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Management of nematodes in banana systems in Uganda

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Abstract

Observations from a screen house experiment to study the host status of cassava and sweet potato to the banana nematodes indicate that both cassava and sweet potato are nonhosts of the major banana nematodes, namely, *Radopholus similis, Helicotylenchus* multicinctus and *Pratylenchus goodeyi.* An experiment aimed at devising cropping sequences that would minimise nematode damage and enable acceptable levels of banana production to be maintained was designed. Banana nematode population densities declined to negligible levels after 13 months of a break-crop of cassava or sweet potato planted immediately after a nematode infested banana crop in on-station field experiment. Most farmers opted for the cassava break-crop when the trial was repeated on-farm at a site in Kayunga district. Populations of *R. similis* reduced to zero while those of *H. multicinctus* reduced to negligible levels within 10 months after planting the cassava break-crop. From these studies, a banana-cassava-sweet potato-banana rotation, use of clean banana planting material and proper crop, soil and water management practices are recommended for improvement and maintenance of banana production in plots previously infested by nematodes at high population levels.

Key words: Banana nematodes, *Radopholus similis, Helicotylenchus multicinctus* and *Pratylenchus goodeyi, Meloidogyne incognita, Rotylenchulus reniformis, Scutellonema* sp, break-crop

Introduction

Banana (Musa spp.) is the most important staple food in Uganda. Annual production is estimated at more than 9 million metric tonnes (FAO, 1997). It is estimated that within the country, 7 million people subsist on the East African Highland Cooking bananas locally known as 'Matooke'. Over 75% of the country's farmers grow bananas on 1.5 million hectares, equivalent to 38% of the land under crops. Severe decline in banana production in the traditional banana growing areas of Uganda has resulted in a spatial shift of banana production from Central and Eastern Uganda to the South-west, a varietal shift from the indigenous cooking and brewing banana types to the exotic brewing banana type (Kayinja), and a change in the cropping pattern from banana to root crops, particularly cassava and sweet potato.

Nematodes have been identified among the major factors responsible for the decline in banana production (Gold et al. 1993). Yield loss due to nematode infestation has been estimated at 37.1% by the third ratoon (Speijer et al., 1999). Although nematicides are fast acting, they are both hazardous to users and the environment and expensive. Nematode resistant 'Matooke' cultivars have not been developed and yet all the indigenous ones are susceptible to nematodes. There is need, therefore, to develop nematode management strategies if economically acceptable levels of banana production are to be maintained. Cultural

methods of control therefore are the best option for the resource poor subsistence farmers that constitute the majority of the Ugandan farming community. Cultural methods such as fallowing and crop rotation focus on the elimination of the host crop from a piece of land for a specified period of time. The success of such methods, therefore, largely depends on how long the target nematode species can survive in the soil without a host.

The principal aims of nematode control by crop rotation are to grow susceptible crops after long intervals so that population levels fall below damage thresholds between crops, and to prevent low populations increasing to damaging levels (Brown, 1987). Cassava and sweet potato which are second and third respectively in importance as food staples, are already being grown as replacements of banana, which is the most important and preferred food crop.

The objectives of this study were, therefore, to generate information on the host status of cassava and sweet potato to banana nematodes, to assess the effect of cropping sequence in banana-root crop rotations on the populations of banana parasitic nematodes, to monitor population fluctuations in order to determine the time required for reduction in nematode populations, if any, to occur, and to devise cropping sequences that will minimise nematode damage and enable acceptable levels of banana production to be maintained.

Methodology

The host status of cassava cultivar 'Bukalasa 11', and sweet potato, cultivar 'New Kawogo', to the banana nematodes *Helicotylenchus multicinctus, Radopholus similis*, and *Pratylenchus goodeyi* was studied in a screen house experiment at Kawanda Agricultural Research Institute (KARI). An East African highland cooking banana, cultivar 'Nabusa', was included as the known host of the three nematode species. Inoculation level was 1200 nematodes/pot, using single species cultures maintained on potted banana plants. Nematode assay was done 12 weeks after inoculation. The reproductive rating (R) which is the ratio of mean nematode count from the test crop to that of a known host (banana) of the nematode species was calculated.

The effect of cropping sequence in banana-root crop rotations on the populations of banana parasitic nematodes was also studied in an on-station field trial at KARI. A nematode infested banana field of the E. African cooking banana cultivar 'Nakyetengu' was used for the study. Banana plants were completely removed from eight out of the 12 plots constituting the banana field. Corms and roots of the removed plants were chopped and ploughed back in the respective plots so as to retain all the nematodes present. Four of the plots were replanted with cassava cultivar 'Bukalasa 11', and the remaining four plots were replanted with sweet potato cultivar 'New Kawogo'. These treatments thus represented continuous banana, banana-cassava and banana-sweet potato cropping sequences. Sampling for nematode assay was done prior to removal of banana plants, at the time of planting the second crop, and at three monthly intervals thereafter. Sampling of cassava roots did not start until 10 months after the crop was planted due to scarcity of roots, caused by a prolonged dry spell which resulted in poor crop establishment.

A bioassay was done 10 months after planting the second crop by growing tissue culture banana plantlets of the E. African cooking cultivar 'Nabusa' in pots containing soil sub-samples taken from large composite soil samples collected from each plot. Nematode assay was done 12 weeks after potting the banana plantlets.

The study was repeated on 27 farmers' fields at Kayunga in Kayunga district. The selected farms were those which had nematode-infested soils with poorly growing bananas. Within the old banana plot, sub-plots large enough to accommodate 25 banana mats were marked for the trial. The farmers were allowed to choose either of the break crops, or to grow both if resources allowed. However, each farm had to have a subplot where bananas were not removed, to represent the continuous banana cropping sequence. The break crops were planted during the first rains of 1997. Farmers harvested their crops as and when they wanted, provided they replanted with the same crop immediately after harvesting the old crop. Replanting with banana cultivars 'Nakitembe' and 'Ndibwabalangira' was done during the first rains of 1999 on all the farms. Monitoring of nematode populations to establish how long it takes before residual nematode population build up to economic levels is still in progress. An impact assessment study has also been carried out but results have not been reported in this paper.

Nematode extraction was by filtration from soil and maceration-filtration technique using a modification of

Table 1. Reproductive rating (R) of banana nematodes on cassava and sweet potato at an inoculation level of 1200 nematodes/pot. n = 4

Nematode species	Reproductive rating	
	Cassava	Sweet potato
H.multicinctus	0.06	0.05
R.similis	0.01	0.02
P.goodeyi	0.00	0.00

Host status (after Tedford & Fortnum, 1988): R > 1.0 = good host; R < 1.0 - > 0.5 = moderate host; R < 0.5- >0.1 = poor host; R < 0.1 = nonhost.

Table 2. Initial H. multicinctus and R. similis populations in banana plots for the banana-root crop rotations.

Nematode species	Mean Nematode Soil (1000 ml)	Count Roots (100 g)
H.multicinctus	705 (2.51)	4152 (3.41)
R.similis	62 (0.74)	2096 (2.60)
P	< 0.001	< 0.05
s.e	0.304	0.230
s.e.d	1.053	0.800

the Baermann funnel technique (Hooper, 1985a, 1985b). Banana root necrosis rating was scored as a percentage, using 5 halves (each from a different root) of 10 cm long, longitudinally split banana root pieces.

Results and discussion

From the screen house experiment, relatively low soil counts of *H. multicinctus* were recorded from cassava and sweet potato (mean counts of 52.6 and 42.3 respectively, compared to 352.3 recovered from banana soil) while negligible numbers of the same nematode species were recorded from roots of both crops. Negligible numbers of *R. similis* were recovered from soil and roots of both cassava and sweet potato while no *P. goodeyi* was recovered from either soil or roots of both cassava and sweet potato. The reproductive rating (Table 1) indicates that cassava and sweet potato are nonhosts of the three major banana nematodes.

In the on-station field trial, the banana nematodes *H. multicinctus,* and *R. similis* were the predominant species just before removal of the banana crop. The population density of *H. multicinctus* was higher than that of *R. similis* (Table 2). *P. goodeyi* was absent while *Meloidogyne incognita* occurred in trace numbers. *Rotylenchulus reniformis* was common, mainly in soil, initially and in subsequent sampling under all cropping sequences. *M. incognita* was more associated with banana-cassava rotation while *Scutellonema* sp. was associated with banana-sweet potato rotation. Results of the bioassay and field nematode population density fluctuation are given in Table 3 and Figures 1 - 2 respectively. Fluctuations in soil populations were observed even in the control, but these were most likely due to climatic changes since the lowest nematode populations were recorded during hot, dry periods. (Figures 1 and 3). However, a period of at least 13 months under cassava or sweet potato was required to reduce soil populations of the major banana nematodes to negligible levels.

Table 3. Mean nematode count, root necrosis rating and fresh root weight from banana plantlets, for different cropping sequences in a bioassay study of banana-root crop rotations

Nematode count					Root	Fresh
H.multicinctus		*R.similis*	*Rotylenchulus sp.*		necrosis	root
Soil	Roots	Roots	Soil	Roots	rating%	wt.(g)
Banana-Cassava						
0.0	9.3	0.0	92.3	5.0	0.0	16.5
0.0	3.5	0.0	20.0	1.8	0.3	21.1
0.0	0.0	0.0	106.3	15.0	0.5	20.1
0.0	0.0	0.0	6.8	0.0	0.3	16.3
Banana-Sweet potato						
0.0	8.8	0.0	12.8	0.0	0.5	18.6
0.0	0.0	0.0	0.0	3.0	0.3	21.4
0.0	4.8	0.0	34.5	8.0	0.3	15.6
6.0	0.0	0.0	87.5	0.0	0.5	17.8
Continuous Banana						
164.3	1687.0	88.5	54.4	0.0	2.8	21.2
132.3	1572.5	8.5	0.0	2.0	2.5	10.4
125.5	1370.5	10.5	35.0	2.3	2.0	13.4
32.5	922.8	299.3	20.0	14.0	2.3	14.0
s.e 34.9	358.0	89.2	39.5	5.8	0.2	2.6

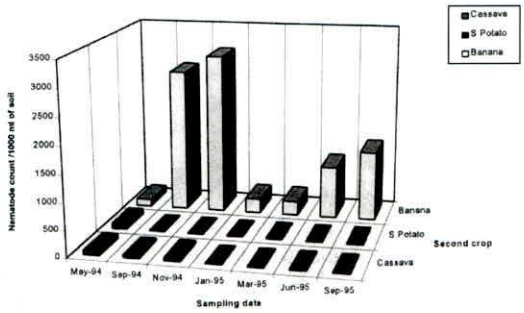
Means were calculated from four replicates. Each mean represents a plot (replicate) for a given cropping sequence in the banana-root crop rotation, and s.e is the standard error of the mean. Data are means of four replicates for three cropping sequences (n = 12). Figures given in parentheses are means of the nematode count data transformed to log (x+1). The significance levels (P), standard error of the mean (s.e) and standard error of the difference (s.e.d) are based on the transformed data.

Out of the 27 farmers selected for the on-farm study, 21 opted for cassava, two for sweet potato, three for both cassava and sweet potato, and one for cassava, sweet potato and a sweet potato/cassava intercrop. Choice of break crop was however greatly influenced by scarcity of mosaic resistant cassava cultivars in the area. Farmers regarded this as an opportunity for them to be provided with planting material of such cultivars by the researchers. This fact was reflected in the impact assessment that was carried out. Farmers cited provision of mosaic resistant cassava planting material and the consequent improved food security as well as income that was realised from sale of both stems and tubers among the positive attributes of the project.

Nematode population trends observed in the on-farm trial were similar to those made in the on-station trial

Figure 1. Soil nematode population density (nematode count/1000ml of soil) fluctuation in banana-root crop rotations.

H.multicinctus



R.similis

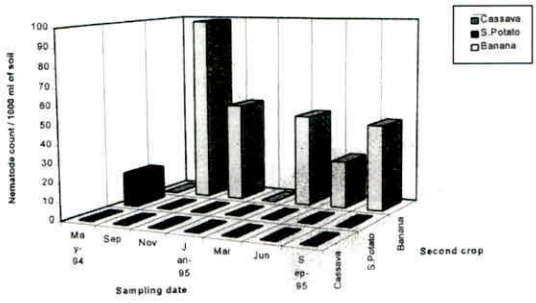
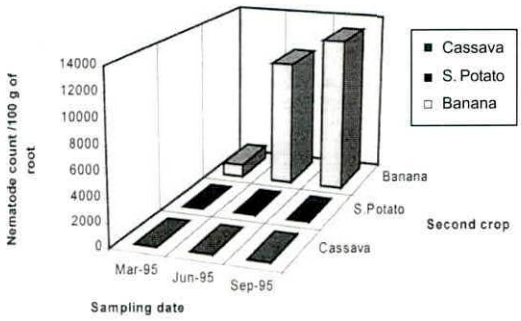


Figure 2. Root nematode population density (nematode count/100g of root) fluctuation in banana-root crop rotations.

H.multicinctus



R.similis

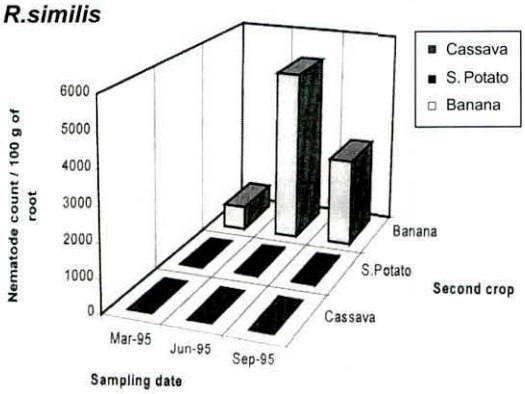


Figure 3. Monthly total rainfall (mm) and mean minimum and maximum temperature (°C) for KARI

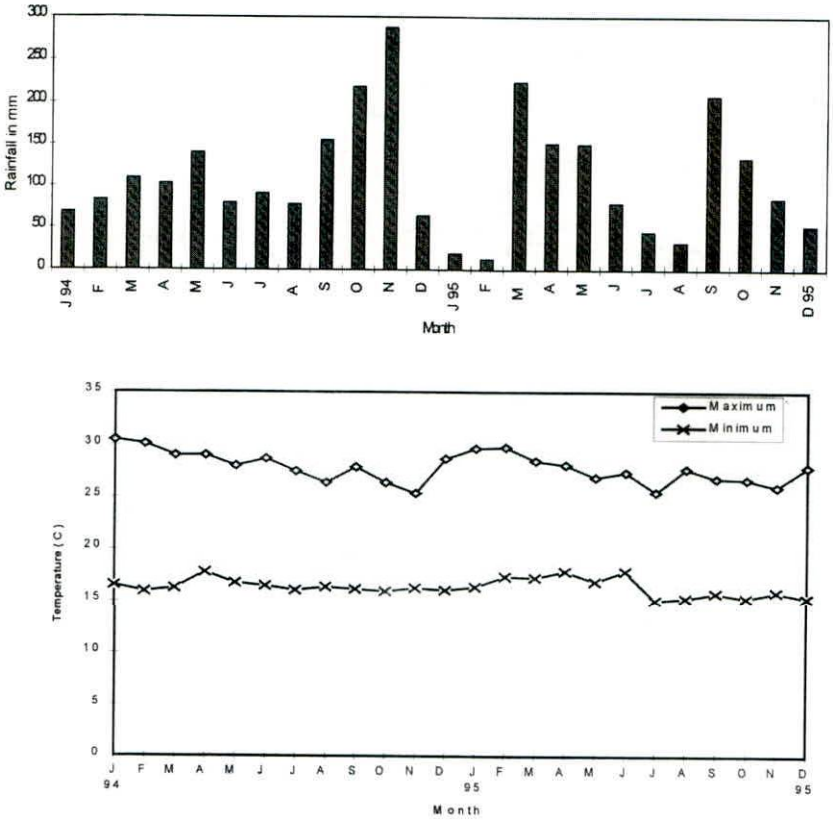
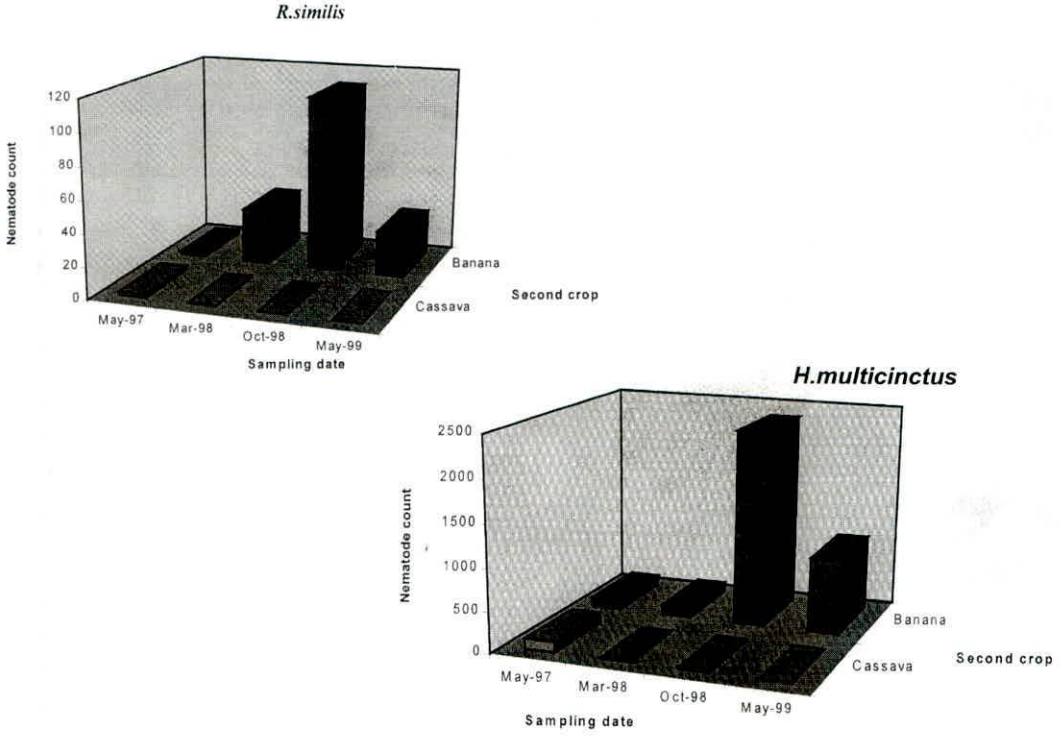


Figure 4. Soil nematode population density (nematode count/1000 ml of soil) fluctuation in the on-farm banana-root crop rotations.



(Figure 4). Populations of *R. similis* had reduced to zero while those of *H. multicinctus* had reduced to negligible levels 10 months after planting the cassava break crop.

Observations from these studies show that cassava and sweet potato are non-hosts, and can reduce soil populations to negligible levels, of the three major banana nematodes, namely, *R. similis, H. multicinctus* and *P. goodeyi.* Cassava and sweet potato would therefore, be the best break crops to use in a banana nematode management strategy, especially since both crops are already important food crops in the banana-growing region of central Uganda.

An effective rotation for banana nematode management should be one that reduces the major banana nematodes without enhancing population build up of other nematode species that have the potential to reduce banana yields. *Meloidogyne spp.* although not abundant, are widespread on banana in Uganda (Kashaija et al., 1994) and could potentially affect banana production. The rate of reproduction of *Meloidogyne spp.* is limited in the presence of other banana nematodes (Luc & Vilardebo´, 1962, quoted by Blake, 1969). Davide & Marasigan (1984) did record, however, a banana bunch weight reduction of 57.1% due to *M. incognita* infestations. A banana-early maturing cassava-late maturing sweet potato-banana cropping sequence is recommended from this study. Cassava matures in 6 - 12 months, but may be kept in the field up to 2 years, depending on the cultivar. The crop should however, be kept in a field long enough to reduce banana nematode populations, but not too long to allow *Meloidogyne* populations to build up since cassava is a good host of *Meloidogyne* spp. Sweet Potato matures in 3 - 6 months, but may be kept in a field for more than 12 months, depending on the cultivar. The sweet potato crop would further reduce major banana nematodes, but also arrest Meloidogyne population build up as none of the sweet potato cultivars tested in various host status experiments results not reported here was susceptible to *M. incognita.*

It is important to keep the field free of weeds. In addition to reducing yields of the crops due to competition, weeds may act as alternate hosts to the important banana nematodes. Results of Hannon, 1963 (quoted by Blake, 1969) suggest that *R. similis* might survive in soil for longer than 14 months unless special precautions are taken to remove susceptible hosts, including weed species.

The most common means of introduction of plant parasitic nematodes to a field is by use of nematode-infested banana planting material. Use of nematode-free banana planting material is therefore a pre-requisite for replanting in soil cleaned of banana nematodes. In addition, proper crop, soil and water management practices must be employed if economically acceptable levels of banana production are to be maintained.

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References

Blake, C.D. (1969). Nematode parasites of banana and their control. In : J.E.Peachey (Ed). Nematodes of Tropical Crops. *Technical Communication of the Commonwealth Bureau of Helminthology 40 : 109 - 132.*

Brown, R.H. (1987). Control strategies in low-value crops. In : R.H.Brown & B.R.Kerry (Eds). Principles and Practice of Nematode Control in Crops. *Academic Press, Australia : 351 - 387.*

Davide, R.G. & Marasigan, L.Q. (1984). Yield loss assessment and evaluation of resistance of banana cultivars to the *nematodes Radopholus similis* Thorne and *Meloidogyne incognita* Chitwood. The *Philippine Agriculturalist 68: 335 - 349.*

FAO (1997). Production Yearbook for 1997, Vol. 51, Rome.

Gold, C.S. et al, Ogenga-Latigo, M.W., Tushemereirwe, W., Kashaija, I. & Nankinga, C. (1993). Farmer perception of banana pest constraints in Uganda : Results from a rapid rural appraisal. In : C.S.Gold & B.Gemmill *(Eds). Proceedings of a Research Coordination Meeting for Biological and Integrated Control of Highland Banana and Plantain Pests and Diseases, Cotonou, Benin, 12 - 14 November, 1991 : 3 - 23.*

Hooper, D.J. (1985a). Extraction of free-living stages from soil. In: J.F.Southey (Ed.). Laboratory Methods for Work with Plant and Soil Nematodes. *Reference Book 402:5 -30.*

Hooper, D.J. (1985b). Extraction of nematodes from plant material. In: J.F.Southey (Ed.). Laboratory Methods for Work with Plant and Soil Nematodes. *Reference Book 402:51 - 58.*

Kashaija et al, I.N., Speijer, P.R., Gold, C.S.& Gowen, S.R. (1994). Occurrence, distribution and abundance of plant parasitic nematodes of bananas in Uganda. *African Crop Science Journal 2 (1): 99 - 104.*

Speijer et al, P.R., Kajumba, C. and Ssango, F., 1999. East African highland banana production as influenced by nematodes and crop management in Uganda. *International Journal of Pest Management 45 (1) : 41 - 49*

Tedford, E.C. & Fortnum, B.A., 1988. Weed hosts of *Meloidogyne arenaria* and *M.incognita* common in tobacco fields in South Carolina. *Annals of Applied Nematology 2: 102 - 105.*