Quantitative and Qualitative Losses in Yield of Some Rice Cultivars due to White Tip Nematode (*Aphelenchoides besseyi*) Infection under Egyptian Field Conditions

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ABSTRACT

The influence of white tip nematode, *Aphelenchoides besseyi* (Christie, 1942) on some morphological, agronomical and grain yield quality traits of some rice cultivars at various growth stages was investigated under field conditions. Two experiments were carried out during 2003 and 2004 seasons at the experimental farm of Rice Research and Training Center (RRTC), Sakha, Egypt. Severe infection was found able to reduce the yield of susceptible cultivar, Giza 171 by 47% in both seasons and its harvest index by 46.2 and 40.4% in 2003 and 2004, respectively. However, nematode infection increased straw yield by 28.8 and 36.1%, unfilled grains/ panicle by 91.4 and 94.3%, unproductive tillers/ m2 by 80 and 93% in 2003 and 2004, respectively. Nematode infection also reduced other agronomic traits such as plant height by 30.3 and 26.3%, flag leaf area by 85.2 and 85.4%, 1000-grian weight by 35.2 and 33.6 %, number of tillers/m^2 by 60.8 and 58.7 as well as the number of panicles/m^2 by 62.5 and 65.9% in 2003 and 2004, correspondingly. Grain quality was also negatively affected in both seasons whereas hulling was reduced by 14 and 16.9% , milling by 17.2 and 18.5%, head rice% by 9.9 and 12.3%, grain shape by 19.9 and 20.4%. Chlorophyll content in the tip part of infected flag leaf was also diminished by 90 and 95%. The severe losses in flag leaf area and chlorophyll content due to nematode infection was highly significant and positively correlated with the reduction in panicle length, panicle weight and 1000-grain weight. The results of regression analysis indicated that each 1% of white tip nematode infection reflects 0.75 and 0.69% grain yield loss of Giza 171. Also, these results emphasized the high sensitivity of Giza 171 to white tip nematode infection.

Keywords: Plant-parasitic nematodes, economic losses, grain quality and yield, Egypt.

INTRODUCTION

Aphelenchoides besseyi (Christie, 1942) is a seed-borne plant-parasitic nematode and is the causal agent of the "white tip" disease of rice.

White tip disease is a widespread disease and presents nearly in all different rice ecosystems all-over the world. It has been found in upland or irrigated rice growing countries in Asia, Tropical America, USSR and Africa (Frannklin and Siddiqi, 1972; Fortuner and Williams, 1975; Ou, 1985). Europe countries including Italy (Moretti, 1997; Cotroneo and Moretti, 2001) and Turkey (Ozturk and Enneli, 1997). Eppo (1998); Giudici *et al*., 2003 and Rajan and Lal (2006) reported that *Aphelenchoides besseyi* is a seed transmitted plant parasitic nematode.

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Received on 5/11/2012 and Accepted for Publication on 26/9/2013.

On susceptible rice varieties, *A. besseyi* feeds ectoparasitically on the meristems of stems, leaves, and buds, and attracted toward young seedlings or germinating seeds. ,Initially, the nematodes are located inside the leaf sheath of the seedlings, as the plants grow, then the nematodes move to the young growing parts of the stem and leaf. On the tillers of affected rice plants, the upper leaves and the panicle are the most affected; the flag leaf often become twisted and curled, hindering the emergence of the panicle. The tips or terminal portions of the leaves become white or chlorotic for a distance up to 5 cm, and these areas later are often dark or necrotic, senesce and frayed. Frequently, the basal or middle parts of the leaves also show chlorotic areas. Later, the nematodes migrate to the panicles, puncture the inflorescence and penetrate into the florets where they feed on ovary, stamens and the developing embryos. Diseased plants are reduced in vigor and height, and produce small panicles. Both the panicle length, weight and the number of spikelets are reduced. The reduction is most evident in the terminal portion of the panicle, where lemma and palea often are absent. Affected panicles show excessive sterility, and the fertile florets at maturity have twisted or distorted glumes and small distorted kernels. The flowers become sterile and this leads to the reduction in a number of grains. Misshapen grains, stunting of the plants, late ripening and maturation, and branching from the upper nodes are commonly noted. The upper leaves, particularly the flag leaf of severely diseased plants, are markedly twisted. Also, length and weight of white-tip affected panicle and number of grains/ panicle were greatly reduced (Todd and Atkins, 1958; Kirby, *et al*., 1977; Rahman and Mcgeachie, 1982; Jairajpuri and Baqri, 1991 and Waele, 2002).

It was reported that *A. besseyi* caused variable yield losses in different countries depending on rice varieties. The estimated rice yield reduction due to *A.besseyi* was 14.5-46.1% in Japan (Nishizawa and Yamamato, 1951) ; 17-34% in USA (Tod and Atkins, 1959); 29-46 % in Taiwan (Hung, 1959); 29-61% in USSR (Tikhonova , 1966); 14.5-71% in India (Rao *et al*., 1985); up to 50 % in Brazil (Tsay, 1998). White tip nematode was initially reported in Egypt by Amin (2002). It was found to be widely distributed in all Egyptian governorates causing remarkable yield reductions to the sensitive old rice cultivars, Giza 171 and Reiho (Abdel-Hadi, *et al*., 2005 and EL-Shafey, 2007). Nandakumar *et al*., 1975 attributed the 21-46 % yield losses to the reduction in Chlorophy11 and improper filling of Kernel. Wang *et al*., (2006) proved that the yield and quality of rice were strongly influenced by the disease, restricting rice production seriously in Jiangsu Province of China. This study aimed to investigate the effect of white tip nematode on some morphological, agronomical and grain quality traits in various growth stages under field conditions of Egypt.

Materials and Methods

1. Effects of white tip nematode infection severity on some agronomic rice traits and yield losses:

In order to create different levels of infection percentage on highly susceptible cultivar Giza 171, nematicides were used in different formulations and doses. The nematicides Furadan and Mocap were used as granules (5 & 10 kg / fed each). Vydate was used as emulsifiable concentrations, EC 2 & 4L /fed. All treatments were arranged in a randomized complete block design with four replicates.

Randomly, five hills were tagged in each treated or untreated plots. During the growing season, vegetative and reproductive characters were recorded to be correlated and emphasized its relationship with the severity of nematode infection. Vegetative characters (number of tillers/m^2, number. of panicles/m^2, number of ineffective tillers, flag leaf area, chlorophyll content, plant height), reproductive characters (panicle length,

panicle weight, no. of filled and unfilled grains/ panicle, 1000-grain weight, grain yield, straw yield and harvest index) were recorded. Also, the nematodes/10g rice grains was extracted by Baermann funnel method and recorded in order to correlate with infection severity. Yield and yield losses due to different nematicidal applications were assessed.

2. Effects of white tip nematode (A. besseyi) infection on flag leaf area and its relation with some rice panicle characters of different cultivars:

Infected and healthy grains of different rice cultivars were cultivated under field conditions in a randomized complete block design with four replicates. The cultivars were Giza 171, Sakha 101, Sakha 102, Sakha 103 and Reiho. Some agronomic traits, i.e. flag leaf area, panicle length, panicle weight, 1000-grain weight and sterility % were measured to calculate loss due to white tip infection. Correlation coefficients were computed among flag leaf area, some panicle traits and white tip nematode.

3. Effects of A. besseyi infection on rice chlorophyll content of flag leaf:

One week after complete heading stage, chlorophyll content of flag leaf of different rice cultivars was assessed using chlorophyll meter (Mod. Spad-502, Minolta Camera Co. Ltd., Japan). The chlorophyll content was assessed in the tip and basal parts of infected flag leaves and compared with that in healthy flag leaves. Thus, the reduction % in chlorophyll content was calculated as influenced by white tip nematode infection.

- ***Disease assessment:***

Percentage of white tip nematode infection*:*

To estimate nematicide efficiency, total rice hills in one square meter were examined to record the infected hills and calculate the infection percentage from the following formula:

$$\text{Percentage of infection} = \frac{\text{No. of infected hills/m}^2}{\text{Total no. of rice hills/m}^2} \times 100$$

- *Severity of infection:*

Severity of white tip infection was estimated as the number of infected leaves/m^2.

Grain yield:

Grain yield of each plot was estimated by harvesting all hills in the plot except one outer row from each side. Total weight was recorded for each plot and weight was adjusted to 14 % moisture content, then the yield was calculated as t/fed.

***Yield loss %*:**

Loss % was estimated according to the equation adopted by Calpuzos *et al*., (1976).

Reduction in grain yield %= 1- Yd/Yh × 100

where: Yd = yield of infected plots , Yh = yield of healthy or protected plots.

Yield components:

The following yield components were considered in both healthy and infected plots for all agronomic traits:

a. Number of tillers/m^2: Number of productive and non-productive tillers from 5 hills selected randomly from each plot were counted and converted to number of tillers /m^2.

b. Number of panicles/m^2: Number of panicles from 5 hills selected randomly from each plot were counted and converted to number of panicles/m^2.

c. Total number of filled grains/panicle: Numbers of filled grains in ten random panicles were counted.

d. Percentage of unfilled grains: Percentage of unfilled grains was calculated from the equation:

$$\text{Unfilled grains \%} = \frac{\text{No. of unfilled grains/panicle}}{\text{Total no. of grains/panicle}} \times 100$$

e. Panicle weight (g): Panicle weight was estimated by weighing ten random panicles and then the mean was calculated.

f. 1000-grain weight (g) : Weight of random 1000

filled grains in each plot was assessed.

g. Harvest index (%): Harvest index was calculated using the following equation:

$$\text{Harvest index \% (HI)} = \frac{\text{Grain yield}}{\text{Grain yield + straw yield}} \times 100$$

***Morphological parameters**:*

a. Plant height (cm): Ten hills were randomly collected from each plot and plant height was measured up to the top panicle of the main stem.

b. Flag Leaf Area (cm^2): Leaf area was estimated using the following formula (Palaniswamy and Gomez, 1974):

LA = K (L × W). Where :

L = leaf length

W = maximum leaf width, and

K = constant (0.75)

Grain Quality:

Samples of rice grains taken from each treatment were examined in grain quality laboratory of the RRTC to determine some of the grain quality characters as the percentage of hulling, milling or head rice in addition to grain shape.

a. Hulling percentage : Hulling percentage was calculated using the following formula:

$$\text{Hulling \%} = \frac{\text{Weight of brown rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

b. Milling percentage : Milling percentage was determined using the following formula:

$$\text{Milling \%} = \frac{\text{Weight of milled rice}}{\text{Weight of rough rice}} \times 100$$

c. Head rice percentage : Head rice percentage was determined using the following formula:

$$\text{Head rice \%} = \frac{\text{Weight of head rice (g)}}{\text{Milled rice weight (g)}} \times 100$$

Grain width, grain shape, hulling (%), milling (%), and head rice (%) were estimated according to Khush *et al*. (1979).

Results and Discussion

Effect of white tip nematode infection on grain yield and yield components:

All characteristics of susceptible cultivars Giza 171 were studied under severe infection level (930 nematodes *of A. besseyi* / 10 g grains) with *A. besseyi*. Data in Table (1) indicated that the white tip nematode infection affected the rice plant vigor in all growth stages.

In vegetative stage, white tip nematode infection reduced the number of tillers /m^2 by 60.8 % (Table 1). The flag leaf area was damaged and dimensioned by 85.2 %, while fresh and dry weight of flag leaf by 81.6 and 90.7 %, respectively. On the other hand, the white tip nematode infection increased the number of unproductive tillers /m2 and straw yield by 80 and 28.8 %. The increase of unproductive tillers associated with the increase of straw yield and the decrease of grain yield. The infected plants were stunted due to nematode infection, the plant height reduced by 30.3 % (Table 1).

In reproductive stage, white tip nematode infection remarkably reduced the number of panicles /m^2 by 62.8 %. The infected panicles length and weight were reduced by 45.7 and 51.3 %, respectively. The white tip infection caused a deformation of panicle branches during panicle initiation, so the no. of unfilled grains/ panicle increased by 91.4 %. Also, 1000-grain weight was decreased by 35.2 %. Finally, as a result of losses in all traits, the yield was significantly reduced by high infection of white tip nematode.

The percentage of reduction in harvest index and grain yield reached 46.2 and 47% in 2003 season, respectively. The same trend of losses was recorded in 2004 season.

White tip nematode reduced both the major traits for rice production; no. of tillers and panicles/m^2. So, white tip nematode is able to destroy the tillering ability. Also, nematode infection induced tillering from upper node

during flowering and maturing stage, therefore, the number of unproductive tillers was increased. Panicles with white-tip symptoms were significantly shorter and lighter than the healthy ones. The infected panicles had few filled grains and the sterile grains were increased. However the weight of 1000 grains decreased from diseased panicles and the nematode population per 10g in diseased panicles was significantly higher than in panicles without apparent disease symptoms by 98.5% (Table 1).

The white tip nematode destroyed the flag leaf area and accordingly reduced the area for photosynthesis. So, as a result of leaf area damage the photosynthetic and net assimilation rate will be affected. These results are in accordance with those of Todd and Atkins, 1958; Kirby, *et al*., 1977;Rahman and Mcgeachie ,1982; Jairajpuri and Baqri,1991and Waele, 2002. They reported that nematode infection resulted in whitened and shredded leaf tips, crinkled or distorted leaves, abnormal leaf greening, distorted floral parts and empty grains and rice panicles infected with *A. besseyi* were significantly shorter, weighed less, had fewer filled grains and lower 1000- grain weight. Also, Rahman and Miah (1989) revealed that the infestation of white-tip nematode not only causes 69.5 % sterile grains in panicles, but the weight of grain is also reduced by 65.4 %. The average losses ranges from 10-30 % but in susceptible varieties the loss has been estimated up to 70 %. Jamali, *et al*. (2007) reported that infection with *A. besseyi* reduced the panicle length by 29.3%, panicle weight 41.9 %, filled grains/ panicle 69.1% and 1000-grain weight by 54.5% and increased the number of sterile grains/ panicle by 71.0% and nematodes/100 grains by 92.3%.

The present results proved the grain yield loss due to the white-tip nematode infection reached 47% and these agreed with those documented in different countries (Todd and Atkins ,1959; Hung ,1959; Tikhonova ,1966; Nandakumar, *et al*. ,1975; Rao, *et al*., 1985; and Tsay ,1998).

Effects of white tip nematode infection on grain quality:

This study aimed at investigating the effects of white tip nematode infection on some grain quality traits; Hulling percentage, milling percentage, head rice and grain shape. Results indicated that the quality traits of rice grains were highly and negatively affected by white tip nematode infection (Table 1). Hulling decreased by 14 and 16.9 %, milling by 17.2 and 18.5 %, head rice by 9.9 and 12.3 % and grain shape by 19.9 and 20.4 % in 2003 and 2004 seasons, respectively. The percentage of different type of cracks increased by 75 % in infected grains compared with healthy grains. Thus, nematode infection increased the broken rice. The cracks have a black color due to secondary infection (Figure 2). The obtained results are in accordance with those of Fukano (1962) who reported that diseased plants were usually stunted. Leaves were dark green, considerably shortened and usually twisted at the shoot apex. They often exhibit chlorosis in the terminal region. Panicles were short in length and produced fewer grains. Unhulled grains were thinner and the percentage of blasted grains was increased. The infection of *A. besseyi* induced yield loss and reduced quality of rice by causing black blots on husked rice. Also, Nishizawa (1976) showed that *A. besseyi* was the primary cause of black wedge-shaped spots on rice kernels. Secondary infection with saprophytic microorganisms such as *Enterobacter agglomerans* was found necessary for the discoloration process. Uebayashi, *et al*. (1976) detected two types of seed symptoms closely related to infection of rice by *A. besseyi*. The first symptom exhibited longitudinal cracked and blackened kernels developed when the nematodes damaged the rice during the early milk stage. The second one appeared as transverse cracked and

wedged kernels developed when damage occurred from the late milk stage to the early yellow ripe stage. These symptoms occurred mostly on the ventral side of the kernel. Immersion of the infected panicles in 1000 ppm of streptomycin significantly reduced the incidence of abnormalities, indicating bacterial involvement. Both cracks increased the percentage of broken rice.

Relationship of white tip nematode infection with some agronomic rice traits and yield loss:

Correlation coefficients were computed among severity of white tip nematode infection and some rice characteristics. Data in Table (2) showed that severity of white tip nematode infection was highly significant and positively correlated with each of the number of ineffective tillers/ m^2, number of juveniles/10g grains and straw yield. While, it was highly significant and negatively correlated with panicle length, panicle weight, number of filled grains/panicle, plant height, flag leaf area, number of tillers /m^2, number of panicles/ m^2, yield t/fed., harvest index, 1000-grain weight and chlorophyll content. White tip nematode infection affected all rice traits (Figure 2).

Table 1. Effects of white tip nematode infection on yield and different characters of rice cv. Giza 171 under field conditions.

Character	2003					
	Healthy plot	Infected plot	Response %	Healthy plot	Infected plot	Response %
Vegetative characters:						
Plant height (cm)	129.6	90.3	-30.3	120.0	88.4	-26.3
Flag leaf area (cm2) (5 leaves)	148.5	22	-85.2	167.5	24.4	-85.4
Fresh weight (g) (5 leaves)	3.8	0.70	-81.6	3.80	0.81	-78.7
Dry weight (g) (5 leaves)	1.40	0.13	-90.7	1.42	0.13	-90.8
No. of tillers /m2	781.3	306.3	-60.8	756.3	312.5	-58.7
No. of unproductive tillers /m2	31.3	156.3	+80	12.0	181.3	+93.4
Straw yield (t/fed).	5.000	7.024	+28.8	4.820	7.541	+36.1
Reproductive characters:						
No. of Panicles /m2	750	281.3	-62.5	712.5	243.0	-65.9
Panicle length (cm)	23	12.5	-45.7	23.6	12.0	-49.2
Panicle weight (g)	3.9	1.90	-51.3	3.8	1.8	-52.6
No. of filled grains / panicle	183.5	50.3	-72.6	185.5	52.0	-72
No. of unfilled grains / panicle	5.3	61.8	+91.4	3.3	57.8	+94.3
1000- grain weight (g)	27.0	17.5	-35.2	26.5	17.6	-33.6
No. of nematode/ 10g grains	3.8	258	+98.5	3.0	267.5	+98.9
Harvest index (HI)	41.3	22.2	-46.2	32.7	19.5	-40.4
Yield (t/fed).	3.552	1.858	-47	3.573	1.895	-47
Grain Quality characters:						
Hulling %	84.5	72.9	-14	84.8	70.5	-16.9
Milling %	75.2	62.3	-17.2	75.7	61.7	-18.5
Head Rice %	64.6	58.2	-9.9	65.1	57.1	-12.3
Grain shape	2.46	1.97	-19.9	2.45	1.95	-20.4
Transverse and longitudinal cracks(150 g)	1	4	+75	1	5	+80

Table 2. Correlation coefficients between white tip nematode severity and some agronomic rice traits.

Character	Severity of infection	
	2003	2004
Number of tillers /m2	-0.764**	-0.712**
Number of panicles /m2	-0.801**	-0.748**
Number of unproductive tillers /m2	0.815**	0.884**
Flag leaf area (cm2)	-0.748**	-0.915**
Chlorophyll content (SPAD value)	-0.787**	-0.749**
Plant height (cm)	-0.803**	-0.772**
Panicle length (cm)	-0.815**	-0.916**
Panicle weight (g)	-0.714**	-0.748**
Number of filled grains/panicle	-0.714**	-0.709**
Number of unfilled grains / panicle	0.875**	0.910**
1000- grain weight (g)	-0.787**	-0.749**
Yield t/fed.	-0.598**	-0.593**
Straw yield t/fed.	0.366**	0.561**
Harvest index	-0.639**	-0.684**
Number of larvae / 10g grains	0.810**	0.907**

** Highly significant at 1%

Effects of white tip nematode) infection on flag leaf area and its relation to some rice panicle characters of different cultivars:

The healthy and infected grains of rice cultivars were cultivated under field conditions to assess the effect of white tip nematode on flag leaf area and its relationship with some agronomic traits. Data in Tables 3 and 4 revealed significant differences between healthy and infected plots in all traits. All cultivars were significantly affected by nematode infection. All traits in all cultivars were highly affected and the most affected cultivar was Giza171 followed by cv. Reiho, however cv. Sakha101 was the least affected one. The flag leaf area in healthy Giza171 plots recorded ten folds over those in infected plots (33.8 cm^2 versus 3.8 cm^2), while, three only folds were recorded in case of sakha101. Other traits recorded remarkable reduction in infected plots compared with healthy ones for all cultivars in the two seasons 2003 and 2004.

Reduction in some rice agronomic traits assessed for all cultivars. Data in Tables 3 and 4 indicated that reduction in the flag leaf area ranged from 65.7-90.5 % and this loss related to the reduction in panicle length which ranged from 20 to 46.2%, panicle weight (31.3 and 58.7%), 1000-grain weight (27.2 and 41.1%) and sterility % (13.9 and 41.4 %) for Sakha 101 and Giza 171 in season 2003. The same trend was obtained in season 2004. Figure 1 showed the symptoms of severe reduction and damage in flag leaf area, chlorophyll content and panicle length. Incomplete exertion, deformation and degeneration of panicles and high percentage of sterility were noticed clearly.

Relationship of white tip nematode infection with flag leaf area and some rice plant characteristics:

Correlation coefficients were computed among affected flag leaf area with infection of white tip nematode, number of nematodes and some rice traits. Data in Table 5 indicated that flag leaf area was highly significant and positively correlated with panicle length, panicle weight, number of branches/ panicle, 1000-grain weight, number of filled grains/panicle, while it was highly significant and negatively correlated with number of unfilled grains/panicle, sterility % and number of larvae/panicle in

2003 and 2004. Flag leaf area was considered the most effective trait and all traits were affected by damaged leaf area. As a result of white tip nematode infection, total photosynthetic area decreased during vegetative stage. This result is in agreement with those of Wan and Zhong (1981) who observed positive correlation between leaf area index and dry matter production. Also, a positive correlation was found between flag leaf area and panicle weight. Likewise, Bashar, *et al*. (1991) reported that flag leaf area has a significant effect on grain yield through grains/panicle and panicle length. Takane, *et al*. (1995) reported that about 70 % of grain yield came from photosynthesis after heading and thus photosynthesis process after heading was extremely important. The major photosynthetic organ after heading is the flag leaf. Takane, *et al*. (1997) found that high yielding cultivars were larger in leaf area index. Jamali, *et al*. (2006) reported that *A. besseyi* causes a chlorotic discoloration in 2 to 5cm on the leaf tip of seedling. At booting stage, the flag leaf of the affected plant was characteristically shortened, twisted and often distorted or split longitudinally. Complete or partial emergence of panicles occurred on infested plants with whitish spikelets on the tip or throughout. The affected spikelets were shrunken, malformed and unfilled.

Effect of white tip nematode on rice chlorophyll content:

The reduction % in chlorophyll content in the flag leaf due to white tip nematode infection was studied for cvs. Giza 171, Reiho, Sakha 101, Sakha102 and GZ 6910-28-1. Data in Table 6 revealed that the chlorophyll contents in infected tip of Giza 171 were 2.2 and 1.9 SPAD value with reduction percentage of 95.0 and 95.2 in seasons 2003 and 2004, respectively.

The following moderate infected portion of the same flag leaf gave chlorophyll contents of 29 and 27.4 SPAD value with reduction % of 29.0 and 31.2%. The highest chlorophyll content was obtained from healthy flag leaves were 40.8 and 39.8 SPAD value. The same trend was recorded with the remaining four varieties in both seasons 2003 and 2004. The obtained results agree with those results of Todd and Atkins, 1958; Kirby *et al*., 1977; Rahman and Mcgeachie, 1982; Jairajpuri and Baqri, 1991; Waele, 2002 who reported that the upper leaves and the panicle are the most affected; the flag leaf often become twisted and curled, hindering the emergence of the panicle. The tips or terminal portions of the leaves become white or chlorotic for a distance up to 5 cm, and these areas later are often dark or necrotic, senesce and frayed. Frequently, the basal or middle parts of the leaves also showed chlorotic areas.

Results in Table 7 indicated that the yield of Giza 171 was highly reduced due to the infection and the yield losses ranged from 1.6 to 47.7% and 2.4 to and 47% in 2003 and 2004 seasons, respectively.

Regression analysis :

White tip infection (WTI) was used as the independent variable and yield loss (y) was used as the dependent variable for the rice cultivar Giza 171 in both 2003 and 2004 seasons. Results in Table 8 indicated that the values of coefficient of determination (R2) for the two seasons were 0.959 and 0.951% of the losses in yield for cv. Giza 171. In other words, 95.9 and 95.1% of yield losses resulted from white tip infection in both seasons, respectively. Concerning the partial regression coefficient, the values of partial regression coefficient for WTI (b) were 0.745 and 0.690% with Giza 171 in both seasons. These results indicated that each 1% of white tip nematode infection reflects 0.745 and 0.690 yield loss % of Giza 171 grain yield. Also, these results proved the sensitivity of Giza 171 to white tip nematode infection (Figure 2).

Table 3. Effect of white tip nematode (*Aphelenchoides besseyi*) infection on flag leaf area and its relation with some rice panicle characters of different cultivars during 2003 season.

Cultivar	State	Flag leaf area cm2 (one leaf)	Panicle length (cm)	Panicle weight (gm)	1000-grain weight (gm)	Sterility %	number of juveniles / panicle
Giza 177	H	31.10	22.8	4.5	27.9	2.4	2.3
	I	7.8	16.8	2.7	18.4	17.7	35.3
Reduction %		74.9	26.3	40.0	34.1		
Sakha 101	H	35.6	26.0	4.8	27.2	1.7	1.8
	I	12.2	20.8	3.3	19.8	13.9	26.3
Reduction %		65.7	20.0	31.3	27.2		
Sakha 102	H	26.8	23.3	4.5	27.8	4.1	3
	I	8.9	16.2	2.5	17.4	24.8	36.4
Reduction %		66.8	30.5	44.4	37.4		
Sakha 103	H	28.6	21.7	4.2	25.0	3.0	3.3
	I	7.7	15.4	2.1	17.4	23.2	44.5
Reduction %		73.1	29.0	50.0	30.0		
Giza 171	H	33.8	23.6	4.6	29.9	5.7	4.5
	I	3.2	12.7	1.9	17.6	41.4	72
Reduction %		90.5	46.2	58.7	41.1		
Reiho	H	27	19.9	4.1	25.7	2.7	3.3
	I	3.4	13.0	1.3	17.1	34.3	65
Reduction %		87.4	34.7	68.3	33.5		

Table 4. Effects of white tip nematode infection on flag leaf area and its relation with some rice panicle characters of different cultivars, 2004 season.

Cultivar	state	Flag leaf area cm2 (one leaf)	Panicle length (cm)	Panicle weight (gm)	1000-grain weight (gm)	Sterility %	number of juveniles/ panicle
Giza 177	**H**	30.5	21.3	4.1	27.7	3.0	2.3
	I	8.3	15.8	2.4	18.6	17.5	33.8
Reduction %		72.8	25.8	41.5	32.9		
Sakha 101	**H**	34.4	25.3	4.9	27.1	1.7	1.8
	I	11.8	19.9	3.1	20.2	17.3	25.0
Reduction %		65.7	21.3	36.5	25.5		

Cultivar	state	Flag leaf area cm2 (one leaf)	Panicle length (cm)	Panicle weight (gm)	1000-grain weight (gm)	Sterility %	number of juveniles/ panicle
Sakha 102	**H**	26.6	22.2	4.8	27.7	4.6	2.8
	I	8.6	17.2	2.4	17.6	19.6	37.0
Reduction %		67.7	22.5	50.0	36.5		
Sakha 103	**H**	25.3	20.7	4.0	23.8	5.0	4.3
	I	7.0	14.3	2.2	17.2	26.6	48.8
Reduction %		72.3	30.9	45.0	27.7		
Giza 171	**H**	34.6	23.3	4.5	27.3	7.0	5.0
	I	3.7	14.4	2.0	16.7	35.5	75
Reduction %		89.3	38.2	55.6	38.8		
Reiho	**H**	22.3	20.0	4.0	25.9	7.8	5.0
	I	3.8	12.9	1.1	17.1	29.9	65
Reduction %		83.0	32.1	72.5	34.0		

H = Healthy, I = Infected

Table 5.Correlation coefficients among flag leaf area, number of *Aphelenchoides besseyi* juveniles and some rice plant characters, 2003 and 2004 seasons.

Characters	Flag leaf area	
	2003	**2004**
Panicle length	0.864**	0.815**
Panicle weight	0.913**	0.864**
Number of branches/ panicle	0.789**	0.667**
1000-grain weight	0.950**	0.959**
Sterility %	-0.797**	-0.709**
Number of filled grains/panicle	0.926**	0.870**
Number of unfilled grains / panicle	-0.633**	-0.532**
No. of larvae / panicle	-0.884**	-0.885**

** Highly significant at 1%

Table 6. Effects of white tip nematode (Aphelenchoides besseyi) infection on chlorophyll content (SPAD value) the flag leaf of some rice cultivars.

Cultivar	Flag leaf	2003		2004	
		Chlorophyll content	Reduction %	Chlorophyll content	Reduction%
Giza 171	Severe infected portion (tip)	2.2	95.0	1.9	95.2
	Moderate infected portion (basal)	29.0	29.0	27.4	31.2
	Check (Healthy leaf)	40.8	-	39.8	-
Reiho	Severe infected portion (tip)	2.0	94.7	3.0	93.1
	Moderate infected portion (basal)	24	36.8	22.6	39.7
	Check (Healthy leaf)	38	-	37.5	-
Sakha 101	Severe infected portion (tip)	3.6	92.2	2.85	93.8
	Moderate infected portion (basal)	31.5	32.0	32.8	28.2
	Check (Healthy leaf)	46.3	-	45.7	-
Sakha 102	Severe infected portion (tip)	3.6	91.2	2.9	92.0
	Moderate infected portion (basal)	27	38.6	25.1	40.4
	Check (Healthy leaf)	44	-	42.1	-
GZ 6910 - 28-1	Sevre infected portion (tip)	4.7	9.0	5.6	87.3
	Moderate infected portion (basal)	33.8	25.4	30.7	30.4
	Check (Healthy leaf)	45.3	-	44.1	-

Table 7. Yield and yield loss % of Giza 171 rice cultivar as influenced by white tip nematode (*Aphelenchoides besseyi*) infection under different nematicides treatments.

Treatment	Rate kg/fed. 30 days after transplanting	Infection %		Yield t/fed.		Yield loss %	
		2003	2004	2003	2004	2003	2004
Apparently healthy seeds	-	23.1	19.7	3.552	3.573	-	-
Mocap 10 G	10	34.7	32.9	3.543	3.486	1.6	2.4
Mocap 10 G	5	41.3	42.7	3.450	3.362	2.9	5.9
Furadan 10 G	10	52.0	50.7	2.873	2.839	19.1	20.5
Furadan 10 G	5	59.6	56.4	2.701	2.857	24.0	20.0
Vydate 24 EC	2 L spray	70.1	68.8	2.352	2.357	33.8	34
Infected seeds	-	94.6	94.9	1.858	1.895	47.7	47.0

Table 8. Regression equation of rice cultivar Giza 171 under different categories of white tip nematode infection %.

Season	Regression equation	R	R2	Adjusted R2	95% Confidence Interval for B		Standard error (S.E)	F
					Lower Bound	Upper Bound		
2003	Y= -21.534+ 0.745WTI	0.979	0.959	0.950	0.567	0.923	0.069	**
2004	Y= -17.533+ 0.690 WTI	0.975	0.951	0.942	0.511	0.968	0.070	**

Y = Yield loss % WTI = white tip infection % ** = Significant at 0.01

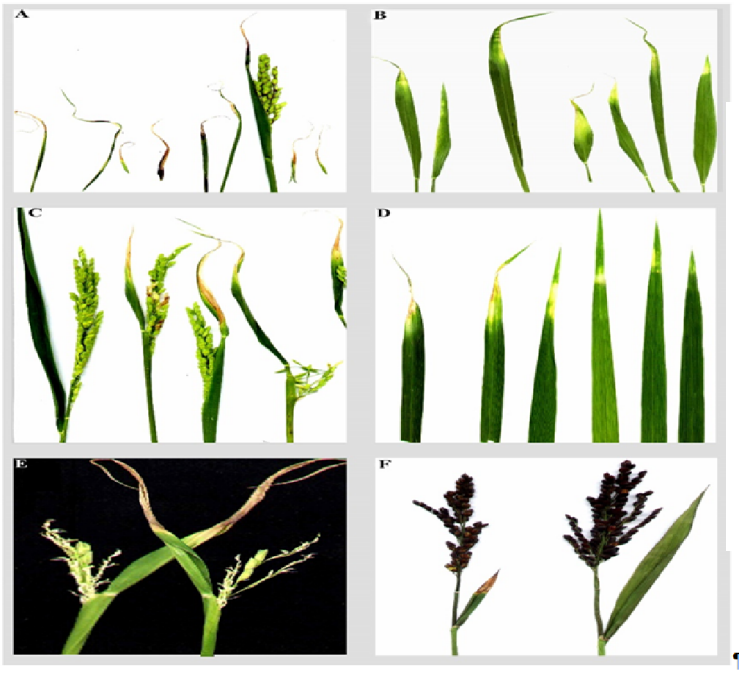

Figure1: A, Damage of flag leaf area and deformation due to white tip nematode infection on rice cultivar Giza 171, B, Chlorosis and stunting of flag leaf, C, Deformation and incomplete of panicle exertion, twisting and necrotic area of flag leaf, D, Development of white tip nematode symptoms from right to left, E, Panicle degeneration and sterility of spikletes, F, Small infected panicle of black rice compared with healthy one. Source, experimental farm of Rice Research and Training Center (RRTC), Sakha, Egypt.

Figure 2: A, Transverse and longitudinal cracks on rice grains of cultivar Giza 171due to white tip nematode infection (*Aphelenchoides besseyi*), B, Healthy and infected rice grains of Giza 171, C, Healthy and stunted plants due to white tip nematode infection, D, Severe white tip nematode symptoms on rice cultivar Giza 171. Source, experimental farm of Rice Research and Training Center (RRTC), Sakha, Egypt

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الخسارة الكمية والنوعية في محصول بعض أصناف الأرز نتيجة الإصابة بنيماتودا القمة البيضاء تحت ظروف الحقل المصرية

الشافعي إبراهيم على الشافعى[1] وربيع عبد الفتاح سعد الشافعي[3]، محمد أحمد عبدالهادى[1]، محمد رشدي سحلي[2]

ملخـــص

أجري هذا البحث لدراسة تأثير نيماتودا القمة البيضاء في الأرز *Aphelenchoides besseyi* علي الصفات المورفولوجية والمحصولية وصفات الجودة لبعض أصناف الأرز في مراحل نموه المختلفة تحت ظروف الحقل. نفذت تجربتان في موسمي 2003 و2004 بمزرعة مركز البحوث والتدريب في الأرز بسخا في مصر. صممت التجارب بنظام القطع العشوائية الكاملة وباستخدام 4 مكررات حيث تم دراسة كل الصفات للصنف الحساس جيزة 171 تحت مستوي الإصابة الشديدة بالنيماتودا. أوضحت النتائج أن الإصابة الشديدة بالنيماتودا أدت إلى حدوث خسارة معنوية في محصول الصنف الحساس جيزة 171 وصلت إلى 47 % وأنخفض أيضاً دليل الحصاد بنسبة (46.2، 40 %) في كلا الموسمين. وعلى الجانب الأخر، تزيد الإصابة بالنيماتودا من محصول القش بنسبة (28.8 و36.1 %) والحبوب الفارغة / سنبلة (91.4 و94.3 %) وعدد الخلفات غير الفعالة/م^2 (80 و93%) وزادت أعداد النيماتودا في السنبلة بنسبة (98.5 و98.9 %) في الموسمين 2003 و 2004 علي التوالي. كما أدت الإصابة إلي نقص الصفات المحصولية الأخرى مثل نقص في طول النبات (30.3 و 26.3 %) ونقص في مساحة ورقة العلم (85.2 و 85.4 %) ووزن 1000 حبة (35.2 و 33.6%) وعدد الخلفات /م^2 (60.8 و 58.7%) وعدد السنابل/م^2 (62.5 و 65.9%). تأثرت صفات الجودة تأثراً معنوياً وسلبياً بالإصابة بمرض ابيضاض القمة. انخفضت نسبة التقشير بنسبة (14 و19.6 %) ونسبة التبييض (17.2 و18.5 %) وrice head (9.9 و 12.3 %) وشكل الحبة (19.9 و 20.4%) في الموسمين 2003 و 2004 علي التوالي. تراوحت نسبة النقص في محتوي ورقة العلم من الكلوروفيل نتيجة الإصابة بمرض ابيضاض القمة ما بين 94–95 %. ارتبطت الخسارة الشديدة في مساحة ورقة العلم ومستوي الكلوروفيل ارتباطاً إيجابياً وعالي المعنوية مع النقص في طول ووزن السنبلة ووزن 1000 حبة. توضح نتائج الانحدار البسيط أن كل واحد بالمائة من الإصابة بنيماتودا القمة البيضاء يقابله 0.745 و0.690% خسارة في محصول حبوب الصنف جيزة 171 مما يدل على حساسية الصنف العالية لمرض القمة البيضاء النيماتودي.

الكلمات الدالة: النيماتودا المتطفلة على النبات ، خسائر اقتصادية، جودة وإنتاج الحبوب، مصر.

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تاريخ استلام البحث 2012/11/5 وتاريخ قبوله 2013/9/26.