EGYPTIAN ACADEMIC JOURNAL OF

BIOLOGICAL SCIENCES ZOOLOGY

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ISSN
2090-0759

WWW.EAJBS.EG.NET

Vol. 14 No. 2 (2022)

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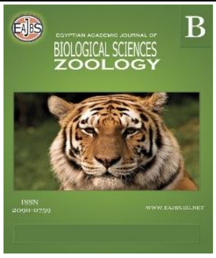
www.eajbs.eg.net

Citation: *Egypt. Acad. J. Biolog. Sci. (B. Zoology) Vol. 14(2) pp: 425-430(2022)*
DOI: 10.21608/EAJBSZ.2022.274668

Egypt. Acad. J. Biolog. Sci., 14(2): 425-430 (2022)

Egyptian Academic Journal of Biological Sciences
B. Zoology
ISSN: 2090 – 0759
http://eajbsz.journals.ekb.eg/



Current Status of Phytonematodes Associated with the Rhizosphere of Some Cultivars of Maize (*Zea mays* L.) in Two Types of Soil in Egypt

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ARTICLE INFO

Article History

Received:9/9/2022

Accepted:15/11/2022

Available:21/11/2022

Keywords:
Phytonematodes, Survey, Maize, Maize cultivars.

ABSTRACT

Phytonematodes are one of the most important pathogens of cereal crops, especially maize (corn). The current study aimed to conduct a survey of phytonematodes associated with the rhizosphere of some dominant cultivars of maize (*Zea mays* L.) in clay and sandy soils in different geographical areas (Sohag and Behaira Governorates). Data revealed a significant difference between nematode population density and soil type between clay and sandy. As well as, the differentiation of maize cultivars in their ability to reproduce nematodes. Also, results showed the spread of six genera of nematodes in the rhizosphere of the maize plants in sandy soil, which belong to three families; *Helicotylenchus*, *Heterodera*, *Hoplolaimus*, *Meloidogyne* and *Tylenchorhynchus*. While only three of them appeared in the clay soil; *Heterodera*, *Paratylenchus* and *Tylenchorhynchus*. In addition, the Pioneer cultivar recorded the highest population density of nematodes (427) in the clay soil, followed by the Triple hybrid cultivar and then the cultivar of Hybrid 131(425). While in sandy soils, the Hi-tech cultivar achieved the highest population density (742) compared to the same cultivar in clay soil (471).

INTRODUCTION

Phytonematodes constitute one of the most important factors determining the productivity of agricultural crops both quantitatively and qualitatively (Lazarova *et al*., 2021; Coyne *et al*., 2018). Its presence, which is often difficult to notice with the naked eye, did not take an adequate economic evaluation in the record of losses and damages caused by various agricultural pests to our main agricultural crops, especially traditional grain crops (Mandal *et al*., 2021; Kumar and Yadav, 2020). As these losses and damages are often caused by causes that are more obvious and easier to detect, such as insects and other plant pathogens, such as bacteria and fungi (Sivasubramaniam *et al*., 2020). Nematodes are microscopic organisms, which attack many plants in their roots under the soil, causing them to enlarge cells and damage tissue (Barker and Koenning,1998). It

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DOI: 10.21608/EAJBSZ.2022.274668

impedes the transfer of food and water from it to the rest of its parts above the soil, so symptoms appear in the form of gradual weakness of its growth, dwarfing in its size, yellowing and wilting of its leaves, eventually causing the plant to die and lose it, often without recognizing the main cause under the soil (Stirling *et al*., 2016; Martin, Gershuny, 1992). Many previous studies were concerned with the effect of nematode pests on both fruit trees and vegetable crops, with relatively few studies on the effect of nematodes on field crops with multiple uses (Georgis *et al*., 2016; El-Borai and Duncan, 2005; Luc *et al*., 2005), especially cereal crops, which necessitated conducting some environmental and pathological studies to know the damage caused by nematode pests on the productivity of these crops (Thompson *et al.*, 2008; Vanstone *et al*., 2008).

Maize (*Zea mays L.*) is the most extensively cultivated highland cereal in the world and the main source of food in many developing nations (Abd El-Gawad, and Morsy, 2017). After rice and wheat, it is Egypt's third-most significant staple crop in terms of acreage and output (Absy and Abdel-Lattif, 2020). The overall area of maize cultivation in Egypt is 888329 hectares or around 25.17% of the total area of cultivated land. The average output is 7.80 tonnes per hectare. It represents roughly 21.90% of the overall production of grains (FAO, 2011). Therefore, the current study aimed to conduct a survey of phytonematodes associated with the rhizosphere of some dominant cultivars of maize in clay and sandy soils in different geographical areas.

MATERIALS AND METHODS

Sampling Sites and Procedure:

A total number of 360 soil and root samples from the rhizosphere of six maize cultivars, Hi-tech, Hybrid 126, Hybrid 131, Pioneer Triple hybrid and Watania hybrid, were collected from two different locations in Egypt, geographically and in soil types:

Sohag Governorate:

Represents the largest provinces in the cultivation of traditional crops, especially grain crops. Samples were collected from Akhmim, Juhayna, Tahta, Tima and Maragha districts. These areas are characterized by hot and dry weather in the summer, with a temperature of 42±5 °C. With heavy to medium clay soil and a traditional irrigation system (immersion).

Behaira governorate:

Due to the dominance of vegetable crops and fruit trees, the cultivation of grain crops is spread in relatively few areas, namely Abu al-Matamir, Nubaria and Hosh Issa, from which samples were collected. areas are characterized by hot and wet weather in the summer, with a temperature of 39±5 °C. With light sandy soil and advanced irrigation systems (nets and sprinklers).

Soil and root samples were obtained by excavating the soil to a depth of 20–25 cm with stainless steel half-tubes. To count and isolate plant parasitic nematodes, the obtained samples were delivered to the lab in polyethylene bags.

Phytonematodes Extraction and Numeration:

Each soil sample (250g) was carefully combined with water before being processed for nematode extraction using Cobb's decanting and sieving methods to remove phytonematodes of various shapes and sizes, Seinhorst wet method, stirring method, and automotive zonal centrifugation and floatation method to remove *Heterodera* from the samples. According to Golden (1971), Mai and Lyon, and the collected phytonematodes, they were counted in a Hawksly slide and classified into genera (1975). The estimation of Population density and Frequency of occurrence is calculated by the following formula:

$$\text{Population density} = \frac{\text{Total number of individual of a genus in a sample}}{\text{Number of the samples containing this genus}}$$

$$\text{Frequency of occurrences} = \left(\frac{\text{Number of samples containing a genus}}{\text{The number of samples collected}}\right) \text{x100}$$

$$\text{Prominence value} = \frac{\text{Absolute density } \chi \sqrt{\text{Absolute frequency}}}{100}$$

$$\text{Relative frequency} = \left(\frac{\text{Frequency of a genus}}{\text{Sum of frequencies of all genera}}\right) \text{x100}$$

RESULTS AND DISCUSSION

The distribution and population density of nematodes commonly in-habiting the rhizosphere of maize fields in the crop in two types of soil; Sohag and Behaira Governorates were studied. The data presented in Tables (1,2 and3) indicated a lack of diversity in the genera associated with maize in both study areas and with different soil types. As well as the lack of genera in the clay soils compared to the sandy soils of the same cultivars of maize.

In general, the results showed the spread of six genera of nematodes in the rhizosphere of the maize plants in sandy soil belonging to three families; *Helicotylenchus* (Hoplolaimidae), *Heterodera* (Heteroderidae), *Hoplolaimus* (Hoplolaimidae), *Meloidogyne* (Meloidogynidae) and *Tylenchorhynchus* (Tylenchorhynchidae). While only three of them appeared in the clay soil; *Heterodera*, *Paratylenchus* and *Tylenchorhynchus*.

Table 1: Prevalence of phytonematodes associated with different cultivars of maize at Sohag (clay soil) and Beheira (sandy soil) Governorates during the growing seasons 2019-2020.

Prevalence of Phytonematodes of maize roots								
	Clay soil						**Sandy soil**	
Dominant Nematode genera in Egypt	cv. Hi-tech	cv. Triple hybrid	cv. Hybrid 126	cv. Watania hybrid	cv. Pioneer	cv. Hybrid 131	cv. Hi-tech	cv. Triple hybrid
Criconemella	-	-	-	-	-	-	-	-
Criconemoides	-	-	-	-	-	-	-	-
Ditylenchus	-	-	-	-	-	-	-	-
Helicotylenchus	-	-	-	-	-	-	+	-
Heterodera	+	+	+	+	+	+	+	+
Hoplolaimus	-	-	-	-	-	-	+	-
Longidorus	-	-	-	-	-	-	-	-
Meloidogyne	-	-	-	-	-	-	+	-
Paratylenchus	+	+	+	+	+	+	-	-
Pratylenchus	-	-	-	-	-	-	+	
Radopholus	-	-	-	-	-	-	-	-
Rotylenchus	-	-	-	-	-	-	-	-
Rotylenchulus	-	-	-	-	-	-	-	-
Tylenchorhynchus	+	+	+	+	+	+	+	-
Tylenchus	-	-	-	-	-	-	-	-
Xiphinema	-	-	-	-	-	-	-	-

Considering the population density (PD) frequency of occurrence (FO) and prominence value (PV) of each genus separately in both types of soils; sandy and clay within six cultivars of maize. In general, the current study found that the amount and kind of agricultural interventions had an impact on the population density and frequency of occurrence for specific genera. In the Hi-tech cv. the *Heterodera* genus achieved the highest presence in sandy soil (127, 96 and12) compared to clay soil (87, 91 and 15) respectively. On the contrary, the *Paratylenchus* genus achieved the highest presence in the clay soil (285, 100 and 50) compared to the sandy soil (35,48 and 2) of the same cultivar. While the results of the presence of the genus *Tylenchorhynchus* converged in both types of soil for the same cultivar.

Also, the study showed the absence of some genera, especially in heavy clay soils in the surveyed localities, where the genus *Helicotylenchus* was significantly present in the clay soil, while it disappeared in the sandy lands on the Triple hybrid cultivar. The same pattern was noted with *Hoplolaimus* and *Meloidogyne* (140, 7 and 4) and (257, 19 and 11) respectively in Hi-tech cultivar. Furthermore, in the sandy soil, the genera of *Helicotylenchus*, *Pratylenchus*, and *Tylenchorhynchus* appeared on Hi-tech type and disappeared on the Triple hybrid cultivar.

By comparing the distribution of genera based on cultivars (Fig. 1), the Pioneer cultivar recorded the highest population density of nematodes (427) in the clay soil, followed by the Triple hybrid cultivar and then the cultivar of Hybrid 131(425). While in sandy soils, the Hi-tech cultivar achieved the highest population density (742) compared to the same cultivar in clay soil (471).

Table 2: Population density and frequency of occurrence of phytonematodes associated with different cultivars of maize at Nubaria, Beheira Governorate during the growing seasons 2019-2020.

Phytonematodes in soil and roots of maize crop						
Nematode genera	**Cv. Hi-tech**			**Cv. Triple hybrid**		
	PD	FO	PV	PD	FO	PV
Helicotylenchus	102	4	2	-	-	-
Heterodera	127	96	12	52	100	5
Hoplolaimus	140	7	4	-	-	-
Meloidogyne	257	19	11	-	-	-
Pratylenchus	35	48	2	-	-	-
Tylenchorhynchus	81	47	4	-	-	-
Total	742	221	-	52	100	-

PD represents population density. FO represents the frequency of occurrence. PV represents prominence value. *Represents the structure of the nematode community.

Table 3: Population density and frequency of occurrence of phytonematodes associated with different cultivars of maize plants at Sohag Governorate during the growing seasons 2019-2020

Phytonematodes							**In soil and roots of maize**											
Genera	**Cv. Hi-tech**			**Cv. Triple hybrid**			**Cv. Hybrid 126**			**Cv. Pioneer**			**Cv. Hybrid 131**			**Cv. Watania hybrid**		
	PD	**FO**	**PV**	**PD**	**FO**	**PV**	**PD**	**FO**	**PV**	**PD**	**FO**	**PV**	**PD**	**FO**	**PV**	**PD**	**FO**	**PV**
Heterodera	87	91	15	59	156	9	80	25	25	230	100	41	183	100	32	99	68	14
Paratylenchus	285	100	50	341	292	60	100	52	52	164	100	29	195	100	35	352	100	62
Tylenchorhynchus	49	88	8	61	67	11	100	12	12	78	93	13	47	89	8	35	92	6
Total*	421	279	-	461	515	-	280	89	-	472	293	-	425	289	-	486	260	-

PD represents population density. FO represents the frequency of occurrence. PV represents prominence value.
*Represents the structure of the nematode community.

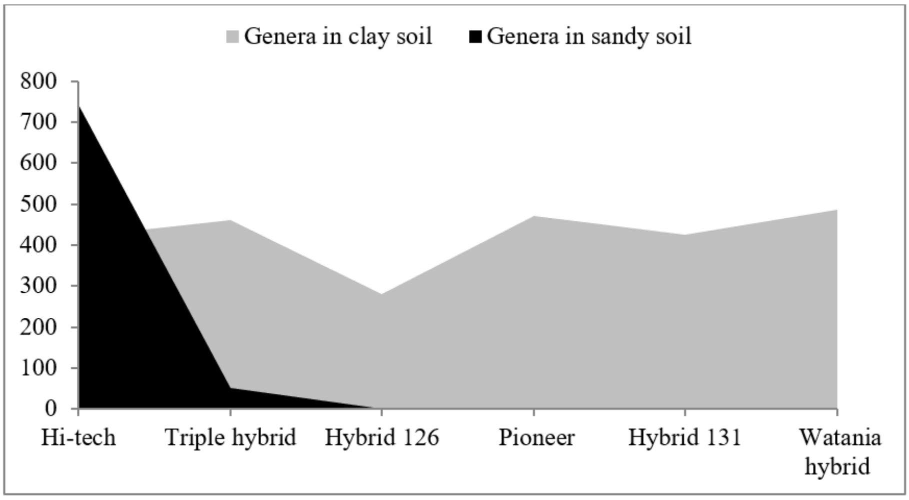

Fig. 1: Distribution and structure of phytonematodes community in two types of soil within different cultivars of maize plants.

The current study clarified the association of nematodes with the roots of the maize plants despite the different types of soil and climatic conditions, in agreement with Kheir et al., (1989). And Srivastava and Jaiswal, (2011). These findings are consistent with those of Abou-Elnaga (1979), who described 50 genera of phytonematodes belonging to 31 families, including the genera found in the current study with variable population densities that may be caused by host and soil type (Youssef, (2013). The genera of *Heterodera*, *Paratylenchus* and *Tylenchorhynchus* represented the most common genera in the rhizosphere maize roots in agreement with Oteifa and Taha (1964), Zirakparvar, (1979), Youssef, (2013) and Fabiyi 2020.

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