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Incidence and Population Density of Nematodes in Corn Fields in Tekirdağ, Türkiye

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ABSTRACT: *This study was conducted to determine the nematode biodiversity in corn (Zea mays L.) growing areas in Tekirdağ, Türkiye. For this purpose, corn fields in Malkara, Şarköy, Süleymanpaşa, and Hayrabolu were surveyed, and a total of 62 soil samples were collected from a soil depth of 0-60 cm. Nematodes were isolated by centrifugal flotation using 475 g/L sugar solution. Nematode identifications were made using polytomous keys. In the study, 30 nematode genera were identified, and among these genera, 11 were plant parasites, three were fungal feeders, nine were bacterial feeders, five were omnivores, and two were predators. Some of the plant parasitic species identified in the study included* ***Ditylenchus dipsaci, Helicotylenchus digonicus, H. varicaudatus, Pratylenchus penetrans, P. thornei****,* ***P. neglectus****,* ***Paratylenchus nainianus, Rotylenchus cypriensis,*** *and* ***Tylenchorhynchus annulatus****. Among all* ***Aphelenchus (Aphelenchida: Aphelenchidae), Cephalobus (Rhabditida: Cephalobidae), Filenchus (Tylenchida: Tylenchidae)****, and* ***Geocenamus (Tylenchida: Merliniidae)*** *were the most abundant and common genera and the heat map generated with XLSTAT represents the nematode abundance. To the best of our knowledge, this is the most recent taxonomic study on nematode diversity in corn fields in Tekirdağ province.*

Keywords: *Nematode,* ***Zea mays L.****, Thrace, Türkiye.*

Tekirdağ, Türkiye'deki Mısır Tarlalarında Nematodların Görülme Sıklığı ve Popülasyon Yoğunluğu

ÖZ: *Tekirdağ'da (Türkiye) mısır (Zea mays* L.*) yetiştirme alanlarında nematod biyoçeşitliliğini belirlemek amacıyla bir çalışma yapılmıştır. Bu amaçla Malkara, Şarköy, Süleymanpaşa ve Hayrabolu'daki mısır tarlaları incelenmiş ve 0-60 cm toprak derinliğinden toplam 62 tarladan toprak örneği alınmıştır. Nematodlar, 475 g/L şeker çözeltisi kullanılarak yapılan santrifüj flotasyon yöntemiyle izole edilmiştir. Nematodların teşhisi teşhis anahtarları kullanılarak yapılmıştır. Çalışmada 30 nematod cinsi tespit edilmiş olup, bu cinsler arasında 11'i bitki paraziti, 3'ü fungus ile beslenen, 9'u bakteri ile beslenen, 5'i omnivor ve 2'si predatör olarak belirlenmiştir. Çalışmada teşhis edilen bazı bitki paraziti türler arasında* ***Ditylenchus dipsaci, Helicotylenchus digonicus, H. varicaudatus, Pratylenchus penetrans, P. thornei, P. neglectus, Paratylenchus nainianus, Rotylenchus cypriensis*** *ve* ***Tylenchorhynchus annulatus*** *yer almıştır.* ***Aphelenchus (Aphelenchida: Aphelenchidae), Cephalobus (Rhabditida: Cephalobidae), Filenchus (Tylenchida: Tylenchidae)****, ve* ***Geocenamus (Tylenchida: Merliniidae)*** *en yoğun ve yaygın cinsler olup, XLSTAT ile oluşturulan yoğunluk haritası nematod bolluğunu temsil etmektedir. Bu çalışma Tekirdağ ilindeki mısır tarlalarındaki nematod çeşitliliği üzerine yapılan en güncel* taksonomik *çalışmadır.*

Anahtar kelimeler: *Nematod,* ***Zea mays L.****, Trakya, Türkiye.*

INTRODUCTION

Corn (*Zea mays* L.) is a widely cultivated cereal with high adaptability to various environmental conditions (Wang and Hu, 2021). It is one of the most commonly consumed crops because it provides moderate amounts of protein, fiber, vitamins and minerals, and is a good source of carbohydrates. Corn is used primarily for livestock feed, ethanol and biofuel production, raw materials in industry, and human consumption. It is grown on approximately 200 million hectares of land worldwide. The U.S. is by far the largest producer of corn, accounting for roughly 30-35% of the world's total production. China is the second and Brazil is the third in production (USDA-ERS, 2021; FAO, 2022)

Türkiye (6.690 metric tons) is one of the world's top 20 corn-producing countries. However, demand for corn is steadily increasing, particularly for use in animal feed. This growing demand is driven by the expansion of the livestock and poultry sectors, which rely heavily on corn as a key ingredient in animal feed formulations. Seventy-three per cent of the corn produced globally is used for animal feed, and in Türkiye, most of the corn produced is utilized for feeding large cattle, small livestock, and poultry (Karadeniz, 2019). In addition, corn is used in various industries, as starch, sweeteners, and biofuels (Gök and Şahin, 2024). Consequently, the country is working to increase corn production, although it still imports corn to meet domestic demand fully.

Corn is a plant that can be grown in various regions of Türkiye, with production being widespread in the Marmara, Aegean, Central Anatolia, and Southeastern Anatolia regions. In the Thrace part of the Marmara, region, corn cultivation areas fluctuate annually. The total acreage of planting areas in Edirne, Kırklareli, Tekirdağ, Çanakkale (Gelibolu and Lapseki), and Istanbul provinces (Çatalca and Silivri) are 21.566 hectares for corn and 5.530 ha for silage corn. Total corn production in these regions varies from 46.951 to 1.032.955 (silage) tons. The average grain yield per decare is approximately 550 to 600 kg, exceeding the global and national average (Turkstat, 2024).

Corn can best grow in fertile, well-drained soils rich in organic matter, which is vital for its growth. Various organisms, including nematodes, inhabit the soil in these cultivation areas. Numerous nematodes can be found in these environments, with hundreds of individual species in the soil. Among nematodes, a group called free-living nematodes contribute positively to soil health. They consume other microorganisms and macroorganisms such as bacteria and fungi, without causing damage to plants. This feeding behaviour helps with nutrient cycling and maintains ecological balance, which is crucial for soil fertility (Yadav *et al*., 2018). On the other hand, the other group called plant-parasitic nematodes represents a significant threat to corn crops. These nematodes feed on roots and extract nutrients, interfering with the plant's ability to absorb water and essential minerals. Their feeding can result in stunted growth, chlorosis, decreased yields, and increased susceptibility to environmental stress like drought and diseases. Various species of plant-parasitic nematodes impact corn differently, each with unique feeding strategies and levels of damage they cause (Singh, 2015). Common species include root-knot nematodes (*Meloidogyne* spp.), and lesion nematodes (*Pratylenchus* spp.) (Thapa *et al*., 2023). Effective management practices must be implemented to reduce the harmful effects of these nematodes and ensure healthy corn yields.

The distribution of nematode species in corn fields varies due to several factors, including soil structure and moisture levels. While plant-parasitic nematodes dominate in some regions, fungal-feeding nematodes are more prevalent in others. Identifying the nematode species responsible for yield loss in corn production areas and determining their prevalence is critical to prevent future damage and developing effective control methods. By identifying the feeding habits of nematodes, whether they are plant-parasitic, fungal-feeding, or bacterivorous, research can inform farmers about the risks posed by nematode populations in the field.

In a recent study conducted in our country, the prevalence of 11 nematode genera including *Pratylenchus* and *Mononchus* was identified in corn fields in the Anatolian part of Çanakkale province, and the findings were published (Yıldız and Gözel, 2022). However, no similar research has been carried out in Tekirdağ province. Based on these considerations, a study was conducted in the corn fields of Tekirdağ, a province in the Thrace region. In Tekirdağ, corn cultivation, especially for silage, is extensive. However, there are no previous data on the nematode fauna in these growing areas. This study aimed to identify and taxonomically classify the nematode genera and species present in the corn fields of Tekirdağ. It also sought to group them according to their feeding habits, to determine their prevalence, and to estimate the density of their populations per 100 cm² of soil. Additionally, the research provided detailed morphological and morphometric information on some important species.

MATERIAL AND METHOD

Study Area Information

The research was conducted in Tekirdağ Province, located in the northwest of Türkiye, along the coast of the Marmara Sea. The most common agricultural activities are vineyards, sunflowers and wheat.

The province has mild, humid winters and hot, dry summers. During the survey, temperatures varied between 24 and 26 °C, with the average total rainfall measured as 9 mm. While corn is cultivated across all districts of Tekirdağ province, production is particularly concentrated in Hayrabolu, Malkara, Muratlı, and Süleymanpaşa districts (Table 1). Non-irrigated cultivation is commonly practised in certain regions, including the centre of the Süleymanpaşa district in Tekirdağ province and the village of Ibribey in Malkara. On the other hand, modern drip irrigation systems are implemented in areas like the village of Karaiğdemir, which is closer to water sources.

Collection of Soil Samples and Extraction of Nematodes

The survey was conducted in corn fields in various districts of Tekirdağ, including Çorlu, Ergene, Malkara, Muratlı, Hayrabolu, Süleymanpaşa, and Şarköy (Table 2, Figure 1). To increase the diversity of soil samples, a minimum distance of 1 km was maintained between sampled plots. The surveys were conducted according to the partial sampling method described by Bora and Karaca (1970), where at least 1% of the total cultivated area in the province was sampled to obtain reliable and statistically valid results. The distance between sampling sites was up to 15 km in some fields in Şarköy, Süleymanpaşa, Çorlu and Ergenede, while it varied between 1-5 km in Malkara and Hayrabolu. The maximum distance between the sampled villages was 156 km.
Field sampling was done following a W-shaped walking pattern to ensure thorough coverage of each field. Soil samples were taken from randomly selected plants within each field to provide a representative sampling of soil composition. Approximately 1 kg of soil was collected from each plot to ensure an adequate sample size for analysis. Soil samples were taken from 0-60 cm depths, specifically targeting the root zone of five plants per field. This depth was chosen because it represents the primary soil layers where Longidoridae nematodes are most likely common.

Table 1. The acreage of corn production in districts of Tekirdağ province (Decare).
Çizelge 1. Tekirdağ ili ilçelerinde mısır üretim alanı büyüklüğü (Dekar).

Plant	Ergene	Hayrabolu	Kapaklı	Malkara	Marmara Ereğlisi	Muratlı	Saray	Süleymanpaşa	Çerkezköy	Çorlu	Şarköy
Corn	250	300	0	160	10	85	50	250	0	0	70
Corn (silage)	1.950	17.700	520	14.000	530	5.300	2.600	3.600	250	350	850

Table 2. The number of surveyed corn fields in districts of Tekirdağ province (Decare).
Çizelge 2. Tekirdağ ili ilçelerinde örnekleme yapılan mısır tarlası sayısı (Dekar).

	Ergene	Hayrabolu	Malkara	Muratlı	Süleymanpaşa	Çorlu	Şarköy
Number of fields samples	3	20	10	5	14	3	7
The acreage of corn fields	12-20	15-30	25-35	20-25	10-30	10-25	15-25

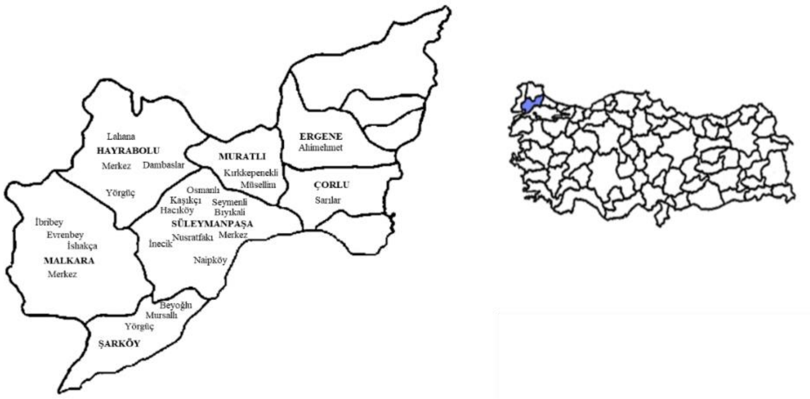

Figure 1. Study area map representing the sampled districts and villages in Tekirdağ.
Şekil 1. Tekirdağ'da örnekleme yapılan ilçe ve köyleri gösteren çalışma alanı haritası.

Nematodes were isolated from the soil samples using the sugar centrifugation method described by Jenkins (1964). For this method, 200 grams of each sample were placed in a container and mixed with water. The mixture was then filtered through a 200-mesh sieve, followed by a 400-mesh sieve. The nematodes caught in the 400-mesh sieve were transferred into a tube. This suspension was centrifuged at 1750 rpm for 5 minutes. Afterwards, a sugar solution (475 g/l) replaced the water, and the sample was centrifuged for 1 minute. In the final step, the suspension was passed through a 400-mesh sieve, and the nematodes were washed with tap water and collected.

Nematode Identification and Classification

Female nematodes were used for species identification. They were placed on slides after being killed at temperature 60°C and preserved in double-strength TAF (Triethanolamine-Formalin) and other fixative solutions (Seinhorst, 1959). The wax ring method was used to fix nematodes on slides (Seinhorst, 1959). Species classification was done according to the criteria outlined in Siddiqi (2000). Most of the nematodes were identified at species level, and their morphometric parameters were calculated using the formula of De Man (1876) provided below (Table 2). Nematodes were identified by examining the morphologic characteristics of the female, such as stylet shape, vulva position, body length, and tail shape. The polytomous key used in the identifications were Loof and Jairajpuri (1968), Choudhary and Jairajpuri (1984), Geraert and Raski (1987), Anderson (1979), Abolafia and Peña-Santiago (1996), Handoo and Golden (1989), Loof and Luc (1990), Brezski (1991), Handoo *et al*. (2007), Scholze and Sudhaus (2011), Wu *et al.*, (2016), and Tran *et al.* (2024). Nematodes which had no females were identified at the genus level. Each nematode species' feeding behaviour and colonizer-persister (c-p) values (1 to 5) were assigned according to Bongers (1990). The abundance heat map was generated in XLSTAT using nematode populations in fields. The frequency of occurrence (f %) of species were calculated as follows:

$$\%\ \text{frequency} = \frac{\text{Number of samples containing species}}{\text{Total number of samples collected}} \text{x100}$$

RESULTS AND DISCUSSION

A total of 30 nematode genera representing a wide taxonomic diversity were identified in a survey of corn fields in the districts of Şarköy, Malkara, Ergene, Hayrabolu, Süleymanpaşa, Çorlu and Muratlı in Tekirdağ. These nematodes belonged to six orders Aphelenchida, Tylenchida, Plectida, Monhysterida, Rhabditida and Dorylaimida, comprising 19 families (Table 3).

Table 3. The taxonomic classification of nematodes identified in corn fields in Tekirdağ province.
Çizelge 3. Tekirdağ ilinde mısır ekim alanlarında teşhis edilen nematodların taksonomik sınıflandırması.

Genera	Order	Superfamily	Family	Species
Acrobeles	Rhabditida	Cephaloboidea	Cephalobidae	*Acrobeles ciliatus* *Acrobeles complexus*
Alaimus	Dorylaimida	Alaimoidea	Alaimidae	*Alaimus primitivus*
Acrobeloides	Rhabditida	Cephaloboidea	Cephalobidae	*Acrobeloides nanus*
Aphelenchus	Aphelenchida	Aphelenchoidea	Aphelenchidae	*Aphelenchus avenae*
Aphelenchoides	Aphelenchida	Aphelenchoidea	Aphelenchioididae	*Aphelenchoides sacchari*
Aporcelaimellus	Dorylaimida	Dorylaimoidea	Aporcelaimidae	*Aporcelaimellus obscuroides*
Boleodorus	Tylenchida	Tylenchoidea	Tylenchidae	*Boleodorus thylactus*
Cephalobus	Rhabditida	Cephaloboidea	Cephalobidae	*Cephalobus persegnis*
Clarkus	Mononchida	Mononchoidea	Mononchidae	*Clarkus papilatus*
Ditylenchus	Tylenchida	Sphaerularioidea	Anguinidae	*Ditylenchus dipsaci*
Dorylaimus	Dorylaimida	Dorylaimoidea	Dorylaimidae	*Dorylaimus* sp.
Eudorylaimus	Dorylaimida	Dorylaimoidea	Dorylaimidae	*Eudorylaimus* sp.
Filenchus	Tylenchida	Tylenchoidea	Tylenchidae	*Filenchus filiformis* *Filenchus thornei* *Filenchus cylindricus*
Geocenamus	Tylenchida	Tylenchoidea	Merliinidae	*Geocenamus brevidens*
Helicotylenchus	Tylenchida	Tylenchoidea	Hoplolaimidae	*Helicotylenchus digonicus* *Helicotylenchus varicaudatus*
Mesodorylaimus	Dorylaimida	Dorylaimoidea	Dorylaimidae	*Mesodorylaimus* sp.
Monhystera	Monhysterida	Monhysteroidea	Monhysteridae	*Monhystera* sp.
Mononchus	Mononchida	Mononchoidea	Mononchidae	*Mononchus* sp.
Panagrolaimus	Rhabditida	Rhabditoidea	Rhabditidae	*Panagrolaimus rigidus*
Prismatolaimus	Triplonchida	Prismatoloidea	Prismatolaimidae	*Prismatolaimus vexilliger*
Prodorylaimus	Dorylaimida	Dorylaimoidea	Dorylaimidae	*Prodorylaimus* sp.
Pratylenchus	Tylenchida	Tylenchoidea	Pratylenchidae	*Pratylenchus penetrans* *Pratylenchus thornei* *Pratylenchus neglectus*
Paratylenchus	Tylenchida	Tylenchoidea	Tylenchulidae	*Paratylenchus nainianus*
Rhabditis	Rhabditida	Rhabditoidea	Rhabditidae	*Rhabditis* sp.
Rotylenchus	Tylenchida	Tylenchoidea	Hoplolaimidae	*Rotylenchus cypriensis*
Tylenchus	Tylenchida	Tylenchoidea	Tylenchidae	*Tylenchus davainei*
Tylenchorhynchus	Tylenchida	Tylenchoidea	Telotylenchidae	*Tylenchorhynchus annulatus*
Tylencholaimus	Dorylaimida	Tylencholaimoidea	Tylencholaimidae	*Tylencholaimus proximus*
Xiphinema	Dorylaimida	Longidoroidea	Longidoridae	*Xiphinema pachtaicum*
Wilsonema	Chromadorida	Plectoidea	Plectidae	*Wilsonema schuurmanstekhoven*

Approximately 66.6% of nematode genera identified in corn fields in Tekirdağ have plant-parasitic or bacterial feeding types (Figure 2). Bacterial-feeding nematodes belong to five order and six families, fungal-feeding nematodes to three orders and three families, omnivores to one order and five families, predators to one order and one family, and plant-parasites to one order and seven families. Bacterial-feeding nematodes play an important role in nutrient cycling, consuming bacteria and releasing nitrogen and other nutrients essential to plant growth (Ferris *et al*., 2001). The diversity of fungus-feeding nematodes is often related to the abundance of fungi in the soil, and nematodes can also have an impact on mycorrhizal fungi, potentially affecting plant-root symbioses (Ingham *et al.*, 1985).

Among the plant-parasitic nematodes, the vast majority (93.3%) were classified as ectoparasites, meaning they feed externally on plant roots and may cause less direct internal damage than endoparasites, which live and feed inside root tissues. Only one genus (6.7%) of plant-parasitic nematodes was identified as endoparasitic. The colonizer-persister (c-p) scale, which assesses nematodes based on their resilience and ecological functions, showed that most nematode species in these samples had a c-p value of 2. In agricultural areas, c-p 2 nematodes are common because they can tolerate moderate soil disturbances, such as tillage, without significant population loss (Ferris *et al*., 2001).

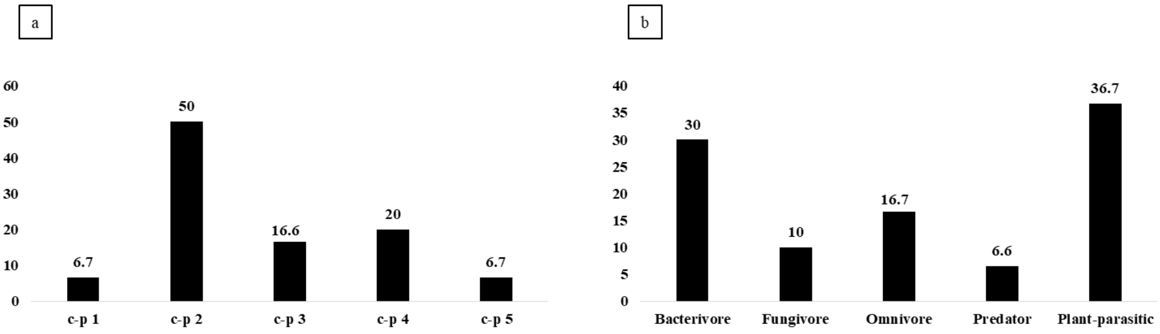

Figure 2. a. The proportion (%) of nematodes in terms of the c-p value, b. The proportion (%) of nematodes in terms of feeding habitat.
Şekil 2. a. Nematodların c-p değeri bakımından % oranı b. Nematodların beslenme habitatı bakımından % oranı.

The survey of nematode species in soil samples collected from corn fields revealed a diverse community with different frequencies of occurrence. *Cephalobus persegnis* (79%), and *Acrobeloides nanus* (50%) were highly abundant bacterial-feeding nematodes in corn fields in Tekirdağ, while *Rhabditis* sp. (27.4%) was also notable among bacterial feeders. Among the fungal feeders, *Aphelenchus avenae* (48.3%) and *Filenchus filiformis* (38.7%) were common. The least common species in the study were *Panagrolaimus rigidus* and *Mononchus* sp., both of which were present in only 1.6% of the samples. The findings from the survey of corn fields in Tekirdağ align with other nematode biodiversity studies in agricultural ecosystems. For example, in the United States, researchers reported that nematode communities are composed predominantly of plant-parasitic and bacterial-feeding types, with taxa such as Tylenchida and Rhabditida being common, similar to the findings in Tekirdağ. Again in other studies in the USA, several plant parasitic species from genera including *Helicotylenchus*, *Pratylenchus*, *Paratylenchus*, and *Tylenchorhynchus* were identified (Simon *et al.*, 2018; Han *et al.*, 2021; Thapa *et al.*, 2023). In a survey covering several districts in Kenya, 55 genera of nematodes were identified in corn fields; and, as found in Tekirdağ, *Aphelenchus* and *Cephalobus* were among the most common (Maina *et al.*, 2019). At the same time in a study conducted in Çanakkale, located in the same region as Tekirdağ, *Tylenchus* sp. was found to be the most common nematode in corn fields, with a prevalence of 30.8%. *Aphelenchus* sp. followed this at 26.2%, *Pratylenchus* sp. at 20.91%, *Ditylenchus* sp. at 17.93%, *Merlinius (Geocenamus)* sp. at 10.11%, *Dorylaimus* sp. at 8.5%, *Tylenchorhynchus* sp. at 5.05%, *Paratylenchus* sp. at 3.9%, *Mononchus* sp. at 2.52%, and *Panagroloimus* sp. at 1.6% (Yıldız and Gözel, 2022).

Table 4 represents the feeding type, c-p value, and frequency of nematode occurrence in corn fields in Tekirdağ.

Table 4. Feeding type, colonizer-persister (c-p) class, and frequency of occurrence of nematodes in corn fields in Tekirdağ province.
Çizelge 4. Tekirdağ ilinde mısır tarlalarında nematodların beslenme şekli, coloizer-persister (c-p) sınıfı ve görülme sıklığı.

Species/genus	c-p class (Colonizer-persister)	Feeding type	Frequency of occurance (%)
Acrobeles cilliatus	2	Bacterial feeder	16.1
Acrobeles complexus	2	Bacterial feeder	11.3
Acrobeloides nanus	2	Bacterial feeder	50.0
Alaimus primitivus	2	Bacterial feeder	12.9
Monhystera sp.	2	Bacterial feeder	9.6
Cephalobus persegnis	2	Bacterial feeder	79.0
Wilsonema schuurmanstekhoven	2	Bacterial feeder	8.0
Rhabditis sp.	1	Bacterial feeder	27.4
Prismatolaimus intermedius	2	Bacterial feeder	3.2
Panagrolaimus rigidus	1	Bacterial feeder	1.6
Aphelenchoides sacchari	2	Fungal feeder	33.8
Aphelenchus avenae	2	Fungal feeder	48.3
Tylencholaimus proximus	2	Fungal feeder	16.1
Clarkus papillatus	4	Predator	3.2
Mononchus sp	4	Predator	1.6
Aporcelaimellus obscuroides	5	Omnivore	38.7
Dorylaimus sp.	4	Omnivore	22.6
Mesodorylaimus sp.	4	Omnivore	22.6
Prodorylaimus sp.	4	Omnivore	4.8
Eudorylaimus sp.	4	Omnivore	11.3
Boleodorus thylactus	2	Root-fungal feeder (Ectoparasite)	17.7
Ditylenchus dipsaci	2	Plant-parasitic (Endoparasite)	16.6
Filenchus thornei	2	Root-fungal feeder (Ectoparasite)	30.6
Filenchus cylindricus	2	Root-fungal feeder (Ectoparasite)	20.9
Filenchus filiformis	2	Root-fungal feeder (Ectoparasite)	38.7
Geocenamus brevidens	3	Plant-parasitic (Ectoparasite)	64.5
Helicotylenchus digonicus	3	Plant-parasitic (Ectoparasite)	12.9
Helicotylenchus varicaudatus	3	Plant-parasitic (Ectoparasite)	4.8
Paratylenchus nainianus	2	Plant feeder (Ectoparasite)	17.7
Pratylenchus penetrans	3	Plant-parasitic (Endoparasite)	3.2
Pratylenchus neglectus	3	Plant-parasitic (Endoparasite)	11.3
Pratylenchus thornei	3	Plant-parasitic (Endoparasite)	8.0
Rotylenchus cypriensis	3	Plant-parasitic (Ectoparasite)	9.6
Tylenchus davainei	2	Root-fungal feeder (Ectoparasite)	11.3
Tylenchorrhynchus annulatus	3	Plant-parasitic (Ectoparasite)	25.8
Xiphinema pachtaicum	5	Plant-parasitic (Ectoparasite)	4.8

Of the plant parasitic nematodes identified in corn fields, several species are capable of causing significant crop damage. Remarkable species include *Pratylenchus penetrans*, *P. thornei*, *P. neglectus*, *Ditylenchus dipsaci*, *Tylenchorrhynchus annulatus*, and *Geocenamus brevidens*, with other species being weaker plant parasites. The presence of plant-parasitic nematodes such as *Ditylenchus dipsaci* (16.6%) and various Pratylenchus species (*P. penetrans* at 3.2%, *P. neglectus* at 11.3% and *P. thornei* at 8%) highlights the risk of nematode damage due to their adverse effects on plant roots. For example, *Pratylenchus penetrans* is a significant pest affecting crops such as sweetcorn and Todd et al. (2016) reported that yield losses increaes up to 49%. Several of these species have been reported globally, *Helicotylenchus varicaudatus*, *H. digonicus*, *Rotylenchus cypriensis*, *P. penetrans*, *P. neglectus*, and *P. thornei*, have been found in corn fields in the USA (Hafez *et al.*, 2010). *H. digonicus* has also been isolated from corn fields in Pakistan (Bernard, 1980; Khan *et al.*, 2009), and in our study *H. digonicus* was found in at least one field in all districts of Tekirdağ, Türkiye. Additionally, *P. neglectus* has been found in corn fields in China, and *P. penetrans* in Rwanda (Windham, 1998; Xia *et al.*, 2021). The prevalence rates of these species vary across regions, with *H. digonicus* showing a 30.9% occurrence in Pakistan compared to 12.9% in Türkiye. *Geocenamus (Merlinius) brevidens*, *Boleodorus tylactus*, and *D. dipsaci* are among the most common nematodes in agricultural areas. *G. brevidens* has been shown to reduce growth and cause stunting in wheat, barley, and corn, while *D. dipsaci* has been identified in corn fields in several countries, including Pakistan (Khan, 2009). *T. annulatus* is also found in corn fields in the USA and Indonesia (Simon *et al*., 2020; Indarti *et al*., 2023). Furthermore, *Filenchus* species are known to proliferate in saprophytic fungi such as *Rhizoctonia solani* and *Chaetomium globosum* (Okada *et al*., 2005), and *Xiphinema pachtaicum*, a nematode in the *X. americanum* subgroup, causes both direct and indirect damage to a variety of crops and ornamental plants worldwide (Loof and Luc, 1990).

The fungal feeder nematode *A. avenae* is typically associated with cereal crops, while *A. sacchari* causes significant damage to sugarcane, corn and other crops. *A. avenae* feeds on fungal hyphal structures like *Botrytis cinerea* (Taher *et al*., 2017) and has a prevalence rate of nearly 70% in Pakistani corn fields (Sikandar *et al*., 2021). *A. sacchari* also targets soil-borne fungi but damages plant roots, increasing susceptibility to fungal and bacterial infections (Perper and Petriello, 1977). *A. obscuroides* is a significant omnivore species in agricultural areas, pastures, and forests in over 50 countries (Yeates, 1993). Similarly, the genus *Tylencholaimus*, first described by de Man in 1876, includes species like *T. proximus*, which feed on various fungi (Wood, 1973). Additionally, bacterial feeder genera such as *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Panagrolaimus*, and *Prismatolaimus* have been reported in corn fields in Kenya, Spain, Slovakia, Sweden and Denmark. These free-living nematodes play important roles in soil ecosystems by aiding in organic matter decomposition and nutrient cycling (Čerevková *et al*., 2018; Maina et al., 2021).

In the corn fields surveyed in Tekirdağ, species from genera *Tylenchorhynchus*, *Helicotylenchus*, and *Pratylenchus* were found mostly and the highest population in intensively irrigated fields in Süleymanpaşa, Malkara and Hayrabolu. Non-irrigated fields had no nematode or lower nematode densities, suggesting that irrigation practices may influence nematode abundance. Irrigation studies in different countries have produced different results. For example, some studies have shown that the population of *Tylenchorhynchus* species is higher in irrigated fields. On the other hand, the effect of irrigation on *Pratylenchus* species are more complex. Some researchers indicate that irrigation can increase *Pratylenchus* populations, while others observe that it may have a decreasing or no effect (Govaerts et al., 2007; Okada and Harada, 2007).

When analysing nematode densities per 100 g of soil, it was observed that the populations of certain bacterial-feeding nematode species, namely *Cephalobus persegnis*, *Acrobeles ciliatus*, *Aphelenchus avenae*, and *Aphelenchoides sacchari* were significantly higher. In addition, among the herbivorous nematodes, *Filenchus filiformis* and *Geocenamus brevidens* showed elevated populations. The heat-map in Figure 3 displays the average nematode density per 100 grams of soil in corn fields in Tekirdağ. The dendrogram on the vertical axis corresponds to districts, while the horizontal axis at the bottom is the nematode genus. The dendrogram at the top groups these genera based on their abundance trends. The heat map uses colours like yellow, red, orange, and black to signify different levels of nematode density. Yellow highlight higher nematode densities, lighter shades of red suggest lower nematode populations for certain genera, whereas dark red and black indicate either the absence or very minimal presence of those genera. Orange and its variants reflect moderate densities. The heat map shows low or absent populations of certain species in Şarköy, Muratlı, Ergene and Çorlu. These districts also correspond to areas with dry soil conditions due to lack of irrigation and rainfall, which is likely to have contributed to the low nematode numbers. In these areas, soil moisture may be a limiting factor for nematode survival and reproduction. Consistent with our findings, these species have also been recognised as the most abundant in studies carried out by other researchers. In research conducted in 8 regions of Kenya on intercropping of corn and pigeon peas, some genera were found in high number in soils, *Acrobeles*, with densities ranging from 21.7 to 190.7 nematodes per 250 g of soil; *Cephalobus*, with a range of 86.7 to 238.3 nematodes per 250 g of soil; *Aphelenchus*, ranging from 39.0 to 177.7 nematodes per 250 g of soil; and *Aphelenchoides*, which showed densities between 30.3 to 99.7 nematodes per 250 g of soil (Maina *et al*., 2021).

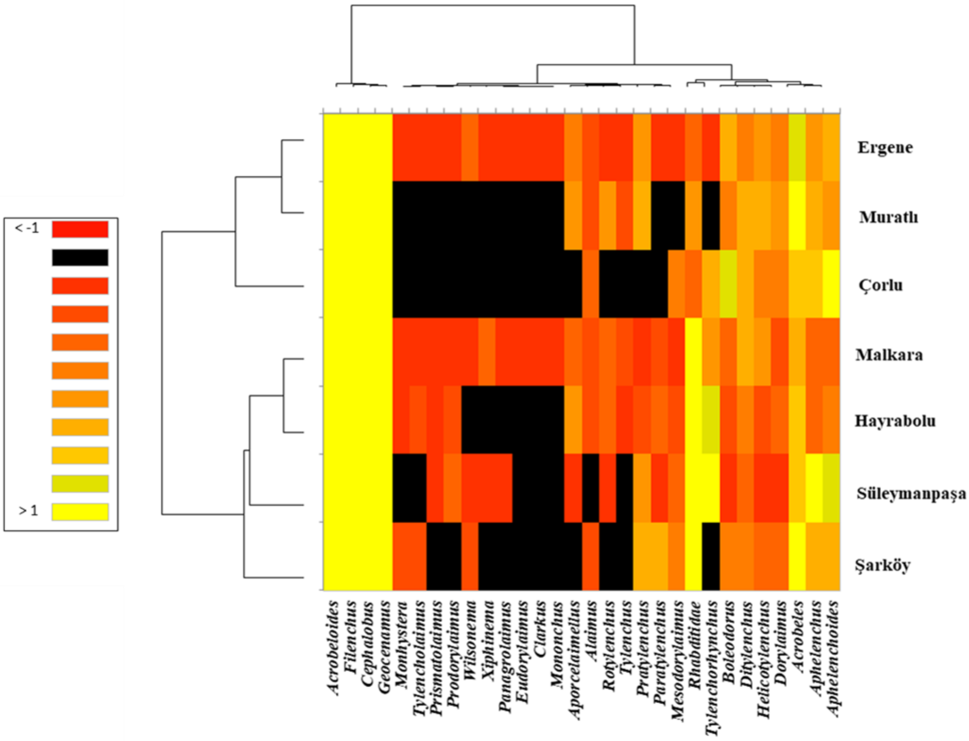

Figure 3. Heat-map representing the nematode average abundance in corn fields in seven districts in Tekirdağ.
Şekil 3. Tekirdağ'da yedi ilçede mısır alanlarında ortalama nematod yoğunluğunu gösteren yoğunluk haritası

CONCLUSIONS

In this study, the nematode fauna in the soil of corn fields in Tekirdağ province was thoroughly investigated. The results showed that the bacterial feeder and plant parasitic species accounted for more than half of the genus diversity of the nematode community. While highly damaging plant parasitic species such as *Meloidogyne* spp., which are known to cause significant damage to crops, were not detected, three species of the economically important genus *Pratylenchus* were identified. These species are fascinating because of their potential impact on plant health. This study is the first to be carried out in Tekirdağ province and provides new insights into the local nematode fauna.

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