Potential role of fruit intercrops in integrated apple aphid management

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Introduction

- Apple aphids, especially *Dysaphis plantaginea* Passerini, are among the most abundant and destructive insect pests of apple tree crops in Belgium, but also in all temperate regions. Their feeding can damage the crop and decrease the yield quality and quantity. Managing these pests by conventional farming and monocropping systems have been often caused a series of environmental problems.
- Developing and implementing fruit intercrop system to enhance the biological control of apple aphids requires detailed basic knowledge of tritrophic interactions among plants, aphids and natural enemies.
- The potential of aphids associated with different kinds of plant habitats, more particularly fruit tree crops, as natural source for economically important beneficials, especially parasitoids, necessary for aphid pest management in apple orchard is presented.

Methodology

- To achieve the principal goal of this study, we started by monitoring the seasonal activity of aphids and their natural enemies during the 2014-2015 growing seasons in several woody and herbaceous plant habitats including apple orchards and the associated flora.
- Based on our monitoring data obtained during 2014-2015, we investigated the potential of a fruit intercrop system to control aphids in the apple orchard.
- This study was carried out in the eastern part of Belgium, Limburg province, using visual observation techniques.
- Data was analysed using Mathematica 5 and Minitab 17 software.

Results & discussion

A - Monitoring data on seasonal and spatial occurrence

- Among tritrophic associations observed in our study, both cherry and plum trees were found to be potentially promising intercrops to control apple aphids, as they were hosting aphids that hardly ever caused economic damage on apple trees (Figures 1-4).
- In addition to common predatory insects like ladybirds and hoverflies, the most abundant parasitoids of both *D. plantaginea* and *Aphis pomi* De Geer were *Ephedrus persicae* Froggatt and *Binodoxys angelicae* Haliday. These beneficials were early present in high density on the black cherry aphid *Myzus cerasi* associated with cherry trees and on the black bean aphid *Aphis fabae* associated with plum trees, 2-3 weeks before its occurring on apple aphid pests.

B - Monitoring data on fruit intercrop system using cherry trees

- Promising outcomes were found during the first year of our work aimed to study the potential of cherry trees to enhance the biological control of apple aphids, in particular *D. plantaginea* and *A. pomi*.
- Installation of aphid-infested cherry trees in an apple orchard led to a significant reduction of aphid populations and their related damages in this trial (Figure 6). Our date indicate two potential underlying factors for this enhanced aphid management in the apple trees:

1. Significant increase of beneficial arthropods (Figure 4).
2. Significant reduction of ants on apple aphid colonies (Figure 5).

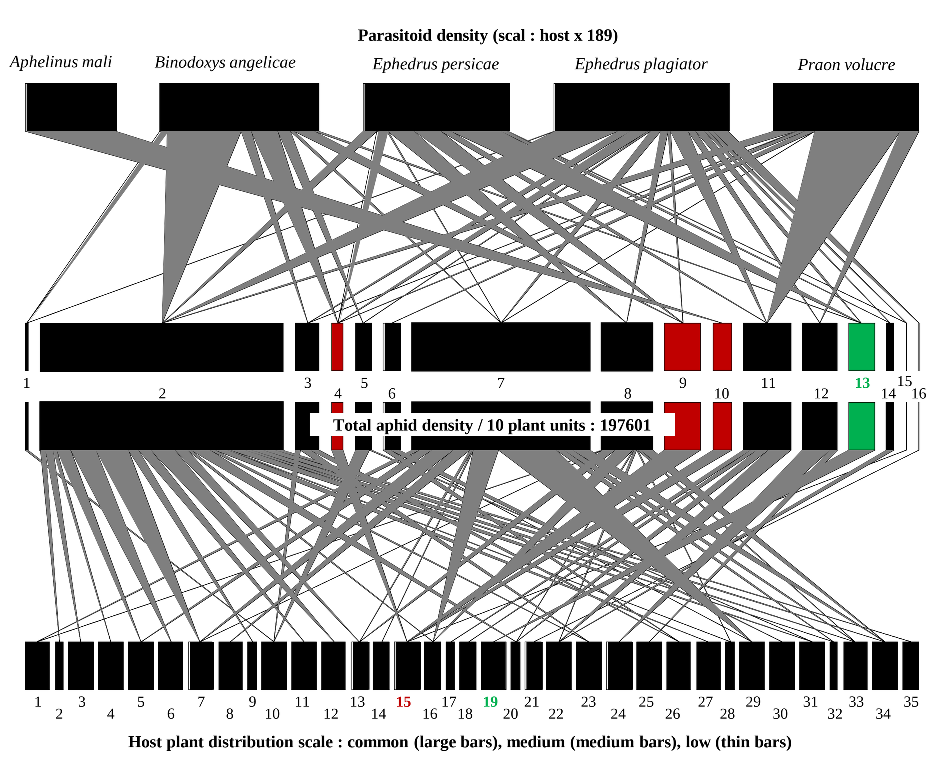

Figure 1. Summary quantitative aphid-parasitoid food web . The three series of bars represent host plants (bottom), aphid abundance (middle), and parasitoid abundance (top), drawn at different scales. In the middle bars : green bars represent promising aphids, red bars represent apple aphid pests, black bars represents other aphids less promising than green ones. Identities of presented species are listed in table 2.

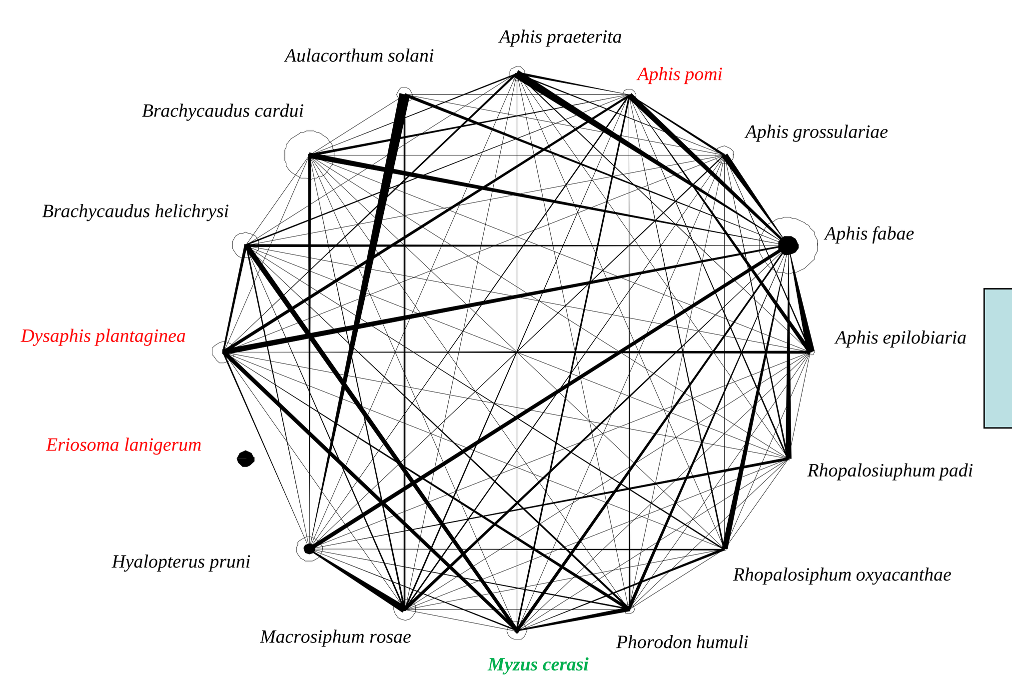

Figure 2. Quantitative parasitoid overlap diagram. The vertices represent aphid species; white circle sizes indicate the relative size of aphid species population; black circle sizes indicate the contribution of the aphid species as a source of its own parasitoids. Polygons between aphid species denote shared parasitoid interaction strength, where the width of the link to each species represents the potential effect derived from another aphid species as a source of parasitoids.

Table 1. Apparent competition extent among the rosy apple aphid, the green apple aphid and other aphids occurring on the associated flora and share common parasitoids.

Aphids		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	←	0.022	0.331	0.049	0.118	0.038	0.008	0.028	0.044	0.090	0.000	0.110	0.027	0.088	0.014	0.009	0.007
	→	0.157	0.120	0.123	0.118	0.155	0.051	0.114	0.081	0.114	0.000	0.061	0.064	0.085	0.083	0.093	0.053
9	←	0.020	0.254	0.030	0.114	0.032	0.000	0.016	0.099	0.150	0.000	0.041	0.002	0.203	0.027	0.025	0.005
	→	0.108	0.073	0.060	0.090	0.105	0.000	0.052	0.143	0.150	0.000	0.018	0.004	0.156	0.127	0.098	0.016

Table 2. Identity of species in the food web included aphid code used in apparent competition analysis

Code	Plant hosts	Code	Plant hosts (continue)	Code	Aphid hosts
1	*Achillea millefolium*	24	*Rosa canina*	1	*Aphis epilobiaria*
2	*Arctium lappa*	25	*Rosa sp.*	2	*Aphis fabae*
3	*Beta vulgaris*	26	*Rubus fruticosus*	3	*Aphis grossulariae*
4	*Capsella bursa-pastoris*	27	*Rumex obtusifolius*	4	*Aphis pomi*
5	*Carduus crispus*	28	*Senecio inaequidens*	5	*Aphis praeterita*
6	*Chenopodium album*	29	*Senecio vulgaris*	6	*Aulacorthum solani*
7	*Cirsium arvense*	30	*Sinapis alba*	7	*Brachycaudus cardui*
8	*Cirsium vulgare*	31	*Sonchus asper*	8	*Brachycaudus helichrysi*
9	*Digitalis purpurea*	32	*Tanacetum parthenium*	9	*Dysaphis plantaginea*
10	*Epilobium hirsutum*	33	*Tanacetum vulgare*	10	*Eriosoma lanigerum*
11	*Euonymus europaeus*	34	*Tripleurosperum maritimum*	11	*Hyalopterus pruni*
12	*Galium aparine*	35	*Vicia faba*	12	*Macrosiphum rosae*
13	*Helianthus annus*			13	*Myzus cerasi*
14	*Leucanthemum vulgare*			14	*Phorodon humuli*
15	*Malus domestica*			15	*Rhopalosiphum insertum*
16	*Myosotis arvensis*			16	*Rhopalosiphum padi*
17	*Phalaris arundinacea*				
18	*Phragmites australis*				
19	*Prunus avium*				
20	*Prunus domestica*				
21	*Prunus padus*				
22	*Prunus spinosa*				
23	*Ribes rubrum*				

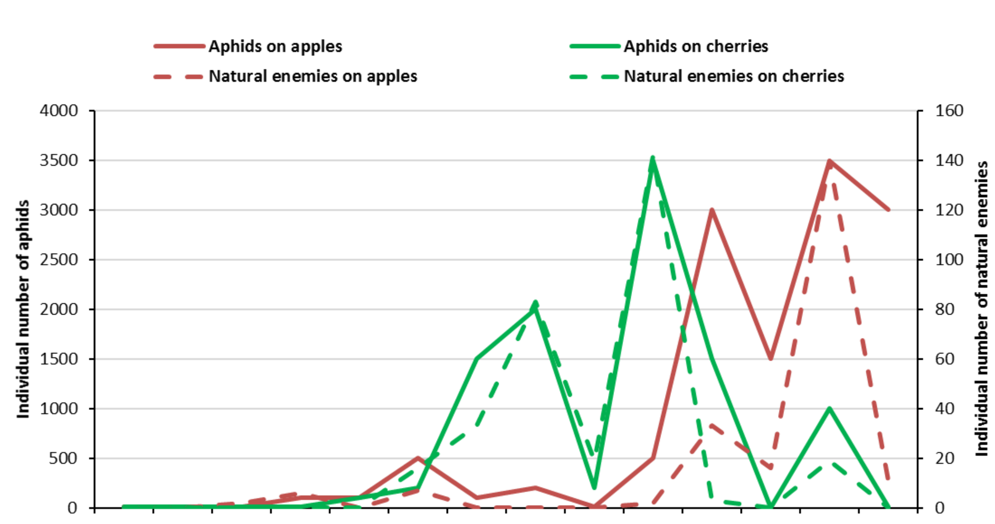

Figure 3. Seasonal occurrence of aphids and their natural enemies in cherry.

Monitoring data on fruit intercrop system using cherry trees

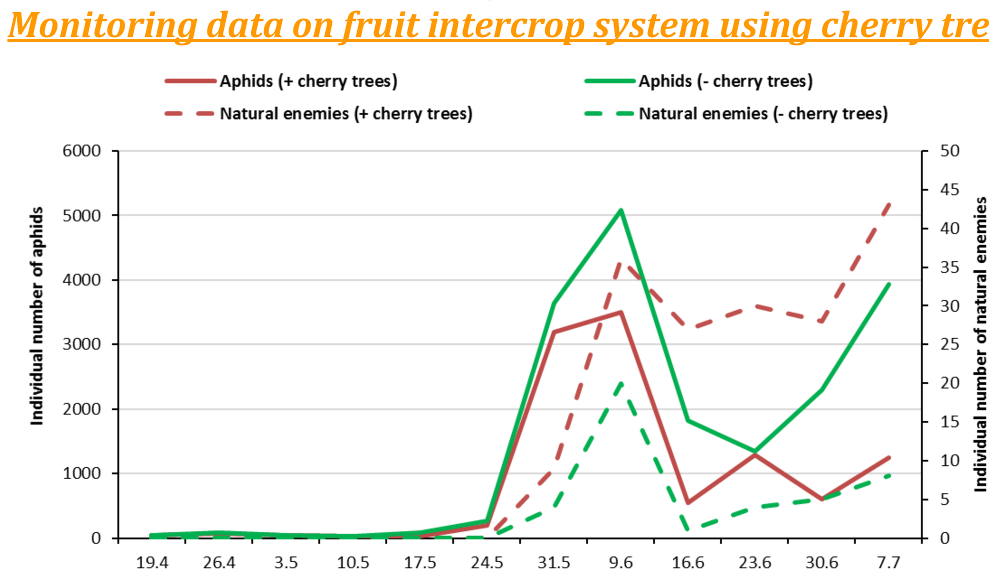

Figure 4. Seasonal occurrence of apple aphids and their natural enemies in apple orchard in case of the presence or absence of cherry intercrop.

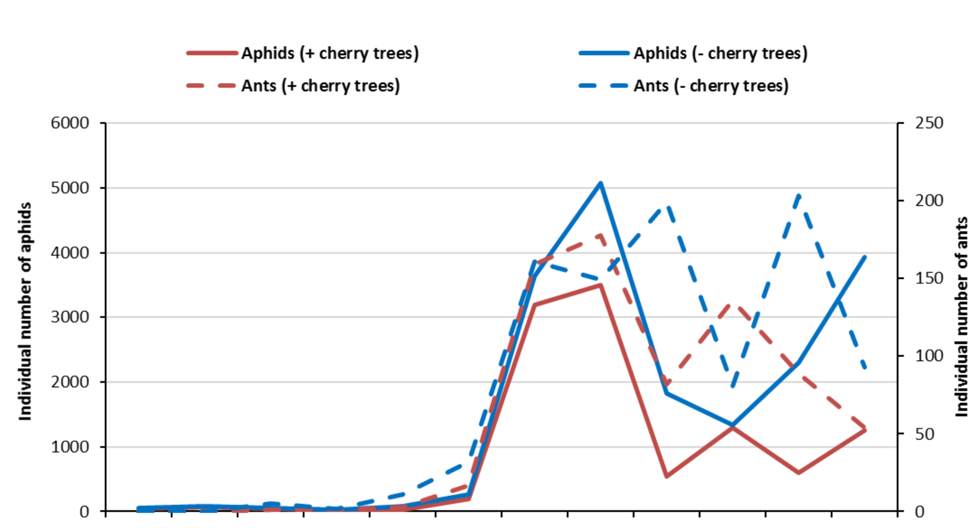

Figure 5. Seasonal occurrence of apple aphids and associated ants in apple orchard in case of the presence and absence of cherry intercrop.

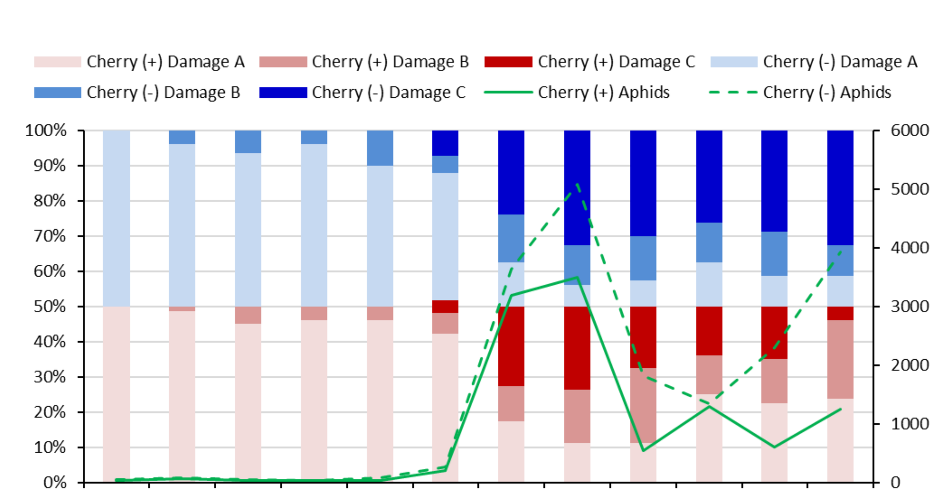

Figure 6. Damage level on apple trees in correlation with seasonal abundances of apple aphids in case of the presence and absence of cherry intercrop.

Table 3. Statistical data related to cherry intercrop test in apple orchard

Date	Aphids	Ants	Beneficials
19.4	ns$	ns	ns
26.4	ns	ns	ns
3.5	ns	ns	ns
10.5	ns	ns	ns
17.5	ns	ns	ns
24.5	ns	ns	ns
31.5	ns	ns	ns
9.6	*	ns	ns
16.6	**	**	***
23.6	ns	ns	*
30.6	**	ns	*
7.7	***	ns	**
Overall	***	*	***

$: * *P* is significant at 0.05; ** *P* is significant at 0.01; *P* is significant at 0.001; ns *P* is no significant; One-way ANOVA, data transformation was applied.

Conclusion

- In conclusion, this investigation provides the first information on agronomic aspects of fruit intercrop using cherry trees in integrated apple aphid management in organic system.
- The Black Cherry Aphid *M. cerasi* lives often in association with high numbers of ants, its presence in intercropping system with apple significantly reduced the number of ants on apple aphid colonies, on which this situation maybe helped beneficials to increase their biological efficiency on aphids.
- More research is needed (1) to investigate the potential of cherry intercrop in apple aphid management in different localities and between years, (2) to understand beneficial movement into and within apple orchards, (3) to compare the effectiveness of insecticides versus biological control of aphids with cherry intercrop in conventional apple, and (4) to determine if there are yield advantages in this kind of intercropping systems.

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