Soil nematode biodiversity in organic and conventional agroecosystems of Northern Greece

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Summary. In this study we describe and compare nematode communities in terms of trophic and generic structure, life strategy and diversity, in soils under asparagus cultivation managed conventionally and organically. Natural hedgerows bordering cultivations were also studied as reference systems. The bacterivore/fungivore group, accounted for 80% of total nematode abundance under organic cultivation, whilst phytoparasites increased in abundance in conventional plots resulting in higher plant parasitic index (PPI). The low generic diversity and strong dominance pattern observed under conventional cultivation indicated a stressed soil environment. In the organically managed system diversity was almost as high as in natural hedgerows, with nematode numbers evenly distributed among genera. However, in hedgerows intermediate abundances of bacterial, fungal and plant feeders were recorded, and the maturity index (MI) and PPI were higher than those of the organically managed system, indicating that organic farming resulted in a more vigorous, pre-mature and probably more productive soil rather than in a more 'natural' one. The different impacts of organic and mineral fertilizers are discussed.

Key words: agroecosystem; asparagus cultivation; diversity; trophic groups; maturity index; Mediterranean, organic/mineral fertilizers.

If environmentalists had to draft a group of organisms with the specific aim to monitor changing soil conditions, to measure biodiversity and the impact of stressors, they certainly would come to a blueprint for organisms with the characteristics of nematodes (Bongers & Ferris, 1999). The ecological significance of these soil organisms lies in their high abundance and diversity, variety of trophic types and reproductive strategies (Yeates, 2003), and in their contribution to soil nutrient turnover (Savin *et al.*, 2001; Ferris *et al.*, 2004).

Nematodes have been used as bioindicators for assessing the effects on soil of different land use (Urzelai, 2000), pollution by heavy metals (Korthals *et al.*, 2000), climatic changes (Bakonyi & Nagy, 2000; Papatheodorou *et al.*, 2004; Stamou *et al.*, 2005), and for describing ecotones between different ecosystems (Imaz *et al.*, 2002). Most often they have been used for evaluating soil conditions under various agricultural practices, such as organic and conventional livestock farming (Mulder *et al.*, 2003), tillage (Fu *et al.*, 2000),

fallow farming (Villenave *et al.*, 2001), different crops (Widmer *et al.*, 2002), different pasture conditions (Yeates, 2003), and use of pesticides (Liang *et al.*, 2001), fungicides (Villenave *et al.*, 2004) or herbicides (Yeates *et al.*, 1999).

Our aim in this study is to use the soil nematode community as an ecological tool for estimating soil disturbance under organic and conventional agriculture. Organic farming has been encouraged by the European Union as a potential solution to many of the agriculture policy problems (Bowler & Ilbery, 1999). In Greece, it is extending constantly, although the actual organic agricultural area remains small and comprises only 0.9% of the total agricultural area (Willer & Yussefi, 2004). Organic farming has gained considerable attention among soil ecologists and particularly nematologists (Freckman & Ettema, 1993; Porazinska & Coleman, 1995; Neher, 1999; Ferris & Matute, 2003 among others). However, only a few studies refer to the Mediterranean basin (e.g. Liang *et al.*, 2001; Garcia-Álvarez *et al.*, 2004).

In most relevant studies focusing on the impact of organic *vs* conventional agriculture on the soil nematode community, the approaches are based on estimation of various diversity indices or specialized nematode indices, e.g. the maturity index (MI) and the plant parasitic index (PPI), and on the differential response of nematode trophic groups. According to Hole *et al.* (2005), the wide range of methodologies is a general explanation of the fact that these studies have yielded results that, to an extent, contradict each other, whilst for nematode populations in particular the same authors argue that they are likely to be affected by other factors even more than by agricultural practice *per se*. Such factors are the cultivated crop species and duration of cultivation (Yeates *et al.*, 1999), the soil type (Yeates *et al.*, 1997) and the microclimate (Stamou *et al.*, 2005).

In this paper we describe and compare nematode communities, in terms of trophic and generic structure, life strategy and diversity, in organically and conventionally cultivated soils, trying to exclude the effect of the factors mentioned above. The cultivated plots of our study, either organic or conventional, were cultivated with *Asparagus officinalis* for more than seven years and were quite close to each other (about 500 m) to ensure the same soil type and microclimate. Moreover, asparagus cultivations were selected because they are perennial and not additionally stressed by annual plantings and, thus, the history of agricultural practices is better reflected on soil conditions. Apart from cultivated plots, we also studied the natural hedgerows that border the cultivated fields of the wider study area and constitute the nearest remnants of natural vegetation. The conservation of natural hedgerows is encouraged by organic standards (Hole *et al.*, 2005). In this study they were used as reference systems, since a relatively undisturbed baseline nematode community was required for comparisons between agricultural practices.

Our work does not aim at a generalized apothegm on the effects of organic and conventional agriculture on the soil nematode community. It aims at revealing differences between differently managed agroecosystems, in which factors that may mask the response of nematodes to different management practice are excluded as much as possible. Another question we aim to answer is to what extent and in which way the nematode community of the cultivated systems, either organic or conventional, differ from the 'natural' one of the hedgerows.

MATERIAL AND METHODS

Sites and sampling. Study sites are located in Krya-Brysi (40°40´N, 22°18´E) at 7 m above sea level and about 55 km east of Thessaloniki, Northern Greece. Soils are alluvial with a silty-loam texture (42% sand, 30% silt, 28% clay) and pH 7.5-8.0. The climate is transient between mediterranean and continental. According to data from the meteorological station of Krya Brysi, mean annual precipitation for a ten year period was 484 mm and mean annual temperature 14°C. January was the coldest month (1°C) with the highest precipitation (58 mm), while the warmest (31°C) and driest (16 mm) month was July.

Table 1. Fertilizing and weed control practices in organic and conventional cultivations. Total amounts [in brackets] and time of application are indicated. All fertilisers used in organic cultivation are permitted for organic agriculture.

ORGANIC CULTIVATION
FERTILIZING
Manure [1T/1,000 m²] - Sept. 2001
Organic fertilizer (Bioazoto, 12% N, 14% C) [200 kg/1,000 m²] - May 2002, 2003
Mineral Potassium Sulphate [550 Kg/1,000 m²] - July 2002, 2003
Organic fertilizer (Dermafert, N P K 8-7-7 + 2MgO + 8SO₃+17 C) [1000 kg/1,000 m²] - July 2002, 2003
WEED CONTROL
Hand hoeing- Summer 2002, 2003
CONVENTIONAL CULTIVATION
FERTILIZING
Synthetic fertilizer (Hydrocomplex supra N P K 6-15-25 + 3MgO + 30SO₃) [100Kg/1,000m²]- July 2001, 2002, 2003
WEED CONTROL
Linuron in form of Afalon for broadleaved grasses [0.2 l /1,000m²] - July 2002, 2003
Fluazifop-p-butyl in form of Fusilade for grass weeds [0.2 l /1,000m²] - July 2002, 2003

The agricultural systems that satisfied the prerequisites set in introduction were organic [O] and conventional [C] cultivations of *Asparagus officinalis*, [O] covering about 9000 m^2 of the wider study site and [C] about 5000 m^2. They were cultivated with asparagus for more than seven years ([O] organically cultivated since 1997 and officially certified as such since 2000). The hedgerows that were adjacent to the cultivated plots [Ho and Hc respectively] were used as reference systems. Their vegetation was similar, consisting of *Rubus ulmifolius, Phragmites australis, Artemisia vulgaris* and less often *Robinia pseudacacia* and *Salix alba*, as well as numerous herbs, such as *Chenopodium album, Avena sp., Hordeum murinum, Urtica dioica, Matricaria perforata* etc. Many of the herbaceous species penetrate the nearby cultivations as weeds. Hedgerows were 2-3 m wide and merely bordered cultivated areas, receiving no treatment at all.

Our sampling scheme represents a straightforward full factorial design of 4 agricultural systems x 4 dates x 3 replicates. More specifically, on each sampling occasion, 3 replicate plots randomly dispersed at each system were sampled by a soil corer 5 cm in diameter and 20 cm in depth. Soil sampling was repeated four times during a period from December 2002 to October 2003, at each system, at intervals that are considered critical within the annual cycle of asparagus; in March (asparagus spears start growing and the harvest begins), in May (end of harvest), in October (the fields are left with no agricultural activities for a few months), and in December (the aboveground parts of asparagus plants are cut and left in the field to decompose). We should note that nematode population dynamics decouple nematode counts across time, creating sufficiently independent data. In the case of the cultivated plots, all samples were taken only in the rows of the asparagus plantations. Areas that were close to hedgerows were not sampled in order to avoid edge effects. Asparagus plantations are not tilled, but during February the soil is ridged up over the asparagus field rows in order to produce white spears. Thus, the plots under organic and conventional cultivation are subject to the same physical disturbance and differ only regarding the type of fertilizers and weed control (Table 1).

Nematodes were extracted from 150 ml of each soil sample. Before taking the subsample, the soil was gently mixed by hand and soil aggregates were broken up. For extraction, we used the modified Cobb's sieving and decanting method proposed by s'Jacob and van Bezooijen (1984), according to which a cotton-wool filter is used in the last step. After counting nematodes, we fixed them with 4% formaldehyde. From each sample at least 150 nematodes were selected randomly and identified to the genus level in most cases, using the identification key of Bongers (1994).

On each sampling occasion, soil water content was also estimated from each soil sample taken. Soil bulk density was measured once, at the beginning of sampling, and was not found to differ among plots, ranging from 1.15 to 1.25 g/cm^3.

Data analysis. Nematode taxa were assigned to trophic groups according to Yeates *et al.*, (1993) and classified along the coloniser-persister gradient (c-p values) following Bongers (1990) and Bongers & Bongers (1998). The MI for free living nematodes (c-p 1-5) and the PPI for plant feeding nematodes were calculated according to Bongers (1990) as $\Sigma v_i p_i$, where v_i is the c-p value of taxon i and p_i the proportion of the taxon in the nematode community.

For testing differences between agricultural systems and sampling dates, we used MANOVA (site x date) under the GLM module twice, first for the nematode indices MI and PPI and second for trophic group abundances. In both cases, soil water content was used as a covariate. LSD post hoc comparisons where performed, when significant differences were revealed. Prior to analyses, data were examined for normality, homogeneity of variance (Levene's test) and independence between variance and mean. Abundance data where log+1 transformed. For all procedures we used the SPSS software package (version 11).

For assessing the diversity of nematode communities at the different agricultural systems, we used the method of diversity ordering proposed by Renyi (1961). Renyi's parametric index of order a shows varying sensitivity to the rare and abundant species of a community, as the scale parameter a changes (Ricotta, 2000). For each community it provides a profile of the most widely used diversity indices. For $a=0$, the index equals log species number, for $a=1$, it equals Shannon's index, for $a=2$, it equals Simpson's index. For a tending to infinity, the index is most sensitive to the abundant species of a community. Thus, when diversity profiles differ in the range of low a values, this is due to the number of species. In the range of high a values, differences between communities are due to presence of abundant species. When diversity profiles intersect, the communities may be ordered differently by different diversity indices. For calculations we used DivOrd (Tothmeresz, 1995).

RESULTS

Mean values of MI, PPI, soil water content (% dry weight), total nematode abundance as well as the percentage contribution of individual trophic groups to the nematode community are presented in Table 2 and the MANOVA results are given in Table 3.

Neither of the two nematode indices differed among sampling dates but significant differences were observed between agricultural systems. MI was significantly higher in the conventionally cultivated plots [C] and the adjacent hedgerow [Hc], exhibiting its lower value under organic cultivation [O]. More pronounced differences were observed with PPI, which gave lower values in [O], higher in [C] and intermediate in hedgerows [Ho, Hc].

The trophic structure of the nematode community also did not differ among sampling dates. Significant differences were observed between agricultural systems and these differences were due to bacterivores and plant feeders, which were the groups with the higher contribution to the total nematode community. The abundance of these two groups changed in opposite directions; bacterivores were more numerous in [O] and reduced in [C], while the reverse happened with plant feeders. In both cases intermediate abundance and percentage contribution was observed in hedgerows [Ho, Hc]. The fungivores constantly contributed more than 13% to the overall community but their abundance did not differ significantly across time or space. In general, the contribution of predators was very low, followed by omnivores.

The contribution, trophic type, and c-p value of each nematode genus are given in Figure 1 in the form of rank abundance graphs for each agricultural system. From the 58 genera (30 families) recorded in total, 28 were bacterivore, 8 fungivore, 8 predator, 2 omnivore and 12 plant feeding. Twenty-four genera were common in all cases, while most of the remaining had a very low contribution and can be considered rare. Assignment to the colonizer-persister gradient demonstrated that opportunists with c-p 2 values were in most cases bacterial and fungal feeders and *vice versa*. Nematodes with c-p 3 value were mostly plant feeders.

In [O] and in hedgerows, the contribution of an individual genus did not exceed 17%. In [C], the community displayed a quite different structure due to the strong dominance of a single genus, namely *Helicotylenchus*. This plant semi-endoparasite accounted for 40% of the community in this case, while the individual contributions of most other genera was less than 6%. The bacterivore *Acrobeloides* and the fungivore *Aphelenchus* were well represented at all experimental plots, constituting together about 20% of the total nematode community. We should note that an extreme switch in the dominance pattern between [C] and [O] was observed; *Helicotylenchus*, although dominant under conventional cultivation was rarely found under the organic one, accounting for only 1 % of the nematode community.

The diversity profiles of the nematode communities at all the investigated agricultural systems are shown in Figure 2. The community under conventional cultivation [C] displayed a much lower diversity compared to the others. Since the profiles differ mainly in the range of high values of the scale parameter *a*, this difference was not due to the number of genera but due to the presence of abundant ones, i.e. nematode numbers were more evenly distributed among genera under organic cultivation and in hedgerows compared to conventional cultivation. This holds true even in the case where data from each sampling occasion were analyzed separately.

DISCUSSION

The nematodes recorded in this study displayed a mean overall abundance of 1157 ind./100 ml soil, which is comparable to data from Yeates *et al.* (1999) for asparagus cultivations and from Stamou *et al.* (2005) for mediterranean grasslands. Fifty eight genera were found, a number similar to those reported by Freckman & Ettema (1993), Neher & Olson (1999), as well as by Ferris *et al.* (2004) for cultivated systems.

The most important trophic group both in terms of abundance and number of genera was in most cases that of bacterivores (represented mostly by Cephalobidae and Rhabditidae), followed by that of plant feeders. This holds also in other cultivated soils (e.g. Yeates, 2003; Yeates *et al.*, 1999; Neher, 1999). The group of fungivores constantly contributed over 13% to the nematode community of our study, being mainly represented by *Aphelenchus* and *Aphelenchoides*, which included over 65% of the fungal feeding community at all sites. These two genera are very commonly found not only in cultivations (Freckman & Ettema, 1993; Neher & Olson, 1999; Yeates *et al.* 1999; Ferris *et al.*, 2004), but also in grasslands (de Goede & Bongers, 1998) or pine forests (McSorley, 1993), which may indicate non specialized habitat requirements. Predators and omnivores comprised a very low proportion of

the total nematode community, as also reported by Ferris et al. (1996), Freckman & Ettema (1993) and Liang et al., (2001) for other cultivations. According to Wasilewska (1997), a high abundance of predators is an indication of the "naturalness" of an ecosystem, whilst De Deyn et al., (2004a) suggest that omnivores are sensitive to nutrient addition. In our study the contribution of both groups remained low even in hedgerows, indicating that although their soil was not subject to any management practice, it was probably affected by the practices on the adjacent cultivations. Nevertheless, the low abundance of these trophic groups makes their use as bioindicators questionable (Yeates & Bird, 1994).

The comparison between agricultural practices demonstrated that, in the conventionally cultivated plots, a ratio of 1:1 was recorded between the plant feeders and the nematodes that feed on decomposers (bacterivores and fungivores). This ratio changed to 1:4.5 under organic cultivation, a shift that relates to the "grazing food web" and the "detritus food web" of Petersen & Luxton (1982), as Yeates et al. (1993) and Wasilewska (1997) pointed out. This shift probably resulted from the different form of nutrient input in the cultivated plots. Mineral fertilizers appeared to have a positive effect on primary consumers, i.e. plant feeders, and a negative one on secondary consumers, i.e. bacterivores and fungivores. Mineral fertilizers are known to be the reason for softer plant tissues as carbohydrates are diverted to protein synthesis instead of cell wall construction (Tisdale & Nelson, 1975), which makes plants more susceptible to parasites. The high proportion of plant feeders in our conventional plots, and most importantly the high proportion of phytoparasites with c-p value 3 among them, resulted in higher PPI values, as also reported by Wasilewska (1997) for sites receiving mineral fertilizers. However, we should note that herbicide application in the conventional system also may have influenced the trophic structure of the community, since Yeates et al. (1999) also found a slight decrease of bacterivores at his herbicide treated asparagus plots.

By contrast, organic fertilizers appeared to have a completely opposite effect on the trophic structure of the community, favoring the secondary consumers, i.e. bacterivores and fungivores, since they act via the microbial soil component. Almost all bacterivores and fungivores recorded in this study were of c-p value 1 and 2. Their high contribution in the organically managed system, as well as the low contribution of the high c-p value omnivores, resulted in a low MI, compared with that of the conventional system. It is interesting to point out that the increase of fungivores from conventional to organic cultivation was less pronounced than the one of bacterivores. This was probably because when the aboveground parts of asparagus plants are cut, they are left to decompose not only in the organic but also in the conventional fields, thus constituting an organic amendment by plant residues. This is known to encourage fungal growth and hence support large populations of fungivores (Bohlen & Edwards, 1994). In relation to plant feeders, Bohlen & Edwards (1994, and references therein) suggest that plant-parasitic nematodes decrease after additions of organic amendments. Indeed, in our study the percentage of all parasites decreased from conventional to organic cultivation, while there was a slight increase of root hair feeders, which according to Yeates (1998) are not harmful to plants. The high proportion of bacterivores and fungivores, as was the case with our organic system, indicates biologically active and productive soils (Ferris & Matute, 2003 and references therein), since feeding by these groups stimulates decomposition and nitrogen mineralization and enhances the level of nutrients available to plants (Ferris et al., 2004).

In comparison with asparagus cultivations, the abundance of bacterivores, fungivores and plant feeders was intermediate in hedgerows. This resulted to a ratio of 1:1.5 and 1:2 between the plant feeding and the decomposer feeding group in [Hc] and [Ho], respectively. MI values decreased from hedgerows to adjacent cultivations and the same holds for PPI values in the case of [O] and [Ho]. This was unsurprising since both MI and PPI indicate the successional stage of a community and, according to Neher & Olson (1999), either organic or conventional agriculture aim to maintain ecosystems at a more productive, pre-mature successional stage. However, the PPI increased significantly from [Hc] to [C], which in line with our previous arguments may be the result of mineral fertilizers. Indeed, the fraction of the plant feeding community, which actually increases in the conventional plots, is that of phytoparasites. Non parasitic plant feeders are more numerous in hedgerows, probably due to higher underground variability in the rooting system and, consequently, higher microhabitat diversity.

Apart from the analysis of trophic structure, the differences between organic and conventional agricultural practices were also revealed when we analysed the generic structure of the communities.
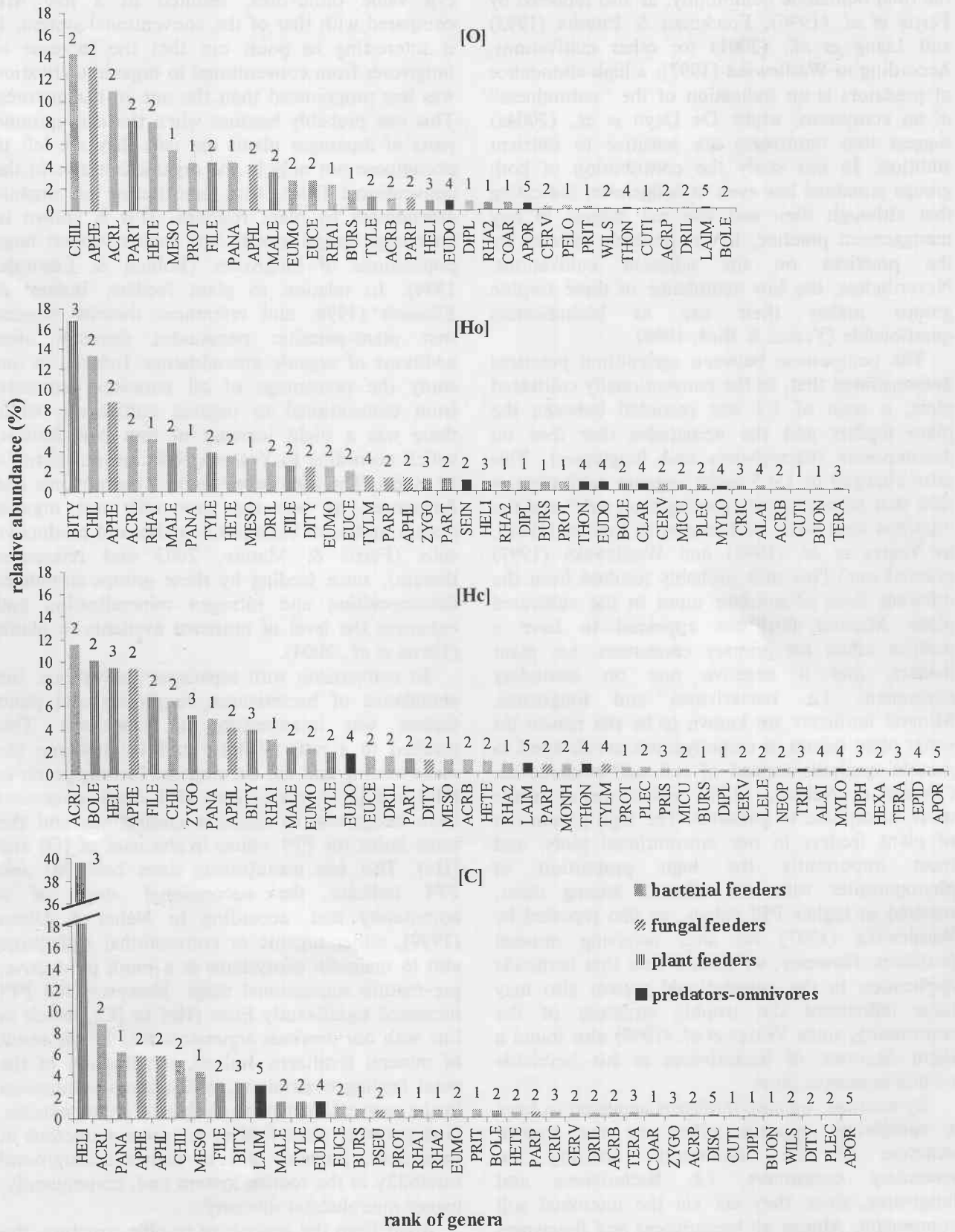
Fig. 1. Rank abundance graphs for nematodes in the studied agricultural systems. Genera are ranked from the most to the least abundant. Numbers on top of bars indicate c-p values. Codes as in Table 2.

Table 2. Mean values of MI and PPI, soil water content, total nematode abundance as well as contribution (%) of individual nematode trophic groups in organic cultivation [O] and adjacent hedgerow [Ho], as well as in conventional cultivation [C] and adjacent hedgerow [Hc]. Standard errors are shown in parentheses for total abundance.

	[O]	[Ho]	[Hc]	[C]
MI	1.79	1.88	2.02	1.97
PPI	2.06	2.53	2.46	2.79
Soil Water Content (% dry weight)	20.71	25.99	19.84	19.81
Total Abundance (ind. / 100 ml soil)	901 (155)	1720 (354)	829 (143)	1181 (224)
Bacterivores (%)	61.73	48.21	38.37	32.52
Fungivores (%)	18.38	15.33	16.33	12.79
Predators (%)	1.60	3.75	2.89	1.63
Omnivores (%)	0.08	–	0.99	2.95
Plant feeders total (%)	18.21	32.71	41.42	50.11
Migratory endoparasites (%)	–	1.22	5.20	0.17
Semiendoparasites (%)	0.95	0.99	9.48	39.54
Ectoparasites (%)	8.18	18.27	5.12	3.64
Epidermall cell and root hair feeders (%)	7.85	8.40	19.80	5.31
Algal, lichen or moss feeders (%)	1.23	3.83	1.82	1.45

Table 3. Results of MANOVA (site x date) for (i) nematode indices MI and PPI, and (ii) trophic groups abundances. Soil water content (WC) was used in both cases as covariate. Superscripts a, b, c indicate differences revealed by LSD-test. Codes as in Table 2. (*: $P<0.05$, **: $P<0.001$, MS: Mean square)

Nematode indices - overall effect					
	Value	Error d.f.	Hypothesis d.f.	F	P
Intercept	0.48	30	2	16.26	**
WC % (covariate)	0.99	30	2	0.04	NS
site	0.30	60	6	8.33	**
date	0.83	60	6	0.97	NS
site x date	0.40	60	18	1.94	*

Univariate results										
	site (3 d.f.)				date (3 d.f)			site x date (9 d.f)		
	LSD	MS	F	P	MS	F	P	MS	F	P
MI	[O]a [Ho]ab [Hc]b [C]b	0.12	3.22	*	0.04	1.07	NS	0.07	1.17	NS
PPI	[O]a [Ho]b [Hc]b [C]c	1.10	19.32	**	0.07	2.11	NS	0.11	1.87	NS

Trophic groups - overall effect					
	Value	Error d.f.	Hypothesis d.f.	F	P
Intercept	0.27	29	3	26.54	**
WC % (covariate)	0.98	29	3	0.17	NS
site	0.35	70.73	9	4.17	**
date	0.85	70.73	9	0.53	NS
site x date	0.23	85.34	27	2.10	*

Univariate results										
	site (3 d.f.)				date (3 d.f)			site x date (9 d.f)		
	LSD	MS	F	P	MS	F	P	MS	F	P
Bacterivores	[C]a [Hc]ab [Ho]b [O]c	1913.07	9.73	**	106.34	0.54	NS	457.98	2.33	*
Fungivores		79.58	1.48	NS	45.37	0.84	NS	121.11	2.25	*
Pred. & Omn.		21.03	1.03	NS	12.38	0.60	NS	34.09	1.66	NS
Plant feeders	[O]a [Ho]b [Hc]bc [C]c	2209.63	11.21	**	87.27	0.44	NS	898.86	4.56	**

Abbreviations of taxa in Fig.1. ACRB: *Acrobeles*, ACRL: *Acrobeloides*, ACRP: *Acrobelophis*, ALAI: *Alaimidae*, APHL: *Aphelenchoides*, APHE: *Aphelenchus*, APOR: *Aporcelaimellus*, BITY: *Bitylenchus*, BOLE: *Boleodorus*, BUON: *Buonematidae*, BURS: *Bursilla*, CERV: *Cervidellus*, CHIL: *Chiloplacus*, CLAR: *Clarcus*, COAR: *Coarctadera*, CRIC: *Criconematidae*, CUTI: *Cuticularia*, DIPH: *Diphtherophora*, DIPL: *Diploscapter*, DISC: *Discolaimidae*, DITY: *Ditylenchus*, DRIL: *Drilocephalobus*, EPID: *Epidorylaimus*, EUCE: *Eucephalobus*, EUDO: *Eudorylaimus*, EUMO: *Eumonhystera*, FILE: *Filenchus*, HELI: *Helicotylenchus*, HETE: *Heterocephalobus*, HEXA: *Hexatylus*, LAIM: *Laimydorus*, LELE: *Lelenchus*, MALE: *Malenchus*, MESO: *Mesorhabditis*, MICU: *Miculenchus*, MONH: *Monhysteridae*, MYLO: *Mylonchulus*, NEOP: *Neopsilenchus*, PANA: *Panagrolaimus*, PARP: *Paraphelenchus*, PART: *Paratylenchus*, PELI: *Pelioditis*, PELO: *Pelodera*, PLEC: *Plectus*, PRIS: *Prismatolaimus*, PRIT: *Pristionchus*, PROT: *Protorhabtitis*, PSEU: *Pseudhalenchus*, RHA1: *Rhabditidae 1*, RHA2: *Rhabditidae 2*, SEIN: *Seinura*, TERA: *Teratocephalus*, THON: *Thonus*, TRIP: *Tripyla*, TYLM: *Tylencholaimellus*, TYLE: *Tylenchus*, WILS: *Wilsonema*, ZYGO: *Zygotylenchus*.

In most similar studies (e.g. Urzelai *et al.*, 2000; Freckman & Ettema, 1993; Yeates *et al.*, 1999; Neher, 1999), results concerning diversity at this level are confusing and even contradictive to each other. This is mainly because the commonly used diversity indices are not fruitful in describing a multidimensional concept, such as a community, reducing it to a single number. In this study, our approach was based on analyzing rank abundance patterns and producing diversity profiles for nematode communities. The similarity of diversity profiles of the organically managed system and the hedgerows supports the widespread idea that organic farming may be a potential solution to the continual loss of biodiversity due to intensification of agriculture. However, our results did not reveal a significant reduction of the number of genera due to conventional management. The most striking difference between the organic and the conventional system was the switch in the dominance pattern of *Helicotylenchus*. This single phytoparasitic genus dominated the community under conventional cultivation, and is also found in high abundance by Yeates *et al.*, (1999) in asparagus cultivations. The predominance of *Helicotylenchus* in the conventionally managed system was the main reason for the lower generic diversity. Ettema (1998), based on the works of Eisenback & Griffin (1987) as well as of Freckman & Caswell (1985), states that plant feeders constitute a trophic group with limited diversity, because of competition for food resources. Moreover, the high abundance of phytoparasites and especially the strong dominance of few species among them, according to Wasilewska (1997), occur in long-term monocultures and are related to environmental degradation. However, in this study the same pattern, i.e. predominance of a single genus resulting in lower diversity, was constantly observed in the conventional system not only in the case of plant feeders but also in the case of other feeding groups, indicating a community with less variety of resources in this system. The high nematode diversity in the organically managed system might result from the increased availability of microhabitats due to organic fertilizers and the lack of herbicides, allowing to an extent immigration from the weed species pool of the larger area. Our suggestion is reinforced by the high diversity observed also in the hedgerows. This is in agreement with the work of De Deyn *et al.* (2004b) who observed strong dominance patterns of nematodes in experimental plant monocultures and more even and diverse nematode communities in plots with higher plant diversity.

To sum up, conventional and organic asparagus cultivation in this study differed regarding the type of nutrient input and weed control. This difference
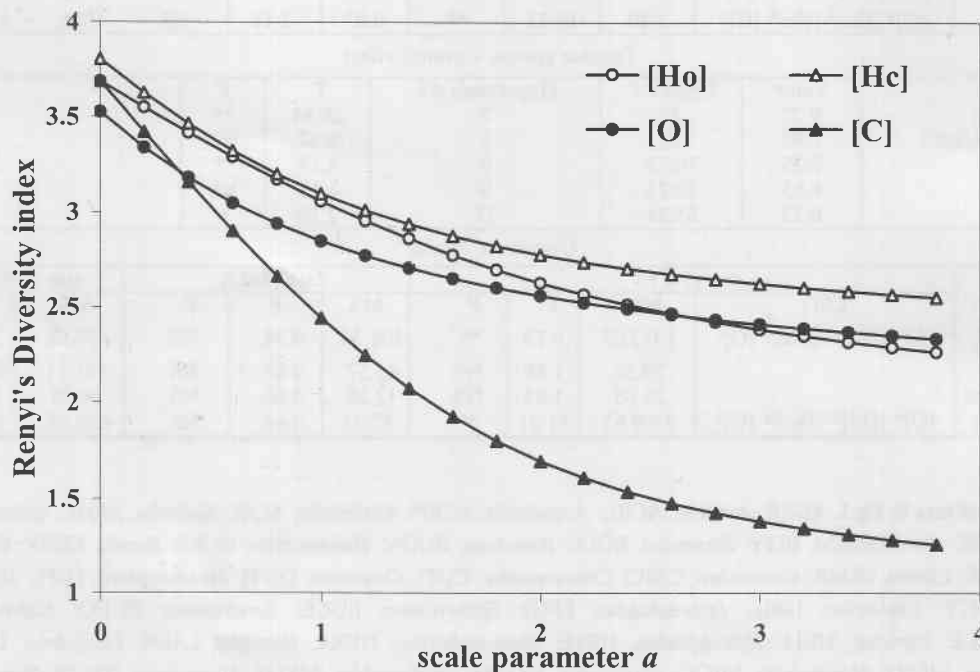

Fig.2. Diversity profiles of nematode communities in the studied agricultural systems. Codes as in Table 2.

was reflected on the soil nematode community in terms of MI, PPI, trophic and generic structure and diversity. The characteristics of the community under conventional asparagus cultivation, i.e. less bacterivores and fungivores, more phytoparasitic nematodes resulting to higher PPI, strong dominance pattern, low diversity, indicated a more stressed soil environment than that of the organically managed system. Under organic cultivation, the community was almost as diverse as the ones of natural hedgerows, with nematode numbers evenly distributed among genera. However, the differences in MI, PPI and trophic structure between the organically managed system and the hedgerows indicated that organic farming resulted in a more vigorous, pre-mature and probably more productive soil rather than in a more 'natural' one.

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Tsiafouli M. A., Argyropoulou M. D., Stamou G. P., Sgardelis St. P. Биологическое разнообразие почвенных нематод в агроценозах с органической и традиционной схемами земледелия в Северной Греции.

Резюме. Представлены результаты изучения и сравнения сообществ почвенных нематод на участках возделывания спаржи при органическом и традиционном земледелии. Сравнивали таксономический состав нематод, разнообразие, трофическую структуру сообщества и жизненные стратегии нематодных сообществ. В качестве экосистем сравнения были исследованы естественные живые изгороди между полями. Группа бактериофагов/мицелиофагов составляла до 80% общего нематодного населения почвы при органическом земледелии, тогда как численность паразитов растений заметно повышалась на участках с традиционным земледелием, что отражалось в повышении индекса PPI (индекс числа фитопаразитических форм). Малое разнообразие родов нематод при отчетливом доминирование немногих из них на участках с традиционным земледелием указывало на стрессовое состояние почвенного сообщества. При органическом земледелии общий уровень разнообразия был почти столь же высок, как в почве ивовых изгородей. При этом численность нематод отдельных родов существенно не различалась. Тем не менее численности нематод, питающихся бактериями, мицелием и растительными тканями, были ниже в почве живых изгородей, чем при органическом земледелии, а индексы MI и PPI были выше. Это оказывает, что при органическом земледелии почвенное сообщество не достигало климаксного состояния и превышало по продукции почву «естественного» сообщества. Обсуждаются возможные механизмы воздействия на почвенные сообщества органических и минеральных удобрений.