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Effects of fertilizer, organic mulch and sucker hot water treatment on nematode populations and productivity of plantain

Akinyemi S.O.S.[1, 2*], A.A. Kintomo[2], T. Ojurongbe[3], P.Y.K. Sallah[1, 4], T. Ndabamenye[1] and D. Nkezabahizi[1]

[1] Institut des sciences Agronomiques du Rwanda (ISAR), Highland Agricultural Research Center, B.P. 73, Ruhengeri, Rwanda ; [2] Current address: National Horticultural Research Institute, P.M.B. 5432, Idi-Ishin, Jericho, Ibadan, Nigeria; [3] Department of Biometry & Population Genetics, Justus Liebig University, Interdisciplinary Research Center, Heinrich-Buff-Ring 26-32, D-35392 Giessen, Germany; [4] CSIR-Crop Research Institute, P.O. Box 3785, Kumasi, Ghana.

Corresponding author email: sosaking2002@yahoo.com

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ABSTRACT

Objectives: To investigate the effects of fertilizer (F), organic mulch (*Tithonia diversifolia*) (M) and hot water treatment (H) on nematode population, growth and yield of plantain (*Musa* AAB, cv 'Agbagba').

Methodology and results: The study was conducted from 2003 to 2005 at the National Horticultural Research Institute, Ibadan, Nigeria. The treatments included: (1) mulching each sucker with 5.0 kg of *Tithonia diversifolia* leaves (M) alone at six- week intervals; (2) hot water immersion (H) of suckers after paring the corms; (3) hot water immersion + 5.0 kg of *Tithonia diversifolia* leaves (HM) at six- week intervals; (4) no mulch nor hot water immersion (C). These sets of treatments were combined with two fertilizer levels (0 and 450 kg/ha N.P.K 15-15-15) to give a total of eight treatments arranged in a randomized complete block design with four replications. Application of Tithonia mulch and hot water treatment without fertilizer significantly reduced the nematode infestation. Application of mulch and fertilizer (MF) significantly increased pseudostem height and girth; and also reduced days to shooting of plantain. The HMF combination resulted in the highest bunch yield of 11.87 t/ha which was not significantly different from HF and MF

Conclusion and application of findings: The use of Tithonia gave the highest positive contribution to nematode reduction. Its combination with fertilizer would be a good option for plantain farmers as it reduces nematode population and increases plantain productivity.

Key words: Fertilizer, Musa (plantain), nematode, *Tithonia diversifolia*, mulch

INTRODUCTION

Bananas and plantains are widely grown across the world's tropical regions and are major food crops in developing countries. It is estimated that about 70 million people in West and Central Africa derive more than 25% of their carbohydrates from plantains making them one of the most important sources of food energy throughout the African lowland humid forest zone (Swennen, 1990),

including Nigeria. It occupies a strategic balance in rapid food production being a ratoon perennial with short gestation period (Akinyemi *et al*., 2005). The crop has formed an integral component of the farming systems in many agro-ecological zones. In addition to being a staple food for rural and urban consumers, plantains are an important source of rural income, particularly for the small holders who produce them in compounds or home gardens (Akinyemi & Tijani-Eniola, 2001; Adesope *et. al*., 2004). Intensification of plantain production in the region is however being hampered by some constraints such as diseases and pests. These include Black sigatoka, Fusarium wilt, banana weevil and nematodes.

Plant-parasitic nematodes constitute one of the major biological constraints in plantain production resulting in estimated annual yield loss of 19.7 – 36.8% (Kashaija *et al*., 1998). The nematodes feed on roots, causing root necrosis which gradually leads to root rotting and reduced number of functional roots (Kashaija *et al*., 1998). Damage to roots impairs nutrient-flow, translates into suppressed shoot growth and subsequently reduced yield of infected plants. Vegetative propagation using infested corms or suckers has disseminated this pest throughout the world. Some important plant parasitic nematodes that have been found associated with banana and plantain include: *Radopholus similis, Pratylenchus goodeyi, Helicotylinchus multicinctus, Hoplolaismus* spp., and *Meloidogyne* spp.

Numerous field experiments have shown the effectiveness of various nematicides against root-knot nematodes but their deleterious effect in the eco-system has necessitated the evaluation of other methods of nematode control (Dirk De Waele & Romulo, 1998). One of these methods is paring of corms superficially to remove lesioned tissue, followed by hot water treatment at 52 to 55 °C for 20 minutes (Sarah *et al*., 1996). This method has been observed to be effective and can be used to establish new fields, expand existing ones, or replac lost plants in existing fields. A major challenge facing farmers is to improve crop husbandry techniques that would delay re-infestation of the fields (Tenkouano *et al*., 2006). One of the promising developments in this area is the prospect of using nematode-suppressive plants such as *Tithonia diversifolia* as mulch (IITA, 2004; Coyne *et. al*., 2005). Considering that research should concentrate on reducing pesticide applications (Queneherve, 1993), it is worth investigating the impact of crop improvement techniques for the benefit of small-scale farmers. The aim of this study was to investigate the effect of sucker treatment, organic mulch and fertilizer on nematode infestation and productivity of plantain.

MATERIALS AND METHODS

Trial site: The study was conducted during the seasons of 2003 - 2004 for the main crop investigation and 2004 - 2005 for the ratoon crop at the experimental site of the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria (7^{o} 23'N; 3^{o} 35'E, 168m above sea level), located in the humid forest/moist savanna transition zone. The rainfall for the location is bi-modal (Table 1) while the experimental site was a sandy loam located in a zone of alfisolic soils (Table 2).

Experiment layout: In July 2003, plantain (*Musa paradisiaca L* cv. 'Agbagba') suckers were planted at 3m x 2m (1666 plants/ha). The nematode control measures to serve as treatments were applied before and/or after planting. The experimental treatments were: (1) hot water immersion (H); (2) mulching with tithonia (M); (3) hot water immersion + mulch (HM); and (4) no mulch nor hot water immersion (C). Each of these treatments was combined with two levels of fertilizer (F) (0 and 450 kg/ha N.P.K 15-15-15), to give a total of eight treatments. Hot water treatment (H) was carried out by paring the suckers and dipping them in hot water (52 °C) for 20 minutes. For the mulch (M) treatment, fresh *Tithonia diversifolia* leaves collected from a nearby field, where they had been growing for two years, were applied at the rate of 5kg/ plantain stand every six-weeks by placing on the soil surface. The fertilizer was applied in two equal splits at 3 and 5 months after planting (MAP). The treatments were arranged in a randomized complete block design with four replications.

Data recorded: Data collected include nematode count (at 6 week intervals), plantain pseudostem height, girth (at 50cm above soil level), number of suckers, height of tallest suckers and bunch weight of main plant and first

ratoon. Plantain bunches were harvested at 90 days after flowering and bunch weights were taken after trimming the rachis to the first bract mark. Data reported here was at 12 MAP for agronomic measurements and 12, 24, 36, 48, 60 weeks after planting (WAP) for total nematode population count. The predominant nematodes observed in the field were *Radopholus similis, Meloidogyne spp*, and *Helicothylenchus spp*.

Data analyses: The analysis of variance (ANOVA) procedure was used for all data and means separated using Fisher's Least Significant Difference (LSD) at 5% level of probability. Contrast was used to detect the contribution of inorganic fertilizer, tithonia mulch and hot water treatment on nematode population at 36, 48 and 60 WAP, and plantain bunch yield.

Table 1: Physical and chemical properties of the soil at the experimental site (NIHORT, Ibadan, Nigeria).

Soil Properties	Value
PH (H20)	6.60
Organic Carbon (g/kg)	15.20
Total Nitrogen (%)	2.10
Available P (mg/kg)	3.50
Exchangeable Ca (cmol/kg)	8.54
Exchangeable Mg (cmol/kg)	1.24
Exchangeable Mn (cmol/kg)	0.14
Exchangeable K (cmol/kg)	0.20
Exchangeable Na (cmol/kg)	0.25
ECEC (cmol/kg)	10.37
Sand %	67
Silt %	17
Clay %	16

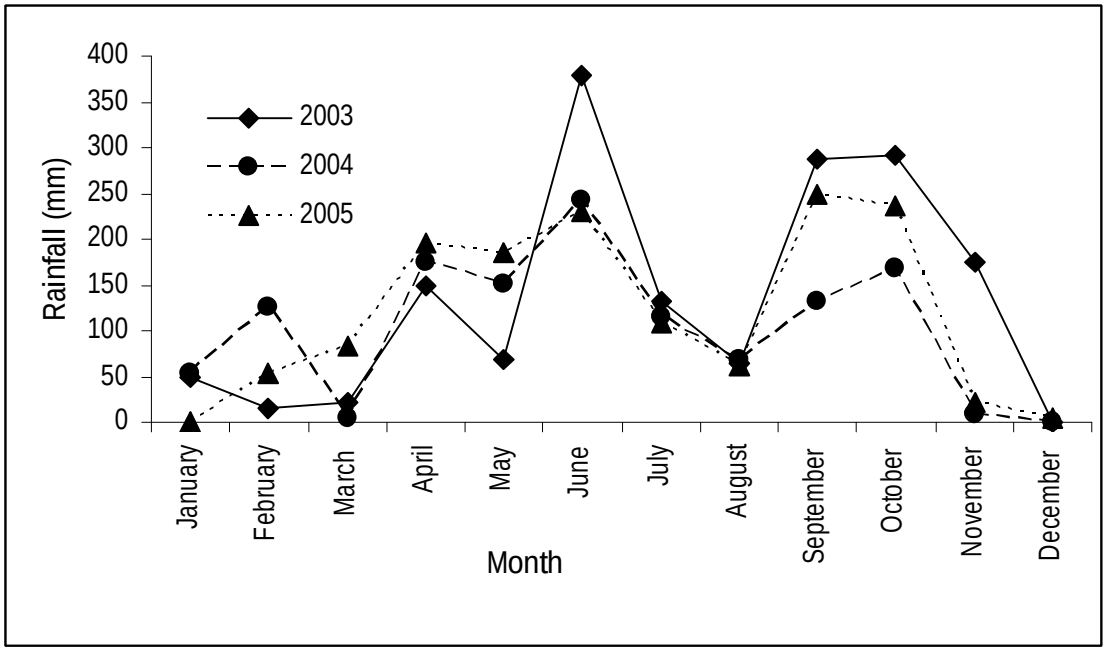

Figure 1: Rainfall distribution (mm) at the NIHORT experimental site (2003-2005) in Ibadan, Nigeria.

RESULTS

Vegetative growth: The treatment of plantain suckers with hot water alone gave the least pseudostem height and girth while treatment with fertilizer + hot water + tithonia mulch combination (HMF) significantly gave the highest height and girth. This combination also gave the highest number of functional leaves, though not significantly different from other treatments except hot water (H) treatment (Table 2). Addition of fertilizer significantly increased the number of suckers produced. The MF and HMF treatments gave the highest number of suckers which was more than double that of hot water treatment alone. On the contrary, all treatments that included hot water treatments gave the tallest suckers irrespective of the fertilizer treatment. Days to shooting were also significantly reduced in mulch treatments. A reduction of 205 and 178 days were observed in non-fertilized and fertilized treatments, respectively, when the mulch treatments where

compared to their corresponding hot water treatments. Overall, hot water + mulch + fertilizer (HMF) gave the best plant growth results except for days to shooting.

Nematode population: The plant parasitic nematode populations increased over time in most treatments (Figure 2). At 12 WAP, no significant difference was observed in nematode populations among the treatments. However, at 24 WAP, nematode populations were significantly more in untreated control (C) and CF (no other treatment + fertilizer) than on other treatments (Figure 2). This significant increase was consistent until the end of the observation time. Nematode populations were lower in all treatments that include hot water. Hot water (H) and hot water + mulch (HM) gave the least counts of 237 and 270/200cm^2 of soil respectively at 60 WAP.

Table 2: Effects of fertilizer, tithonia mulch and hot water sucker treatment on the growth performance of plantain (cv'Agbagba') at 12 months after planting.

Treatment	Pseudostem height (cm)	Pseudostem girth (cm)	No. of - functional leaves	No. of suckers	Height of tallest suckers (cm)	Days to shooting
H	150.75c	39.50bc	6.25b	2.25d	135.75a	556a
HM	180.00abc	43.25abc	7.25ab	2.75cd	86.00ab	476b
M	172.75bc	45.00ab	8.25ab	4.25bc	80.50ab	351d
C	175.75abc	42.13bc	7.50ab	3.00cd	71.50b	538a
HF	171.75c	37.25c	7.00b	5.25b	111.25ab	520a
HMF	206.50a	49.00a	9.50a	7.25a	134.25a	465bc
MF	193.88ab	45.70ab	8.25ab	7.50a	82.00ab	342d
CF	190.25ab	43.50abc	7.50ab	4.00bc	63.25b	437c

a,b,c: means followed by the different letter within a column are significantly different by LSD at 5% level. H= Hot water, HM = Hot water + mulch, M = mulch, C = Control (no treatment), HF = Hot water + fertilizer, HMF = Hot water + mulch + fertilizer, MF = Mulch + fertilizer, CF = Control + fertilizer.

Plantain yield: Plantain bunch yield in both main and ratoon crop was influenced by all the treatments. Bunch yield was significantly higher in fertilized treatments than on the non fertilized treatments. The main bunch yield of 11.63, 11.87 and 11.47 t/ha obtained in HF, HMF and MF, respectively, was 33, 28 and 29% higher than that on their corresponding treatments without fertilizer (H, HM and M) (Figure 3). This increase in bunch yield in the fertilized treatments was also observed in the ratoon bunch yield, though the ratoon yields were generally lower than those of the main crop.

Table 3: The mean effect of fertilizer (F), tithonia mulch (M) and hot water treatment (H) on nematode population and bunch yield of plantain.

	Nematode population						Main bunch weight (t/ha)		Ratoon bunch weight (t/ha)	
	36 WAP		48 WAP		60 WAP					
	Mean Effect	Pr > F	Mean Effect	Pr > F	Mean Effect	Pr > F	Mean Effect	Pr > F	Mean Effect	Pr > F
F	26.75	<0.001	78.19	<0.001	49.97	<0.001	2.94	<0.001	1.63	<0.001
M	-329.44	<0.001	-437.50	<0.001	-719.03	<0.001	1.48	<0.001	0.97	0.003
H	-114.75	<0.001	-247.19	<0.001	-495.53	<0.001	1.57	<0.001	1.67	<0.001

WAP = Weeks after planting; F=Fertilizer; M = Mulch; H =Hot water.

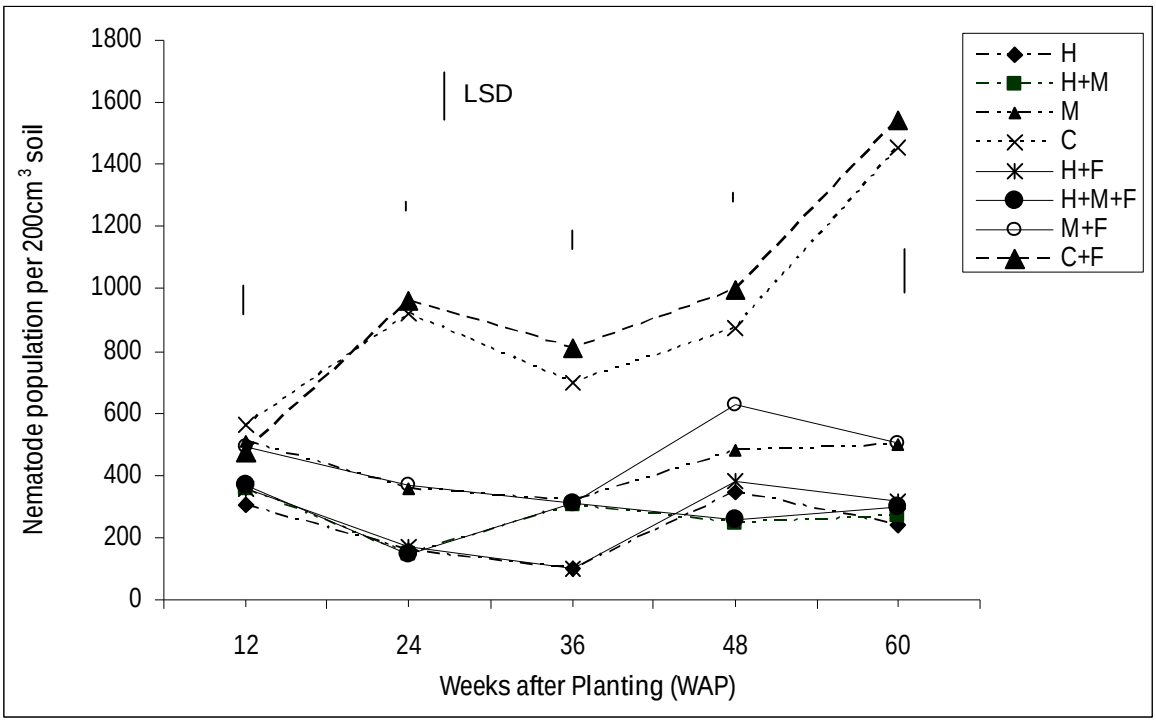

Figure 2: Influence of hot water treatment, mulch and fertilizer on nematode population on plantain cv 'Agbagba.'
Key: H=hot water; H+M = hot water + mulch; M = mulch; C =control; H+F = hot water + fertilizer; HMF=hot water + mulch +fertilizer; MF =mulch + fertilizer; CF= control + fertilizer.

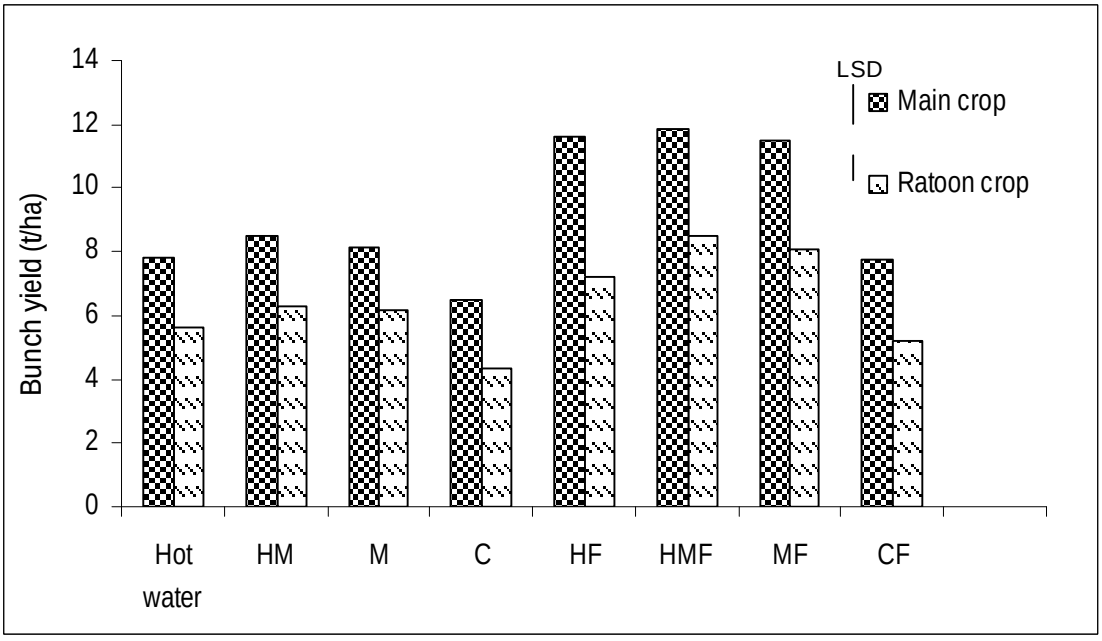

Figure 3: Influence of hot water treatment (H), mulch (M) and fertilizer (F) on the bunch yield of plantain cv. 'Agbagba'.

Mean effect: The analysis of the main effect showing the contribution of fertilizer, tithonia mulch and hot water treatment revealed that application of fertilizer was significantly positive ($p<0.001$) contributing to

nematode population increase (Table3) On the other hand, tithonia mulch and hot water treatment was significantly negative, indicating that their application contribute to reduction in nematode population. The negative contribution of these two parameters increased with duration from 36 to 60 WAP. The contribution of tithonia mulch in reducing nematode population was higher than that of hot water treatment (Table 3). All these three main factors contributed positively to both main and ratoon bunch weight. However, the contribution of fertilizer was higher than that of tithonia mulch and hot water treatment.

DISCUSSION

The reduction in growth parameters of plantain when subjected to the hot water treatment may be due to the initial heat shock experienced by the suckers (Tenkouano *et. al.*, 2006). Subsequent significant increase in height of the tallest suckers from hot water treatment might have resulted from activation of buds within the plantain corms which gave early sucker emergence (Kwa, 2003). The use of hot water would have cleaned the suckers of initial pests thus preventing build-up of nematodes (Sarah, 1989; Tenkouano *et al.*, 2006).

The influence of fertilizer in increasing crop performance including plantain has been established for long. The addition of fertilizer and mulch might have been responsible for the growth increase observed in the combined treatments. The conservation of soil moisture through the use of mulch and enhancement of soil nutrient through the use of fertilizer might have prompted the release of nitrogen, potassium and phosphorus. This might have promoted the production of leaves leading to faster growth and subsequent reduction in days to shooting as reported by Robinson (1996) and Jama *et. al*. (2000).

The use of *Tithonia* mulch could also be compensating for nematode damage by improving root growth. Its effect could also be through increasing populations and activity of beneficial soil organisms that are antagonistic to plantain nematodes, or through production of nematicidal compounds (Bridge, 1996; 2000). The result of this study is in agreement with the observation of Nisar *et al*. (1989) and Coyne *et. a*l. (2005), who reported that *Tithonia diversifolia* is active against nematodes.

This study further revealed that the use of fertilizer might not reduce infestation of nematodes in plantain, but its combination with *Tithonia diversifolia* could result in reduced nematode infestation and high bunch yield of plantain. Several recent studies have reported that tithonia use as mulch reduces nematode damage and also improves yield of crops (Coyne *et al*., 2005; Gowen *et. al*., 2005).

Based on the findings of this study, we conclude that the use of tithonia could be a useful technique for controlling nematode infestation in plantain fields. Its use solely and combination with hot water treatment gave the same result, suggesting that it may not be necessary to use hot water where Tithonia will be applied. The combination of Tithonia mulch and inorganic fertilizer would be a suitable option for small scale farmers as it reduced nematode population and increased plantain yield at relatively little additional costs.

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