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INFLUENCE OF SOIL PROPERTIES ON PLANT NEMATODE POPULATION DENSITY UNDER *Chromolaena odorata* FALLOW

***ODEYEMI, I. SEGUN[1]. AFOLAMI, S. OLAOLUWA[1] AND AZEEZ J.OLADIPUPO[2]**

[a] Department of crop protection, Federal University of Agriculture, Abeokuta, P.M.B. 2240, Abeokuta, Nigeria.

Corresponding Author: odeyemi_presi@yahoo.com

ABSTRACT

Relationships between soil abiotic factors and population densities of plant parasitic nematodes species under planted fallow of *Chromolaena odorata* was investigated for 2 years. Soil samples were collected at 0 – 30 cm depth to determine population of nematode species and soil physico-chemical properties was done at test initiation and afterwards at 6 months interval for 2 years. Four genera of plant parasitic nematode species (*Meloidogyne spp*., *Pratylenchus spp*, *Helicotylenchus* spp. and *Xiphinema* spp) and two free – living (Rhabditids and *Dorylaimus* spp.) were identified in the fallow. Soil organic Matter and soil N were significantly higher at 2 years than at 6, 12 and 18 months. Population density of plant parasitic nematode species significantly reduce as the fallow period extend reaching minimum at 2 years of fallow. Highest percentage reduction of 90.3 % was observed in population of *Xiphinema* at 2 years of fallow, followed by *Pratylenchus* with 51.5 % reduction in population and lowest reduction of 44 % was observed in *Meloidogyne* population. Negative and significant relationship existed between soil physico-chemical properties and population density of plant parasitic nematode species indicated that soil characteristics play an important role in the abundance, distribution and structure of nematode communities.

Keywords: Abiotic factors; bush fallow; *Chromolaena odorata*; Nematode species; suppression

INTRODUCTION

Nematodes successfully colonize a greater variety of habitats than any other group of multicellular animals. Many of the nematode species are free-living, feeding on bacteria or fungal spores, whereas others are predatory or parasitic in habit (Hunt *et al*., 2005). Damage and yield losses caused by plant pathogens, including plant-parasitic nematodes, are, on average, greater in tropical than in temperate regions because of greater pathogen diversity, more favourable environmental conditions for pathogen colonization, development, reproduction and dispersal (De Waele and Elsen, 2007). Thus Plant parasitic nematodes have economic and financial impact on Agriculture in the Tropics where subsistence agriculture predominates.

Management of plant parasitic nematodes involves the manipulation of nematode densities to non-injurious or sub-economic threshold levels using several measures in relation to the whole production system. The diversity of nematodes in agro-ecosystems and the total abundance of members of different trophic levels are largely controlled by the biophysical, chemical and hydrological conditions of the soil (Yeates and Bongers, 1999). The soil as a habitat for nematodes can be changed through management practices such as monoculture, tillage, drainage, application of agrochemicals, irrigation, organic mulch and fallowing (Freckman and Ettema, 1993; Tian *et al*., 2005).

In Nigeria and many parts of West Africa, fallowing is still considered as an important management practice for maintaining soil productivity mainly because subsistent farmers in this region generally cannot afford fertilizer use (Tian *et al*., 2005). Following cropping, traditional farmers leave their lands to fallow with re-growth of natural vegetation before the next cropping to replenish nutrients removed by crops. During the fallow period, *Chromolaena odorata* (Siam weed) frequently predominates in the humid tropics (Kang *et al*., 1997). *Chromolaena odorata*, a fast growing shrub produces large amounts of biomass during fallow periods and improves soil organic matter, total N, available P and cation exchange capacity (Tian *et al*., 2005).

During *C. odorata* fallow, nutrients are taken up by the vegetation from various depths of soil and stored in the biomass, then returned to the surface soil via litter fall, root decomposition and root exudates thus, stabilising the physical, chemical and biological condition of the soil (Koutika *et al*., 2005; Ikuenobe and Analiefo, 2003; Webster and Wilson, 1987; Dove, 1986).

Nematodes as invertebrate organisms spend a considerable part of their life-cycle in the soil. In addition to the host plant, soil type is also known to be a major factor that affects nematodes distribution. Variation in the population and abundance of nematode species depends on certain physical and chemical soil factors in the topsoil making nematodes to be extremely susceptible to minute change in their environment. The physical characteristics of soil are important to occurrence and population dynamics of nematodes. Consequently, the study reported here was set out with the aim: (i) to determine population densities of nematode species and soil physiochemical properties under *Chromolaena odorata* fallow (ii) to find out the relationship between different soil properties and abundance of the nematode species under *C. odorata* fallow.

MATERIALS AND METHODS

Description of the study area

The *C. odorata* fallow was established on farmland that was previously cropped with maize for two seasons on the Agricultural Media Resources and Extension Centre (AMREC) Demonstration Farm, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria (latitude 7°N, longitude 3°21'E). The field was slashed and tilled manually using cutlass and hoe. The treatment plot size of 7 m x 5 m with a space of 2.5 m between plots was established. The treatment plot was replicated 12 times. Ten weeks old *C. odorata* seedlings raised in nursery bed were transplanted for establishment at spacing of 0.5 m x 1 m (20,000 stands per hectare). Before full establishment of *C. odorata* plants, rouging of other weeds was carried out at 2 weeks intervals for six months.

Soil Sampling and preparation

Soil samples were collected at 0 – 30 cm depth to determine population of nematodes, physical and chemical properties of soil. Soil samples were taken subsequently at six months interval for 2 years. At each sampling stage, ten soil-core samples were taken with the aid of a soil auger from each treatment plot at a soil depth of 20 cm with auger diameter of 2.5 cm. The soil samples were thoroughly mixed to form one composite sample per treatment plot out of which 250 g was taken for nematode extraction. The soil samples used for physical and chemical analysis were taken at spots very close to those taken for nematode assay.

Extraction of Nematodes from the soil samples

Nematodes in soil samples were extracted using the Whitehead and Hemming (1965) modified tray method of the Baermann technique. Two hundred and fifty grammes of soil from the composite samples was placed in the upper sieve of a pair of sieve sandwiched with a double ply serviette paper and placed in a bowl containing 250ml of water for 18 hours.. The sandwich sieves containing the soil samples were removed from the bowls and the water-nematode residuum was poured into 500ml Nalgene bottles with spouts and left for 5 hours. Rubber tubing (3mm inside diameter) was filled with water and then slipped over the spout to drain excess supernatant. The suspension was then concentrated to 25ml by removing excess water supernatant through the settling- siphon method of Caveness, 1975. The nematode suspension was then placed in a counting dish for identification and estimation of population. Nematodes were identified to genus by placing a specimen with a sharpened broom stick on a slide with a drop of water covered (with a cover slip) and examined under a compound microscope using the pictorial key of Mai and Lyon (1975) and taxonomic keys of Luc *et al*. (1990).

Soil sample analysis for physico – chemical properties

Soil samples collected were processed by air drying and sieving with a 2 mm mesh aperture sieve in the laboratory and analysed for physical and chemical properties. Chemical analysis was carried out following the Tropical Soil Biology and Fertility (TSBF) methods of soil and plant analysis (Okalebo *et al*. 1993), for percentage sand, percentage clay, percentage silt, percent soil moisture, percent organic carbon, percentage organic matter, soil pH, nitrogen (N), available Phosphorus (P), Exchangeable potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na). For each of the soil property, the samples were analysed in triplicates.

Data analysis

Data collected on nematode populations were log (x+1) transformed before subjection to repeated measures analysis of variance (ANOVA). Significant means were separated using Duncan multiple range test at $P < 0.05$. Correlation and regression analyses were used to evaluate the relationship among the soil properties and nematode species and population densities. This was done using the SAS package version 8.0 (SAS, 1999).

RESULTS

Nematode species and population dynamics under fallow

Nematode genera identified at test incitation under *C. odorata* fallow and throughout the study were *Meloidogyne* sp, *Pratylenchus* sp., *Helicotylenchus* sp, *Xiphinema* sp and two non-parasitic (Rhabditidae sp. and Dorylaimus sp.) as shown in Table 1. Population of the nematode species varied significantly ($p < 0.05$) as the duration of the fallow increased. Population of the plant parasitic nematodes (*Meloidogyne* sp., *Pratylenchus* sp, *Helicotylenchus* sp *and Xiphinema* sp) reduced significantly under fallow with highest reduction at 2 years of fallow. However, as duration of fallow lengthened, a significant but increasing trend was observed in Rhabditids population densities under fallow with highest mean population reached at 2 years of fallow. Also, Highest mean population of *Dorylaimus sp.* was observed at 2 years.

pH and other soil physico – chemical properties under fallow

Fallowing with *C. odorata* had significant effect on soil chemical properties (Table 2). Soil pH and Organic carbon in the soil under *C. odorata* fallow increased consistently as fallow period extended till 2 years. Also, as the fallow period increased the soil organic matter content and total nitrogen of the soil under the fallow increased significantly with highest value for organic matter content and total nitrogen observed at 2 years of fallow. Exchangeable sodium was highest at the inception of the fallow and lowest at 18 months. Potassium content in soil under the fallow consistently increased as the fallow period extended. Highest potassium content was observed at 2 years. Duration of fallow had significant effect on exchangeable magnesium and Calcium in soil under the fallow plots. Magnesium content was highest at the initial compared with other sampling period as the fallow period increased. On the contrary, calcium content under the fallow plots increased significantly as the fallow period progressed reaching the highest value at 18 months.

Soil physical properties under *C. odorata* fallow varied significantly as shown in Table 3 although the soil textural class was constant. Percentage sand content of soil reduced with duration of fallow significantly at 12 months and up to 2 years of fallow. The percentage clay content of soil under the fallow period was consistent except for a significant reduction at 6 months and 2 years of fallow. Percentage silt in soil under the fallow plots significantly increased along the period of fallow up to 2 years of fallow.

Association of nematode species with soil physico-chemical properties

The relationship among nematode species and some soil properties are shown in Table 4. Correlation of population densities of identified nematodes with pH was negative with coefficient r values for *Meloidogyne* sp, - 0.39, for *Pratylenchus* sp, - 0.33 and - 0.35 for *Helicotylenchus* sp. Soil organic matter content was negatively correlated with populations of *Meloidogyne* sp., *Pratylenchus* sp., *Helicotylenchus* sp, *Xiphinema* sp and positively with *Dorylaimus* spp. with r coefficients – 0.72, - 0.65, - 0.71, - 0.56 and 0.30 respectively. Total nitrogen was positively correlated with population densities of Rhabditids with r value of 0.32. Soil potassium correlated negatively with *Meloidogyne* sp (r = - 0.39) and *Pratylenchus* sp. (r = - 0.30) population densities under *C. odorata* fallow. Percentage sand content under fallow correlated positively with *Meloidogyne* sp, *Pratylenchus* sp and *Helicotylenchus* sp populations with coefficient values of 0.42, 0.42 and 0.45 respectively. On the contrary, Percentage clay content of the soil correlated negatively with *Meloidogyne* sp (r = - 0.33) while silt content in the soil under *C. odorata* fallow correlated negatively with *Meloidogyne* sp, *Pratylenchus* sp, *Helicotylenchus* sp and *Xiphinema* sp with r values of – 0.43, - 0.42, – 0.47 and – 0.43 respectively. Soil Calcium, Potassium and moisture content had similar negative correlation with population densities of *Meloidogyne* sp, *Pratylenchus* sp *Helicotylenchus* sp and Xiphinema in soil under *C. odorata* fallow.

Contribution of various soil physico - chemical properties to variation in population densities of nematode species under C. odorata fallow.

The result of the stepwise regression analysis of soil properties on population densities of identified nematode species are contained in Tables 5 and 6. Soil sodium content (R^2 = 0.05), phosphorus (R^2 = 0.67) and % silt (R^2 = 0.18) among soil physico-chemical properties had significant and negative contribution to the variation in *Meloidogyne* sp population. Significant and negative contribution to variation in *Pratylenchus* sp population under fallow was due to sodium content in soil under *C. odorata* fallow (R^2 = 0.05). Available phosphorus (R^2 = 0.67) and % silt (R^2 = 0.22) had negative and significant contribution to population of *Helicotylenchus* sp. The variation in *Xiphinema* sp. population under fallow was due to negative and significant contribution by organic matter (R^2 =0.22). Moreover, increase in population of Rhabditids and *Dorylaimus* species observed under *C. odorata* at 2 years of fallow were traceable to positive and significant contribution of soil organic matter (R^2 = 0.09) and total nitrogen (R^2 = 0.10) for Rhabditids and Total nitrogen for *Dorylaimus* (R^2 = 0.08).

Table 1: Mean population density of nematode species identified per 250 g of soil under *Chromolaena odorata* fallow

Duration under Fallow (Months)	Meloidogyne sp	Pratylenchus sp	Helicotylenchus sp	Xiphinema sp	Rhabditids	Dorylaimus
0	257.2 a	361.6 a	233.1 a	104.00a	209.7bc	278.5 c
6	249.2 a	331.3 b	229.7 a	78.67 b	222.8b	288.6 c
12	185.7 b	305.6 b	165.8 b	41.54c	231.1 ab	298.5 bc
18	169.3 bc	236.7 c	162.3 b	30.22c	255.6 a	306.6 b
24	143.3 c	175.1 d	123.3 c	10.11 d	259.5 a	360.1 a
SE±	2.7	3.86	2.79	5.43	5.58	6.58

Table 2: Soil properties under *C. odorata* fallow at varying period of fallow

Duration under Fallow (Months)	pH in H_2O 1:1	Organic matter (%)	Total N (%)	Na (cmolkg^{-1})	K (cmolkg^{-1})	Mg (cmolkg^{-1})	Ca (cmolkg^{-1})	Avail. P (mgkg^{-1})	Moisture (%)
0	6.20c	4.46c	0.12e	0.93a	1.16d	2.05a	2.89b	5.21e	4.80e
6	6.11c	4.64c	0.17d	0.87b	1.46c	1.80c	2.94b	9.97d	10.98c
12	6.16c	4.59c	0.18c	0.85bc	1.50bc	1.89b	2.94b	15.06c	8.20d
18	6.33b	5.33b	0.21b	0.82c	1.61b	1.94b	3.05a	21.93b	12.38b
24	6.47a	6.00a	0.34a	0.90ab	1.73a	1.92b	3.05a	23.94a	12.55a
SE±	0.10	0.28	0.008	0.09	0.18	0.11	0.05	0.83	0.50

Table 3: Soil physical properties under *C. odorata* fallow at varying period of fallow

Duration under Fallow (Months)	Sand (%)	Clay (%)	Silt (%)	Textural Class
0	95.10a	2.64b	2.26d	Sandy Loam
6	93.36b	2.59b	4.05c	Sandy Loam
12	92.73d	2.66b	4.61b	Sandy Loam
18	93.52b	2.95a	4.53b	Sandy Loam
24	91.17d	2.53c	6.30a	Sandy Loam
SE±	0.10	0.11	0.28	

Table 4: Correlation among Soil physico-chemical properties and nematode species under *C. odorata* fallow

	pH	Org C	Or-ganic matter	ECE C	Total N	Na	K	Mg	Sand (%)	Clay (%)	Silt (%)	Ca	Available P	Moisture
Meloi-dogyne sp	- 0.39**	-0.03	- 0.72**	- 0.61**	- 0.15	- 0.11	- 0.39**	0.03	0.42**	- 0.33*	- 0.43**	- 0.31*	- 0.82**	- 0.59**
Pratylen-chus sp	- 0.33*	0.02	- 0.65**	- 0.58**	- 0.29	- 0.01	- 0.30*	0.03	0.42**	- 0.19	-0.42**	- 0.51**	- 0.88**	- 0.66**
Helicoty-lenchus sp	- 0.35*	-0.02	- 0.71**	- 0.72**	- 0.17	0.047	- 0.26	0.06	0.45**	- 0.21	-0.47**	- 0.45**	- 0 .92**	- 0.70**
Xiphinema sp	- 0.01	-0.07	- 0.56*	- 0.65**	0.36*	0.230	- 0.24	0.10	- 0.21	0.03	-0.43**	- 0.65**	0.19	0.12
Rhabditids	0.10	-0.19	0.28	0.13	0.32*	0.091	0.08	- 0.06	0.20	- 0.21	-0.29	0.07	0.15	0.19
Dory-laimus	0.07	0.01	0.30*	0.29	0.28	- 0.06	0.06	- 0.11	0.04	- 0.16	-0.07	0.19	0.23	0.16

** - Correlation values are significant at $p < 0.01$

* - Correlation values are significant at $p < 0.05$

Table 5: Multiple regression equations, partial correlation and regression coefficient of chemical properties contribution to nematode species under *C. odorata* fallow.

		Intercept	pH	org C	Organic matter	Total N	Na	K	Mg	Ca	Available P	Moisture
Meloidogyne sp	=	2063	- 70.02	- 7-76	- 26.65*	+710.71	- 122*	- 33.16	- 67.40	- 251.6	- 4.03*	+ 7.27
Partial R2	0.73						0.05				0.67	
Pratylenchus sp	=	3248	- 34.69	+ 2.04	- 32.67*	- 106.0	- 152*	- 102	- 65.17	- 578.06	- 6.77	- 3.78
Partial R2	0.83						0.05				0.78	
Helicotylenchus sp	=	637	- 10.94	- 2.91	- 7.70*	- 2.45	- 41.05	- 19.78	+ 35.59	- 149	- 3.16*	+ 0.12
Partial R2	0.86										0.86	
Xiphinema sp	=	1187	- 8.32	+ 3.70	- 14.89*	- 60.03	+ 154	- 0.37	- 45.28	+ 269*	+ 0.39	+ 0.88
Partial R2	0.29				0.22					0.07		
Rhabditids	=	- 886	+ 91.52	+ 1.15	+ 18.98*	+ 2019*	- 104	+ 57.96	- 86.59	+ 232.6	- 8.13	+ 14.89
Partial R2	0.19				0.09	0.10						
Dorylaimus	=	- 468	+ 29.82	+ 22.00	+ 362*	+ 2200*	- 202	+ 160.7	- 29.27	+ 384.97	- 11.09	- 1.59
Partial R2	0.17				0.09	0.08						

* Values are significant at $p< 0.05$

Table 6: Multiple regression equations, partial correlation and regression coefficient of soil physical properties contribution to nematode species under *C. odorata* fallow.

		Intercept	% Sand	% Clay	% Silt
Meloidogyne sp.	=	871.66	- 2.71	- 10.95	- 11.93*
Partial R2	0.18		-	-	0.18
Pratylenchus sp.	=	2340.09	- 8.56	-7.67	- 13.12
Partial R2	0.00		-	-	-
Helicotylenchus sp.	=	616.11	- 2.28	- 2.29	- 6.34*
Partial R2	0.22		-	-	0.22
Xiphinema sp.	=	- 537.51	+ 0.02	+ 2.88	- 9.43
Partial R2	0.19		-	-	- 10.22*
Rhabditids	=	437.45	- 6.47	- 7.17	- 18.89
Partial R2	0.00		-	-	-
Dorylaimus	=	- 479.55	+ 0.79	- 8.34	- 9.72
Partial R2	0.00				

* Values are significant at $p < 0.05$

DISCUSSION

The influence of soil physico chemical properties on population densities of nematode species was investigated under *C. odorata* fallow. Soil fertility was significantly improved under *C. odorata* after fallowing for 2 years. This finding corroborate the earlier observations of Kang *et al*., 1997 and Tian *et al*., 2005 that *C. odorata* fallow improves soil organic matter, total N, available P and cation exchange capacity in the soil.

The Significant reduction in the population of plant parasitic nematodes observed under *C. odorata* fallow in this study could be as a result of many factors. *C. odorata* as a plant has been shown to contain nematicidal compounds such as alkaloids, saponins and flavonoids which were tested and found toxic to plant-parasitic nematodes (Adegbite and Adesiyan, 2005; Fatoki and Fawole 2000). These active compounds, or precursors of active compounds, serve as allelochemicals against plant parasitic nematodes and are more effective in nematode suppression when the plant secreting them are grown for continuous secretion into the rhizosphere (Odeyemi et al., 2013). On the other hand, the minute variation in soil properties under *C. odorata* fallow also may alter the population of nematodes in the soil. The findings of Taylor (1971) and Fawole (1992) stressed that, environmental factors are of great importance in influencing fluctuation in nematode population. In this study, it was observed that percentage sand tend generally to harbour larger population of plant parasitic nematodes than clay and silt, this may be due to more efficient aeration in sandy soil and moreover, nematodes move with ease through the root zone in sandy soils than in clay soils. This is further buttressed by the significant relationship observed between nematode population and percentage sand, clay or silt in our study (Arévalo et al., 2007; Cadet *et al.*, 2004; Jaraba *et al.*, 2007; Dabiré and Mateille, 2004). In this study, the suppression of plant parasitic nematode population observed under *C. odorata* fallow might also be as a result of increase in organic matter content observed under *C. odorata* fallow due to heavy litter fall and decomposition during the fallow. As the fallow period extends the increase in soil organic matter tend to suppress population of plant parasitic nematodes (Hoitink and Ramos, 2004 , and Oka, 2010). The findings of this study further provide evidence of mechanisms involved in the suppression of plant parasitic nematode species population densities under *C. odorata* asides nematicidal compounds it exudes into the soil, it also alters soil physico - chemical properties of the soil making the rhizosphere inimical for plant parasitic nematodes.

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