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INFLUENCE OF *Heterodera sacchari* (LUC AND MERNY) POPULATION DENSITIES ON GROWTH AND YIELD COMPONENTS AND OF SOME INTERSPECIFIC UPLAND RICE GENOTYPES

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ABSTRACT

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A pot experiment was undertaken to determine the effects of H. sacchari on growth and yields of some improved upland rice genotypes (NERICA 2, ARICA 4, ARICA 5, ART-3-7LP9P8-3-B-B-5l2-1, ART-15-7-16-38-1-B-B-2 and ART-16-19-5-4-1-1) by varying population densities of H. sacchari The experiment was a 6 X 3 factorial laid out in a randomized complete block design. Three-week old rice seedlings were inoculated with 0 (control), 5,000 and 10,000 eggs and second stage juveniles (J2) of H. sacchari/pot. Results indicated that rice height, number of tillers, days to panicle emergence, fresh and dry shoot weights, fresh root weight, root damage and total seed weight of inoculated rice genotypes were significantly ($p \leq 0.05$) reduced compared with the uninoculated plants. Inoculated plants took significantly longer days to panicle emergence. Seed weight was significantly ($p \leq 0.05$) reduced when rice plants were inoculated with 5,000 or 10,000 nematodes. Among the genotypes infected with 10,000 eggs and J2, yield was reduced by 69.1% (NERICA 2), 66.9% (ART-15-7-16-38-1-B-B-2), 59.1% (ART-3-7LP9P8-3-B-B-2-1), 50.4% (ARICA 4), 48.3% (ART-16-19-5-4-1-1) and 39.5% (ARICA 5). H. sacchari population increased significantly on inoculated as compared with their respective controls. These findings suggest that H. sacchari is a serious pest of interspecific upland rice genotypes, and cultivation of these hybrids on H. sacchari-infested field may lead to poor yield and subsequent increase in the population density of H. sacchari in the field.

Keyword*: Genotypes, Heterodera sacchari, interspecific hybrid, root damage, rice yield,*

INTRODUCTION

Rice is one of the most important grains consumed by majority of the world's human population (Li and Xu, 2007; International Rice Research Institute (IRRI), 2015), and it is grown worldwide in 150 million hectares (m ha) and over 45% of the area is in rain-fed ecosystems (Africa Rice Center (WARDA), 2008; Onyango, 2014). In Nigeria, rice is cultivated in nearly all parts of Nigeria under upland, lowland, deep-water and mangrove ecologies but the bulk is produced in the upland and lowland (rain-fed and irrigated). However, the potential for rice production lies in the upland ecologies where the land resources are vast. Approximately 492,600 hectares of the 1.7 m ha of rice is currently cultivated for rain-fed upland rice production while 788,160 ha is used for rain-fed lowland rice cultivation in Nigeria (Africa Rice Center (WARDA), 2008; FAO, 2011). The crop is extremely sensitive to a number of abiotic (nutrient deficiency, soil acidity and drought) and biotic (fungi, bacteria, insects and nematodes) constraints leading to reduction in crop yield (Babatola, 1983; Johnson *et al.*, 1997; Plowright *et al.*, 1999; Scardaci *et al.*, 2003; Atera *et al.*, 2011).

In order to reduce the problems associated with pests and diseases on upland rice, the development of interspecific upland rice hybrids with higher harvest index, improved input responsiveness and consequently higher yield potential have been a major breakthrough in rice production systems (Bernier *et al.*, 2007). In Nigeria and Côte d' Ivoire, reports demonstrated that endo-parasitic nematodes such as the cyst forming nematode (*Heterodera sacchari*), root-knot nematode (*Meloidogyne incognita*), root lesion nematode (*Pratylenchus* spp) and *Hirschmanniella* spp are among the major biotic constraints severely reducing the yield of interspecific upland rice hybrids (Plowright *et al*., 1999; Afolami and Orisajo, 2003; Akpheokhai, 2013). *Heterodera sacchari* and *M. incognita* are highly specialized in their mode of parasitism, and are economically important soil-borne pathogens invading the roots of upland rice hybrids in Nigeria (Afolami and Orisajo, 2003; Akpheokhai, 2013). Reports obtained in Nigeria showed that interspecific rice hybrids planted on a naturally infested *H. sacchari* field had poor plant growth, extensive root damage, wilting and eventual death of plants, resulting in reduced plant population and yield reduction (Akpheokhai *et al.*, 2014). Continuous cultivation of *H. sacchari* infested field with susceptible upland NERICA rice hybrids may lead to yield reduction of 80% or even total crop failure (Akpheokhai, 2013). The root systems of infected susceptible upland rice were found to be necrotic, dark brown and twiggy (Babatola, 1983; Coyne *et al.*, 1998). Sections of *H. sacchari* infected rice roots CV NERICA 1 revealed extensive damage of the epidermal layer, disorganisation of the cortical cells and vascular elements of the entire root system due to the establishment of multinucleate cells (syncytia) induced by the nematode to derive nourishment (Akpheokhai *et al.*, 2015). Root damage affects plant water relations (Wilcox-Lee and Loria, 1987), and thus *H. sacchari* infection can greatly decrease water use efficiency, nutrient sinks and diversion of assimilates from the susceptible host (Audebert *et al.*, 2000; Melakeberhan, 2004, Akpheokhai *et al*., 2015). In view of the above stress imposed by *H. sacchari* on upland interspecific rice hybrids, they fail to express their

impressive agronomic traits and attain full potential value for yield increase. Therefore, it is pertinent to investigate the response of six elite interspecific upland rice genotypes commonly available in Nigeria to *H. sacchari* and determine the effects of varying population levels on host plant health.

MATERIALS AND METHODS

This study was conducted in University of Uyo (Lat. 5^{o} 20´N and 5° 30´ N, Long. 7° 27´ E and 5´ 62 E at 68.0 m above sea level, average annual rainfall 2500 mm, relative humidity 78%, monthly mean temp. range: 22-32^{o}C, soil type: Ultisol) in the year 2015. Sandy-loam topsoil was collected from the arboretum in the Department of Forestry, Faculty of Agriculture, University of Uyo, Uyo, Akwa Ibom State and sterilized for 2 hours thirty minutes at a temperature of 90°C using a 100 litres aluminum pot (Taylor and Sasser, 1978). After sterilization, the soil was allowed to cool for 24 hours and transferred into 5-litre plastic buckets and arranged in the Arboretum. *Heterodera sacchari* extraction was carried out in the Pathology Laboratory, Department of Crop Science, University of Uyo, Uyo, Nigeria. *Heterodera sacchari* used for the pot studies was initiated from single cyst and maintained on a susceptible interspecific rice hybrid CV NERICA 1 (Akpheokhai *et al.*, 2014) in pots in a greenhouse. The cysts were initially obtained from Africa Rice Centre (ARC) field station at Ikenne Ogun State (Long. 6° 32´ E and 4° 40´ E, Lat. 2° 67´ N and 7° 97´ N at 60.8 m above sea level), Nigeria. Inoculum was collected from mature cysts of *H. sacchari* recovered by floating organic debris, extracted from soil using a jet of water. The cysts extracted from soil were placed in a glass Petri dish containing 10 ml of distilled water, and while observing with the aid of a dissecting microscope, cysts were individually pierced and crushed using a dissection needle in order to liberate the eggs and second-stage juveniles (J2) (Coyne *et al.*, 2007). Broken cysts were washed into a measuring cylinder and the suspension agitated with a magnetic stirrer for five minutes to free eggs and J2. The liberated eggs and J2 were collected in a 1 L beaker. Subsequently, eggs and J2 were collected on nested sieves of 90 µm, 38 µm and 25 µm aperture sizes; where aperture size 90 µm trapped the cyst cuticle, 38 µm and 25 µm trapped the J2 and eggs, respectively (Coyne, 1999). The eggs and J2 suspension was adjusted to a concentration of 5000 nematodes/ml of distilled water.

Source of interspecific rice hybrids

Six interspecific upland rice genotypes (NERICA 2, ARICA 4, ARICA 5, ART-3-7LP9P8-3-B-B-2-1, ART-15-7-16-38-1-B-B-2 and ART-16-19-5-4-1-1) were obtained from Africa Rice Center (ARC) formerly known as West African Rice Development Association (WARDA) located at International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Pot experiment

Four seeds of each rice genotype were planted in 5 litres plastic pots containing steam-sterilized sandy-loam soil. The experiment was a 6 x 3 factorial (six interspecific rice genotypes and three levels of *H. sacchari* inoculum) in a Randomized Complete Block Design with 4 replications and pots were arranged in an open field. Two weeks after planting, rice seedlings were thinned down to one plant per pot and three weeks after sowing, seedlings were inoculated separately with 0 (no nematode i.e. uninoculated which served as control), 5,000 or 10,000 eggs and J2/plant (i.e. 1 nematode per cm^3 of soil or 2 nematodes per cm^3 of soil, respectively). Inoculation was accomplished by pipetting 1 or 2 mls of nematode suspension into four holes of 3 cm deep, made into the soil, 3 cm away from the plant while distilled water was introduced into the holes made for the uninoculated plants. Soon after inoculation, holes were covered with sterilized sandy-loam topsoil. Immediately after inoculation, data were taken on height (cm) using measuring tape and number of tillers by counting. Subsequently, these data were collected fortnightly until 8 weeks after inoculation. Also, number of days to panicle emergence was taken per plant. The plants were irrigated daily with 7mm of water throughout the period of the study using a watering can. At harvest, data were taken on fresh and dry shoot weights (g), fresh root weight (g), root damage on a scale of 1 – 5 as described by Coyne *et al*. (2007) and modified in Akpheokhai (2013) where; 1= no damage (clean), 2= (1-10% slight damage), 3= (11-30% mild damage), 4= (31-50% moderate root damage) and 5= (>51% severe root damage), total seed weight (g) / plant, and nematode reproduction. Samples were weighed using a digital (OHASUS CS200 Model) weighing balance in the Crop Science Pathology Laboratory, University of Uyo.

Nematode extraction and estimation of nematode reproduction

Rice plants from each pot were upturned and roots separated from soil by hand picking, rinsed with tap water, dabbed dry, thereafter observed for root development and damage. Roots were chopped finely into 1-2 cm and mixed thoroughly before sub-samples were taken. Number of J2 from 5 g chopped roots and in 250 cm^3 of soil were extracted, using the modified Baermann filter technique (Hooper, 1986). The number of J2 was estimated from 2 ml aliquots taken from a 10 ml nematode suspension using a compound microscope (Wild Leitz GMBH Leica Wild Model). White females and cysts were extracted from root sub-sample; the females and cysts of *H. sacchari* on roots were dislodged with a jet of water and decanted through nested sieves, 2000 µm, which trapped soil particle and plant debris, while 250 µm sieve trapped the nematode. White females and cysts were rinsed from the 250 µm sieve into a filter paper held in a funnel and air-dried; cysts extracted from 250 cm^3 soil were collected from 250 µm for estimation (Coyne *et al.*, 2007). Recovered females and cysts were removed and

counted from samples with the aid of dampened camel hair brush under a Leica Wild M3C stereomicroscope. Final nematode population per pot was determined by summing together total number of white females in pot, total number of J2 in soil and root/pot, total number of matured cysts in soil and root/pot, total number of matured cysts in soil and root/pot X average number of eggs and J2 per cyst. Reproductive factor (RF) was determined by P_f/P_i; where P_f = Final nematode population, P_i = initial nematode population i.e. 5,000 or 10,000 eggs and J2/plant, depending on treatments (Taylor and Sasser, 1978). A repeat of this experiment was done without any modification in order to validate the data.

Statistical procedure

Nematode counting was transformed using Log10 (X+1) before analysis in order to follow normal distribution (Gomez and Gomez, 1984). The two trials were combined and subjected to Analysis of Variance using generalized linear models (GLM) of statistical analysis system (SAS) 9.1 (2002), and means were compared with Least Significant Difference (LSD) at 5 % level of probability.

RESULTS

Effects of various inoculum densities of *Heterodera sacchari* on height and tillers of six rice genotypes from inoculation to eighth week

At inoculation, there were no significant differences ($p \leq 0.05$) in the rice height at different *H. sacchari* population densities across all genotypes (Fig. 1). At four weeks after inoculation (WAI), the inoculated plants reduced significantly ($p \leq 0.05$) in height when compared with the control. In addition, at 8 WAI, uninoculated rice plants was significantly taller (64.0 cm) than the plants inoculated with 5000 or 10,000 eggs and J2 with height of 56.7 cm and 51.2 cm, respectively. Rice height reduced with increasing *H. sacchari* inoculation density and the adverse effect of nematode on height of NERICA rice cultivars was conspicuous from 4 WAI and continued till 8 WAI when the experiment was terminated (Fig. 1). The means of the data collected in the two trials were not significantly different ($p \leq 0.05$). Therefore, the data were combined for analysis and their means presented.

The number of tillers produced per plant at inoculation was not significantly different ($p \leq 0.05$) between the control and the inoculated plants (Fig. 2). At 4 WAI, the uninoculated plants increased significantly ($p \leq 0.05$) in the number of tillers produced when compared with the inoculated plants. At 8 WAI, the control produced the highest number of tillers (7.6 tillers) compared to the number of tillers obtained from plants inoculated at 5000 or 10,000 eggs and J2, with 5.7 tillers and 5.2 tillers, respectively. This trend persisted till the experiment was terminated (Fig. 2).

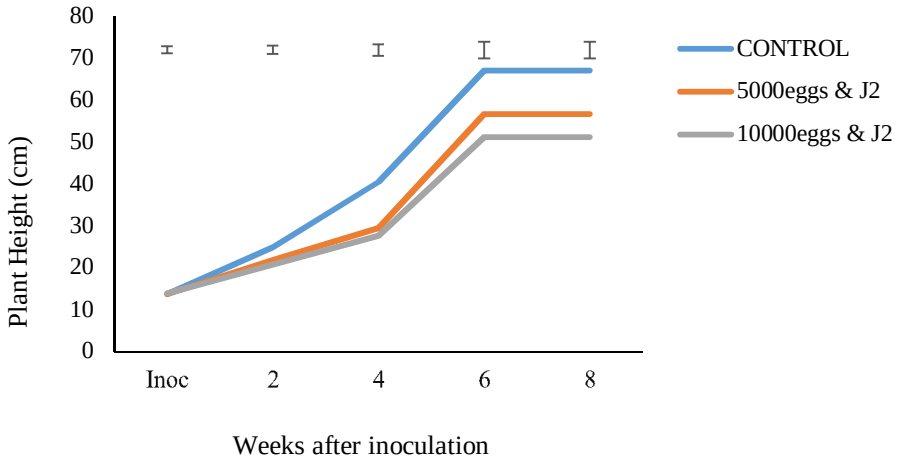

Fig 1: Effect of *Heterodera sacchari* population densities on rice height in pot.
LSD bars are for comparing treatment means at each specific time, J2 = second-stage juveniles

Effects of various inoculum densities of *Heterodera sacchari* on growth and yield of six rice genotypes from inoculation to eighth week

The number of days to panicle emergence increased with increase in the initial nematode inoculation densities (Table 1). The length of time taken for panicles to emerge increased significantly ($p<0.05$) but was delayed in the infected interspecific rice genotypes from the time taken to produce panicles by the uninoculated plants (Table 1). Panicle emergence in rice plants infected with 10,000 eggs/ J2 of *H. sacchari* were delayed by 15 days (NERICA 2), 10 days (ART-3-7LP9P8-3-B-B-2-1), 9 days (ART-16-19-5-4-1-1), 9 days (ARICA 4), 6 days (ART-15-7-16-38-1-B-B-2) and 5 days (ARICA 5) compared to their respective controls (Table 1).

The fresh and dry shoot weights reduced significantly ($p \leq 0.05$) in *H. sacchari*-infected rice genotypes when compared with the control across all rice genotypes. The fresh shoot weight of uninoculated rice ranged from 64.7 g (ART-16-19-5-4-1-1) – 50.9 g (NERICA 2). Among the inoculated rice, fresh shoot weight ranged from 51.1 g (ART-16-19-5-4-1-1) – 38.0 g (NERICA 2). Similar trends were observed in the dry shoot weight (Table 1). In general, the reduction in fresh and dry shoot weights of infected plants increased with increase in the initial nematode population density (Table1).

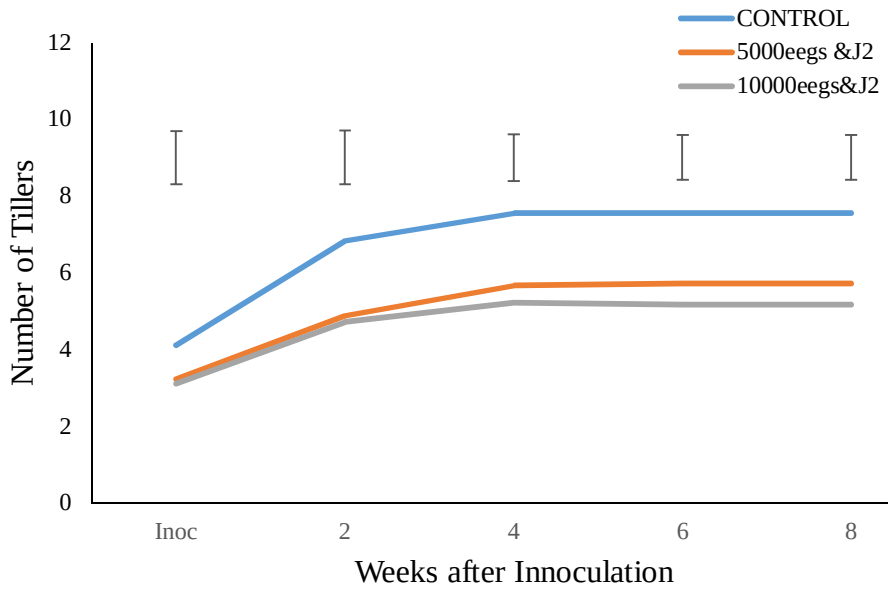

Fig 2: Effect of *Heterodera sacchari* population densities on number of tillers in pot.
LSD bars are for comparing treatment means at each specific time, J2 = second-stage juveniles

Furthermore, the fresh root weight of *H. sacchari* infected rice reduced significantly ($p \leq 0.05$) with increase in the nematode density compared with the control in all rice genotypes (Table 1). Over 50% of the roots were severely damaged when rice genotypes were inoculated with 10,000 eggs and J2 of *H. sacchari*. The root weight was reduced by 63.8%, 63.5%, 60.1%, 55.2%, 54.7% and 50.4% in NERICA 2, ART-15-7-16-38-1-B-B-2, ART-3-7LP9P8-3-B-B-2-1, ART-16-19-5-4-1-1, ARICA 5 and ARICA 4, respectively (Table 1). The root damage scores obtained from *H. sacchari* infected plants were significantly higher in rice genotypes inoculated with 5,000 or 10,000 eggs and J2 of the cyst nematode when compared with the uninoculated rice genotypes (Table 1).
The total seed weight (yield) was significantly higher ($p \leq 0.05$) in the uninfected rice genotypes than the infected plants inoculated with eggs / juveniles of *H. sacchari* in the pots (Table 1).Total seed reduction in *H. sacchari* infected plants in pots ranged from 23.7 – 69.1%. Specifically, seed weight were reduced by 69.1% (NERICA 2), 66.9% (ART-15-7-16-38-1-B-B-2), 59.1% (ART-3-7LP9P8-3-B-B-2-1), 50.4% (ARICA 4), 48.3% (ART-16-19-5-4-1-1) and 39.5% (ARICA 5) in plants infected with 10,000 nematodes (Table 1).
Reproduction of *Heterodera sacchari* at different population densities on six rice genotypes
The total number of J2 recovered from root and soil of *H. sacchari* infected plants were significantly higher ($p \leq 0.05$) compared to the uninoculated rice genotypes (Table 2). Rice genotype ART-15-7-16-38-1-B-B-2 inoculated with 10,000 eggs and J2 had the highest number of juveniles (5308.4 J2) which was closely followed by NERICA 2 (5283.4 J2) while the lowest number of J2 was recovered from ARICA 4 (4525.0 J2) inoculated with 5000 eggs and J2 (Table 2). The highest number of cysts in root and soil were recovered from rice genotype ART-3-7LP9P8-3-B-B-5l2-1 inoculated with 10,000 eggs and J2 (5333.3 cysts) while the lowest was recovered from ART-16-19-5-4-1-1 (1649.6 cysts) these values were significantly different ($P \leq 0.05$) from the uninoculated (0.0 cysts) plants across all genotypes (Table 2). Total number eggs and J2 per cyst ranged from 69.4 to 95.8 nematodes and the final mean nematode population was highest in ART-3-7LP9P8-3-B-B-5l2-1 inoculated with 10000 eggs and J2 (492458.0 nematodes) while the lowest was ART-16-19-5-4-1-1 inoculated with 10000 eggs and juveniles (146292.0 nematodes). The Reproductive factor (R.F) of the inoculated rice plants were significantly higher ($p \leq 0.05$) than the R.F of the uninoculated plants across all the rice genotypes (Table 2). Specifically, rate of nematode multiplication in inoculated ARICA 4, ARICA 5, ART-3-7LP9P8-3-B-B-2-1 and ART-15-7-16-38-1-B-B-2 increased as the initial nematode population increases from 5000 to 10000 nematodes per plant in the life of the crop (Table 2).

Table 1: Effect of *Heterodera sacchari* population densities on number of growth and yield of six interspecific upland rice genotypes in pot

Rice Genotype	*H. sacchari* (Pi)	Days to panicle emergence	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Root damage	Total seed weight (g)/pot
NERICA 2	Control	62.7±0.3	50.9±2.8	22.5±2.1	150.3±18.2	1.0±0.0	12.6±0.9
	5000	72.0±0.6	40.8±1.7	17.8±1.4	70.8±6.7	5.0±0.1	7.2±0.4
	10000	78.3±0.9	38.0±2.7	16.8±1.5	54.4±3.0	5.0±0.1	3.9±0.3
ARICA 4	Control	68.3±0.9	57.7±0.9	25.6±0.6	128.8±16.9	1.0±0.0	11.7±2.0
	5000	74.0±2.6	46.3±1.9	20.0±1.6	83.8±15.6	4.2±0.2	7.5±0.4
	10000	77.3±2.1	44.3±1.7	18.6±1.5	63.8±10.7	5.0±0.2	5.8±0.3
ARICA 5	Control	66.0±1.5	62.0±2.6	24.1±2.2	162.8±5.2	1.0±0.0	10.9±0.9
	5000	73.0±2.3	50.3±0.5	18.9±1.7	115.9±8.3	3.8±0.2	7.3±0.7
	10000	71.3±1.3	43.6±2.8	15.8±2.5	73.8±15.1	5.0±0.1	6.6±2.0
ART-3-7LP9P8-3-B-B-2-1	Control	68.3±0.3	63.3±3.8	30.0±1.8	116.9±5.4	1.0±0.0	12.7±1.1
	5000	72.0±1.5	52.3±1.0	20.3±0.6	71.9±5.4	4.2±0.2	8.1±0.5
	10000	78.3±0.7	45.3±2.3	19.2±0.6	46.7±8.1	5.0±0.1	5.2±0.3
ART-15-7-16-38-1-B-B-2	Control	68.8±0.3	58.2±4.1	22.2±2.4	118.4±6.2	1.0±0.0	10.9±0.4
	5000	77.7±1.0	44.6±3.3	18.5±1.1	59.9±14.5	4.7±0.1	6.5±0.6
	10000	75.0±1.9	38.0±4.0	16.2±2.6	43.2±5.3	5.0±0.1	3.6±0.3
ART-16-19-5-4-1-1	Control	64.7±1.2	64.7±0.7	25.0±0.5	180.2±10.5	1.0±0.0	14.3±0.7
	5000	70.3±0.9	55.1±1.9	19.1±1.4	125.9±4.9	3.1±0.2	10.9±0.4
	10000	73.7±1.2	51.1±1.7	17.2±1.5	80.7±5.4	5.0±0.1	7.4±0.5
	LSD ($P \leq 0.05$)	1.5	5.0	2.1	19.8	0.3	1.2

Root damage (1-5) where; 1= no damage (clean), 2= (1-10% slight damage), 3= (11-30% mild damage), 4= (31-50% moderate root damage) and 5= (>51% severe root damage)

DISCUSSION

The results of this study showed that *H. sacchari* is an important pest of susceptible upland interspecific rice hybrid. Nematode damage increased with increase in the initial nematode population density which consequently led to reduction in top growth, poor tillering, chlorotic plants, poor root growth, necrotic dark-brown and twiggy root system of infected plants. The yield of infected rice hybrids reduced and therefore, plant could not attain their full genetic potential. Coyne and Plowright (2000) reported a reduction in the height and grain yield of rice cultivar IDSA6 by 52.6% and 74.1%, respectively at a density of 400 cysts of *H. sacchari* per plant. Also, Afolami and Orisajo (2003) observed poor plant height, number of tillers, number of panicles and grain yield in rice cultivars IDSA 10, Moroberekan, WAB450-1-B-P-33-HB, WAB450-1-B-P-38-HB, FARO 43 and WAB340-b-b-1-HB, when rice cultivars were inoculated with 5000 eggs of *M. incognita* per plant in a pot trial. They observed that the infected plants had dark brown, twiggy roots and severe weight reduction. This observation corresponds with the work of Audebert *et al.* (2000) that *H. sacchari* affected the visual root structure of ISDA6 rice which led to dark brown, stubby tips and root necrosis. Babatola (1984) also reported twiggy, blackened and root necrosis of plants infested with *H. sacchari.*

Generally, it was also observed that the number of white females and cyst recovered increased with increase in inoculum density. This result is consistent with the findings of Babatola (1983), Reversat and Destombes (1998), Plowright *et al.* (1999), Audebert *et al.* (2000) who reported that the number of nematodes increased exponentially with increase in initial population levels of *Heterodera* spp. on rice. Salawu (1986) also reported a steady increase of *H. sacchari* white females and cyst recovered from both soil and root as inoculum density increased on both local and exotic sugarcane varieties. Furthermore, the reproductive factor of nematode reduced at the inoculation level of 10,000 eggs and J2 in NERICA 2, ARICA 5 and ART-16-5-9-22-3-B-B-2. This is due to competition for available food resources and space required for nematode activities, survival and reproduction.

The destruction of rice roots by the nematode led to the inability of roots to absorb water and mineral elements from the soil for growth and development of the plants because of the activities of *H. sacchari.* These activities include penetration, establishment of syncytia, development and reproduction within the root system. These syncytia are multinucleate feeding sites which serve as metabolic sinks as a result making the roots non-functional, inability to translocate synthesised nutrients to various parts of the plant for healthy development. Melakeberhan (2004) stressed that reduction in top growth and subsequent yield reduction, could be due to the disruption of the root system by the destructive, adaptive and neoplastic feeding behaviour of endoparasitic nematodes. The combination of these effects subsequently led to poor growth and eventual yield reduction of infected rice hybrids. The effect of *H. sacchari* infection on number of days to panicle emergence varied among rice genotypes. The panicles of ARICA 5 and ART-15-7-16-38-1-B-B-2 emerged earlier at 5.3 days and 6.2 days, respectively at the inoculation density of 10000 eggs and J2 of *H. sacchari* compared with other rice genotypes that took between 9.0 and 15.6 days. This result is in line with Babatola (1983) who observed delay in days to

50% flowering in upland rice, CV Faro 11, when plants were inoculated with 100 cysts per pot. He also observed a subsequent reduction in yield which ranged from 23.5% - 57.4% when Faro 11 was inoculated with 100 and 400 cysts, respectively. The damage caused by *H. sacchari* infection on roots ranged from 50.4 – 63.8% in all rice genotypes at higher nematode population. In addition, the roots of all *H. sacchari* infected rice hybrids were severely damaged at all inoculation densities. ARICA 5 may be a promising interspecific hybrid with a seed reduction of 39.5% in the presence of the nematode at the inoculation density of 10000 nematodes. In addition, uninoculated ART-16-19-5-4-1-1 rice genotype produced more seeds than the other rice genotypes planted. These genotypes (ARICA 5 and ART-16-19-5-4-1-1) maybe incorporated with *H. sacchari* resistance in the future breeding programmes.

CONCLUSION

Findings in this study may prove useful in predicting the effect of different inoculum densities of *H. sacchari* on the growth, development and yield of upland interspecific rice genotypes. However, based on the damage caused by *H. sacchari* on some elite interspecific upland rice hybrids, it is important to carry out further breeding work in order to fortify ARICA 5 and ART-16-19-5-4-1-1 rice genotypes with *H. sacchari* resistance alongside agronomic qualities acceptable to farmers. Furthermore, rice hybrids should be screened for nematode resistance before they are released to farmers to reduce the effect of notorious plant- parasitic nematodes such as *H. sacchari* in the field. In addition, a comprehensive survey of rice fields is pertinent in order to have information of the health status of fields before rice production in Nigeria.

Table 2: *Heterodera sacchari* reproduction on six interspecific rice genotypes at different inoculation densities in pot

Genotype	*H. sacchari* (Pi)	Total J2 In pot (root +soil)	Total cyst in pot (root +soil)	Number of eggs and J2 per cyst	Final nematode population in pot (Pf)	Reproductive factor (Rf)
NERICA 2	Control	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
	5000	4841.7±318.7	3000±500.0	79.87±1.0	247108.0±39586.9	49.42±7.9
	10000	5283.2±336.2	4000±1000.0	92.67±6.4	369017±79162.5	36.90±7.9
ARICA 4	Control	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
	5000	4525.0±257.1	1666.7±666.7	67.0±5.0	122792±54462.4	24.56±10.9
	10000	4800.0±114.6	3166.7±1013.8	87.5±12.8	262733±58725.7	26.67±5.9
ARICA 5	Control	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
	5000	2558.4±91.1	2000.00±577.4	74.47±3.4	157292±56650.4	31.46±10.1
	10000	3450.0±86.0	2666.70±666.7	80.1±14.4	234783±93926.8	23.49±9.4
ART-3-7LP9P8-3-B-B-2-1	Control	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
	5000	3875.0±85.7	2666.7±726.5	75.53±6.7	208275±54167.3	41.66±10.8
	10000	4791.7±58.3	5333.3±1855.9	95.8±10.0	492458±124617.6	49.25±12.5
ART-15-7-16-38-1-B-B-2	Control	0.0±0.0	0.0±0.0	0.0±0.0	0.0	0.0±0.0
	5000	4658.2±48.9	2166.7±600.9	71.27±5.3	163825±50515.2	32.77±10.1
	10000	5308.2±34.2	4166.7±600.9	86.23±5.2	377875±72250.9	37.79±7.2
ART-16-19-5-4-1-1	Control	0.0±0.0	0.0	0.0±0.0	0.0±0.0	0.0±0.0
	5000	3416.7±50.3	1333.3±440.9	69.37±8.0	107417±40220.4	20.28±8.0
	10000	4291.6±52.1	1666.7±333.3	83.73±1.4	146292±29648.4	14.63±3.0
LSD ($p \leq 0.05$)		1750.7	1649.6	18.59	133165	17.60

J2 = second-stage juvenile, analysis of data undertaken on log10 (X + 1) transformed; back-transformed means presented

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