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Full Length Research Paper

Reaction of some maize (*Zea mays* l.) varieties to infestation with root-knot nematode, *Meloidogyne incognita* under field conditions

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Field trials were conducted in 2008 and 2009 to investigate the reaction of 13 varieties of maize (*Zea mays* L.) to natural infestation of root knot nematode, *Meloidogyne incognita* at the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, Nigeria under field conditions. Used maize varieties were ART/98/SW6-0B, BR-9928 DMR, BR-9943 DMR, DMR-ESR-White, DMR-ESR-Yellow, DMR-LSR-White, DMR-LSR-Yellow, ILE-1-OB, Obatampa, Suwan-1-SR, TZSR-Y-1, TZPB-SRW and Western Yellow. They were obtained from IAR&T, IITA, Ibadan and Ghana. Ten weeks after planting, 15 randomly selected plants per variety were assessed for root galling. Data were also collected on plant height, ear height, stem girth, days to 50% silking, days to maturity and yield (kg/ha). According to study results, gall index and nematode reproduction factor varied significantly among the maize varieties; ART98 SW6-OB recorded the tallest height of 200 and 195 cm respectively in 2008 and 2009 while the least (170 cm) was recorded for TZPB-SRW in the two cropping seasons. Stem girth ranged from 6.3 to 5.0 cm in 2008 and 6.2 to 4.9 cm in 2009. Ear height ranged from 72.5 to 65.5 cm in 2008 and from 70.5 to 64.5 cm in 2009. Days to 50% silking ranged from 60 to 48 in 2008 and ranged 59 to 48 in 2009. Days to maturity ranged from 120 to 70 days in the two cropping seasons. Grain yields ranged from 3650 to 2025 kg/ha in 2008 and ranged from 4125 to 2625 kg/ha in 2009. Based on gall index ratings, ART98SW6-OB and ILE1-OB were resistant to *M. incognita*, BR-9928 DMR, BR-9943 DMR, DMR-ESR-W and DMR-ESR-Y, totally 4 varieties, were found as tolerant, DMR-LSR-W and DMR-LSR-Y varieties were found as hypersusceptible while Obatampa, Suwan 1-SR, TZSR-Y-1, TZPB-SRW and Western Yellow were found as susceptible to *M. incognita.*

Key words: Field conditions, maize (*Zea mays* L.), *Meloidogyne incognita*, resistance, screening.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals crops used in the human diet in large parts of the world and an important feed component for livestock. In terms of total world production, maize on average over the last five years outranked paddy rice (*Oryza sativa*) and wheat (*Triticum aestivum*). Global production exceeds 600 metric tonnes (McDonald and Nicol, 2005), with about 60% produced in the developed countries, particularly by the United States of America, China produces 27% of the world's maize and the rest is grown in countries of Latin America, Africa and Southern Asia with a large proportion being produced in the tropics and subtropics.

Maize is the most important cereal crop produced in Nigeria. Its importance has grown from being a food crop to a cash crop with its production now being market driven (Manyong et al., 1996). Furthermore, productivity of the crop has increased from 1.2 tonnes/ha in the early 1980s to its present level of 1.7 tonnes/ha due to several interventions by the government (Alene et al., 2009). Increase in population and improvement in general income levels in developing countries will increase demand for meat (especially poultry) and other animal products hence, there will be an increase in the quantity of grains needed for feeds.

In Nigeria, maize is the main carbohydrate food source for both rural and urban families. Return to research investment on maize in Nigeria is 1:38 suggesting that for every Naira invested a return of ₦ 38 is expected resulting in poverty reduction of 3% per year translating to 1.2 million persons being lifted out of poverty every year (Alene et al., 2009).

Many plant pathogens and pests, including plant parasitic nematodes cause considerable loss during crop development and aggravate plant damage under moisture and other stress conditions (McDonald and Nicol, 2005). Information on the importance of plant parasitic nematodes used to be very limited, but a significant number of publication on maize-nematode associations have appeared over the past decade. This implies increasing awareness of the importance of nematode damage to this very important food and fodder crop.

Previously, the crop was commonly regarded as a non-host to several nematode species (Idowu and Fawole, 1990; Toida et al., 1991; Rodriguez-Kabana, 1992), probably because yield losses may go unnoticed as a result of extensive root-systems, inadequate control measures (Riekert, 1996; Koenning et al., 1999) or lack of typical symptoms (Asmus et al., 2000). Awareness that specific extraction (Riekert 1995) and resistance assessment methods (Ibrahim et al., 1993) may affect quantifications is a major factor when considering the importance of nematodes to a crop such as maize. The prominence of maize in the global and many local economics and as a staple food to millions emphasizes the fact that the impact of nematode parasitism on this crop should not be underestimated. The extensive use of maize in rotation systems further necessitates a profound knowledge of the crop's host status to economically important nematode species.

Over 60 nematode species have been found associated with maize in different parts of the world (McDonald and Nicol, 2005). Most of them have been recorded from roots and soil around maize roots with information on the biology or pathogenicity of many of these species not readily available. The most important groups of plant parasitic nematodes demonstrated to be important limiting factors in maize production from all over the world are; the root knot nematodes, *Meloidogyne* species; the root lesion nematodes, *Pratylenchus* species; and the cyst nematodes, *Heterodera* species (McDonald and Nicol,2005).

Root knot nematodes which comprised of more than 50 species are considered economically important on maize (McDonald and Nicol, 2005). Some species have a worldwide distribution and have wide host ranges, while others are limited in distribution and are more hosts specific. Several races with differential host ranges occur within species (Sasser and Triantaphyllou, 1977; Kleynhans, 1991). It is important, therefore, to know the status and distribution of root knot nematodes on an important crop such as maize. *Meloidogyne incognita* and Javanese root knot, *Meloidogyne javanica* had been detected damaging maize in almost all maize-growing regions of the world. African root knot, *Meloidogyne africana* and Peanut root knot, *Meloidogyne arenaria* have been recorded on maize in India (Krishnamurthy and Elias, 1967) and Pakistan (Maqbool, 1980, 1981).

Four races of *M. incognita* and race 2 of *M. arenaria* sometimes reproduce well on maize but some cultivars exhibit specificity to a specific race (Lopez, 1981, Oteifa and Elgindi, 1982; Williams and Windham, 1990; Ibrahim et al., 1993; Windham and Williams, 1994; Davis and Timper, 2000). Although root knot nematodes occur frequently in maize fields, information on economic losses is lacking. However, indirect observations when nematicides are applied in root knot infected soils suggest that these nematodes are economically important in maize (Riekert, 1996; Riekert and Henshaw, 1998). In Jamaica (Hutton, 1976, 1981) greater root knot damage occurred when maize was sown after sugar cane.

Failure to demonstrate yield reduction due to nematode parasitism in maize was explained by Dickson and McSorley (1990) as being a result of extensive root growth in this crop after the seedling stage. This is due to high fertilization and watering levels applied to this crop and it obscures measurable injury levels. Koenning et al. (1999) add a lack of adequate control measures on maize as a reason for ignorance of nematode damage on the maize. Goswani and Raychaudhuri (1978) studied the interaction between mosaic virus and *M. incognita* in pot trials. They found that the mosaic symptoms appeared earlier and nematode reproduction was greater when both pathogens were together than when alone. It remains an important aspect to be alert to root knot nematode infestation of maize particularly in low input production conditions.

In Nigeria, most studies on the development of tolerant/resistant maize varieties have been on *Pratylenchus* species (Egunjobi, 1974). *Pratylenchus brachyurus* has been reported to be responsible for 28.5% yield reduction in maize (Egunjobi, 1974). However in recent times, *M. incognita* had been observed to be widespread in South western Nigeria, posing great threat to maize production, information on economic losses is lacking (Adegbite et al., 2006, 2008). The aim of this study is to assess the tolerant/resistant level of some developed maize varieties to natural field infestation of root knot nematode, *M. incognita* using gall index and yield and with the hope of identifying promising varieties for use in further breeding programmes.

MATERIALS AND METHODS

Field trials were conducted in 2008 and 2009 at the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, Nigeria. The experimental plot had been cropped previously for two years with cowpea, *Vigna unguiculata* L. Walp. (Ife Brown variety) which is susceptible to root knot nematode in order to increase the population densities of *M. incognita* (Adegbite et al., 2005). The site was naturally infested with *M. incognita* (about 400 juveniles and 450 juveniles per 250 cm^3 at

Table 1. List of maize varieties evaluated for resistance to root-knot nematode (*Meloidogyne incognita*) under field conditions.

Variety	Pollination	Source
ART/98/SW6-OB	*Allogamae*	IAR&T, Ibadan Nigeria
BR-9928 DMR	‘’	IITA, Ibadan Nigeria
BR-9943 DMR	‘’	‘’
DMR-ESR-White	‘’	‘’
DMR-ESR-Yellow	‘’	‘’
DMR-LSR-White	‘’	‘’
DMR-LSR-Yellow	‘’	‘’
ILE-1-OB	‘’	IAR&T, Ibadan Nigeria
Obatampa	‘’	Ghana
Suwan-1-SR	‘’	IITA, Ibadan Nigeria
TZSR-Y-1	‘’	‘’
TZPB-SRW	’	‘’
Western Yellow	‘’	‘’

planting in 2008 and 2009 respectively). The identity of the *M. incognita* was confirmed using perineal patterns as described by Eisenback et al. (1981). Low to moderate population densities of root lesion nematode, *Pratylenchus* spp., Dagger nematode, *Xiphinema* spp., and Spiral nematode, *Helicotylenchus* spp were also present on the experimental site. The experiments were established on 2nd April 2008 and 6th April 2009, respectively and arranged in a randomized complete block design with thirteen (13) varieties screened. Out of the 13 varieties screened, two high quality protein maize varieties and one open pollinated yellow variety were collected from Head Cereals Improvement Programme of Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, one from Ghana and the rest nine were collected from International Institute of Tropical Agriculture (IITA), Ibadan-Nigeria (Table 1). Each maize variety was replicated four times and each plot size was five rows of five (5) metres length. Three seeds of each of the thirteen varieties were planted per hole at a spacing of 20 x 90 cm. After seeds germinated, plants were thinned to one per stand. The field was ploughed, harrowed and the seeds were planted on the prepared field by hand. The seeds were not treated with seed dressing pesticides. Weeds were controlled manually at 2 and 8 weeks after planting. A basal application of fertilizer was applied at 3 weeks after planting using 300 kg of NPK 25-10-10 fertilizer and 100 kg of single superphosphate and 5 kg of Zinc sulphate (equivalent to 75 kg N, 50 kg P_2O_5, 30 kg K_2O and 14 kg S per ha).

Soil samples were taken from the treatment plots before and after harvest and analyzed for nematode population counts in order to determine the initial and final population of the nematodes (P_i and P_f). On each sampling period, fifteen soil core samples were taken from the plot at a depth of 20 cm and thoroughly mixed to form composite sample. Composite samples were taken to the laboratory in sealed plastic bags where they were stored at 10°C for 24 h. The samples were then thoroughly mixed and 250 cm^3 sub-samples were processed using the tray method of Whitehead and Hemming (1965).

Ten weeks after planting, fifteen randomly selected plant samples per plot were carefully uprooted and adhering soil washed off for assessment of root galls using a stereoscopic microscope, that is, 0 = immune, 1 = highly resistant, 2 = moderately resistant, 3 = moderately susceptible, 4 = susceptible and 5 = highly susceptible. Eggs were extracted from roots and estimated using the sodium hypochlorite method of Hussey and Barker (1973). Host status rating was determined using rating scheme developed by Sasser et al. (1984) based on root gall and reproduction factor (R), where

$$R = P_f/P_i$$

P_i is the initial population density and P_f is the final population density of nematodes).

At harvest, fifteen randomly selected plant per plot were measured for the following parameters: Plant height (in which the height of each plant was measured from the soil surface to the tip of the highest leaf in cm), ear height (measured from the soil surface to the tip of the ear in cm), stem girth (measured using vernier callipers in cm), days to 50% silking, days to maturity (calculated from period of planting to period of harvest), and the grain yield which was expressed as kg/ha (Adegbite et al., 2005). Data were subjected to analysis of variance and means separated using the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Data collected in 2008 and 2009 are shown in Tables 2 and 3. The study identified variations in the reaction of maize varieties to natural infestation of *M. incognita*. ART98 SW6-OB recorded the highest plant height (200 cm) though it was similar ($P<0.05$) to BR-9928-DMR, BR-9943 DMR, ILE1-OB and Suwan 1-SR in the two cropping seasons which was followed by DMR-ESR-W which recorded 185 cm, which was also similar ($P<0.05$) to DMR-ESR-Y, DMR-LSR-W, DMR-LSR-Y, Obatampa, TZSR-Y-1, TZPB-SRW and Western Yellow.

Ear height ranged from 72.5 to 65.5 cm in 2008 and 71.5 to 64.5 in 2009. Stem girth ranged from 6.3 to 5.0 in2008 and 6.2 to 4.9 in 2009 while ART98SW6-OB has the highest and TZSR-Y-1 has the least in 2008 similar trend was observed in 2009. Days to 50% silking ranged from 60 to 48 days in 2008 and it ranged from 59 to 48 days in 2009. Days to maturity ranged from 120 to 70 days in the two cropping seasons.

Table 2. Reaction of maize varieties to infection by *M. incognita* under field conditions – 2008.

Varieties	Plant height (cm)[a]	Ear height (cm)	Stem girth (cm)	Days to 50% silking	Days to maturity	Gall index	Host status	Nematode reproduction factor P_f/P_i	Yield kg/ha
ART98SW6-OB	200a	72.5a	6.3a	56a	70b	1.4c	R	0.55c	3650a
BR9928DMR	195a	70.0a	5.6a	55a	120a	1.9c	T	1.50b	2650b
BR-9943DMR	190a	69.7a	5.8a	56a	120a	1.9c	T	1.50b	2755b
DMR-ESR-W	185b	68.0a	5.3a	50a	85b	1.8c	T	1.50b	2865b
DMR-ESR-Y	182b	66.7a	5.2a	48a	85b	1.9c	T	1.50b	2786b
DMR-LSR-W	180b	72.3a	5.1a	48a	85b	2.4b	H	0.60c	2238c
DMR-LSR-Y	182b	70.5a	5.3a	50a	70b	2.5b	H	0.65c	2218c
ILE1-OB	190a	68.5a	6.2a	55a	75b	1.4c	R	0.60c	3755a
Obatampa	184b	71.5a	6.3a	54a	85b	2.9b	S	2.5a	2045d
Suwan-1-SR	190a	70.5a	5.8a	60a	90b	3.5a	S	2.5a	2034d
TZSR-Y-1	175a	65.5a	5.0a	54a	85b	3.5a	S	2.5a	2028d
TZPB-SRW	170b	68.8a	5.1a	56a	85b	3.8a	S	2.5a	2044d
Western Yellow	185b	67.5a	5.2a	56a	56a	85b	S	2.5a	2025d

Means followed by the same letter in the same column are not different (P<0.05). R= Resistant, T= Tolerant, H=Hypersusceptible, S= Susceptible.

Table 3. Reaction of maize varieties to infection by *M. incognita* under field conditions – 2009.

Varieties	Plant height (cm)	Ear height (cm)	Stem girth (cm)	Days to 50% silking	Days to maturity	Gall index	Host status	Nematode reproduction factor P_f/P_i	Yield kg/ha
ART98SW6-OB	195a	70.5a	6.2a	55a	70b	1.5c	R	0.60c	4125a
BR-9928DMR	190a	70.1a	5.4a	54a	120a	1.8c	T	1.40b	3675b
BR-9943DMR	190a	70.1a	5.6a	54a	120a	1.8c	T	1.40b	3476b
DMR-ESR-W	183b	69.3a	5.1a	48a	85b	1.6c	T	1.30b	3452b
DMR-ESR-Y	180b	66.9a	5.1a	48a	85b	1.7c	T	1.30b	3442b
DMR-LSR-W	183b	71.5a	5.0a	48a	85b	2.1b	H	0.75c	3150b
DMR-LSR-Y	184b	69.9a	5.1a	48a	70b	2.2b	H	0.75c	3148c
ILE1-OB	189a	67.9a	6.1a	54a	75b	1.2c	R	0.55c	4260a
Obatampa	182b	71.2a	6.1a	53a	85b	2.6b	S	2.8a	2678d
Suwan-1-SR	189a	74.0a	5.6a	59a	90b	3.2a	S	2.8a	2632d
TZSR-Y-1	175b	64.5a	4.9a	54a	85b	3.2a	S	2.8a	2630d
TZPB-SRW	170b	67.2a	4.9a	55a	85b	3.5a	S	2.8a	2678d
Western Yellow	183b	66.9a	5.0a	55a	85b	3.5a	S	2.8a	2625d

Means followed by the same letter in the same column are not different (P<0.05). R= Resistant, T= Tolerant, H=Hypersusceptible, S= Susceptible.

Based on host status ratings (Sasser et al., 1984), ART98SW6-OB and ILE1-OB were resistant to *M. incognita* and had gall indices and reproduction factor less than 2 and 1 respectively, similar trends were observed in the two cropping seasons. BR-9928 DMR, BR-9943 DMR, DMR-ESR-W and DMR-ESR-Y were tolerant to *M. incognita* with gall indices and reproduction factors less than 2 and greater than 1 respectively; similar trends were observed in the two cropping seasons. DMR-LSR-W and DMR-LSR-Y were hypersusceptible to *M. incognita* with gall indices and reproduction factors greater than 2 and less than 1 respectively, similar trends were observed in the two cropping seasons while the rest five varieties Obatampa, Suwan1-SR, TZSR-Y-1, TZPB-SRW and Western Yellow were susceptible to *M. incognita* with gall indices and reproduction factors of greater than 2 and 1 respectively, similar trends were observed in the two cropping seasons. Similar results have been reported where most of IITA developed varieties exhibited variations to reaction of infestation to root-knot nematode (*M. incognita*) under similar field conditions (Idowu, 1981; Idowu and Fawole, 1990; Ibrahim et al., 1993). The present study which was a combination of root-gall index, nematode reproduction factor, yield and other plant growth parameters to confirm resistance, tolerance or susceptibility of varieties to *M. incognita* was very superior to traditional gall index scale. The defect in the traditional gall index scale as a sole measure of plant damage in screening crop plants for resistance to root knot nematodes had been highlighted by Florini (1997).

Management systems are built around key pests (organisms that cause significant reduction in crop yield every year unless some pest control action is taken). *Meloidogyne* species frequently attain that status, even in the presence of other plant pathogens. The basic objective in any pest management is to increase both quantity and quality of crop yield. With increased pressure on land for industrial, infrastructural and urban development, as well as for agricultural production, fallow periods are becoming shorter and food crops are planted more frequently with resultant build up of nematode population.

Repeated growing of susceptible varieties can lead to a rapid increase of *Meloidogyne* species and substantial damage to crops. Crops losses due to nematode attack are estimated in order to establish the economic importance of certain nematode species in certain crops and to devise a control strategy based on sound pest management criteria. If crop losses are considerable, even if confined to relatively small areas, it appears easy to assign them to nematodes once a close association is established between losses and the presence of large numbers of a certain nematode species in the plant or in the soil surrounding its roots. Various options exist for the control of nematodes.

Nematicides, fallow systems and well-planned crop rotation systems have been employed for nematode control, but these have problems. The use of resistant crop varieties appears to be the most dependable management strategy for a lasting solution to nematode menace. The study identified some maize varieties that were resistant, tolerant, hypersusceptible and susceptible to *M. incognita* under field conditions over a 10-week period. Resistant cultivars inhibit nematode reproduction, and the resulting reduction in nematode population densities may permit the cultivation of susceptible crops more often in a rotation scheme (Sasser and Kirby, 1979).

Moreover, other characteristics being equal, resistant or tolerant cultivars will out yield susceptible plants in root knot nematode infested fields. By combining the information on maize yield, host status of various maize varieties, plant breeders can improve maize production whose importance has grown from being a food crop to a cash crop with its production now being market driven.

Identification and development of resistant cultivars would have the advantage of increasing and stabilizing yields as well as being available to growers at little extra cost. This calls for screening, selection and breeding of those genotypes of maize cultivars with the desired heritable characteristics for resistant to root knot nematodes.

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