EDAPHIC MESOFAUNA COMMUNITY STRUCTURE IN ORGANIC AND CONVENTIONAL MANAGEMENT OF CRANBERRY (*Vaccinium* sp.) PLANTATIONS: AN AGROECOLOGICAL APPROACH

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ABSTRACT

The aim of the present study was to determine and compare taxa richness, abundance and diversity of the edaphic mesofauna community between plantations of cranberries (*Vaccinium* sp.) subjected to organic and conventional management in farms in central-south Chile (37°28'S), as also to evaluate changes produced in their diversity and abundance diversity and abundance, as result of the change from conventional to organic management. In July 2006 two farms were chosen, one with one year under organic management (OM1) and a second one under six years of certified organic management (OM6). Each farm was divided in four quadrants, each one with a surface of 2,500 m^2. In each quadrant was extracted one sample with six replicas of 188.5 cm^3 each. Samples were processed in the laboratory using the Berlesse-Tullgren system for the extraction of mesofauna and the subsequent counting and identification of specimens. To compare the organic managed plantation, it was selected a farm under conventional management (CM) with similar climatic and edaphic conditions. On each parcel, taxa richness, abundance, alpha (α) diversity, dominance and beta (β) diversity were determined. Significant differences between diversity values were determined with Student's t test ($\alpha = 0.05$). It is concluded that taxa richness is similar in all plantations, independent of agricultural management, whereas abundance of each taxon individually is different between both types of management. There are significant differences in diversity between the organic plantations (OM1 versus OM6) and between the conventional (CM) versus organic plantations ($P<0.05$). Qualitative (taxocenotic) and quantitative (biocenotic) similarity recorded in the edaphic communities from both types of plantation management may be explained by soil type and climate similarity, as well as by the homogeneity of the edaphic ecosystem.

Keywords: edaphic mesofauna, organic farming, conventional farming, *Vaccinium* sp., mediterranean climate.

INTRODUCTION

At the level of arable and livestock farming, emphasis has been placed on the importance of edaphic fauna for sustainable agriculture, based on their multiple functions in the ecosystem (Primavesi, 1990, Hendrix *et al.* 1990, Crossley *et al.* 1992, Stork and Eggleton, 1992, André *et al.* 2001). In fact, it has been shown that the management practices carried out in organic agriculture increase the functional diversity of edaphic micro-arthropods (Paoletti and Pimentel, 1992, Mader *et al*. 2002, Benttsson *et al*., 2005, Diepeningen *et al*., 2006) as compared with conventionally practices (Lara *et al*. 1986, Doles *et al*. 2001, Peredo *et al*. 2002).

In Chile, there are no studies on community structure of edaphic mesofauna in soils subjected to organic management. In this respect, we have hypothesized that when organic management is started in a plantation after a conventional management, the incorporation of high amounts of organic material to the soil will increase the diversity of resources for edaphic organisms. Therefore, we may expect to find a community structure conformed by a great diversity of taxa at low abundance in cranberries (*Vaccinium* sp.) plantations in a transitional year from conventional to organic management. On the other hand, in plantations subjected for a longer period to organic management, we can expect to find only those mesoedaphic organisms which adapt to this condition, with a reduction in the diversity of taxa, but an increase in the abundance of the species. At the same time, we expect that the edaphic community structure of plantations under conventional agricultural practices will be different on diversity and abundance compared to organic practices. In this context, the objectives of this research were i) to determine and compare taxa richness, abundance and diversity of the edaphic mesofauna community structure between cranberries plantations subjected to organic and conventional management in farms of central-south Chile, and ii) to evaluate the changes in their diversity and abundance, as a result of management change, from a conventional to an organic one.

MATERIALS AND METHODS

Study area

The study was carried out in a private farm in cranberries plantations located 15 km west of the city of Los Angeles, Bío-Bío Region, Chile (37°28’S). The climate of the zone is Mediterranean. The mean annual precipitation is 1,303 mm, mostly concentrated between March and August. The maximum average temperature of the warm period (January) is 29°C and the minimum average temperature of the cold period (July) is 5°C (Del Pozo and Del Canto, 1999). The soils are derived from volcanic ashes deposited recently over an unrelated substrate, which is compacted but not cemented, with slow permeability. The soils are very deep, well drained, with high humidity retention (Tosso, 1985).

Organic management utilizes inputs allowed by international certification norms, consisting mainly in the periodic incorporation of compost elaborated with manure obtained from intensive poultry farms, complemented with the incorporation of phosphoric rock in winter and compost tea through the irrigating system. Weed control is carried out by mechanic methods, complemented with the establishment of between-row winter crops, which in addition allow curculionid larvae control.

On the other hand, in the conventional management, soil is fertilized with phosphorous (triple superphosphate) in fall and nitrogen (urea) in spring, by means of synthetic chemical products. Weed control is done mechanically complemented with herbicides (Gliphosate and Azolan) and pre-emergent residual herbicides (Simazine plus Pendimethanyl) in spring.

Sampling design

In July 2006, two farms were chosen, one with one year under organic management (OM1) and a second one under six years of certified organic management (OM6). The OM1 was considered as a transition plantation, since it had previously been conventionally managed. Each farm was divided in four 2,500 m^2 quadrants. In each quadrant was extracted one sample with six replicates of 188.5 cm^3 each. The extraction was done with a corer to a depth of 15 cm. This depth was established in consideration of the depth levels with the greatest presence and activity of edaphic mesofauna (Neher and Barbercheck, 1999). The samples were mounted over seven days using a modified Berlesse-Tullgren system (Lara *et al.*, 1986) to ensure the extraction of the edaphic organisms. The organisms were collected in alcohol at 75% and the specimens obtained were studied under a stereoscopic microscope, counted and identified taxonomically at the level of order and sub-order, to compare and analyse diversity and abundance of the edaphic mesofauna. To compare the organic managed plantation, it was selected a farm under conventional management (CM) with similar climatic and edaphic conditions.

Data analysis

The richness and abundance of taxa per plot were estimated, as also the diversity and homogeneity of the mesofauna groups in each plantation (CM, OM1 and OM6) (sensu Doles *et al*., 2001). The density was estimated in (n m^{-2}). The α diversity and dominance were calculated using the Shannon (H') Index (Cox, 1968) and the Homogeneity (Equity) Index (J) (Krebs, 1985). In addition, the β diversity was determined to establish the taxocenotic and biocenotic similarities using the Bray Curtis Index estimated with the Biodiversity Pro software. To evaluate whether significant differences exist between the values of the diversity indices obtained in the two communities in the first year, Student's t test ($\alpha = 0.05$) was applied (Zar, 1999)

RESULTS AND DISCUSSION

Table 1 shows the taxa recorded in the present study, with their respective abundances and densities. In both the organically managed and the conventional plantations, the same taxa of edaphic mesofauna were recorded, with the exception of Protura, recorded only in the plantation with conventional management (CM), and Diplopoda only in the organic management plantation, in both cases with very low abundance (Table 1).

The most abundant taxa were Acarina and Collembola. Differences in abundance appeared between the organic plantations (OM1 and OM6) and the conventionally managed plantation (CM). In this sense, although the presence/absence of edaphic mesofauna groups was similar in the two cranberries plantations (organic and conventional management), clear differences were observed in the abundance of each taxon in the different plantations.

The most abundant taxon of edaphic mesofauna in all the cranberries plantations under organic management was Acaridida, followed in descending order by Oribatida, Tarsonemida and Gamasida; Entomobryomorpha was the most abundant of the Collembola (Table 1). In the plantation under conventional management (CM), the most abundant taxa of mites were Oribatida and Prostigmata, and Poduromorpha among the Collembola. Regarding the analysis of values between the organic plantations, in OM1 were recorded 235 individuals of Oribatida (24 samples).

Table 1. Abundance (A), mean (X), standard deviation (DE) and density (D) of edaphic mesofaunistic taxa present in conventional management Vaccinium sp. plantation (CM) versus *Vaccinium* sp. plantations with one(OM1) and six (OM6) years of organic management in Central-South Chile.

	CM			**OM1**			**OM6**		
Taxa	**A**	**X (DE)**	**D: n/m^2**	**A**	**X (DE)**	**D:n/m^2**	**A**	**X (DE)**	**D: n/m^2**
Oribatida	725	29(26)	14500	235	9.4(6.6)	4700	404	16.2(13)	8100
Gamasida	65	2.6(3.5)	1300	108	4.3(3.1)	2150	104	4.2(3.4)	2100
Uropodina	9	0.4(26)	200	6	0.2(0.5)	100	12	0.5(0.8)	250
Prostigmata	117	4.7(3.5)	2350	34	1.4(1.2)	700	33	1.3(1.5)	650
Tarsonemida	50	2(2.7)	1000	179	7.2(8.2)	3600	95	3.8(6)	1900
Acaridida (A+L)	52	1.4(4)	700	255	10.1(19)	5050	493	16.(60)	8250
Total Acarina	1018			817			1141		
Entomobryomorpha	38	1.5(2.3)	750	114	4.6(6.6)	2300	69	2.8(2.9)	1400
Poduromorpha	128	5.1(6.7)	2550	83	3.3(5.7)	1650	70	2.8(3.7)	1400
Symphypleona	0	0	0	0	0	0	0	0	0
Total Collembola	166			197			139		
Diplopoda	0	0	0	4	0.2(0.5)	350	2	0,1(0,3)	50
Quilopoda	8	0.3(0.9)	150	3	0.1(0.3)	50	1	0,04(0,7)	20
Protura	1	0.04(0.2)	20	0	0	0	0	0	0
Diptera (L)	1	0.04(0.2)	20	20	0.8(2.6)	400	3	0,1(0,3)	50
Nematoda	3	0.12(0.3)	60	14	0.6(1.1)	280	9	0,4(0,7)	200
Total Abundance	2378		23540	2055		21050	2566		24170
Average values (X)	158.5		1810.8	137.0		1619.2	171.1		1859.2

This value increased to almost double in OM6 (Table 1). According to Behan-Pelletier (2002), this group specialises in the exploitation of temporary habitats, behaving as a +r strategist, with a high rate of reproduction and short life cycle (8 to 21 d). This behavior is favoured by the hipopus, a larval stage which disperses effectively to habitats offering a high availability of food. Tarsonemida increased considerably in OM1, stabilising at lower abundances in plantations with longer periods of organic management. Next in abundance is Gamasida, with very similar abundances between the different plantations. Among Collembola, Entomobryomorpha and Poduromorpha are more abundant in OM1 than in OM6 (Figure 1).

In the plantation with conventional management (CM), Oribatida is the most abundant taxa, with higher values recorded than in plantations under organic management, reaching a total of 725 individuals in the 24 samples analysed, followed by Poduromorpha with 128 individuals and Prostigmata with 117 individuals per sample (Figure 1). Edaphic mesofaunistic studies carried out by Peredo *et al*. (2002) in plum plantations under conventional practices in the central region of Chile, reported only the presence of Gamasida and Uropodina (Acarina) in low abundance, as well as total absence of Collembolla. On the other hand, results of the present study on edaphic community structure in plantations under organic management fit with those obtained by Peredo *et al*. (2002) in naturalized prairies in the surroundings of plum plantations.

Table 2 shows the values for diversity (H') and homogeneity (J) for each type of plantation. Although the H' values are similar between the organic plantations, the highest value was recorded in OM1. This fact was as expected, since this plantation is considered in transition to organic management, in which the agro-chemical consumables of the pre-existing conventional management are being replaced by other low energy alternatives, allowing a greater inward movement of different edaphic groups in search of food, thus increasing biodiversity (Altieri, 1999). In the other organic plantation (OM6), given the longer period under this management, the stability in the diversity values of the edaphic mesofauna taxa would be explained by the accumulation of organic material, providing a substrate which releases nutrients and appropriate maintenance of the soil structure. This stability results in taxa richness, which would be represented by those groups which adapt best to organic management.

The differences in the H' values between OM1 and OM6, which show the highest and lowest values for H' respectively, were significant ($P<0.05$). Differences between the H' values of the conventional plantation and the H' values of the organic ones were also significant ($P<0.05$), which would indicate changes in the edaphic mesofauna communities subjected to organic conversion. Studies done by Schrader *et al*. (2006) in communities of Collembola subjected to organic conversion in northern Germany (Trenthorst), also indicated an increase in diversity after three years. In the present study, the communities of micro-arthropods increased significantly their diversity values during the year of transition to organic management (OM1) and whereas in OM6 this parameter diminishes (to then get stabilized) at a value lower than in OM1, but higher than in CM.

The homogeneity values (J') (Table 2) differed between CM and OM1. The lower value obtained in CM is explained by the high dominance of Oribatida, while the higher value obtained in OM1 is explained by their reduced dominance among the taxa. These results corroborate

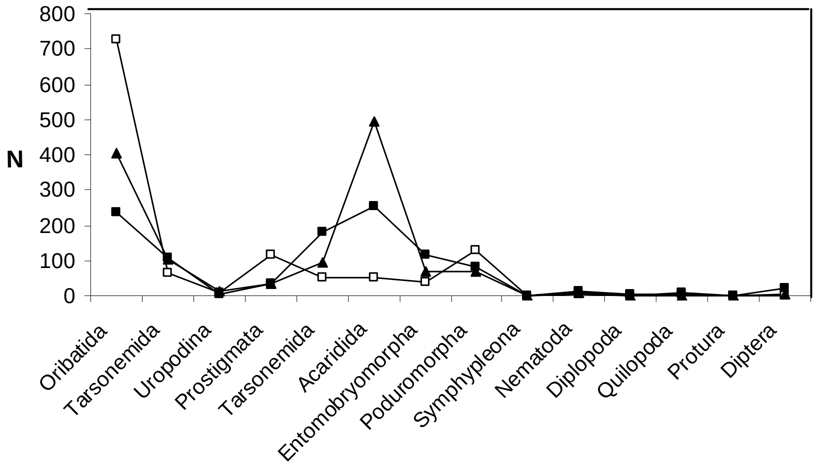

Figure 1. Comparison of abundance of edaphic mesofaunistic taxa present in conventional management *Vaccinium* sp. plantation (CM) versus *Vaccinium* sp. plantations with one (OM1) and six (OM6) years of organic management in central-south Chile. (white square: CM; black square: OM1; triangle: OM6).

Table 2. Diversity values (H'), highest diversity (H max), homogeneity (J) and edaphic mesofauna richness present in conventional management *Vaccinium* sp. plantation (CM) versus Vaccinium sp. plantations with one (OM1) and six (OM6) years of organic management in central-south Chile.

Indexes	CM	OM1	OM6
Shannon H' Log Base 10,	0.61	0.852	0.712
Shannon Hmax Log Base 10,	1.079	1.079	1.079
Shannon J'	0.565	0.79	0.66
Taxa Richness	12	12	12

the structural change experienced by the edaphic communities in cranberries plantations submitted to a management change (conventional to organic management) as was OM1.

As indicated above, there is a high taxocenotic (qualitative) similarity between the groups of edaphic mesofauna recorded between the plantations subjected to organic management (OM1 and OM6) and the taxa recorded in CM (Figure 2a). However, there are quantitative differences in the biocenosis of the edaphic communities in the two types of plantations, as is shown in Figure 2b. The dendrogram shows two similarity groups separated at the level of the 50.62%, which separates the CM community from the organic plantations. At the same time, organic plantations (OM1 and OM6) are similar at 75%. The great similarity would be explained by the similar niche conditions generated after the transition year. Bargett (2002) indicates that of the great number of studies done to date, few show

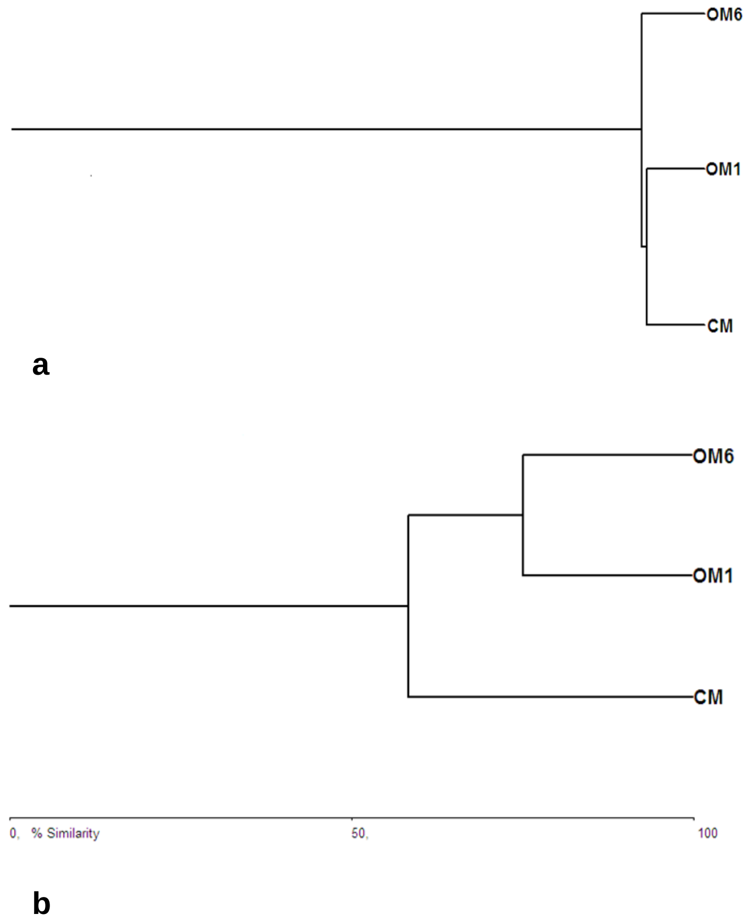

Figure 2. Taxocenotic (a) and biocenotic (c) similarity dendrogram of *Vaccinium* sp. plantation with conventional management (CM) and *Vaccinium* sp. plantations with one (OM1) and six (OM6) years of organic management in central-south Chile in central-south Chile.

that edaphic diversity is regulated by competition or disturbances; rather, its regulation is attributable to the nature of the soil, given the extreme variety of habitats in both time and space provided by division by niche, resources or habitat specialization, thus allowing extensive co-existence of species or taxa. In this respect, the results of the present study indicated high qualitative and quantitative similarities between the communities of edaphic mesofauna in both types of management (organic and conventional). This may be explained by similarities in the type of soil and climate, or those due to ecosystem homogeneity, since the weed control in this monoculture has an impact on the root homogeneity below the surface.

In this way, a similar habitat in both the CM and the OM plantations is provided, as well as a similar availability of resources for edaphic organisms, corroborating the indications of Bargett (2002). The results of the present study allow us to note that the Oribatidae is the dominant group of mites in the type of soil and climate where the cranberries plantations are located, although it is more satisfactorily expressed in plantations with conventional management. These results agree with Noti *et al*. (2003) who indicate that soil properties, especially moisture content, which increases in a greater proportion in the winter season in temperate climates, are fundamental for the expression of the abundance of Oribatidae. On the other hand, Acarididae is the taxa which presents the best expression in plantations with organic management and probably influences the development of the Oribatida, given the low abundance found in this type of plantation as compared with conventional management.

The high taxa richness (Table 2) in the organic plantations (OM1 and OM6) indicated that the ecosystem functions fulfilled by groups of edaphic mesofauna ensure stability and ecosystem services. Nevertheless, as in monocultures the biodiversity is reduced significantly, it would be useful to carry out proper management of the vegetation which accompanies the monoculture of cranberries. In this sense, the intensive management or cleaning carried out between the rows would make them to act as fragments of habitat at the scale of edaphic mesofauna, avoiding the exchange between species and the colonization of such spaces.

A greater environmental heterogeneity below the soil surface, provided by the diversity of plant roots, would ensure a greater edaphic biological diversity and the existence of all the functional groups, especially those taxa which have no equivalent trophic role. This would ensure that essential soil functions such as the nutrients cycling and carbon mineralization are expressed, increasing fertility and improving the soil structure. The importance of soil organisms for plants has been extensively proved in the last century and today there is no doubt that edaphic diversity is being considered as a tool for sustainable agriculture, hence the importance of making progress in knowledge of edaphic biodiversity in Chile.

CONCLUSIONS

Our results allow to conclude that taxa richness is similar in plantations with conventional (CM) and organic management (OM1 and OM6), whereas abundance of each taxon individually is different between both types of management. The highest value for diversity (H') and homogeneity (J) were observed in the plantation with one year of transition to organic management (OM1). At the same time, there are significant differences in diversity between both organic plantations, as well as between the conventional and the organic plantations. Qualitative and quantitative similarity recorded in the edaphic communities from both types of plantation management may be attributed to soil type and climate similarity, as also to the homogeneity of the edaphic ecosystem.

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