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Research

Effects of Soil Organic and Inorganic Amendments on Plant-Parasitic Nematodes Population in Citrus

Judith j. Kiptoo[1*], Daniel l. Mutisya[2], Peris w. Nderitu[3], Rotich Godfrey[4], Gaudencia j. Kiptoo[5], Kibet j. Edith[6]

[1]Department of Biological Sciences, University of Nairobi, Nairobi, Kenya; [2]Department of Biological Sciences, University of KALRO Katumani, Machakos, Kenya; [3]Department of Biological Sciences, Egerton University, Chuka University, Chuka. Kenya; [4]Department of Biological Sciences, Masinde Muliro University of Science &Technology, Kakamega, Kenya; [5]Department of Biological Sciences, Egerton University, Njoro, Kenya, [6]Department of Biological Sciences, University of Eldoret,Eldoret, Kenya.

ABSTRACT

Plant-Parasitic Nematodes (PPNs) are problematic to citrus production as they are reported to cause tremendous economic damage leading to reduced quality and yield of fruits. A study was carried out to evaluate nematode response to varied citrus plots of organic and inorganic regimes in two ecologically varied sites in Kenya. The two farms were established in Wote (Muambani) in Makueni County and ADC Suam Orchards in Kitale of Uasin Gish County. In each of the two sites 16 plots were demarcated for soil treatments of (i) Organic manure; (ii) NPK 17:17: 17, (iii) Manure+NPK and (iv)-Nil fertilizer as Control for the plots. These treatments were placed circular around each orange tree radially one-metre from the stem where each plot had 12 plants with 5-metre spacing between trees. The results showed that least nematode infestation occurred on organic amendment at 61.3 and 53.0 parasitic nematodes per plant sample for Kitale and Wote sites respectively. This was 58 % parasite reduction at the two farms in comparison to 145.5 and 124.8 sample counts at the two farms of Kitale and Wote respectively. Combining both organic and inorganic amendments led to 36% parasite reduction. The results lead to recommending an organic amendment in citrus orchards to manage nematodes for higher yields.

Keywords: Plant-parasitic nematodes; Manure; Ecological

INTRODUCTION

Plant-parasitic nematodes (PPNs) constitute a major constraint to citrus production where they parasitize on the crop leading to secondary infection caused by soil-borne fungal and bacterial pathogens. Injury in the root system causes reduced water and nutrient uptake leading to development of small, stunted and chlorotic leaves and fruits, resulting in yield losses.The most common and widely employed control method is chemical nematicides to suppress the pest populations below economic threshold. However, due to the negative impact of nematicides to environmental, animals and human health, their use is increasingly becoming restricted. Conversely, interest in low-cost ecofriendly alternative methods of nematode suppression is growing rapidly [1,2]. For example, organic amendments especially the use of animal manures, has increased significantly in the world over the years and are expected to grow in the future [3].

Successful use of organic manure to reduce parasitic nematode populations and their damage in crops such as cassava, coffee and citrus has been demonstrated in the recent past making this approach a cheap and ecofriendly candidate component for an integrated management strategy to manage PPNs and other crop pests. Besides improving the ability of soil to provide nutrients to crop plants, organic manure provides substrates which cause build-up of micro-organisms that serve as food used by free living nematodes to increase their population rapidly. Furthermore [4], free living nematodes have been reported to accelerate decomposition of soil organic matter thus increasing nitrogen

Correspondence to: Judith j. Kiptoo, Department of Biological Sciences, University of Nairobi, Nairobi, Kenya, Tel: 25464895626; E-mail: juditkiptoo@gmail.com

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and phosphorous which favours their increase. In Kenya, various control options have been used to manage PPNs, including soil amendments by use of organic manure, cover crop, resistant cultivar, crop rotation and biological control [5].

Proper crop nutrition is an important aspect to maintain soil health and also manage the population of parasitic nematodes [6]. Organic amendments has been reported to increases the soil biodiversity and stimulate the nematode destroying fungi for control of PPNs and reduce their population as well as using adhesive conidia, knobs, braches and mycelia to parasitize nematodes [7]. Moreover, organic manure have been reported to be rich in nitrogen and phenolic compounds as they decompose and release substances which are toxic to PPNs hence reducing their population. In some cases some plant extracts especially from marigold have been effective in killing these pests. Several studies have shown animal manures can be used to control phytonematodes [8]. Therefore, the inclusion of organic materials could be an alternative to the use of nematicides in integrated management of PPNs in citrus. This study was aimed at investigating the effect of soil inorganic and organic amendments for control of PPNs in nematodes in citrus production.

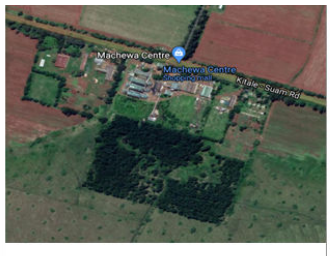
METHODOLOGY

Study Sites

The citrus orchards were selected for the experimental trial at Suam orchard in Trans-Nzoia County and Wote in Machakos (Figure 1).
The experiment was conducted in citrus orchards for three successive years (2017 to 2019). The trees were more than 7 years old at a spacing of 4 m x 5 m grown under similar cultural management practices of the sweet orange (Citrus sinensis).

Soil assessment test were done before laying of the experimental trial. Different combinations of fertilizers (organic and inorganic fertilizers) were used in different blocks [9-13].

The management practices carried out twice per year was irrigation, pruning and disease control.



Trans-Nzoia County, Suam orchard	Makueni County, Wote farm at Muambani
N 01° 14. 977	S 01° 58. 837
E 034° 48. 886	E 037° 20. 224
Altitude: 1908 m	Altitude: 1254 m

Figure 1: Comparable sweet orange study sites at Suam (Kitale) and Muambani (Makueni) during production period of 2017-2019

Soil samples and extraction of nematodes

Four soil samples were collected per year from 2017 to 2019 using a soil augur at 15-30 cm beneath the tree canopy in different treatments [14-17].

The collection of soil samples were done after every four months. The auger was dipped into 70 ethanol between sampling intervals for sterilization to avoid contamination of the treatments. The soil samples were taken from the citrus orchard from the beginning of the experimental trial to assess the effect of organic and inorganic fertilizer on PPNs population [18-21].

A composite soil sample weighing 200 g was collected from five root samples admix and kept in a plastic bag, labelled bag then sealed and placed into a cool box for transportation to the laboratory for nematode extraction. Extraction of nematodes was done using a modification of Baermann's technique [22,23].

The roots were thoroughly washed to remove the soil particles and examined for galling and root-knot infection. The soil sample weighing 200 g was put on a sieve plate with soviet in between the soil and the sieve plate and under a plate with half-filled water.

The setup was left undisturbed for 48 hours to allow the nematodes to swim through to the water on the plate. The nematode suspension was collected and was sieved through 25 micrometer apertures to obtain a 20 ml that was placed on a beaker [24-28].

A micropipette was used to draw a fixed volume of 2 ml of the nematodes suspension from the 20 ml beaker and placed on a counting dish under a microscope.

Quantification was done by counting the number of nematodes in 2 ml and repeated three times and the average recorded.

Identification was done through morphological examination by use of pictorial keys [29-32].

RESULTS

Nematode density

Trees treated with combined application of organic manure and NPK exhibited the lowest number of plant parasitic nematodes followed by pure organic manure and the highest number was recorded on control and NPK treated trees [33,34] (Table 1).

Table 1: Site major nematode species density on citrus during 2017-2019.

Site	Nematode density	T. semipenetran	Meloidogyne spp
Kitale	665.3	108.0	51.1
Wote	636.0	91.1	72.2
F	25	7.25	36.6
p	0.0154	0.0759	0.0091

Effect of fertilizer

Least nematode density was observed in manure treated plots, significantly reduced to 61.3 and 53.0 for Kitale and Makueni sites from highs of 145.5 and 124.8 nematodes per sample respectively. Manure combined with NPK (17:17:17) was observed to lower the densities more significantly than NPK (17:17:17) alone (Table 2).

Table 2: Soil site fertility effect to nematode density on citrus during 2017-2019.

Site	Manure	NPK 17:17:17	Manure-NPK	No-fertilizer
Kitale	61.3	135.5	91.8	145.5
Wote	53.0	108.5	90.5	124.8
F	4.42	7.52	3.51	4.67
p	0.1291	0.08	0.2563	0.1645

Fruit yield increase

There was marked yield increase at Kitale and Makueni sites where tonnage was at 8.1 and 7.8 t/ha in 2019 for Kitale and Makueni sites from previous 2.6 and 2.1 t/ha respectively (Figure 2). Both Kitale and Makueni appeared to demonstrate steady fruit yield increase from 2017 to 2019 period [35,36].

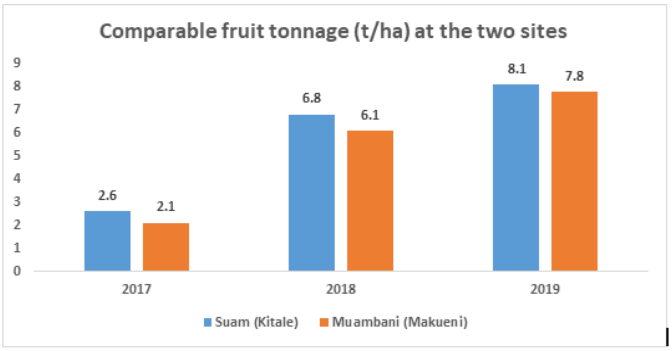


Figure 2: Comparable yield increase with input of fertilizers in 2017-2019 at Kitale and Makueni sites

Soil fertility improvement

The comparable macronutrient levels of the two farms showed higher increase from initial low levels in 2017 to higher status in 2019 for NPK(17:17:17) and NPK+Manure (Figure 3). Nitrogen levels appeared low for Muambani site in Makueni.

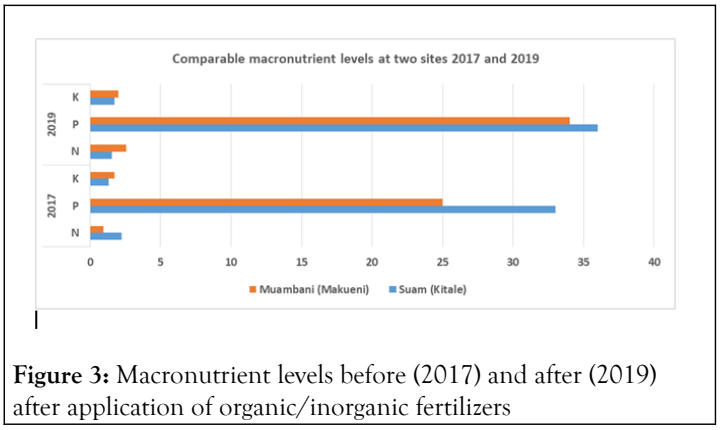


Figure 3: Macronutrient levels before (2017) and after (2019) after application of organic/inorganic fertilizers

DISCUSSION

The results from the present study indicates a reduction of PPNs on trees treated with pure organic manure and combination of 50% manure and 50% NPK, this is in agreement with many studies that have shown deceased populations of PPNs following addition of organic manure. Nevertheless this is the first time the work was carried out on orange trees in Kenya [37]. The explanation could only be attributed to the gradual decomposition of organic manures that released the toxic substances to plant-parasitic nematodes that suppressed and prevented development of nematode cohorts in the surrounding soil, hence reducing their population. Further, the marked reduction of the parasite populations from the study results could have been due to the addition of organic manure that increased the soil biodiversity which is significant for soil health as well as stimulation of the nematode destroying fungi which suppressed PPNs.

The results of this study confirmed that soil organic and inorganic amendments can improve the plant nutrient leading to high plant vigor contributing to development of partial prevention of

root damage of orange trees against parasitic nematodes. Other studies have also reported increased plant height and spread in sweet oranges as result of combined application of organic and inorganic fertilizers [38]. Unique bio fertilizers from sources like chicken droppings have been reported to suppress nematode densities even in tomato crop. Elsewhere good results on suppression of the parasitic pests have been achieved by use of mulch and periotic additions of inorganic fertilizers.

Results from the fruit yield showed increased levels at the two sites when tonnage turnout of the first year (2017) was compared to the final year (2019). Various attributes brought in by fertilization could have been achieved as improved soil structure, subsequently leading to increased soil water holding capacity which enhanced the activity of naturally occurring micro-organisms which parasitize nematodes in the soil, thus protecting plants against nematode attack**.** The results of this study concur with Ram et al. (2007), maximum yield and fruit number were recorded consistently for two years on orange trees. Thus as per present study observation the use of organic fertilizer and inorganic fertilization is necessary for sustainable citrus production. This is in agreement with Ibe et al., (2011) and Hiwarale et al. (2004) where the plant height, canopy spread and fruit yield of sweet orange was enhanced by inoculation of bio fertilizers. Soil test results in the final year (2019) indicated increased macronutrient levels at the two sites, Makueni and Kitale. This was demonstrated as sustainable soil fertility maintenance for orange tree production and improved microflora with increased bio fertilizer application [39,40]. This study results here highlight the need to fertilizer well orange trees for higher yields and prevention of severe nematode parasite in orchards in ecologically different sites.

CONCLUSION

The present work results here compel us to recommend that farmers be encouraged to increase fertilizer use; combined organic and inorganic to suppress nematode pests on the roots of the trees. This will lead to healthy trees and increased fruit yield and it has been ascertained from the present work and in reference to earlier studies. Plant parasitic nematodes are not causing much damage or the loss and is not that much economical but there is yield reduction and the production cost increases very high when compared to the yield

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