academicJournals

Vol. 6(8), pp. 112-121, September, 2014
DOI: 10.5897/JEN2014.0104
Article Number: 29E317247569
ISSN 2006-9855

http://www.academicjournals.org/JEN

Journal of Entomology and Nematology

Full Length Research Paper

Soil nematode communities associated with hazelnut orchards in Turkey

Faruk Akyazi[1]*, Senol Yildiz[2] and Anil Firat Felek[1]

[1]Plant Protection Department, Agricultural Faculty, University of Ordu, 52200, Turkey.
[2]Plant Protection Department, Agricultural Faculty, University of Bingöl, 12000, Turkey.

Received 7 August, 2014; Accepted 9 September, 2014

The study was conducted to investigate the status of soil nematode communities in hazelnut orchards in Ordu province, Turkey. Nematodes were identified to genus level and allocated to trophic groups. A total of 50 taxa were found from hazelnut growing areas including 19 plant parasites, 12 bacterivorous, 4 fungivorous, 4 predators and 11 omnivorous. Genera *Tylenchus* (94.5%), *Gracilacus* (79.1%) and *Helicotylenchus* (56.4%) as plant parasites, *Acrobeloides* (68%) as bacterivores and *Aphelenchoides* (68.2%) as fungivorous were widespread and found in all districts. The highest abundance of plant parasites was in Kabataş (277 individual/ 100 cm^3 soil) followed by Gölköy (196.6 ind./ 100 cm^3 soil) district. *Criconemella*, *Meloidogyne, Paratylenchus* and *Pratylenchus* were found as important genera by means of the damage potantial on hazelnut as plant parasitic group. The other trophic groups were at desirable level for an healthy soil system.

Key words: Hazelnut orchards, hazelnut nematodes, nematode community, nematode abundance, Ordu.

INTRODUCTION

Hazelnut (*Corylus avellana* L.) is one of the most important nut crops of Turkey, and Turkey is ranked the first place worldwide for hazelnut production and export value. Annual hazelnut production of Turkey is 660 000 tons with shell. Turkey supplies 70% of the world's hazelnut exportation as 146 322 tons with shell among top 20 exporter countries (FAO, 2013). The hazelnut is considered one of the most ancient plants with naturally occuring cultured varieties and wild types in the Black Sea region. The ecological conditions of Black Sea Region of Turkey overlap best with the requirements of hazelnut by moderate climate and high relative humidity throughout year. Although hazelnuts have been grown in more than 35 cities around Turkey, production is primarily concentrated along Turkey's Black Sea coast (Güney, 2014). The provinces Ordu, Giresun, Sakarya, Samsun, Trabzon and Bolu are the main places for hazelnut production in Turkey, but Ordu can be named as the leading province of hazelnut production for Turkey. The growth practices are traditional and generally syntethic fertilizers are used. The irigation method is also ancient and the source of water is rainfall. The pest management approach is conventional with pesticides based on mites and insects. There is no concern of farmers for nematode management by the lack of information for nematodes, high slope of the agriculture orchards and the difficulties of training system. The training system of hazelnut trees in Turkey is multi-stem system for *C. avellana*. Multi-stem form is named as "Ocak" in Turkey

*Corresponding author. E-mail: farukakyazi@hotmail.com.

and that contains 8 or 10 stems of the plant. Harvest is carried out by hand. Another training system is single-trunk form for *Coryllus colurna* which can be grafted with shrub form, *C. avellana* and suituble for mechanical harvest. In addition to that, single-trunk form is a modern training system for Ordu province and Turkey and still in trails of Hazelnut Research Institute (Giresun, Turkey).

Hazelnut has some pests and diseases. Therefore commercial hazelnut production is difficult without management. Considering the pests of hazelnut, the pest status of hazelnut have been investigated by many of the scientists so far and the main focus was on the insect and mite pests of hazelnut. For instance, insects can reduce the yield of hazelnut between 15-60% and the level of this loss is dependent on the year, growing conditions and control measures (Milenkovic and Mitrovic, 2001). This explains the reason of intensive focus on insect pests. Insects and mite species as the pests of hazelnut for Turkey and other countries were reported by many authors (AliNiazee, 1983; Hill, 1987; Ioachim and Bobarnac, 1997; Ak et al., 2005; Özman-Sullivan, 2006; Saruhan and Tuncer, 2010; Saruhan and Şen, 2012). General control strategies against the pests on crops may include application of insecticides, classical and augmentative biological control, utilization of resistant varieties, and use of bio-based preparations (AliNiazee, 1998). Until the discovery of the management or control techniques of the pests mentioned above, the first step to carry out is to identify the pests species or determine the fauna of the cultivar. In addition to these perspectives, nematode fauna for hazelnut is also a subject in the limited numbers of researches and management. Only a few authors pointed out the nematode pest status of hazelnut in some countries: Greece (Kyrou, 1976), Spain (Pinochet et al., 1992) and California, US (Norton et al., 1984). When considering Turkey for the nematode pest status of hazelnut; only Kepenekci (2002) studied on nematodes associated with hazelnut and pointed out several nematodes occuring in hazelnut orchards and reported the nematodes, *Filenchus afghanicus Hemicycliophora punensis, Pratylenchoides hispaniensis, Pratylenchus pratensisobrinus, Helicotylenchus crenacauda*, *Hemicycliophora sturhani, Merlinius (=Scutylenchus) lenorus, Tylenchorhynchus cylindricus* as plant parasitic species and *Ditylenchus anchilosposomus* as fungivorous species in the west part of Blacksea region of Turkey. In this context, it is difficult to say that there are investigations adequately about nematodes of hazelnut in Turkey and worldwide. Therefore, the requirement to detailed investigation of nematodes in the hazelnut rhizosphere was obvious and it was determined with this investigation on province scale where the hazelnut production is ancient and commercial. We hope to elucidate the hazelnut producers clearly about the presence and importance of nematodes on hazelnut with this study.

Our objectives were to make an investigation for more detailed nematode faunal assemblages including the free-living and plant parasitic trophic groups in hazelnut orchards of Ordu province. This survey will provide a backround for further research about nematode fauna of hazelnut.

MATERIALS AND METHODS

This study examined the frequency of occurence and abundance of particular nematode trophic groups in hazelnut growing areas in Ordu province, Turkey. The totals of 110 hazelnut orchards from 18 districts (Figure 1) were surveyed for investigation.

Description of the study sites

A survey was carried out in Ordu provinces, in Black Sea Region of Turkey located at Latitude 40° 59' 5" N and Longitude 37° 52' 44" E on the altitude ranging from 10 to 1900 m above sea level with mean annual rainfall of 1177. 0 mm. Ordu has a borderline oceanic/humid subtropical climate like most of the eastern Black Sea coast of Turkey; with warm and humid summers; cool and damp winters. The water temperature is always cool and fluctuates between 8 and 20°C throughout the year. A distinct characteristic of Ordu is its being the center of hazelnut production. Ordu is the most important producer city (230.397, 0 ha) and produces the 32% of the hazelnut production of Turkey. Sampling was done randomly in orchards of the 18 districts.

Soil status of the province

The soil status of Ordu province is presented in Table 1. The soils of the province can be mainly considered as reasonably good in organic content, clay in soil texture, low calcerous and mostly acidic in soil reaction.

Soil sampling

During September 2013, a total of 110 hazelnut orchards in Ordu province were surveyed for plant parasitic and free-living nematodes. Five “Ocak” from each orchard were selected randomly and soil samples were taken from the rhizosphere at 5-30 cm depth, from the both sides of an Ocak regardless of direction. Soil probe is used once on each side of an Ocak. In this way, ten points from one orchard were sampled. The collected ten soil samples from each orchard were mixed homogeneously to constitute a composite sample. Each soil sample was thoroughly mixed and 1 kg of subsample was taken from the soil composite. The soil samples were put into polyethylene bags and properly labeled, then they were brought to laboratory. Soil samples were stored for two weeks at 4°C in refrigerator till the extraction time. After extraction, the rest of soil composite was stored in the refrigator in case of the of the soil.

Extraction of nematodes from soil

The soil samples were mixed and 100 cm^3 aliquot of each subsample was extracted by using modified Bearmen Funnel Technique (Hooper et al., 2005). Then, nematodes were counted and identified to genus level using light microscope. For each genus, frequency of occurance and nematode abundance in the eighteen districts were calculated. Abundance and frequency were represented by individual/100 cm^3 soil and %, respectively for the five trophic groups including plant parasitic, bacterivorous, fungivorous, omnivorous and predator nematodes by following Yeates et al. 1993.

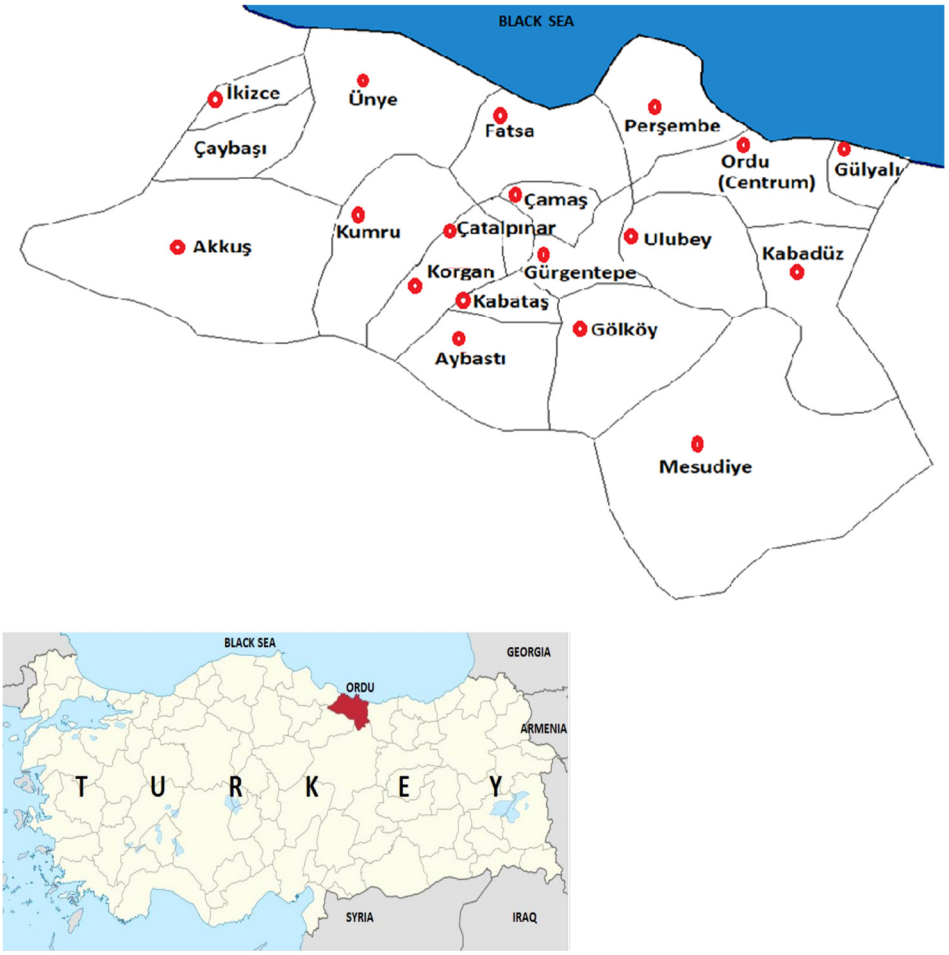

Figure 1. Map of Ordu province indicating the surveyed locations of hazelnut plantation, (Anonymous, 2014).

Table 1. The soil status of Ordu province (Şekeroğlu et al., 2006).

Parameter	Soil parameter		%
Status of texture	Loamy		12.1
	Clay loamy		58.6
	Clay		29.0
Status of calcerous content	Low calcerous	<1%	83.1
	Calcerous	1-5%	4.7
	Moderately calcerous	>5-15	6.0
Organic content	Low-moderately fine	<2%	21.4
	Moderately	2-3%	25.0
	Good	3-4%	23.3
	High	>4%	30.3
pH (soil reaction)	Moderately acidic	4.5-5.5	19.6
	Slightly acidic	5.5-6.5	27.9
	Neutral	6.5-7.5	34.9
	Slightly alkaline	7.5-8.5	0.5

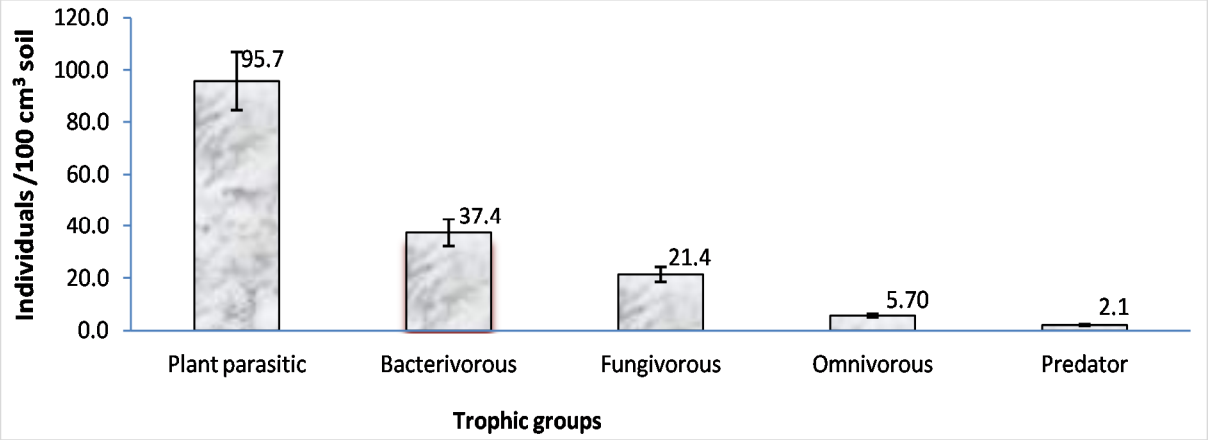

Figure 2. Mean nematode abundance of the five trophic groups in the hazelnut orchads in Ordu province (means ± standard deviation).

During the identification, Siddiqi (2000), Yeates et al. (1993), Jairajpuri et al. (1992) and the illustrated web pages such as Interactive Diagnostic Key to Plant Parasitic, Freeliving and Predaceous Nematodes by UNL Nematology Lab for free-living nematodes were used mainly.

RESULTS

Nematode faunal analysis of 110 hazelnut orchads showed that the plant parasitic nematodes were the most abundant (95.7 ind./100 cm^3 soil) trophic group (Figure 2). As plant parasitic group; the genera, *Tylenchus, Gracilacus, Helicotylenchus* has been found in the all investigated districts (Table 3). The nematodes of the genus *Tylenchus* were the most abundant (45.8 ind./100 cm^3 soil) with frequency of occurrence of 94.5% followed by genus *Gracilacus* (25.4; 79.1%), *Helicotylenchus* (8.4; 56.4%), *Pratylenchus* (2.3; 22.7 %), *Meloidogyne* (5.9; 14.5%) and *Criconemella* (1.6; 24.5 %) (Table 2). The mean abundance of plant parasitic nematode species were the highest in Kabataş district (277 ind./ 100 cm^3 soil) followed by Gölköy (196.6) and Çamaş (170.8) districts (Figure 3).

Bacteriovorouss were the second widespread and diverse group with ten genera after plant parasitic nematodes. The bacterivorous genera, *Acrobeloides* and *Plectus* were recorded in all districts and the mean abundance and frequency values were 20.6 (61.8%) and 2.3 (49.1%) respectively (Table 2). The abundance of this group was the highest in Aybastı (104.8 ind./ 100 cm^3 soil) followed by Perşembe (83.5) and Çamaş (74.6) (Figure 3). The fungivorous group had the highest values in Akkuş (92 inds./ 100 cm^3 soil) followed by Kabataş (39.7) and Perşembe (31.5) (Figure 3). The genera, *Aphelenchoides* and *Aphelenchus* in this group were recorded in all districts and the abundance and frequency values were 13.5 (68.2%) and 5.0 (53.6%) respectively. *Ditylenchus* and *Tylencholaimus* were also recorded fungivorous genera: (2.6; 22.7%) and (3.5; 37.3%) respectively (Table 2).

Amoung the omnivorous group, the most abundant and frequent genera were *Aporcelaimus* (2.5; 50.9%), *Prodorylaimus* (1.0; 20.9%), *Eudorylaimus* (0.7; 16.4%) (Table 2) for this trophic group. Omnivorous reached the highest abundance in the Fatsa and Ünye districts (12.2 ind./100 cm^3 soil) (Figure 3). The highest abundance of predators was in Gülyalı (8.3 ind./ 100 ml soil) followed by Ulubey (5.4) and Mesudiye (4.3) districts (Figure 3) and the first three genera were represented by *Clarkus* (1.0, 28.2%), *Tripyla* (0.7; 22.7%) and *Mononchus* (0.5; 18.2%) nematodes (Table 2).

DISCUSSION

In this survey, the distribution of nematodes under trophic groups was detected at genus level regarding their abundance and frequency values for hazelnut. This study is the first detailed faunistic and numeric investigation of nematode assemblages belonging to different trophic groups for hazelnut in the region and Turkey.

At the end of our investigation, the abundance and frequency of *Tylenchus* were relatively higher than the other plant parasitic groups. Even though it is a weak parasitic group, this genus might have a damage potantial for hazelnut with its high abundance (45.8 ind./ 100 cm^3 soil) and frequency (94.5%) values. Siddiqi (2000) also reported that *Tylenchus* feeds on algae, mosses and lichens. The *Gracilacus* is the second remarkable genus as being encountered plant parasitic group in all districts with abundance of 25.4 ind./ 100 cm^3 soil and frequency of 79.1%. *Gracilacus* spp. can feed deep in the cortical tissue of the roots with their long stylet (Siddiqi, 2000). The species of this genus, *Gracilacus straeleni,* was for the first time reported in soil around the roots of hazelnut (*C. avellana*) in northern

Table 2. Mean frequency of occurence (%) and nematode abundance (per 100 cm^3 / soil) associated with hazelnut orchards in Turkey.

Trophic groups	Number of positive samples	Frequency (%)	Abundance (per 100 cm^3 /soil)	Range
Plant parasitic				
Tylenchus	104	94.5	45.8	(2-375)
Gracilacus	87	79.1	25.4	(1-575)
Helicotylenchus	62	56.4	8.4	(1-161)
Pratylenchus	25	22.7	2.3	(1-63)
Meloidogyne	16	14.5	5.9	(2-196)
Criconemella	27	24.5	1.6	(1-42)
Paratylenchus	20	18.2	1.1	(2-35)
Merlinius	12	10.9	1.2	(1-85)
Rotylenchus	9	8.2	0.9	(1-65)
Tylenchorhynchus	7	6.4	0.5	(2-25)
Heterodera	7	6.4	0.7	(3-43)
Trophurus	6	5.5	0.7	(1-37)
Nagelus	4	3.6	0.2	(2-10)
Xiphinema	3	2.7	0.1	(2-5)
Psilenchus	3	2.7	0.1	(2-7)
Filenchus	2	1.8	0.2	(11-15)
Paratrophurus	2	1.8	0.5	(15-43)
Criconema	2	1.8	0.1	(2-3)
Unknown	4	3.6	0.2	(1-3)
Bacterivorous				
Acrobeloides	68	61.8	20.6	(1-228)
Plectus	54	49.1	2.3	(1-20)
Cephalobus	50	45.5	4.3	(2-41)
Eucephalobus	52	47.3	3.8	(1-56)
Monhysteridae	42	38.2	1.6	(1-12)
Rhabditis	27	24.5	2.7	(1-101)
Prismatolaimus	25	22.7	0.8	(1-10)
Alaimus	25	22.7	0.8	(1-11)
Alaimidae	15	13.6	0.6	(1-13)
Achramodora	11	10.0	0.4	(1-11)
Wilsonema	9	8.2	0.5	(1-25)
Cervidellus	5	4.5	0.1	(1-3)
Fungivorous				
Aphelenchoides	75	68.2	13.5	(1-238)
Aphelenchus	59	53.6	5.0	(1-35)
Ditylenchus	25	22.7	2.6	(1-39)
Tylencholaimus	41	37.3	3.5	(1-47)
Predators				
Clarkus	31	28.2	1.0	(1-11)
Tripyla	25	22.7	0.7	(1-8)
Mononchus	20	18.2	0.5	(1-6)
Seinura	2	1.8	0.0	(1-2)
Omnivorous				
Aporcelaimus	56	50.9	2.5	(1-28)
Prodorylaimus	23	20.9	1.0	(1-15)
Eudorylaimus	18	16.4	0.7	(1-18)
Dorylaimus	14	12.7	0.5	(1-9)
Aporcelaimellus	9	8.2	0.4	(1-8)

Table 2. Contd.

Unknown	9	8.2	0.2	(1-4)
Dorylaimidae	6	5.5	0.2	(2-8)
Mesodorylaimus	5	4.5	0.2	(1-15)
Campydora	5	4.5	0.2	(1-5)
Belondira	4	3.6	0.1	(1-4)
Actinolaimidae	1	0.9	0.0	(2-2)

Greece. The abundance was about 100 specimens/200 g soil and the plant showed the discoloration of the leaves and retarded growth (Kyrou, 1976). This indications suggests that hazelnut might be host of *Gracilacus* but need to be identified at species level and the damage potantial on hazelnut cultivars should be examined for Turkey. *Helicotylenchus* was the other recorded genus (56.4%) in all districts but in low abundance (8.4 ind./ 100 cm^3 soil). The low values of abundance for this genus showed that it has no damage potantial on hazelnut, but it must be considered that *Helicotylenchus* is the migratory endoparasite which causes cell destruction without modifying the host tissues (Luc et al., 2005). *Helicotylenchus* was also reported as the dominant genus in conventional agricultural areas (Tsiafouli et al., 2004). Conventional hazelnut production is a great part of Ordu province. Kepenekci (2002) reported that *Helicotylenchus crenacauda* occured in 12 out of 20 soil samples of hazelnut. Therefore, in case of any high population of this genus, there might be the problem on the root system of hazelnut and requires the detailed damage threshold on hazelnut. The genus *Pratylenchu*s was also recorded as 2.3 ind./ 100 cm^3 soil and 22.7 % but not in all districts. Pinochet et al.(1992) detected the damage potantial on hazelnut in species level of *Pratylenchus vulnus* that can succesfully reproduce on hazelnut in Spain. Norton et al. (1984) reported that hazelnut (*C. avellana*) is the host of *Pratylenchus crenatus* in California. *Pratylenchus pratensisobrinus* was recorded on the root and soil of hazelnut in Turkey by Kepenekci (2002). These reports are evidence that *Pratylenchus* has a potantial to damage hazelnut and needs to be identified at species level and study of its damage at different population levels for root system. Some investigations in Turkey also pointed out the presence of *P. thornei*, and *P. neglectus* on wheat (Sahin et al., 2008) and *P. thornei* on cabbage (Mennan and Handoo, 2006).The other genera as plant parasitic group, *Meloidogyne*, *Criconemella, Paratylenchus* are important genera by means of the damage potantial on other perennial crops except hazelnut.Yüksel (1982) reported that *Meloidogyne* spp. are not destructive to hazelnut which is one of the most important crop of the Black Sea region. Since that report, there is no detailed investigation about the damage potantial of genus *Meloidogyne* on hazelnut and that remained unknown. Although genus *Criconemella* is in high frequency but in low number (1.6; 24.5 %) for Ordu province, no report was pointed out *Criconemella* damage on hazelnut till now. The importance of this genus can be mentioned as having species that cause damage on perennial crops (Nyczepir and Pusey, 1986; Nyczepir et al., 1997). Hunt et al. (2005) also identified the genus as migratory ectoparasites on perennial crops, trees and vines, but only a few species have been proved to be harmful. As the last important plant parasitic genus, *Paratylenchus* was also considerably in high frequency but low number (1.1; 18.2%). Although the occurence and damage status of this genus were reported on some prennial crops (Campos and Villain, 2005; El-borai and Duncan, 2005), the status on hazelnut is still unknown.

Acrobeloides was the most abundant (20.6 ind./ 100 cm^3 soil) and frequent (61.8%) genus among bacterivore genera. This genus was reported as the dominant genus in conventional production areas (Tsiafouli et al, 2004; Yildiz and Elekcioglu, 2011; Yildiz, 2012) and also contains species that provides long-term effectiveness in the soil for the biological control of the fungi. The nematode of the genus consumes a range of rhizosphere-inhabiting bacteria. After digestion process, the nematodes release the bacterial contents into the soil which play the suppression role of fungi and may also promote plant growth in this way (Bird and Ryder, 1993). The nematodes of the genus Plectus also frequently occured (49.1%) but in low abundance (2.3 ind./ 100 cm^3 soil). This genus is one of the most widely distributed and common nematode taxa of freshwater and terrestrial habitats in the world and can survive under extreme desiccation, freezing conditions and other types of stress (Adhikari, 2010). In addition, species of *Plectus* reproduce through parthenogenesis and this cosmopolitan genus contains 78 species (Tahseen and Mustaqim, 2011). Therefore, these all perspectives of the genus might be the reason that makes the genus to be recorded in all district in our investigation.

The fungivorous genera, *Aphelenchoides, Aphelenchus, Ditylenchus,* and *Tylencholaimus* were found in this study. Fungivorous nematodes have been viewed to play an important role in organic matter decomposition (Ishibashi and Choi, 1991). Omnivorous and predatory nematodes were the last groups found in the investigation. When compared with the other groups, they were relatively in low abundance (Omnivores: 5.7 and predators:

Table 3. Mean frequency of occurence (%) and range of the important plant parasitic nematode genus by districts.

Region	*Criconemella* spp.		*Gracilacus spp.*		*Helicotylenchus* spp.		*Meloidogyne* spp.		*Paratylenchus* spp.		*Pratylenchus* spp.		*Tylenchus* spp.	
	Frequency	Range	Frequency	Range	Frequency	Range	Frequency	Range	Frequency	Range	Frequency	Range	Frequency	Range
Merkez	42	1-3	67	1-80	25	6-10	17	4-21	17	2-4	0	0	100	1-107
Akkuş	25	0-1	75	4-12	100	4-60	100	8-102	50	3-6	75.0	1-8	100	15-123
Aybastı	0	0	25	0-34	75	1-22	25	0-36	25	0-2	0	0	75	9-70
Çamaş	80	3-42	80	3-102	80	4-15	0	0	20	0-4	0	0	80	7-375
Çatalpınar	0	0	75	5-121	25	0-1	25	0-2	25	0-14	25	0-14	100	9-163
Fatsa	18	3-8	91	2-185	55	1-17	18	33-88	0	0	27	2-63	100	3-105
Gölköy	0	0	100	2-55	71	4-161	0	0	43	2-19	57	2-46	100	10-325
Gülyalı	33	0-2	67	2-15	67	6-10	0	0	0	0	0	0	100	9-40
Gürgentepe	29	3-4	100	1-61	100	1-60	14	0-21	0	0	0	0	100	1-190
İkizce	0	0	100	2-13	50	2-27	0	0	0	0	50	6-11	100	4-19
Kabadüz	60	2-10	80	2-22	40	2-4	20	0-11	0	0	20	0-6	80	6-70
Kabataş	0	0	100	1-575	33	0-2	0	0	0	0	0	0	66	2-225
Korgan	60	3-6	80	2-15	40	1-6	0	6	20	0-10	20	0-17	75	1-207
Kumru	0	0	75	2-41	75	4-20	0	0	50	2-4	50	2-4	100	15-59
Mesudiye	0	0	33	0-7	67	4-15	0	0	67	2-7	33	0-2	100	2-10
Perşembe	10	0-4	90	3-120	50	1-20	10	0-6	20	5-35	30	1-9	100	8-213
Ulubey	56	2-11	44	2-35	78	2-53	11	0-15	22	2-5	22	1-2	100	6-63
Ünye	0	0	100	1-216	30	0-2	20	13-196	10	0-2	20	4-14	100	1-107

2.1 ind./ 100 cm^3 soil) (Figure 2). Omnivorous and predatory could be more sensitive in defining the soil ecosystem status (Xiang et al., 2006), but they undoubtedly play an important role by feeding all types of organisms. Predator nematodes eat all types of nematodes or protozoa while omnivorous consume a variety of organisms including bacteria, fungus, protozoa, other nematodes and roots and may have a different diet at each life stage (Hoorman, 2011).

The soil properties on nematode communities cannot be overlooked as well. The texture might effect the density and distribution of nematodes in soil profile (Mcsorley and Frederick, 2002) and when the percentage of clay increased, the root penetrating ability of plant parasitic nematodes might decrease (Prot and Van Gundgy, 1981). The soil reaction factors can also have some effect on nematode groups. In general, pH is inhibitory to most nematode activities below 5.0 and above 8.0 (Ravichandra, 2008). For instance, the number of nematodes was negatively affected in acid soil reaction at pH 4.0 with lowest nutrient application rate. In additon to combinations of higher nutrient rates, low pH significantly reduced the number of bacterial-feeding nematodes, whereas it increased the number of hyphal-feeding nematodes. Indirect effect of nutrient and pH via other components of the soil food web is also in question (Korthals et al, 1996). Organic content is another important fraction of the soils and it can be considered as a positive source on nematode communities. Shabeg et al. (2007) reported that during period of 4 years in field plots of different crops transitioning from conventional to organic farming practice, nematode faunal profile estimates showed that the food webs were highly enriched and moderately to highly structured and the decomposition channels were bacterial in both systems. Bacterivore nematodes were more abundant in the organic soil compared to conventional system.

By the lights of these, the nematode communities vary in different sites and are effected by agronomic applications. In case of any nematode management attempts on hazelnut, as for other crops, site, land or country-spesific management pratices must be considered and applied because

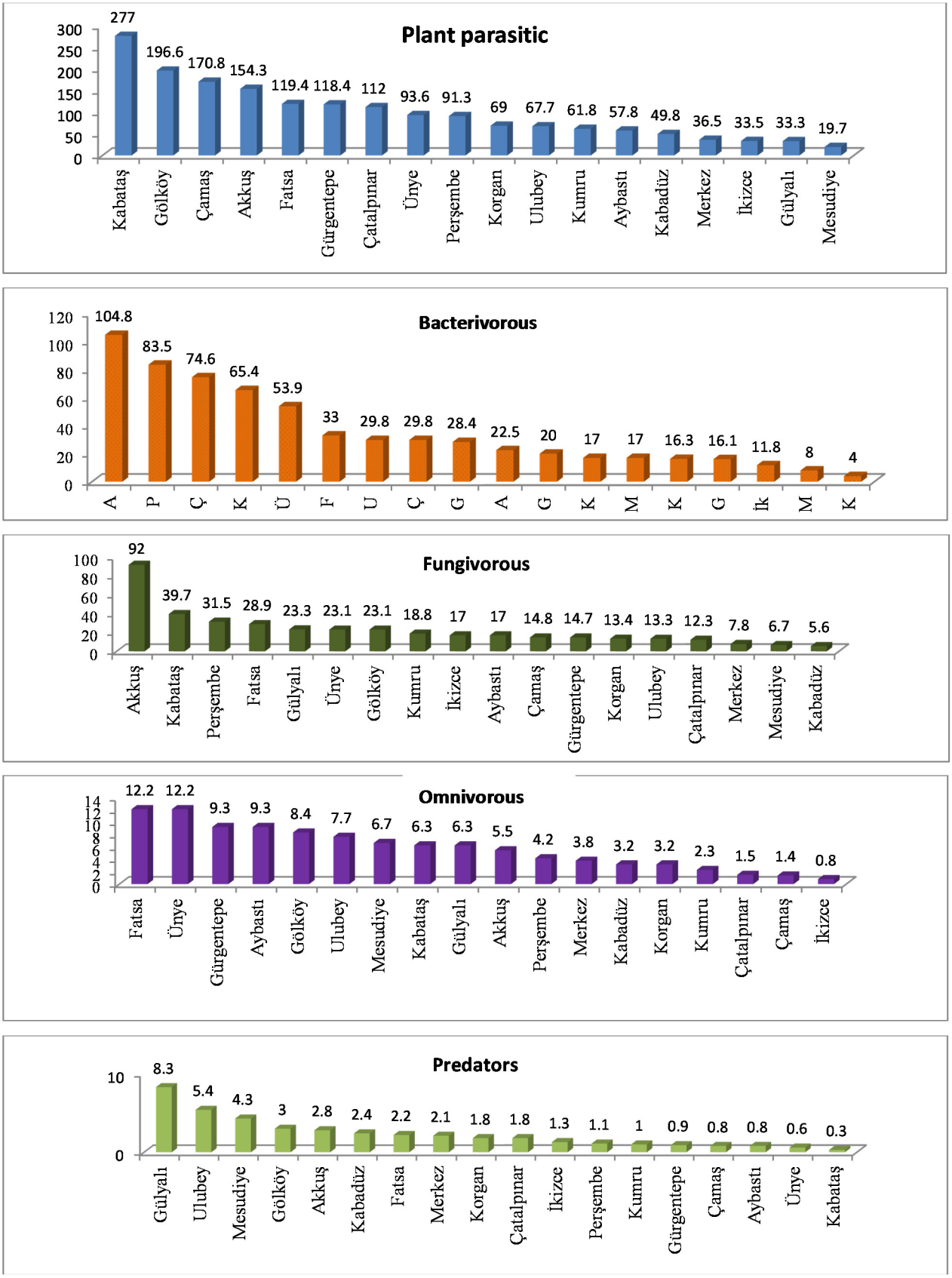

Figure 3. The mean abundance (ind./100 cm^3 soil) of trophic groups: plant parasitic, bacterivorous, fungivorous, omnivorous and predators among districts.

nematode groups are dependent on the effects of spesific conditions.

As a concequence, this survey pointed out the general nematode status of hazelnut for an intensive production area. Many factors such as fertilization, climate, soil texture, cultivation and cultivar are expected to affect the abundance and frequency. Therefore, the results would change from region to region. When considering the levels of free living trophic groups (bacterivorous, fungivorous), the values were in desirable levels for ecosystem. On the other hand, plant parasitic group was the highest in abundance and frequency of occurrence. This suggested that it has potential for damage or yield loss in case of any increasing levels especially for *Pratylenchus* and *Gracilacus* genera which need to be studied on. The nematode problems might seem as unimportant on hazelnut for classical Ocak training system because of the lack of any management practice on hazelnut, but will undoubtly be very important for any further application with modern training systems like single trunk tree form grafted with cultivar. Because the growth decline on single trunk form can be observed easily when compared with the multistem shrub form (Ocak), the modern systems are in progress for hazelnut in Black Sea region. In these perspectives, any study on yield loss caused by nematodes on hazelnut would provide more information for management of the crop, especially for modern systems in world scale and Turkey. This faunistic investigation is expected to be beneficial for researchers and growers in the future.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Adhikari BN, Tomasel CM, Li G, Wall DH, Adams BJ (2010). Antarctic nematode plectus murrayi: an emerging model to study multiple stress survival. Cold Spring Harb Protoc. (11):pdb.emo142.

Ak K, Uysal M, Tuncer C (2005). Bark beetle (Coleoptera: Scolytidae) species which are harmful in hazelnut orchards, their short biology and densities in Giresun, Ordu and Samsun provinces of Turkey. J. Fac. Agric. 20:37-44.

Aliniazee MT (1983). Pest status of filbert (Hazelnut) insects: A 10-Year Study. Can. Entomol. 115:1155-1162.

Aliniazee MT (1998). Ecology and management of hazelnut pests. Ann. Rev. Entomol. 43:395-419.

Anonymous (2014). http://www.turkiye-rehberi.net/ordu-haritasi.asp

Bird AF, Ryder MH (1993). Feeding of the nematode *Acrobeloides nanus* on bacteria. J. Nematol. 25:493-499.

Campos VP, Villain L (2005). Nematode parasites of coffee and cocoa. In: Plant parasitic nematodes in subtropical and tropical agriculture, M. Luc, R.A. Sikora, J. Bridge (eds), *2nd Edition* CAB International.

El-Borai FE, Duncan LW (2005). Nematode parasites of subtropical and tropical fruit tree crops. In: Plant parasitic nematodes in subtropical and tropical agriculture, Luc M, Sikora RA, Bridge J (eds), *2nd Edition* CAB International.

Güney OI (2014). Turkish hazelnut production and export competition. Yyu J. Agric. Sci. 24:23-29.

Hill DS (1987). Agricultural insect pests of temperate regions and their control. Cambridge University Press, 659 p.

Hooper DJ, Hallmann J, Subbotin SA (2005). Methods for extraction, processing and detection of plant and soil nematodes. In:. Plant parasitic nematodes in subtropical and tropical agriculture. Luc M, Sikora RA, Bridge J (eds),Wallingford (UK): CAB International. p. 53–86.

Hoorman JJ (2011).The role of soil protozoa and nematodes. The Ohio State University, fact sheet, SAG-15-11, pp.5.

Hunt DJ, Luc M, Manzanilla-López RH (2005). Identification, morphology and biology of plant parasitic nematodes. In: Plant parasitic nematodes in subtropical and tropical agriculture. Luc M, Sikora RA, Bridge J (eds). *2nd Edition* CAB International.

Ioachim E, Bobarnac B (1997). Research on the hazelnut pests in Romania. Acta Hort. 445:527-536.

Ishibashi N, Choi DR (1991). Biological control of soil pests by mixed application of entomopathogenic and fungivorus nematodes. J. Nematol. 23: 175-181.

Jairajpuri MS, Ahmad W (1992). Dorylaimida: Free-living, predaceous and plant-parasitic Nematodes. Leiden: E.J. Brill. Jan 1, 458 pp.

Kepenekci I (2002). A survey of Tylenchida (Nematoda) found in hazelnut (*Corylus* sp.) Orchards in the west black sea region of Turkey. Nematropica 32:83-85.

Korthals GW, Bongers T, Kammenga JE, Alexiev AD, Lexmond, TM (1996). Long-term effects of copper and ph on the nematode community in an agroecosystem. Environ. Tox. Chem. 15: 979–985.

Kyrou NC (1976). New records of nematodes in Greece. Plant Disease reporter, 60(7):630.

Luc M, Bridge J, Sikora RA (2005). Reflections on nematology in subtropical and tropical agriculture. In: Luc M, , Bridge J, Sikora RA (eds) Plant parasitic nematodes in subtropical and tropical agriculture. 2nd Edition. CABI Publishing. Wallingford pp. 871.

McSorley R, Frederick JJ (2002). Effect of subsurface clay on nematode communities in a sandy soil. Appl. Soil Ecol. 19(1): 1-11.

Milenkovic S, Mitrovic M (2001). Hazelnut pests in Serbia. Acta Hort. (ISHS) 556:403-406.

Mennan S, Handoo ZA (2006). Plant Parasitc Nematodes associated with cabbages (Brassica spp.) in Samsun (middle black sea region) of Turkey. Nematrop. 36(1): 125-128.

Nyczepir AP, Pusey PL (1986). Association of *Criconemella xenoplax* and *Fusarium* spp. with root necrosis and growth of peach. J. Nematol. 18(2):217-220.

Nyczepir P, Wool BW, Reigi-I.Ard GL (1997). Impact of *Meloidogyne incognita* on the incidence of peach tree short life in the presence of *Criconemella xenoplax*. Suppl. J. Nematol. 29 (4S) :725-730.

Norton DC, Donald PL, Kiminski J, Myers R, Noel G, Noffsinger EM, Robbins RT, Schmitt DP, Sosa-Moss C, Vrain TC (1984). Distribution of plant-parasitic nematode species in North America. Society of Nematologists. 205pp.

Özman-Sullivan SK (2006). Harmful mites and their economic importance in hazelnut orchards. J. Fac. of Agric. OMU. 21(2): 261-264.

Pinochet J, Verdejo S, Soler A, Canals J (1992). Host range of a population of *Pratylenchus vulnus* in commercial fruit, nut, citrus and grape rootstocks in Spain. J. Nematol. 24:693-698.

Prot JC, VanGundy SD (1981) effect of soil texture and the clay component on migration of *Meloidogyne incognita* second-stage juveniles. J. Nematol. 13(2):213-217.

Ravichandra NG (2008). Plant nematology I. K. International Pvt Ltd, 720 pp.

Sahin E, Nicol J, Yorgancılar A, Elekcioglu I, Tulek A, Yıldırım A, Bolat N (2008). Seasonal variation of field populations of *Heterodera filipjevi*, *Pratylenchus thornei* and *P. neglectus* on winter wheat in Turkey. Nematol. Medit. 36(1): 51-56.

Saruhan I, Tuncer C (2010). Research on damage rate and type of gree_nshıeldbug (*Palomena prasina* l. Heteroptera: pentatomidae) on hazelnut. Anadolu J. Agric. Sci. 25(2):75-83.

Saruhan I, Şen M (2012). Damage ratio of hazelnut weevil (*Curculio nucum* l. Col.: curculionidae) on different hazelnut varieties. Anadolu J. Agric. Sci. 27(2):70-75.

Shabeg SB, Grewal PS, Somasekhar N, Stinner D, Miller SA (2007). Soil nematode community, organic matter, microbial biomass and nitrogen dynamics in field plots transitioning from conventional to

organic management, Appl. Soil Ecol. 37(3):256-266.
Siddiqi MR (2000). Tylenchida: Parasites of plants and insects, 2nd Edition. Cabi publishing, 833pp.
Şekeroğlu N, İslam A, Sıralı R, Özkutlu F (2006). Doğu Karadeniz Bölgesi tarımına genel bir bakış. Hasad. 22:80-95.
Tahseen Q, Mustaqim M (2011). Descriptions of six known species of *Plectus* Bastian, 1865 (Nematoda, Plectida, Plectidae) from India with a discussion on the taxonomy of the genus. Zootaxa. 3205: 1–25.
Tsiafouli M, Monokrousos N, Papatheodorou E, Argyropoulou M, Sgardelis S, Diamantopoulos I, Stamou GP (2004). Organic agriculture and soil quality. Proceedings 10th MEDECOS Conference, April 25 – May 1, 2004, Rhodes, Greece, Arianoutsou & Papanastasis (eds).
Xiang MF, Wei OU, Qi LI, Yong J, Zhong WD (2006).Vertical distribution of and seasonal fluctuation of nematode trophic groups as affected by land use. Podosphore. 16(2):169-176.
Yeates GW, Bongers T, Degoede RGM, Freckman DW, Georgieva SS (1993). Feeding-habits in soil nematode families and genera an outline for soil ecologists. J. Nematol. 25: 315-331.
Yıldız Ş, Elekcioglu IH(2011). Şanlıurfa ilinde tarımsal ve doğal alanlarda nematod biyoçeşitliliği. Türk Entomol. Derg. 35 (2): 381-394.
Yıldız Ş (2012). Nematode biodiversity in a semi-arid pasture under different grazing regimes. Afr. J. Agric. Res. 7(3):414-417.
Yüksel HS (1982). Root-knot nematodes in Turkey, Proceedings of the third research and planning conference on root-knot Nematodes *Meloidogyne* spp. 13-17 September 1982. Coimbra, Portugal.