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Full Length Research Paper

Host-status of thirty-two maize genotypes to *Meloidogyne incognita* race 2 and *Meloidogyne javanica* in South Africa

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***Meloidogyne incognita* race 2 and *Meloidogyne javanica* are widely distributed in South Africa where they cause enormous crop yield losses. Host-status of commercial maize (*Zea mays* L.) genotypes to the two nematode species was investigated under greenhouse conditions. Thirty-two maize genotypes, for each nematode species were arranged in a randomised complete block design, with six replicates. The experiments were conducted in summer and repeated in autumn. Fifty-six days after inoculating each treatment with 10 000 juveniles, reproductive factors and penetration indices (PIs) were subjected to analysis of variance and means separation achieved using Duncan's multiple-range test. Reproductive factors suggested that three open-pollinated varieties, namely: OBATAMPA, QPM-SR and QS-OBA were non-host to both *M. incognita* race 2 and *M. javanica* in all trials. Certain hybrids and OPVs were also non-hosts to the two nematode species, although the result was not consistent throughout all the trials. Penetration indices suggested that OBATAMPA had post-infectional non-host status, whereas QPM-SR and QS-OBA had pre-infectional non-host status. In conclusion, results of this study demonstrated that non-host status to *M. incognita* race 2 and *M. javanica* existed in certain maize genotypes that are commercially available in South Africa. Also, in some of the genotypes, the non-host status was introgressible.**

Key words: Penetration index, pre-infectional resistance, post-infectional resistance, reproductive factors.

INTRODUCTION

Nematode-plant resistance has received increasing attention since the suspension of the ozone-depleting fumigant nematicides (Cook and Evans, 1987). Generally, nematode resistance offers environment-friendly solutions and is compatible to interventions such as biological agents, bio-nematicides, solarisation and fallowing (De Brito and Antonio, 1989; Starr et al., 2002). However, the challenge is that root-knot nematodes (*Meloidogyne* spp.) have a wide host-range, global distribution and multiple races, all of which may limit the use of plant resistance. Generally, host-status in plant-parasitic nematodes is assessed using reproductive factors (RFs) which are quotients of final nematode numbers (Pf) and initial nematode numbers (Pf): RF = Pf/Pi (Seinhorst, 1965). Host-status and host-sensitivity concepts are both used as indicators of whether a host is resistant, tolerant or susceptible to plant-parasitic nematodes (Seinhorst, 1967). Two major forms of nematode resistance are pre-infectional and post-infectional (Kaplan and Keen, 1988). Penetration indices (PIs) are used as indicators of whether resistance is pre- or post-infectional (Pofu et al., 2010). The essence of PI is that it provides information whether the resistance is introgressible or not (Pofu and Mashela, 2011; Pofu et al., 2010). In Mississippi, USA, 64 maize (*Zea mays* L.) genotypes were tested for resistance to *M. incognita* race 4 and *M. javanica*, with only six genotypes being resistant (Aung et al., 1990; Windham and Williams, 1988, 1994).

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Also, in Florida, USA, McSorley and Gallaher (1991) demonstrated that some maize genotypes were resistant to *M. incognita* race 4 and *M. javanica*. In Kenya, certain maize genotypes were shown to be resistant to *M. incognita* race 4 and *M. javanica* (Mweke et al., 2008). The existence of *Meloidogyne* races in different countries suggests that the resistant genotypes developed against *Meloidogyne* species in one country may not be used in another country with different biological races.

Generally, exotic maize genotypes do not perform satisfactorily in South Africa (De Waele and Jordaan, 1988; Keetch and Buckley, 1984), with the result that local maize-producing farmers rely on locally-produced genotypes. Widely distributed *Meloidogyne* species in South Africa are *M. incognita* race 2 and *M. javanica*, with *M. incognita* race 4 occurring in cotton-producing regions (Kleynhas et al., 1996). The host-status of commercially available maize hybrids and varieties to *Meloidogyne* species in South Africa is not documented. The objective of this study was to determine: i) the host-status of selected commercial maize genotypes to *M. incognita* race 2 and *M. javanica*, and ii) the form of nematode non-host status.

MATERIALS AND METHODS

Study location and experimental design

A greenhouse experiment was initiated at the Agricultural Research Council-Grain Crops Institute, Potchefstroom, Republic of South Africa (26° 43' 0" S; 27° 6' 0" E) in summer (November to January) 2005/2006 growing season and repeated in autumn (February to April) 2006 growing season. Day/night ambient temperatures averaged 26°C (maximum) and 20°C (minimum), respectively, with maximum day temperatures controlled using thermostatically-activated fans. 25-cm diameter plastic pots (5 ℓ) were filled with methyl bromide-fumigated soil, comprising 3.9% clay, 93.6% sand, 1.9% silt, 0.6% organic matter and soil pH(H_2O) 6.5. Pots were placed on the greenhouse benches at 0.5 m inter-row and 0.6 m intra-row spacing. The 32 maize genotypes comprised: i) 16 commercial maize hybrids (AFG4410, AFG4520, LS8511, LS8507, CRN3505, CRN5549, PAN6146, PAN6479, PAN6966, PAN6777, PAN6053, PAN6549, PAN6126, PAN67, PAN6114, SAM1101), ii) 15 open-pollinated varieties (QS-OBA, QS7707, QPM-SR, OBATAMPA, AFRIC1, ZM523, PANTHERA, DKC61-24, DKC61-25, DKC78-15B, DKC80-10, DKC80-12B, PHB3203, PHB30D05, PHB32A05B) and; iii) one exotic nematode-resistant inbred line (MP712W). Treatments (maize genotypes) were arranged in a randomised complete block design, with six replicates. Two seeds per treatment were planted, with emerging seedlings manually thinned to one at 5 days after emergence. *M. incognita* race 2 and *M. javanica* inocula were prepared by extracting eggs from roots of greenhouse-grown nematode-susceptible tomato (*Solanum lycopersicum* L.) cv. 'Floradade' plants in 1% NaOCl (Hussey and Barker, 1973). Separate trials were conducted and repeated for each nematode species. Seedlings were each inoculated at 7 days after emergence with 10000 second-stage juveniles (J2s) on roots exposed around the stems of each seedling using a 20 ml syringe.

After inoculation, roots were covered with the growing mixture being used in the trials and each treatment received 800 ml of tapwater every other day. Fertilisation was according to soil nutrient analysis results which consisted of 0.2 g mono ammonium phosphate (MAP), 0.2 g potassium chloride (KCl), 0.2 g NPK 2:3:2 (30) and 0.1 g limestone ammonium nitrate (LAN) per plant at planting. Weeds, pests and diseases were not present.

Data collection

At harvest, 56 days after inoculation, plants were cut off at the ground level, roots removed, carefully washed, dried with paper towel and weighed. Nematode juveniles and eggs were extracted from total roots/treatment in 1% NaOCl using the maceration and blending method (Hussey and Barker, 1973). The materials were rinsed through nested sieves 750, 250, 150, 45 and 10-µm opening sieves. Juveniles and eggs were collected from the 10-µm-opening sieve and counted under a light microscope. Nematodes in soil samples were extracted from a 100 ml soil sub-sample using the sugar-floatation and centrifugation method (Jenkins, 1964). Nematode counts from root and soil samples were converted to total root system and total pot soil, respectively, to generate an estimated final population density (Pf) which was divided by the initial population density (Pi) to generate the reproductive factor (RF = Pf/Pi). Total nematode numbers from the total root system were divided by the total nematode numbers from the soil to generate the penetration index (PI) which estimated the number of nematodes inside the root system relative to those in the soil.

Data analysis

The RFs and PIs were subjected to analysis of variance using the SAS programme. Mean separation for significant treatment was achieved using the Duncan's multiple-range test.

RESULTS

In Experiments 1 and 2, *M. incognita* race 2 contributed 71 and 94%, respectively, to the total treatment variation (TTV) in the RF (Table 1). Similarly, *M. javanica* contributed 92 and 96% to the TTV in the RF of the respective trials (Table 3). In Experiment 1, for *M. incognita* race 2, the standard, 5 hybrids (PAN67, PA6114, PAN6126, PAN6549, SAM1101) and 5 varieties (AFRIC1, QS-OBA, QPM-SR, OBATAMPA, ZM523) had RFs less than one, with 11 hybrids (AFG4410, AFG4520, LS8511, LS8507, CRN3505, CRN5549, PAN6146, PAN6479, PAN6966, PAN6777, PAN6053) and 10 varieties (DKC80-10, DKC80-12B, DKC78-15B, DKC61-24, DKC61-25, PANTHERA, PHB3203, PHB30D05, PHB32A05B, QS7707) having RFs greater than one. In Experiment 2, the RF was less than one in 3 hybrids (PAN6126, PAN6114, SAM1101) and 4 varieties (QS-OBA, QPM-SR, OBATAMPA, PHB3203), but greater than one in 13 hybrids (AFG4410, AFG4520, CRN3505, CRN5549, LS8507, LS8511, PAN67, PAN6549, PAN6479, PAN6777, PAN6966, PAN6146, PAN6053) and 11 varieties (AFRIC1, DKC61-24, DKC61-25, DKC78-15B, DKC80-10, DKC80-12B, PANTHERA, PHB30D05, PHB32A05B, QS7707, ZM523) (Table 2). In the *M. javanica* trial, the standard, 3 hybrids (PAN6114, PAN67, SAM1101) and 3 varieties (QS-OBA, QPM-SR, OBATAMPA) had RFs less than one in Experiment 1; with 13 hybrids (AFG4410, AFG4520, LS8511, LS8507,

Table 1. Analysis of variance for reproduction factor and penetration indices of *Meloidogyne incognita* race 2 on 32 maize genotypes comprising 16 local commercial maize hybrids, 15 open-pollinated varieties and an exotic *Meloidogyne*-resistant inbred line (MP712W) at 56 days after inoculation.

Source	Experiment 1					Experiment 2				
	RF value			Penetration index		RF value			Penetration index	
	Degrees of freedom	Sum of squares	%	Sum of squares	%	Degrees of freedom	Sum of squares	%	Sum of squares	%
Replicate (A)	5	4.28	1	38.95	2	5	1.59	0	186.69	2
Treatment (B)	31	262.16	71	645.26	22	31	965.86	94	5215.78	62
Error (A*B)	155	103.4	28	2216.39	76	155	63.41	6	3030.63	36
Total	191	369.84	100	2900.61	100	191	1030.86	100	8433.11	100

Table 2. Reproduction factor and penetration indices of *Meloidogyne incognita* race 2 on 32 maize genotypes comprising 16 local commercial maize hybrids, 15 open-pollinated varieties and an exotic *Meloidogyne*-resistant inbred line (MP712W) at 56 days after inoculation.

Genotype	Experiment 1					Genotype	Experiment 2				
	Nematodes/ root system	Nematodes/ 5 ℓ soil	Final population (Pf)	[1]RF-value	Penetration index (PI)		Nematodes/ root system	Nematodes/ 5 ℓ soil	Final population (Pf)	[1]RF-value	Penetration index (PI)
AFG4410	16 898	30 667	47 564	4.76 p	0.55 ab	LS8511	18 153	101 917	120 070	12.01 p	0.18 a
DKC80-10	19 079	19 367	38 446	3.84 p	0.98 ab	CRN3505	25 568	29 208	54 776	5.48 o	0.88 ab
AFG4520	15 640	19 242	34 882	3.49 no	0.81 ab	AFG4410	11 203	40 950	52 153	5.22 o	0.27 a
LS8511	13 073	20 275	33 348	3.33 mno	0.64 ab	PAN67	8 512	43 258	51 770	5.18 o	0.19 a
DKC80-12B	14 570	14 792	29 362	2.94 lmno	0.98 ab	PAN6549	8 268	34 433	42 702	4.27 n	0.25 a
CRN3505	11 861	15 133	26 994	2.70 lmno	0.78 ab	PANTHERA	5 504	34 650	40 154	4.02 mn	0.16 a
CRN5549	10 056	16 675	26 731	2.67 klmn	0.61 ab	PAN6479	23 897	10 367	34 263	3.43 lm	2.33 b
PAN6146	19 818	6 075	25 893	2.59 klmn	3.26 bcd	PHB32A05B	11 316	22 808	34 124	3.41 lm	0.49 ab
PHB32A05B	14 003	9 758	23 761	2.38 jklmn	1.44 bc	PAN6777	15 797	16 533	32 330	3.23 lm	0.95 ab
PHB3203	18 924	4 617	23 541	2.35 ijklmn	4.11 cd	PAN6966	14 753	14 250	29 003	2.00 kl	1.04 b
PAN6479	13 787	6 883	20 670	2.07 hijklm	2.01 bc	DKC78-15B	8 549	17 725	26 273	2.63 jkl	0.50 ab
DKC61-24	15 090	5 183	20 273	2.03 ghijklm	2.91 bcd	CRN5549	16 162	6 358	22 520	2.25 hij	2.54 b
PAN6966	10 237	8 400	18 637	1.86 fghijklm	1.22 bc	DKC80-12B	17 727	4 691	22 418	2.24 hij	3.81 cd
DKC61-25	14 159	4 308	18 468	1.85 fghijklm	3.29 bcd	AFRIC1	7 810	14 208	22 018	2.20 hij	0.55 ab
PHB30D05	12 013	5 733	17 747	1.77 fghijkl	2.11 bc	PAN6146	15 250	5 550	20 800	2.08 ghij	2.76 bc
PAN6777	8 065	8 858	16 923	1.69 efghijkl	0.91 ab	AFG4520	11 416	7 783	19 199	1.92 fghi	1.55 b
LS8507	8 799	6 100	14 899	1.49 defghijk	1.44 bc	DKC61-25	12 361	4 250	16 611	1.66 efgh	2.87 bc
DKC78-15B	751	12 642	13 333	1.33 cdefghij	0.06 a	DKC80-10	12 493	3 917	16 410	1.64 efgh	3.22 cd
QS7707	6 525	6 047	12 567	1.26 bcdefgh	1.08 b	DKC61-24	10 853	4 483	15 337	1.53 defg	2.43 bc
PAN6053	8 758	2 375	11 133	1.11 abcdefg	3.69 bcd	PAN6053	13 890	553	14 423	1.44 defg	25.11 f
PANTHERA	1 074	9 792	10 866	1.09 abcdefg	0.11 a	ZM523	11 398	1 367	12 765	1.28 cdef	8.63 de
PAN6549	1 951	7 200	9 151	0.92 abcdefg	0.27 a	PHB30D05	10 367	2 183	12 550	1.26 cdef	4.64 cd

Table 2. Count'd.

PAN6126	4 721	3 942	8 663	0.87	abcdef	1.21	bc	QS7707	7 968	4 275	12 243	1.22	cdef	1.82	b
ZM523	4 950	2 775	7 725	0.77	abcdef	1.78	bc	LS8507	7 593	3 275	10 868	1.09	bcde	2.29	bc
AFRIC1	1 988	4 208	6 197	0.62	abcde	047	a	PAN6114	8 182	1 250	9 432	0.94	bcde	6.72	de
PAN67	691	4 558	5 309	0.53	abcd	0.15	a	PAN6126	5 810	3 283	9 093	0.91	bcde	1.79	b
SAM1101	1 780	2 275	4 055	0.41	abcd	0.78	ab	SAM1101	7 845	692	8 537	0.85	abcd	11.54	ef
OBATAMPA	1 395	2 308	3 703	0.37	abcd	0.61	ab	OBATAMPA	3 609	3708	7 318	0.73	abcd	0.97	de
PAN6114	183	2 975	3 158	0.32	abc	0.06	a	PHB3203	3 013	3 800	6 813	0.68	abcd	0.79	ab
QPM-SR	312	2 558	2 870	0.29	abc	0.12	a	QPM-SR	3 653	1 917	5 569	0.57	abc	1.91	ab
QS-OBA	60	1 409	1 469	0.15	ab	0.04	a	QS-OBA	1 794	2 642	4 436	0.44	ab	0.68	ab
MP712W	31	198	229	0.02	a	0.15	a	MP712W	406	1 117	1 523	0.15	a	0.36	a

Means in the same column with the same letter do not differ significantly at P ≤ 0.05 according to the Duncan's multiple-range test (DMRT). Pf = Nematodes per root system + nematodes per 5 ℓ soil; [1]RF = final egg and J2 numbers (Pf) ÷ initial egg and J2 numbers (Pi = 10 000); PI = Nematodes per root system ÷ nematodes per 5 ℓ soil.

Table 3. Analysis of variance for reproduction factor and penetration indices of *Meloidogyne javanica* on 32 maize genotypes comprising 16 local commercial maize hybrids, 15 open-pollinated varieties and an exotic *Meloidogyne*-resistant inbred line (MP712W) at 56 days after inoculation.

Source	Experiment 1					Experiment 2				
		RF value		Penetration index			RF value		Penetration index	
	Degrees of freedom	Sum of squares	%	Sum of squares	%	Degrees of freedom	Sum of squares	%	Sum of squares	%
Replicate (A)	5	2.85	0	223.73	2	5	3.33	0	1 321.69	2
Treatment (B)	31	1 053.59	92	5 234.15	44	31	2 217.34	96	17 452.4	28
Error (A*B)	155	84.11	8	6 420.11	54	155	84.84	4	42 781.7	70
Total	191	1 140.55	100	11 878.1	100	191	2 305.51	100	61 555.8	100

CRN3505, CRN5549, PAN6966, PAN6479, PAN6777, PAN6053, PAN6126, PAN6549, PAN6146) and 12 varieties (AFRIC1, DKC80-10, DKC80-12B, DKC61-24, DKC61-25, DKC78-15B, PANTHERA, PHB3203, PHB30D05, PHB32A05B, QS7707, ZM523) having RFs that were greater than unity; whereas in Experiment 2, 4 hybrids (PAN6114, PAN6126, LS8507, CRN5549) and 6 varieties (QS7707, QPM-SR, QS-OBA, OBATAMPA, PHB3203, DKC80-12B) had RFs less than one, with 12 hybrids (CRN3505, AFG4410, AFG4520, PAN67, PAN6479, LS8511, PAN6777, PAN6053, PAN6146, PAN6549, PAN6966, SAM1101) and 9 varieties (PHB30D05, PHB32A05B, PANTHERA, ZM523, DKC61-24, DKC61-25, DKC80-10, DKC78-15B, AFRIC1) having RFs greater than unity (Table 4).

In Experiment 1, the standard, 10 hybrids (AFG4410, AFG4520, LS8511, CRN3505, CRN5549, PAN6777, PAN6549, PAN67, SAM1101, PAN6114) and 8 varieties (DKC80-10, DKC80-12B, DKC78-15B, PANTHERA, AFRIC1, OBATAMPA, QPM-SR, QS-OBA) had PIs less than one for *M. incognita* race 2; whereas, 6 hybrids (PAN6146, PAN6479, PAN6966, LS8507, PAN6053, PAN6126) and 7 varieties (PHB32A05B, PHB3203, DKC61-24, DKC61-25, PHB30D05, QS7707, ZM523) had PIs greater than one. In Experiment 2, the standard, 6 hybrids (LS8511, CRN3505, AFG4410, PAN67, PAN6549, PAN6777) and 7 varieties (AFRIC1, PANTHERA, PHB3203, PHB3205B, DKC78-15B, OBATAMPA, QS-OBA) had PIs less than one for *M. incognita* race 2; whereas, 10 hybrids (PAN6479, PAN6966, CRN5549, PAN6146, AFG4520, PAN6053, LS8507, PAN6114, PAN6126,

Table 4. Reproduction factor and penetration indices of *Meloidogyne javanica* on 32 maize genotypes comprising 16 local commercial maize hybrids, 15 open-pollinated varieties and an exotic *Meloidogyne*-resistant inbred line (MP712W) at 56 days after inoculation.

Genotype	Experiment 1						Genotype	Experiment 2				
	Nematodes/ root system	Nematodes/5 ℓ soil	Final population (Pf)	[1]RF-value	Penetration index (PI)			Nematodes/root system	Nematodes/ 5 ℓ soil	Final population (Pf)	[1]RF-value	Penetration index (PI)
PAN6146	8 392	92 775	101 167	10.12 p	0.09 a		CRN3505	30 835	120 583	151 418	15.14 q	0.26 a
DKC80-10	21 792	57 700	79 492	7.95 o	0.40 a		AFG4410	21 692	85 000	106 692	10.67 p	0.25 a
AFG4410	21 742	42 317	64 058	6.41 n	0.50 a		PAN6479	20 573	67 058	87 632	8.76 o	0.31 a
AFG4520	17 958	37 167	55 125	5.51 m	0.48 a		LS8511	19 371	53 108	72 479	7.25 o	0.37 a
PHB3203	7 708	43 017	50 725	5.07 lm	0.18 a		PHB30D05	15 852	48 442	64 293	6.43 n	0.33 a
LS8511	21 967	28 275	50 242	5.02 lm	0.77 ab		PAN6777	14 661	41 792	56 453	5.65 lm	0.35 a
PHB32A05B	15 967	33 183	49 150	4.92 klm	0.49 a		PAN6053	14 571	37 875	52 446	5.24 kl	0.38 a
DKC80-12B	15 883	33 000	48 883	4.89 jklm	0.48 a		PAN6146	14 458	34 233	48 691	4.87 ij	0.42 a
DKC61-24	8 600	36 908	45 208	4.52 ijkl	0.22 a		PAN6549	13 682	28 950	42 632	4.26 gh	0.48 a
CRN3505	16 908	28 050	44 958	4.50 ijkl	0.61 ab		PAN6966	12 510	25 633	38 143	3.81 fgh	0.49 a
CRN5549	18 658	24 150	42 808	4.28 ijkl	0.78 ab		ZM523	12 153	24 567	36 719	3.67 efg	0.50 a
DKC61-25	6 833	32 975	39 808	3.98 ijk	0.21 a		DKC61-25	10 449	20 358	30 808	3.08 efg	0.51 a
PAN6966	11 725	27 733	39 458	3.95 ij	0.42 a		AFG4520	10 073	19 583	29 657	2.97 ef	0.54 a
PAN6479	9 283	29 292	38 575	3.86 i	0.33 a		DKC80-10	10 010	19 367	27 692	2.77 e	0.58 a
PHB30D05	8 317	27 475	35 792	3.58 hi	0.30 a		DKC78-15B	9 967	17 167	27 177	2.72 e	0.57 a
PAN6777	11 892	17 083	28 975	2.90 gh	0.69 ab		DKC61-24	8 325	15 583	25 550	2.56 d	0.65 ab
LS8507	8 075	16 692	24 767	2.48 fg	0.48 a		PANTHERA	7 964	13 375	16 598	1.66 d	1.16 b
PAN6053	3 308	18 308	21 617	2.16 efg	0.19 a		SAM1101	7 943	8 633	16 569	1.66 d	0.24 a
QS7707	8 217	13 050	21 267	2.13 efg	0.63 ab		AFRIC1	7 824	5 400	13 343	1.33 cd	1.60 b
PAN6126	5 667	11 383	17 050	1.71 def	0.50 a		PHB32A05B	7 159	5 117	12 941	1.29 cd	0.24 a
DKC78-15B	14 300	2 267	16 567	1.66 def	6.31 cd		PAN67	6 189	4 617	11 268	1.13 bcd	2.12 bc
PAN6549	8 600	7 550	16 150	1.62 cdef	1.14 b		CRN5549	5 896	4 108	8 806	0.88 abc	2.35 bc
ZM523	4 583	11 308	15 892	1.59 cdef	0.41 a		LS8507	4 679	2 617	8 363	0.84 abc	2.58 bc
AFRIC1	5 350	6 775	12 125	1.21 bcde	0.80 ab		DKC80-12B	4 573	2 467	6 738	0.67 abc	2.09 bc
PANTHERA	8 850	2 542	11 400	1.14 bcd	3.48 bcd		PAN6126	3 788	2 458	6 298	0.63 abc	2.60 bc
SAM1101	3 633	5 642	9 275	0.93 abcd	0.64 a		PHB3203	3 628	2 425	6 099	0.61 abc	0.42 a
PAN67	6 017	1 675	7 692	0.77 abcd	3.59 bc		PAN6114	3 194	2 058	6 053	0.61 abc	1.55 b
OBATAMPA	3 808	2 700	6 508	0.65 abc	1.41 b		OBATAMPA	3 788	1 183	4 971	0.50 abc	3.21 bc
QPM-SR	4 167	642	4 808	0.48 ab	6.49 cd		QS-OBA	790	2 458	3 248	0.32 abc	0.32 a
PAN6114	4 000	625	4 625	0.46 ab	6.40 cd		QPM-SR	1 636	617	2 253	0.23 ab	2.67 a
QS-OBA	1 083	2 275	3 358	0.34 ab	0.48 ab		QS7707	297	383	680	0.07 a	0.78 ab
MP712W	825	2 028	2 853	0.08 a	0.41 a		MP712W	253	398	651	0.07 a	0.64 ab

Means in the same column with the same letter do not differ significantly at P ≤ 0.05 according to the Duncan's multiple-range test (DMRT). Pf = Nematodes per root system + nematodes per 5 ℓ soil; [1]RF = final egg and J2 numbers (Pf) ÷ initial egg and J2 numbers (Pi = 10 000); PI = Nematodes per root system ÷ nematodes per 5 ℓ soil.

SAM1101) and 8 varieties (DKC80-12B, DKC61-24, DKC61-25, DKC80-10, ZM523, PHB30D05, QS7707, QPM-SR) had PIs greater than one (Table 2). In Experiment 1, the standard, 13 hybrids (PAN6146, AFG4410, AFG4520, LS8511, CRN3505, CRN5549, PAN6966, PAN6479, PAN6777, LS8507, PAN6053, PAN6126, SAM1101) and 11 varieties (DKC80-10, PHB3203, PHB32A05B, DKC80-12B, DKC61-24, DKC61-25, PHB30D05, QS7707, ZM523, AFRIC1, QS-OBA) had PIs less than one for *M. javanica*; whereas, 3 hybrids (PAN67, PAN6114, PAN6549) and 4 varieties (DKC78-15B, PANTHERA, OBATAMPA, QPM-SR) had PIs greater than one. In Experiment 2, the standard, 11 hybrids (CRN3505, AFG4410, PAN6479, LS8511, PAN6777, PAN6053, PAN6146, PAN6549, PAN6966, AFG4520, SAM1101) and 10 varieties (PHB3203, PHB30D05, PHB32A05B, ZM523, DKC61-24, DKC61-25, DKC80-10, DKC78-15B, QS-OBA, QS7707) had PIs less than one for *M. javanica*; whereas, 5 hybrids (PAN67, CRN5549, LS8507, PAN6126, PAN6114) and 5 varieties (AFRIC1, PANTHERA, DKC80-12B, OBATAMPA, QPM-SR) had PIs greater than one (Table 4).

Scrutiny of the aforementioned analysis showed that three open-pollinated varieties, namely: OBATAMPA, QPM-SR and QS-OBA were non-hosts to both *M. incognita* race 2 and *M. javanica* in all trials, with RF values that were not different from the exotic resistant standard. Also, OBATAMPA had post-infectional non-host status, whereas QPM-SR and QS-OBA had pre-infectional non-host status in all trials.

DISCUSSION

Host-status is described using the RF which is a measure of the reproductive potential of a nematode on a given host (Windham and Williams, 1988). All RFs below unity suggested that the nematodes failed to reproduce, whereas those above one indicate that the nematodes reproduced. In this study, hybrids and varieties with RF values below one were considered to be non-hosts to the two test nematode species. Results of this study suggested that three open-pollinated varieties (OBATAMPA, QPM-SR and QS-OBA) had non-host status to *M. incognita* race 2 and *M. javanica* in all trials. Interpretation of the RF values, as in this study, requires the comprehension of the impact of the equilibrium point (E) and the nematode reproductive rate on the RF values. Beyond E, all RF values are below one since competition for infection sites is intense, resulting in reduced reproductive rates (Seinhorst, 1967). In support of this view, in their study of the citrus nematode (*Tylenchulus semipenetrans* Cobb) race in South Africa, Kwaye et al. (2008) used Pi that was far above E (that is, 40000 juveniles) on differential hosts that were either hosts or non-hosts, with the result that RF values were all below one. In other words, the Pi used in determining the host-status must invariably be less than E. Duncan and McSorley (1987) argued that for most plants where the RF value was greater than one at Pi values below E, the plants were hosts, regardless of whether populations decreased at time-related final populations. The argument suggested that even at inoculum levels of Pi lower than E, with increasing infection time, E might be attained, resulting into a situation where the RF was below one, with the subsequent inaccurate inference that the plant was a non-host.

In this study, the E points of *M. incognita* race 2 and *M. javanica* for all the hybrids and varieties are not documented. Since one inoculum level (Pi = 10000 juveniles) was used and the RF values in certain hybrids and varieties were below one, one cannot safely infer that this was due to the incompatibility between the test nematodes and the maize hybrids and varieties. However, to guide against the impact of time-related final populations, which may lead to the misinterpretation of the RF values due to the cyclic nature of Pf on various crops (Ferris, 1985; Pofu et al., 2010), the experiments were harvested 56 days after inoculation. This duration allowed for ca. three nematode generations for the test species (Sikora and Fernandez, 2005). The higher number of nematode juveniles in the roots of certain hybrids and varieties than those in the soil, vice versa, confirmed the view that nematode host-status is either pre- or post-infectional (Acedo et al., 1984; Caswell et al., 1991; Ibraham et al., 1980; McSorley and Gallaher, 1991; Ploeg, 1999; Raja and Dasgupta, 1986; Roberts, 1993; Siddiqui and Alam, 1988; Steele and Savitsky, 1981; Veech, 1981; Weischer, 1982). Roots of certain cultivars of sorghum (*Sorghum* bicolour L. Moench), cowpea (*Vigna unguiculata* L. Walp), marigold (*Tagetes patula* Linnaeus), Castor bean (*Ricinus communis* L. Packard, 1869), velvet bean (*Mucuna pruriens* L. DC. Var. utilis, Wall ex Wight, Baker ex Burk) and sunn hemp (*Crotalaria juncea* L. Rotar and Joy) released phyto-chemicals that suppressed various nematode species in the rhizosphere prior to infection (McSorley and Gallaher, 1991; Roberts, 1993). Kaplan and Keen (1988) argued that resistance to endo-parasitic nematodes was generally expressed after infection and that active mechanisms involved chemical compounds produced post-infectionally, rather than preformed constitutive compounds.

Resistance to the reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira) in *T. patula*, *Meloidogyne* juveniles in *Tagetes erecta* (Caswell et al., 1991), *Pratylenchus* in species of *T. patula* (Siddiqui and Alam, 1988; Veech, 1981) and *M. incognita acrita* in some wild races of “fig-leafed” gourd (*Cucurbita ficifolius* Bouche) and African horned cucumber (*Cucumis metuliferus* E. Mey. ex Naud*)* were all post-infectional (Fassuliotis, 1970). PI results in various maize genotypes suggested the existence of both pre- and post-infectional forms of resistance to *M. incognita* race 2 and *M. javanica* occur in

tested genotypes which implies the availability of genetic materials for introgression breeding programmes (Pofu and Mashela, 2011).

Conclusion

Results of this study suggested that three open-pollinated varieties, namely OBATAMPA, QPM-SR and QS-OBA were non-hosts to *M. inc*ognita race 2 and *M. javanica*. However, the non-host status should be validated using a range of Pi levels in order to demonstrate that the RF values of less than one observed in these varieties were not influenced by the equilibrium point. In the validation tests, biomass should also be measured to assess host-sensitivity, and therefore, resistance of these varieties to the two nematode species.

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