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Use of edaphic factors to map the spatial distribution of root knot nematodes in tobacco plantations

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Root-knot nematodes are the most economically important group of plant parasitic nematodes. They are unevenly distributed in the soil making blanket nematicide applications uneconomic. Soil edaphic factors have been reported to be related to nematode distribution and hence can indicate nematode distribution in the soil. This study seeks to find out if the relationship of soil edaphic factors and nematode distributions can be used effectively to manage nematodes. Two year studies were carried out in 2011 and 2012. In this study, 3.3 ha fields were divided into 60 plots to determine factors that have an effect on nematode distribution and tobacco growth. Results in the first year indicated that there was a significant weak negative linear correlation between root-knot nematode populations and electrical conductivity(r = -0.298: p= 0.042). In the second year, more parameter were evaluated. Results indicated that there was a significant weak negative linear correlation between root-knot nematodes and electrical conductivity (r = -0.32; p =0.015), plant height and nematode populations (r =0.19; p= 0.18), plant height and percent clay (r =0.245; p= 0.059) and electrical conductivity and percent silt (r =0.22; p= 0.11). In some studies, electrical conductivity was recommended for use as a quick indicator of nematode distribution. In this study the weak correlations shows that it cannot be reliably used. It was noted that soils close by usually have little variation in texture and hence geo-mapping of nematodes is not feasible in small fields.

Key words: Electrical conductivity (EC), root knot nematodes, spatial distribution, geo-mapping.

INTRODUCTION

Root-knot nematodes of the genus *Meloidogyne* (Goeldi, 1892) are the most important plant parasitic nematodes parasitizing almost every plant species causing an estimated yield loss in cultivated crops of 100 billion dollars annually (Palomares et al., 2007; Strajanar and Sirca, 2010; Shaukat et al., 2009; Ramazan and Mehmet, 2010). Despite the widespread distribution of nematodes, crop assessment work has shown that their importance varies from field to field. In some fields, nematode populations increase rapidly to damaging levels while in others, populations remain low and responses to nematicides are not obtained (Stirling and Kopittke, 2000). Historically, management of nematode-induced crop damage has been achieved with the utilization of plant resistance, crop rotation and other cultural practices (Chitwood, 2002). To date, management strategies for plant-parasitic nematodes continue to rely on nematicides because of limited availability of resistant cultivars with high yield potential (Faske and Starr, 2007). However, indiscriminate use of synthetic pesticides for controlling nematodes is likely to give rise to phytotoxicity, environmental pollution and nematode resistance especially in developing countries (Adegbite and Adesiyan, 2005).

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As many agricultural chemicals are undergoing intense scrutiny with regards to the above mentioned issues, a multi tactic- integrated approach is becoming increasingly important in controlling nematodes (Zasada et al., 2010).

In an Integrated Pest Management system, monitoring for pests and determining their economic threshold is important to determine the necessity to control the nematodes. This therefore means embracing the use of pesticides while recognizing their enormous benefits as well as their dangers and public dislike of their use (Evans et al., 2002). Nematodes generally are unevenly distributed in soil, and often it is prohibitively time consuming and expensive to examine the large number of samples required to adequately analyze a field (Evans et al., 2002; Jinya et al., 2006). Identification of specific areas within individual fields for nematicide application may allow producers to reduce the amount of nematicide applied for nematode control and lower production costs through site-specific management (SSM).

Site specific management is practical only when affordable nematode distribution maps are developed (Monfort et al., 2007). Exploiting the potential and sustainability of site-specific management, however, depends on identifying the right spatio-temporal conditions for SSM that in turn, are dependent on applying appropriate diagnostic sampling strategies, establishing cause-and-effect relationships of yield-limiting factor(s) and asking strategic questions before tactical questions (Melakeberhan, 2002).

Various edaphic factors affect the population density, dynamics and distribution of nematodes. Soil bulk density and moisture content, various nutrients and elements and soil texture all can influence nematode communities (Monfort et al., 2007). These factors affect the nematode dynamics directly or indirectly by manipulating the host's response to its environment (Francl, 1993). The impact of nematodes on plant growth is worse when soil nutrients are less favourable to plant growth than when conditions are favourable. The level of nutrient differences between favourable and less favourable conditions need not have large differences to show a significant impact of host response to the problem (Melakeberhan, 1999). Such differences in nutrient balance in the field are primarily caused by soil texture (Melakeberhan, 2002). Soil texture can influence nematode density and distribution both horizontally and vertically and has been suggested as a useful predictor of nematode densities and distributions that may be of value in predicting economic damage potential (Monfort et al., 2007). This project therefore seeks to evaluate factors governing and indicating root knot nematode distribution and pathogenicity on tobacco yield response.

MATERIALS AND METHODS

Site description

The field plots were located at Kutsaga Tobacco Research Station, which is located 15 km east of Harare, the capital city of Zimbabwe. It is characterized by sandy loam soils and receives average rainfall of about 700 mm/year. Tobacco cultivar KM10, which is susceptible to nematodes, was planted in the 2009 to 2010 growing season and the field was left fallow in the 2010/2011 growing season. The evaluations were then carried out in 2011 to 2012, growing season. Cultivar KM10 is parent to most tobacco cultivars, grown in Zimbabwe. It is very susceptible to nematodes scoring 5 to 8 on Daulton and Nusbaum (1961) gall rating scale when inoculated with 5000 *Meloidogyne javanica* juveniles for 6 to 8 weeks. Hundred rows, each with approximately 45 plants (3.24 ha) were divided into 60 plots. Each plot measuring 540 m^2 and having 60 plants.

Procedure

Plant heights were measured as yield indicator. Measurements were taken from top of the ridge to the apical meristem at 8 weeks after planting. Sampling of nematodes in each plot was done using an auger (500 cm^3) to a depth of 23 cm. Sixteen cores were taken from each plot and the soil were mixed thoroughly by hand. A one kilogram sub-sample was then taken to set bioassays with 5 weeks old tomato seedling, c.v. Red Khaki in 13 cm diameter pots. A 200 g/soil was sub-sampled for nematode extraction using Elumnier two flask method modified with Bearman sieves and were then set for 48 h. Electrical conductivity (using a Hanna instruments HI 8820N) was read after shaking 10 g soil in 50 ml distilled water for 30 min. A 50 g subsample from the harvest sample was used to determine particle size composition using hydrometer method (Bouyoucos, 1962).

Data analysis

Data on root-knot nematode galling index from bioassays, electrical conductivity and percent soil particle size composition was regressed to plant heights to evaluate the correlation between tobacco yield and the above mentioned factors at 95% confidence interval.

RESULTS

In 2011, a correlation between electrical conductivity (EC) and nematode population distribution was evaluated. A significant weak linear correlation was observed (r = -0.298: p= 0.042). In 2012, more parameters were measured. In all the plots however, the soil texture did not show significant differences and hence was classified sandy. Percent silt ranged from 0 to 10 and it had an insignificant weak positive linear correlation (p = 0.11; r = 0.22) with electrical conductivity (Figure 1). Electrical conductivity had a significant negative linear correlation (p = 0.015; r = -0.32) with nematode populations (Figure 2). Consequently, as the nematode populations increased, tobacco plant heights decreased (p =0.18; r = 0.19) (Figure 3). In the study area, percent clay was very low. It ranged from 6 to 8% and had an insignificant weak negative correlation with plant height (p = 0.059; r = -0.245) (Figure 4).

DISCUSSION

Electrical conductivity has been described by Seifi et al.

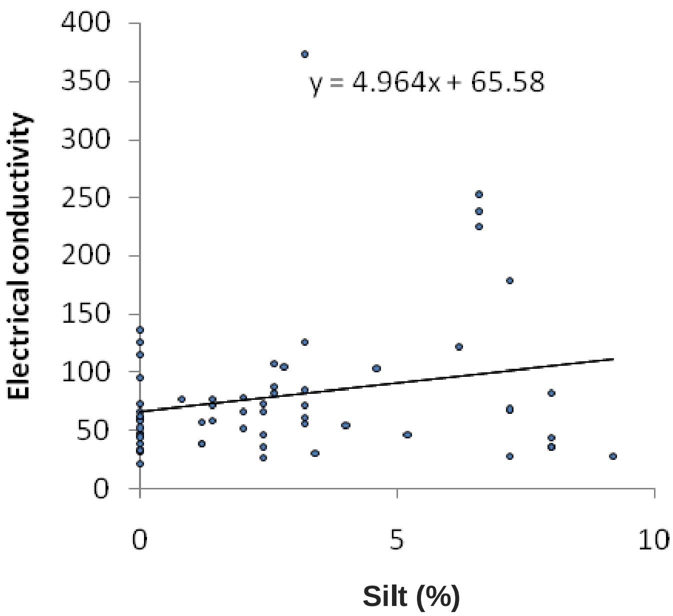

Figure 1. Linear correlation between plant height and percentage silt composition.

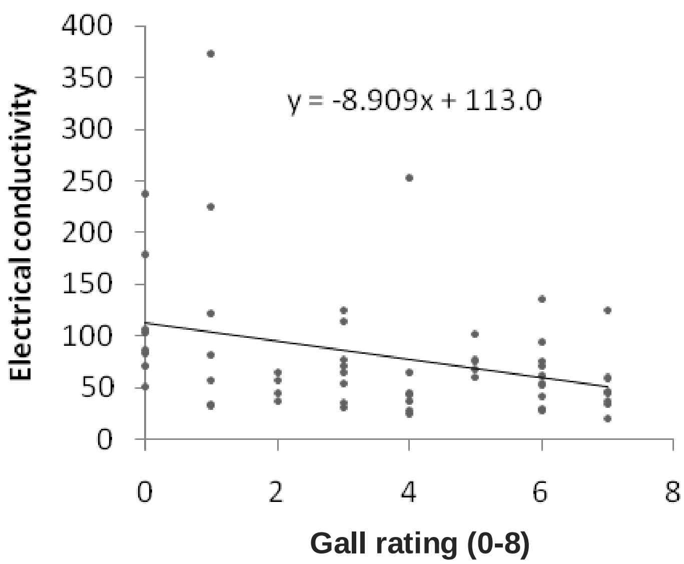

Figure 2. Linear correlation between Electrical conductivity and gall rating.

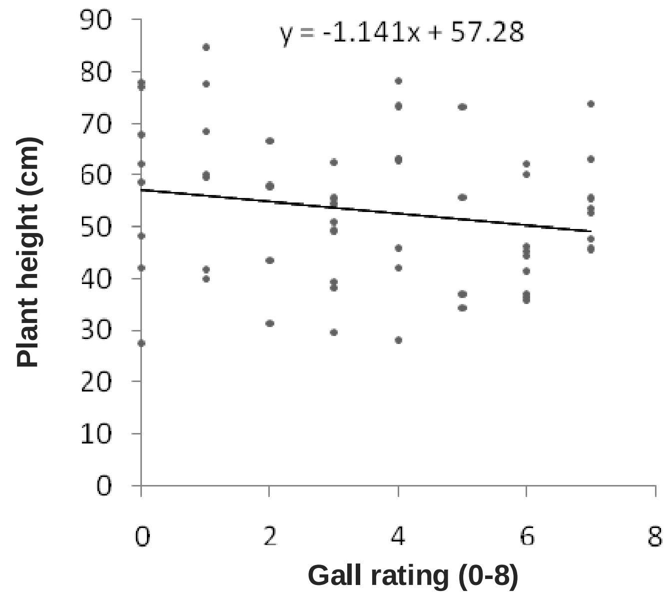

Figure 3. Linear correlation between plant height and gall rating.

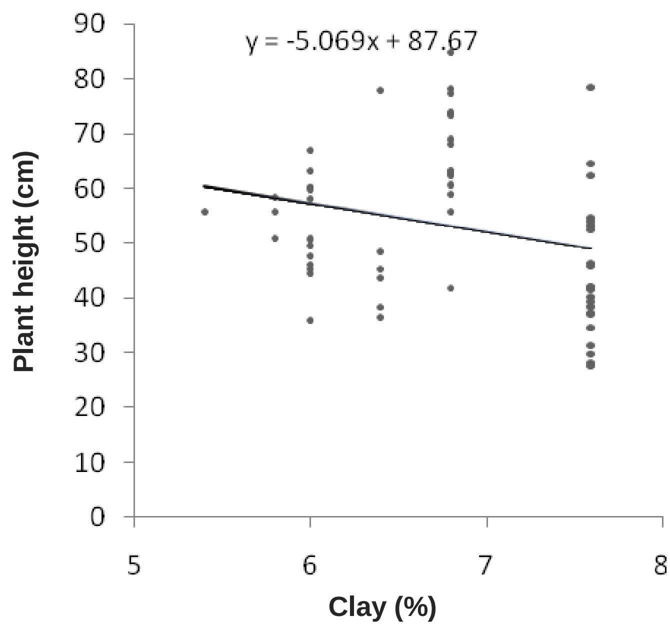

Figure 4. Linear correlation between plant height and percentage clay composition.

(2010) as the ability of a material to transmit an electrical current. Despite the multiple causes of EC variability, bulk soil EC measurements have been related to individual factors that limit soil us e and productivity such as clay content. In this study, a positive linear correlation between EC and silt observed was because the soil was characterized sand, an increase in the fine particles.

A steady increase in electrical conductivity with an increase in fine silt could be transformed to a decrease in reduced leaching of ions and hence electrical conductivity readings increased nematode populations. The reduction in nematode populations in finer soil particles can be owed to low reproduction of root knot nematodes in fine sand than in course sand. This was demonstrated by Wallace in 1969.

This was also observed by Francl (1993) when he observed high within-plot variances in *glycine* populations. These variations were attributed to soil environmental effects being the main reason and soil texture governed the occurrence of elements.

Importantly, similar reports have been made by Koenning et al. (1996) who observed that *Meloidogyne incognita* numbers were highly affected by soil type as opposed to *Rotylenchulus reniformis* under cotton culture. These results are however in contrast to those by Robbin (1974), who observed that reproduction of *B. longidorous* was actually greater in fine sand than in course sand.

Gall ratings were used in this study as indicators of nematode populations. In most tobacco growing regions of the world, plants infected with root knot nematodes become stunted (Ng'ambi. 1999). From this study, suppression of plant growth increased with an increase in nematode numbers. These results agree to those of Johnson (1970) who observed that nematode inoculation treatments depress plant heights of root-knot susceptible tobacco but not in resistant varieties. The negative linear correlation between EC and plant height and nematode populations implies that the former two can be interchangeably related to the later. As opposed to measuring plant heights to predict nematode populations, EC can be measured prior to planting to map nematode distribution. This can lead to selective management of different areas in the same field. This observation goes along with findings by Ortiz (2007). Hartsock et al. (2000) also found value in the use of EC to delineate within- field variability.

Even though the use of geostatistics have been successfully used to determine nematode distribution and within field variability in a number of studies, this seems not to be practical on small fields. As can be noted from this study, very weak correlations were observed. This is because soil properties tend to be more similar in samples that are progressively closer to each other (Xin-Zhong et al., 2007). Currently, 80% of tobacco farmers in Zimbabwe are small-scale growers, growing tobacco on small pieces of land mostly less than 1 ha. Since damage by nematodes differ in distinct soil textures, analysis of samples from different individual fields should be handled separately and recommendations given accordingly by experts.

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