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Napier grass stunt disease in East Africa: Farmers' perspectives on disease management

George O. Asudi [a, b, *], Johnnie van den Berg [b], Charles A.O. Midega [a], Jimmy Pittchar [a], John A. Pickett [c], Zeyaur R. Khan [a, b]

[a] International Centre of Insect Physiology and Ecology (icipe), P.O. Box 30772, 00100 Nairobi, Kenya
[b] Unit for Environmental Sciences and Development, North West University, Private Bag X6001, Potchefstroom 2520, South Africa
[c] Biological Chemistry and Crop Protection Department Rothamsted Research, Harpenden, Herts AL5 2JQ, UK

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ABSTRACT

Napier or Elephant grass (*Pennisetum purpureum*), the most important livestock fodder crop in East Africa, is under threat from Napier grass stunt (NGS) disease. This disease is caused by a phytoplasma, which is transmitted by the leafhopper, *Maiestas banda* (Hemiptera: Cicadellidae). After inoculation, the disease rapidly infects the whole plant causing extensive damage to Napier grass plants. There is therefore a need to develop an integrated management approach for the disease. A survey was conducted in three East African countries (Kenya, Uganda and Tanzania) during which 198 farmers were interviewed using semi-structured questionnaires. The questionnaire addressed the prevalence of NGS, source of planting material and Napier grass cultivars grown. Farmers were also questioned on how they perceived the severity of the disease, management options and on the knowledge of the existence of wild grass hosts of the disease and its vector. Disease prevalence in survey areas was expressed as a percentage of the total 198 fields assessed. Chi-square ($\chi 2$), *F* tests and one-way analysis of variance (ANOVA) were conducted to asses any differences between districts, gender and education levels with regards to the knowledge and perceptions of NGS in the three countries. The prevalence of NGS ranged from 33% in Uganda to 95.7% in Kenya with an average of 55.1%. Among the farmers interviewed, 49.5% were able to recognize NGS symptoms. Most farmers did not have effective management approaches for the disease but cited a variety of measures including roguing and introduction of alternative fodder grasses that could potentially form part of an integrated management approach for the disease. Sedge grass (*Cyperus* sp.) and Star grass (*Cynodon dactylon*) were listed by the respondents as the likely hosts of stunt diseases caused by phytoplasma. It has been long suspected that weeds could play a role in the spread of phytoplasma by acting both as reservoirs from which healthy plants could be re-infected and also as hosts for the vectors. Since there is no well-established control method for NGS, the majority of farmers uproot infected plants and replant with new ones to lower the infection pressure by providing fewer infected plants for vectors to feed on. This pinpoints the need for farmers' awareness and the need to develop resistant Napier grass cultivars as a management option.

1. Introduction

Napier or Elephant grass (*Pennisetum purpureum* Schumach) constitutes between 40 and 80% of forages in East Africa where it is used by smallholder dairy farmers in intensive (zero grazing) and semi-intensive dairy cattle production systems (Farrell et al., 2002a; Orodho, 2006). The grass is also widely used for soil and water conservation in hilly slope areas, and serves as mulch in banana-farming regions. It has also been reported as a prospective bio-fuel crop in the region (Jones et al., 2004; Orodho, 2006). Napier grass is currently used in the region as a trap plant in the management of cereal stem borers, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), the most injurious insect pests of cereals and the main

* Corresponding author. International Centre of Insect Physiology and Ecology (icipe), P.O. Box 30772, 00100 Nairobi, Kenya.
E-mail addresses: gasudi@icipe.org (G.O. Asudi), johnnie.vandenberg@nwu.ac.za (J. van den Berg), cmidega@icipe.org (C.A.O. Midega), jpittchar@icipe.org (J. Pittchar), john.pickett@rothamsted.ac.uk (J.A. Pickett), zkhan@icipe.org (Z.R. Khan).

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target pests in the 'push–pull' strategy (PPS) (Cook et al., 2007; Pickett et al., 2014). The strategy involves intercropping a cereal crop such as maize (*Zea mays* L.) with a stemborer-repellent plant (push), usually *Desmodium*, with the trap crop, Napier grass planted as a border crop (pull) around this intercrop. Napier grass is more attractive to stemborer moths than maize for oviposition but supports only minimal survival of larvae. Therefore, when planted as a trap crop around a cereal crop it attracts more oviposition by stemborer moths than the main crop leading to a decrease in pest pressure and reduced yield losses (Van den Berg, 2006; Khan et al., 2010; Midega et al., 2010).

Napier grass stunt (NGS) disease is caused by a phytoplasma, a cell wall-less bacterium of the genus '*Candidatus* (*Ca.*) Phytoplasma' (Class – Mollicutes; order – Acholeplasmatales) (IRPCM, 2004). Based on 16S rDNA sequences, phytoplasmas associated with NGS in Kenya and Uganda belong to the 16SrXI group '*Ca* Phytoplasma oryzae' or rice yellow dwarf, while those occurring in Ethiopia are known as African sugarcane yellow leaf (ASYL) phytoplasma, a member of the 16SrIII, '*Ca.* Phytoplasma prunii' or X-disease (Jones et al., 2004, 2007; Nielsen et al., 2007; Arocha et al., 2009). Two phytoplasmas closely related to NGS were detected in other wild grasses in the western part of Kenya. These are Bermuda grass white leaf (BGWL) phytoplasma detected in *Cynodon dactylon* and *Hyparrhenia* grass white leaf (HGWL) found in *Hyparrhenia rufa*. HGWL is classified as a '*Ca*. Phytoplasma oryzae' strain and is closely related to NGS while BGWL belongs to the 16SrXIV group or *'Ca*. Phytoplasma cynodontis' (Obura et al., 2010, 2011). In Ethiopia, phytoplasmas detected in *Medicago sativa* and *C. dactylon* were classified as ASYL (Arocha et al., 2009). These studies suggested that *H. rufa*, *M. sativa* and *C. dactylon* could be alternative host plants for NGS and could play a role in the spread of the disease in East Africa.

Napier grass stunt was first reported in Kenya in 1997, in Uganda in 2001, in Ethiopia in 2004 and has been observed in Tanzania (Alicai et al., 2004; Orodho, 2006; Jones et al., 2004, 2007; Nielsen et al., 2007). In the field, NGS symptoms manifest in re-growth of Napier grass plants after cutting or grazing, with the affected shoots becoming pale yellow green and seriously dwarfed, with low biomass that is unable to sustain the feed requirements of dairy cows. Often the whole Napier stool is affected with complete loss in yield leading to eventual death of the plant (Alicai et al., 2004; Orodho, 2006; Jones et al., 2004, 2007; Kabirizi et al., 2007; Nielsen et al., 2007). The primary means of NGS spread is through the introduction of infected cuttings by farmers and/or insect vectors carrying the phytoplasma (Orodho, 2006; Obura et al., 2009; Koji et al., 2012). In Kenya, *Maiestas banda* (Kramer) (Hemiptera: Cicadellidae), transmits NGS (Obura et al., 2009) while in Ethiopia, *Exitianus* sp. (Hemiptera: Cicadellidae) and *Leptodelphax dymas* (Fennah) (Hemiptera: Delphacidae) have been indicated as potential vectors in the transmission of ASYL (Arocha et al., 2009). Since Napier grass is vegetatively propagated (Orodho, 2006), NGS presents a serious phytosanitary problem. Although some resistant Napier cultivars were earlier developed and introduced in the region, recent observations report that they have also lost resistance (Mulaa et al., 2010; Kawube et al., 2014), most likely to more aggressive strains of the pathogen. There is, therefore, no effective control method for the disease.

The level of infection of a crop by phytoplasma is therefore dependent on the abundance of insect vectors and alternative host plants harbouring the pathogen (Lee et al., 2003; Sharon et al., 2005). Similar with other phytoplasmal diseases, NGS is also exasperated under poor soil conditions and poor management of weeds in addition to poor harvesting of the plants (Orodho, 2006; Kabirizi et al., 2007). In particular, weeds and other plants provide a reservoir for the phytoplasmas and insect vectors (Weintraub and Beanland, 2006). As research into the epidemiology of NGS intensifies, there is need to provide more information on the existing farmers' knowledge and perceptions about the disease, which are currently lacking. Therefore, it is essential to identify the target farmers and further understand the farmers' needs and resources, their perception of the problem, as well as enlisting their support and collaboration in developing an appropriate management strategy. Previous studies have focused mainly on the farmers' knowledge and perception about NGS (Kabirizi et al., 2007; Khan et al., 2014) while neglecting knowledge on the existence of wild hosts. Therefore, the objectives of this study were to evaluate farmers' knowledge and perceptions of NGS and its wild grass hosts, establish farmers' current practices in managing the disease and identify NGS management challenges and intervention opportunities, aimed at developing an effective integrated management approach for the disease.

2. Materials and methods

2.1. The study area

This study was conducted in five districts in East Africa known to be NGS prone. These were Busia and Bungoma districts in western Kenya, Busia and Bugiri districts in eastern Uganda and Tarime district in northern Tanzania (Fig. 1). Altitudes at surveyed sites in Kenya ranged from 1211 to 1478 m above sea level (m a.s.l.), 1082–1243 m a.s.l. in Uganda and from 1232 to 1670 m a.s.l. in Tanzania. In total, 198 farmers and fields were surveyed with 57 in Uganda, 91 in Kenya and 50 in Tanzania. Of these, 30 farmers were in Busia district (Uganda), 27 farmers in Bugiri district, 44 farmers in Busia (Kenya), 47 farmers in Bungoma and 50 farmers in Tarime (Tanzania). The study focused on these areas because of the reported presence of NGS and the adoption for PPS (Jones et al., 2004).

2.2. Data collection

Surveys were carried out between March and July 2012. Purposive sampling was used. In this approach, farmers growing Napier grass for livestock production or practicing PPS were identified and interviewed. A semi-structured questionnaire administered through face-to-face interviews with the respondents was used to obtain information on the prevalence of NGS, first observation of the disease symptoms and its spread. This data was recorded in a series of binary responses (Khan et al., 2014) by asking the farmers if they knew NGS and its wild hosts, if they were aware of the occurrence of the disease on their farms, and how they discern its symptoms. The responses to this were recorded as 1 and 0, where 1 was a 'yes' answer and 0 a 'no' answer. Fields planted with Napier grass were randomly selected for data collection and those containing one or more plants with observable NGS symptoms were considered as infested. These symptoms were recorded as foliar yellowing (mentioned by farmers as yellow leaves), stunted growth, drying or death of plants. Subsequently, the farmers were asked to score the NGS severity on a scale range of 0–3, where 0 = no problem, 1 = low severity, 2 = medium severity and 3 = high severity. Farmers were also asked about their willingness to replace Napier grass with alternative fodder grasses, with responses treated as binary variables of 1 and 0, where 1 = yes and 0 = no. The other information addressed in the questionnaire included farmers' socio-economic characteristics namely age, gender and education level, rate of spread of NGS on their farms, presence and spread of the disease on their neighbours' farms, the source of planting materials, cultivars of Napier grown, existence of resistant Napier cultivars, seasonal prevalence of NGS and possible control measures.