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NEMATODE DISTRIBUTION AND DAMAGE TO YAM IN CENTRAL AND EASTERN UGANDA

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ABSTRACT

Yams (*Dioscorea* spp.) are food crops of growing significance in sub Saharan Africa. Unfortunately, nematodes are major pests to their production. A study was undertaken in major yam growing areas of Uganda to investigate the association of plant parasitic nematodes with damage symptoms. Nematodes were assessed from tubers, roots and surrounding soil for seven cultivars belonging to *Dioscorea alata, D. bulbisiana, D. burkilliana* and *D. cayenensis* at harvest. *Pratylenchus sudanensis* was found in the greatest density and was followed by *Meloidogyne* spp. Higher densities of both nematodes were observed in the tubers rather than roots. Although symptoms of cracking and galling were relatively low, *P. sudanensis* incidence was strongly associated with cracking and *Meloidogyne* spp. with galling. *Pratylenchus sudanensis* and *Meloidogyne* spp. incidence their associated damage were, however, negatively correlated, suggesting inter-species competition. Principal components analysis of data suggested that differences in susceptibility to *P. sudanensis* occur between yam cultivars and species.

Key Words: *Dioscorea, Meloidogyne, Pratylenchus,* tuber cracking

RÉSUMÉ

Les ignames (*Dioscorea* spp.) sont une culture alimentaire d'importance croissante en Afrique sub–saharienne. Malheureusement, les nématodes sont des parasites majeurs qui gênent sa production. Une étude était menée dans les principales régions productrices de l'igname en Ouganda en vue de pouvoir mener investigation sur l'association des nématodes parasitant les plantes avec les symptômes de dommages. Les nématodes étaient évalués à partir des racines, tubercules, et sol environnant pour 7 cultivars appartenant à *Dioscorea alata, D. bulbisiana, D. burkilliana* et *D. cayenensis* à la récolte. *Pratylenchus sudanensis* était considérée l'espèce à plus haute densité et était suivie par *Meloidogyne* spp. Des densités plus élevées des nématodes étaient observées plus dans les tubercules que dans les racines. Bien que les symptômes de craquelures et d'irritations étaient relativement bas, *P. Sudanensis* et *Meloidogyne* spp. étaient respectivement associées à la craquelure et à l'irritation. *Pratylenctus Sudanensis* et *Meloidogyne* spp. présentaient des damages associés, qui étaient cependant négativement corrélés suggérant une compétition inter-espèces. L'analyse principale des données a suggéré des différences à la susceptibilité du *P. Sudanensis* surviennent entre cultivars et espèces d'ignames.

Mots Clés: Dioscorea, Meloidogyne, Pratylenchus, craquelure detubercules

INTRODUCTION

Yams (*Dioscorea* spp.) are tropical tuber crops grown as a source of carbohydrates, but also for use in ceremonial activities (Degras, 1993). They are cultivated world wide, but principally in West Africa, where approximately 95% of world annual production (37 million tonnes) in grown (FAO, 2004). In East Africa, yams constitute an important subsistence food crop and component of the farming system (Wanyera *et al*., 1996).

In Uganda, yam production is widespread, but is primarily concentrated in the Eastern and Central areas, although its cultivation has steadily declined (Wanyera et al, 1996). The water yam (*Dioscorea alata*) and its yellow counterpart (*Dioscorea cayanensis*), are primarily grown in Uganda, although other species are also cultivated. The white Guinea yam (*Dioscorea rotundata*), which is globally the most popular species due to its palatability, is not traditionally grown in Uganda, but is becoming increasingly popular with yam growers through recent introductions (Khizzah, 1995; Wanyera *et al*., 1996). Compared to other root and tuber staple crops, yams are rich in proteins, fats and vitamins (Degras, 1993).

Amongst the various constraints to production of yam, nematode pests are of significant importance (Bridge *et al*., 2005). In West Africa, the yam nematode, *Scutellonema bradys*, is a major causal agent of dry rot (Adesiyan and Odihirin, 1977; Hahn *et al*., 1989; Coyne *et al*., 2006); while in Central America, *Pratylenchus coffeae* causes similar damage to that of *S. bradys* (Acosta and Ayala, 1976). *Meloidogyne* spp. can also cause in-field and post-harvest losses to yam, although information for *Meloidogyne* spp. is less conclusive (Bridge *et al*., 2000). A survey of parasitic nematodes on root and tuber crops in Uganda (Coyne *et al*., 2003) established that both *Meloidogyne* spp. and *Pratylenchus sudanensis* were common on yam. It has also been shown (Mudiope *et al*., 1998) that yams could be severely damaged by *Meloidogyne* spp. in Uganda, substantially affecting newly introduced, high yielding cultivars of *D. rotundata*. However, the pathogenicity and the extent of damage caused by *P. sudanensis* to yam in the field is currently unknown. This study was undertaken to establish the nematode species causing tuber damage to *Dioscorea* spp. in the major yam producing regions of Uganda.

MATERIALS AND METHODS

This study was conducted in 1998. Seven geo-political districts in the major yam growing areas of Central and Eastern Uganda, representative of the common agro-ecologies (Jagtap, 1993) were selected for this study namely, Rakai, Masaka, Luweero and Mukono in Central; and Iganga, Mbale and Kapchorwa in Eastern Uganda. In each district, between 4 - 7 farms neighbouring each other were randomly selected and visited for yam collection. Each of the 4-7 farms was considered as a single site.

At each site, at least seven tubers of the most common cultivar (cv) were collected from mature plants in separate fields, along with roots and soil from each plant. Samples of the less commonly grown cultivars were additionally collected in cases where they existed. Whole tubers and roots, and soil from the root zone were collected and stored separately in plastic bags. For each tuber, the levels of galling and cracking were scored using: 0 = no damage, 1 = slight damage (< 20% of the tuber surface affected with galls or cracks), 2 = moderate damage (20-50% of the tuber surface affected with galls or cracks), and 3 = severe damage (> 50% of the tuber surface affected with galls or cracks).

Motile nematodes were extracted from tubers, roots and soil separately. Nematodes were isolated from tubers from a single 2 g tuber core (1 cm wide and 2 cm deep), and removed using cork borer. The cores were rinsed briefly in tap water to remove soil, before chopping finely with a knife and placing on a modified Baermann sieve (Hooper *et al*., 2005) for seven days. Nematode extracts were removed daily and stored in a beaker at 4 ^{o}C and replaced with fresh water on each occasion. Nematode suspensions for each sample were combined, reduced to 25 ml and nematode population densities assessed from 3 x 2 ml- aliquots using a light microscope. Roots were first rinsed in tap-water to remove soil debris, dabbed dry with a paper towel and cut into approximately 2 cm pieces with a knife.

Nematodes were extracted from 2 g root sub-samples removed from the chopped roots of each sample. Each sub-sample was macerated using a kitchen blender for 7 seconds and the suspension rinsed onto a modified Baermann sieve for extraction for 12 hours. Nematodes from the soil were assessed from a 50 g sub-sample using the modified Baermann sieve method, after first passing the soil through a 2 mm aperture sieve to remove soil aggregates, stones and debris.

Nematodes species identifications were confirmed at the Plant Protection Institute, South Africa from samples fixed in 4% formaldehyde solution. Nematode densities were estimated and recorded per 100 g or tuber fresh weight or per 50 g soil. Mean nematode densities were calculated for each of the districts involved. Protection Institute, South Africa from samples fixed in 4% formaldehyde solution. Nematode densities were estimated and recorded per 100 g root or tuber fresh weight or per 50 g soil. Mean nematode densities were calculated for each of the districts involved.

Analysis of variance was done on nematode density data for the two dominant species and damaged indices. Nematode population densities data were normalised using $\log_n (x + 1)$ transformation prior to analysis (Gomez and Gomez, 1984). Pairwise regression analysis was undertaken using the two nematodes species densities and the two damage indices, and between nematode densities from the different sources on plants. Components of variance were estimated using the VARCOMP procedure in SAS (SA, 1999) and principal components analysis undertaken on nematode densities and damage indices. Nematode means for yam cultivars were compared using the probability functions of the least square means procedure with SAS.

RESULTS

A total of seven cultivars within for species of Dioscorea (*D. alata, D. bulbisiana, D. burkilliana and D. cayenemsis*) were identified during the study (Table 1). The cv Kyetutumula (*D. cayenensis*) was encountered at all sites except in Kapchorwa, while cultivar diversity was relatively greater in Mbale.

Numerous nematode species were recovered from the samples (data not shown). The majority however, occurred infrequently and in low densities, particularly in the soil. Only *P. sudanensis* and *Meloidogyne* spp. were encountered in tuber samples, both of which consistently occurred and in high densities in soil and root samples. Analysis, therefore, focused on these two species. Relatively higher nematode densities were observed in tubers for both *P. sudanensis* and *Meloidogyn*e spp., followed by roots, while soils had lower relative densities. *Pratylenchus sudanensis* densities varied among districts. Mean densities of approximately 1500 nematodes g^{-1} tube fresh weight (TFW) were recovered from the Masaka and Rakai districts; and 245 per g^{-1} TFW in Kapchorwa. Tubers from Mbale, Mukono and Iganga districts were infected with nematode

TABLE 1. *Dioscore*a species cultivars and nematode pests in seven districts in Eastern and Central Uganda

Cultivar	*Dioscorea* sp.	Districts[E]						
		Rakai	Masaka	Kapchorwa	Mbale	Iganga	Mukono	Luweero
Kyetutumula	*D. cayenensis*	+	+	+	+	+	+	-
Kikwa	*D. burkilliana*	-	+	-	-	-	-	-
Makunyi	*D. bulbisiana*	-	+	-	-	-	-	-
Masebe	*D. alata*	-	+	-	-	-	-	+
Nandigoya	*D. alata*	-	-	+	+	-	+	-
Ndaggu Nganda	*D. alata*	-	-	-	-	-	+	-
Ndaggu Nziba	*D. alata*	+	-	-	+	-	-	-

[E]Cultivar present (+) or absent (-)

densities less <100 *P. sudanensis* g-1 TFW, while no *P. sudanensis* was recovered in Luweero. No *Meloidogyne* spp. were isolated from tubers from Rakai and Mukono districts; while tubers from Kapchorwa and Luweero had the highest densities of *Meloidogyne* spp. (ca. 20 nematodes g^{-1} TFW). *Pratylenchus sudanensis* root densities were positively correlated ($P < 0.01$, $r = 0.4$) with soil densities, however, there was no correlation between tubers and soil densities (data not shown).

A large proportion of the variation in tuber damage and nematode densities was explained by cultivar differences within sites (>33%, Table 2). Correlations also indicated strong positive associations between *P. sudanensis* and cracks on the tubers ($r = 0.98$, $P < 0.002$) and between *Meloidogyne* spp. and tuber galling ($r = 0.95$, P, <0.009). However, densities of *P. sudanensis* and *Meloidogyne* spp. were highly divergent ($r = -0.753$, $P < 0.05$), as was the association between tuber galling and cracks ($r = -0.79$, $P < 0.034$) (Table 3).

Following principal components analysis of nematode densities and tuber damage, the components prin 1 and 2 accounted for 79 and 20%, respectively, of total variation, of which nematodes densities and associated damage contributed substantially to prin 1 (Table 4). The pairwise comparision of the least square means of prin 1 suggests that cv Ndaggu Nziba is the most nematode susceptible cultivar (Table 5). Ndaggy Nziba (LS mean = 1.74) was more susceptible than cv Nandigoya ($P<0.05$), cv Masebe ($P < 0.023$), cv Kyetutumula ($P < 0.049$) or cv Ndaggu Nganda ($P < 0.008$).

DISCUSSION

In this study, *P. sudanensis* was the most common species associated with yam in the main yam growing areas of Uganda; followed by *Meloidogyne* spp. This contradicts earlier reports (Mudiope *et al*., 1998; Coyne *et al*., 2003), which found *Meloidogyne* spp. to be the most frequent nematodes on yam in Uganda. This was due to the previous exclusion of central and northern Uganda (Coyne *et al*., 2003). The current study suggests that *P. sudanensis* is more widespread than previously reported (Coyne *et*

TABLE 2. Total variance for severity of root-knot nematode galling, skin cracking and nematode population densities for sites and yam cultivars in Eastern and Central Uganda

Factors	Variable (%)			
	Cracking	Galling	*P. sudanensis*	*Meloidogyne* spp.
Site	1.2	4.8	8.3	13.7
Cultivar	48.1	37.8	49.3	33.1
Not explained	50.7	57.4	42.4	53.2

TABLE 3. Pairwise correlation coefficients (r) between nematode population densities and nematode damage indices on yam tubers in East and Central Uganda

Parameter	*Meloidogyne* spp. [E]	Tuber cracking	Galling
P. sudanensis	-0.75*	0.98**	-0.84*
Meloidogyne spp.		-0.70	0.95**
Tuber cracking			-0.79*

[E]coefficient significant at $P \leq 0.05$ (*) and $P \leq 0.01$ (**)

TABLE 4. Eigenvectors (W) and loadings (L) of principal components analysis for nematode population densities and nematode damage indices on yam tubers in East and Central Uganda in 1998

	Principal score 1 (Prin 1)		Principal score 2 (Prin 2)	
	W	L	W	L
Pratylenchus sudanensis	0.510	0.907	0.461	0.413
Meloidogyne spp.	-0.485	-0.863	0.549	0.492
Tuber cracking	0.493	0.876	0.530	0.476
Root-knot galling	-0.510	-0.908	0.451	0.405
Accounted variation (%)	79.0		20.1	

TABLE 5. Least Square means of Principal score 1 from seven yam cultivars and levels of significance for pairwise comparisons of cultivars from all yam sites sampled in East and Central Uganda

Cultivar	n	LS means	Std error	P > t of the difference between any two cultivars					
				2	3	4	5	6	7
Kikwa	14	00.220	1.08	0.941	0.504	0.436	0.864	0.176	0.123
Kyetutumula	48	-0.131	0.45		0.352	0.295	0.871	0.696	0.049
Makunyi	10	-1.29	1.09			0.142	0.337	0.050	0.341
Masebe	21	0.86	0.77				0.416	0.443	0.023
Nandigoya	15	0.00	0.65					0.123	0.050
Ndaggu Nziba	12	1.74	0.79						0.008
Ndaggu Nganda	6	-2.86	1.11						

al., 2003). The study also provides for the first time, strong evidence of the association between *P. sudanensis* densities and cracked (damaged) yam tubers. The importance of *P. sudanensis* to yam production and pathogenicity to specific species (and cultivars) of *Dioscorea* has yet to be determined.

In West Africa, *S. bradys* is a serious production constraint of yam, the field and particularly during storage (Bridge, 1973; Bridge *et al*., 2005); while *P. coffeae* is a primary namatode pest of yam in the Pacific region (Bridge, 1988) and Central America (Acosta and Ayala, 1976). *Meloidogyne javanica* has been identified as the primary nematode species on yams in Uganda (Mudiope *et al*., 1998), thus supporting observations from an earlier study (Coyne *et al*., 2003). In the current study, however, it is interesting that the presence of *Meloidogyne* spp. and related galling damage were negatively correlated with *P. sudanensis* densities and tuber cracks. This suggests interspecific competition between the two nematodes. Similar competition on yam was observed between S. bradys and P. cofeae in Puerto Rica (Acosta and Ayala, 1976) and French West Indies (Castagnone-Sereno and Kermarrec, 1988), where *P. coffeae* was seen to out-compete or exclude *S. bradys*. Although dual infections resulted in overall greater tuber damage (Acosta and Ayala, 1976), infection by one dominant species is more commonly observed (Castgnone-Sereno and Kermarrec, 1988).

Yam species and cultivars are known to vary in susceptibility to both *Meloidogyne* spp. and *S. bradys*. However, there is limited information on differences in susceptibility to *Pratylenchus* spp. (Bridge *et al*., 2005).

The significant differences observed in susceptibility to *P. sudanensis* among yam cultivars, offer a possibility that sources of

resistance are available in some indigenous cultivars. The distribution of cultivars also appears quite varied within Uganda, which may possibly be a result of different levels of pest or disease resistance, resulting from when yam was more prevalent. The cv Ndaggu Nganda (*D. alata*) and cv Makunyi (*D. bulbisiana*) appear to have some resistance to both *P. sudanensis* and *Meloidogyne* spp., and supported relatively low densities of these nematodes species. Greater densities of *P. sudanensis* occurred in the tuber than in roots, indicating that *P. sudanensis* is likely to cause damage during storage, similar to *S. bradys* and *P. coffeae*; and likely to reduce the viability and usefulness of infected tubers for use as seed material Bridge *et al*., 2005.

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