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Population dynamics of *Heterodera zeae* under stress of a cropping sequence regime in Egypt

A.E. Ismail† and A.M. Kheir*

Plant Pathology Department, Nematology Laboratory, National Research Center, Cairo, Egypt
**Agricultural Zoology & Nematology Department, Faculty of Agriculture, Cairo University, Egypt*

†Corresponding author emails: iismail2002@yahoo.co.uk, President@nrc.sci.eg

Abstract

Population dynamics of juveniles and cysts of corn cyst nematode, *Heterodera zeae* under stress of a cropping sequence regime revealed that the average numbers in each stage greatly fluctuated. The density of juveniles or cysts gradually increased with the favorable host (Giza 2 corn) to reach its peak at the crop maturity, while the nematode population dropped sharply when the field became fallow. Likewise, the population densities of the previous stages declined gradually even though in the presence of the non host crop (Meskawii Egyptian clover).

Successful establishment of a plant parasitic nematode species is depending on how much the environmental conditions are favoring its survival. Such environmental conditions usually involve both biotic and abiotic factors. The corn cyst nematode (CCN), *Heterodera zeae* has been regarded as one of the most noxious nematodes to corn in several parts of the world. In Egypt, the CCN has been recorded in different localities (Aboul-Eid & Ghorab, 1981; Ismail, 1985; Abadir, 1986; Moussa *et al*., 1988; Ismail *et al*., 1993; Ismail, 2009). Seasonal variations in populations of the corn cyst nematode or of other nematode species are due to seasonal circumstances and host crops. The population dynamics of *H. rostochiensis* on potato were studied by Evans (1969) over one growing season. He found that the hatching and invasion occurred early in the season at low temperatures. Most juveniles in the roots were observed in May and June. Gair *et al*., (1969) observed that populations of *H. avenae* decreased under continuous and rotational spring oats and subsequently under spring barley. Chawla & Prasad (1973) and Khan *et al*., (1973) reported that monoculture of some crops resulted in the build-up of nematode populations, but proper crop rotation practices reduced the populations of safe levels incapable of inflicting damage. Effect of the non-host crops cultivars (alfalfa, barley, bean, onion, potato and wheat) on *H. schachtii* population dynamics was studied by Griffin (1980). He found that the nematode population greatly decreased with onion and bean more than with any of the other crop including fallow. Kerry *et al*., (1982) found that spring oats were the most heavily invaded cereal with *H. avenae* and produced the smallest shoots. The juveniles invaded cereal roots in decreasing numbers as follows: Spring oats > autumn oats > spring barley > spring wheat > autumn barley > autumn wheat. Studies by Brown (1984) showed that crop rotations which include periods of fallow or of non-host crop reduced population levels of *H. avenae* and improve yields. The results by Srivastava & Sethi (1986) revealed one high peak of *H. zeae* under maize-cowpea-wheat rotation coinciding with maize maturity, indicating host specificity. Ismail (2009) found that *H. zeae* numbers fluctuated greatly according to the cropping system regime used. In broad bean-corn and Egyptian clover-corn rotations, the population densities were low during the growing season of the winter crops (broad bean and Egyptian clover), then the nematode gradually increased as corn was grown and peaked in September and October for juveniles and cyst, respectively. However, in barley-corn and wheat-corn rotations, the nematode population relatively high during the winter season leaving considerable initial populations for the next crop. Subsequently in the corn crop, the nematode multiplied rapidly reaching the peaks in August and September for juveniles and cysts. Therefore, this study was carried out to elucidate the behavior of *H. zeae* under stress of a cropping sequence regime under field conditions in Egypt.

Materials and Methods

A clay loam soil field located at the Agricultural Research Center, Ministry of Agriculture, naturally infested with *Heterodera zeae*, was chosen to study the influence of cropping sequence on the nematode populations throughout 17 months starting in May 2011 to September 2012. The field was divided into plots of 10 × 7 meter each. Giza 2 corn and the Egyptian clover cv. Meskawii were cultivated in the summer and winter seasons, respectively to represent a host and a non host to the corn cyst nematode. Between the cultivating seasons, the field was remained fallow. Soil samples were taken from sampling sites in monthly intervals by a special auger to the depth of about 30 cm around rhizosphere of the growing plants or from the fallowed soil. A total of three soil subsamples were taken at each sampling site to form a composite sample. Samples were put in polyethylene bags and brought to the laboratory for nematode extraction. The population density of the nematode was determined under the following regime:

Corn cv. Giza 2 (June, 2011 to September, 2011), Fallow (October, 2011 to November, 2011), Egyptian clover cv. Meskawii (December, 2011 to February, 2012), Fallow (March, 2012 to May, 2012) and corn cv. Giza 2 (June, 2012 to September, 2012).

Bioassay of nematode and plant growth: The soil of each sample was mixed thoroughly after taking off the plant, and divided equally to subsamples. One part was processed for extraction of *H. zeae* juveniles by the sieving and decanting technique (Barker, 1985), while the other part of soil was processed for cyst extraction using Fenwick apparatus (Fenwick, 1940). Cysts were separated from debris and other organic materials by using a very fine drawing brush (Ismail, 1985), then the collected cysts were counted. Roots of the plants were cut off, weighed, measured and stained in hot acid fuchsin-lactophenol and then cleared with plain lactophenol (Taylor & Sasser 1978). Number of the developmental stages (D.S.), white females (W.F.) and brown cysts (B.C.) per root were counted. Shoots of each plant was also weighed and measured.

Results

A corn field infested with *H. zeae* located at Agricultural Research Center, Ministry of Agriculture was selected to study the influence of a host (corn cv. Giza 2) and a non host (Egyptian clover cv. Meskawii) as well as fallow period on population density of *H. zeae*. Data presented in Table 1 indicated that the average number of the nematode juveniles and cysts fluctuated greatly between seasons according to the cropping sequence. At the beginning, before corn cultivation in May 2011, the population density of *H. zeae* was 10 juveniles and 14 cysts per 250 g soil. When corn had been sown in June, juveniles and cysts number increased to 115 juveniles and 24 cysts per 250 g soil. The population of either juveniles or cysts were then steadily increased during the growing seasons to reach the peak at the crop maturation period in September at which their densities were 810 juveniles and 58 cysts. Then, by October and November 2011 when the field became fallow, the nematode population dropped sharply and no juveniles were extracted from soil (Table 1). Likewise, the population densities of either juveniles or cysts were then declined gradually even though in the presence of the non host crop; the Egyptian clover cv. Meskawii during December, 2011 to February, 2012. Also, during the fallowing period from March to May, 2012 the nematode population still too low. When the favorable host; corn cv. Giza 2 was planted in June, 2012 the population densities of both juveniles and cysts were increased gradually to reach the peak in September, 2012 as they were 260 juveniles and 39 cysts per 250 g soil (Table 1).

Table1. Population fluctuation of *Heterodera zeae* under a fallow-corn-fallow-clover-fallow-corn regime (per 250 g soil).

Nematode stage	2011											2012					
	Fallow	Corn				Fallow		Clover			Fallow		Corn				
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Juvenile (J_2)	10	115	280	660	810	0	0	39	20	0	15	30	10	85	150	175	260
Cyst	14	24	28	36	58	8	13	12	6	6	7	8	11	19	22	27	39

Discussion

The role of non-host crops and fallowing in eliminating nematode population is effectively utilized in cropping sequence regimes. Population dynamics of *H. zeae* were assessed under stress of a host (corn cv. Giza 2), and a non host (Egyptian clover cv. Meskawii) and fallow. The obtained results indicated that the average number of juveniles and cysts fluctuated greatly during seasons. On corn, the population increased gradually as the plants had grown to reach the peak at the plant maturity; while on clover and fallow, number of juveniles and cysts sharply declined. These findings are in agreement with Ismail (2009), who found that *H. zeae* population densities were low during the growing season of the winter crops (broad bean and Egyptian clover), then the nematode gradually increased as corn was grown and peaked in September and October for juveniles and cysts, respectively however, in barley-corn and wheat-corn rotations, the nematode population was relatively high during the winter season leaving considerable initial population for the next crop. Subsequently in the corn crop, the nematode multiplied rapidly reaching the peaks in August and September for juveniles and cysts, respectively. Also, Khan *et al*., (1976) and Alam *et al*., (1977) found that population of other genera i.e., *Hoplolaimus indicus*, *Meloidogyne incognita*, *Tylenchus filiformis* and *Trichodorus mirzai* were greatly influenced by the cropping sequence. The highest build-up of *H. indicus* occurred on corn and eggplant but gram brought about a great reduction in the nematode population (Khan *et al*., 1976). When Srivastava & Sethi (1986) studied that population dynamics of *H. zeae*, *Rotylenchulus reniformis* and *T. vulgaris* in corn-cowpea-wheat rotation, they recorded one high peak of *H. zeae* coinciding with the corn maturity. Also, Brown (1984) claimed that crop rotation which included periods of fallow, or non host crop caused in reducing population levels of *H. avenae* and in improving yields.

It is well known that population of nematodes in the soil are profoundly affected by the types of crops which are grown and that yields are reduced as nematode population size increased. Suitable cropping sequence regime attempts to keep nematode population to a level at which crop damage is reduced to a minimum rate.

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