Control of aphid populations by the implementation of “push-pull” strategies

Gembloux Agro-Bio Tech
Functional and evolutionary entomology

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Research work in China

- PIC project ⟶ cooperation between China and Belgium

- Objective:

Reduce pesticide applications to improve the quality of vegetables in China

- Specific objective:

Control aphid populations in vegetable crops by the implementation of “push-pull” strategies

Introduction

- **Conservation biological control:**

"Enhancement of naturally occurring wild populations of natural enemies, by means of habitat management or manipulation of their behaviour "

- **Aphidiphagous beneficial insects:**

Ladybirds

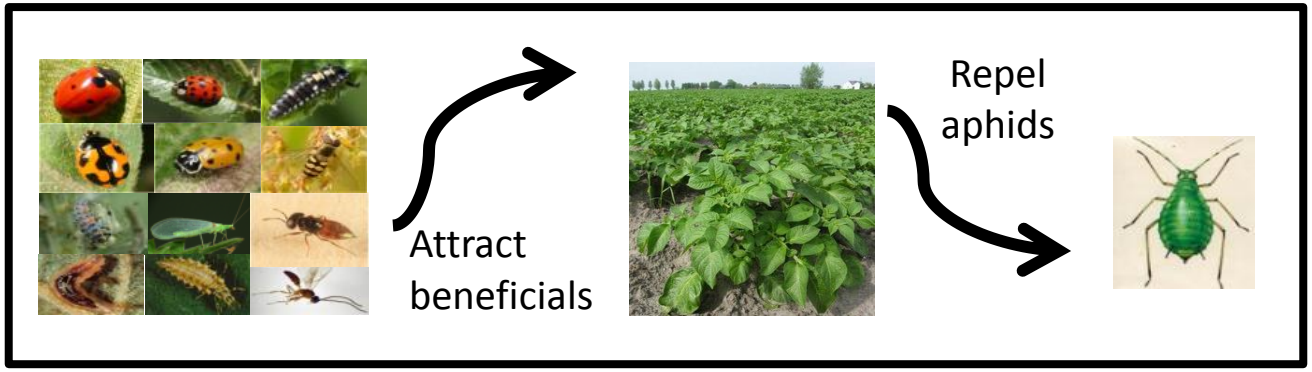
Hoverflies

Lacewings

Parasitoid wasps

Introduction

- **“Push-pull ”** approach:



- ***Semiochemicals*:** Informative molecules used by insects and plants to communicate

- ***Intercropping*:** Grow a crop in association with another one, in the same field

Objectives

1. Characterize the socio-economic structure of rural households in Shandong province

2. Implement and evaluate different “push-pull” strategies in potato and courgette fields.

The work focused on aphidophagous beneficial insects

3. Elaborate informative sheets for Chinese farmers

Material and methods

1. Characterization of the socio-economic structure of rural households in Shandong

- A survey was conducted in this province
- 27 questionnaires were submitted in various villages in three different districts
- Two periods: from 15 to 17 July 2009 and 1 to 3 August 2009

Results

- Chinese farmers have a little knowledge about pests and beneficial insects
- But also about the toxicity of pesticides
- No farmers heard about alternative methods
- There is a relationship with the level of formation

Conclusion: information must reach Chinese farmers

Material and methods

2. Implementation of “push-pull” strategies to control aphid populations by the action of their natural enemies

Semiochemicals:

- (E)-β-farnesene (EBF)
- (Z)-3-Hexenyl acetate
- Garlic extract

Intercropping:

- Pea/courgette
- Pea/potato

2 crops:

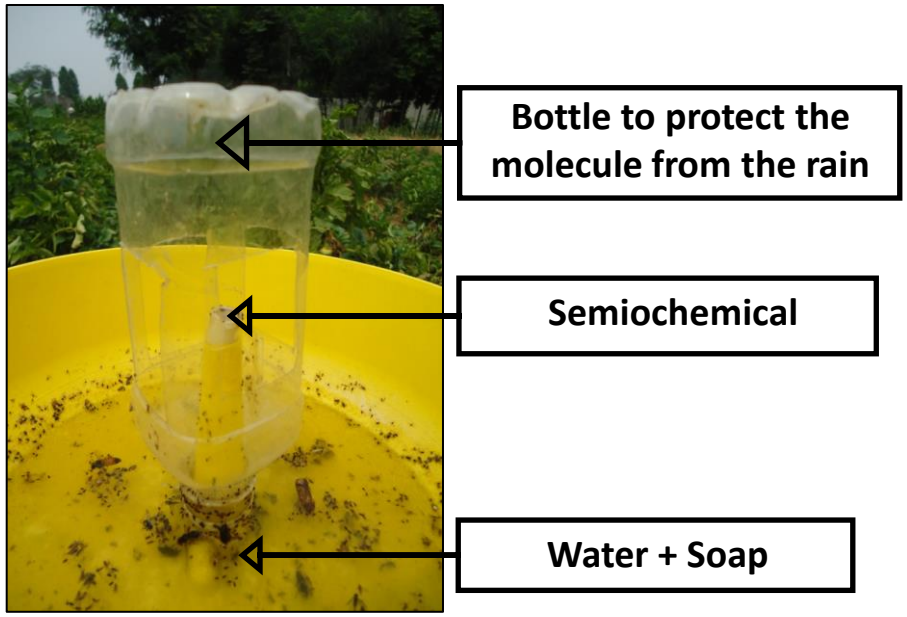
Potatoes

Courgettes

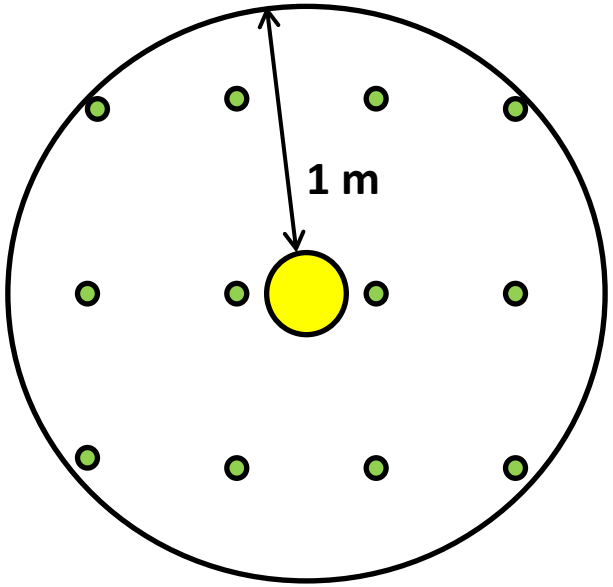
Material and methods

Two methods

Collection of beneficials in yellow traps every week



Observation of beneficial on plants every week



Results

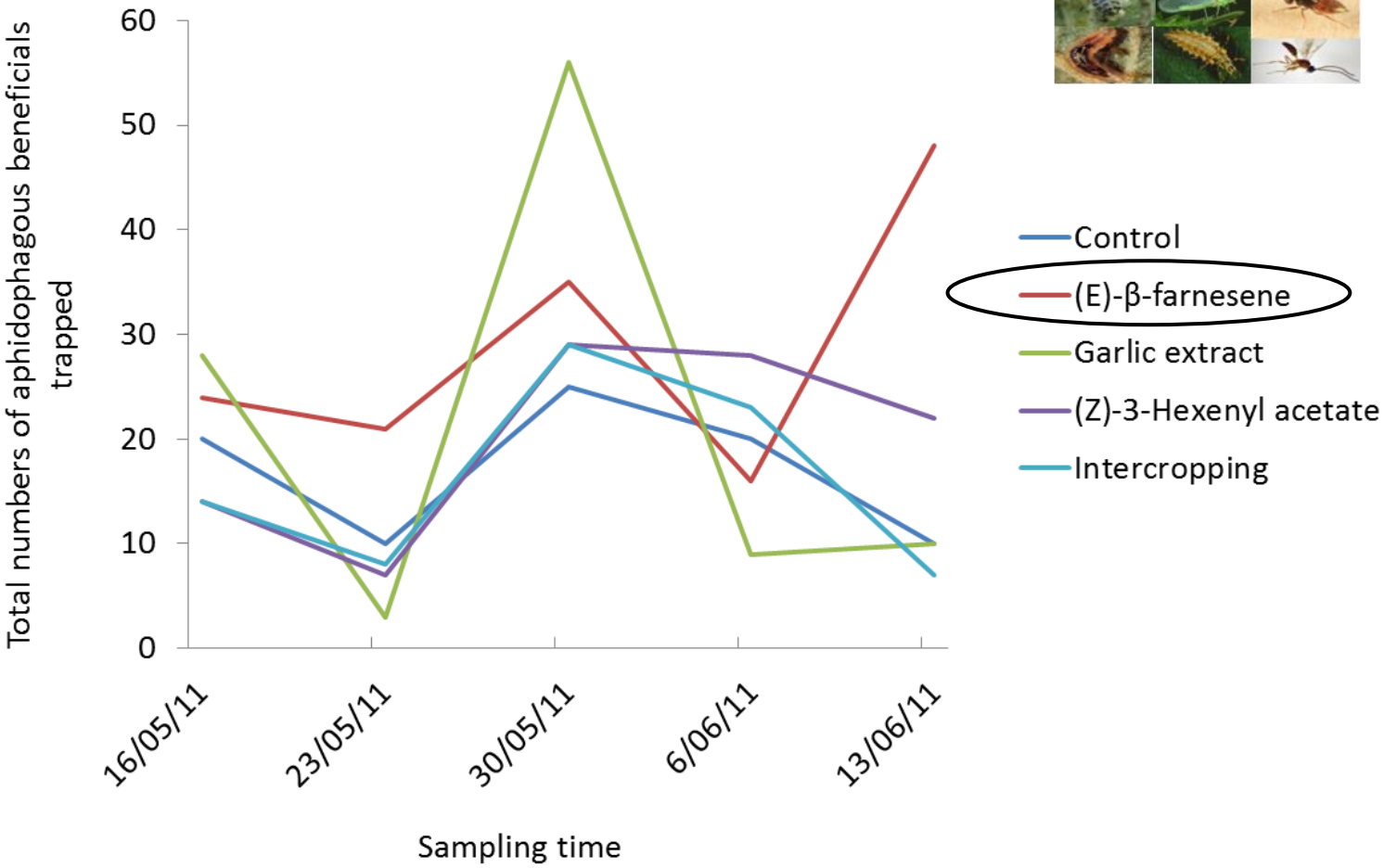
Courgettes (*Cucurbita pepo* L.)							
Species trapped in the different treatments			T1	T2	T3	T4	T5
Predators	Coccinellidae	*C. septempunctata* (adult) ←	16	34	19	23	19
		C. septempunctata (larva)	0	0	0	1	0
		H. convergens (adult)	2	3	4	0	3
		Platynaspis sp. (adult)	5	7	2	4	0
		P. japonica (adult)	4	2	3	0	4
		P. japonica (larva)	0	0	0	2	0
		H. axyridis (adult)	0	0	0	0	1
	Syrphidae	*E. tenax* (adult)	1	0	1	1	0
		E. corollae (adult)	0	3	3	4	5
		E. arbustorum (adult)	0	2	0	0	0
	Chrysopidae	*C. carnea* (adult)	1	1	0	0	2
		C. carnea (larva)	0	0	0	0	2
		C. pallens (adult)	1	0	0	0	0
		Larva of Chrysopidae	0	0	0	0	1
Parasitoids	Braconidae	*Lysiphlebus sp.*	6	9	12	4	7
		A. avenae	0	1	0	1	1
		D. rapae	1	0	0	0	2
		A. gifuensis ←	19	17	16	16	12
		L. gracilis	1	4	19	8	4
	Aphelinidae	*Aphelinus sp.* ←	24	61	27	21	37
Total			81	144	106	85	100

Total: 516

(T1: Intercropping ; T2: (E)-β-farnesene ; T3: Garlic extract ; T4: Control ; T5: (Z)-3-Hexenyl acetate)

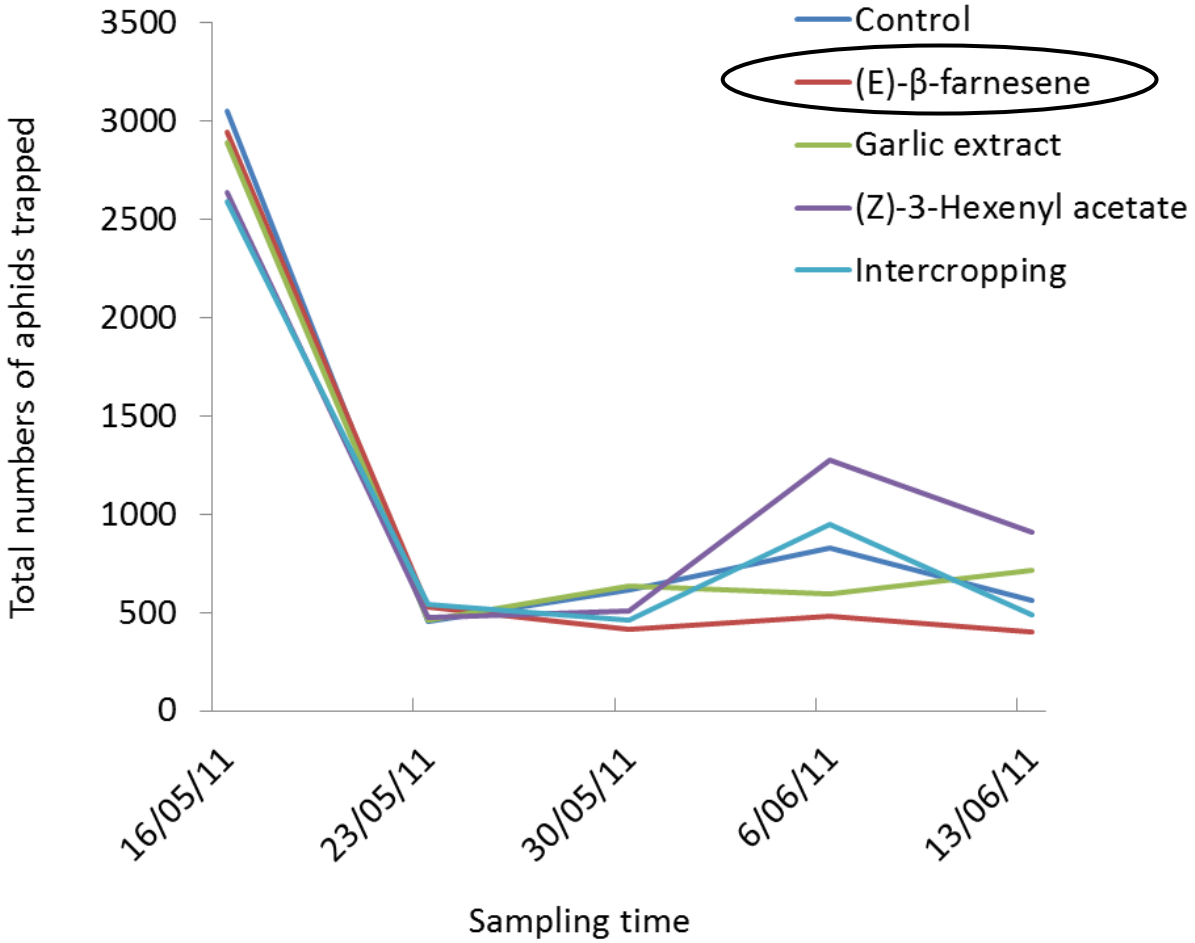
Results

Courgettes



Results

Courgettes



E. Bosquée

Results

Courgettes *(Cucurbita pepo L.)*							
Species of beneficials observed in the different treatments			T1	T2	T3	T4	T5
Predators	Coccinellidae	*C. septempunctata* (adult)	4	1	5	4	3
		C. septempunctata (larva)	0	3	7	4	5
		P. japonica (adult)	4	4	3	3	2
		P. japonica (larva)	0	0	0	0	1
	Syrphidae	*E. corollae* (adult)	5	3	5	3	3
		S. scripta (adult)	1	0	1	0	0
		Larva of Syrphidae	1	1	0	2	0
	Chrysopidae	*C. carnea* (larva)	0	0	2	2	1
		Larva of Chrysopidae	0	0	1	0	1
Parasitoids	Braconidae	*A. avenae*	0	0	0	0	1
		A. gifuensis	12	9	10	11	6
		L. gracilis	0	0	0	1	0
Total			27	21	34	30	23

Total: 135

Results

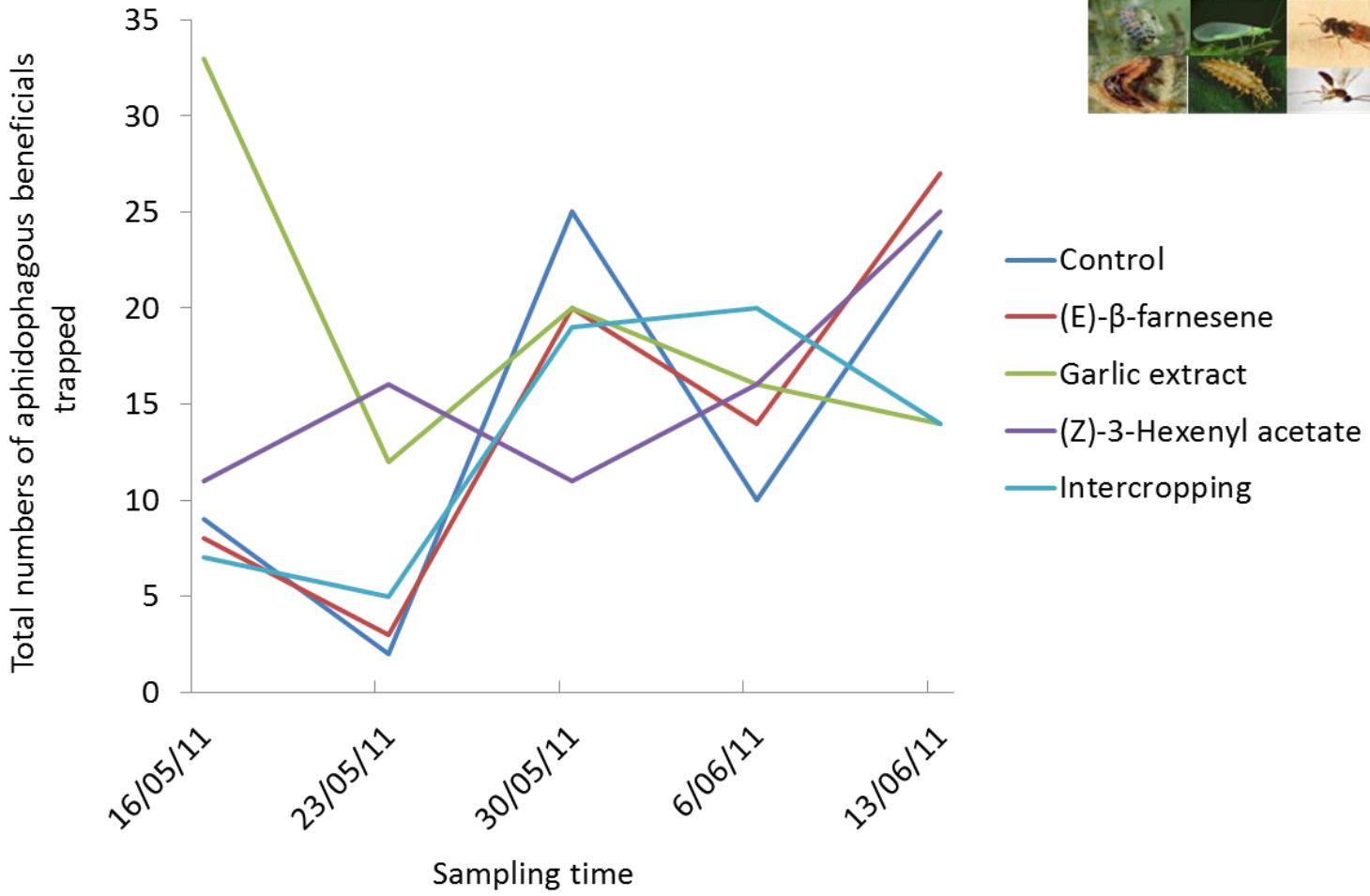
Potatoes (*Solanum tuberosum* L.)							
Species trapped in the different treatments			T1	T2	T3	T4	T5
Predators	Coccinellidae	*C. septempunctata* (adult)	0	0	5	3	3
		C. septempunctata (larva)	0	0	0	1	0
		H. convergens (adult)	0	0	2	1	0
		Platynaspis sp. (adult)	2	2	1	4	1
		P. japonica (adult) ←	12	10	9	3	6
		H. axyridis (adult)	5	2	3	0	0
	Syrphidae	*E. tenax* (adult)	1	0	1	0	1
		E. corollae (adult)	0	2	0	0	0
		E. arbustorum (adult)	1	0	0	0	0
		S. macrogaster (adult)	1	1	0	0	1
	Chrysopidae	*C. carnea* (adult)	7	7	2	3	6
		C. carnea (larva)	0	0	1	1	0
		Larva of Chrysopidae	0	0	0	1	0
Parasitoids	Braconidae	*Lysiphlebus sp.*	1	2	2	2	3
		A. avenae	2	1	4	1	1
		D. rapae	2	0	0	0	1
		A. gifuensis ←	27	18	42	17	11
		L. gracilis	0	2	2	3	0
	Aphelinidae	*Aphelinus sp.* ←	18	25	21	30	31

Total: 381

(T1: (Z)-3-Hexenyl acetate ; T2: (E)-β-farnesene; T3: Garlic extract; T4: Control ; T5 : Intercropping)

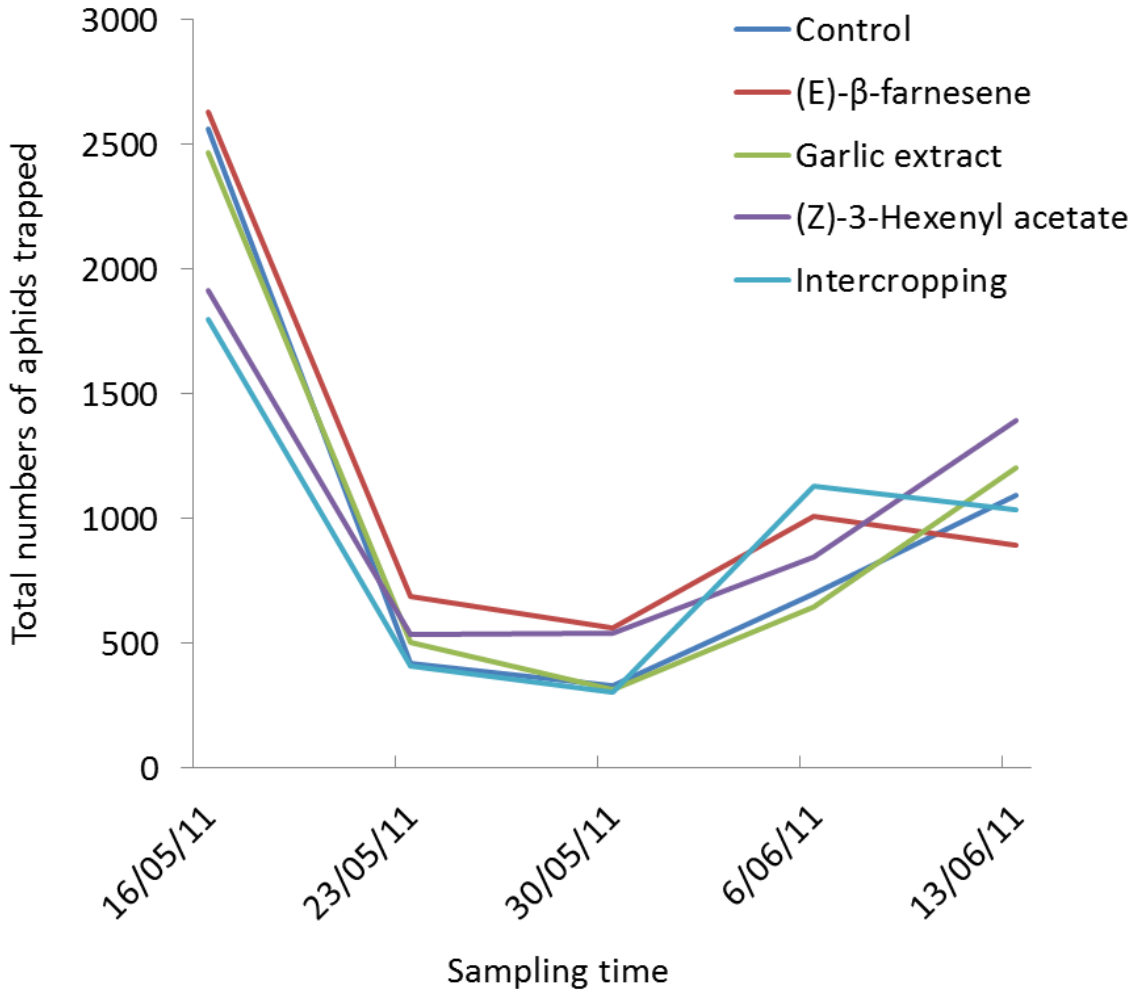
Results

Potatoes



Results

Potatoes



E. Bosquée

Results

Potatoes (*Solanum tuberosum* L.)							
Species of beneficials observed in the different treatments			T1	T2	T3	T4	T5
Predators	Coccinellidae	*C. septempunctata* (adult)	0	0	0	2	0
		C. septempunctata (larva)	0	0	1	10	1
		P. japonica (adult)	0	0	2	0	3
		P. japonica (larva)	0	3	0	0	1
		H. axyridis (adult)	0	0	0	0	1
		H. axyridis (larva)	0	0	0	0	1
	Syrphidae	*E. corollae* (adult)	3	3	5	3	3
		S. scripta (adult)	1	2	0	0	1
		Larva of Syrphidae	0	0	0	1	0
	Chrysopidae	*C. carnea* (adult)	0	0	1	0	0
		C. carnea (larva)	0	1	0	0	0
		Larva of Chrysopidae	0	1	1	1	0
Parasitoids	Braconidae	*Lysiphlebus sp.*	1	0	0	1	0
		A. avenae	0	1	0	0	0
		A. gifuensis	10	11	12	8	9
		L. gracilis	0	1	0	0	0
Total			15	23	22	26	20

Total: 106

Discussion

<u>These results are probably due to:</u>

- The small size of the experimental plots
- The presence of several different crops near to the plots (lack of homogeneity)

⟶ Difficult to compare treatments

Conclusions

- (E)-β-farnesene has good potential to be used in the « push-pull » approach
- This molecule gave good results in other studies (Zhou Haibo 2012 – PhD thesis in Belgium)
- Further research is therefore necessary to confirm this potential and to reevaluate the other molecules and the intercropping.

Material and methods

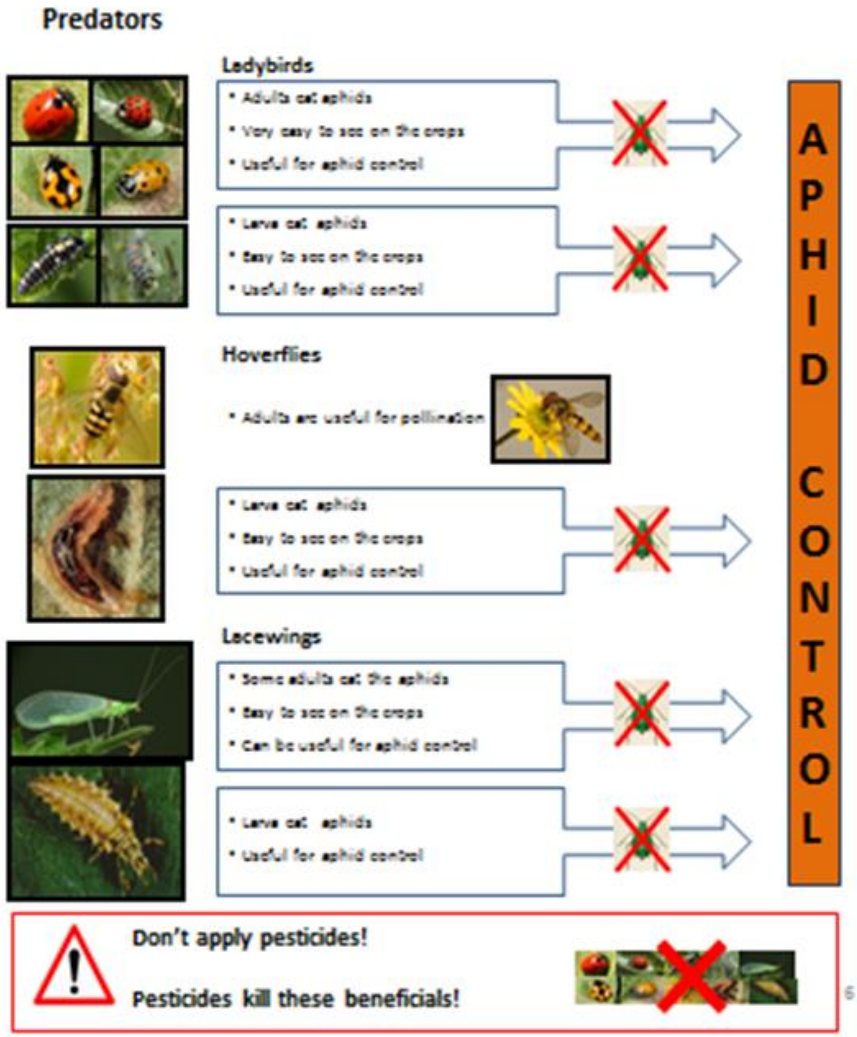
3. Elaboration of informative sheets for Chinese farmers

Topics:

- Aphids and related viruses
- Aphidophagous beneficials found in potatoes and courgettes fields
- Neutral insects
- Danger of pesticides

Results

Aphidophagous beneficials found in potatoes and courgettes fields: their role on aphid populations control



Research work in Belgium

- PhD project

- Objective:

Develop sustainable crop pest control methods by combining cultural associations with the use of semiochemical releasers

- Objective for the first year:

Study the effect of cultural associations on the populations of aphids and aphidophagous beneficials

Introduction

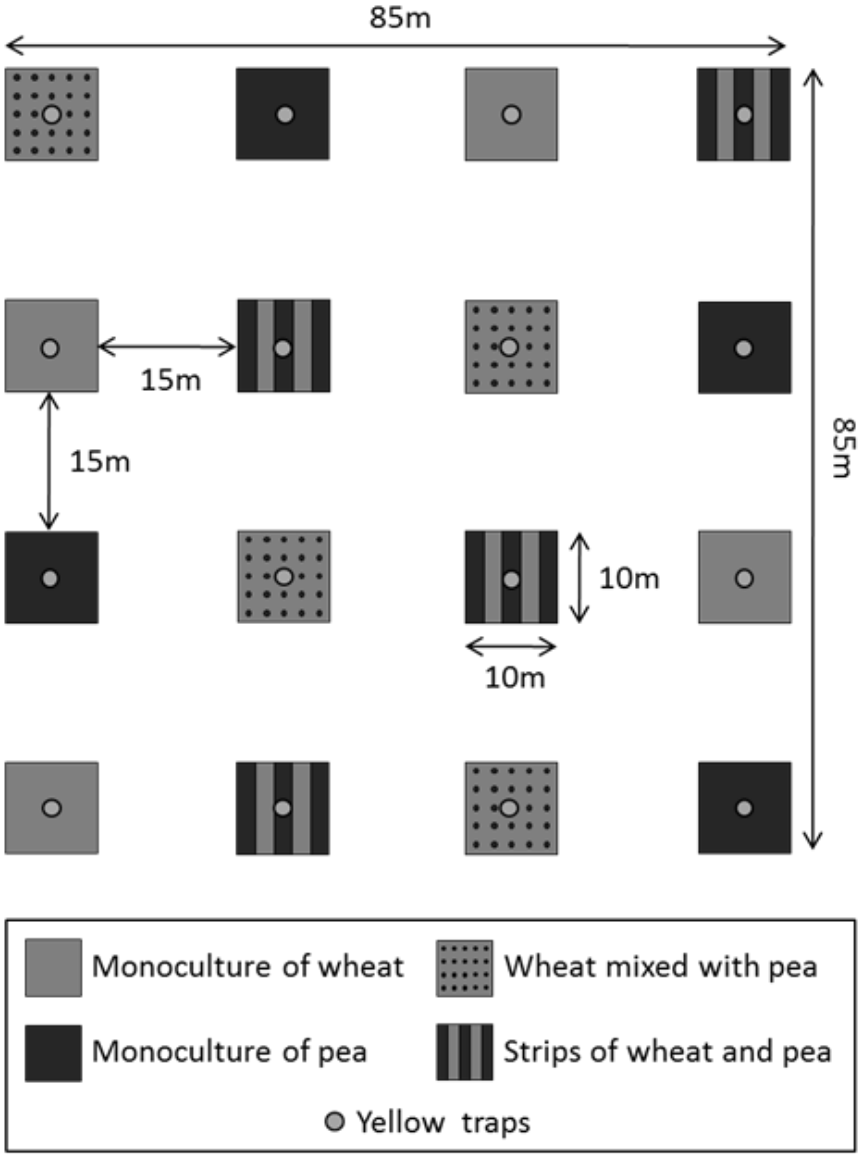
- *resource concentration hypothesis* (Root, 1973)

"specialist herbivores are more likely to find and remain on host plants that are concentrated in dense or pure stands (monocultures)."

- *enemy hypothesis* (Root, 1973)

"natural enemies are expected to be more abundant in complex environments and therefore supress herbivores more efficiently in polycultures."

Material and methods




Pea
Wheat

Material and methods

- Sampling of aphids and aphidophagous beneficials

  Yellow traps

  (winged aphids + aphidophagous predators and parasitoids)

  ✚

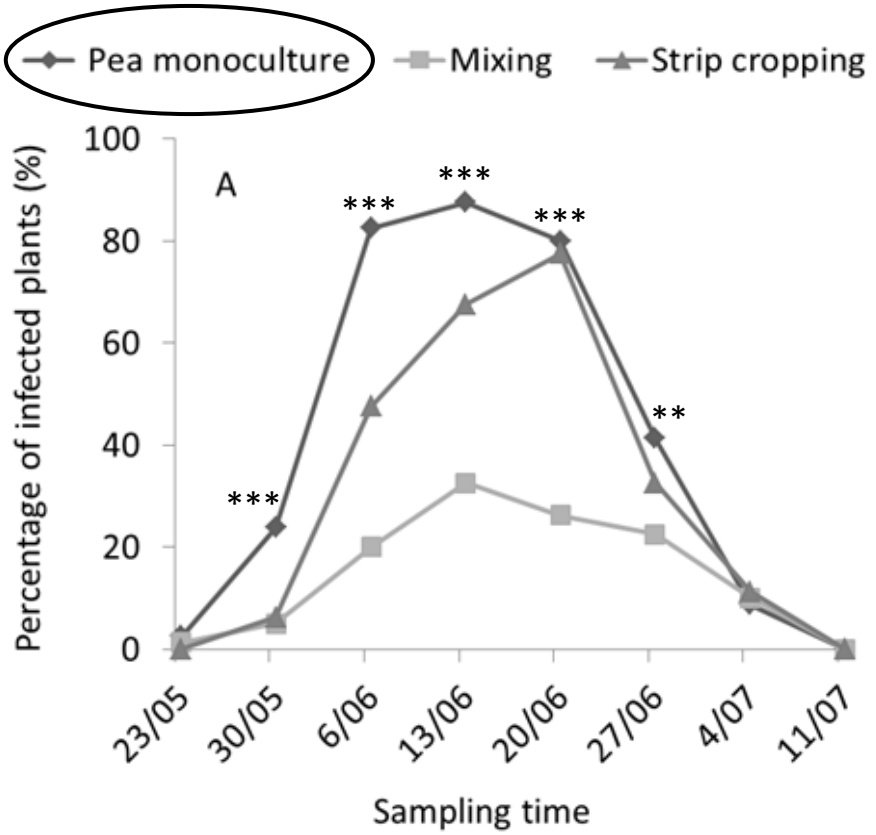
  Observations on plants

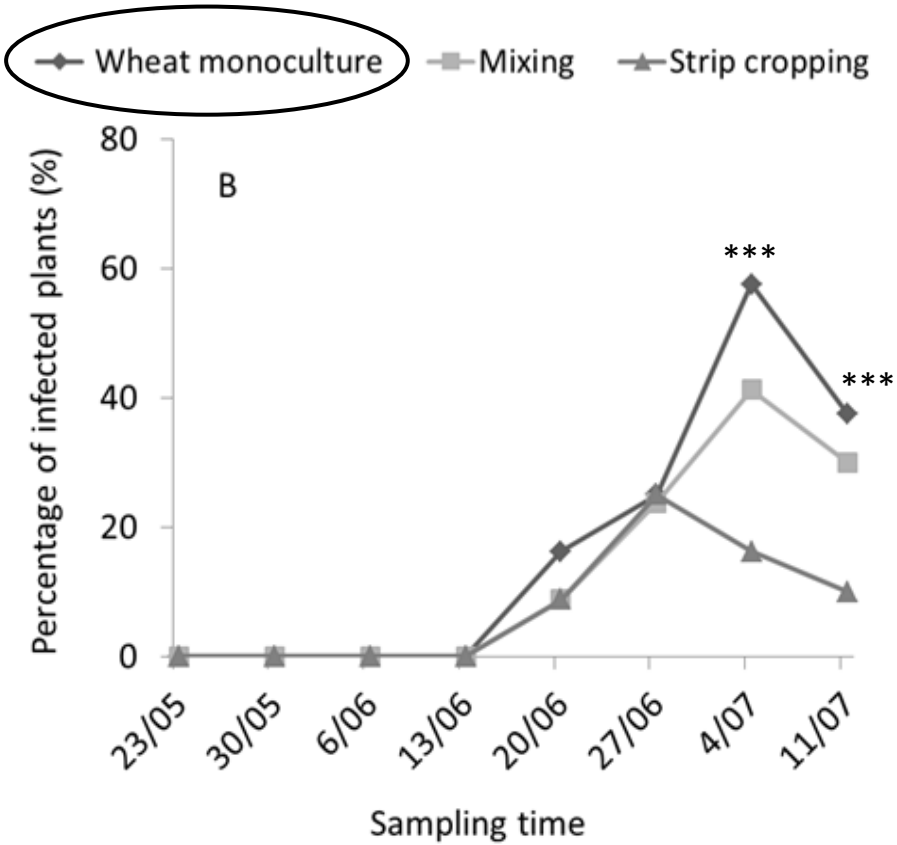
  (aphids)

- Quantitative food web

Results

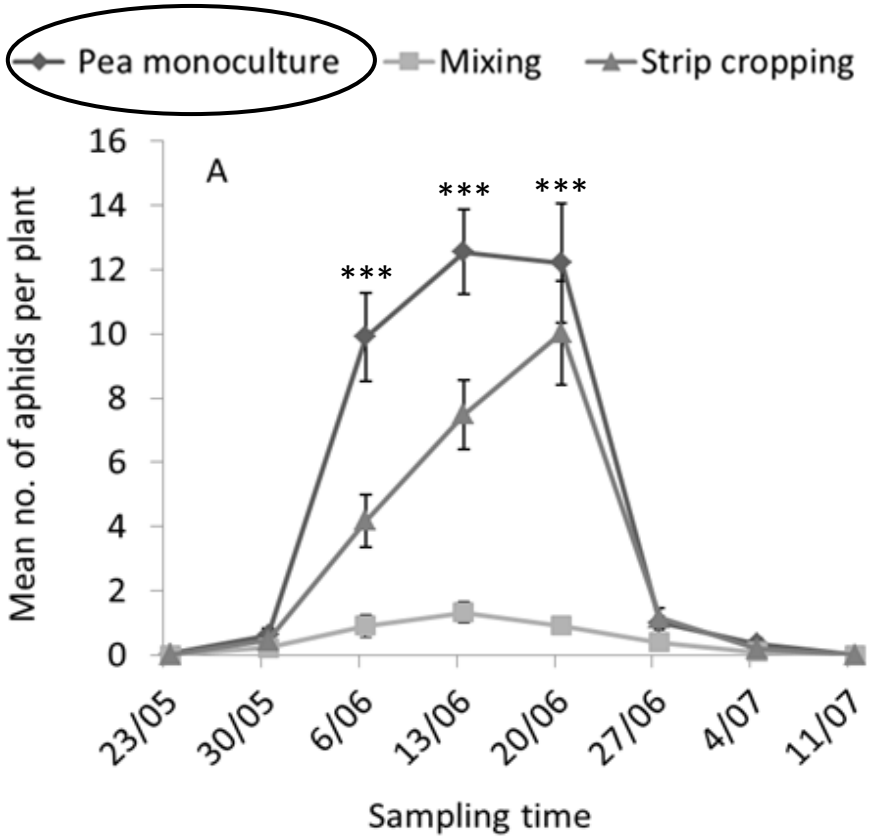
Observations on plants - % of infected plants

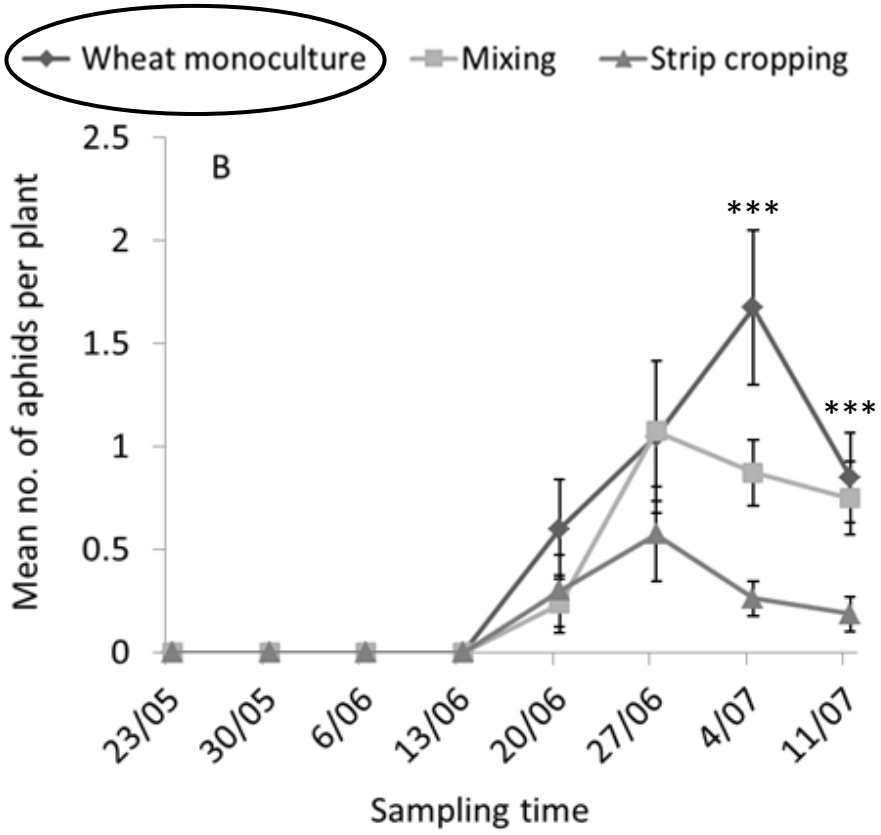




Results

Observations on plants - evolution of aphid colonies





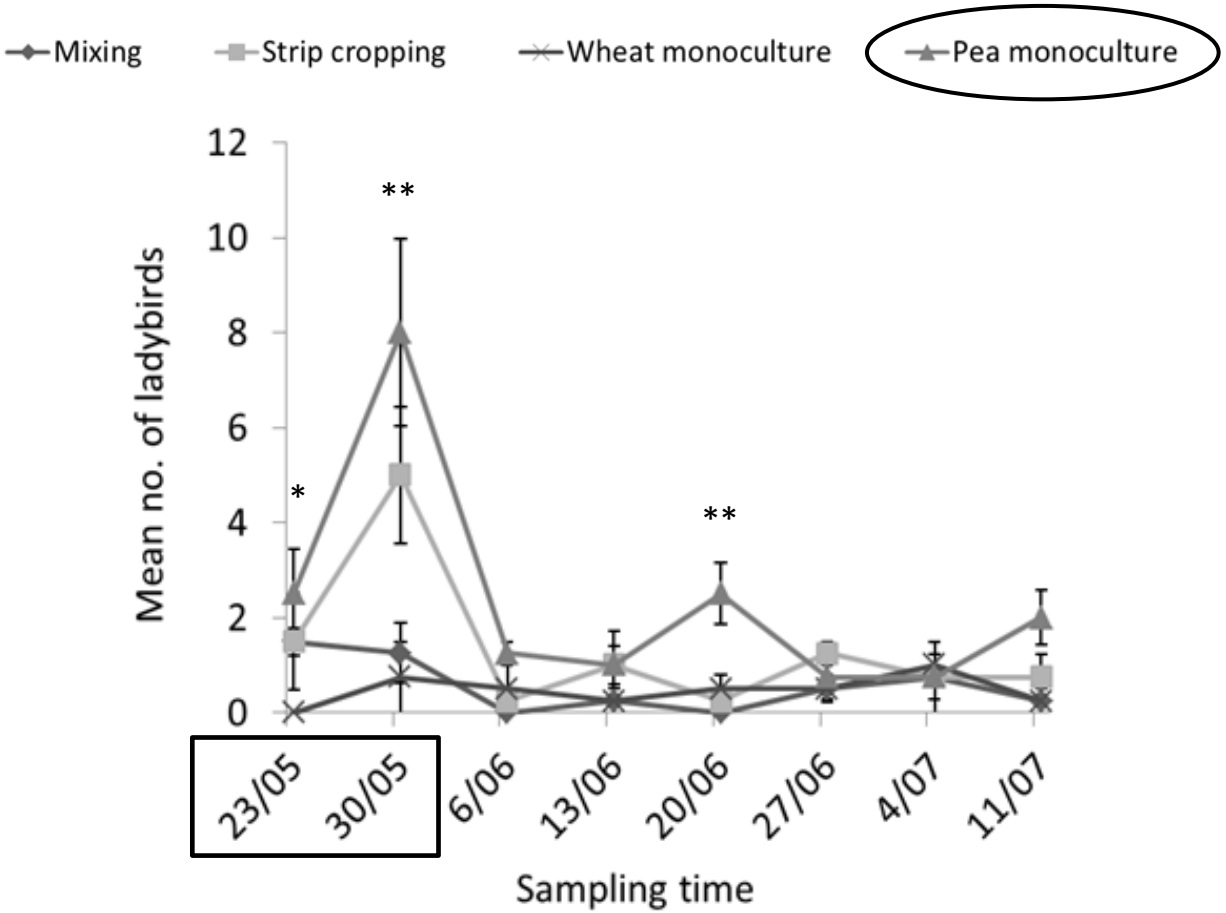
Results

Yellow traps - aphidophagous beneficials

Species	Treatments M	SC	WM	PM	%º
Ladybirds			**50.2%***		
Adalia decempunctata (Linnaeus)	0	0	1	1	**1.3**
Coccinella septempunctata Linnaeus	9	18	4	40	**47.0**
Harmonia axyridis (Pallas)	3	11	3	13	**19.9**
Propylea 14-punctata (Linnaeus)	6	13	7	21	**31.1**
Tytthaspis 16-punctata (Linnaeus)	0	1	0	0	**0.7**
Hoverflies			**29.9%***		
Episyrphus balteatus (De Geer)	2	2	6	4	**15.6**
Eupeodes corollae (Fabricius)	4	1	9	3	**18.9**
Melanostoma mellinum (Linnaeus)	4	0	3	0	**7.8**
Melanostoma scalare (Fabricius)	1	0	5	0	**6.7**
Platycheirus manicatus (Meigen)	0	1	0	0	**1.1**
Platycheirus peltatus (Meigen)	1	0	1	0	**2.2**
Sphaerophoria scripta (Linnaeus)	15	6	17	2	**44.4**
Syrphus ribesii (Linnaeus)	1	1	0	0	**2.2**
Syrphus vitripennis Meigen	0	1	0	0	**1.1**
Lacewings			**8.6%***		
Chrysopa phyllochroma Wesmael	0	0	0	1	**3.8**
Chrysoperla carnea (Stephens)	8	5	4	8	**96.2**
Braconid wasps			**11.3%***		
Aphidius ervi Haliday	0	1	0	1	**5.9**
Aphidius matricariae Haliday	1	0	0	0	**2.9**
Aphidius picipes (Nees)	1	0	0	1	**5.9**
Aphidius rhopalosiphi De Stefani-Perez	4	9	5	4	**64.7**
Aphidius salicis Haliday	0	0	1	0	**2.9**
Diaeretiella rapae (M'Intosh)	1	0	0	0	**2.9**
Ephedrus sp.	0	1	0	0	**2.9**
Praon volucre (Haliday)	1	1	1	1	**11.8**
Total number of aphidophagous species	**62**	**72**	**67**	**100**	
Proportion of total numbers of aphidophagous species (%)	**20.6**	**23.9**	**22.3**	**33.2**	

Results

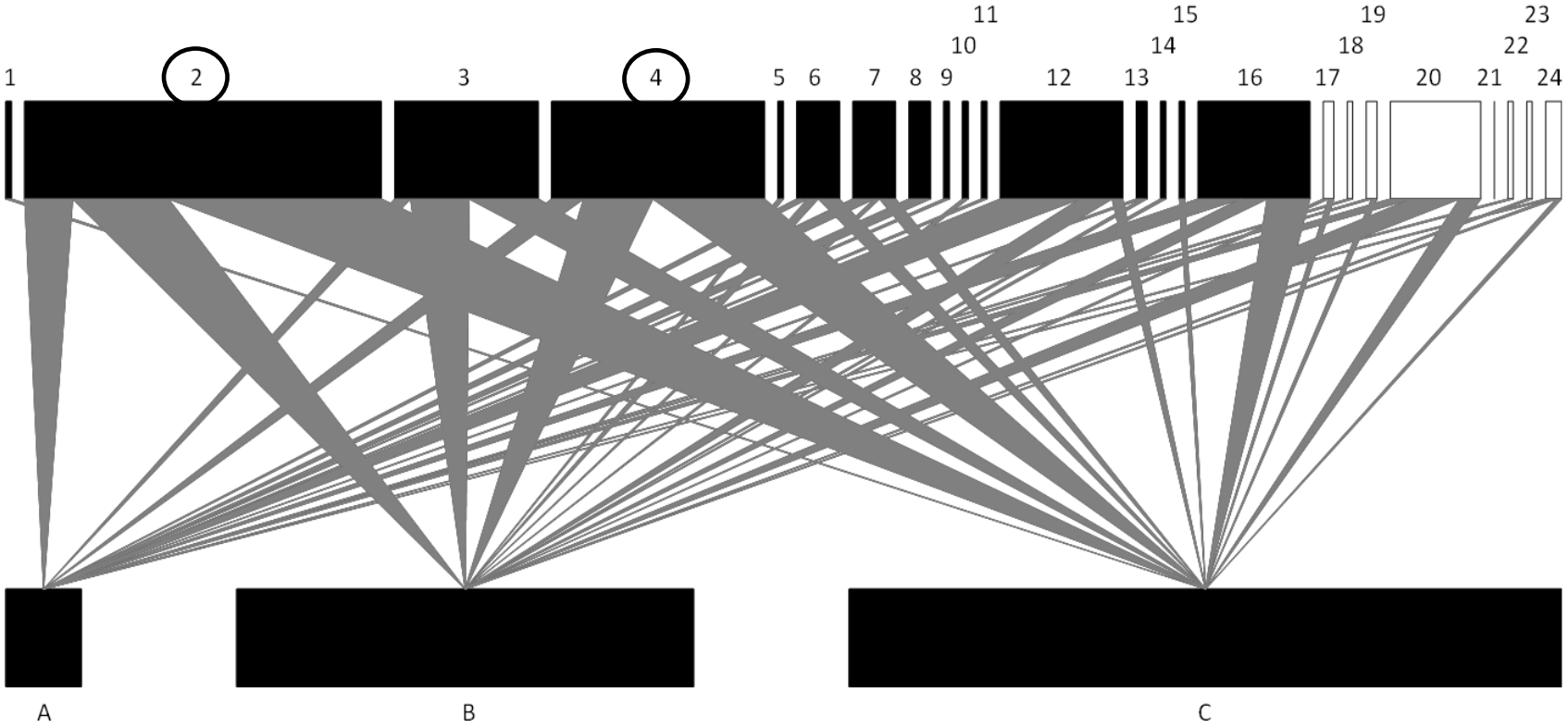
Yellow traps - Ladybirds



Results

- Food web - Pea

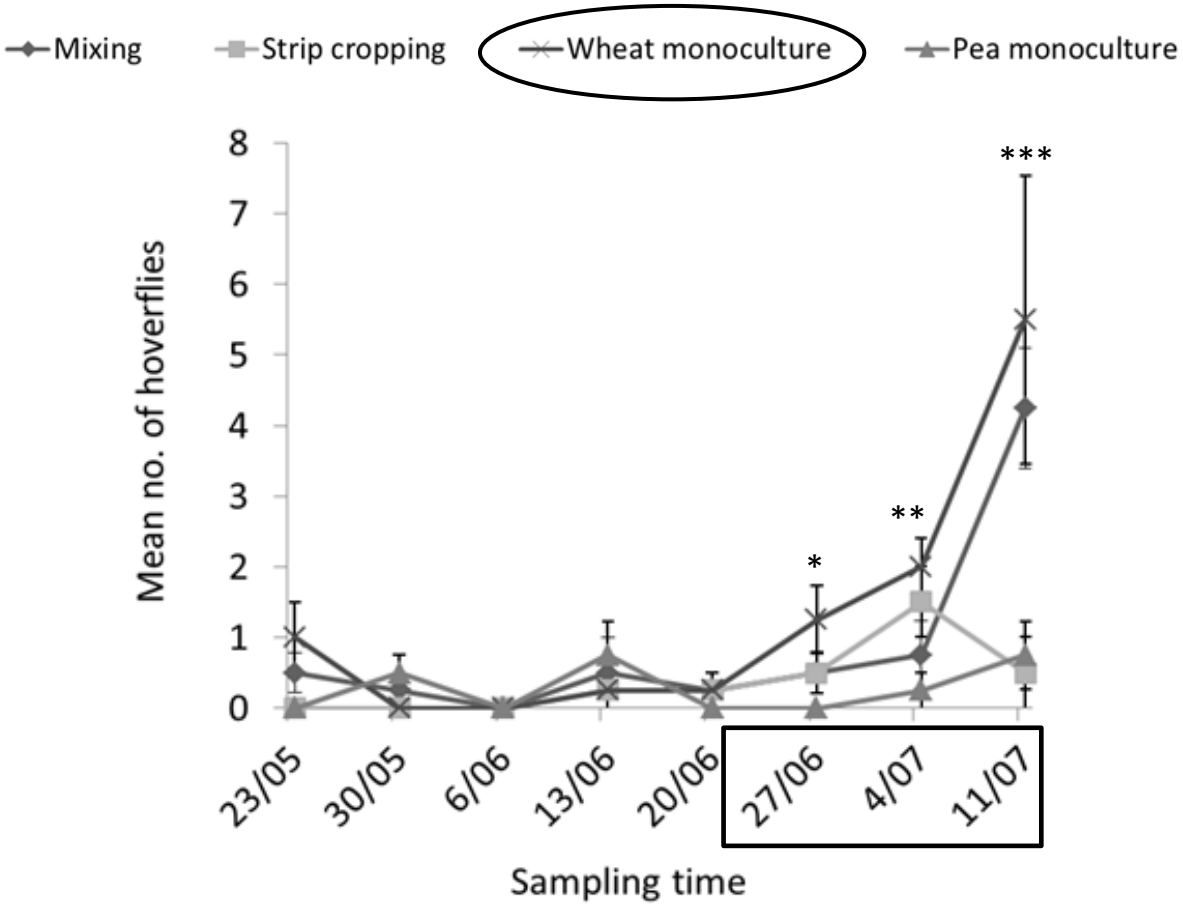
Density (total numbers) of predators and parasitoids trapped in the treatments containing peas (scale: host x 22)



Density (total numbers) of *Acyrthosiphon pisum* observed on pea plants (total host density: 5126)

Results

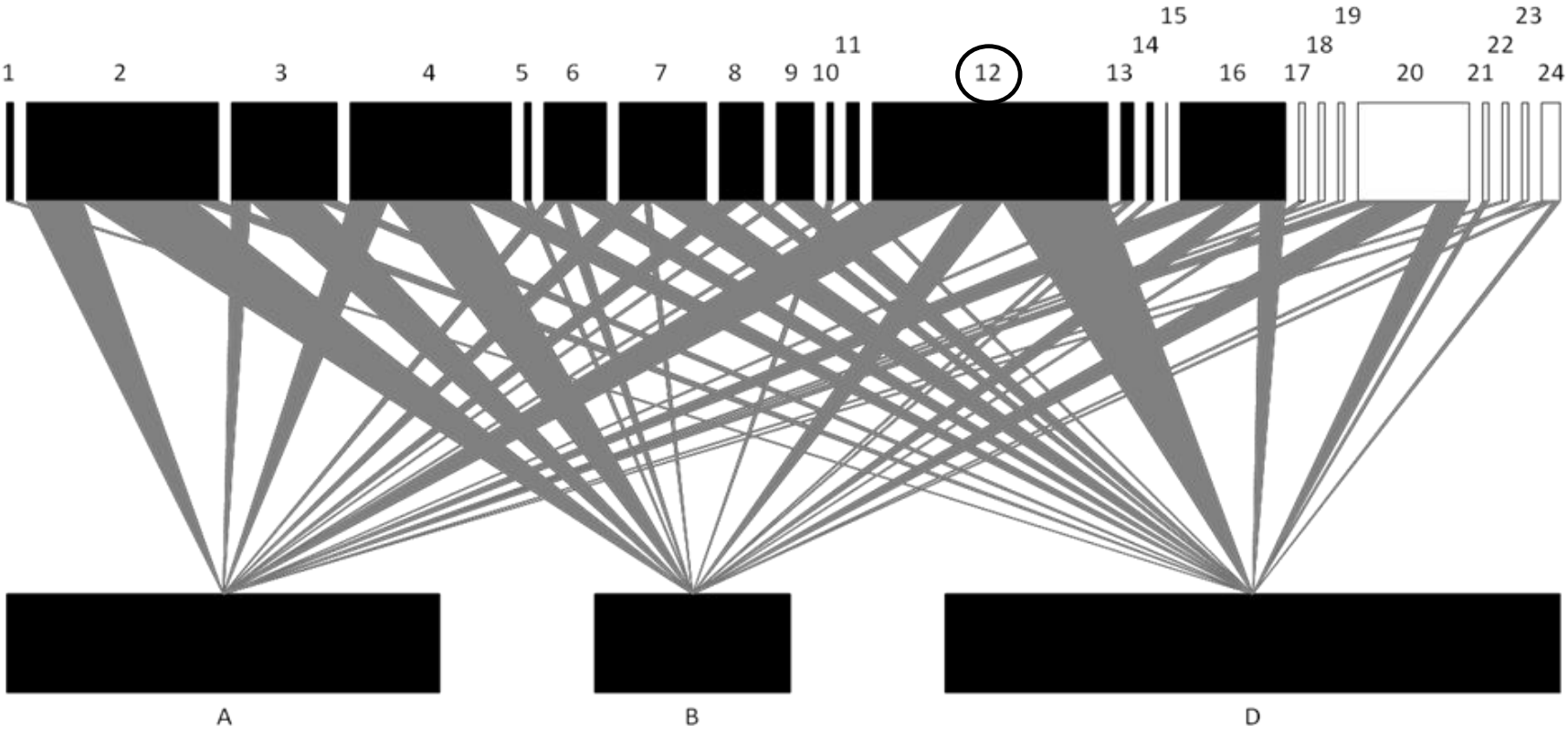
Yellow traps - Hoverflies



Results

- Food web - Wheat

Density (total numbers) of predators and parasitoids trapped in the treatments containing wheat (scale: host x 3)



Density (total numbers) of wheat aphids (*Sitobion avenae* + *Metopolophium dirhodum*) observed on wheat plants (total host density: 675)

Discussion

- Not many conclusions can be drawn from the trapping of winged aphids.
- The results of the observations on plants support Root's (1973) *resource concentration hypothesis*.
- Results from trapping of aphidophagous beneficials do not support Root's (1973) enemy hypothesis.
- There is a direct relationship between the presence of aphids and the abundance of their natural enemies (food webs).

Conclusions

- Cultural associations can prevent both crops from aphid infestations
- The mixing is specially efficient for the pea
- This practice may be effective in keeping aphid populations below the economic threshold in years of high pest pressure
- However, natural enemies were not particularly attracted by associations
- Additional methods are needed to attract beneficials into associations

Perspectives

Experiments for 2013:

- Combination of cultural associations with the use of semiochemicals seems very promising (Wang *et al*., 2011).
- Slow-release devices (alginate beads)
- Methyl salicylate already proved to be attractive


Thank you for your attention!