Asian Journal of

Plant Pathology

ISSN 1819-1541

Academic
Journals Inc.

www.academicjournals.com

Asian Journal of Plant Pathology 4 (1): 67-72, 2010
ISSN 1819-1541 / DOI: 10.3923/ajppaj.2008.48.53

Abundance and Distribution of Plant Parasitic Nematodes Associated With Sugarcane in Western Kenya*

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Abstract: A study was conducted to determine the factors influencing plant-parasitic nematode occurrence, abundance and distribution in the sugarcane fields. Four sugarcane growing zones; Nzoia, Mumias, West Kenya and Busia of Kenya were selected from which 81 fields randomly selected and sampled. Soil samples were taken from sugarcane rhizospheres and nematodes extracted from 200 cm^3 soil using the modified Baermann funnel technique. Nematodes were then fixed and mounted on slides and identified to genera level using identification keys. Nematodes of the genera *Pratylenchus*, *Scutellonema* and *Meloidogyne* were predominant in the sugarcane belt of western Kenya with mean densities of 61, 54 and 39, respectively. Nzoia, which falls in a marginal sugarcane zone harboured the highest proportion of these plant parasitic nematodes (55%), while West Kenya zone had the least proportion (4%). Soil texture influenced nematodes with more than 50% occurring in sandy soils compared to other soil types. Build-up of plant parasitic nematodes occurred with subsequent ratoon crops up to the second ratoon before declining in the third ratoon. Anthropogenic effects were significant with 70% higher numbers of plant parasitic nematodes in the out-grower farms compared to the factory-managed farms. This study has revealed the influence of soil texture, crop cycle and anthropogenic factors on abundance and distribution of plant parasitic nematodes in western Kenya sugarcane zones. It has also set the justification of further work to determine the economic importance of the nematodes.

Key words: Crop cycle, *Meloidogyne* spp., *Pratylenchus* spp., *Scutellonema* spp., soil texture

INTRODUCTION

Sugarcane, a tall perennial, thick stemmed grass is a complex hybrid between *Saccharam officinarum* L. and *S. spontaneum* L. (Cadet and Spaull, 2003). It is grown in more than 80 countries throughout the tropics and subtropics where it is among the principal sources of revenue, fiber and fuel. In many countries, sugarcane is used by peasant farmers to produce crude sugar and more than half of the cane grown in Brazil is used to produce ethyl alcohol (Stirling *et al*., 2005). In Kenya, sugarcane is an important cash crop earning farmers approximately US$ 100 million annually. However, the yields have been on a steady decline over the last decade from 91 t ha^{-1} in 1996 to 71 t ha^{-1} in 2005. A wide range of arthropod pests, fungi, bacteria, viruses plant parasitic nematodes and noxious weeds-individually or in complexes, cause significant losses in sugarcane (Cadet *et al*., 2003). Plant parasitic nematodes are one of the most common pests that have build-up over time and thus contributing to the decline in cane yield. Nematode diversity in sugarcane is greater than in most other cultivated crops with more than 48 genera of endo-and ectoparasitic nematodes having been recovered from the sugarcane rhizosphere (Cadet and Spaull, 2003).

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**Originally Published in Asian Journal of Plant Pathology, 2008*

The threat posed by nematodes is aggravated by the fact that sugarcane is a perennial crop which is grown under continuous monoculture. This aspect has been shown to favour the build-up of some selected pests and diseases to economic threshold levels (Mazhar *et al*., 2002). According to Cadet *et al*. (2003), yield losses due to pests and diseases in major crops are estimated at 20-50%, standing at 20-30% in sugarcane. Studies carried out in Pakistan, a tropical environment similar to Kenya showed that the damage caused by plant-parasitic nematodes is more serious and complex than in the temperate countries since the climate is suitable for nematode multiplication throughout the year (Maqbool *et al*., 2001). Surveys carried out in sugarcane growing areas of Kenya showed that lesion nematodes (*Pratylenchus* spp.) were widespread in this crop (Kandji *et al*., 2003). This study was therefore undertaken with the aim of determining the occurrence, abundance and distribution of nematodes in Nzoia, Mumias, West Kenya and Busia sugar cane zones.

MATERIALS AND METHODS

In this study, a total of 7 factors were hypothesized to influence occurrence, abundance and distribution of plant parasitic nematodes. These factors included; historical background, soil texture, Agro-Ecological Zone (AEZ), altitude, variety, crop cycle and crop management practices. A total of 81 samples were collected from randomly selected farms in four sugarcane production zones namely Nzoia, Mumias, Busia and West Kenya. A total of 20 sub-samples were taken from each farm and thoroughly mixed before drawing a composite sub-sample of about 1 kg which was transported to the laboratory. Extraction was done following the modified Baermann funnel technique described by Hooper *et al*. (2005). The effect of three soil textural classes, clay, clay loam and sandy clay on nematodes was evaluated. The influence of climatic factors on nematodes in the region was assessed by sampling three Agro-Ecological Zones (AEZs) namely lower midlands 2 (LM2), upper midlands 2 and 3 (UM2 and UM3) as described by Jaetzold and Schmidt (1983). The effect of the crop cycle was evaluated by taking samples from the plant crop, first ratoon, second ratoon, third and more ratoon crops. Anthropogenic factors were evaluated by assessing two sugarcane management practices; the management practices employed by the factories in the nucleus estates and that of the out-grower farmers. Factory managed nucleus estate farms were characterized by incorporation of organic substrates in the form of sugarcane baggasse and filtermud as opposed to farmer managed out-grower farms where no organic substrates were applied. All data collected were log transformed and subjected to General Linear Model and means separated by Duncan's Multiple Range Test using SAS Release 8.1.

RESULTS

Mean population densities of plant-parasitic nematodes associated with sugarcane were variable ($p \leq 0.05$) among the four sugarcane zones in Western Kenya (Table 1). Among all zones, Nzoia was the most heavily infested followed by Mumias, Busia and West Kenya in decreasing order of infestation. The most dominant nematodes detected were of the genera *Pratylenchus, Scutellonema* and *Meloidogyne* with overall mean numbers of 61, 54 and 39 in 200 cm^3 soil, respectively. Nematodes of the genera *Rotylenchus*, *Aphelenchoides*, *Tylenchus* and *Helicotylenchus*, showed moderate occurrence as compared to *Paratylenchus*, *Hoplolaimus*, *Ditylenchus* and *Xiphinema* amongst others whose occurrence was low in the sugarcane growing zones.

Soil texture had a significant effect on the distribution of plant-parasitic nematodes in the sugarcane zones studied (Table 2). Generally, sandy soils harboured more plant-parasitic nematodes compared to clay loam and clay soils which had lower nematode populations. Nematodes of the genera *Pratylenchus*, *Scutellonema* and *Tylenchus* were predominantly higher in sandy soils while *Hopololaimus* spp. and *Tylenchorhynchus* spp. were significantly higher in clay-loamy soils. Clay soils were significantly dominated by *Ditylenchus* spp., *Paratylenchus* spp. and *Rotylenchus* spp.

Table 1: Mean population densities of plant-parasitic nematodes associated with sugarcane crop in Nzoia, Mumias, West Kenya and Busia in western Kenya zones

	Mean nematode population density in 200 cm^3					
Nematode	Nzoia	Mumias	West Kenya	Busia	Overall mean	F probability
Pratylenchus spp.	56a	78a	9b	82a	61	**
Scutellonema spp.	61a	61a	0b	58a	54	**
Meloidogyne spp.	52a	43a	0b	17b	39	**
Rotylenchus spp.	29b	29b	66a	4c	29	**
Aphelenchoides spp.	45a	10b	0b	0b	23	**
Tylenchus spp.	37a	7ab	0b	18ab	22	**
Helicotylenchus spp.	18ab	25a	1b	2b	16	**
Tylenchorhynchus spp.	15a	13ab	2b	7ab	12	**
Xiphinema spp.	4b	4b	0b	9a	4	**
Ditylenchus spp.	3ab	10a	0b	0b	4	**
Hoplolaimus spp.	6a	2b	0b	3ab	4	*
Paratylenchus spp.	23ab	11b	34a	33a	22	*
Others	2	2	0	2	2	NS

*Significant at p≤0.05, **Significant at p≤0.01, NS: Not Significant, Means followed by the same letter(s) along rows are not significantly different

Table 2: Effect of soil texture on the distribution of plant-parasitic nematodes associated with sugarcane in Western Kenya

	Mean population density in 200 cm^3			
Nematode	Sandy clay	Clay loam	Clay	F probability
Scutellonema spp.	70a	22b	25b	**
Ditylenchus spp.	2b	4b	12a	**
Hoplolaimus spp.	4ab	9a	0b	*
Paratylenchus spp.	24ab	10b	27a	*
Rotylenchus spp.	25b	18b	55a	*
Tylenchorhynchus spp.	12ab	22a	4b	*
Pratylenchus spp.	73a	37b	40b	*
Tylenchus spp.	33a	2b	0b	*
Others	14	12	6	NS

*Significant at p≤0.05, **Significant at p≤0.01, NS: Not Significant, Means followed by the same letter(s) along rows are not significantly different

Table 3: Effect of sugarcane crop cycle on the density of plant-parasitic nematodes in Western Kenya

	Mean population density in 200 cm^3				
Nematode	Plant crop	Ratoon 1	Ratoon 2	Ratoon 3+	F probability
Ditylenchus spp.	1b	2b	18a	4b	**
Pratylenchus spp.	62ab	65ab	81a	40b	*
Tylenchorhynchus spp.	4c	17ab	21bc	8b	*
Other phytonematodes	23a	26a	25a	21a	NS

*Significant at p≤0.05; **Significant at p≤0.01; NS: Not Significant, Means followed by the same letter(s) along rows are not significantly different

The abundance of plant-parasitic nematodes was significantly influenced by the crop cycle (Table 3). Densities of nematodes of the genera *Pratylenchus*, *Ditylenchus* and *Tylenchorhynchus* steadily increased in the first two cycles of the crop (ratoon 1 and 2) followed by a rapid decline in the third and subsequent crop cycles. The populations of all other plant-parasitic genera that are frequently associated with sugarcane remained constant throughout the cropping cycles. Sugarcane management practices led to significant differences in numbers of plant parasitic nematodes associated with sugarcane in the study area (Table 4). Populations of plant-parasitic nematodes were significantly higher in out-grower farms compared to factory managed nucleus estates. With the exception of nematodes of the genus *Hoplolaimus*, numbers of nematodes of the other genera were higher in out-grower farms compared to factory-managed farms.

Table 4: Effect of management practices on the distribution of plant-parasitic nematodes in Western Kenya

	Mean population density in 200 cm^3		
Nematode	Nucleus estate	Outgrowers	F probability
Pratylenchus	47b	67a	**
Scutellonema	36b	62a	**
Meloidogyne	26b	45a	**
Rotylenchus	17b	35a	**
Hoplolaimus	6a	3b	**
Paratylenchus	9b	28a	*
Aphelenchoides	9b	3a	*
Tylenchus	6b	29a	*
Others	9	9	NS

*Significant at $p \leq 0.05$; **Significant at $p \leq 0.01$; NS: Not Significant, Data are means of 81 samples. Means followed by the same letter(s) along rows are not significantly different

DISCUSSION

This study has demonstrated that nematodes of the genera *Pratylenchus*, *Scutellonema* and *Meloidogyne* are widespread in sugarcane fields of Western Kenya. These findings are in agreement with previous studies elsewhere (Cadet and Spaull, 2003; Cadet *et al*., 2003). Sugarcane is normally grown in a continuous monoculture with usually no more than a few months break between removing the last ratoon crop and replanting the field. This practice favours the development of relatively large number of some species, especially those that are highly pathogenic to sugarcane crop like *Pratylenchus* spp and *Meloidogyne* spp. (Mazhar *et al*., 2002). Previous studies on different crops have shown that root-knot and lesion nematodes are widespread and occur in large numbers in western Kenya (Desaeger and Rao, 2000). Lesion nematodes are widely recognized as pests of cereals while root-knot nematodes are devastating on leguminous and vegetable crops (Arim *et al*., 2006).

Nzoia sugar zone was more heavily infested with nematodes compared to the other zones within the study site. Part of Nzoia lies in marginal sugarcane areas (UM2 and UM3) as opposed to the entire Mumias zone which lies within the ideal sugarcane zone in LM1 (Jaetzold and Schmidt, 1983). It is conceivable that the conditions experienced in marginal sugarcane areas are more favourable for multiplication of nematodes and hence the high density observed in Nzoia as compared to Mumias Scheme. In addition, unthrifty crops growing in marginal areas are more vulnerable to attack by nematodes (Walker, 2004). Busia zone is the most recently established sugarcane production zone so that the nematode numbers are yet to build up in the fields. In the West Kenya zone, sugarcane is established using cane tops, this practice combined with the long period the crop stays in the field, is thought to cause accelerated yield decline. Ploughing the sugarcane under after only one ratoon crop may be a viable option to manage nematodes (Agyarko and Asante, 2005). The frequent disruptions of the nematode cycles may have limited their multiplication leading to the less numbers observed (Desaeger and Rao, 2000). Sugarcane in West Kenya and Busia is produced wholly by out-grower farmers where extended fallow periods between subsequent crops are common. According to Agyarko and Asante (2005) periodic fallowing has contributed to the reduced numbers of nematodes.

This study has also shown that soil texture is a major factor that influences abundance and distribution of plant parasitic nematodes. The higher numbers of plant-parasitic nematodes associated with sandy soils could be attributed to high porosity and aeration that favour nematode mobility. The poor drainage associated with clay soils may explain the low numbers of nematodes recovered from these soils. Similar studies have revealed that the effect of soil texture on the distribution of some of the nematodes is more than that of climatic or topographic factors (Mateille *et al*., 2002; Cadet *et al*., 2003). According to Cadet and Spaull (2003), it is the quantity of sand and organic matter in soil that appears to affect the distribution of nematodes associated with sugarcane. It has been suggested that sandy soils enable easy movement of nematodes and provide optimum aeration which leads to increased pathogenicity. The negative effect of nematodes on plants is aggravated by the fact that sandy soils have a lower water and nutrient holding capacity (Avendaño *et al*., 2004).

Generally, higher nematode numbers were recorded in the out-grower farms as compared to the factory-managed nucleus estates. Bagasse and filter press mud are applied in nucleus estates on a routine basis and may account for nematode suppression as well as increase in sugarcane yields (Akhtar and Malik, 2000). According to Maqbool *et al*. (2001), the quality of planting material, especially the varieties, may be a contributing factor to the differences that occurred between the two management types. Indeed in Western Kenya, factory-managed farms use certified seed that is well treated and most likely free from nematodes as opposed to the individual farmers.

This study showed that numbers of plant parasitic nematodes increased steadily in the ratoon crops and then declined after the third ratoon. Increase in nematode numbers could be due to multiplication of the nematodes as a result of continuous presence of susceptible crops (Kratochvil *et al*., 2004). According to Quader *et al*. (2001) populations of plant parasitic nematodes were continuously building up in Australasian vineyard fields mainly due to the perennial nature of the crop. Loss of plant growth vigour coupled with competition among the nematodes, for limited reserves could explain the decline (Akhtar and Malik, 2000). In addition, the subsequent build-up of microorganisms that are antagonistic to nematodes partly results in their decline after the third ratoon (Kiewnick and Sikora, 2004; Tiyagi and Shamim, 2004).

CONCLUSION

Sugarcane fields in the western sugarcane zones of Kenya were heavily infested with plant parasitic nematodes with the predominant ones being in the genera *Pratylenchus*, *Scutellonema* and *Meloidogyne*. The marginal sugarcane zone in Nzoia is more heavily infested with nematodes than the other zones. Sandy soils are more suitable for plant parasitic nematodes and application of organic amendments in the form of sugarcane bagasse and filter mud could account for the lower numbers of plant parasitic nematodes in sugarcane fields under the management of sugarcane factories. More work is required to determine the economic importance of the nematodes associated with sugarcane in Kenya.

ACKNOWLEDGMENT

The Kenya Sugar Research Foundation (KESREF) is acknowledged for funding this study.

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