THE IMPACT OF SOME COMPOUNDS UTILISED IN ORGANIC OLIVE GROVES ON THE NON-TARGET ARTHROPOD FAUNA: CANOPY AND SOIL LEVELS

C-ECOLOGICAL ASPECTS

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An increasing literature body is devoted to the study of efficacy and risks concerning compounds allowed in organic farming and new compounds considered harmless for environmental and human health. The great biodiversity inhabiting olive agroecosystem lead to a biotic control of many pest species. The only widespread pest causing economic damages is the olive fly, *Bactrocera oleae*. The side effects of compounds allowed against the olive fly in open field are still little known as well as the agronomical methods for mitigating them. The aims of this research were to evaluate the impact of compounds allowed in organic olive farming and searching for more ecocompatible farming strategies. The research was carried out in Southern Italy. Experimental olive grove were untilled, and the grass cover was periodically managed. Six theses composed by 200 plants were randomly chosen and sprayed with rotenone, kaolin, a mixture of copper oxychloride and propolis, and dimethoate. Due to different actions of active agents involved in this research, arthropods were sampled at canopy and soil levels. The same compound showed different consequences on arthropods at canopy and soil levels. The sprayed compounds showed few negative effects in respect to previous studies. This fact could be attributed to the grass cover which probably reduced the effects of active agents with short term efficacy. In definitive, the grass cover could be play an important role in minimising the impact of sprayed compounds on non target arthropods furnishing a shelter against the direct contact with active agents.

Key words: pesticides, coenotic balance, organic farming, Italy.

Introduction

Recently, an increasing literature body is devoted to the study of efficacy and risks concerning compounds yet allowed in organic farming or new compounds considered harmless for environmental and human health. While many studies are available on the pesticides residues in food and their effects on human health, researches devoted to the study of risks concerning the use of pesticides in open field and their effects on non target biota are less abundant. The olive crop is the most widespread and ancient agroecosystem in Mediterranean territories, having an high coenotic complexity. The great biodiversity inhabiting this agroecosystem lead to a natural biotic control of many pest species which attain only locally and/or temporally the damage threshold. The only pest species everywhere causing economic damages to farmers is the olive fly, *Bactrocera oleae* (Gmelin, 1790) (Diptera Tephritidae). This species have negative effects on quantity and quality of production. Against this phytophagous a list of pesticides allowed in organic olive farming is available. The side effects of these compounds in open field are still little known as well as the agronomical and ecological methods for mitigating them.

In agroecosystems the arthropod fauna is very abundant and quality and quantity composition of their communities strongly depends on human activities and landscape parameters. The easy sampling and the availability of arthropods in any environmental context lead many authors to use arthropods as environmental thermometer useful for monitoring the ecosystem health.

The aims of this research were (1) to evaluate the impact of compounds allowed in organic olive farming, (2) searching for more ecocompatible olive farming strategies, and (3) searching for bioindicators of olive ecosystem health among arthropods.

Material and Methods

Study area

The study area was located in the municipality of Mirto-Crosia, Calabria, Southern Italy, at 5m a.s.l. within the experimental field of CRA - Experimental Institute for Olive Growing which consist of 15-18 years old olive plants belonging to several cultivars, cultivated in the same environmental and agronomic conditions. Experimental olive grove were untilled, and the grass cover was periodically managed. The climat is tipically Mediterranean, having a long dry and warm period, and a short wet and cold period. The soil is alluvial being the study area located on the estuary of Trionto river, mainly composed by silty clayey sands.

Experimental design

Data were decadly collected from late June to early December 2006, i.e. during the ripening of drupes and until the olive harvest. Six theses composed by 200 plants were randomly chosen. One thesis was treated the 25th of August and the 28th of September with rotenone (300 ml/hl of Rotena® Serbios, Rovigo, Italy) (MIR5), a compound allowed in organic farming. One thesis was treated the 21st of August and the 28th of September with kaolin (5 kg/hl of Surround® WP Crop Protectant, Engelhard Corporation, Iselin, NJ, USA) (MIR7), a promising compound in controlling the main insect pests of olive groves. One thesis was treated the 25th of August and the 28th of September with a mixture of copper oxychloride (250 g/hl of Cupravit Blu WG® Bayer Cropscience, Milan, Italy) and propolis (150 ml/hl of Propoli+® Progetto Geovita Div. Agricom, Turin, Italy) (MIR8), utilised against both diseases and olive fly (*Bactrocera oleae* Gmel.) (Diptera Tephritidae). Two thesis were treated the 2nd of August, the 1st September and the 2nd of October with dimethoate (150ml/hl of Rogor 40® Isagro s.p.a., Milan, Italy) (MIR1, MIR2), the most utilised pesticide in conventional olive groves. One untreated thesis was utilised as control (MIR6).

Due to different actions of active agents involved in this research, arthropods were sampled at canopy and soil levels. The sampled taxa were known for their sensitivity to environmental perturbations. At the canopy level the occurrence and the abundance of nine taxa (Arachnida: Araneae and Opiliones; Insecta: Hymenoptera Ichneuomonoidea, other Hymenoptera, Coleoptera Coccinellidae, Macrolepidoptera, Neuroptera, Mecoptera, Diptera Syrphidae) was registered by using three yellow chromotropic traps per thesis, usually utilised for the monitoring of olive fly population trend (Raspi and Malfatti, 1985). At the soil level the occurrence and the abundance of six taxa (Arachnida: Araneae; Crustacea: Isopoda; Insecta: Coleoptera Carabidae, Coleoptera Staphylinidae, other Coleoptera, Hymenoptera Formicidae) was registered by using pit-fall traps, usually utilised for the monitoring of Carabid beetles species assemblages (Brandmayr et al., 2005).

Data analysis

Collected data were submitted to various analyses in order to detect the differences in community structure, the responses of sampled taxa to treatments, and the effects of compounds on the efficiency of trophic levels.
In order to assess the responses of treatments of a given taxon an index of phenological dynamics was utilised. Although intrinsic differences among sampled stands and seasonal changes in the composition of communities occur as confounding factors, the effect of treatments is detectable in the field carrying out comparison of a stand with itself. Phenological dynamics, homogeneous within a given thesis, are differently influenced by the insecticide spray depending on the taxon sensitivity. This is emphasized by partitioning the season in a 'before' and in an 'after' treatments. The ratio after/before treatments (A/B_{ratio}) of the abundance of sampled taxa gave good information on the effect of treatments (Iannotta et al., 2007). This analysis was carried out at canopy and soil levels.
An index of coenotic balance (CB) was proposed by Iannotta et al. (2007) in order to evaluate the efficiency of trophic levels. They assumed that (1) in natural ecosystems antagonists are less abundant than indifferent insects which represent the major part of their preys, and that (2) the use of pesticides alters this ratio causing a relative higher decreasing of indifferent insects in the short time in respect to antagonist insects. The index of Coenotic Balance is coded as follows: $CB = n_I/n_A$, where n_I equals to the number of individuals belonging to indifferent insect taxa, and n_A equals to the number of individuals belonging to antagonist insect taxa). Higher values are determined by better coenotic balances. This analysis was carried out at canopy level only by grouping Araneae, Opiliones, Ichneumonoidea, Coccinellidae, Neuroptera and Syrphidae in the Antagonists category (*A*), including predators and parasitoids, and other Hymenoptera, Macrolepidoptera and Mecoptera in the Indifferent category (*I*), including saprofagous, phytophagous and pollinators. The presence in the order Hymenoptera of taxa belonging to both trophic categories led us to suppose that this order could be utilized as a surrogate of the whole entomocoenosis. The superfamily Ichneumonoidea was chosen as representative of antagonist taxa because of relatively simple to identify. As consequence, the surrogate index of Coenotic Balance ($CB_{hym/ichn}$) is: $CB_{hym/ichn} = n_{hym}/n_{ichn}$, where n_{hym} equals to the number of individuals belonging to Hymenoptera, and n_{ichn} equals to the number of individuals belonging to Ichneumonoidea.

Results

Canopy level

A total of 2,902 individuals belonging to selected taxa were collected (tab. 1). The most abundant taxon was other Hymenoptera (n = 1,003; 34.6%), followed by Ichneumonoidea (n = 884; 30.4%). The highest number of individuals was collected within control thesis (MIR6), whilst the lowest one was collected within kaolin thesis (MIR7). Neuroptera, Macrolepidoptera and Syrphidae were more abundant in conventional olive groves, Araneae was more abundant in the rotenone thesis (MIR5), other taxa were more abundant in control thesis (tab. 1).

Tab. 1. Abundance at the canopy level of sampled taxa in experimental theses as individuals and (density of activity, DA).

	Conventional		Organic			Control		
	MIR1	MIR2	MIR5	MIR7	MIR8	MIR6	TOTAL	%
other Hymenoptera	111 (2.2)	127 (2.5)	213 (4.3)	137 (2.7)	177 (3.5)	238 (4.8)	1,003	34.6
Ichneumonoidea	125 (2.5)	162 (3.2)	143 (2.9)	104 (2.1)	120 (2.4)	230 (4.6)	884	30.4
Macrolepidoptera	76 (1.5)	44 (0.9)	40 (0.8)	37 (0.7)	23 (0.5)	39 (0.8)	259	8.9
Neuroptera	106 (2.1)	54 (1.1)	13 (0.3)	4 (0.08)	18 (0.4)	38 (0.8)	233	8.0
Mecoptera	4 (0.08)	4 (0.08)	27 (0.5)	29 (0.6)	16 (0.3)	83 (1.7)	163	5.6
Syrphidae	26 (0.5)	39 (0.8)	21 (0.4)	18 (0.4)	22 (0.4)	10 (0.2)	136	4.7
Coccinellidae	10 (0.2)	11 (0.2)	37 (0.7)	10 (0.2)	22 (0.4)	40 (0.8)	130	4.5
Araneae	15 (0.3)	5 (0.1)	27 (0.5)	17 (0.3)	10 (0.2)	18 (0.4)	92	3.2
Opiliones	0 (0)	0 (0)	0 (0)	2 (0.04)	0 (0)	0 (0)	2	0.07
TOTAL	473 (9.4)	446 (8.9)	521 (10.4)	358 (7.2)	408 (8.1)	696 (13.9)	2,902	
%	16.3	15.4	18.0	12.3	14.1	24.0		

The ratio after/before treatments (A/B_{ratio}) shown the dimethoate, the kaolin and the rotenone as the compounds having the higher knock-down effect on the sampled arthropod community at the canopy level (tab. 2). Although Neuroptera were very abundant in theses treated with dimethoate, they have showed a very high decrease as consequence of treatments. The rotenone was the worst compound for Araneae and Ichneumonoidea, the kaolin was the worst compound for other Hymenoptera and Coccinellidae, while the mixture copper/propolis seems to be harmless for the chosen taxa at canopy level (tab. 2).

Tab. 2. The ratio after/before treatments (A/B_{ratio}) at canopy level. Conventional theses were grouped and successively analysed as an unique sample. No ratios are disposable for Opiliones and Mecoptera because of any individuals were collected before the treatments. Data about Syrphidae were not significant because of the late appearance of the adult stage.

	MIR1,2	MIR5	MIR7	MIR8	MIR6
Araneae	1.64	0.12	1.46	2.82	2.49
other Hymenoptera	1.17	1.00	0.56	1.29	0.90
Ichneumonoidea	2.31	1.00	1.21	1.74	2.85
Coccinellidae	1.30	1.85	0.34	2.00	0.53
Macrolepidoptera	1.18	1.55	1.78	1.13	0.48
Neuroptera	0.17	1.97	1.00	4.85	11.61
Syrphidae	8.66	0.43	-	9.41	0.00
TOTAL	0.85	0.98	0.93	1.75	1.57

The coenotic balance was very similar among organic and control theses, showing a significant decreasing in conventional theses (tab. 3). The coenotic balance computed utilising all the sampled taxa better discriminate the theses according to the management regime than the coenotic balance computed on the basis of hymenopteran taxa. The latter index could be utilised when quicker analysis are requested. Among the treated theses, the kaolin thesis (MIR7) preserve the higher CB value and, consequently, the best coenotic balance.

Tab. 3. Results of coenotic balance computing.

	MIR1	MIR2	MIR5	MIR6	MIR7	MIR8
CB	0.68	0.65	1.16	1.07	1.31	1.13
$CB_{ime/icne}$	0.89	0.78	1.49	1.03	1.32	1.48

Soil level

A total of 23,393 individuals belonging to selected taxa were collected (tab. 4). The most abundant taxon was Formicidae (n = 10,303; 44.0%), followed by Isopoda (n = 5,528; 23.6%). The highest number of individuals was collected within the rotenone thesis (MIR5), whilst the lowest one was collected within a dimethoate thesis (MIR1). All taxa were very scarce in conventional theses, while no significant differences have been showed by organic theses and the control. In fact, only Carabidae and Staphylinidae were more abundant in control than in organic theses (tab. 4).

The ratio after/before treatments (A/B_{ratio}) shown the rotenone, the dimethoate and the mixture copper/propolis as the compounds having the higher knock-down effect on the sampled arthropod community at the soil level (tab. 5). Carabidae and Staphylinidae, both generalist predators, have been seriously affected by dimethoate. Araneae and other Coleoptera were the only taxa more abundant within the untreated thesis (MIR6) than within the treated theses. The kaolin was the compound having the lowest incidence on the arthropod populations at the soil level (tab. 5).

Tab. 4. Abundance at the soil level of sampled taxa in experimental theses as individuals and (density of activity, DA).

	Conventional		Organic			Control		
	MIR1	MIR2	MIR5	MIR7	MIR8	MIR6	TOTAL	%
Formicidae	824 (21.4)	873 (17.4)	2,515 (50.2)	2,829 (58.9)	1,798 (39.2)	1,464 (29.2)	10,303	44.0
Isopoda	143 (3.7)	477 (9.5)	2,034 (40.6)	696 (14.5)	934 (20.4)	1,244 (24.8)	5,528	23.6
Carabidae	287 (7.5)	355 (7.1)	464 (9.3)	504 (10.5)	242 (5.3)	640 (12.8)	2,492	10.7
Araneae	83 (2.2)	133 (2.7)	534 (10.7)	584 (12.2)	483 (10.5)	589 (11.8)	2,406	10.3
other Coleoptera	140 (3.6)	151 (3.0)	899 (17.9)	344 (7.2)	245 (5.3)	475 (9.5)	2,254	9.6
Staphylinidae	7 (0.2)	10 (0.2)	39 (0.8)	112 (2.3)	36 (0.8)	203 (4.1)	407	1.7
Opiliones	0 (0)	1 (0.02)	0 (0)	1 (0.02)	0 (0)	1 (0.02)	3	0.01
TOTAL	1,484	2,000	6,485	5,070	3,738	4,616	23,393	
%	6.3	8.6	27.7	21.7	16.0	19.7		

Tab. 5. The ratio after/before treatments (A/B_{ratio}) at soil level. Conventional theses were grouped and successively analysed as an unique sample. No ratios are disposable for Opiliones because of any individuals were collected before the treatments. Data about Staphylinidae were not significant because of the collection of very scarce populations.

	MIR1,2	MIR5	MIR7	MIR8	MIR6
Araneae	0.40	0.23	0.36	0.21	0.54
Isopoda	1.39	1.55	1.26	0.92	1.24
Carabidae	0.22	1.38	1.65	1.55	1.36
Staphylinidae	0.16	0.72	2.42	10.64	2.55
other Coleoptera	0.42	0.03	0.20	0.36	0.59
Formicidae	0.66	0.26	0.58	0.62	0.65
TOTAL	0.55	0.47	0.67	0.65	0.86

Discussion

The results obtained at canopy level were in some cases different from results obtained at soil level, showing different responses of arthropods communities to treatments according to both their behavioural features and the properties of their habitat. For example, the taxon of Araneae was strongly affected by spraying on the canopy, but seems to be only little affected on the soil. The same compound showed different consequences at canopy and soil level. In detail, the active agents were analysed and discussed from the most negative to the least one:

1. The dimethoate reduced the total abundance of arthropods on the canopy and created the strongest coenotic imbalance among trophic functional units. Araneae and Neuroptera were the taxa more affected by this active agent at canopy level, but on the soil all taxa were strongly affected reducing the A/B_{ratio} of predators Carabidae and Staphylinidae. The abundance of arthropods on the soil was very low. This active agents had negative effects for the arthropod fauna of both the canopy and the soil.
2. The mixture copper oxychloride/propolis reduced the total abundance of all sampled arthropods, mainly Hymenoptera and Mecoptera on the canopy and Isopoda, Carabidae and Staphylinidae on the soil. In detail, the phenological dynamics of Ichneumonoidea, Araneae and Isopoda was particularly knocked down. The coenotic balance on the canopy was unaffected by the spraying of the mixture. Among the compounds here considered as organic, this mixture had the strongest negative effect on non target arthropods, mainly at soil level.

3. The rotenone reduce the total abundance of arthropods during the season on the canopy where Icneumonoidea and Mecoptera were the most affected. At soil level the rotenone seems to have no significant knock down effects. Although a decreasing of population dynamics was registered by using the A/B_{ratio}, a good coenotic balance was yet preserved.
4. The kaolin reduced the abundance of arthropods at canopy level, but it preserves a good coenotic balance among trophic guilds and have no impact on the soil arthropods communities. On the canopy only Lepidoptera were unaffected by the kaolin spraying, on the soil no taxa seems to be significantly affected. This could be due to the interference between kaolin particle film and the feeding strategies utilised by pollinators, phytophagous and predators.

In previous study, Iannotta et al. (2007) stated that compounds allowed in organic olive groves are harmful for non target arthropods. In this study the utilised active agents (rotenone, copper oxychloride) have shown only few negative effects. This fact could be attributed to the grass cover of here sampled experimental theses which probably reduced the effects of active agents with short term efficacy. In definitive, the grass cover could be play an important role in minimising the impact of sprayed compounds on non target arthropods furnishing a shelter against the direct contact with active agents.

In conclusion, the use of compounds allowed in organic olive farming have an environmental impact lower than conventional pesticides. The impact could be minimised by the soil grassing.

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