DAMAGE TO YAM (*DIOSCOREA* SPP.) BY ROOT-KNOT NEMATODE (*MELOIDOGYNE* SPP.) UNDER FIELD AND STORAGE CONDITIONS IN UGANDA

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ABSTRACT

Mudiope J., D. L. Coyne, E. Adipala and H. A. L. Talwana. 2012. Damage to yam (*Dioscorea* spp.) by root-knot nematode (*Meloidogyne* spp.) under field and storage conditions in Uganda. Nematropica 42:137-145.

Although root-knot nematodes (*Meloidogyne* spp.) are a widely distributed pest of yam (*Dioscorea* spp.), the level of damage the yams incur, either alone or in association with other plant-parasitic nematodes is largely undetermined. The current study assessed the damage *Meloidogyne* spp. caused in the field and during storage, following inoculation onto clean seed material and also to yam planted into infested fields. In general, *Meloidogyne* spp. caused little galling to roots and tubers, and limited reduction in plant growth and yield. Of three species tested, *D. rotundata* was the most susceptible and most heavily affected by *Meloidogyne* spp. infection, *D. alata* was the least affected, and *D. cayenensis* was intermediately affected yam species. *Meloidogyne* spp. infection of tubers significantly exacerbated yam tuber weight loss during storage, particularly during the first 2 months, and moreover reduced and delayed tuber sprouting. Farmers need to select tubers free of *Meloidogyne* spp. symptoms prior to storage to reduce losses from tuber deterioration, and while selecting planting material for the succeeding season.

Key Words: East Africa, galling, sprouting, tuber deterioration, yield loss

RESUMEN

Mudiope J., D. L. Coyne, E. Adipala and H. A. L. Talwana. 2012. Daño al name (*Dioscorea* spp.) causado por el nematodo agallador (*Meloidogyne* spp.) en campo y en almacenamiento en Uganda. Nematropica 42:137-145.

Aunque los nematodos agalladores (*Meloidogyne* spp.) son una plaga del ñame (*Dioscorea* spp.) ampliamente distribuida, se desconoce en gran medida el daño que causan al cultivo solos o en asociación con otros nematodes fitoparásitos. Este estudio evalua el daño causado por *Meloidogyne* spp. en el campo y durante el almacenamiento, tras la inoculación de materiales de siembra limpios y en ñame sembrado en campos infestados. En general, *Meloidogyne* spp. causó poco agallamiento en las raíces y tubérculos, y reducción limitada en el crecimiento de las plantas y en la producción. De las tres especies de ñame evaluadas, *D. rotundata* fue la más susceptible y la más afectada por la infección de *Meloidogyne* spp., *D. alata* fue la menos afectada, y *D. cayenensis* se afectó de manera intermedia. La infección con *Meloidogyne* spp. afectó significativamente la pérdida de peso de los tubérculos durante el almacenamiento, particularmente durante los primeros dos meses, y redujo y retrasó el rebrote. Los agricultores deben seleccionar tubérculos libres de síntomas de *Meloidogyne* spp. antes del almacenamiento y como material de siembra, para reducir las pérdidas.

Palabras Clave: Africa del Este, agallamiento, rebrotes, deterioro de tubérculos, pérdida de producción

INTRODUCTION

Yam (*Dioscorea* spp.) is a multispecies crop of over 600 species with *D. rotundata* (white yam), D. alata (water yam), and *D. cayenensis* (yellow yam) being the most commonly cultivated and consumed species in the humid and sub-humid tropics (Coursey, 1967; Kay 1987). Yam is the third most important source of carbohydrates after cassava and sweet potato, especially across sub-Saharan Africa (SSA) where over 95% of total global production occurs (Scott *et al.* 2000a, 2000b; FAOstat 2010). Yam is also a good source of protein, essential amino acids, vitamins, and minerals such as calcium, magnesium and phosphorus (Ferguson *et al.*, 1980; Hahn *et al.*, 1987). Furthermore, an important characteristic of yam is its storability over extended periods, providing year-round food security and enabling planting flexibility during unseasonal dry periods (Hahn *et al.*, 1989; Degras, 1993; Ocitti, 2001). Yam is also often symbolically revered across SSA ethnically and socially in numerous rituals, ceremonies and functions (Smit, 1989; Degras, 1993).

Yam is a common but localised crop across East Africa (Wanyera *et al.*, 1996; Mwirigi 2008; Serenje & Shaali 2010). Demand for the crop is high regionally, yet vegetative propagation of the crop through tubers undermines the quality and quantity of planting materials available, leading to poor production (Wanyera *et al.*, 1996). Yam is susceptible to a host of pests and diseases, including plant-parasitic nematodes, which further affect productivity, tuber quality and storability. Although nematodes are recognised as important yam pests (Bridge *et al.*, 2005), nematode species associated with the crop vary geographically. In West Africa, *Scutellonema bradys* and *Meloidogyne* spp. are reported as most important (Bridge *et al.*, 2005; Coyne *et al.*, 2006), whereas *Meloidogyne* spp. and *Pratylenchus sudanensis* are reported as the key nematode species in East Africa (Coyne *et al.*, 2003; Mudiope *et al.*, 2007). *Pratylenchus coffeae* is important in Central and South America (Bridge *et al.*, 2005). However, many questions about the role of a specific nematode species in limiting yam productivity remain unanswered. While *Meloidogyne* spp. are widely distributed on yam (Bridge *et al.*, 2005; Coyne *et al.*, 2003; Coyne *et al.*, 2006; Mudiope *et al.*, 2007), the pathogenicity and level of damage they cause singly and/or in combination with other nematodes remains unclear. The nematode's role in the decline of yam tuber yields and storability of tubers is also not certain. The current study is aimed at establishing the nature and level of damage that *Meloidogyne* spp. causes on yam under pre- and post-harvest conditions in Uganda.

MATERIALS AND METHODS

Yam cultivars used and preparation of planting material

Three yam species *D. rotundata* (cv. DRC 97/00725), *D. alata* (cv. Ndaggu Nziba) and *D. cayenensis* (cv. Kyetutumula) were used to assess the effects of *Meloidogyne* spp. infection and damage on yam growth and yield in pot and field experiments. Tubers of each species were hot water treated at ~ 50ºC for 20 minutes (Coyne *et al.*, 2010) to disinfest the tubers of nematodes and other tuber-borne pests and diseases. The disinfested tubers were thereafter cut into mini-setts (~50 g each), dipped in Benlate fungicide suspension (1 g /l of water) and surface-dried before planting. In both experiments, treatments included two factors: yam cultivar (three yam species) and *Meloidogyne* spp. inoculum level (0, 100, 1,000 or 3,000 eggs and/or juveniles per plant).

Inoculum source and preparation

Meloidogyne spp. infected *D. rotundata* tubers were washed with non-chlorinated tap water to remove any adhering soil nematodes before peeling to a depth of ~2 mm where yam parasitic nematodes mainly occur (Bridge *et al.*, 2005). Peelings were bulked and used to inoculate 2-week-old susceptible tomato (*Solanum esculentum* cv. 'Moneymaker') plants that were grown in steam-sterilized sandy loam soil filled into plastic pots. The growing tomato plants were placed under a temporary shade made of papyrus mats placed over polythene sheeting and supported by wooden poles. The tomato plants were uprooted 8 weeks after inoculation and the galled roots carefully rinsed with tap water before chopping to ~1 cm lengths. The chopped root pieces were then macerated in a kitchen blender with a little water for 10 s. Following maceration, a 1% sodium hypochlorite solution was added to the macerated tissues and the roots agitated for 2 min to aid release of eggs from the gelatinous matrix of the egg masses. The macerated tissue was poured through nested 250 µm and 215 µm pore sieves to collect debris, and nematode eggs and second-stage juveniles (J2) were caught in a collecting plate. The procedure was repeated until sufficient eggs were collected. Prior to inoculation, the eggs and juveniles were rinsed several times with non-chlorinated tap water.

Effect of Meloidogyne *spp. infection on yam growth and yield*

Pot experiment. Mini-setts were placed in steam-sterilized sawdust beds under shade to sprout. At 6 weeks, uniformly sprouted and growing setts were transplanted to 10-l perforated polythene bags filled with 8 kg steam-sterilized soil (1:2 sand:topsoil volume by volume mixture). Yam mini-setts were inoculated at transplanting by pipetting 5-10 ml of an aqueous suspension containing 0, 100, 1,000 or 3,000 eggs and/or juveniles onto and around the yam mini-setts. Pots were arranged in a completely randomized design outdoors, with six replications per treatment. The plants were watered three times weekly until harvest at 3 months after transplanting. The experiment was conducted three times.

Three months after transplanting, plants were harvested after heavily watering them the previous day to soften the soil and enable removal of roots and tubers without damage. Tubers and roots were rinsed free of adhering soil, dabbed dry and their fresh weights recorded. *Meloidogyne* spp. gall damage was visually assessed using a gall index: 0 = no damage; 1 = trace (1 – 10%) damage; 2 = slight (11 – 30%) damage; 3 = moderate (31 – 50%) damage; 4 = severe (51 – 80%) damage and 5 = very severe (81 – 100%) damage (Sasser *et al.*, 1984). Shoot dry weight was determined by oven-drying at 80ºC. For each plant, tubers were peeled to a depth of ~2 mm with a kitchen peeler and the roots chopped into ~2 cm pieces. The peelings and roots were thoroughly mixed before removing a 2 g sub-sample to extract nematodes using the maceration technique described above. The extracted suspension was poured into glass beakers and allowed to settle before reducing the volume to 25 ml by carefully siphoning off excess water. The J2 and eggs were stained using Acid Fuchsin (Hooper *et al.* 2005) to aid counting under a Leica MZ 9.5 dissection microscope. Nematodes were counted from triplicate 2 ml aliquots and the numbers reported per 100 g fresh roots and tuber peel weight.

Field experiment

The field experiment was conducted at the International Institute of Tropical Agriculture (IITA) Research Station at Namulonge, situated 0º 31 'N, 320 35 'S, 1128 m above sea level, in central Uganda. The soils of this area are mainly deep tropical dark reddish-brown tropical sandy loam, characteristic of the Buganda catena (IITA, 1992). The soils are heavy, but well-drained, with a pH 5.0 - 6.0, and average organic matter levels of 2 - 3% in the surface (0 - 20 cm) horizons. The area experiences average minimum and maximum temperatures of 15º and 31ºC, respectively, and bimodal rainfall with the first wet season occurring March to June and the second September to December (IITA, 1992).

The field was ploughed and harrowed once with a tractor before ridging using hand-hoes. The treatment plots consisted of five ridges, 180 cm long and 10 cm high, spaced at 100 cm between ridges. Yam mini-setts were planted into ~5 cm deep holes lined with a small amount of sterile sawdust to help 'carry' nematode inoculum. The spacing between mini-setts within a ridge was 50 cm, giving 6 plants per ridge and 30 plants per plot. At planting, an aqueous suspension containing 0, 100, 1,000 or 3,000 eggs and/or J2 was poured into the hole containing the setts and sawdust. Thereafter, the planting holes were covered with soil and the ridges reformed. A randomized complete block experimental design with a factorial arrangement of treatments with three replications was used. The experiment was conducted twice in different fields during 2002 and 2003. The experiments were rainfed (no additional irrigation), received no fertiliser or pesticide, and were hand-weeded as required.

Prior to each planting, five random soil cores of 2 cm wide x 20 cm deep were removed per plot, mixed thoroughly and nematodes extracted from a 100 ml soil sub-sample using a modified Baermann method (Hooper *et al.*, 2005). Nematodes were identified (to genus level) as *Pratylenchus* spp., *Scutellonema* spp., *Rotylenchus* spp., *Helicotylenchus* spp. and *Meloidogyne* spp. with mean population density of each respective genera being less than 5 nematodes/100 ml of soil during the first planting (planted 25 May 2002), and less than 15 nematodes/100 ml of soil during the second planting (planted 27 March 2003).

The experiments were terminated 7 months after planting, and the number of plants per hill, tuber fresh weight, tuber galling and *Meloidogyne* spp. densities assessed, as described above.

Assessing the effect of Meloidogyne *spp. on yam storability*

Immediately after harvest of the second planting in October 2003, the field was harrowed once with a tractor before ridging again using hand-hoes. Prior to planting, soil samples were removed as described above to determine the density of *Meloidogyne* spp., which was estimated as 42,683-juveniles/100 ml of soil. Hot water treated mini-setts of *D. rotundata* (cv. DRC 97/00725) were planted in this *Meloidogyne* spp. infested field. Tubers were harvested 7 months after planting and categorised according to their degree of visible galling: 0 = no galls, 2 = moderately (31-50%) galled, and 3 = severely (> 50%) galled. For each category, 10 tubers were selected from the harvested tubers and stored in slatted wooden boxes, raised above the ground in a ventilated yam barn at Namulonge for 4 months. The survival of *Meloidogyne* spp. life stages and the effect of *Meloidogyne* spp. infection on yam tubers during storage was assessed by recording the fresh weight of all tubers, and the number of nematode eggs, J2 and females per 100 g tuber monthly of the moderately and severely galled tubers. The experiment was repeated during July 2004 – February 2005 with the initial field infestation by *Meloidogyne* spp. estimated at 56,875-juveniles/100 ml of soil.

Statistical treatment of data

Prior to analysis of variance, nematode densities were square-root transformed to normalise variance. Analysis of variance using the general analysis of variance procedure of Genstat® statistical Software (Lawes Agricultural Trust) and means separated using Least Significant Difference (LSD) at 5% probability level. Simple Pearson's correlation coefficients between nematode densities, damage and growth parameters were also calculated. For both the pot and field experiments no differences ($P > 0.05$) were observed in results between experimental repeats, and so data were combined for analysis.

RESULTS

Meloidogyne *spp. damage and infection in yam planted in pots and in the field*

The galling damage indices were generally low on plants grown in pots and in the field (Tables 1 & 6) with no significant ($P > 0.05$) differences observed among yam cultivars. Relatively, higher damage was observed on *D. rotundata* roots and tubers whereas low damage was observed on *D. alata* roots and tubers. The galling damage increased with increase in nematode inoculum level in all cultivars but damage was significantly ($P<0.05$) higher only in plants inoculated with 1000 and/or 3000 *Meloidogyne* spp. Nematode

Table 1: Nematode damage scores (galling index*) on roots and tubers of yam grown in pots, assessed 3 months after inoculation with *Meloidogyne* spp.

	Roots				Tubers			
Nematode eggs per plant	0	100	1000	3000	0	100	1000	3000
D. rotundata	0.0	0.3	1.2	2.1	0.0	0.0	1.0	2.1
D. cayenensis	0.0	0.1	0.9	1.5	0.0	0.1	0.7	1.5
D. alata	0.0	0.1	1.0	1.7	0.0	0.1	0.4	0.9
	-	ns	ns	ns	-	ns	ns	ns

ns = cultivar means are not significantly different ($P \leq 0.05$).

Table 2: *Meloidogyne* spp. population density in pot-grown yam roots and tubers, assessed 3 months after inoculation.

	Nematode count/100 g fresh root				Nematode count/100 g fresh tuber			
Nematode eggs per plant	0	100	1000	3000	0	100	1000	3000
D. rotundata	0	1750b	7736b	36726b	0	479a	3257b	8992b
D. cayenensis	0	875a	4347a	13056a	0	500a	3128b	5514ab
D. alata	0	854a	2722a	8986a	0	424a	1597a	3878b
	-				-			

Nematode counts were square root transformed prior to analysis; back-transformed data presented; data in columns followed by the same letter are not significantly different ($P \leq 0.05$).

Table 3: Effect of *Meloidogyne* spp. infection on plant growth of three pot-grown yam cultivars, assessed 3 months after inoculation.

	Roots (g)				Tubers (g)				Dry shoots (g)			
Nematode eggs per plant	0	100	1000	3000	0	100	1000	3000	0	100	1000	3000
D. rotundata	14.2a	12.4a	11.3a	11.2a	31.8a	29.9a	24.2a	22.4a	10.7a	9.0a	8.9a	7.0a
D. cayenensis	18.2a	22.4ab	20.0ab	19.6a	25.3a	26.5a	27.1a	23.0a	14.9a	14.0a	11.3a	11.0a
D. alata	34.0b	29.9b	27.2a	30.7b	100.3b	99.9b	98.7b	98.4b	24.2b	23.3b	23.0b	22.8b

Data in columns followed by the same letter are not significantly different ($P \leq 0.05$).

population densities were significantly ($P<0.05$) lower in *D. alata* roots and tubers than in *D. rotundata* and *D. cayenensis* both in pots and field at all levels of initial *Meloidogyne* spp. inoculum (Tables 2 and 6). For each yam cultivar, higher ($P<0.05$) nematode population densities were recovered from roots than tubers, and the nematodes recovered increased with increase in initial *Meloidogyne* spp. inoculum.

Although variable, nematode infection affected plant growth to some degree, mostly observed with *D. rotundata,* which had 30% lower tuber yields following inoculation of 3000 eggs compared with the control, while *D. alata* was unaffected (Table 3). The simple Pearson's correlation coefficients also show a similar trend, with nematode population density in tubers significantly and negatively correlated with tuber fresh weight and shoot dry weight of *D. rotundata* only (Table 4). No clear effect of nematode inoculation was observed in the field on yield of the respective cultivars. Yield was generally higher for *D. alata* than *D. rotundata* and *D. cayenensis* (Table 5).

Survival of Meloidogyne spp. *life-stages in stored yam tubers*

All tubers lost weight during storage, with significantly ($P \leq 0.05$) more weight loss observed in the severely galled tubers, which was consistently more than double the loss in non-galled tubers (Fig. 1). During storage sprouting of tubers was also negatively affected by galling damage, with delayed or reduced sprouting of yam tubers observed on the moderately

Table 4: Simple Pearson's Correlation coefficients among *Meloidogyne* spp. population density, their associated damages and growth parameters of three yam cultivars assessed 3 months after inoculation in pots.

Variable	Root nematode density	Tuber nematode density	Root gall damage	Tuber gall damage	Tuber fresh weight	Shoot dry weight
Dioscorea rotundata						
Tuber nematodes	0.76***					
Root gall damage	0.86*	0.68*				
Tuber gall damage	0.78*	0.77*	0.79*			
Tuber fresh weight	-0.68*	-0.60*	-0.64*	-0.64***		
Shoot dry weight	-0.61*	-0.52*	-0.51*	-0.55**	0.65***	
Root fresh weight	-0.41ns	-0.35 ns	-0.47**	-0.38 ns	0.35 ns	0.31**
Dioscorea cayenensis						
Tuber nematodes	0.732***					
Root gall damage	0.704*	0.598*				
Tuber gall damage	0.794*	0.686*	0.853**			
Tuber fresh weight	-0.340 ns	-0.208 ns	-0.445**	-0.385***		
Shoot dry weight	-0.589*	-0.464 ns	-0.421**	-0.582**	0.269 ns	
Root fresh weight	-0.362 ns	-0.178*	-0.415*	-0.422 ns	0.471**	0.303 ns
Dioscorea alata						
Tuber nematodes	0.518***					
Root gall damage	0.641*	0.372 ns				
Tuber gall damage	0.671*	0.636*	0.748*			
Tuber fresh weight	-0.133 ns	-0.232 ns	-0.071 ns	-0.3131 ns		
Shoot dry weight	-0.380 ns	-0.026 ns	-0.319 ns	-0.277*	-0.033 ns	
Root fresh weight	-0.330 ns	-0.080 ns	-0.266 ns	-0.129 ns	-0.081 ns	0.440**

***, **,* = significant correlations at P=0.001, P=0.01 and P=0.05, respectively; ns = not significant

Table 5: Effect of *Meloidogyne* spp. infection on tuber yield of three yam cultivars planted in open field plots, assessed 7 months after inoculation

	Fresh tuber weight/plant (g)			
Nematode eggs per plant	0	100	1000	3000
D. rotundata	1282	1209	1145	1058
D. cayenensis	1040	958	874	844
D. alata	1819	1809	1686	1663

Data in columns followed by the same letter are not significantly different ($P \leq 0.05$).

and severely galled tubers compared with non-galled tubers (Table 7). Nematode eggs were most abundant in both moderately and severely galled tubers. Relatively higher population densities of all nematode stages were recovered in severely galled than moderately galled tubers. *Meloidogyne* spp. population densities in yam tubers declined with duration of storage, and no nematode was recovered after 4 months of storage (Fig. 2). No nematodes were recovered in non-galled tubers during the first month of storage and, therefore, assessment was discontinued in the subsequent months.

DISCUSSION

Meloidogyne spp., in general, caused only limited galling to yam roots and tubers, plant growth and yield following inoculation in pots and the field. It is possible that the initial nematode population

Table 6: Tuber galling damage and nematode population density of three yam cultivars assessed 7 months after inoculation with *Meloidogyne* spp. and planting into field plots.

	Galling index				Nematode count/100 g fresh tuber			
Nematode inoculation (eggs per plant)	0	100	1000	3000	0	100	1000	3000
D. rotundata	0.1	0.5	0.8	1.3	341	1489	3816	9138
D. cayenensis	0.1	0.2	0.5	0.8	177	947	2439	4867
D. alata	0.0	0.2	0.3	0.5	203	368	1010	2549

Data in columns followed by the same letter are not significantly different ($P \leq 0.05$); Nematode densities were square-root transformed prior to analysis; back-transformed data presented.

Table 7: Percent tuber sprouting of *Dioscorea* rotundata during storage with varying levels of galling damage (N= 73).

	Storage period (months)			
Pre-storage tuber condition	1	2	3	4
No galls	74	90	100	100
Moderately galled	54	62	97	100
Severely galled	29	61	80	70

Data in columns followed by the same letter are not significantly different ($P \leq 0.05$).

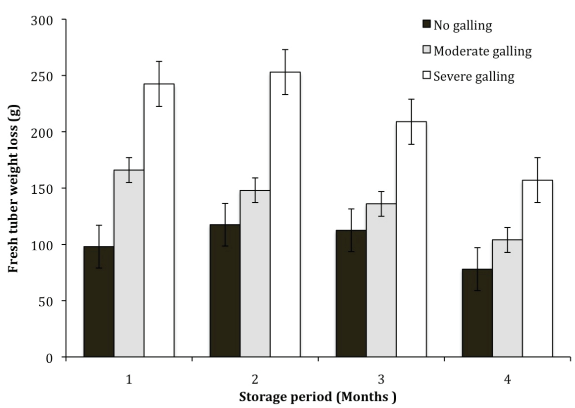

Fig. 1: Weight loss during storage of *Dioscorea rotundata* tubers with varying levels of *Meloidogyne* spp. galling damage (bars represent standard error of the difference among monthly means). (above)

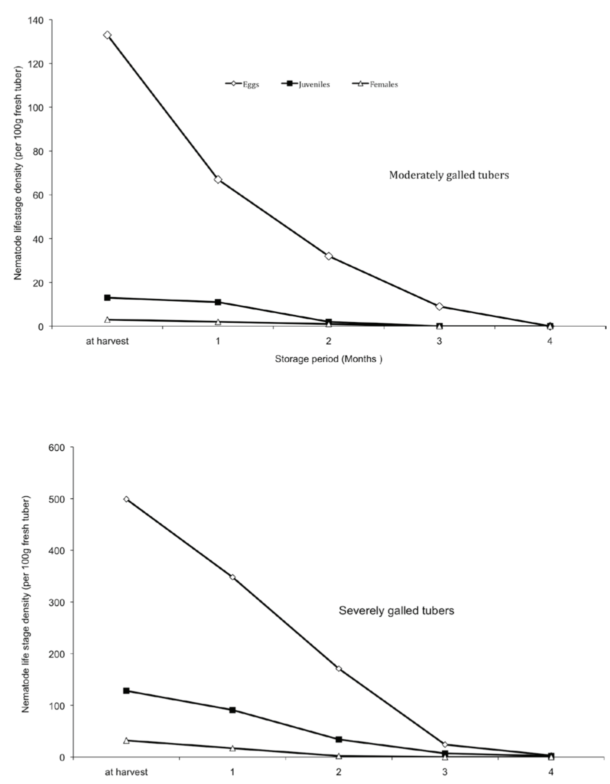

Figure 2: Monthly change in densities of *Meloidogyne* spp. life-stages in moderately and severely galled *Dioscorea rotundata* tubers during storage. (right)

density (inoculum) was too low to cause sizeable and observable damage, and subsequent reduction in plant growth and yield would be higher when arising from tuber-borne infection. The subtleness of the nematode damage on yam (like in many crops) may be among the reasons that have generally led to an assumption that they are not serious production constraints of yam and subsequently overlooked by research and development. However, in many cases, nematodes are capable of reproducing on yam and cause sizeable reductions in growth and yield (Bridge, 1973; Bridge *et al.*, 2005; Baimey *et al.*, 2006). Nematode damage on yam disfigures tubers, which appear abnormal and unappealing to the consumer and consequently reduce their marketability and value. Nematode-damaged tubers are therefore more likely to be retained by the farmer for home consumption or as planting material for the following season. However, even moderately galled tubers were shown to have significantly reduced ability to sprout in the current study, which would affect the stands in the field, in addition to directly impacting yield per plant. *Meloidogyne* spp. has also been shown to affect the quality of yam tuber tissues, which become sugary to taste with infection, and tubers are less preferred by consumers (Fawole, 1988). In an attempt to remove the galling by peeling, farmers further reduce the marketable yam quantities (Nwauzor and Fawole, 1981).

From the current study, *D. alata* appears the least susceptible of the three most common yam species, which supports previous comparative assessments (Hahn *et al.*, 1989; Coyne *et al.*, 2006) which reported *D. alata* as relatively resistant and *D. rotundata* as susceptible. The relative higher damage observed on *D. rotundata* corresponded with the relative higher nematode population density and ultimately yield losses. *Dioscorea rotundata* plants inoculated with 3000 nematode eggs had 17% less tuber yield than uninoculated plants in the field, and 30% in pots. Whereas yield loss in *D. cayenensis* inoculated plants was estimated at 19%. in the field.

Although *D. alata* appears less susceptible to *Meloidogyne* spp. infection and damage, it is preferred less by farmers in Uganda (Wanyera *et al.*, 1996). Farmers prefer *D. rotundata* due to its taste, textural quality and shorter growth period (Wanyera *et al.*, 1996; Coyne *et al.*, 2005). Subsequently, there is expansion in acreage of *D. rotundata* in Uganda and East Africa since its recent introduction from West Africa (Kizzah, 1995). However, its susceptibility to local pests and disease may hinder its further expansion (Wanyera *et al.*, 1996; Coyne *et al.*, 2005). Specifically, *D. rotundata* appears most susceptible to *Meloidogyne* spp. infection in East Africa (Mudiope *et al.*, 1998; Coyne *et al.*, 2006). Therefore, strategies that lead towards reducing nematode infection of planting material require attention for developing and implementing at the smallholder farmer level to minimise losses.

During storage, *Meloidogyne* spp. infection of tubers exacerbated tuber weight loss, an otherwise natural phenomenon (Girardin *et al.* 1997, 1998), with the more severely galled tubers losing over twice the weight of non-galled tubers. This loss is higher than previously reported from Nigeria by Nwauzor and Fawole (1981), who observed losses of 25 to 75% within a storage period of 16 weeks. This loss could be due to nematodes altering tuber metabolism processes, especially the inter-conversion of starch to simple sugars and increased tuber respiration (Adesiyan *et al.*, 1975). Survival of the various *Meloidogyne* spp. developmental stages also differed with scarcely any females recovered after 2 months of storage. However, J2 were recovered up to 4 months, albeit in small numbers. Interestingly, there was no evidence of reinfection of the tubers by J2 and their further development into females. The decrease in *Meloidogyne* spp. population densities during storage is possibly a host reaction, which isolates and kills the nematodes in necrotic areas within the tubers (Bridge, 1973; Fawole, 1988), which contrasts with the migratory endoparasitic species *Pratylenchus* spp. and *S. bradys* that reproduce during storage (Bridge, 1982).

Meloidogyne spp. infection in stored yams was associated with reduced and delayed sprouting of tubers, possibly as a result of interrupted nutrient availability (Vaasta *et al.*, 1998; Carneiro *et al.*, 2002; Hurchanik *et al.*, 2004). Combined with the reduced yield potential of infected planting material, this exacerbates the overall impact of *Meloidogyne* spp. on yam yield in addition to tuber quality. Selection of high quality, healthy planting material should therefore be a priority for farmers, and the development of sustainable seed systems of healthy seed promoted at national and regional levels. Treatment with hot water (Bridge, 1982; Coyne *et al.*, 2010) or with a pesticide dip (Morse *et al.*, 2009) of planting material would help break the cycle of nematode infection and improve yam productivity.

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