Soil arthropod diversity in organic, integrated and conventional olive orchards in Crete

VASILEIOS GKISAKIS[1,2,4], DIMITRIOS KOLLAROS[3], PAOLO BÀRBERI[2], IOANNIS LIVIERATOS[4] AND EMMANOUIL KABOURAKIS[1]

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Abstract

Soil fauna biodiversity and its functional counterpart were monitored in olive orchards under conventional, organic and integrated management, for a year in Messara valley, Crete, Greece. Counter groups of functional taxa were defined, with respect to services of biological pest control and of nutrient cycling in the olive agroecosystem. Comparison of the different management systems in terms of abundance and diversity of soil arthropods and functional groups was performed. Formicidae, Coleopteran family of Tenebrionidae, Araneae, Colembola and Opiliones were the most abundant taxa found. A trend of higher total abundance and richness was found in the organic olive orchards, however not statistically significant. Functional arthropod abundance followed a similar trend. Diversity indices did not show a constant pattern in terms of management system comparison; however a trend of higher diversity appeared in the less-intensified organic orchards.

Introduction

Olive production is often a conventional agricultural protocol with applications of mineral fertiliser and chemosynthetic pesticides that can be high in intensive modern olive orchards. Such production often faces ecological problems (Kabourakis, 1999). Biodiversity is particularly affected by intensive farming practices, forcing agroecosystems to impoverishment (Biaggini, 2007).

Soil biodiversity is especially regarded as offering stability against disturbance and stress (Brussaard, 2007). The elements of agricultural biodiversity providing desired services has been be regarded as “functional” with several definitions emerged, depending on stakeholder’s objectives and priorities (Moonen and Bàrberi, 2008; Bàrberi, 2013).

The diversity of soil arthropod fauna in twenty four olive orchards in southern Crete was monitored for one year using a standard sampling method. Soil arthropod diversity was related to orchard management and the agroecological zone of the location of the orchards. This investigation was designed to optimise the efficiency of soil arthropod diversity management in olive orchards under different organic, integrated and conventional management systems.

Material and methods

Study location and surveyed orchards

The survey was done in twenty four pilot orchards located in eight different sites in Messara valley, a representative olive producing region of southern Crete. Orchards were selected following discussions with stakeholders and based on previous research carried out in the area (Kabourakis, 1999). Each study site included three neighbouring orchards (organic, integrated and conventional). The sampling period included 5 weekly measurements in each season, starting in autumn 2011 to summer 2012 (in total 20 weeks/year).

[1] Ecological Production Systems, Institute of Viticulture and Horticulture, National Agricultural Research Foundation, Heraklion, Crete, Greece, http://www.nagref.gr, eMail: ekab@nagref-her.gr

[2] Institute of Life Sciences, Scuola Superiore Sant'Anna (SSSA), Pisa, Italy, www.sssup.it, eMail: paolo.barberi@sssup.it

[3] Laboratory of Ecology, School of Agriculture, Technological Educational Institute (TEI) of Heraklion, Crete, Greece, www.teicrete.gr, eMail: kollaros@staff.teicrete.gr

[4] Departement of Sustainable Agriculture, Mediterranean Agronomic Institute of Chania (MAICh), Crete, Greece, www.maich.gr, eMail: gisakis@maich.gr, livieratos@maich.gr

Soil arthropod fauna monitoring

Soil arthropods were collected using pitfall traps. Each trap was left in site for 7 days. The arthropods were identified down to order level of taxonomy and to the level of class for Chilopoda and Diplopoda. Coleoptera were further taxonomized for the families of Scarabeidae, Carabidae, Staphylinidae and Tenebrionidae due to their functionality. Family Formicidae was counted independently from order Hymenoptera due to its abundance.

Data analysis

Comparison of different management systems was performed in terms of number of arthropods collected (total abundance). Richness and other indices of diversity were calculated, including the Shannon, reverse Simpson's and Pielou's Index. In addition, catches of functional fauna were grouped regarding the important and prioritized agroecosystem services of biological pest control and soil nutrient cycling they deliver. Statistical analyses were carried out using SPSS 20.0 for MS Windows.

Results

Total arthropods capture during the whole sampling period amounted to 115,364 individuals, of which 44,283 were trapped in the organic, 36,715 in the conventional and 34,367 in the integrated orchards. The arthropods were classified into 16 taxa, represented in all management systems (Table 1). Differences in total abundance were not statistically significant. Nevertheless, higher number of catches appeared in the organic orchards for all measurements, except winter. In similar studies, lower abundance of arthropods was found in conventional olive orchards (Ruano et al., 2004) and greater abundance in organic olive orchards (Cotes et al., 2010).

Table 1. Soil arthropod fauna abundance of taxa, functional groups and, and values of richness and biodiversity indices for organic (Org), conventional (Conv) and integrated (Int) management systems.

Season	Autumn			Winter			Spring			Summer			Whole period		
Management system	Org	Conv	Int	Org	Conv	Int	Org	Conv	Int	Org	Conv	Int	Org	Conv	Int
Taxa															
Acarina	68	35	97	43	21	40	1732	526	441	915	840	188	2758*	1422	766
Araneae	551	604	617	574	456	655	1234	912	1039	1407	1111	1239	3766	3083	3550
Coleoptera	921	778	798	280	296	287	12132	9638	10116	3003	4344	2963	16336	15055	14165
scarabeidae	168	84	53	6	7	9	824	170	136	6	4	9	1003	265	206
carabidae	229	200	213	43	38	43	428	331	257	24	41	43	724	611	556
staphylinidae	204	147	136	101	165	114	649	562	688	8	8	17	961	882	955
Tenebrionidae	30	17	29	32	6	16	6982	5876	5942	987	1226	681	8032	7126	6669
other	291	330	367	98	79	106	3250	2698	3093	1978	3064	2214	5616	6172	5779
Collembola	517	520	533	495	495	509	627	292	727	381	664	393	2020	1970	2162
Dictyoptera	1	3	0	13	0	13	36	25	35	1437	987	1314	1487	1014	1362
Formicidae	905	460	686	64	81	69	4555	3560	4079	6943	5129	5028	12467	9230	9862
Hemipt./Heteropt.	7	5	10	0	2	0	84	97	61	51	484	140	141	588	210
Hemipt./Homopt.	18	19	42	47	64	61	328	269	387	108	69	127	502	421	617
Hymenoptera	39	34	42	11	4	9	111	33	81	246	198	177	407	270	309
Isopoda	163	120	229	24	15	23	503	677	702	327	300	271	1018	1113	1225
Opiliones	816	432	437	476	299	531	1207	820	987	4	0	3	2503	1551	1958
Orthoptera	33	15	28	15	7	12	68	105	81	127	207	267	243	333	388
Thysanura	3	35	13	3	7	13	45	19	23	30	16	9	80	78	58
Other taxa counted: Chilopoda, dermaptera, diplopoda (<1%)															
Total	4074	3090	3556	2097	1801	2238	22740	17092	18863	15914	14418	12151	44825	36402	36808
Mean/trap	16,98	12,87	14,82	8,74	7,51	9,32	94,75	71,22	78,60	66,31	60,08	50,63	46,69	37,92	38,34
functional taxa	3653	2653	3043	1860	1591	2021	18785	13746	15021	11032	9340	7880	35330	27331	27966
BPC	2704	1843	2090	1258	1040	1411	8073	6186	7050	8385	6289	6330	20420	15358	16881
NC	949	811	954	602	551	610	10712	7561	7972	2647	3051	1551	14910	11973	11086
S	15	15	14	15	12	15	16	16	16	16	14	14	16	16	16
J	0,762	0,844	0,799	0,763	0,844	0,810	0,540	0,593	0,607	0,632	0,711	0,680	0,674	0,748	0,724
H'	1,565	1,478	1,512	1,450	1,360	1,289	1,325	1,298	1,395	1,436	1,513	1,476	1,444	1,412	1,418
1-D	0,731	0,738	0,734	0,713	0,696	0,672	0,595	0,592	0,635	0,666	0,708	0,691	0,676	0,684	0,683

In terms of specific taxa, Coleoptera was the most abundant, dominated mostly by family Tenebrionidae, and it was followed by Formicidae, Araneae and Collembola. The differences of taxa abundance between management systems were not statistically, except Acarina, being higher in the organic than the integrated olive orchards, in the whole period results ($p<0.05$)

Functional arthropods captured throughout the whole sampling periods numbered 90,630 individuals, representing 76,7% of total arthropod catches. In the organic orchards 35,331 functional individuals were counted, in the conventional 27,331 and 27,967 in the integrated orchards.

Differences of functional taxa abundance between management systems were not statistically significant. However, a trend of higher total catches appeared in the whole period results for the organic orchards, followed by the integrated and conventional. The seasonal measurements presented the same pattern, except in the summer where the conventional ranked second, and in winter, where the integrated ranked first (Table 1). The above, not surprisingly, resemble to the results of total arthropod abundance, since the functional part accounts for a large part of the total catches.

Differences of all biodiversity indices between management systems were not statistically significant. Nevertheless, values of the Shannon index appeared higher in organic, followed by the integrated and conventional orchards in the whole period results. In the seasonal measurements, the indices values did not present a constant pattern.

Discussion

Less-intensively managed orchards appeared to support higher soil arthropod abundance and diversity of soil arthropods. Differences between management systems were not statistically significant; however a trend of higher total and functional taxa abundance in less the less intensive management systems was rather obvious. The composition of soil arthropod fauna was similar to that of previous surveys. Breakdown of the total abundance to functional groups with regards to prioritised agroecosystem services, proved to be a helpful approach for our biodiversity survey.

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