SURVEY OF PLANT PARASITIC NEMATODES AND BANANA WEEVIL ON *ENSETE VENTRICOSUM* IN ETHIOPIA

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Summary. Twenty five sites, representative of seven agro-ecological zones of enset (*Ensete ventricosum*) crops, were sampled between September 1998 and January 1999. At each site, five 1-2 year old enset plants were sampled to check for the presence of nematodes present in their roots. The predominant nematode species found was *Pratylenchus goodeyi* (prominence value = 5640 per 100 g fresh root weight (FRW)), followed by *Aphelenchoides ensete* (prominence value = 137 per 100 g FRW), and *Meloidogyne* spp. (prominence value = 26 per 100 g FRW). Leaves of young enset plants often showed severe streak-like symptoms. *Aphelencoides ensete* was the only nematode isolated from these leaves and may be associated with the streak-like symptoms. A total of 71 different enset cultivar names were recorded during the survey, with different levels of *P. goodeyi*. Split pseudostem traps failed to detect the banana weevil, *Cosmopolites sordidlus*.

Ensete ventricosum (Welw.) Cheesman ('Enset' in Amharic) is cultivated from mid-altitude to the highlands (ca. 1500-3000 m asl) of the south, southwest and central regions of Ethiopia (Alemu and Sandfrod, 1996; Bezuneh and Feleke, 1996). Believed to have evolved over thousands of years in Ethiopia, it is an indigenous sustainable form of agriculture that has existed for hundreds of years under traditional methods of crop cultivation without the use of chemical fertilizers and pesticides (Brandt and Teferi, 1991). Enset is primarily cultivated for food and secondarily for fiber. It also has several other uses including fodder, medicine, construction of houses and green wrapping material. Enset is a staple food for over 15 million people in Ethiopia.

In certain regions of Ethiopia enset production is declining, while in other regions its production is stable or even increasing. Declining soil fertility (Kena, 1996), pests and diseases (especially bacterial wilt) (Quimio and Tessera, 1996), and socio-economic factors (Sandford and Kassa, 1996) may contribute to these regional differences. In order to establish research priorities, a survey was conducted to generate a baseline data set on the occurrence, distribution and abundance of parasitic nematodes and banana weevil on this indigenous crop.

MATERIALS AND METHODS

The 1982 agro-ecological map of enset distribution (Ministry of Agriculture of Ethiopia, 1982) was used as a basis for a stratified site selection (Table I). The procedure used had been developed for highland banana (Gold *et al.*, 1994a). Enset-producing regions were divided into 20 by 20 km grids. Twenty-five grids were then selected based on the representative area coverage; for example, the larger the area covered by an agro-ecological zone, the larger the proportion of grids selected from it. Grids to be surveyed were selected with a bias to accessibility by road. In each grid, five representative farms were selected with some bias to include areas with declining enset production.

For each of the farms visited, the latitude and longitude were recorded using a Global Positioning System (GPS) receiver and the elevation using an altimeter.

Based on information provided by farmers, the most abundant enset cultivar(s) were selected for root damage assessment (% dead or necrotic roots). This was done by uprooting five 1-2 year old plants (Speijer and De Waele, 1997) grown in nurseries adjacent to the older enset plants on the farm. Five roots were taken randomly from each plant and these were combined into a single sample and then taken to the laboratory for nematode extraction.

Split banana pseudostems were used as traps to determine the presence of the banana weevil, *Cosmopolites sordidus* Germar 1824. If banana was not available, enset pseudostems were used as traps. The traps were set at three different points on each farm and left for one or two nights before checking for weevils. Where banana and enset were grown on the same farm, the weevil incidence was also assessed by checking the rhizomes of harvested banana plants (Gold *et al.*, 1994b).

The root segments used for damage assessment were taken to the laboratory at Ambo Plant Protection Research Center and chopped into pieces of about 5 mm in length. These were mixed thoroughly and a 5 g subsample was taken for nematode extraction (Speijer and De Waele, 1997) using the modified Baermann tray method (Southey, 1986). After extraction, the nema-

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todes were killed by placing them in a hot water bath at 65 °C for 3 minutes and then fixed in formaldehyde and acetic acid (F:A, 4:1) (Southey, 1986) at Ambo Plant Protection Research Center. Fixed samples were sent to the International Institute of Tropical Agriculture-Eastern and Southern Africa Regional Center (IITA-ESARC) in Uganda, where they were identified, counted in 2-ml aliquots and densities per 100-g fresh root weight (FRW) estimated. A subset was sent to Dr. E. van den Berg (Plant Protection Research Institute, South Africa) for confirmation of species identification.

The agro-ecological zones, sites within the agro-ecological zones, farms within the sites and cultivars within farms were considered as selected randomly. The observed nematode counts for the dominant species were transformed using a natural log (counts + 1) transformation. Components of variance were also estimated using the VARICOMP procedure in SAS (SAS, 1992). Prominence values [PV = population density x √(frequency of occurrence)/10] were calculated for each nematode species (De Waele *et al.*, 1998).

RESULTS

A total of 25 sites were visited, ranging from 1,523 meters above sea level (masl) to 2,797 masl in elevation and representing seven different agro-ecological zones (Table I). A total of 71 different cultivar names (Alemu and Sandfrod, 1996) were recorded (Table II). Only seven cultivar names were reported at more than one site, of which Genticho, Ado and Nobo were encountered most frequently.

The predominant nematode species observed in enset roots was *Pratylenchus goodeyi* (prominence value = 5640 per 100 g FRW), followed by *Aphelenchoides ensete* (prominence value = 137 per 100 g FRW), and *Meloidogyne* spp. second stage juveniles (prominence value = 26 per 100 g FRW). *Pratylenchus goodeyi* was found in all samples, while *A. ensete* was found in 87% of the samples and the *Meloidogyne* spp. (second stage juveniles) in 60% of the samples (Fig. 1). The densities per 100 g FRW for *P. goodeyi* ranged from 905 (Chelelektu) to 20,228 (Agena) between sites and from 40 (Siskel) to 54,840 (Semwa) between cultivars.

Analyses of variance revealed that 28% of the variation in *P. goodeyi* densities could be attributed to variation among cultivars within farms (Table IV). The highest density per 100 g FRW of *Meloidogyne* spp. per site was 367 at Limu and per cultivar was 1,480 for Gimbo. For *A. ensete*, the highest density was observed at Shebe

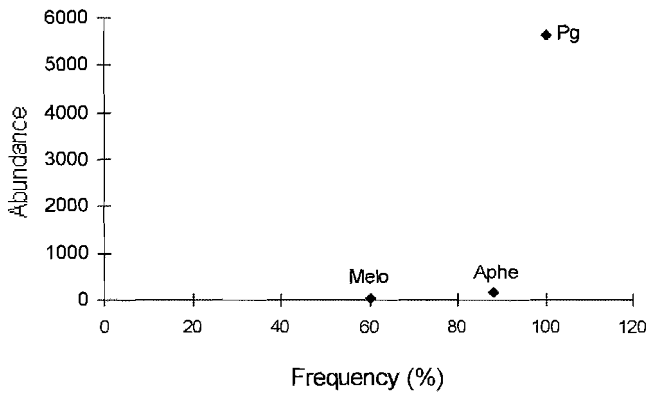

Fig. 1. Frequency and abundance of the major nematode species in roots of enset in Ethiopia (Pg: *P. goodeyi*; Melo: *Meloidogyne* spp. second stage juveniles; Aphe: *A. ensete*).

Table I. Agro-ecological zones and survey sites selected in Ethiopia.

Agro-ecological zone	Area (ha)	Sites selected (masl)
Hot to warm sub-moist low lands and plateau remnants (H2)	1,844,000	Gazer (1,523), Jinka (1,560), Bonga (1,840), Shebe (1,939), Geresse (2,145), Aletawendo (2,248), Hageresalam (2,797)
Tepid to cool moist mid to high altitude (SH2)	1,688,000	Leku (2,061), Agaro (2,065), Jimma (2,075), Angacha (2,284), Agena (2,330), Limu (2,386).
Hot to warm sub-humid lowlands to mid altitude (SH1)	1,684,000	Waka (1,710), Areka (2,011), Gunchure (2,159), Dedo (2,386), Tocha (2,390).
Tepid to cool sub-humid low to high altitude (M)	712,000	Chelelekitu (1,863), Yirgalem (1,967), Solemo (2,538), Fesehagenet (2,544).
Tepid to cool humid mid to high altitude (PH2)	372,000	Shewa-Gimira (2,117)
Hot to warm humid lowlands to mid altitude (PH)	204,000	Mizan (1,658)
Tepid per humid low to high altitude (SM)	128,000	Gedeo (2,061)

masl = meters above sea level

Table II. Nematode species densities per 100 g fresh root weight of the 71 enset cultivars encountered in the 25 sites in Ethiopia.

Cultivar	Nematode species			Cultivar	Nematode species		
	Pg	*Aph*	*Melo*		*Pg*	*Aph*	*Melo*
Semwa	54,840	0	0	Melo	3,540	0	0
Gesa	35,840	0	0	Tebere	3,500	0	0
Misir	32,600	0	0	Ado	2,694	80	0
Janjiro	26,520	0	0	Arpha	2,680	340	0
Korkori	25,660	300	0	Agade	2,630	0	0
Bukma	19,820	0	0	Zinke	2,320	0	0
Adinona	19,380	760	0	Ameratiyen	2,300	0	0
Anchiro	16,020	1,150	0	Astara	2,200	70	60
Shodode	13,890	85	0	Gentich	1,851	33	10
Gayo	12,980	1,780	0	Argama	1,800	0	0
Nechoa	11,960	120	25	Jinka	1,620	0	180
Heila	10,620	220	0	Intado	1,520	0	20
Kucha	10,200	280	0	Kerese	1,480	40	40
Tibla	9,620	0	0	Kineb	1,440	140	340
Amiya	9,360	180	0	Dego	1,400	0	100
Merza	8,700	0	333	Kancho	1,300	0	0
Ferezia	8,660	140	0	Gena	1,213	0	0
Mergu	8,400	0	0	Gonasa	1,213	0	0
Yore	8,400	0	0	Sikubai	1,060	60	0
Guariye	8,200	260	0	Torabe	940	0	0
Lekaka	8,160	140	0	Ungame	925	65	475
Gimbo	7,430	90	1,480	Boss	760	0	160
Girbo	7,140	60	0	Tuzuma	760	80	20
Geno	5,930	95	0	Dirbo	640	0	40
Bocho	5,413	66	6	Dalank	626	146	0
Midasho	4,940	0	180	Ark	420	0	0
Disho	4,730	20	0	Nipho	360	0	0
Mai	4,640	120	0	Barxhe	280	20	30
Molge	4,570	60	20	Xhori	280	120	0
Nobo	4,397	409	14	Guferek	200	0	0
Gulumo	4,300	20	0	Amarat	120	0	60
Litso	4,140	90	0	Bumbo	100	0	0
Bededet	4,100	240	0	Ginimbu	100	0	40
Sapara	4,100	580	0	Yedi	60	0	0
Utero	3,600	0	0	Siskel	40	240	0
Benezhe	3,540	140	0				

Pg: Pratylenchus goodeyi, Aph: Aphelenchoides ensete, Melo: Meloidogyne spp.

(1,287 per 100 g FRW) for the cultivar Gayo (1,780 per 100 g FRW) (Table II).

The percentage of dead roots ranged from 0% to 70% (for cultivar Genticho at Chelektu) but the average generally did not exceed 8% (Table 3). Similarly, the percentage of roots with necrosis ranged from 0% to 40% (for cultivar Dalank at Mizan), but the average generally was not more than 9% (Table III).

No banana weevils were found in any of the traps set on any of the farms at any of the sites. The high elevation has probably prevented the diffusion of this insect pest into this region (Gold *et al.*, 1994b).

Table III. *Pratylenchus goodeyi* densities, and percentage dead roots and root necrosis observed on 1-2 year old seedlings of enset averaged for six altitude ranges in Ethiopia.

Altitude Range (masl)	*P. goodeyi*/ per 100 g FRW)	Dead roots (%)	Root necrosis (%)
2901-3000	40	1	3
2601-2900	7,841	5	9
2301-2600	7,271	5	6
2001-2300	5,206	6	7
1701-2000	4,483	8	5
1400-1700	3,421	8	6

Table IV. Variance components for log transformed (ln x+1) *P. goodeyi* densities per 100 g FRW, percentage dead roots and percentage root necrosis for enset cultivars in Ethiopia.

Source of Variation	Variation		
	P. goodeyi (ln x+1)	Dead roots (%)	Root necrosis (%)
Zone	2	3	2
Site (Zone)	11	10	1
Farm (Site)	15	14	7
Cultivar (Farm)	28	7	9
Standard Error	44	66	81

DISCUSSION

Pratylenchus goodeyi has been reported before in Ethiopia (O'Bannon, 1975; Peregrine and Bridge, 1992) and is suspected to be highly associated with bacterial wilt disease of enset (Quimio and Tessera, 1996), caused by *Xanthomonas campestris* pv. *musacearum*. The nematode may increase the susceptibility of the plant to the bacteria by damaging the roots and, perhaps, may play a role in the transmission of the disease (Quimio and Tessera, 1996).

Although there is no conclusive evidence that all the 71 clones (Alemu and Sandfrod, 1996) encountered during this survey were different cultivars, the great differences observed in *P. goodeyi* densities supported by the cultivars suggest that there may be inherent differences of susceptibility among them. This variance in susceptibility among the cultivars may play a role in cultivar and production shifts, in a similar way to the shifts observed for *Musa* in Tanzania (Speijer and Bosch, 1996), and may be an important area in which to pursue further research.

Meloidogyne spp. can cause production losses in *Musa* and several other crops (Gowen and Quénéhervé, 1990). In Ethiopia, three species: (*M. incognita*, *M. javanica* and *M. ethiopica*) were found infecting enset (Mandefro and Dagne, 2000). Although the low nematode densities observed in this survey suggests that *Meloidogyne* spp. are a minor pest of enset, the possibility remains that they may affect production as there are three species involved.

During our survey (1998-1999), we extracted *A. ensete* from the roots. However, this species was described by Swart *et al.* (2000) based on specimens isolated from enset leaves with streak-like symptoms. Enset leaf streak can affect the young seedlings and the succulent leaves of suckers. Quimio (1991) reported an *Aphelenchoides* sp. affecting enset leaves and considered it to be the causal agent for the leaf streak. However, Tiedt *et al.* (1999) observed a strong association of leaf streak with the bacterium *Xanthomonas campestris* pv. *strelitzia* and suggested that *A. ensete* transfers the bacterium into the leaves, where the bacterium causes the symptoms.

The data suggest that the *Ensete* root systems that we examined may have been in a slightly healthier condition than, for example, roots of *Musa* in Zanzibar, with a percentage of dead roots of 8% and root necrosis of 15% (Gold *et al.*, 1994b). The random errors observed for percentage dead roots, 66%, and root necrosis, 81%, suggest that other parameters, such as nematode distribution, crop management and soil type, have a greater influence on root damage than the parameters of the agro-ecological zone, site or cultivar.

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