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ABUNDANCE AND BIODIVERSITY OF SOIL ARTHROPODS IN ONE CONVENTIONAL AND TWO ORGANIC FIELDS OF MAIZE IN STOCKLESS ARABLE SYSTEMS

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Simoni S., Nannelli R., Castagnoli M., Goggioli D., Moschini V., Vazzana C., Benedettelli S., Migliorini P. – Abundance and biodiversity of soil arthropods in one conventional and two organic fields of maize in stockless arable systems

Soil arthropod community was evaluated, in three different farming systems in Central Italy, in the context of a long-term experimental stockless arable system (MOLTE). The soil arthropodofauna was recorded in two organic agrosystems of different age (16-year old organic, named OldO; 6-year young organic, named YngO) and in one conventional (Co), at a fixed time on maize. Arthropods, extracted by Berlese-Tullgren funnels, were counted and identified at order or suborder taxonomic level.

In the three maize fields, the farming system affected both abundance and biodiversity of arthropods. The arthropod density ranged from about 20,000 individuals/m^2 in OldO to about 45,000 in YngO. The number of oribatid mites was higher in Co than in OldO, while YngO showed the highest density of collembolans. The mite/collembolan ratio was the highest in Co (6.43), the lowest in YngO (1.95). Both biodiversity indices adopted – ΔV, synthetic index of degree of diversity change of ecological systems and QBS, index of biological soil quality – showed the highest values for YngO. On the whole, differences in the arthropod community were higher in the YngO-OldO comparison than in OldO-Co. The soil arthropod community tended to be characterized by lower density of specimens and lower number of taxa in the OldO organic system than in the YngO.

KEY WORDS: biodiversity, organic agriculture, conventional agriculture, soil mites, collembolans, maize.

INTRODUCTION

Comparative research studies on biodiversity in conventional and organic systems provide evidence of a positive effect of organic farming (STOLZE *et al.*, 2000; MÄDER *et al.,* 2002; SCIALABBA and HATTAM, 2002; STOLTON, 2002, 2005; PIMENTEL *et al.,* 2005;) and in particular on soil quality and soil biodiversity when confronting long term experiment (ESPERSCHUTZ *et al.,* 2007; FLIEßBACH *et al.,* 2007; BIRKHOFER *et al.,*2008). Soil quality assessment is a complex issue by depending on combination of the physical, chemical and biological properties that contribute to soil functions, modified by long-lasting effects on land use (KNOEPP *et al.,* 2000). As the number and the variety of factors involved in soil quality definition, researchers therefore turn to the use of indexes significantly expressing the key components of soil quality (OECD, 2001). Several authors proposed methods for soil quality assessment based on soil mesofauna communities, particularly soil arthropods (e.g. BLOCKSOM and JOHNSON, 2009; BALDIGO *et al.,* 2009). HOLE *et al.,* 2005 reviewed that organic practices were positive on the numbers within various taxon of birds, mammals, butterflies, spiders, earthworms, beetles, other arthropods, plants, soil microbes, in comparison to conventional systems on 66 out of 76 studies and some agricultural practices (prohibition/reduction of chemicals, pesticides and inorganic fertilisers, management of non-cropped habitats; preservation of mixed farming) are shown to be beneficial to a wide range of taxa, and in particular to farmland wildlife. Many studies have also focused on the development of biotic indicators for the evaluation of biodiversity in agricultural systems systems (BOCKSTALLER *et al.,* 1997; DALSGAARD and OFICIAL, 1997; MORSE *et al.,* 2001; LOPEZ-RIDAURA *et al.,* 2002; CAPORALI *et al.,* 2004; PACINI *et al.,* 2009), both in commercial farms (MIGLIORINI *et al.,* 2008; PACINI *et al.,* 2003) and in long term experiments (LTE) (LEIGH and JOHNSTON, 1994; MÄDER *et al.,* 2002; PIMENTEL *et al.,* 2005; RAUPP *et al.,* 2006; MIGLIORINI and VAZZANA, 2007). A considerable pilot research study, entitled 'European network for the planning and the management of Ecological and Integrated Arable Farming Systems (E/IAFS)' (VAZZANA *et al.,* 1997; VEREIJKEN, 1997, 1999) aimed at the evaluation of sustainability using a systemic approach, was set both to define a reference frame for agro-environmental indicators and to assess a prototype agro-ecosystem methodology.

Among the organisms living in the upper surface of the soil, the microarthropod community is an important component of soil biodiversity interacting with all the other system components (GOEDE and BRUSSAARD, 2001). A well balanced soil arthropod community is essential in decomposing crop residues to form humus and in recycling mineral nutrients for successive crops (PERSSON, 1989; TOMLIN and PROTZ, 1990; KACZMAREK *et al.,* 1995). They

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may also affect plant species diversity through selective feeding on roots and mycorrhizal fungi (DE DEYN *et al.,* 2003). In comparison to the natural environment, a reduced arthropod fauna inhabits the soil in agricultural systems; the diversity and abundance of this fauna are highly sensitive to effects by agricultural management practice (CROSSLEY *et al.,* 1992) and form part of the biological data set considered useful for soil quality evaluation (VAN STRAALEN and VERHOEF, 1997; GOEDE and BRUSSAARD, 2001; PARISI *et al.,* 2005; VAN STRAALEN and VERHOEF, 1997). Crop, sampling data, age of the crop, depth of soil samples and soil moisture, in addition to farming system, affect the occurrence, specifically, of Collembola and Acari, the most representative group of soil arthropods (DEKKERS *et al.,* 1994). The mite/collembolan ratio (BACHELIER, 1986) is, for example, one of the indices most commonly used to measure the stability of an environment and of the soil quality. However, giving the different methodologies available and differences in the temporal and spatial dimensions of the analyses, the data generated from these studies have been frequently inconclusive and their comparison is difficult. For this reason the effect of multi-year farming management on arthropod fauna of arable soil needs to be better understood.

Recently, in the study of soil arthropods in agricultural systems, the trend has been to define methodology and/or indices which facilitate data collection and large scale comparison. In this contest, a composite approach seems more advisable than studies conducted only on either individual species or small groups of arthropod species: the synthetic index of degree of change of diversity of an ecological system (ΔV) (CANCELA DA FONSECA and SARKAR, 1996) and the index of biological quality of soil (QBS) (PARISI, 2001), which are not dependent on an identification at the species level, but consider arthropods grouped at more general ordering, go in this direction.

This paper aims at evaluating whether and how the abundance and diversity of soil arthropods can reflect farming systems in a long term experimental Mediterranean stockless arable system. By means of analysis of diversity at a high taxa level, using the above mentioned indices, the effect on soil arthropod fauna was determined at a fixed time with focus on a selected crop (maize, *Zea mays*) to evaluate three farming systems, two different organic at different ages and a conventional, different for the crop rotation and input used after 19 years system set.

MATERIAL AND METHODS

DESCRIPTION OF EXPERIMENTAL AREA

Experimental fields

The Montepaldi Long Term Organic Experiment (MOLTE) is active since 1991 (VAZZANA *et al.,* 1997; RASO and VAZZANA, 1999; BEDINI *et al.,* 2013; MIGLIORINI *et al.,* 2013) on the farm of the University of Florence, Italy (location Montepaldi, San Casciano Val di Pesa, Long. 11°09'08" E, Lat. 43°40'16" N) covering a surface of about 15 hectares at 90 m a.s.l.; MOLTE includes the following three different micro agroecosystems (AES):

a) "Old Organic" (OldO) of 5.2 ha, divided into four fields, under organic management (according to the EU regulation for organic farming CEC reg. 2092/91 and CE 834/07) since 1991;
b) "Young Organic" (YngO) area of 5.2 ha, divided into four fields and converted into organic management in 2001;
c) "Conventional" (Co) area of 2.6 ha divided into two fields under conventional management, where farming techniques used were those normally used in the territory of the study area.

Each field of maize considered covers 1.3 hectares (260 m x 50 m) (Fig. I). Following the local land use, a regular four-year crop rotation is adopted in organic agroecosystems. Since 2001, the crop rotation in the YngO and OldO system was the same: green manure crops + maize – winter cereal (barley or wheat) + red clover – leguminous crop (red clover II or annual clover or field bean) – winter cereal (barley or wheat). A biennial rotation is adopted in the conventional AES: sunflower or maize – winter cereal (barley or wheat). In the organic systems the crops are not fertilized except for cereals with a mix of animal manure based (cattle and poultry) commercial fertilizers at the medium rate of 15 units of N, 17 of P_2O_5 per ha per year according to the average residues obtained in previous year as well as the expected yield. The conventional system crops are fertilized using chemical fertilizers, according to the following medium rates (units per ha per year): 120 N, 70 P_2O_5 units for winter cereal and 95 N, 65 P_2O_5 for maize. The tillage system is based on ploughing at a depth of 25-30 cm both for organic and conventional systems. In the organic systems weed control is performed by preventive control means and mechanical cultivation (crop rotation, low nitrogen, early cultivars, false planting and straw arrow) and disease control is based on

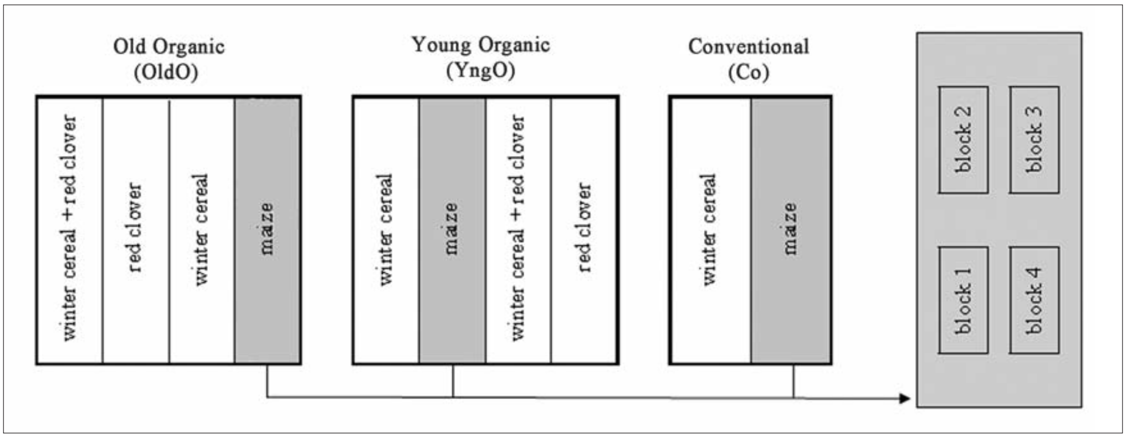

Figure 1 – Layout of the maize field in MOLTE long-term experiment in 2007. Every crop was grown in each year.

indirect control (crop rotation and cover crop, ecological infrastructure, no chemicals, low nitrogen). In the conventional system, weed control is performed chemically (pre-emergence and/or post-emergence) with PRIMAGRAM® Gold for maize and GRASP®, ATPLUS® and LOGRAN® for winter cereal. For disease control, only when necessary, very few treatments are used.

The studied agroecosystems are surrounded by ecological infrastructures such as natural and artificial hedges, in particular the organics.

The study is inserted in the frame of an experimental design created to compare micro pilot farms with a systems approach and to verify if the agricultural management systems (organic vs conventional) had some effect on soil quality and fertility, crop production, energy efficiency, biodiversity, product quality while climate and initial soil condition was the same. The three systems were different only for the crop rotation and the input used and, here, after 19 years, some conclusions on soil biodiversity and this paper is focusing.

Climate

Climatic conditions of the experimental area are typical of the sub-Apennine zones. The average 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 maximum that exceeded 30°C in summer.

Soil characteristics

The soil of MOLTE is composed by parent rock material derived from Pliocene sediments (slope zones) and by river Pesa fluvial deposit from Holocene (plane zones). Based on the textural characteristics, the soil was classified from "silty clay loam" to "clay loam" with the common presence of gravel. The soil chemical analysis showed that in the experimental area the pH was moderately alkaline with a low level of organic matter content, total nitrogen, available phosphate and exchangeable potassium. Differences were evident only in the total N with OldO>>YngO>Co and in total C with YngO>>OldO> Co (MIGLIORINI *et al.,* 2013).

As regards to the soil contents, some parameters and contents were analysed and compared among the three different AES's (Table 1).

ARTHROPOD COMMUNITY EVALUATION IN FIELDS OF MAIZE

Soil sampling

The arthropod community was assessed on mid-September, 2007 on maize residues after harvesting. This season time, and, generally, late summer on agricultural crops, is corresponding to the movement of significant portions of arthropod community that, after reaching deeper soil layers in July-August drier period, move again towards upper soil surfaces (NANNELLI and SIMONI, 2002).

Every field considered was divided in four blocks; in each block, four soil cores (core size: 35 cm^2 surface, 5-7 cm deep), were randomly sampled obtaining 16 samples for agroecosystem (OldO, YngO, Co). Furthermore, each field soil area was characterized as concerns some soil parameters. The arthropod extraction was performed separately for each of the soil cores. They were carefully placed on a 1.5 mm mesh above Berlese-Tullgren funnels for a minimum of four days; the extracted material was preserved in 95% ethanol+1% glycerol. This method, largely used in ecological studies of soil arthropods, allows for the extraction of mites, collembolans and those arthropods within a dimension of <1.5 mm which are present in the soil samples. Arthropods were counted, identified and classified on a taxonomic level not lower than either order or suborder. For mite groups, we followed the KRANTZ (1978) classification, commonly used in soil ecology studies.

Data treatment and statistical analysis

To evaluate the effect of the managements on the microarthropod groups considered, as the constraints leading to the restricted randomization of the experimental design, a split-plot Anova was performed where variation sources were represented by the three different micro-agroecosystems (YngO, OldO, Co) managements and by the nested source of management and field subplots. To achieve homoscedasticity of variance and perform analysis, the logarithmic transformation – ln (x+0.5) – was applied to the abundance data counts Yamamura (1999).

Correlation analysis (Spearman test) was performed to verify the association in the presence of the different groups. The Acari/Collembola and Oribatida/Collembola ratios were evaluated by means of the chi square test. All statistical procedures were performed using the SPSS-package (SPSS, 1994).

Biodiversity indices

The differences in biodiversity recorded were compared using the synthetic index of degree of change of diversity of an ecological system (CANCELA DA FONSECA and SARKAR,1996) that can be calculated as follows:

$$V = [\, V(x) + V(S) + V(n) + V(H'_x) + V(H'_y)] \,/\, 5$$

where V is the degree of change in biodiversity, as derived by CANCELA DA FONSECA, (1966), x is the mean abundance of taxonomic group (oribatids, other mites, collembolans and all other arthropods), S the number of taxonomic groups, n the number of sampling units containing the taxon, H'_x is the taxonomic index of diversity, H'_y the cenotic (spatial) index of diversity. In V_{global}, each parameter was calculated as the sum of means, while in V_{mean} as the mean of sums. The indices range between -1 and +1. The absolute value measures the differences between the two systems, while the positive or negative sign indicates if the system assumed as the control

Table 1 – Abundance (mean number of specimens per samples ± SE) of soil microarthropods in Young organic (YngO), conventional (Co), old organic (OldO). Means in the column followed by different letter are significantly different (Tuckey test, *P*<0.05).

Treatm.	Oribatida	Other mites	Collembola	Other arthropods
OldO	25.50±4.82a	29.81±5.50	11.38±2.40a	3.31±0.79
YngO	51.25±10.14b	50.19±7.36	52.06±14.59b	4.56±1.08
Co	67.88±15.38b	61.94±19.05	20.19±3.78a	6.75±2.83

respectively shows either a lower or higher diversity degree than the other.

Arthropod biodiversity and biological quality of soil were evaluated using the QBS index proposed by PARISI (2001), based on a practical classification which assigns scores to each group of microarthropods considering morphological features on the basis of their adaptation to the edaphic environment (EMI, Ecomorphological Index). The QBS index is obtained from the sum of the scores (PARISI, 2001; PARISI *et al.,* 2005).

RESULTS

ABUNDANCE AND DISTRIBUTION IN THE DIFFERENT TAXONOMIC GROUPS

The total mean number of arthropods extracted per core was 70.00±10.41 (mean±SE) (about 20,000 individuals/m^2) in OldO, 158.06±23.85 (about 45,160 individuals/m^2) in YngO and 156.75±34.42 (about 44,785 individuals/m^2) in Co.

The highest numbers were registered in the two groups including the mites: 48.203±6.711 (mean±SE) individuals/core in the Oribatida group, in comparison to 47.313±7.165 individuals/core of the sum total of other mites, i.e Actinedida (or Prostigmata), Gamasida and Acarida (or Astigmata) together. Collembola had a total of 27.875±5.594 individuals/core, while all the other remaining arthropods were the least represented with 4.875±1.043 individuals/core.

The split plot ANOVA showed that the agroecosystem significantly affected the abundance of arthropods ($P<0.001$). In general, the agroecosystem management highly affected the density of oribatids and collembolans: multiple Post hoc comparisons showed a significant higher density of oribatids in Co than in OldO and in YngO ($P=0.009$), a higher density of collembolans in YngO than in OldO ($P=0.002$) and Co ($P=0.014$), respectively (Table 1).

The mites' percentage, including Oribatida, Astigmata, Prostigmata and Mesostigmata, registered on the arthropod communities was 64% in YngO, 79% in OldO and 83% in Co.

The mite percentages registered on the arthropod communities was 64% in YngO, 79% in OldO and 83% in Co. All comparisons of percentage densities between mites and other arthropods were significantly different (χ^2, $P<0.01$). With the exclusion of mites from the count, collembolans were the most representative arthropods (Table 2). Only in the comparison OldO-Co there was no difference in the percentage values (Table 2). In YngO the collembolans represented approximately the 90% and in the two remaining systems about 70%. The ratio of frequency of Oribatida and Collembola was different in all systems tested (χ^2, $P<0.000$). The oribatid-collembolan ratio was particularly low in YngO, and more than doubled in OldO and tripled in Co. The same trend was observed when the mite-collembolan ratio was considered (Table 2).

Regarding the mite distribution within the taxonomic groups, similar presence was of Oribatida and Gamasida in YngO and OldO (Fig. II). By comparing Yngo and Co managements (Table 3) the Oribatida density did not differ from Gamasida, from Actinedida; at the same, densities of Gamasida and Prostigmata were similar; all the other comparisons significantly differed (χ^2, 0.05 $<P>0.0001$). In the OldO-Co comparison, the significant differences were in the relative presence of Oribatida with Actinedida and with Collembola (χ^2, $P<0.001$), respectively (Table 3).

Correlations among the most represented arthropod groups are reported in Table 4. By considering oribatids, the most numerous mites, they are correlated with prostigmatids and mesostigmatids; analogously, Collembolans, the most representative insects are correlated with mesostigmatids, which were also significantly correlated with all other mite groups ($P=0.001$).

BIODIVERSITY INDICES

Both the global and mean indices of the degree of change of biodiversity indicated a higher difference between OldO and YngO than between each of latter and Co (Table 5). In OldO, the biodiversity was smaller than in the two other systems and this difference increases when the mean index was considered (Table 5). In YngO, the biodiversity was slightly higher than in Co.

The biological soil quality index (Table 6) showed the highest value (QBS-ar =183) in YngO, while the differences between OldO and Co were not significant (QBS-ar = 117 and 134, respectively). Analyzing the groups which contributed more to the calculation of this

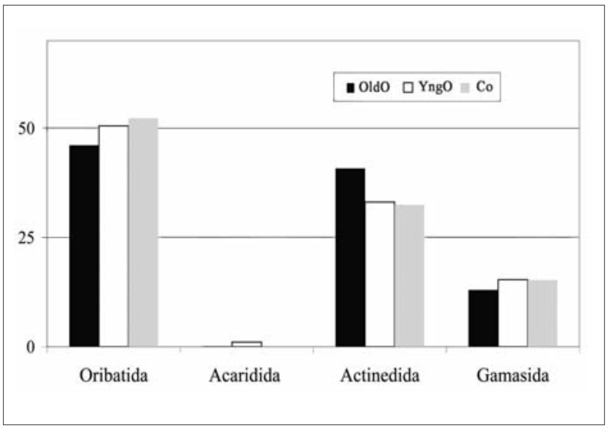

Figure 2 – Distribution (%) of different taxonomic groups of soil mites in the three managements.

Table 2 – Distribution (%) of soil mites -Oribatida, Astigmata, Prostigmata, Mesostigmata-, collembolans and other arthropods, Acari-Collembola, and Oribatida-Collembola ratio in YngO, Co, OldO. Significance in ratios was evaluated by means of the χ^2 test ($P<0.05$).

Treatm.	Oribat.	Astigm.	Prostigm.	Mesostigm.	Collemb.	other arthropoda	Acari/Coll. ratio	Orib./Coll. ratio
OldO	36.43	0.09	32.23	10.27	16.25	4.73	4.86b	2.24b
YngO	32.42	0.67	21.23	9.84	32.94	2.89	1.95a	0.98a
Co	43.30	0.00	26.87	12.64	12.88	4.31	6.43c	3.36c

Table 3 – Significance (χ^2) of the differences in presence percentages of main soil taxa in the different management systems.*: $P<0.05$; ** $P<0.01$; *** $P<0.001$.

Comparison	YngO-OldO	YngO-Co	Co-OldO
Acari - Other arthropoda	***	***	**
Other arthropoda – Collembola	***	***	ns
Oribatida – Collembola	***	***	***
Oribatida – Gamasida	ns	ns	ns
Oribatida – Actinedida	***	ns	***
Oribatida – Acaridida	*	***	ns
Acaricida – Actinedida	**	***	ns
Acarida – Gamasida	*	***	ns
Gamasida – Prostigmata	**	ns	**

Table 4 – Correlation, on the whole, among the most represented arthropod groups.

Comparison	Pearson Correlation	Significance (*P* value)	N
Oribatids - collembols	0.167	0.256	48
Oribatids - Other arthropods	0.493	0.000	48
Oribatids - Prostigmatids	0.638	0.000	48
Oribatids - Mesostigmatids	0.473	0.001	48
Collembols - Other arthropods	0.077	0.601	48
Collembols - Prostigmatids	0.104	0.482	48
Collembols - Mesostigmatids	0.473	0.001	48
Other arthropods - Prostigmatids	0.633	0.000	48
Other arthropods - Mesostigmatids	0.171	0.246	48
Prostigmatids- Mesostigmatids	0.641	0.000	48

Table 5 – Parameters for the calculation of the global and mean index of the degree of change of biodiversity and the global and mean index (ΔV) of soil microarthropods. Young organic versus conventional (YngO-Co), old organic versus conventional (OldO-Co) and old biological versus young organic (OldO-YngO).

Treatm.	V(x)	V(S)	V(n)	$V(H'_x)$	$V(H'_y)$	ΔV
Global						
YngO vs Co	0.004	0	0	0.030	0.029	0.013
OldO vs Co	-0.381	0	0	0.018	0.026	-0.068
OldO vs YngO	-0.386	0	0	-0.012	-0.003	-0.080
Medium						
YngO vs Co	0.004	0	0	0.042	0.188	0.047
OldO vs Co	-0.381	0	0	0.019	-0.081	-0.089
OldO vs YngO	-0.385	0	0	-0.023	-0.264	-0.135

index, Orthoptera were present only in YngO, while Pauropoda and Isopoda were characteristic only of the organic systems (Table 6).

DISCUSSION

MOLTE is an agronomical system that preserves a rich vegetal (Migliorini *et al.,* 2009; 2013), mostly attributable to its location in an environment characterized by natural vegetation, woods and hedges. This likely also affects the abundance and diversity of arthropod fauna that are higher than in other similar agricultural systems. An average of 36,362 microarthropods/m^2 were shown to inhabit the superficial layer of soil at MOLTE, where the mites represented about 75% (27,271/m^2) and collembolans 22% (7,999/m^2) of the total analysed. In MASCOT (Barberi and Mazzoncini, 2006), the most similar system to the system analysed in the present study, as regard to geographical area and soil type, the mean presence of microarthropods did not exceed 21,700 individuals/m^2: mites represented about 62% (13,493 individuals/m^2), while collembolans were only 7,000 corresponding to 32% (Mazzoncini *et al.,* 2010). In an intensive maize monoculture in different locations of the Po Valley (Northern Italy), mite mean density ranged from 757 to 8,509 individuals/m^2 (Mahunka and Paoletti, 1984; Tabaglio *et al.,* 2009) and collembolans were 20,000 in treated maize and doubled in untreated maize (Sabatini *et al.,* 1997). Probably the differences in density of the most representative soil arthropods (generally higher for mites and lower for collembolans in Tuscan

Table 6 – Ecomorphological Index (EMI) for the microarthropods occurring in the study sites and QBS_{ar}. Values followed by the same letters are not significantly different (Mann-Whitney test, $P<0.05$).

Ecomorphological forms	OO	YO	Co
Diplura		20	20
Collembola	20	20	20
Psocoptera	1	1	1
Orthoptera		20	
Hemiptera (Aphididae)		1	1
Tysanoptera			1
Coleoptera	1	1	1
Hymenoptera (Formicidae)	5	5	5
Diptera	10	10	10
Other holometabolous insects	10	10	10
Acari	20	20	20
Araneida		5	5
Isopoda	10	10	
Diplopoda		20	20
Pauropoda	20	20	
Symphyla	20	20	20
QBS_{ar}	117a	183b	134a

maize field) are due more to greater differences in agricultural management and environment than to intrinsic soil characteristic and climatic conditions.

The abundance of mites and their positive correlation with all "other arthropods" confirm their complex role in the soil. The more detailed positive correlations found seem to corroborate that the prevalently predators Gamasida, may also prey on collembolans and that Actinedida, characterized by species with different feeding habits, may also feed on oribatids and /or that these two groups are not in competition for food.

It is a general opinion that arthropod abundance and biodiversity are the highest in uncultivated or natural systems as well as in low-input systems (Cancela da Fonseca and Sarkar, 1996; Cortet *et al.,* 2002; Parisi *et al.,* 2005; Siepel, 1996; Solbrig 1992) and that microarthropods occur in larger numbers in organic than in integrated and conventional farming systems (Hansen *et al.,* 2001). Mite diversity, especially oribatid mites, were reported to decrease through forest > organic cultivation > pasture of closeness areas (Badejo *et al.,* 2004. From our results, statistical analysis on both the relative abundance and biodiversity indexing provided evidenced for differences in soil arthropod communities depending on management system. However, the organic system OldO is characterized by the lowest presence of arthropods, especially oribatids. The differences were further emphasized if we consider the distribution percentages of arthropods in the taxonomic groups considered. These differences were higher in the OldO-YngO comparison and lower in the OldO-Co comparison. In particular, the mite-collembolan ratio significantly changed between different soil management. Mite abundance usually exceeds collembolan abundance in good quality soil and in more stable environments (Bachelier, 1986). Drought (Lindberg and Bengtsson, 2005) and certain agricultural practices such as tillage (Ferraro and Ghersa, 2007; Tabaglio *et al.,* 2009) may lower the mite density more than the collembolan population. Oribatid mites, one of the most important components of mesofauna, require a long period to recover from soil disturbances (Behan-Pelletier, 1999; Lindberg and Bengtsson, 2005; Osler and Murphy, 2005) in accordance with their k-reproduction strategy. In MOLTE, the mite/collembolan ratio was significantly higher in the conventional than in the two organic systems. This is in agreement with values observed in other systems with maize both in Northern Italy (Parisi *et al.,* 2005) and in Central Italy (Mazzoncini *et al.,* 2010). In the latter it was hypothesized that the highest disturbance, made by machinery in the organic systems compared to the conventional, could explain both the general highest abundance of microarthropods and the highest mite/collembolan ratio in conventional maize (Mazzoncini *et al.,* 2010). However this hypothesis could not fully explain our results, as in MOLTE the two organic systems are subjected to the same type of soil management.

The indices of the degree of change of biodiversity (ΔV) based on the abundance and distribution of oribatids, "other mites", collembolans and "other arthropods" confirm a lower biodiversity (at least on the taxonomic level considered) in OldO in comparison to the other two systems, but they also showed that the greatest difference was between OldO and YngO. Analogous trends in organic versus conventional was also observed in MASCOT (Mazzoncini *et al.,* 2010).

With the calculation of the Biological Soil Quality index (QBS_{ar}), where relevance is attributable to arthropods with greatest edaphic adaptation and where mites are consdered as an unique group, while other arthropods are split between their respective classes, orders or suborders, we generally found very high values compared with those known for other agroecosystems (Gardi *et al.,* 2002; Parisi, 2001; Parisi *et al.,* 2005; Tabaglio *et al.,* 2009). In all situations tested, QBS was higher than 100, considered an indicator of good soil quality (Parisi, 2001). The QBS values in the present study were higher than that found in MASCOT, the most similar agroecosystem studied (Mazzoncini *et al.,* 2010). Furthermore in MOLTE, the QBS_{ar} values were similar in OldO and Co (being only slightly lower in OldO). However, the two systems only have in common eight eco-morphological forms out of the 10 and 13 respectively found in OldO and Co (Table 5). Surprising, the highest QBS_{ar} was in YngO, which also showed the highest microarthropods abundance, the greatest differences with OldO as evidenced by V and by the percentage distribution of mite taxa, but the lowest mite/collembolan ratio. Also, for these last data it is impossible, as in the comparison with Co, to attribute some effect to the more numerous tillage and /or more disturbance because the soil was managed in the same way in the two organic systems.

The soil analysis conducted in other studies evidenced that OldO was richest in total N while YngO was the richest in total C (Migliorini *et al.,* 2013). Probably these differences which are both dependent on the different farming systems and on the duration from organic conversion, are determinant for our results.

CONCLUDING REMARKS

The situation regarding the small arthropods community in the soil immediately after maize harvesting in a Tuscany location evidenced the largest differences between the two organic systems of different age. The old organic system (OldO) is characterized by less individuals and taxa than the young organic (YngO). It is suggested that in the OldO system, where the arthropod community probably already reached its balance, the abundance of specimens and biodiversity tended to be lower than in the young one. To extend this assumption, it is necessary to increase our knowledge on soil arthropods in a large number of crops, farming systems, geographical situations and also to focalize on the age of considered system. The identification of specimens found at a deeper level may also result in different conclusion about biodiversity. Furthermore, taxonomic affinity does not necessarily reflect the same behaviour in soil arthropods (Cortet *et al.,* 2011). Consequently on investigation on species ranked in functional groups, according to their trophic behaviours and distribution could enhance our understanding of the complexity of mechanisms which regulate the relationship among different soil taxa and their influence on soil quality.

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