Incidence and Potential Host-Plant Resistance of Peanut (*Arachis hypogaea* L.) to Plant Parasitic Nematodes in Southern Ghana, West Africa

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ABSTRACT

A survey was conducted during 1999 and 2001 in Ashanti, Brong Ahafo, Eastern, and Volta regions of Ghana, West Africa, to identify nematode pests of peanut (*Arachis hypogaea* L.). Information from the survey is being used to formulate appropriate integrated pest management (IPM) strategies for peanut production in these regions. Ten genera of plant parasitic nematodes belonging to three Orders were identified. Population density and distribution of genera varied in the four peanut-growing regions. Six genera, *Helicotylenchus, Meloidogyne* (juveniles), *Paratrichodorus, Pratylenchus, Rotylenchulus*, and *Xiphinema* were found in all four regions. *Hoplolaimus* was found only in the Eastern region. *Trichodorus* and *Tylenchorhynchus* were absent from Ashanti and Brong Ahafo regions but present in Eastern and Volta regions. Nematode genus *Rhignema* of the Order Rhigonematida was isolated from millipedes sampled from the rhizosphere of peanut. Twenty-one peanut cultivars and experimental lines were assembled from the Savanna Agricultural Research Institute (SARI) in Ghana, the Crops Research Institute (CRI) in Ghana, and North Carolina State University in the US and were compared for resistance to nematodes in the field in Ghana at Kwadaso near Kumasi during 2000 and 2001. Eight nematode genera were identified in the field with seven of the eight genera found in the rhizosphere of peanut. Cultivars differed in their ability to suppress nematode populations. Eleven cultivars demonstrating promise for nematode suppression were selected for further screening. Six weed species were predominant in the experimental field before land preparation, and three endoparasitic nematodes, *Pratylenchus brachyurus, Meloidogyne arenaria*, and *Rotylenchulus reniformis* were extracted from the root system of some of the weed species. The highest nematode population was associated with *Verona cinerea. Sida acuta* was not infected by nematodes.

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Cultivated peanut (*Arachis hypogaea* L.) is a geotropic annual, self-pollinating, herbaceous legume native to South America (Hammons, 1982). Debrah and Waliyar (1996) reported that 25.7 million tons, from 21 million hectares of land, are cropped with peanut worldwide with Asia alone accounting for about 70% and Africa 20% of total production. In West Africa, important producing countries include the Burkina Faso, Gambia, Ghana, Mali, Nigeria, Niger, and Senegal.

Minton and Baujard (1993) reported that nematodes damage peanut in all production regions of the world. Nematode infestation of peanut lead to various symptom expression and damage. *M. arenaria* infected plants become yellow and stunted as early as 40 days after planting (Zhang, 1985). *Meloidogyne* spp. cause galling on peanut roots, pods, and pegs (Taylor and Sasser, 1978). Lesions caused on roots, pods, and pegs by *Pratylenchus brachyurus* permit easy entry of fungi and bacteria to cause peg and pod rot (Jackson and Sturgen, 1973). Sasser and Freckman (1987) reported that annual losses caused by nematodes to peanut were estimated at 12%, translating into losses of over one billion US dollars.

Peanut is an important food and oil crop in Ghana. Principally, peanut is cultivated in the forest and savanna transitional zones of southern Ghana and the savanna regions of northern Ghana. In a survey of peanut production problems in five communities in northern Ghana, about 50% of respondents implicated insect pests as major constraint to production (Salifu, 1996). However, the importance of nematodes in peanut production has not been thoroughly defined.

Rodriguez-Kàbana et al. (1994) reported that *M. arenaria* damage to peanut could be so severe that continuous production of the crop is impossible in fields with high populations of this nematode. Nematicides and crop rotation are

frequently employed to manage plant parasitic nematodes. Oudejans (1991) reported that the number of nematicides available for use by farmers is limited, especially in West Africa, and the cost of nematicides can be cost prohibitive and not sustainable (ACES, 1993). Additionally, human exposure and environmental hazards associated with nematicide application are a concern in developing countries (Anon, 2000; Thomas, 1996).

Nematodes have extensive host ranges (Saka and Carter, 1987), and benefits of rotation are not always realized because of sustained survival on crops and weeds within the same field. Incorporating host-plant resistance is often the least expensive and most effective approach to reducing disease and nematode severity in crop fields. Incorporating host-plant resistance into peanut production systems used by low-resource farmers in Africa is the most sustainable approach to managing disease and nematodes (FAO, 1982).

Presence of nematodes in four principal peanut-growing regions in southern Ghana was surveyed to identify the nematode pests associated with peanut. These data are currently being used to develop appropriate pest management strategies for peanut production for the region. Research was also conducted to determine colonization of cultivars grown in southern Ghana by native parasitic nematodes. The ultimate goal is to incorporate germplasm with substantial resistance into integrated pest management systems to sustain and increase peanut production in Ghana.

Materials and Methods

Survey of Peanut Fields.

Field sampling of nematode in Ghana during the 1999 and 2001 cropping seasons included twelve farms in the Ashanti and Brong, fourteen farms in Eastern region, and sixteen farms in the Volta region. Soil and peanut root samples were collected from the 54 farms at harvest by randomly selecting five samples at three locations within the rhizosphere of peanut using a 5-cm diameter auger to a depth of 20 cm. Samples were bulked and thoroughly mixed before a composite sample of 200 cm^3 was stored in a sealed polyethylene bag until nematode extraction was performed. Samples from all 54 farms were assayed for nematodes to compare frequency of occurrence and relative abundance of parasitic nematodes.

Nematodes were extracted from 200 cm^3 of soil using Cobb's decanting and sieving method combined with a blender-cotton wool filter procedure (Southey, 1986; Schouten and Arp; 1991). Nematode suspension was concentrated to 25 cm^3 by siphoning off the supernatant. Nematodes were relaxed in water at 60 C for 3 min and fixed with formalin:acetic acid:distilled water solution (10:1:89). Nematode suspension from 1-cm^3 aliquots were placed in a counting dish and the nematodes identified with a binocular stereoscopic and compound microscopes using standard reference (CIH, 1975). Nematode genera were counted and expressed as number per 200 cm^3 of soil. In the case of peanut root, 5 cm^3 samples replicated three times were assayed for nematodes using only the Blender-cotton wool filter method (Schouten and Arp, 1991). Sample size was variable in the case of millipedes, which were sampled from the rhizosphere of peanut due to differences in age and size of millipedes. The gut system of millipedes was extracted using the method described previously.

Host-Plant Resistance to Nematodes.

Twenty-one peanut cultivars and experimental lines from the Savanna Agricultural Research Institute (SARI) and Crops Research Institute (CRI) in Ghana and from North Carolina State University in the US were collected and screened for nematode resistance during 2000 and 2001 in field trials located at Kwadaso near Kumasi, Ghana. Cultivars included: AADRO 93, AT 120, Georgia Green, GK 7 High Oleic, ICGX-SM 89029, ICGV-SM 86047, ICGV 87160, ICGV 86556, NC 7, NC 10 C, NC-V 11, NC 12 C, RRR-MDR-8-19, RRR-UGA-9, RRR-MDR-8-16, RRR-M 576-79, RRR-M249-74, Shitoachi, Sinkarzei, Southern Runner, and VA 93 B. Cultivars and experimental lines were seeded in rows spaced 76 cm apart in conventionally prepared seedbeds. Plot size was five rows by 5 m in length. The experimental design was randomized complete block with 4 replications.

During land preparation, soil and roots of weed species on the experimental site were randomly sampled and processed for nematodes using Cobb's decanting and sieving method combined with a blender-cotton wool filter procedure (Southey, 1986; Schouten and Arp, 1991). At harvest, soil samples were randomly taken from the rhizosphere of peanut in addition to samples of peanut roots for extraction. Throughout the investigation, nematodes were extracted from 200 cm^3 of soil and 5 cm^3 of root samples. Nematodes were relaxed in warm water (60 C) for 3 min and fixed with 40:1:89 (formalin:glacial acetic acid:distilled water) solution. One-cm^3 aliquots were removed and nematodes were identified using a binocular stereoscopic and compound microscopes using standard reference (Anon, 1975). Nematodes were counted and expressed as number per 200 cm^3 of soil. Data were

Table 1. Plant parasitic nematodes genera from Ashanti, Brong Ahafo, Eastern, and Volta regions of southern Ghana during 1999 and 2001.

Nematode genera	Order	Region of southern Ghana			
		Ashanti	Brong Ahafo	Eastern	Volta
		No./200 cm^3			
Aphelechiodes	Tylenchida	69	0	193	143
Helicotylenchus	Tylenchida	315	245	239	205
Hoplolaimus	Tylenchida	0	0	95	0
Meloidogyne	Tylenchida	454	344	741	561
Paratrichodorus	Diplonchida	216	59	180	196
Pratylenchus	Tylenchida	460	401	559	423
Rotylenchulus	Tylenchida	205	319	320	185
Trichodorus	Diplonchida	0	0	192	234
Tylenchorhynchus	Tylenchida	0	0	111	66
Xiphinema	Diplonchida	96	91	135	113
Total	-	1815	1489	2765	2126
Number of genera	-	7	6	10	9

log transformed {log (X+1)} before analysis using SAS. Means were separated by the Student-Newman-Keuls Test at $p \leq 0.05$.

Results and Discussion

Survey of Peanut Fields.

Ten genera of plant parasitic nematodes were found belonging to the orders Tylenchida and Dorylaimida (Table 1). Nematodes were found associated with ten different cultivars of peanut grown in the four production regions. Peanut cultivars grown in the Ashanti region were Konkoma, Broni, Kowoka, and China. In Brong Ahafo region, cultivars included Konkoma, Bremawuo, Afromo, and China. In Eastern region cultivars included Konkoma and Cameroon with Klukluklui, Kpedevi, and Goroga grown in the Volta region. Ten, nine, seven, and six genera of nematodes were found in the Eastern, Volta, Ashanti, and Brong Ahafo regions, respectively (Table 1). Six genera; *Helicotylenchus, Meloidogyne, Paratrichodorus, Pratylenchus, Rotylenchulus*, and *Xiphinema*, were found in all the four regions (Table 1). *Hoplolaimus* was found only in the Eastern region. The genera *Trichodorus* and *Tylenchorhynchus* were not found in Ashanti or Brong Ahafo regions but were present in Eastern and Volta regions.

Meloidogyne (juveniles) alone constituted approximately 37% of the total population and occurred in 41 of the 54 farms sampled (Table 2). *Pratylenchus*, *Helicotylenchus*, *Pratylenchus*, and *Helicotylenchus* consisted of 25, 12, 37, and 33% of the nematode genera. Relative abundance of *Tylenchorhynchus*, *Hoplolaimus*, *Aphelenchoides*, and *Xiphinema* was below 5% while *Tylenchorhynchus* was found in two fields with a relative abundance of less than 1%. The number of

Table 2. Frequency of occurrence and relative abundance of plant parasitic nematodes associated with 54 farms in four regions of southern Ghana during 1999 and 2001.

Nematode genera	Order	Population	Frequency of occurrence	Relative abundance
		No./200 cm^3	No. of farms	%
Aphelechiodes	Tylenchida	723	9	3
Helicotylenchus	Tylenchida	2569	33	12
Hoplolaimus	Tylenchida	241	4	1
Meloidogyne	Tylenchida	8119	41	37
Paratrichodorus	Diplonchida	1182	25	5
Pratylenchus	Tylenchida	5602	37	25
Rotylenchulus	Tylenchida	2072	34	9
Trichodorus	Diplonchida	1069	17	5
Tylenchorhynchus	Tylenchida	196	2	1
Xiphinema	Diplonchida	513	17	2

Table 3. Number of nematodes recovered from roots of peanut.

Nematode genera	Nematode population
	No./5 g root
Meloidogyne	254
Pratylenchus	203
Paratrichodorus	174
Rotylenchulus	93

nematodes associated with peanut roots ranged from 93 to 254/5 g root (Table 3). The highest mean population of 104 *Rhigonema* was extracted from millipedes sampled from the rhizosphere of peanut in the Brong Ahafo region while the lowest mean of 48 was recovered from millipedes found in the Volta region (Table 4).

Results of these surveys indicate that plant parasitic nematodes occur in all the four regions of southern Ghana. Nematodes encountered during the survey such as the lesion nematode (*Pratylenchus brachyurus*), peanut rootknot nematode (*Meloidogyne arenaria*), testa nematode (*Aphelenchoides arachidis*), and spiral nematode (*Helicotylenchus multicinctus*) have been reported previously (Sharma, 1985). However, absence of particular nematodes from a region does not imply that the nematodes are non-existent in the region. A possible suggestion might be that peanut is not a favorable host. Also, different biotic and abiotic stresses might explain why some nematodes were found in some regions but absent from others. However, it is evident that the ten different cultivars of peanut grown in the four regions support large populations of *Helicotylenchus, Meloidogyne*, and *Pratylenchus. Meloidogyne arenaria*, which is endoparasitic, was the most abundant nematode found in peanut root system. *Pratylenchus, Paratrichodorus*, and *Rotylenchulus* followed in that order. *Rhigonema* species have been reported to parasitize the gut system of millipedes (Hunt, 1998). Results in the current study are in concert with those from other West African regions; Bos (1977) found *Aphelenchoides arachidis* on peanut in northern Nigeria. *Criconemella* species have been reported on peanut in Gambia (Merny et al., 1974). In Senegal, Netscher (1975) reported that *Meloidogyne* species reproduced on peanut.

Table 4. Number of *Rhigonematid* nematode recovered from roots of peanut in four regions of southern Ghana.

Nematode genera	Nematode population
	No./5 g root
Meloidogyne	254
Pratylenchus	203
Paratrichodorus	174
Rotylenchulus	93

Table 5. Distribution of nematodes in the experimental area at the beginning of the 2000 experiment.

Nematode genera	Population density[a]
	No./200 cm^3
Meloidogyne	117
Pratylenchus	106
Helicotylenchus	87
Rotylenchulus	73
Paratrichodorus	31
Trichodorus	20
Xiphinema	10
Criconemella	7

[a]Data are the average of 30 samples.

Additional research is needed to establish interactions among nematodes and other pathogenic organisms in the development of disease complexes in peanut (Patel et al., 1985). For sustainable peanut production in southern Ghana, plant parasitic nematodes must be managed effectively, and results from these surveys will assist practitioners in germplasm development and selection and formulation of management strategies that utilize control measures in addition to host plant resistance.

Host-Plant Resistance to Nematodes.

Eight genera of nematodes were identified at the beginning of the trial, with *Meloidogyne* being the most abundant and *Criconemella* being the least abundant (Table 5). Six weed species, *Verona cinerea, Sida acuta, Panicum maximum, Brachiaria distichophylla, Chromolaena odorata*, and *Sporobulus pyramidalis*, were predominant at this location. Some of these weed species were also found to be infected with the same three genera of nematodes found in peanut roots (Table 6.). *Verona cinerea* gave the highest nematode population. Nematodes were not extracted from *Sida acuta* samples. The isolation of nematodes from weed species collaborated previous findings demonstrating that weeds serve as alternate hosts of nematodes (Khan and Khan, 1985). Nematode's ability to survive on native flora makes management of these pests extremely difficult to manage using crop rotation only. Significant crop loss can occur when nematodes found in these experiments are not controlled or suppressed (Minton and Baujard, 1993). The nematode *Trichodorus similis* was found during the initial soil sampling but was not present at harvest (Sharma, 1985).

At harvest, lesion nematode (*Pratylenchus brachyurus*), peanut root-knot nematode (*Meloidogyne arenaria*), reniform nematode (*Rotylenchulus*

Table 6. Incidence of parasitic nematodes on selected weed species.

	Weed genera[a]					
Nematode genera	*Verona cinerea*	*Brachiaria distichophylla*	*Sporobulus pyramidalis*	*Panicum maximum*	*Chromolena odorata*	*Sida acuta*
Meloidogyne	Yes	Yes	No	No	No	No
Pratylenchus	Yes	Yes	Yes	Yes	Yes	No
Rotylenchulus	Yes	Yes	Yes	Yes	No	No

[a]Yes indicates presence. No indicates not present.

reniformis), dagger nematode (*Xiphinema elongatum*), ring nematode (*Criconemella ornata*, *Paratrichodorus minor*), and spiral nematode (*Helicotylenchus multicintus*) were extracted from the peanut rhizosphere. Three endoparasitic nematodes, *Pratylenchus brachyurus, Meloidogyne arenaria*, and *Rotylenchulus reniformis*, were isolated from peanut roots (Table 7). The cultivars or experimental lines ICGX-SM 87057, AT 120, NC-V 11, Southern Runner, RRR M 576-79, RRR - MDR-8-16, Georgia Green, and Shitaochi had lower nematode populations at harvest during 2000 compared with the other plant entries (Table 7). The experiment was repeated the following year (2001) and all the eleven cultivars identified the previous year except ICGX-SM 87057 and Shitaochi had lower nematode populations (Table 8).

Host plant resistance represents the inherent ability of crop plants to restrict, retard or overcome pest infestations (Kumar, 1984) and thereby, improve the yield and /or quality of the harvestable crop product. Resistant cultivars are economical and environmentally safe method for control of root knot nematodes (Dent, 1990; Netscher and Mauboussin, 1973; Roberts and Thomason, 1986), although races may exist which are able to break resistance (Fargette, 1987). Additional research under a wider range of edaphic and environmental conditions is needed to determine nematode resistance under production systems in Ghana.

Table 7. Plant parasitic nematode population from the rhizosphere of peanut at harvest during 2000.

Cultivars or experimental lines	*Meloidogyne*	*Pratylenchus*	*Helicotylenchus*	*Rotylenchulus*	*Paratrichodorus*	*Xiphinema*	*Criconemella*
	No./200 cm^3						
AADRO-93	384	545	164	294	294	224	32
AT 120	20	26	29	23	29	18	3
Georgia Green	19	19	41	35	48	67	17
GK 7 high oleic	523	486	491	374	181	238	138
ICGX SM 89029	347	440	444	329	254	169	139
ICGV 87160	291	400	356	506	345	218	155
ICGV 86556	395	462	385	459	277	188	188
ICGV SM 86047	286	341	243	380	252	20	146
NC 7	3945	24	57	36	32	15	38
NC 10C	110	183	262	195	72	195	37
NC-V 11	7	34	105	25	30	11	0
NC 12C	372	476	269	252	169	195	157
RRR UGA-9	490	570	239	194	330	170	214
RRR MDR-8-19	239	452	319	392	346	225	0
RRR MDR-8-16	26	30	57	18	44	72	0
RRR M576-79	34	15	32	31	37	39	53
RRR M249-74	387	509	351	332	241	220	155
Shitochi	24	17	103	27	31	74	37
Sinkarzei	29	23	35	22	28	10	49
Southern Runner	24	15	125	17	30	0	32
VA 93B	318	680	223	27	339	253	191
CV (%)	18.9	20.3	32.3	16.5	29.3	40.5	40.0
Standard error	34.5	37.5	64.7	29.3	34.9	32.6	28.1
Significance ($P < 0.01$)	*	*	NS	*	*	*	*

Table 8. Plant parasitic nematode population from the rhizosphere of peanut at harvest during 2001.

Cultivars or experimental lines	*Meloidogyne*	*Pratylenchus*	*Helicotylenchus*	*Rotylenchulus*	*Paratrichodorus*	*Xiphinema*	*Criconemella*
	No./200 cm^3						
AADRO-93	597	661	340	223	233	275	55
AT 120	50	47	43	31	22	20	28
Georgia Green	43	40	43	46	25	28	22
GK 7 high oleic	652	430	417	338	115	235	115
ICGX SM 89029	309	452	459	395	224	142	139
ICGV 87160	226	366	335	601	306	236	144
ICGV 86556	473	553	340	452	253	118	124
ICGV SM 86047	1407	458	337	413	227	36	146
NC 7	830	447	329	243	250	241	103
NC 10C	76	152	13	177	114	42	68
NC-V 11	47	48	41	35	35	30	26
NC 12C	341	436	231	238	147	129	119
RRR UGA-9	478	592	232	148	334	149	209
RRR MDR-8-19	238	437	349	339	313	249	34
RRR MDR-8-16	61	68	46	40	51	50	0
RRR M576-79	31	30	53	24	50	84	19
RRR M249-74	437	543	522	543	422	315	133
Shitochi	422	245	257	179	94	50	42
Sinkarzei	109	106	117	131	114	72	28
Southern Runner	36	43	27	36	28	10	27
VA 93B	427	711	325	182	228	277	143
CV (%)	38.8	35.7	29.4	33.8	45.8	44.8	33.8
Standard error	52.9	83.8	102.3	88.6	153.1	103.1	65.1
Significance ($P < 0.01$)	*	*	*	*	*	*	*

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