PLANT-PARASITIC NEMATODES ASSOCIATED WITH BANANA (*MUSA* SPP.) IN RUSITU VALLEY, ZIMBABWE

James Chitamba[1]*, Pepukai Manjeru[1], Cleopas Chenai Chinheya[2], Nhamo Mudada[3] and Maxwell Handiseni[4]

[1]Agronomy Department, Midlands State University, P. Bag 9055, Gweru, Zimbabwe; [2]Nematology Department, Kutsaga Research Station, P.O. Box 1909, Harare, Zimbabwe; [3]Plant Quarantine Services Institute, P. Bag 2007, Mazowe, Zimbabwe; [4]Department of Plant Pathology & Microbiology, Texas A&M University, College Station, TX77843, USA. *Corresponding author: Email: chitambajc@gmail.com

ABSTRACT

Chitamba, J., P. Manjeru, C.C. Chinheya, N. Mudada, and M. Handiseni. 2013. Plant-parasitic nematodes associated with banana (*Musa* spp.) in Rusitu Valley, Zimbabwe. Nematropica 43:113-118.

Banana is one of the most important food and cash crop in Zimbabwe as well as in the world. Plant-parasitic nematodes are one of the major constraints of banana production and are therefore a threat to food security. A field survey to quantify and classify plant-parasitic nematodes associated with banana was conducted in Rusitu Valley, which is one of the major smallholder banana production areas of Zimbabwe. Plant-parasitic nematodes were surveyed from soil and banana roots collected from forty smallholder banana farms. *Meloidogyne* spp., *Radopholus similis, Pratylenchus* spp. and *Helicotylenchus* spp. were the major plant-parasitic nematodes associated with banana plants in Rusitu Valley. In terms of absolute frequencies, *Meloidogyne, Radopholus, Pratylenchus*, followed by *Helicotylenchus* were the most frequently found genera throughout the soil assay. However, *Meloidogyne* was the most abundant whilst *Radopholus* the least in terms of total number of nematodes in soil in all the sampled fields.

Key words: Helicotylenchus, Meloidogyne, plant-parasitic nematodes, *Pratylenchus, Radopholus similis*.

RESUMO

Chitamba, J., P. Manjeru, C.C. Chinheya, N. Mudada, and M. Handiseni. 2013. Los nematodos que parasitan plantas asociados al banano en el Valle de Rusitu. Nematropica 43:113-118.

El banano es uno de los cultivos más importantes desde el punto de vista alimentario y económico tanto en Zimbabue como a nivel mundial. Los nematodos que parasitan plantas representan uno de los principales factores limitantes en la producción del banano y, por tanto, una amenaza para la seguridad alimentaria. Un ensayo de campo realizado en el Valle de Rusitu, que constituye una de las mayores superficies de productores de banano en Zimbabue, fue llevado a cabo con el objetivo de cuantificar y clasificar los nematodos parásitos asociados al banano. Los nematodos parásitos fueron evaluados en muestras de suelo y raíces de banano obtenidas en cuarenta granjas productoras de banano. El mayor número de nematodos parásitos asociados a la banano en el Valle de Rusitu fueron *Meloidogyne* spp., *Radopholus similis, Pratylenchus* spp. y *Helicotylenchus* spp. En términos absolutos de frecuencia, *Meloidogyne, Radopholus, Pratylenchus,* seguidos por *Helicotylenchus* fueron los géneros detectados con más frecuencia en las muestras de suelo. No obstante, en relación al número de nematodos detectados en muestras de suelo de todo tipo de terreno, la mayor abundancia se encontró en el género *Meloidogyne* mientras que *Radopholus* presentó la menor abundancia.

Palabras clave: Helicotylenchus, Meloidogyne, nematodos fitoparasitos, *Pratylenchus, Radopholus similis*.

INTRODUCTION

Banana (*Musa* spp.) is a staple food crop in much of Sub-Sahara Africa; the region produces nearly 30 million tonnes of the crop annually (Gold *et al*., 1999). Among the fruit crops, bananas rank first in terms of gross output and production area (Vinh and Quy, 1995). Production increased in recent years but, this has been due to increase in area planted rather than increase in productivity (Ouma, 2009). An estimated 30 million people worldwide subsist on bananas and related species as the principal source of dietary carbohydrate (Karamura *et al*., 1998). In Zimbabwe, much of the production is by small-scale subsistence farmers. Bananas fruit all-year-round and grow well in low-lying areas such as Rusitu, Honde and Burma Valleys (Dzitiro, 2010). Banana production in the country on small scale is quite significant although statistics are not readily available (Svotwa *et al*., 2007). Apart from being a key food crop, the crop is increasingly becoming an important source of income for the resource poor farmers.

Plant-parasitic nematodes are a major primary pest of banana crop worldwide (Gowen and Quénéhervé, 1990; Kashaija *et al*., 1994; Pattison, 2011). The burrowing (*Radopholus similis*) and spiral (*Helicotylenchus multicinctus*) nematodes are of enormous concern among the many plant-parasitic nematodes associated with banana (Wang and Hooks, 2009) and they usually occur together in banana roots in farmers' fields (Gowen, 1993). Root-knot nematodes (*Meloidogyne* spp.) and the burrowing nematode (*R. similis*) can significantly weaken root systems, reduce yields, topple plants before harvest, make plants more prone to wind knockdowns, reduce fertilizer uptake and utilization, and reduce the banana-growing lifespan of a given piece of land (Nelson *et al.*, 2006). *Radopholus similis* is a major banana root pathogen, causing lesions to roots and rhizomes, banana decline, yield losses, and toppling; the nematode has relatively wide non-*Musa* host range (Nelson *et al.*, 2006). In most cases, farmers incorrectly attribute these problems to insufficient moisture, poor soil nutrition or shallow soil. Brooks (2004) reported that burrowing and spiral nematodes are a worldwide problem in banana growing regions causing yield losses of 40% and 30-60% in Africa and India respectively.

Rusitu Valley is one of the principal banana producing areas of Zimbabwe (Mudyazvivi, 2010). About 80% of the bananas consumed in Zimbabwe come from Manicaland Province especially in the Rusitu and Honde Valleys where the small scale farmers are located, and the Burma Valley where commercial production is located (Boonstoppel and Mudyazvivi, 2010). The tonnage of banana contributed by the smallholder communal farmers from Rusitu Valley is significant although production statistics are not readily available (Mwashayenyi, 1995). The crop is sold on the fresh market and due to its all year round fruiting habit; it is a very reliable, important source of food and income to these banana dependent communities. Bananas are grown on a monoculture system in the area hence there are ideal conditions for nematode survival and increase of their populations.

Nematodes are a problem in the sandier parts of Zimbabwe (Mwashayenyi, 1995), but there is currently no official published quantitative information on the diversity of plant-parasitic nematodes associated with the banana crop in the country. Most growers are unaware that nematodes are a cause of banana production problems (Brooks, 2004). Nematode species abundance patterns and importance vary over time and space; the underlying mechanisms influencing nematode distribution and pest status are unknown (Kashaija *et al*., 1994). Hence, there is a need to carry out a survey on major plant-parasitic nematodes associated with banana in major banana production areas of the country such as Rusitu Valley.

Moens *et al*. (2001) and Pattison *et al.* (2002) reported that nematode numbers play an important role in the decision process of recommendations for nematicide use or other control applications. A certain nematode number per a given functional root mass is used as an economic threshold for nematicide application. Therefore, there is a need for a survey to identify and quantify plant-parasitic nematodes associated with banana.

Considering the economic importance of bananas as well as the destructive nature of nematodes to the crop, the present study was undertaken with the objective of providing quantitative information about population densities and frequencies of the major plant-parasitic nematode species associated with banana in smallholder farmer fields of Rusitu Valley, Zimbabwe.

MATERIALS AND METHODS

Study area and description

An extensive survey on plant-parasitic nematodes associated with banana was conducted from March to June 2012 among smallholder banana farmers in Rusitu Valley, a major smallholder banana production area. The area is found in Chimanimani District, Manicaland Province, located at an altitude of about 460 m above sea level and latitude of 19°59'S and 32°49'E (Fig. 1). The area falls under Natural Region I of Zimbabwe's Agro-ecological Zones, receiving an annual rainfall ranging from 1000 mm to 2000 mm and 635 mm effective rainfall. The main banana varieties grown in the area are Williams and Dwarf Cavendish.

Nematode sampling

Samples included in this survey came from long-term ratoon banana from small-scale farmer fields in

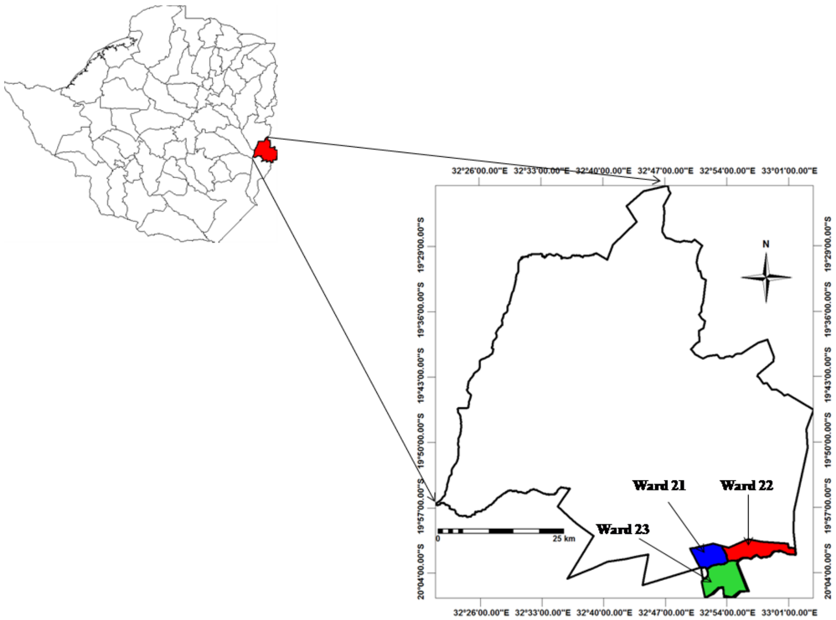

Figure 1. Map of Rusitu Valley wards studied, Chimanimani District, Zimbabwe.

Rusitu Valley communal lands from which small scale banana production is extensive in the country. A total of 40 farms from the production area were surveyed. A total of 10 soil and 10 root subsamples were collected randomly from each farm, composited to make a single 200 g soil and 100 g root samples from each farm. Thus, a total of 40 samples were collected.

Approximately 30 cm width × 30 cm length × 30 cm depth holes were dug at the base of each of the sampled banana plants with a shovel, and an auger was used to collect soil samples in the rhizosphere. Soil and roots from each rhizosphere were collected, placed in labelled plastic bags, and put in insulated cooler boxes so as to protect the samples from direct sunlight and high temperatures.

Nematode extraction

Soil and root samples collected from Rusitu Valley were taken to the Nematology laboratory at Tobacco Research Board (Kutsaga Research Station) for nematode extraction. The banana roots were rinsed free of soil with tap water and moisture on the surface of roots was allowed to dry before the root weight was collected. Soil samples were processed for nematodes by decanting and sieving followed by the modified Baermann funnel technique (Baermann, 1917). The root samples were washed in running tap water, chopped into small pieces of about 1 cm and then thoroughly mixed. From each of the samples, 5 g were taken and macerated in an Osterizer kitchen blender for 10 seconds at low speed, using Taylor and Loegering method (1953), modified by Araya (2002). The resultant mixture was removed from the blender and washed through a series of five nested sieves of 170 µm, 170 µm, 53 µm, 53 µm and 28 µm (28-µm sieve at the bottom, 170-µm sieve at the top). The residue on the two 170-µm sieves was discarded while that on the 53-µm and 28-µm sieves was back-washed with tap water into a Baermann funnel and nematodes were collected after 48 hours.

Nematode identification and counting

Nematodes were identified and counted to determine the population densities of all plant-parasitic nematodes present in both the soil and root samples. Plant-parasitic nematodes were identified to genus and/or species level by using a stereoscope microscope and values were converted to numbers per 200 g soil and 100 g of fresh roots.

Data analysis

Frequency distribution analysis for each nematode genus by farmer field was counted and the absolute frequency of each nematode genus was calculated (Barker, 1985).

RESULTS

Plant-parasitic nematodes in soil

From the 40 farmer fields surveyed in Rusitu Valley, the major plant-parasitic nematodes associated with banana in the soil were *R. similis, Meloidogyne* spp., *Helicotylenchus* spp. and *Pratylenchus* spp. (Table 1). These were present in varying densities between farms. Out of the 40 farms, the most abundant nematode based on total number of nematodes per each genus was *Meloidogyne* spp. with a highest average population density of 1675 nematodes 200 g^{-1} soil, followed by *Pratylenchus* spp. and *Helicotylenchus* spp. which had average population densities of 509 and 469 respectively. *Radopholus similis* was the least abundant with a population density of 408 200 g^{-1} soil. The average population density of all nematode species from the 4 genera for the 40 farms was 3061 nematodes 200 g^{-1} soil (Table 1). *Meloidogyne* spp. and *R. similis* were wide spread and occurred in 95% and 87.5% of the farms surveyed respectively. *Pratylenchus* spp. and *Helicotylenchus* spp. occurred in 77.5% and 75% of the farms surveyed respectively (Table 1).

Table 1. Analysis of plant-parasitic nematode species from 40 soil and 40 root samples of banana grown in Rusitu Valley.

Nematode spp.	Average No. of nematodes 200 g^{-1} soil	Average No. of nematodes 100 g^{-1} root	No. of samples collected	No. of fields tested positive		Absolute frequency of distribution (%)	
				Soil	Root	Soil	Root
Radopholus similis	408	6450	40	35	37	87.5	92.5
Meloidogyne spp.	1675	16775	40	38	38	95.0	95.0
Helicotylenchus spp.	469	2050	40	30	30	75.0	75.0
Pratylenchus spp.	509	3300	40	31	31	77.5	77.5

Plant-parasitic nematodes in banana roots

From the 40 farmer fields surveyed in Rusitu Valley, the major plant-parasitic nematodes associated with banana roots present were *R. similis, Meloidogyne* spp., *Helicotylenchus* spp. and *Pratylenchus* spp. (Table 1). Basing on total number of nematodes per genus, the most abundant nematode was *Meloidogyne* spp. with a highest average population density of 16775 nematodes 100 g^{-1} banana roots, followed by *R. similis* and *Pratylenchus* spp. which had average population densities of 6450 and 3300 respectively. *Helicotylenchus* spp. was the least abundant with a population density of 2050 nematodes 100 g^{-1} banana roots and it was absent in 10 farms (Table 1). The average population density of all nematode species from the 4 genera for the 40 farms was 28 575 nematodes 100 g^{-1} banana roots (Table 1). *Meloidogyne* spp. and *R. similis* were wide spread and occurred in 95% and 92.5% of the farms surveyed respectively whilst *Pratylenchus* spp. and *Helicotylenchus* spp. occurred in 77.5% and 75% of the farms surveyed respectively (Table 1).

DISCUSSION

Various genera of banana parasitic nematodes were found in Rusitu Valley. This agrees well with Gowen and Quénéhervé (1990), Kashaija *et al.* (1994), Araya (2005), Pattison (2011), and Chavez and Araya (2010) who reported that nematode species with different feeding habits usually exist as mixed populations in banana fields. Migratory endoparasitic nematodes that feed on the root cortex of banana plants (*R. similis* and *Pratylenchus* spp.), sedentary endoparasitic nematodes that penetrate banana roots, migrate and settle at a feeding site (*Meloidogyne* spp.) as well as the ectoparasitic nematode (*Helicotylenchus* spp.) were observed to be prevalent in Rusitu Valley from the survey. The results are consistent with those by Gowen *et al.* (2005) who reported that nematode parasitism in the banana crop are characterised by several nematode species causing simultaneous infections.

Nematode genera detected in this survey are similar to those found in Costa Rica (Araya *et al*., 2002), Uganda (Kashaija *et al*., 1994), Ecuador (Chavez and Araya, 2010), Tamil Nadu, India (Srinivasan *et al.*, 2011), Greece (Tzortzakakis, 2008), and Belize (Bridge *et al.*, 1996). *Meloidogyne* spp. was the most abundant nematode inhabiting banana fields in Rusitu Valley. These findings concur with those of Wang and Hooks (2009) who also found that *Meloidogyne* spp. was the most dominant plant-parasitic nematode species extracted from the soils of banana fields in Hawaii. Cropping of susceptible crops such as sugarcane, citrus, pineapple, and legumes with banana probably lead to the high abundance of *Meloidogyne* spp. in the soil around banana plants in the surveyed area.

Based on the nematode abundance, *Pratylenchus* and *Helicotylenchus* were more abundant than *Radopholus.* These findings are similar to those found in Uganda by Kashaija *et al.* (1994) and Tanzania by Sikora *et al.* (1989) where the two genera were more abundant and widely spread than *R. similis*. The low frequency and abundance of *R. similis* could be attributed to its low competitiveness and suppression by high levels of *Pratylenchus* spp. since both nematodes have the same feeding site (Chavez and Araya, 2010). *Helicotylenchus* and *Radopholus* are diverse pests of banana (Gowen and Quénéhervé, 1990) causing considerable damage (Kashaija *et al.*, 1994) but, in terms of total numbers, *Meloidogyne* and *Pratylenchus* were the most abundant genera in Rusitu Valley. The relative importance of *R. similis* as a major banana pest is supported by the observations by Speijer and Fogain (1999), cited by Araya (2002) and Gowen *et al.* (2005) in African countries. The high population densities and frequencies of *R. similis* in many banana fields in Rusitu Valley can be attributed to the long-term monoculture practice that lead to ideal conditions for nematode survival and reproduction.

Much variation in nematode populations among farms in Rusitu Valley can be attributed to interactions with other organisms, inter-specific nematode competition, the influence of root status as well as soil heterogeneity (Gowen and Quénéhervé, 1990). Different soil fertility, cropping systems and water management practices among farmers could also have contributed to the variations.

In conclusion, *R. similis, Pratylenchus* spp., *Helicotylenchus* spp. and *Meloidogyne* are the major plant-parasitic nematodes associated with banana in Rusitu Valley. Considering the destructive nature of these nematode species in various banana producing countries, sound research and management practices have to be in place to minimize crop damage to improve income and well-being of the banana dependent community of Rusitu Valley. Further studies should evaluate the extent of banana damage caused by plant-parasitic nematodes on banana in Rusitu Valley, followed by development of integrated pest management strategies against these pests. Replacement of the long-term ratoon monocultured crop with nematode free planting material (suckers) planted on fields not previously grown under bananas would be a good starting point.

ACKNOWLEDGEMENTS

The research was supported by the International Development Research Centre (IDRC), Canada, through the Bentley Cropping Systems Fellowship. The authors thank Russel Muzhandu and Leroy Nhumwa for their logistical and technical support. All the Rusitu Valley smallholder banana farmers are acknowledged for hosting the research, with special thanks to Mr. Robert Mudada and his entire family.

LITERATURE CITED

Araya, M., D. De Waele, and R. Vargas. 2002. Occurrence and population densities of nematode parasites of banana (*Musa* AAA) roots in Costa Rica. Nematropica 32:21-33.

Araya, M. 2002. Metodología utilizada en el laboratorio de nematología de CORBANA S.A. para la extracción de nematodos de las raíces de banano (*Musa* AAA) y plátano (Musa AAB). CORBANA 28:97-110.

Araya, M. 2005. Study of the effect of *Musa* genotype, soil type, and weed management on their nematodes and nematodes damage distribution. Doctoral Thesis No 655, Katholieke Universiteit Leuven.

Baermann, G. 1917. Eine einefache Methode Zur Auffi ndung von Ankylostomum (Nematoden) larven in Erdproben. Geneeskundig Tijdschrift voor Nederlandsch Indie. 57:131-137.

Barker, K. R. 1985. Sampling nematode communities. Pp. 3-17. *in:* Barker, K. R., Carter, C. C. and Sasser, J. N. (Eds.) An Advanced Treatise on *Meloidogyne*. Volume II: Methodology. North Carolina State University Graphics, Raliegh, NC, U.S.A.

Boonstoppel, E. and E. Mudyazvivi. 2010. The case of making teaching and learning materials practical and locally relevant in Zimbabwe. SNV Netherlands Development Organisation Case Studies 2010:1-4.

Bridge, J., D. J. Hunt, and P. Hunt. 1996. Plant-parasitic nematodes of crops in Belize. Nematropica 26:111-119.

Brooks, F. E. 2004. Plant-parasitic nematodes of banana in American Samoa. Nematropica 34:65-72.

Chavez, C. and M. Araya. 2010. Spatial-temporal distribution of plant-parasitic nematodes in banana (*Musa* AAA) plantations in Ecuador. Journal of Applied Biosciences 33:2057-2069.

Dzitiro, G. 2010. Banana production manual for secondary school leaders and pupils. The Ministry of Education, Sport, Arts and Culture. Harare, Zimbabwe. Pp. 4.

Gold, C. S., E. B. Karamura, A. Kiggunda, F. Baganda and A. M. K. Abera. 1999. Geographic shifts in highland banana (*Musa* group AAA-E. A.) production in Uganda. African Crop Science Journal 7:223-298.

Gowen S. R. 1993. Yield losses caused by nematodes on bananas and some management techniques appropriate to farmers fields in Africa. Pp. 199-208. *in:* Biological and Integrated Control of Highland Banana and Plantain Pests and Diseases. Proceedings of a Research Coordination Meeting, 12-14 November 1991, Cotonou, Benin (C.S. Gold & B. Gemmill, eds.). IITA, Ibadan, Nigeria.

Gowen, S. R. and P. Quénéhervé. 1990. Nematode parasites of bananas, plantains and abaca. Pp. 431-460. *in:* Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. M. Luc, R.A Sikora and J. Bridge (eds). CAB International.

Gowen, S. R., P. Quénéhervé, and R. Fogain. 2005. Nematode Parasites of Bananas and Plantains. Pp. 611-643. *in:* M. Luc, R. A. Sikora, and J. Bridge, Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 2nd edition. CAB International Edit., Wallingford Oxon, U.K.

Karamura E., E. Frison, D. A Karamura. and S. Sharrock. 1998. Banana production systems in Eastern and Southern Africa. Pp. 401-412. *in:* Picq, C., E. Foure and E.A. Frison (eds). Bananas and Food Security. INIBAP, Montpellier, 1998.

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

Moens, T., M. Araya, and D. De Waele. 2001. Correlations between nematode numbers and damage to banana (*Musa* AAA) roots under commercial conditions. Nematropica 31:55-65.

Mudyazvivi, E. 2010. Agricultural demonstrations work: the case of raising smallholder banana production in Zimbabwe. SNV Netherlands Development Organisation Case Studies 2010:1-5.

Mwashayenyi, E. 1995. Banana production and research in Zimbabwe. InfoMusa 4:12-13

Nelson, S. C., R. C. Ploetz, and A. K. Kepler. 2006. Species profiles for Pacific Island Agroforestry: *Musa* species (banana and plantain). www.traditionaltree.org

Ouma, G. 2009.Intercropping and its application to banana production in East Africa: A review. Journal of Plant Breeding and Crop Science 1: 013-015.

Pattison, A. B., J. M. Stanton, J. A. Cobon and V. J. Doogan. 2002. Population dynamics and economic threshold of the nematodes *Radopholus similis* and *Pratylenchus goodeyi* on banana in Australia. International Journal of Pest Management 48:107-111.

Pattison, A. B. 2011. The importance of the antagonistic potential in the management of populations of plant-parasitic nematodes in banana (*Musa* AAA) as influenced by agronomic factors. Ph.D. Thesis, Rheinischen Friedrich-Wilhelms-Universität, Bonn, Germany.

Sikora R. A., N. D. Bafokuzara, A. S. S. Mbwana, G. W. Oloo, B. Uroni and K. V. Seshu Reddy. 1989. Interrelationship between banana weevil, root lesion nematode and agronomic practices and their importance for banana decline. FAO Plant Protection Bulletin 37:151-157.

Srinivasan, R., S. Kulothungan, P. Sundararaju and C. Govindasamy. 2011. Biodiversity of plant parasitic nematodes associated with banana in Thanjavur district of Tamil Nadu. International Journal of Plant, Animal and Environmental Sciences 1:63-69.

Svotwa, E., I. O. Manyanhaire, and P. Makombe. 2007. Sustainable use of wetlands: A Case for Mwaonazvawo Village in Mutasa. Journal of Sustainable Development in Africa 9:20-36.

Tzortzakakis, E. A. 2008. Plant parasitic nematodes associated with banana crop in Crete, Greece. Acta agriculturae Slovenica 91:97-101.

Vinh, D. N. and T. D. Quy. 1995. Banana production in Vietnam: constraints and potential. Pp. 51-57. *in:* George, P. (ed.). Vietnam: banana production, biotechnology and diversity. Report of an international workshop, Banana Improvement Project.

Wang, K.-H. and C. R. R. Hooks. 2009. Plant-parasitic nematodes and their associated natural enemies within banana (*Musa* spp.) plantings in Hawaii. Nematropica 39:57-73.

Received: *Recibido:* *27/III/2013*

Accepted for publication: *Aceptado para publicación:* *14/VI/2013*