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Occurrence and Geographical Distribution of *Heterodera avenae* on Some Cultivated Wheat Areas in Egypt

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ABSTRACT

Occurrence and distribution of the wheat cyst nematode *Heterodera avenae* was studied during 2016-2018 cropping seasons in 12 provinces of Egypt. A total of 929 soil and root samples from 125 locations in 42 districts, were collected and analyzed. *H.avenae* was detected only in samples of Ismailia province but not in samples collected from the other provinces. The nematode cysts were found in 33 out of 187 samples collected from 20 locations in Ismailia with 16.7% frequency of occurrence. The highest incidence of the nematode was found in Al-Kassasein district with 28.6% frequency of occurrence, followed by Serabeum (20%), Abu- Suweir (14.5%) and Fayed (3.7%). Also *H.avenae* was detected in light- textured as sandy, loamy sand and sandy loam soils. No cysts were detected in heavy soil. Symptoms on wheat under Egyptian conditions were quite corresponded with those occurring on wheat grown in other wheat- growing regions of the world.

Key words: Wheat, *Heterodera avenae,* occurrence, soil type, symptoms

INTRODUCTION

Wheat *Triticum aestivum* L. is the most important cereal crop in Egypt, as it is the principle source of bread which form an essential part of Egyptian food of low cost protein, lipids and amino acids. The cereal cyst nematode *Heterodera avenae* is considered one of the major disease agents of wheat throughout the world (Nicol and Rivoal, 2008). The first detected of cereal cyst nematode in Germany was by (Kohn, 1874). Now it is disseminated in many countries around the world including Austratia, Canada , USA, Japan, India, Israel and most European countries (Meagher, 1977; Swarup and Sosa-Moss, 1990), countries within North Africa including Morocco, Tunisia, Libya and Algeria (Sikora, 1987; Saxena et al., 1988; Mokabli et al., 2001), and countries within West Asia including Pakistan and Saudi Arabia (Maqbool, 1988; Ibrahim et al., 1999). The wheat cyst nematode *H.avenae* was found to cause severe damage to wheat in most cereal – growing regions of the world, causing an economic loss in its yield. Loss was found to be correlated with nematode population density and the environmental factors (Meagher, 1982; Rivoal and Starr, 1988; Stanton and Fisher, 1988). Annual loss was equivalent to USD 70 million in Australia, USD 4.5 million in Europe USD 9.6 million in India (CAB International , 1999) and USD 3.4 million in the Pacific Northwest region of USA (Smilely, 2009).

A dramatic loss (more than 90%) was associated with severe infection (Ibrahim et al., 1999 and Namouchi- Kachouri et al., 2008).

In Egypt, the cereal cyst nematode *H.avenae* was first recorded on wheat and barley in Beheira province **(**Ibrahim et al.,1986). It was also recorded on wheat in a survey conducted in Alexandria and Beheira provinces in northern Egypt (Ibrahim and Handoo, 2007). Recently *H.avenae* was recognized in Ismailia province in Eastern Egypt (Baklawa et al., 2012; Korayem and Mohamed, 2015). In spite of this, there are not enough information concerning the occurrence and distribution of *H.avenae* in wheat-growing areas throughout Egypt. Hence a large-scale survey on the wheat cyst nematodes in Egypt well spotlights the dissemination and its potential for future spread. Therefore, the objective of this study was to perform a survey on the occurrence, distribution and population density of *H.avenae* in provinces which cultivate considerable areas from wheat in Egypt. Examination of symptoms on wheat plant as well as incidence of nematodes in relation to soil texture was also discussed.

MATERIALS AND METHODS

Locations of survey: A survey was performed for three years 2016, 2017 and 2018 in 12 provinces (Governorates) i.e. Beheira, Ismailia, Sharquia, Monufia, Gharbia, Dakahlia, Qalyobia, Kafr-El-Sheikh, Giza, Faiyum, Beni-Suef and Menya. A total of 929 soil and root samples were collected from 125 locations (villages and /or farms) in 42 districts (Fig.1 & Table 1).

Collection of samples: Soil and root samples were collected from the rhizosphere region of wheat, 2-3 weeks before harvest, by digging the soil to a depth of 15-20 cm. Samples were kept in plastic bags, supporting with data (location, the date, cultivar *etc*.) stored in the refrigerator at 4-5^{o}C until processing for analysis. Some soil and root samples were taken during early vegetative period of wheat (25-50 days after emergence) from the infected areas for assaying the nematode population density (J_2) in the soil and roots.

Nematode extraction and identification: The brown cysts of *Heterodera* was extracted and assayed from 100g of soil dried at room temperature by Fenwik-Can method (Fenwick, 1940), and were identified according to shape of the valval cone (Woats and Baldwin, 1998). Second stage juveniles (J_2) were extracted from soil according to method of Christe and Perry (1951), and juveniles in roots were extracted according to Fallis (1943).

***Symptoms of damage*:** During early vegetative stage of wheat (about 40-50 days after emergence), certain patches of yellow and poor growth plants were observed then the wheat young plants were collected from these patches. Roots were gently washed to remove soil from the roots, then shoots and roots were examined and photographed. Root samples were collected from the infection area during flowering stage of wheat for detecting the nematode white females on roots. At harvest, plant and root samples from the infected area were also taken, examined and photographed.

Soil texture analysis: Soil types were determined according to Jackson (1973).

Data analysis: The population densities of nematodes (Second juveniles J_2 and the brown cyst were counted in 100g soil. Frequency (F) and absolute frequency (FO%) and prominence value (PV) were calculated according to Norton(1978).

F= number of positive samples/total sample,

FO% = (number of positive samples/total number of collected samples) * 100

PV = Population density $\sqrt{\text{frequency}}$ (F).

RESULTS AND DISCUSSION

The occurrence and distribution of wheat cyst nematode *Heterodera avenae* was studied in 42 districts located in twelve provinces (Fig.1). All of samples collected from 125 locations were cyst nematode negative except of samples collected from locations of Ismailia province. The cysts of *H.avenae* were found in 33 samples out of 187 from Ismailia with a general frequency of occurrence of 17.6% (Table 1).

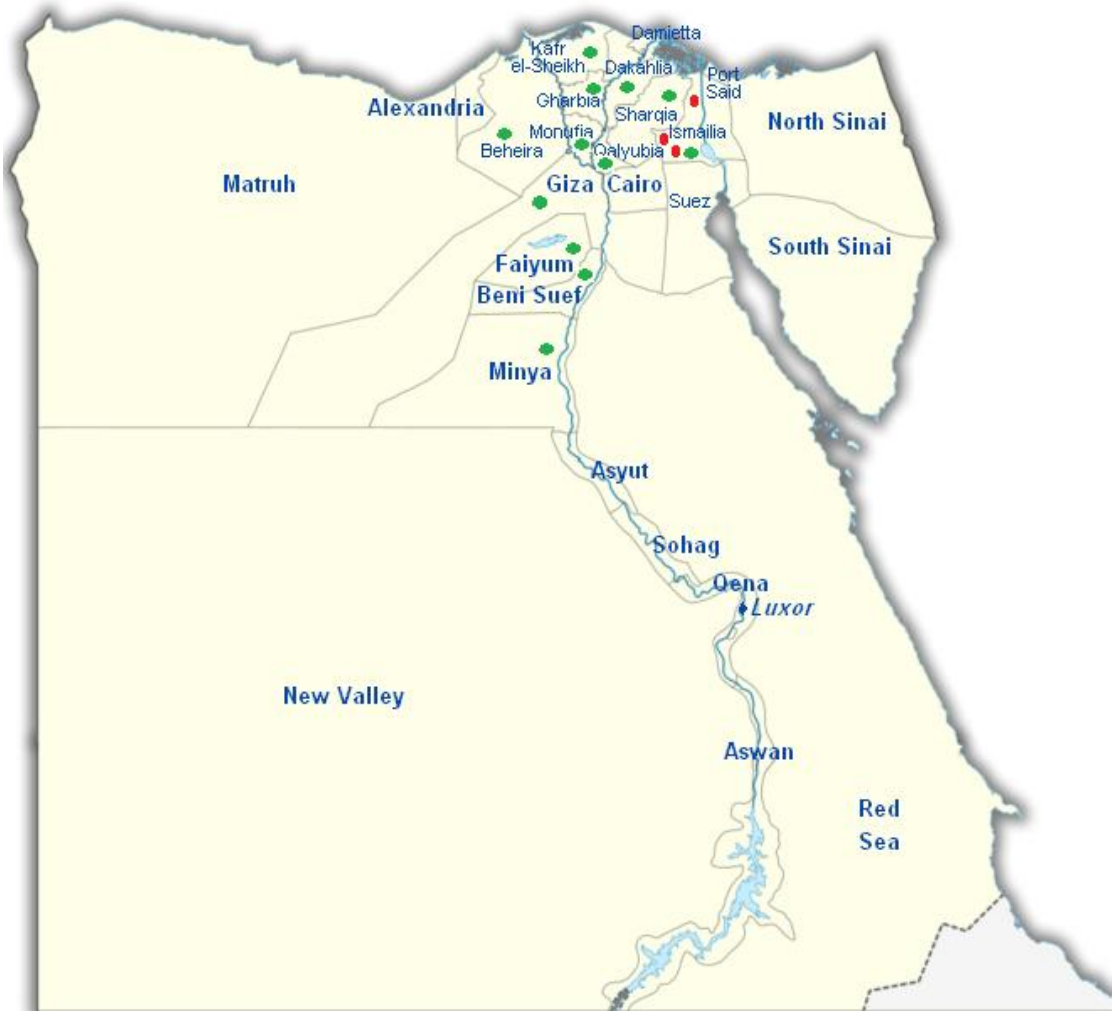

Fig. 1. Map of Egypt indicating governorates in which samples were collected.
■ Governorates were processed for sampling.
■ Localities in which *Heterodera avenae* was detected.

Table 1. Occurrence of *Heterodera avenae* in different provinces in Egypt.

Province	No. districts	No. villages (locations)	No. samples	No. positive samples	Absolute frequency FO%
Ismailia	5	20	187	33	17.6
Sharqia	2	3	45	-	-
Dakahlia	2	8	50	-	-
Kafr-el-Sheikh	1	3	30	-	-
Beheira	7	22	200	-	-
Gharbia	2	8	50	-	-
Monufia	4	7	76	-	-
Kalyubia	4	10	56	-	-
Giza	4	15	85	-	-
Beni-Suef	3	7	50	-	-
Faiyum	4	13	50	-	-
Minya	4	9	50	-	-
Total	42	125	929	-	-

FO% = No. of positive samples /Total No. of collected samples *100

Data presented in Table (2) showed that cysts of *H.avenae* were detected in four out of five regions in Ismailia province. These regions were Al-Kassasein, Serabeum, Fayed and Abu-Suweir. No cysts were found in samples collected form Tell-El-Kebirdistrict. The highest incidence of nematodes was found in Al-Kassasein district with 28.6% frequency of occurrence (population density of 1230 J_2/100g soil, 23white females per one g roots, 35 cysts/100g soil and 18.8 prominence value). Less nematode incidence and population density were found in samples collected from Serabeum, Abu-Suweir and Fayed regions, as the nematode frequency of occurrence and prominence values which were recorded 20% and 9.4, 14.5% and 5.8, 3.7% and 1.4, respectively

Table 2. Occurrence and population density of *Heterodera avenae* in wheat fields of Ismailia province.

Regions	No. collected samples	No. positive samples	FO%	Population density *			Prominence value (PV)
				J_2 in 100g soil	White females in 1 g roots	Cysts in l00 g soil	
Abu -Suweir	55	8	14.5	210	4	15	5.8
Al-Kassasein	70	20	28.6	1230	23	35	18.8
Fayed	27	1	3.7	75	3	7	1.4
Serabeum	20	4	20.0	250	10	21	9.4
Tell-El-Kebir	15	-	-	-	-	-	-

* Second juveniles (J_2) in soil and white females in roots were counted 25-50 days after wheat emergence, while No. cysts in soil were counted at 2-3 weeks before harvest.

PV = density $\sqrt{\text{frequency}}$, based on number of cysts per 100g soil.

Different soil types were collected from Ismailia province (Table 3). Data indicated that textures of soil samples were classified as sandy, loamy sand, sandy 1oam, and clay. The nematode cysts were detected in sandy, loamy sand and sandy loam soils. No cyst nematodes were found in clay soil. The occurrence of *H.avenae* in both loamy sand and sandy loam soils was approximately similar, as nematode frequency of occurrence (27.0 and 26.7%, respectively). Nematode occurrence was somewhat less in sandy soil (22.4%).

Symptoms associated with *H. avenae* infection were examined during the growing season (November – April). They were recognized from 45-50 days after emergence

Table 3. Occurrence of the wheat cyst nematode, *Heterodera avenae* in different soil types in Ismailia province.

Soil type	Number of samples	Number of positive samples	% Frequency of occurrence (FO%)
Sandy	85	19	22.4
Loamy sand	37	10	27.0
Sandy loam	15	4	26.7
Clay	50	-	-

FO% = (number of positive samples/total number of collected samples) * 100

Fig. 2. Symptoms of *Heterodera aveane* infection in the field about 40-50 days after emergence. (Appearance of patches with stunted plants with a pale green color.

and were characterized by unregularly patches of poor growing, yellowish and stunted plants randomly distributed in wheat fields (Fig. 2).

Specific symptoms occurred only on roots, which showed a slightly thickened giving an appearance of a knotted root system (Fig.3 A1).While leaves of infected plants showed a pale yellowish green in color (Fig.3B1). The white females were also recognized on root about 50 days after emergence (Fig 4). At harvest the mature plants were stunted and the whole root system showed a mass short, thickened, much-branched root (Fig.5).

The present study showed that the wheat cyst nematode, *Heterodera avenae* was detected in samples collected from Ismailia province but not in samples collected from other provinces (11 provinces). The nematode cysts were found in four out of five regions in Ismailia.

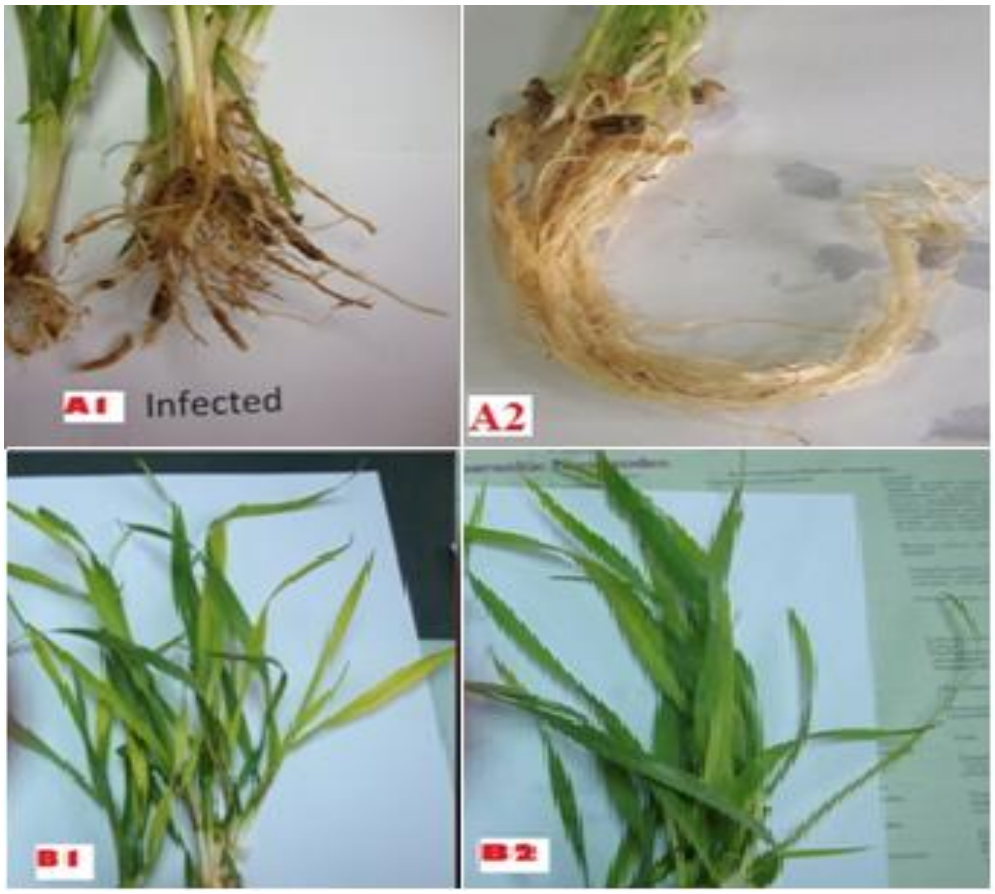

Fig. 3. Symptoms of *Heterodera avena*e damage to roots and shoots of wheat seedlings, 45 days after emergence .

A1: Roots of infected plants. Not bushy or knotted appearance on roots system.
A2: Roots of non-infected plants.
B1: Shoots of infected plants.Note the pale yellowish green colour on leaves.
B2: Shoots of non-infected plants

Fig .4.White female of *Heterodera avenae* on wheat roots about 50 days after emergence

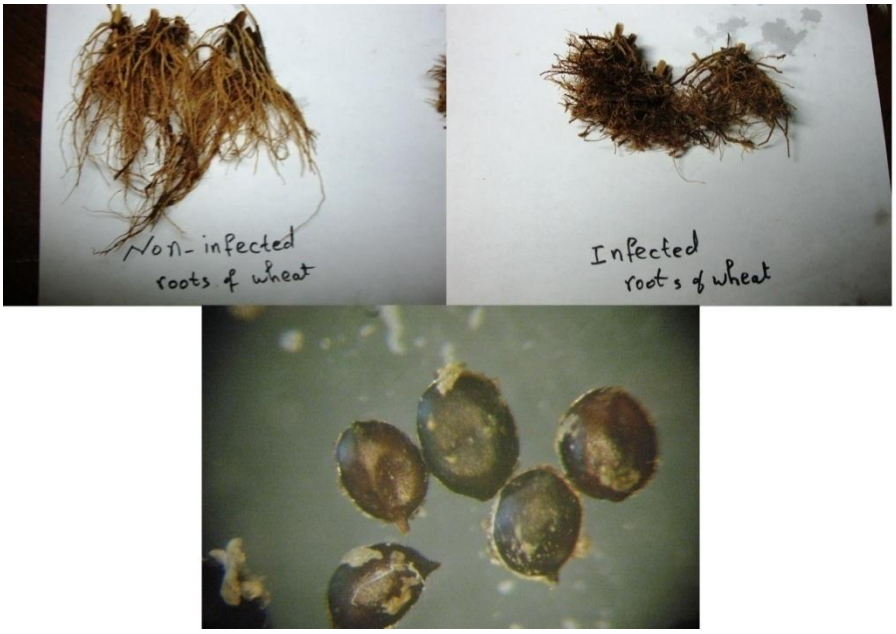

Fig. 5. Shape of roots at harvest and brown cysts. (infected roots are stunted and much branched)

Similar findings were also obtained by Baklawa et al. (2012),-who performed a survey on *H.avenae* in wheat production areas in Ismailia and reported that, *H.avenae* was detected in five out of seven regions in East and West Ismailia. Data also indicated that *H.avenae* occurred in sandy, loamy sand and sandy loam soils, but not in clay or loamy claysoils.Previous results showed also that *H.avenae* distribution and damage were clearly influenced by soil type (Kort, 1972; Meagher, 1972; Swarup and Sosa-Moss, 1990). *H.avenae* was only detected in the light–textured well drained soils such as sandy, solonized and brown soils and the grey clay but friable soils in Victoria, Australia, while it has not been detected in the heavy, poorly-structured soil in other

wheat-growing regions of Victoria which are adjacent and climatically similar to the infested areas (Meagher, 1968 and 1972).

Symptoms associated with *H. avenae* infection on wheat grown under environmental conditions of Egypt were corresponded with those occurring on wheat grown in other different ecological conditions throughout the world. As symptoms were characterized by appearance of patches of stunted plants with leaves of yellowish green colour and by roots with branched and knotted appearance (Griffin, 1984; Swarup and Sosa-Moss, 1990; Smiley and Nicol, 2009; Ahmadi and Maafi, 2014).

In summary, we confirm that wheat cyst nematode *H.avenae* is distributed in some localities of Ismailia province. This nematodes cause severe damage to wheat yield, so it is considered a major limiting factor for wheat production in the world. Currently, Ministry of Agriculture in combination with other Governmental Establishments has reclaimed great areas of sandy lands in different locations of Egyptian deserts (more than 600,000 feddan) for wheat planting. Because the environmental conditions of these new reclaimed sandy areas are quite suitable for *H.avenae* development and reproduction, precaution measures should be taken to prevent nematode introduction into these new reclaimed regions.

ACKNOWLEDGEMENT

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الملخص العربي

ظهور نيماتودا الحويصلات (*Heterodera avenae*) على القمح وانتشارها الجغرافي في مصر

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الدقي – الجيزة

تم دراسه ظهور وتوزيع نيماتوداحويصلات القمح خلال الفترة من عام ٢٠١٦-٢٠١٨ في ١٢ محافظة من محافظات زراعة القمح في مصر وهي محافظات : البحيرة – كفر الشيخ – الدقهلية – الغربية – الشرقية – الإسماعيلية – المنوفية – جيزة – بني سويف – الفيوم – المنيا.
حيث تم جمع ٩٢٩ عينة من التربة وجذور القمح من ١٢٥ قرية موزعة في ٤٢ مركز من مراكز هذه المحافظات.

وقد أوضحت الدراسة ما يلي:

١- تم اكتشاف نيماتودا حوصلات القمح في العينات الواردة من محافظة الإسماعيلية فقط دون باقي العينات الواردة من المحافظات حيث كانت سالبة.
٢- نسبة ظهور نيماتودا الحويصلات في عينات الإسماعيلية كانت ١٦,٧% (٣٣ عينة موجبة من مجموع ١٨٧ عينة) .
٣- اعلي نسبة تواجد وظهور لنيماتوداالحويصلات فى مراكز محافظة الإسماعيلية كان في مركز القصاصين بنسبة ظهور قدرها ٢٨,٦% يليه مركز سرابيوم (٢٠%) ثم أبو صوير ١٤,٥% وأخيراً فايد (٣,٧%).
٤- لم تسجل العينات الواردة من مركز التل الكبير ظهور نيماتوداالحويصلات.
٥- حويصلات النيماتودا كانت موجودة في الأراضي الرملية والرملية الطفلية والطمييية الرملية – وغير موجودة في الاراضي الطينية الثقيلة.
٦- أعراض الإصابة على القمح في ظل الظروف المناخية والبيئية لمصر كان متطابقاً مع أعراض الإصابة على القمح في بقية دول العالم.

هذا البحث اجري ضمن الخطة البحثية رقم ١١(٢٠١٦-٢٠١٩) بالمركز القومي للبحوث مشروع رقم ١١٠٨٠٨٠٧