Linnaeus)	1	1	0	0	**2.2**
13	*Syrphus vitripennis* Meigen	0	1	0	0	**1.1**
	Lacewings (Chrysopidae)		**8.7%[b]**			
14	*Chrysopa phyllochroma* Wesmael	0	0	0	1	**3.8**
15	*Chrysoperla carnea* (Stephens)	8	5	4	8	**96.2**
	Braconid wasps (Braconidae)		**10.7%[b]**			
16	*Aphidius ervi* Haliday	0	1	0	1	**6.3**
17	*Aphidius matricariae* Haliday	1	0	0	0	**3.1**
18	*Aphidius picipes* (Nees)	1	0	0	1	**6.3**
19	*Aphidius rhopalosiphi* De Stefani-Perez	4	9	5	4	**68.8**
20	*Diaeretiella rapae* (M'Intosh)	1	0	0	0	**3.1**
21	*Praon volucre* (Haliday)	1	1	1	1	**12.5**
Total numbers of beneficial species		**62**	**70**	**66**	**100**	
Proportion of total numbers of beneficial species (%)		**20.8**	**23.5**	**22.1**	**33.6**	

a Proportional representation of each species by family
b Relative occurrence of each family in the beneficial population

Insect trapping (Yellow pan traps)

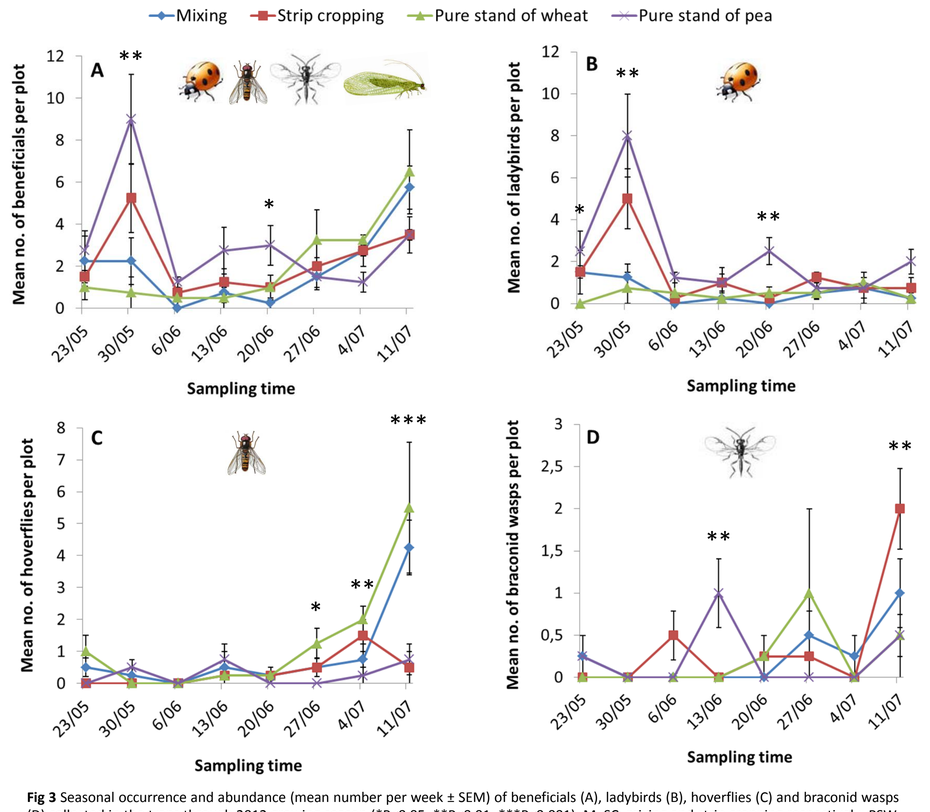

Fig 3 Seasonal occurrence and abundance (mean number per week ± SEM) of beneficials (A), ladybirds (B), hoverflies (C) and braconid wasps (D) collected in the traps through 2012 growing season (*P<0.05; **P<0.01; ***P<0.001). M, SC, mixing and strip cropping respectively; PSW, PSP, pure stand of wheat and pure stand of pea respectively .

At the species level…

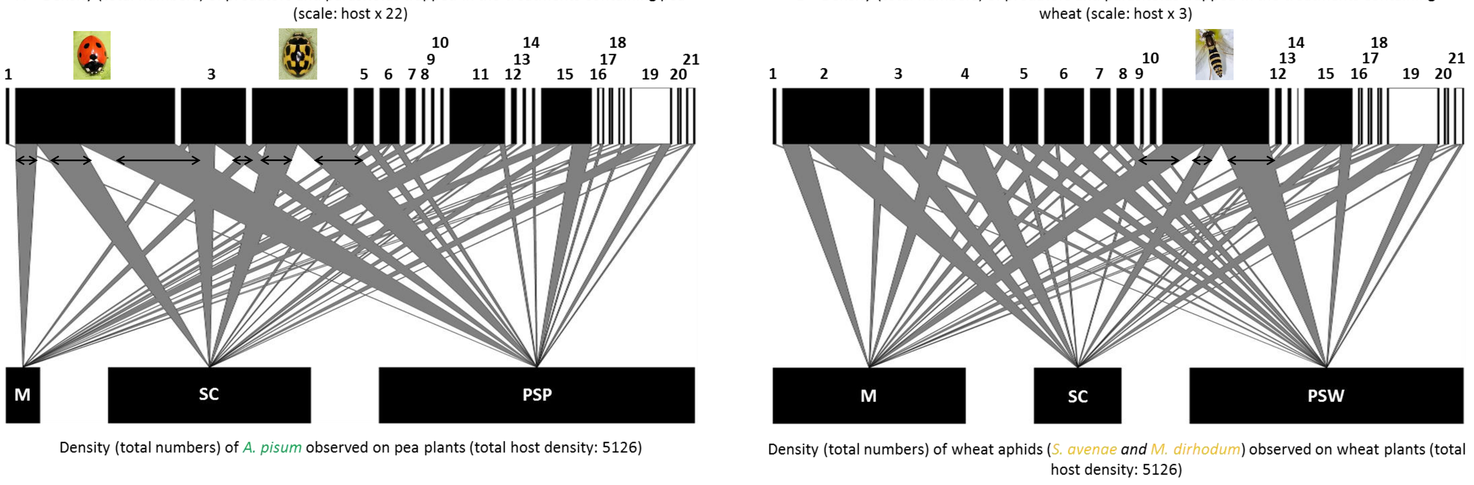

Fig 4 Distribution of beneficial species according to aphid density on pea (A) and wheat (B) plants. In the top, black bars and white bars represent predator and parasitoid abundance, respectively. The widths of bars are magnified relative to those of aphids by the factor given in the upper legend. The species identities (numbers) are given in Table 1. In the bottom, black bars represent aphid abundance in the different treatments: M, SC, mixing and strip cropping respectively; PSP, PSW, pure stand of pea and pure stand of wheat respectively. Beneficial species and aphids are linked by triangular wedges. Their relative widths represent the abundance of beneficials according to aphid density in each treatment.

Discussion

- Results from the observations on plants support the ***resource concentration hypothesis***. The mixing condition was particularly beneficial for the pea.
- Regarding beneficials, our results suggest that the ***resource concentration*** and ***enemies hypotheses*** can sometimes be antagonistic. In fact, adult beneficials were more abundant in pure stands compared with crop associations.
- Adding one crop may be not enough to benefit from alternative sources of prey, nectar and pollen.
- It is also possible that the concentrations of volatile compounds (*e.g.* herbivore-induced plant volatiles, aphid honeydew and aphid alarm pheromone), that are attractive for some adult beneficials, were higher in pure stand plots since aphid populations were denser compared with associations. Some species, such as *C. septempunctata, P. 14-punctata* and *S. scripta* may have perceived these cues more efficiently.

Perspectives: combine crop associations with semiochemical releasers to attract beneficials.

Root RB (1973) Organization of a plant-arthropod association in simple and diverse habitats: the fauna of collards (Brassica oleracea). Ecological Monographs 43:95–124.
Rodriguez-Saona C, Blaauw BR, Isaacs R (2012) Manipulation of natural enemies in agroecosystems: habitat and semiochemicals for sustainable insect pest control. In: Larramendy ML, Soloneski S (ed) Integrated Pest Management and Pest Control – Current and Future Tactics. InTech, Rijeka, Croatia, pp 89–126.