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AGRICULTURE
Research Article

Ibs-Bf and Qbs-Ar Comparison: Two Quantitative Indices Based on Soil Fauna Community

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Received: October 27, 2015; **Published:** November 09, 2015

Abstract

Defining soil quality has become more and more important in recent years, as a result of increased land use, intensive agriculture and soil degradation. These topics have prompted researchers to find new methods for defining soil condition and evaluating soil quality. Alongside the already proven physical-chemical methods, biological indices based on soil fauna were developed in the last twenty years. Alteration in soil chemical, physical or biological properties can affect soil fauna, in terms of biodiversity, abundance and functional relationships among taxa. Accordingly, soil fauna community generally is well-developed and diversified in soil with good quality in terms of organic matter content, absence of pollution and degradation etc. In this paper we aim to evaluate if the responses of two indices, the most dated QBS-ar and the newest IBS-bf, both based on soil fauna community, are comparable. The two indices differ completely in methodology and partially for the taxa they take account and some other aspects.

For comparing of the two indices, 14 agricultural sites in the Veneto region (Italy) were identified, 6 with organic and 6 conventional managements; two uncultivated areas (grasslands and brushwood) were chosen as control. Three soil cores for QBS-ar application and 1 for IBS-bf application were collected both in spring and autumn 2014. The results showed differences between organic managements, conventional managements and control areas for both indices. Both protocols recorded the same trend. The highest value was found in the control, intermediate value in organic and the lowest in the conventional managements. Moreover, QBS-ar index showed significant higher values compared to IBS-bf (in both managements). According to this consideration, the Scientific Committee of the World Biodiversity Association decided to take into account the results of this experimentation and partially modified the IBS-bf index. In this paper we reported these changes. However, it is important to underline that both indices showed a similar trend, confirming that the soil fauna is a good tool to assess soil biological quality.

Keywords: *Bioindicators; Biodiversity Indices; Organic and conventional managements; Soil arthropods; Soil fauna*

Introduction

As highlighted by Bastida., *et al*. [1], the term "soil quality" has been assigned a variety of definitions, ranging from a purely agricultural to a more environmental point of view. The most known definition comes from Karlen., *et al*. [2] who defined soil quality as "the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation". Although the difficulty of identifying a general soil quality definition, it is still very important to preserve soil quality for all the ecosystems services provided by soil. Soil quality could be evaluated using a large number of indicators (chemical, physical, biological) depending on the scale and the aim of the study. Chemical indicators, i.e. solid organic matter, and physical indicators, i.e. bulk density and aggregate stability, are the most frequently used indicators. The need to support chemical-physical parameters with biological analysis has become more important in the last twenty years. Van Straalen and

Krivolutsky. [3] Defined a bio indicator system as a set of indicators, each related to one particular aspect of the environment and jointly maximizing the amount of information. Doran and Zeiss [4] suggested that soil quality indicators should follow:

a. Sensitivity to variations of soil management
b. Good correlation with the beneficial soil functions
c. Helpfulness in revealing ecosystem processes
d. Comprehensibility and use for land managers
e. Cheap and easy to measure.

Generally soil quality bio monitoring is too difficult to apply for land managers because the measurement systems are often too complex, too expensive or both [5]. The major problems concerning the application of the indices already developed are related to the low standardization level or the limited spatial scale where they can be applied [1]. Among several indices that have been developed over the last few years, it is worth mentioning the QBS-ar [5] and the IBS-bf [6]. Both these indices are based on soil fauna, the first on soil micro arthropod community while the second on earthworms, molluscs and arthropods. The most dated QBS-ar has been applied in several ecosystems, agricultural lands, grasslands, urban soils, woods at different level of naturality and degraded soils [7-18]. One of the main strengths of this protocol is that its application does not require specific taxonomic skills entail on analysis at the species level. The IBS-bf is inserted together with other eleven actions in the "Biodiversity Friend" protocol, proposed by World Biodiversity Association in 2010 to assess the biodiversity conservation in agriculture. IBS-bf has been applied in the last five years to evaluate the soil biological quality of about 250 farms distributed all over Italy, from Trentino to Sicily. Considering that, both indices are based on soil fauna, this paper aims to evaluate if they are able to give comparative information about biological soil quality in conventional and organic farms. We also compare the results obtained by the application of the QBS-ar and the IBS-bf with the Shannon-Weiner diversity index and Pielou evenness index.

Materials and Methods

Study Areas

The study was conducted in 14 sites located in the Province of Verona, Veneto region, Italy. Six of them were managed with conventional agriculture, six with organic management, two were uncultivated (grassland and brushwood); these last two sites were considered as control. In Table 1 are reported some information about study areas.

Soil Biological Quality Indices

QBS-ar index

The QBS-ar (acronym of Soil Biological Quality, in Italian "Qualità Biologica Del Suolo") is a biological index that takes into account soil micro arthropod community. It is based on the concept that the number of micro arthropod groups well adapted to soil is higher in soil characterized by good "biological quality" (understood as good stability, high organic matter content and high biodiversity level). The main phases for obtaining QBS-ar value are:

a. Soil sampling
b. Micro arthropod extraction
c. Determination of biological forms and assignment of the Ecological-Morphological Index (EMI), and
d. Calculation of the QBS-ar index as the sum of the EMI values

[5]. This index was developed in order to overcome the well-known difficulties of identifying the species level of edaphic mesofauna and with the intention of evaluating the micro arthropods' level of adaptation to the soil environment life. Within each taxon (class for Myriapoda, order for Exapoda, Chelicerata and Crustacea), QBS-ar method requires searching for the biological form (morpho-type) that is most adapted to soil. This morpho-type receives an eco-morphological score (EMI) proportionate to its adaptation level to soil. EMI values ranges from 1 (epi-edaphic forms) to 20 (eu-edaphic forms). To sum of all the EMIs of a sample is the QBS-ar value of that sample [5]. For more information about the QBS-ar applications see [5,9,12,17 and 19].

Three soil samples were collected in each site. A total of 42 soil samples were collected both in autumn and spring 2014. Each soil sample measured 100 cm^2 and was taken up to a depth of 10 cm. Micro arthropods were extracted using the Berlese-Tüllgren funnel, collected in a preservative solution of 75% ethyl alcohol and 25% glycerol by volume, and identified at different taxonomic levels (class for Myriapoda, order for Exapoda, Chelicerata and Crustacea). The organisms belonging to each taxon were also counted in order to estimate their density at the sampling depth (10 cm) by extrapolating the number of individuals to $1m^2$. The number of organisms was used to calculate the Shannon-Weiner diversity index and Pielou evenness index.

IBS-bf

The "Biodiversity Friend" method [6] is based on the analysis of soil samples in which the presence of soil animals (Arthropoda, Gastropoda and Oligochaeta) is detected to determine the IBS-bf (acronym of Soil Biodiversity Index, in Italian "Indice di Biodiversità del Suolo"). The presence of each group is recorded with a score based on the QBS-ar method, in the survey form. Compared to the QBS-ar method, the IBS-bf takes into consideration Gastropoda and Oligochaeta, in addition to Arthropoda.

For the IBS-bf application one soil sample was collected in each area. The protocol of the IBS-bf needs a "free-hunting" of organisms (with or without aspirator). During this operation the exploration of the muscicolous, saproxylic and lapidicolous environments should be carried out. In the IBS-bf survey the collecting of the specimens is not required; the simple observation of the animals will be recorded on the survey form. The synthetic value obtained is used in the "Biodiversity Friend" checklist to evaluate the conditions of the cultivation substrate.

The technique used for the IBS-bf soil survey is based on the use of the entomological litter reducer. The survey is made by digging a volume of soil of about three square decimetres. The hole must have a depth of about 25-30 cm. The soil is collected and put into an entomological litter reducer, equipped with a 10 mm mesh sieve. The material obtained is sieved again through another sieve with 4 mm mesh on a white square piece of cloth (1 x 1m large). The large soil particles collected in the sieve are put in a corner of the cloth. At this point, the operator begins the identification of the invertebrates, directly or with the help of a magnifying glass. The different taxa founded are identified; their presence is noted on the survey form. In case of uncertain identification, for large size organisms (more than 5 mm), a camera can be used, while small size organisms can be collected by means of entomological pincers or little brush and put in a test-tubes with ethyl alcohol 70% to be identified successively. The samples should be collected in workable (in "tempera") soil; too dry or too rainy periods must be avoided. The most favourable seasons are spring and early autumn. However, surveys must be realized with sunny and warm conditions (more than 18°C), to stimulate the soil fauna to move after sieving. Further investigations by hand-collecting can be made under stones deeply buried in the soil, if they are present in the crop. At the end of the survey, which can not take more than 40 minutes, the operator sums all the scores registered on the form IBS-bf. According to the "Soil Biodiversity Index" a biologically active soil should reach a total score of 100 or more [6].

A total of 14 soil samples were collected in each season. As for the QBS-ar, also in this case the number of organisms observed was used to calculate the Shannon-Weiner diversity index and the Pielou evenness index.

Statistical Analysis

Data of the indices were analysed with Wilcoxon test, for paired samples, in order to highlight differences between organic and conventional management. The same statistical test was used to highlight differences between QBS-ar and IBS-bf, and with the two biodiversity indices (H' and J) computed following the two different protocols. Statistical analyses were performed with software R 3.2.1 [20].

Results

Indices

Statistical analysis of the data showed significant differences both between indices and management. The highest values of the QBS-ar index were recorded in the control areas (Figure. 1), and considering the type of management, statistical analysis highlighted differences between the two managements (p-value = 0.043), showing the highest value in the organic ones. In particular, QBS-ar was highest in the organically-farmed vineyards, while lowest in conventionally-farmed strawberry during spring. In autumn, the highest value was recorded in the grasslands while the lowest in the conventionally-farmed asparagus. Despite the different trends between the two seasons the lowest value was recorded in the conventional management while the highest in the organic or control areas.

Compared to conventional management the IBS-bf index (Figure 1) showed a trend similar to the one observed for the QBS-ar. This trend showed higher values in organic management, but highest values in control areas. Indeed, the highest value was recorded during the spring in the brushwood (control area) and the lowest in organically-farmed apples, and conventionally-farmed strawberry. In autumn, we recorded a same trend, with the highest value in brushwood and the lowest in conventionally strawberry farming. Despite these differences between the two managements and the control areas, statistical analysis failed to show any significant differences. Unfortunately, there is no previous data to confirm this trend.

Statistical analysis between the two indices showed significant differences both for organic and conventional managements (p-value respectively = 0.002, 0.004). In both cases, QBS-ar index showed higher values compared to IBS-bf index.

The results obtained on the Shannon-Wiener and Pielou indices, both calculated on the abundance of the animals extracted by the QBS-ar protocol, confirmed the trend observed for the QBS-ar index. Shannon-Wiener showed the highest value in control area, intermediate in organic and the lowest in conventional management (Figure 2a). The same trend was recorded for Pielou evenness index (Figure 3a). However, statistical analysis failed to show any significant differences. The same biodiversity indices, applied on densities data derived from IBS-bf protocol, confirmed the trend observed above (Figure 2b and 3b). Regarding Shannon-Wiener index, statistical analysis failed to show any significant difference between the two management. On the contrary, the two Pielou evenness indices, computed following the two protocols, were statistically different both for organic and conventional management (p-value respectively = 0.050, 0.001).

Animal Densities

Densities of organisms were recorded both during QBS-ar and IBS-bf application. Considering the arthropod densities, obtained applying the QBS-ar protocol, we recorded the highest densities in the conventional kiwi cultivation, followed by organic asparagus and vineyards 2 in spring (Table 2). The two control areas recorded intermediate densities, while strawberry, both organic and conventional, the lowest. Almost all the cultures and managements showed micro arthropods well adapted to soil, such as Protura, Diplura and Symphyla. Pseudoscorpiones were only collected in the organic and conventional vineyard 1, in the conventional vineyard 2 and in the two control areas. Otherwise, in autumn, the highest value was recorded in grassland followed by the two organic management vineyards and the lowest in conventional asparagus and, once again, in conventional strawberry (Table. 3). According to the spring sampling, the autumn ones showed micro arthropods well adapted to soil in the organic and conventional kiwi cultivation, in the organic cultivation of both vineyards and, finally, in the two control areas. In the autumn sampling we collected Pseudoscorpiones not only in vineyards and control areas, but also in apple and kiwi cultivation managed in the conventional way.

Densities of organisms collected during IBS-bf protocol application were higher in kiwi, vineyard 2 and asparagus cultivation, all organic, in spring (Table 4). The lowest were recorded in organic apple cultivation and conventional strawberry. In the last cases we recorded a very low number of organisms belonging to one taxon only, Coleoptera. The two control areas recorded intermediate values. In the spring sampling, for IBS-bf calculation, Isopoda were found only in asparagus and kiwi cultivation, both organic, and Pseudoscorpiones only in grassland (Table 5). In autumn, indeed, we found higher densities in asparagus organic, once again, and in apple organic. The lowest were recorded in strawberry cultivation, both organic and conventional. As in spring, control areas, recorded intermediate values.

Moreover, in the IBS-bf application, we found groups not recorded in the QBS-ar, such as Orthoptera, Dermaptera and, also, a higher number of Coleoptera. Instead, in the IBS-bf we did not find organisms well adapted to soil, such as Protura, Diplura and Symphyla. Moreover, in general, we found higher densities, both total and for each taxon, using the QBS-ar application.

Discussion

The present study confirms that organic agriculture preserve the biodiversity of the soil. As highlighted by many authors [21-24], tillage, a typical conventional practice, alters not only many aspects of soil environment, such as soil water content, compaction, porosity and temperature [25], but also soil fauna community. Tillage itself may alter and affect soil organisms, according to their susceptibility to soil compaction and disturbance. Tabaglio., *et al*. [17] showed that four years of no-tillage on a silt loam under continuous maize increased not only soil organic carbon, total N, C/N, exchangeable K and water aggregate stability but also soil micro arthropod community. Tillage makes soil more susceptible to wind and water erosion which, in second place, may influence organic matter and nitrogen in the top layer of the soils [25]. On the other hand, as underlined by McLaughlin and Mineau [25], conservative tillage, including minimum tillage and no-tillage, generally reduces the physical disturbance of soil and often leaves the crop residues from the previous year growth on the surface, increasing the soil organic matter content. Organic farming could be characterized by less use of herbicides and insecticides and especially this latter could be dangerous not only for insects on the plant or on the soil surface but also for earthworms and soil arthropods [25, 26]. Herbicides could influence organisms' performances and change ecological interactions among species [23]. Recent studies [27] showed that also herbicides have negative effects on the activity of soil organisms. Both QBS-ar and IBS-bf confirmed higher soil biological quality in organic agriculture than in the conventional one. It is possible that, inside the two managements considered in this study, soil micro arthropod communities might be differently affected by crops or cultivation. Different crops, indeed, requires different actions. For example, kiwi cultivation does not need lots of actions because its resistance to pathogens and parasites [28]. Our results confirm that the indices values found in the kiwi cultivations (organic and conventional) are higher as those we found in the control areas. Because of their lower resistance to pathogens, vineyards and apples need more cultivation acts than kiwi, such as fertilization, herbicides and pesticide treatments [29]. Generally strawberry is a crop with a high impact on soil, needing mulching and lots of chemical treatments against phytophagous [30]. Soil organisms could be negatively affected by these treatments and our data confirm this trend; in effect we found lower indices values almost always in strawberry cultivation. The same trend was observed for the animal densities.

Considering the main focus of this study, IBS-bf and QBS-ar showed the same trend. Indeed, both indices showed the highest median value in the control (grassland and brushwood), whereupon organic management, and, at the last, conventional management. Concerning QBS-ar, this result confirmed the data observed by Tabaglio., *et al*. [17], Aspetti., *et al*. [8] and by more than 20 years of experimentation [31]. Aspetti., *et al*. [8] highlighted that QBS-ar seems to change more according to agricultural management, as well as to different crops and fertilization, than soil type. Moreover, they found that QBS-ar, in fixed agricultural conditions is stable and repeatable at the field scale, but sensitive to climate. Rüdisser., *et al*. [16] showed that the QBS-ar reacts sensitively to land use and hence can serve as an important surrogate indicator for sustainable land use practices.

Results of the IBS-bf differs from QBS-ar in particular in the total amount of organisms recorded, in the lower values and in the lack of discovery of organisms well adapted to soil, such as Protura, Diplura and Symphyla. But, on the other hand, the higher mesh of the sieve, used in IBS-bf protocol, allows discovering more epigean organisms, such as Coleoptera, Araneida, Orthoptera and Dermaptera.

Conclusion

According to the results obtained in this study, the Scientific Committee of the World Biodiversity Association suggested to modify the IBS-bf protocol, to be more consistent with QBS-ar, as follows:

a. Increase of the soil volume to be examined
b. Separation of the soil sample in three different subunits
c. Revision of the scores of some taxa.

In particular, the soil volume passed from 3 dm3 to 6 dm3 of sieved soil. This larger quantity has to be collected from three different samples (2 dm3 each), in three sites at the distance of 25m from each other, at the vertices of an equilateral triangle, inside the crop; each sample is 20 cm deep. The soil obtained by the three subunits must be examined as a singular sample on which to calculate the IBS-bf. The scores of the taxa were modified in the following way: Lumbricidae and Acari passed from a score of 25 to 20; Orthoptera

(Gryllidae and Gryllotalpidae) passed from a score of 10 to 20 and Embioptera passed from a score of 15 to 10. Furthermore, Chilopoda, with an original score of 10, were separated in two groups: Lithobiomorpha (score 10) and Geophilomorpha (score 20); also Collembola, with a previous score of 20, were separated in two groups: epigean species (with furca) score 10, and soil species (without furca) score 20.

In conclusion, the present study confirms the micro arthropod community as good tool to assess soil quality, both for QBS-ar and IBS-bf, and the latter, even if requires more experimentation and implementation, can become a good and cheap index to evaluate soil biological quality, especially in agricultural ecosystems.

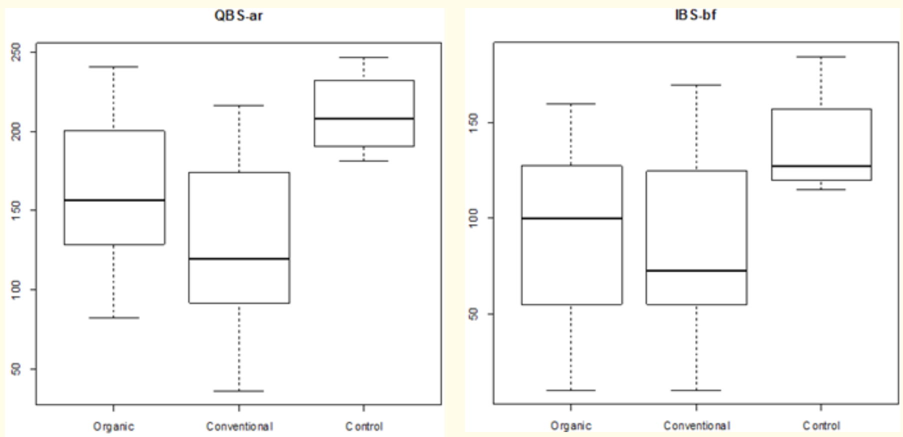

Figure 1: *QBS-ar and IBS-bf values detected in the three studied conditions. Box-plots show median, standard deviation and first and third quartiles.*

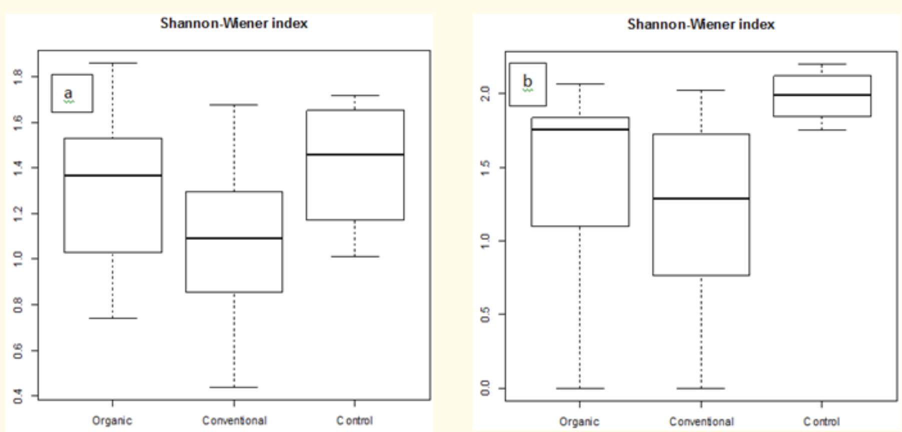

Figure 2: *Shannon - Wiener indices detected using the animal abundances obtained by the application of QBS-ar (a), and IBS-bf (b) protocols respectively. The box-plots show median, standard deviation and first and third quartiles.*

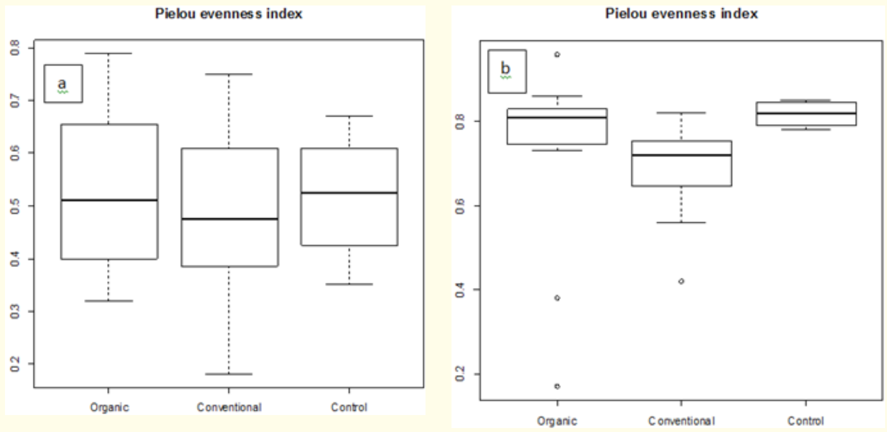

Figure 3: *Pielou eveness indices detected using the animal abundances obtained by the application of QBS-ar (a), and IBS-bf (b) protocols respectively. The box-plots show median, standard deviation and first and third quartiles.*

Farm name	Coordinates	Type of management	Culture	Soil
Lanza	45,318681 N 11,054014 E	Conventional	*Actinidia spp. (Kiwi)*	Gravelly soil
Corte dell'Olmo	45,362809 N 10,984812 E	Organic	*Actinidia spp. (Kiwi)*	Gravelly soil
Paese	45,347419 N 11,104865 E	Conventional	*Malus communis (Apples)*	Gravelly soil
Malacchini	45,381295 N 11,182025 E	Organic	*Malus communis (Apples)*	Gravelly-clay soil
Eredi Ferro	45,430381 N 11,189503 E	Conventional	*Vitis vinifera L. (Vineyard 1)*	Limestone
Fondo Prognoi	45,466705 N 11,056069 E	Conventional	*Vitis vinifera L. (Vineyard 2)*	Gravelly soil
Fasoli	45,445225 N 11,173192 E	Organic	*Vitis vinifera L. (Vineyard 1)*	Gravelly soil
Zanoni	45,459112 N 11,056294 E	Organic	*Vitis vinifera L. (Vineyard 2)*	Gravelly soil
Anderloni	45,338267 N 11,056444 E	Conventional	*Fragaria spp. (Strawberry)*	Sandy soil
Ca' Magre	45,242166 N 11,011796 E	Organic	*Fragaria spp. (Strawberry)*	Sandy soil
Dossi	45,333930 N 11,055886 E	Conventional	*Asparagus officinalis L. (Asparagus)*	Sandy soil
Filippi	45,287149 N 11,136401 E	Organic	*Asparagus officinalis L. (Asparagus)*	Sandy soil
Grassland - Forte Preare (Montorio)	45,461163 N 11,048151 E	Grassland (dry grassland with Xero-*Brometum* features)		Limestone
Woodland (within Eredi Ferro farm)	45,431570 N 11,188667 E	Brushwood (mixed wood with *Quercus ilex L., Carpinus betulus L., Quercus sp. pl., Ruscus aculeatus L.*)		Limestone

Table 1: *Farm name, geographical coordinates, type of management, culture and soil type of the 14 studied sites.*

		Apple		Asparagus		Kiwi		Stra berry		Vineyard 1		Vineyard 2		Brush wood	Grass-land
Taxa		C	O	C	O	C	O	C	O	C	O	C	O		
Pseu-doscorpi-ones										21	106	21		212	297
Araneida		21	85	21		276				21	21	42	276		64
Opiliones										21					
Acari		5244	1677	3715	22866	9427	7176	616	191	3270	17367	2972	6200	5924	10255
Isopoda			21				234				21	21	21		21
Diplopoda					212	170	318		21	149	297			64	1614
Pauropoda		42			21	297	446			1019	403	21	21	170	149
Symphyla					21	64	42		42	85	467		297	85	297
Chilopoda				21		21					64		64	64	21
Protura				106		297	42			191	149		21	127	149
Diplura						149				127				64	
Collembola		403	2378	1699	4650	13949	2144	42	106	1805	24437	1614	4883	5945	2590
Microcory-phia											42				
Der-maptera															
Orthoptera												64			255
Psocoptera					21										170
Hemiptera			234		234	1635	1146			743	425	170	276	42	85
Thys-anoptera				21	21		42					42	64	616	127
Coleoptera	adults	106	42	85	149	531	1338	127	21	106	212		212	149	21
	larvae	212	212	170	170	467	149	64	21	106	786	64	127		85
Diptera	adults														
	larvae	106	510	149	361	340	106			21	234	21	361		1125
Hy-menoptera	adults	255	106	106	1019	6242	3248		21	5053	26306	11210	16752	212	977
	larvae										828				
Lepi-doptera	larvae												21		
TOT		6389	5265	6093	29745	33865	16431	849	423	12738	72165	16262	29596	13674	18302

Table 2: *Number of microarthropods (ind/m^2) recorded during QBS-ar protocol application in spring sampling (O: organic, C: conventional).*

		Apple		Asparagus		Kiwi		Strawberry		Vineyard 1		Vineyard 2		Brus wood	Grass-land
Taxa		C	O	C	O	C	O	C	O	C	O	C	O		
Pseudoscorpiones		85				85					149				297
Araneida				21			42		42		42	64	106	21	85
Opiliones															
Acari		14798	1359	340	2718	11231	2208	382	3992	8365	12994	9490	11380	1741	27856
Isopoda			21			191	892				21			42	42
Diplopoda		21			127	127	64			21	64		21	21	658
Pauropoda			42			21	42		85		743	64	234	64	255
Symphyla		64	106		127	21	191	64	21	106	510	127	807	149	170
Chilopoda		106				42	85				552	64	42	127	21
Protura			64	42			21			21	149		85	467	467
Diplura					21	64					212		106		722
Collembola		361	1040	679	764	12590	977	531	18089	828	12123	11932	16624	1847	7962
Microcoryphia							21								
Dermaptera															
Orthoptera															
Psocoptera		42	21	64	21		42	127	21	85	64	21	85		85
Hemiptera		425	21	21	234	21	85	64			892	170	977	21	85
Thysanoptera													21		
Coleoptera	adults	191	42	21	64	403	318	21	170	106	106	191	127	212	212
	larvae				234	127	127		170	127	743	361	191		149
Diptera	adults														
	larvae	21	42	21	85	106	21		828		488	42	658	85	212
Hymenoptera	adults	21	42		15478	1104	276			1210	1805	2229	3121	594	127
	larvae														
Lepidoptera	larvae								21				21		21
Total		16135	2800	1209	19873	26133	5412	1189	23376	10869	31657	24755	34606	5391	39426

Table 3: *Number of micro arthropods (ind/m^2) recorded during QBS-ar protocol application in autumn sampling (O: organic, C: conventional).*

	Apple		Asparagus		Kiwi		Strawberry		Vineyard 1		Vineyard 2		Brush-wood	Grass-land
Taxa	C	O	C	O	C	O	C	O	C	O	C	O		
Pulmonata	333					333				667	333	333	667	10333
Enchytraeidae				6667										
Lumbricidae				667	667	333							1000	
Pseudoscorpiones														1000
Araneida	333		5333	4333	333	333		667	1667	1333	333			667
Opiliones														
Acari	333		17667	3333	6000	3333		2667	1667	1000	333		2333	4667
Isopoda				333		2000								
Chilopoda Lithobiomorpha													667	
Chilopoda Geophilomorpha					1333								1000	
Diplopoda				10333				1333	667	333	333		2000	6667
Collembola (epigeous species)			1000						1000				667	
Collembola (endogeous species)														1333
Diplura														
Thysanura	333													
Orthoptera (Gryllotalpidae and Grillidae)								333					667	
Dermaptera								333						
Blattoidea														
Psocoptera														
Coleoptera	4667	667	10333	9667	4667	9667	1000	667	3000	4333		1667	2667	
Hymenoptera Formicidae				5000	4333	65000		4000	14333	3000	6667	44667	6000	10000
Diptera larvae				667	667	1667				667			333	1000
Coleoptera larvae	333		1667		2333	667			1000	333				
Other Holometabola larvae			333		333	333						333		667
TOT	6333	667	36333	41000	20667	83667	1000	10000	23333	11667	8000	47000	18000	36333

Table 4: *Number of organisms (ind/m²) recorded during IBS-bf protocol application in spring sampling (O: organic, C: conventional).*

	Apple		Asparagus		Kiwi		Straw-berry		Vineyard 1		Vineyard 2		Brush wood	Grass-land
Taxa	C	O	C	O	C	O	C	O	C	O	C	O		
Pulmonata	67	67			33			33		100		100	567	333
Enchytraeidae	67			267	33		67							433
Lumbricidae	33	33		33	33	100				33	33	33	33	67
Pseudoscorpiones	100				33				33				133	133
Araneida	100	767		333	67	167		33	67	333	67	33	200	133
Opiliones													33	
Acari	33	733	33	467	300	233		67	400	200	433	567	200	
Isopoda		400		100	900	233				33		167	100	33
Chilopoda Lithobiomorpha	33	67	33	100	67	0			33			67		
Chilopoda Geophilomorpha				67	33	33			33	67			33	
Diplopoda		67		67	167	167				133			200	367
Collembola (epigeous species)									67		600	133		
Collembola (endogeous species)														
Diplura									100	267			67	33
Thysanura														
Orthoptera (Gryllotalpidae and Grillidae)					33									
Dermaptera														
Blattoidea														
Psocoptera													33	
Coleoptera	633	1767	367	1167	467	900	233	33	333	433	33	1200	167	233
Hymenoptera Formicidae	33	967	67	967	700	600			167	700	633	600	533	1200
Diptera larvae	67	33			67	67					33	100		100
Coleoptera larvae		33		133	67				33	200	100	167	33	33
Other Holometabola larvae		100												
TOTAL	1167	5033	500	3700	3000	2500	300	167	1267	2500	1933	3167	2333	3100

Table 5: *Number of organisms (ind/m^2) recorded during IBS-bf protocol application in autumn sampling (O: organic, C: conventional).*

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