Presence of aphid predators in common wheat *(Triticum aestivum L.)* in organic and conventional agroecosystems of Tuscany

V. MOSCHINI[1], P. MIGLIORINI[2], P. SACCHETTI[3], G. CASELLA[1], C. VAZZANA[1]

Abstract

The aim of this study is to compare the presence and evolution of aphid predator populations in common wheat in three agro-ecosystems of different management, two organic of diverse age and a conventional one, in relation to field margins. The study was carried out in the Montepaldi Long Term Experiment in Tuscany, in 2008. Insect predators belonging to the families of Coccinellidae, Syrphidae and Chrysopidae were assessed. The presence of eggs, larvae, pupae and adults in the ecological infrastructures of the field margins as well as inside wheat crop at three different distance from the field's margin (0 m, 15 m, 30 m) was estimated. Results show that ladybirds are more affected by agroecosystem management and field margin type than the other insect predators. In fact they are present in greater numbers in organic farming systems than in conventional one and in the more complex and rich ecological infrastructure. The number of insect predators within the wheat crop was not affected by the distance from the field's margin.

Keywords*: Field margins; aphid predators; organic agriculture; wheat; ecological infrastructure.*

Introduction

The type and abundance of biodiversity in agriculture change across agroecosystems which differ in age, diversity, structure and management. In general, the degree of biodiversity in agroecosystems depends on four main characteristics (Southwood and Way, 1970): 1. The diversity of vegetation within and around it; 2. The permanence of the various crops within it; 3. The intensity of management; 4. The extent of the isolation of the agroecosystem from natural vegetation. The studies suggest that the more diverse the agroecosystems and the longer this diversity remains undisturbed, the more internal links develop to promote greater insect stability (Altieri, 1999). It has been demonstrated that biodiversity is undoubtedly amplified in organic agroecosystems compared to conventional ones (Hole et al. 2005) and that biodiversity may be positively improved by managing habitat and field margins adjacent to cultivated fields (Landis et al., 2000). Although several studies have been dealt with the effects of field margins on beneficial insects in different countries, Italy included (Leather et al., 1999; Denys et al., 2002; Burgio et al., 2006), specific researches are needed to define the most suitable features of field margins according to different crops, habitats and agricultural landscape.

The aim of this study was to evaluate the effects of different type of agricultural management (two organic agro-ecosystems of different age and a conventional one) and field margins on the presence and evolution of aphid predators populations in common wheat.

Material and Methods

The Montepaldi Long Term Experiment (MOLTE) has been active since 1991 (Vereijken, 1994; Vazzana et al. 1997; Migliorini and Vazzana, 2007; Vazzana et al., 2008) on the farm of the University of Florence (location Montepaldi, San Casciano Val di Pesa, Long. 11° 09' 08''E, Lat. 43° 40' 16'' N) covering a slightly sloping surface of about 15 hectares at 90 m a.s.l.. The MOLTE experiment includes the following three different micro agro-ecosystems (AES):

- "Old Organic" (OO) of 5.2 ha, divided into 4 fields under organic management (EC reg. 2092/91 and following regulations) since 1992;
- "Integrated/Young Organic" (YO) with an area of 5.2 ha, divided into 4 fields under EC regulations 2078/92 (integrated farming) from 1992-2000 and converted into organic management since 2001;
- "Conventional" (CO) area of 2.6 ha divided into 2 conventional fields, where farming techniques used were those normally used in the territory of the study area for conventional management.

The agroecosystems are surrounded by ecological infrastructures such as natural and artificial hedges. In particular, one natural hedge (260 m x 3 m) physically separates the Old Organic system from the Young Organic system (field's margin C); the second hedge (260 m x 3,5 m), planted at the beginning of '90 and formed by autochthons species, separates the Old Organic system from the rest of the farm (field's margin D); a herbaceous strips (260 m x 6 m) separates the Conventional from the Young Organic system (field's margin A). There are also herbaceous strips in

[1] DIPSA, Department of Plant, Soil and Environmental Science, University of Florence, Piazzale delle Cascine 18 – 50 144 Firenze, Italy. E-mail:valentina.moschini@unifi.it; concetta.vazzana@unifi.it, giovanna.casella@unifi.it, Internet: www.dipsa.unifi.it
[2] University of Gastronomic Sciences, Piazza Vittorio Emanuele, 9 – Frazione Pollenzo – 12042 Bra (CN), Italy. E-mail: p.migliorini@unisg.it; Internet: www.unisg.it
[3] DIBA, Department of Agricultural Biotechnology, University of Florence, Via Maragliano 75-77 – 50 144 Firenze, Italy. E-mail: patrizia.sacchetti@unifi.it; Internet: www.diba.unifi.it

drains water between Old and Young Organic systems (field's margin B). The analysis of ecological infrastructures biodiversity (Daget and Poissonet, 1969; Shannon and Weaver, 1963) resulted in a higher biodiversity in term of number of species and Shannon Index in the organic hedges and strips than conventional (Migliorini and Vazzana, 2007; Moschini, 2011) (data not shown). Climatic conditions of the experimental area are typical of the Mediterranean sub-Apennines zone. The annual rainfall is about 770 mm with its maximum in autumn and spring and minimum in the period June-August. The annual mean temperature is 14.1 °C with a maximum which can exceed 30°C in summer and minimum temperatures in January.

A survey of the most important groups of predators feeding on cereal aphids in Central Italy was carried out in 2008. Seven samplings were carried out from May to July, from the beginning of aphid infestation up to the wheat harvest. In each agroecosystem the presence of aphid predators was evaluated in the wheat field at three different distances from the field margin (0, 15 and 30 m) as well as in the adjacent ecological infrastructure (hedge or herbaceous strip). Moreover, in both wheat fields and field margins, samplings were replicated three times in the top, middle and bottom area. The relative density of Coccinellid predators, Syrphids (Diptera) and Chrysopids (Neuroptera) was estimated by sampling adults with the aid of a sweeping net. This sampling technique was preferred for its easy usage and reliability in evaluating predators of cereal aphid (Schotzko and O'Keeffe, 1989). Each sample consisted in 4 sweeps whilst walking slowly down the row. The number of insects collected was divided by the sampled surface. Besides adults, the presence of preimaginal instars was evaluated by counting the number of eggs or egg batches, larvae and pupae of the three studied families in a one-square-meter area by accurate visual examination. Insects sampled were identified up to family level except for *Propylea quatuordecimpunctata* (L.), *Coccinella septempunctata L.* and *Adonia variegata* (Goetze), since in previous investigations in the same habitat they resulted as the most abundant predators on cereal aphids (unpublished data). The experimental data were subjected to ANOVA fixed model and the significance of variances was tested by Fisher's F test. Mean comparison was carried out according to MSD and Bonferroni tests (Systat 9.0).

Results

Wheat fields in organic and conventional agro-ecosystems

The analysis of variance (ANOVA) for the variables number of eggs, larvae, pupae and adults of insects sampled for the factors "agro-ecosystem's management" and "distance from the field margin" are reported in tables 1 and 2. Data on number of ladybird egg batches, syrphid eggs and chrysopid adults, are not shown since these insect stages were occasionally detected.

The type of agro-ecosystem management significantly affected the number of *P. 14-punctata* adults, that is higher in the Old Organic (0.329 n/m^2) compared to the Conventional system (0.154 n/m^2). Also total ladybird adults are more abundant in the Old (0.364 n/m^2) and Young (0.308 n/m^2) Organic systems than in the Conventional one (0.162 n/m^2). Moreover the overall number of ladybirds is significantly higher in the Old Organic (0.563 n/m^2) and Young Organic (0.476 n/m^2) systems than in the Conventional one (0.289 n/m2) (Table 1).

Table 1 - *Effect of agro-ecosystem management and the distance from field's margin on the number of Coccinellidae (n/m^2). OO: Old Organic system; YO: Young Organic system; CO: Conventional system.*

	***Coccinellidae* in the wheat fields**							
	P. 14-punctata adults	*A. variegata adults*	*C. 7-punctata adults*	*other ladybird adults*	*total ladybird adults*	*ladybird larvae*	*ladybird pupae*	*total ladybirds*
				n/m^2				
Agroecosystem's management (S)	*	n.s.	n.s.	n.s.	**	n.s.	n.s.	**
OO	0.329a	0.012	0.019	0.004	0.364A	0.198	0.000	0.563A
YO	0.277ab	0.015	0.004	0.012	0.308A	0.158	0.008	0.476A
CO	0.154b	0.004	0.004	0.000	0.162B	0.123	0.004	0.289B
Distance from field margin (D)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Top - 0 m	0.238	0.023	0.012	0.000	0,273	0.083	0.000	0.357
Top - 15 m	0.238	0.000	0.000	0.000	0,238	0.214	0.000	0.452
Top - 30 m	0.226	0.000	0.012	0.000	0,476	0.178	0.000	0.416
Bottom – 0 m	0.190	0.000	0.000	0.023	0,213	0.154	0.000	0.369
Bottom – 15 m	0.381	0.035	0.012	0.012	0,440	0.154	0.000	0.595
Bottom - 30 m	0.238	0.035	0.000	0.000	0,273	0.202	0.023	0.500
Middle - 0 m	0.226	0.000	0.012	0.000	0,238	0.119	0.000	0.357
Middle - 15 m	0.309	0.000	0.023	0.000	0,332	0.142	0.000	0.476
Middle - 30 m	0.238	0.000	0.012	0.012	0,262	0.190	0.012	0.464
S * D	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

** significant for P ≤ 0.01; * significant for P ≤ 0.05; n.s. not significant.

Table 2 - *Effect of agroecosystem management and the distance from field's margin on the number of* Syrphidae *and* Chrysopidae *(n/m^2). OO: Old Organic system; YO: Young Organic system; CO: Conventional system.*

	***Syrphidae* in the wheat fields**			***Chrysopidae* in the wheat fields**		
	hoverfly adults	*hoverfly larvae*	*total hoverflies*	*green lacewing eggs*	*green lacewing larvae*	*total green lacewings*
			n/m^2			
Agroecosystem's management (S)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
OO	0.095	0.008	0.103	0.000	0.004	0.012
YO	0.095	0.000	0.095	0.035	0.012	0.047
CO	0.087	0.008	0.095	0.083	0.004	0.087
Distance from field margin (D)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
S * D	n.s.	*	n.s.	n.s.	n.s.	n.s.

** significant for P ≤ 0.01; * significant for P ≤ 0.05; n.s. not significant.

Table 3 - *Effect of field's margin on number of* Coccinellidae *(n/m²)*.

	Number of *Coccinellidae* in the field's margin						
	P. 14-punctata adults	*A. variegata adults*	*C. 7-punctata adults*	*other ladybird adults*	*total ladybird adults*	*ladybird larvae*	*total ladybirds*
	n/m²						
Field's margin (FM)	**	n.s.	n.s.	n.s.	**	n.s.	**
A - CO	0.139AB	0.002	0.004	0.055	0,196B	0.043	0.240B
B – YO	0.071B	0.000	0.000	0.012	0,083B	0.071	0.154B
C – YO/OO	0.095B	0.000	0.012	0.000	0,107B	0.023	0.131B
D - OO	0.333A	0.035	0.000	0.154	0,523A	0.035	0.559A
Ecological infrastructure zone (Z)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Top	0.185	0.000	0.001	0.058	0,244	0.050	0.294
Bottom	0.127	0.008	0.010	0.067	0,213	0.039	0.252
Middle	0.167	0.017	0.001	0.040	0,226	0.041	0.267
FM*Z	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

** significant for P ≤ 0.01; * significant for P ≤ 0.05; n.s. not significant

Ecological infrastructure at field's margin of organic and conventional agro-ecosystems

The results of insects sampling in the ecological infrastructures at field's margin of organic and conventional agro-ecosystems are shown in tables 3 and 4. The analysis of variance (ANOVA) highlights as the number of ladybird's *Propylea* adults is higher in D ecological infrastructure (0,333 n/m²) in Old Organic system, than in C (0,095 n/m²) and B (0,071 n/m²) field's margin, respectively placed between Old and Young Organic systems the first and in Young Organic system the second one. Also the total number of ladybirds is higher in D ecological infrastructure (0,559 n/m²) compared to all the other infrastructures (A: 0,240 n/m²; B: 0,154 n/m²; C: 0,131 n/m²) (Table 3). The factor "Ecological infrastructure zone" did not produce statistically significant difference in variables analysed.

Table 4 - *Effect of field's margin on number of* Syrphidae and Chrysopidae *(n/m²)*.

	Syrphidae in the field's margin			*Chrysopidae* in the field's margin	
	hoverfly adults	*hoverfly eggs*	*total hoverflies*	*green lacewing eggs*	*total green lacewings*
	n/m²				
Field's margin (FM)	n.s.	n.s.	n.s.	n.s.	n.s.
A - CO	0.109	0.015	0.094	0.053	0.000
B – YO	0.035	0.059	0.095	0.023	0.095
C – YO/OO	0.047	0.000	0.047	0.000	0.000
D - OO	0.119	0.000	0.119	0.190	0.762
Ecological infrastructure zone (Z)	n.s.	n.s.	n.s.	n.s.	n.s.
FM*Z	n.s.	n.s.	n.s.	n.s.	n.s.

** significant for P ≤ 0.01; * significant for P ≤ 0.05; n.s. not significant

Discussion and conclusion

Aphid predators investigated in this research were differently affected by the type of agro-ecosystem management as well as by ecological infrastructures adjacent to fields. As expected, Coccinellids showed the highest relative density among predators feeding on cereal aphids, similarly to outcomes obtained in comparable field investigations (Burgio et al., 2006). Syrphids, although are known to be reliable landscape bioindicators (Burgio and Sommaggio, 2007), did not show consistent activities: neither in wheat fields nor in the ecological infrastructures their presence (as adult or egg) may be related to any of the factors here considered. Alike considerations may be drawn examining results obtained for green lacewings. In addition the number of Chrysopids collected was always sparse, with the highest value recorded in the oldest hedgerow, more complex and highly biodiverse. Syrphids and Chrysopids may appear not suitable to highlight the effects of agro-ecosystem management, anyway data may be affected also by the short sampling period and/or by sampling technique not effective for these insects. On the contrary Coccinellids allowed to evidence differences among different types of agro-ecosystem management: as a matter of fact the relative density of *P. 14-punctata*, as well as of the density of ladybirds was higher in the organic wheat than in the conventional one. Although in the present study all the factors which potentially may affect ladybird activity and distribution were not examined, the higher presence of Coccinellids in the long term organically managed wheat (Old organic) undoubtedly show the positive effect of agro-ecosystem management on this beneficial insect predators. The Coccinellid activity appear to be comparable in the three zones along fields or ecological infrastructures. Likewise, no differences have been displayed between wheat field edges and inner zones. Coccinellid populations show a homogeneous dispersion and distribution in the fields as well in the adjacent field margins, as a consequence the field size seems to be appropriate for the local environment. The uniform dispersal of coccinellids may be explained by the abundant presence of *P. 14.punctata* which is known for taking advantage of non-crop habitats more than other species (Zhou et al., 1994).

In conclusion, organic agro-ecosystem management contributed to increase the relative density of Coccinellid predators in wheat and the presence of ecological infrastructures bordering fields positively affected their consistent distribution.

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