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Damage Potential of *Heterodera avenae* on Wheat Growth and Yield in Relation to Nitrogen Fertilization in Egypt

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ABSTRACT

Symptoms and effect of *Heterodera avenae* on wheat growth and yield were examined in an infested field of wheat irrigated by central pivot system during 2014-2015 season. Symptoms of the infection appeared in the field in patches with stunted plants having leaves of pale green colour. Symptoms on wheat roots was characterized by branching with knotted appearance. Initial nematode population density (Pi) was estimated by 1325 j_2 in 200 g soil and 400j_2 in 5g roots, about 45 days after emergence, and by 200 brown cysts in 200g soil at harvest. Then grain yield of infected plants decreased by 21.6% compared with yield of healthy plants. When the infected plants received double dose of nitrogen, their grain yield decreased by 15.9% compared with that of healthy plants.

Key words: Wheat, cyst nematode, symptoms, damage, yield, Egypt.

Introduction

The cereal cyst nematode *Heterodera avenae* has been early detected in Europe and Canada (Meagher, 1977). It occurs now in most wheat- growing regions of the world including semi- arid, tropical and subtropical regions. (Holdeman and Watson, 1977, Smiley and Nicol, 2009). Damage caused by *H. avenae* to wheat has been reported by many investigators, as reduced tillering, early yellowing of leaves, premature maturation and smaller seed yield, were diagnosed (Rivoal and Sarr, 1987; Swarup and Sosa Moss, 1990; Romero *et al*., 1991; Al- Hazmi *et al*., 1999; Nicol, 2002; Smiley *et al*., 2005; Ahmadi and Maafi, 2014). That damage was found to be correlated with the nematode population density in soil and with the prevalent biotic and a biotic factors (Duggan, 1961; Meagher and Brown,1974; Ibrahim *et al*. 1999; Namouchi Kachouri *et al*. 2008).

Although, the cyst nematode *Heterodera avenae* has been detected in some localities of Egypt associated with cereal crops (Ibrahim *et al*., 1982, 1988; Oteif *et al*., 1997; Ibrahim and Handoo, 2007), studies on the damage associated with *H.avenae* infection and the loss in yield of wheat is neglected. Therefore the present work was conducted in the field to consolidate symptoms of the nematode infection on wheat shoots and roots and to estimate the loss in wheat growth and yield, under two different doses of nitrogen fertilization.

Material and Methods

Location, growing and sampling:

During 2014-2015 season, seeds of wheat (*Triticum sativum* L. cv. Misr-1) were grown in mid November -2014 in a field naturally infected with the cyst nematode *Heterodera avenae*, located in the 6th October farm at Ismaelia province, Egypt. The soil texture of the infected area was characterized by loamy sand and it was cultivated with wheat for several years interrupted some seasons by fallow. The farm was irrigated by central pivot system, and the nitrogen fertilization was added to all wheat – growing area through the irrigation system at rate of 70Kg N per acre in the form of ammonium nitrate.

About 45 days after emergence, uneven patches of poor growing plants were observed. Then many samples (soil and whole plants) were taken from patches of poor plants and from that of healthy plants for assaying the *H. avenae* population in soil and roots and to examine symptoms appearing on shoots and wheat roots. About three weeks after appearance of symptoms on wheat shoots, three infected patches received an additional dose of nitrogen at rate of 17.3gN/m^2 in the form of ammonium nitrate using a manual atomizer. Other samples were taken during the growing season to follow up symptoms of attack on shoots and wheat roots, appearance of brown cysts and their final population in soil and to estimate growth and yield.

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Nematode extraction and identification:

200g soil were processed for nematode extraction by sieving method (Cobb, 1918), while juveniles penetrating roots were extracted according to Fallis, (1943). The brown cysts of nematodes were assayed in soil at harvest according to Hooper, (1990). Species of the nematode was identified as *H.avenae* based on morphological and morphometric features (Handoo, 2002).

Yield loss assessment:

At harvest, damage and loss in yield were assessed in three treatments i.e. infected patches with one dose from nitrogen, infected ones with double dose from N and non infected ones with one dose of N.

About 500 plants from each treatment were manually removed to picture the shape of infected and healthy roots, and to estimate the length of plants and grain yield. Data were subjected to analysis of variance and the comparison between means was done according to LSD at P= 0.05.

Results

Nematode assaying:

Initial nematode population density (Pi) in soil and roots of wheat was assayed at appearance of symptoms on shoots, about 45 days after emergence. Nematode density in soil ranged from 800 to 2200 juveniles (j_2) with average of $1325j_2$ per 200g soil, while it was 400 individuals per 5g roots. At harvest number of the brown cysts of *H.avenae* was 200 and 220 cysts in average per 200g soil in patches receiving normal dose and double dose of nitrogen, respectively. The number of cysts occurred in the infected patches receiving normal dose of N was not significantly different with that occurred in patches receiving double doses of N. (Table 1).

Symptoms:

No specific symptoms were occurred on shoots, as the seedlings with heavily damaged roots appeared as pale green plants and aggregated in patches (Fig. 1). The first leaf of the infected plants showed a yellowish green colour which starts at the tip and extends over the whole leaf surface (Fig. 2). Symptoms of the infection on roots were more specific. At first of infection, roots became slightly thickened in the region of nematode invasion, (Fig.2). At harvest the whole root system became a mass of short, thickened and much branched roots. (Fig. 3).

Fig. 1: symptoms of *Heterodera aveane* infection in the field about 45 days after emergence. (Appearance of patches with stunted plants with a pale green color.

Fig. 2: Shape of leaves and roots of infected and healthy seedlings, 45 days after emergence.
A: infected seedlings have leaves yellowish green color with branched and thickened roots.
B: healthy seedlings.

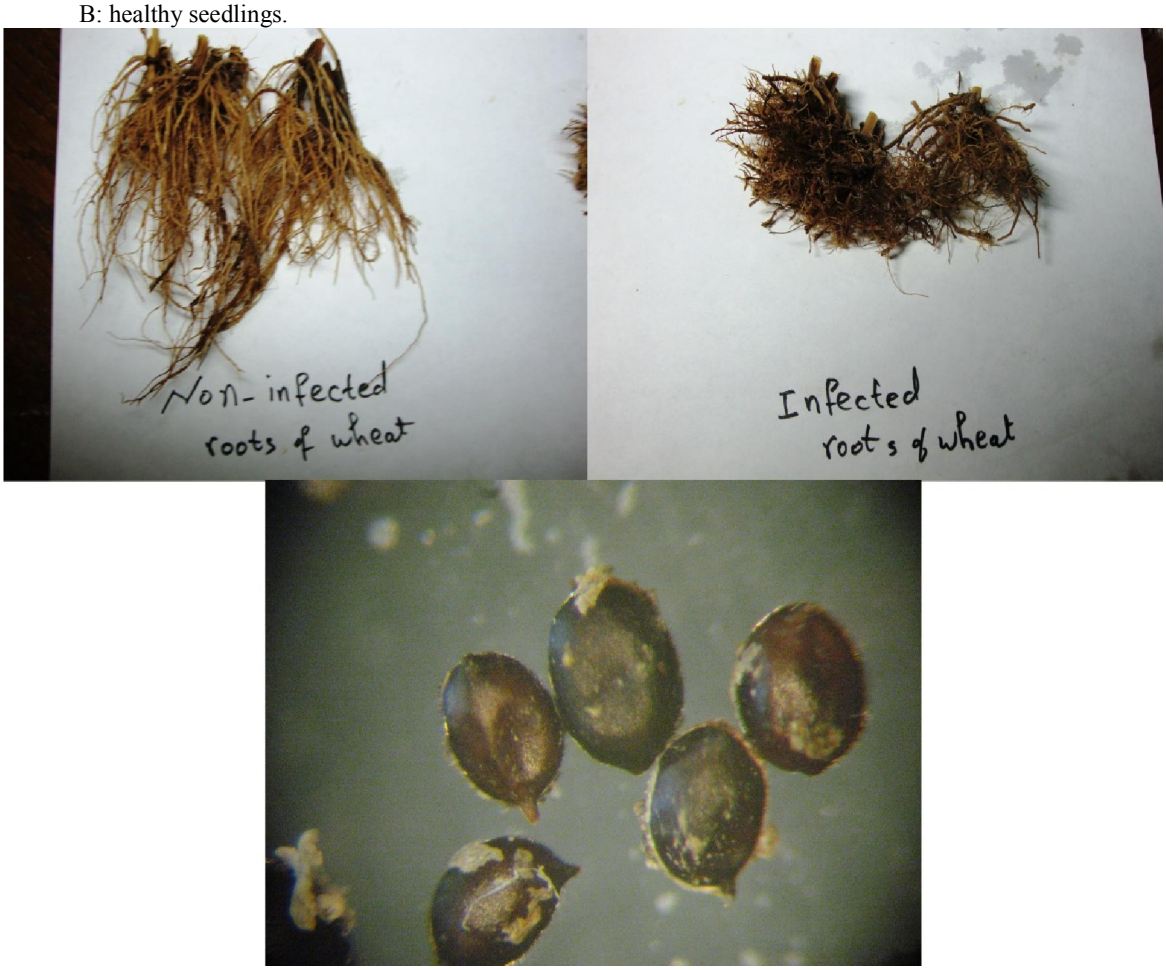

Fig. 3: Shape of roots at harvest and brown cysts. (infected roots are stunted and much branched).

Yield assessment:

Data presented in Table (1) indicated that growth and yield of wheat were reduced by nematode infection. The plant length was significantly reduced by 16.5%, and yield of grain was significantly (P= 0.05) reduced by 21.6%, while length of spikes was not affected. When the infected patches were received a double dose from nitrogen, a significant improvement in their growth and yield was occurred, as their grain yield increased by 10% compared to yield of infected plants receiving a normal dose of nitrogen. In other word, the reduction in grain yield of infected plants receiving double dose from nitrogen decreased by 15.9% only compared to yield of healthy plants.

Table 1: Effect of *Heterodera avenae* on wheat growth and yield under two different doses of nitrogen fertilizer.

Rate of nitrogen fertifizer	Status Plant	Plant length (cm)	Spike length (cm)	Grain yield (g/m^2)	Yield reduction %	Pi	PF
70 KgN/acre	Infected	86a	11.4a	400a	21.6	1325(400)	200a
140 KgN/acre	Infected	90a	11.5a	440b	15.9	1325 (400)	220a
70 KgN/acre	Non-infected	103b	11.7a	510c	-	-	-

- *Data followed by the same letter are not significantly different (P= 0.05) according to LSD method.*
- *Pi: Average of juveniles in 200g soil and 5g roots.*
- *Pf: Average of final nematode population (number of brown cysts in 200g soil).*

Discussion

Our results indicated that the symptoms associated with *H.avenae* on wheat (*Triticum sativum* cv. Misr-1) grown under Egyptian conditions were typical and corresponded with symptoms on wheat grown in the other different ecological regions. As they were characterized by appearance of patches of stunted seedlings with yellowish green leaves, while the infected roots were characterized by branching and knotted appearance (Anderson, 1961; Griffin, 1984; Swarup and Sosa Moss, 1990; Smiley and Nicol, 2009; Ahmad and Maafi, 2014). Data indicated that the grain yield of infected plants reduced by 21.6% compared with that of healthy ones. These results confirm previous reports which concluded that grain yield loss of wheat infected with *H. avenae* was 40-50% in Morocco (Rammah, 1994), up to 90% in Spain (Romero *et al.,* 1988), and up to 93.5% in Saudi Arabia (Al- Yahya *et al.,* 1996), according to initial nematode population density.

Reduction in the yield of infected plants by nematodes seem to be correlated with nitrogen fertilization. Our results showed that yield of the infected plants was improved by adding additional dose from nitrogen fertilizer, in spite of that, yield of infected plants which received a double dose of nitrogen remained significantly less than yield of healthy plants. Also many reports suggested that damage caused by nematodes to plants was correlated with the initial nematode population density in soil, and with biotic and abiotic factors (Stone, 1968; Swarup and Soss Moss, 1990; Korayem and Bondok, 2013; Korayem *et al.,* 2015).

Therefore much studies are needed for determining the damage thresholds and loss in the yield under different biotic and abiotic factors. As good knowledge about these parameters in relation to the prevalent ecological and biological factors, will support for planning effective and safety management methods, without use of the chemical nematicides which pollute the environment.

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