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Analysis of nematode assemblage in Kenyan Vertisol, Cambisol and Arenosol soil groups: II- Edaphic factors influencing nematode communities[a]

Andrew K. Thuo[1], John W. Kimenju[1], George M. Kariuki[2], George N. Karuku[1], Philip K. Wendot[2], and Haddish Melakeberhan[3]*

[1]University of Nairobi, Department of Plant Science and Crop Protection, [2]Kenyatta University, Department of Agricultural Science and Technology,

[3] Michigan State University (MSU), Agricultural Nematology Laboratory, Department of Horticulture.

Abstract:

As part of developing a database of types of biological and physiochemical degradations, the aim of this study was to determine the relationships among soil physical-chemical properties, and nematode assemblages in Vertisol, Cambisol and Arenosol soil groups (orders) under subsistence farming in Kenya. It was determined that nematodes can be effectively utilized as evaluative and descriptive indicators to assess the differences in soil degradation using edaphic parameters under different seasonal, regional, soil group and disturbance levels.

Introduction:

Sub-Saharan Africa's available cropland is faced by a variety of constraints that include degradation of its cropland, practice of inappropriate and unsustainable agricultural methods, dwindling soil productivity, deficient land management and conservation strategies in addition to human encroachment on natural. Nematodes enable agriculturalists to infer vital soil processes due to their ever-present, high abundance, prompt reaction to environmental shifts and close inter-relationship with soil characteristics. The objective of this study was therefore to determine how nematode faunal assemblages and edaphic parameters associations could be utilized as evaluative and descriptive indicators of soil quality in Vertisols, Cambisols and Arenosols.

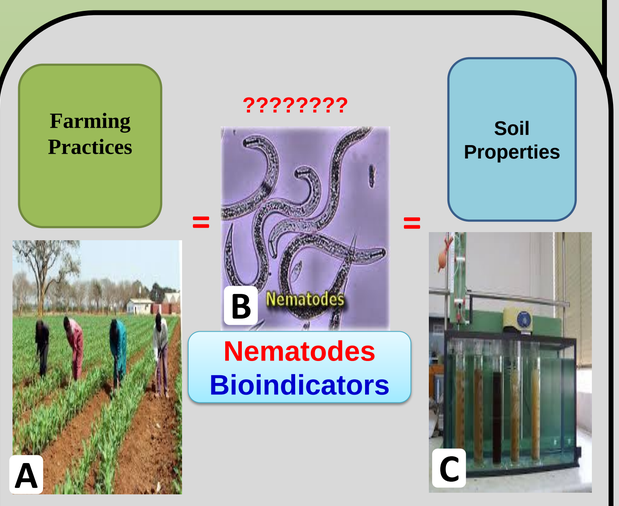

Fig. 1 A: Farmers Hand digging their farms. **Fig. 1 B:** Farmers Hand digging their farms. **Fig. 1 C:** Farmers Hand digging their farms

Methodology

A total of 576 soil samples from Vertisols, Cambisols and Arenosols were collected from disturbed (tilled, agricultural) and adjoining undisturbed (untilled, natural vegetation) soils in two regions (North and South) over the cold/dry (Season 1), warm/rainy (Season 2) and hot/dry (Season 3) seasons. Nematodes were extracted, assigned to herbivore, bacteriovore, fungivore, predator and omnivore trophic groups whereby maturity (PPI, MI, MI2-5, ∑MI and ∑MI2-5), fertility (FI=PPI/MI), and soil food web indices were calculated as described by Yeates *et al.* (1993) and Bongers & Bongers (1998). Respective soil physiochemical properties were also determined and correlations with nematode .

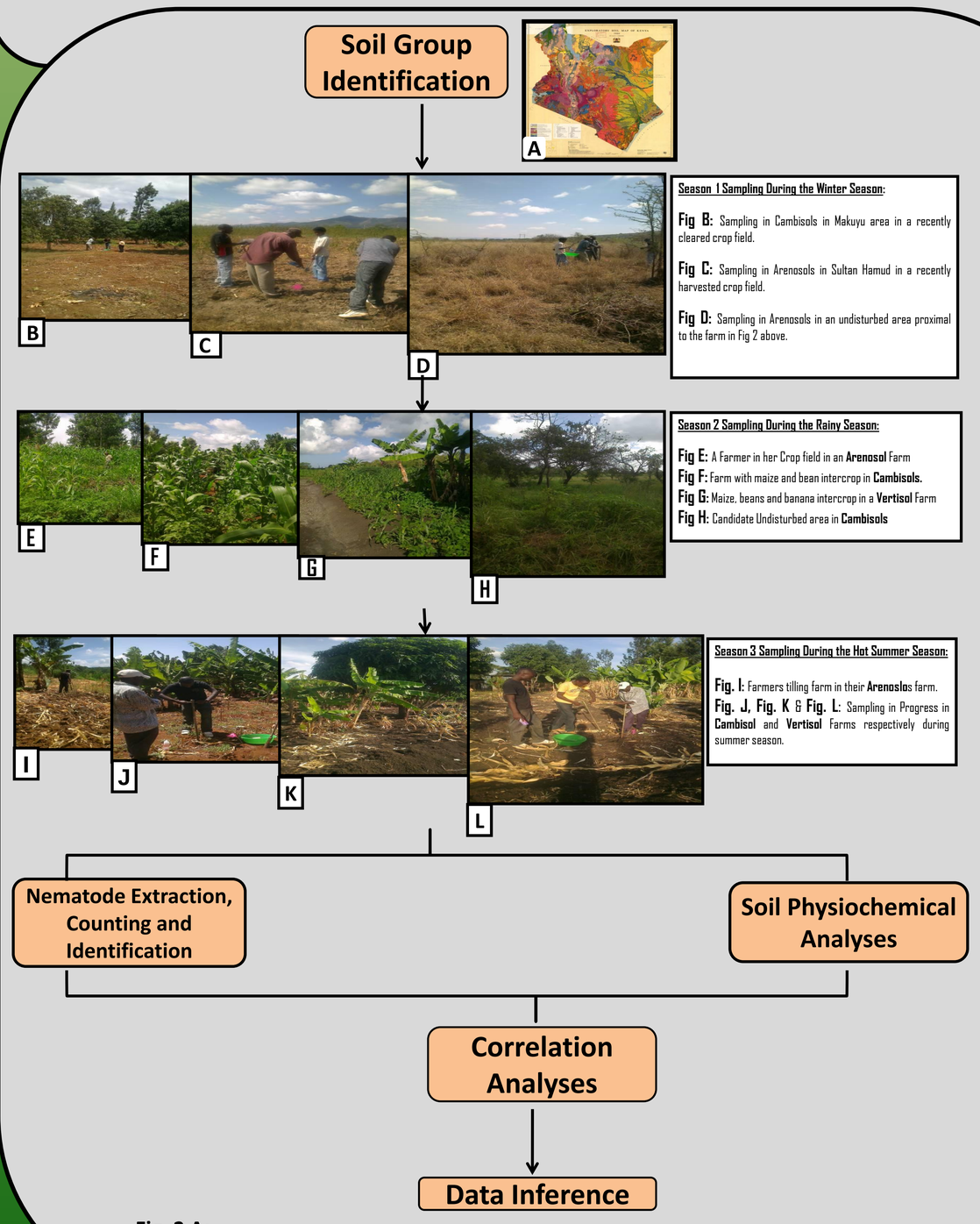

Fig. 2 A: Exploratory Soil map of Kenya indicating the various soil groups.

Fig. 2 B-L: Soil Sampling in the Vertisols, Cambisols and Arenosols in different regions under different disturbance levels in Kenya

Results

1. ph, soil temperature and organic matter, Nitrogen and available NH_4^+ and NO_3^-P, Ca , Mg, Soil texture was Relatively Variable across the Soil groups, Seasons, Regions and Disturbance levels depending on each soil parameter as in **Fig. .3**
2. Omnivores and predators increased when SOM, C and Mg increased. Fungivores decreased when SOM, C and Mg increased and decreased when K^+, pH and NO_3^- increased. Predators, omnivores and herbivores increased with decreases in P and NH_4^+. Omnivores decreased when NH_4^+ increased. Furthermore, herbivores increased when Ca^{2+} and N increased and decreased when K^+, NO_3^- and pH increased. Predators and Omnivores occupied similar niches while fungivores and bacterivores were found in closely similar conditions as in Fig. 4. An increase in K and NH_4^+ caused an increase in numbers of *Hoplolaimus*, *Hemicycliophora, Tylenchus and Eucephalobus* spp. while an increase in soil pH and available P influenced the occurrence of *Plectus, Cervidellus* and *Tylenchorrynchus* spp. An increase in total N and SOM positively influenced the occurrence of *Scutellonema, Helicotylenchus, Longidorus, Xiphinema* and *Criconemella, Dorylaimoides, Labronema and Discolaimoides* spp. as in Fig. 5
3. Season 2 had a significantly highest maturity index followed by Season 3 and Season 1 had the lowest. The northern region had significantly higher maturity index (MI 2-5) than the southern region. It was also observed that the natural (undisturbed) soils had significantly higher maturity indices (MI, Σ MI, MI2-5, ΣMI2-5) and FI compared to disturbed soils as in **Table 1.** The BI in both Season 1 and Season 3 was significantly higher than in Season 2. The EI in Season 1 and Season 2 were significantly higher than in Season 3. In addition, the SI was highest in Season 2 and lowest in Season 1. Significant differences were observed in the BI, EI and SI between the Northern and Southern sites. The Northern sites had significantly higher EI and SI compared to the Southern sites. The Southern sites had a significantly higher BI than the Northern sites. The natural (undisturbed) soils had a significantly higher SI compared to the disturbed soils. Conversely, the disturbed soils had a significantly higher BI than the natural soils as in Table 2.
4. Natural soils in both Northern **(Fig. 6 C)** and Southern **(Fig. 6 A)** sites were better structured and less exhausted while the disturbed soils in the South **(Fig. 6 B)** revealed to be more nutrient deficient, stressed and unstructured compared to the disturbed soils in the North **(Fig. 6 D)**. The natural Arenosols **(Fig. 7 A)**, Cambisols **(Fig. 7 C)** and Vertisols **(Fig. 7 E)** had better structure and enrichment compared to Arenosols **(Fig. 7 B)**, Cambisols **(Fig. 7 D)** and Vertisols **(Fig. 7 F)** under cultivation. Natural soils retained their structure across the seasons better than the disturbed soils. It was noted that in the disturbed soils, the structure and enrichment improved from Season 1 **(Fig. 8 B)** to Season 2 **(Fig. 8D)** and then both declined in Season 3 **(Fig. 7 F)**.

Assessment of Edaphic Parameters

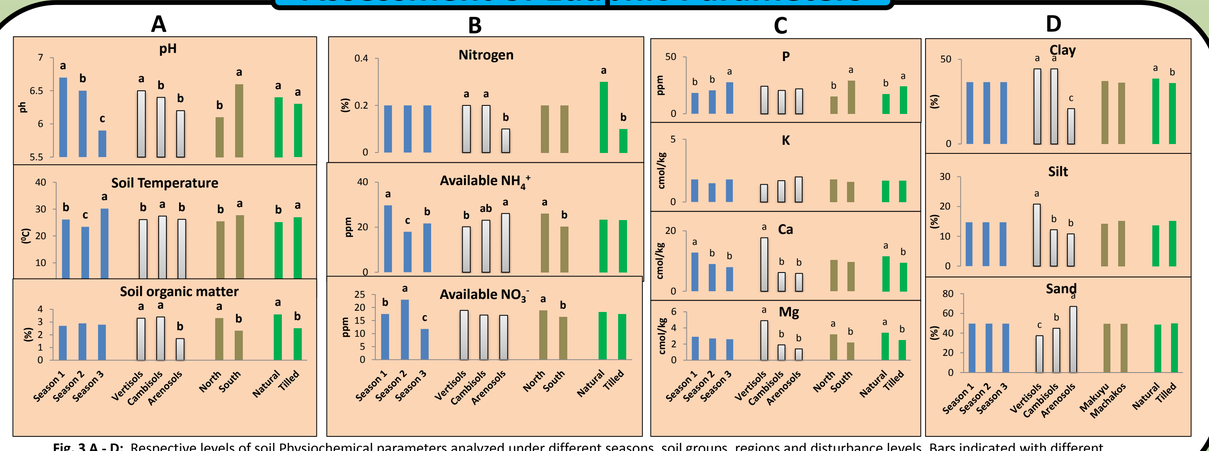

Fig. 3 A - D: Respective levels of soil Physiochemical parameters analyzed under different seasons, soil groups, regions and disturbance levels. Bars indicated with different letters indicate significantly different means at $p < 0.05$.

Nematode and Soil Correlations

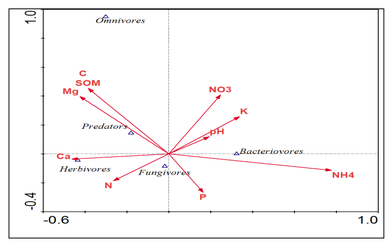

Fig. 4. *Detrended canonical correspondence analysis (DCCA) ordination diagram showing relationship between nematode feeding groups and soil characteristics (Mg, SOM, C, NO_3^-, K, NH_4^+, P, N, Ca)*

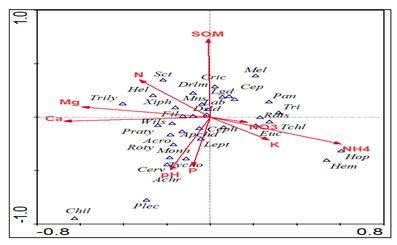

Fig. 5. *Detrended canonical correspondence analysis (DCCA) ordination diagram showing the occurrence of different nematode genera in relation to soil characteristics (Mg, SOM, C, NO_3^-, K, NH_4^+, P, N, Ca).* (**Hop**-*Hoplolaimus*, **Hem**-*Hemicyclophora*, **Euc**- *Eucephalobus*, **Tchl**- *Tylenchus*, **Mel**- *Meloidogyne*, **Pan**-*Panagrolaimus*, **Tri**- *Trichodorus*, **Rdts**- *Rhabditis*, **Sct**- *Scutelonema*, **Cric**-*Criconemella*, **Cep**- *Cephalobus*, **Lgd**- *Longidorus*, **Lab**- *Labronema*, **Drlm**-*Dorylaimodes*, **Mns**- *Monhysteridae*, **Dsld**- *Discolaimoides*, **Hel**- *Helicotylenchus*, **Trily**- *Trichotylenchus* ,**Xiph**- *Xiphinema*, **Fil**- *Filenchus*, **Wils**- *Wilsonema*, **Praty**-*Pratylenchus*, **Chil**- *Chiloplacus*, **Plec**- *Plectus*, **Achr**- *Achromadora*, **Cerv**-*Cervidellus*, **Tycho**- *Tylenchorhynchus*, **Monh**- *Monhystera*, **Roty**- *Rotylenchus*, **Lept**- *Leptonchus* and **Apchd**- *Aphelenchoides* spp.)

Soil Ecological Indices

Table 1. *Effects of different soil groups, seasons, sites and disturbance levels on ecological disturbance indices of nematodes*

Variables		PPI	MI	MI2-5	ΣMI	ΣMI2-5	FI
Soil Group	Vertisols	2.5	2.0	2.1	2.3	2.4	1.2[b]
	Cambisols	2.6	2.0	2.1	2.3	2.4	1.3[a]
	Arenosols	2.5	2.1	2.2	2.0	2.3	1.2[b]
Seasons	Season 1	2.5	1.9[b]	2.1 [b]	2.2[b]	2.3[b]	1.3
	Season 2	2.6	2.1[a]	2.2[a]	2.3[a]	2.4[a]	1.3
	Season 3	2.5	2.0[ab]	2.1[ab]	2.3[a]	2.4[ab]	1.2
Sites	North	2. 6	2.0	2.2[a]	2.2	2.4	1.3
	South	2.5	2.0	2.1[b]	2.3	2.3	1.3
Disturbance	Natural	2.6	2.2[a]	2.4[a]	2.4[a]	2.5[a]	1.2[b]
	Disturbed	2.5	1.9[b]	2.1[b]	2.2[b]	2.37[b]	1.3[a]

PPI: plant parasitic index, **MI:** maturity index, **MI2-5:** maturity index of c-p 2-5, **ΣMI:** sum of maturity index, **ΣMI2-5:** sum of maturity index of c-p 2-5 under each ecological index. Means followed by different letters within soil groups, regions and soil status in each season, region and nature of soil are significantly different at $P < 0.05$.

Soil Food Web Indices

Table 2. *Effect of different soil groups, seasons, sites and disturbance levels on soil nematode food web indices and nutrient cycling.*

Variables		BI	EI	SI
Soil Group	Vertisols	54.81	33.24[a]	23.51
	Cambisols	55.90	33.78[a]	21.25
	Arenosols	58.18	27.50[b]	22.66
Seasons	Season 1	57.29[a]	34.43[a]	14.80[c]
	Season 2	49.49[b]	34.97[a]	30.96[a]
	Season 3	62.19[a]	25.00[b]	21.71[b]
Sites	North	46.57[b]	41.62[a]	26.68[a]
	South	66.29[a]	21.06[b]	18.16[b]
Disturbance levels	Natural	46.36[b]	30.29	39.63[a]
	Disturbed	59.74[a]	31.91	16.54[b]

Means followed by superscripts indicate significantly different indices at $P < 0.05$. Where BI= Basal index, EI = Enrichment index and SI = Structural index

Soil Food Web Structure

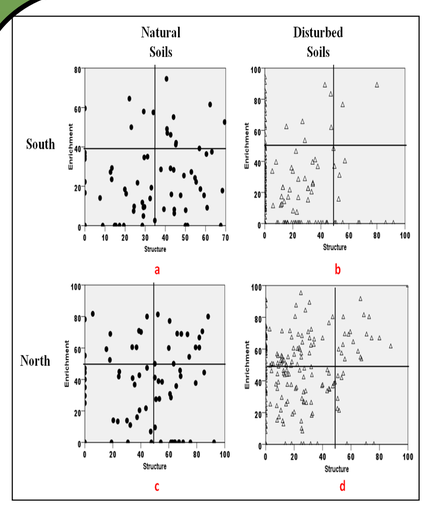

Fig. 6: Soil food web structure in natural (**a** & **c** [●]) and disturbed (**b** & **d** [Δ]) soils in the Southern and Northern sites

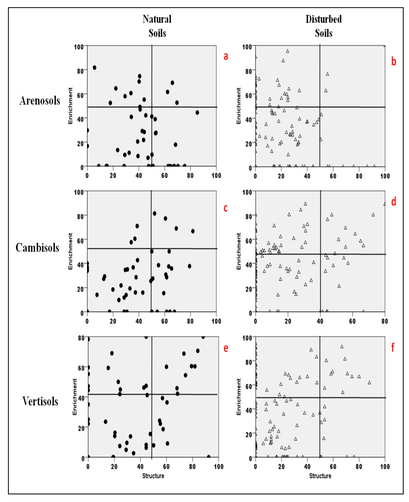

Fig. 7: Soil food web structure in natural (**a, c** & **e** [●]) and disturbed (**b, d** & **f** [Δ]) soils in **Arenosols, Cambisols** and Vertisols soils groups

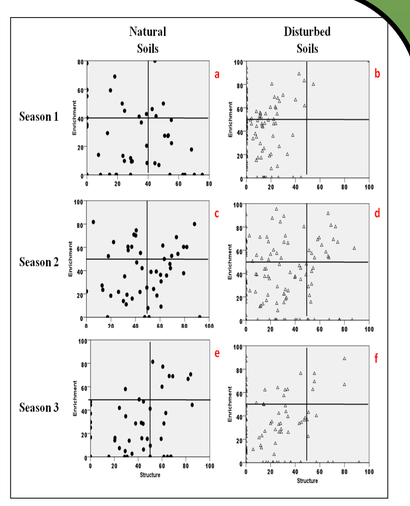

Fig. 8: Soil food web structure in natural (**a, c** & **e** [●]) and disturbed (**b, d** & **f** [Δ]) soils in seasons 1, 2 and 3.

Conclusions

1. Different seasons, soil groups, sites and disturbance levels have their variable significant influences on the relationship between soil nematode communities and soil properties in their respective ecosystems. Cambisols, natural soils, moisture presence and active root growth that occurred in Season 2 and soils in the northern sites, favored high diversity and abundance of nematodes.
2. data indicate by the nematode soil food web condition, Cambisols and Vertisols possess better agricultural potential than Arenosols although all the three soil groups should receive equal attention to address their fragile condition.
3. It was thus established that nematodes could be effectively utilized to assess soil degradation and soil health status as reliable bioindicators.

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