



Research Article

Response of Soil Nematode Communities to Zero-Tillage Weed Control Practices

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Abstract | Fluctuations in abundance of soil nematodes have extensively been used to predict adverse effects of anthropogenic activities on soil biodiversity. The objective of this study was to select the more promising zero-tillage weed control (ZWC) strategy that will have beneficial solutions in addition to sustain soil biodiversity better. Variation in densities of diverse soil nematodes across plots, which were subjected to different ZWC approaches, was assessed and analyzed. Both systemic glyphosate and non-systemic paraquat significantly reduced densities of soil nematodes, similar to the way 'weeding by zero-tillage' did. Moreover, treatments involving glyphosate alone, paraquat alone, 'glyphosate + paraquat' and 'weeding by zero-tillage' significantly suppressed plant parasitic nematodes across plots. Root-knot nematodes (i.e., *Meloidogyne* spp.) were more suppressed in plots, where each of the four ZWC strategies was applied. However, paraquat alone or 'glyphosate + paraquat' in plots significantly reduced densities of *Pratylenchus* species better than glyphosate alone or 'weeding, using a cutlass' could achieve. Considering the suppressed diverse feeding groups of nematodes in plots, none of the ZWC practices showed the likelihood to sustain soil biodiversity. Nonetheless, foliar applications of weedicides on weeds appeared to be beneficial in suppressing more genera of plant root-damaging nematodes than 'weeding, using a cutlass' could achieve. Overall, ZWC practices modulated soil nematode communities in the field.

Received | November 2024; **Accepted** | February 09, 2025; **Published** | April 09, 2025

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Citation | Heve, W.K. and I.D. Otabil. 2025. Response of soil nematode communities to zero-tillage weed control practices. *Pakistan Journal of Nematology*, 43(1): 50-60.

DOI | <https://dx.doi.org/10.17582/journal.pjn/2025/43.1.50.60>

Keywords | Zero-tillage weed control, Soil nematode feeding groups, Sedentary endoparasitic nematodes, Migratory endoparasitic nematodes, Migratory ectoparasitic nematodes, Weedicides



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Introduction

Weedicide usage is widespread across Ghana (Obiri *et al.*, 2021; Ansah *et al.*, 2023). People use them to control weeds and bushes in residential and agricultural landscapes, largely because weedicides have been perceived by majority of the

users to be cheaper than cost of labour (Obiri *et al.*, 2021; Ansah *et al.*, 2023). Selective weedicides are largely used by Ghanaian farmers for 'post-planting' weed control in cultivated fields of maize, rice and vegetables, among others (Obiri *et al.*, 2021; Addai *et al.*, 2022). However, these farmers often prefer using non-selective weedicides for suppression of weeds in

their plantations in Ghana (Ansah *et al.*, 2023).

Weedicides have been observed for contributing to significantly increase yields of cultivated rice and maize in the field (Addai *et al.*, 2022; Lukangila *et al.*, 2024). Nonetheless, the surge in indiscriminate application of weedicides by Ghanaian farmers to control weeds on surface of agricultural soils can be environmentally detrimental to biodiversity (Addai *et al.*, 2022; Ansah *et al.*, 2023). Thus, these farmers need to adopt better approaches to judiciously use weedicides in landscapes. Unfortunately, studies on side effects of weedicides on soil health to suggest environmentally-friendly alternative weed control practices to farmers are lacking in Ghana. Such studies are required because similar several useful suggestions by Bach *et al.* (2020) have aimed at managing agricultural fields in such a way that farmland use practices, including weed control, should maintain biodiversity and soil health. The latter often integrates numerous bio-based solutions for sustainable soil productivity to achieve the majority of the United Nation's goals in the future (Bach *et al.*, 2020). As a result, soil health status of zero-tillage systems at geographical locations has been examined and predicted using earthworms and nematodes, among others, as soil-borne bio-indicating invertebrates (Ara Khanum *et al.*, 2022; Pires *et al.*, 2023; Young and Unc, 2023; Bartz *et al.*, 2024).

To large extent, activities of soil-dwelling earthworms have contributed to soil fertility, effective functioning, biodiversity, improved ecosystem services and worldwide food production (Blouin *et al.*, 2013; Kumar *et al.*, 2021; Fonte *et al.*, 2023). However, nematode biodiversity largely emanates from the fact that, for any organism that exists on the Earth at any trophic levels, there is a group of nematodes that will specifically feed on it (Hossain *et al.*, 2016; Fourie *et al.*, 2017; Heve, 2021). As a result, there are numerous feeding groups of soil-borne nematodes, which include bacterivorous, fungivorous, herbivorous, protoctivorous, algivorous, predatory and insectivorous groups, among others (Hossain *et al.*, 2016; Fourie *et al.*, 2017; Heve, 2021). Hence, nematodes are very diverse in terms of feeding groups, making them to be a better soil health bio-indicator under varying environmental conditions (Ara Khanum *et al.*, 2022; Pires *et al.*, 2023; Young and Unc, 2023).

Conventional tillage practices, which disturb

soil structure, adversely affect persistence of entomopathogenic nematodes and microarthropods in soil ecosystem (Millar and Barbercheck, 2002; Dubie, 2010; Campos-Herrera, 2015). Moreover, sufficient soil organic matter due to cover crops enhances abundance and activities of entomopathogenic nematodes and soil microbial invertebrates (Marquez, 2017; Blanco-Pérez *et al.*, 2022). In effect, previous studies have used soil nematode communities and composition to predict influence of climate change and anthropogenic factors on soil ecosystems in cropped fields (Wang *et al.*, 2019, 2022; Mokuah *et al.*, 2023). Although zero-tillage weed control (ZWC) practices mostly sustain soil ecosystem to be stable in the field (Wardak *et al.*, 2022), we hypothesized that abundance of naturally-occurring diverse groups of soil nematodes will adversely be affected in plots where ZWC has been adopted. Therefore, the objective of this study was to examine any short-run side effects of different ZWC approaches on soil nematode biodiversity across agricultural plots. The results of the current study will provide documented evidence for further research or for developing strategies that will better conserve soil biodiversity in the future.

Materials and Methods

Experimental site

This experiment was carried out in a field (geographical coordinate = 6°03'02" N, 0°00'15" W; altitude = 70.35 m), which is within the premises of the University of Environment and Sustainable Development, in the Yilo Krobo municipality of Eastern Region, Ghana. From 26th August to 20th September, 2024, during which the field trial was done, the measured daily mean temperatures ranged from 23 to 29 °C, whereas observed precipitation in the period was 197 mm. According to Owoade *et al.* (2021), the dominant soils in Yilo Krobo Municipal are calcic vertisols, which have high clay content, ranging from 32 to 41% (Baidoo *et al.*, 2024).

Pre-weed control treatment to the study field

The study field had been fallowed for at least 10 years. Bushy grasses and short shrubs present at the site were cleared close to the ground, using a cutlass for zero-tillage method, which maintained topsoil structure. On the third day following the day weeds were cleared, all mulches or plant residues were removed to allow weeds to regenerate and develop for a month in the study field. After removing the

mulches on the third day, the weeded study field was divided into five (5) plots in such a way that each plot had surface area of 7.3 x 20.8 m², which is equivalent to 1.52 centihectare (cha).

Zero-tillage weed control treatments across plots

Nwura nwura[®] and Gramosun[®] were locally-registered weedicides used for field treatments in this study. *Nwura nwura* contained 360 gL⁻¹ of glyphosate in soluble liquid (SL) form, whereas Gramosun had 480 gL⁻¹ paraquat in SL form. These two weedicides were applied to control growing weeds in three (3) out of five (5) plots on the 26th of August, 2024. Using a 15-litre knapsack sprayer, *Nwura nwura* (which had glyphosate) was applied, according to the manufacturer's recommended application rate (200 mL ha⁻¹), to control growing weeds in the first plot. Using a separate 15-litre knapsack sprayer, Gramosun (which had paraquat) was applied at the manufacturer's recommended application rate (200 mL ha⁻¹) to control growing weeds in the third plot. Both *Nwura nwura* and Gramosun were mixed in ratio 1:1 into a clean 15-litre knapsack sprayer, and then applied to control growing weeds in the second plot that was between the first and the third plots. In the fourth plot, growing weeds were maintained to develop. The fifth plot was weeded very close to the ground, using a cutlass, which did not loosen topsoil structure. The zero-tillage weed control (ZWC) treatments in the first, second, third and fifth plots represent common practices among farmers in Ghana. All treatments across plots were allowed to act for four (4) weeks before soil sampling was done.

Random soil sampling

On 20th September, 2024, a soil auger sampler was screwed into the ground up to 20 cm depth in such a way that about 300 g of a sub-sample of soil was fetched into the core of the sampler. Using the zig-zag soil sampling technique described by Heve *et al.* (2015a) for soil nematode analysis, five (5) sub-samples (each was about 300 g) were randomly taken from different spots in a plot (i.e., 1.52 cha). These sub-samples were pooled to make about 1.5 kg of a bulk soil sample. However, from each plot, three (3) of such similar bulk soil samples were taken for nematode extraction.

Actively-motile nematode extraction from bulk soil samples

Each bulk soil sample in a white polythene bag was

thoroughly homogenized by agitating it. Actively-motile live nematodes were extracted from 200 mL of each of these bulk soil samples, using the modified Baermann funnels, which were set up to extract motile nematodes over four (4) days (OEPP/EPPO, 2013; Tintori *et al.*, 2022).

Nematode diagnostics and quantification

The individual nematodes belonging to the various feeding groups were identified in nematode suspensions under a microscope, using the morphological features of nematodes described in reports (Smart and Nguyen, 1988; Fourie *et al.*, 2017; Heve, 2021; Perry *et al.*, 2024). Moreover, actively-motile live plant-feeding nematodes were further identified to the genus level, using their morphological characteristics in reports (Smart and Nguyen, 1988; Fourie *et al.*, 2017; Heve, 2021; Perry *et al.*, 2024). The identified live nematodes in suspensions were counted under a microscope and then quantified in varying volumes of nematode suspensions, similar to the procedures used by Heve *et al.* (2015b).

Data analysis

R software [R.v.4.4.1 ~ RStudio.v. 2024.09.0-375] of the R Core Team (2024) was used for all statistical analyses. The mean ± standard errors (SE) of observations were estimated across nematodes groups and then presented in bar graphs. Normality of data was examined using Shapiro-Wilk test (Gotelli and Ellison, 2013). Because the p-value of Shapiro-Wilk test was ≤ 0.05 for each nematode group, Dunn's test was used to compare 'mean ± SE' values of data between varying treatments across plots (Gotelli and Ellison, 2013; Dinno, 2015).

Results

Diverse soil nematode communities belonging to specific feeding groups

Described observations (Figure 1) covered each of the soil nematode communities that feed on specific substrate(s). Thus, the analyzed data were for bacteria feeding nematodes (Figure 1A), omnivorous nematodes (Figure 1B), fungi feeding nematodes (Figure 1C), plant feeding nematodes (Figure 1D) and *Tylenchus* species that feed on protoctists, algae or mosses (Figure 1E). However, observations presented in Figure 1F were pooled data from Figure 1A-E.

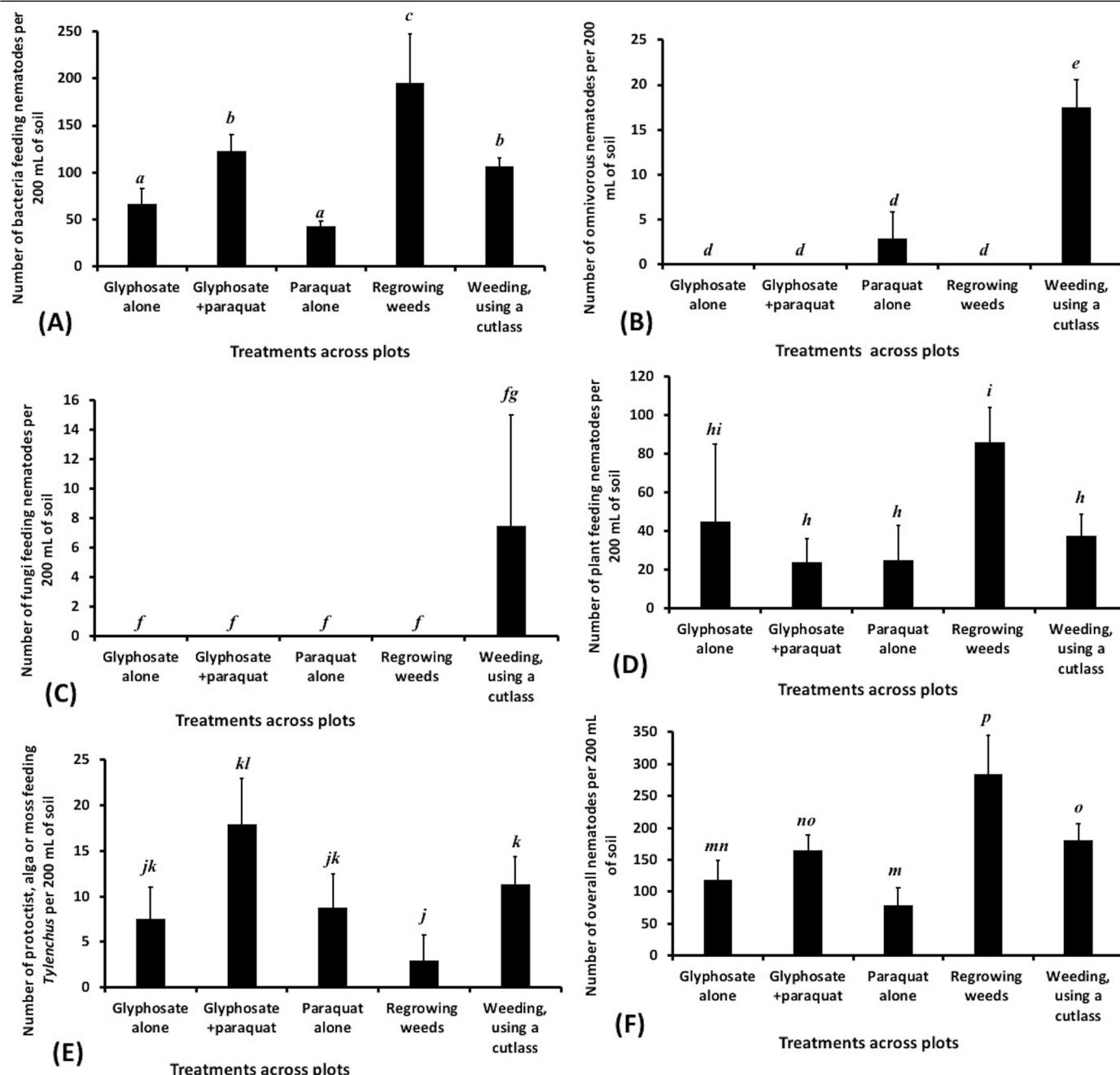


Figure 1: Feeding groups of diverse soil-borne nematode communities retrieved from 200 mL of soil samples taken from plots that had different treatments: (A) bacteria feeding, (B) omnivorous, (C) fungi feeding, (D) plant feeding, (E) protozoist, alga or moss feeding *Tylenchus*, and (F) total of all nematodes in soil samples from plots. Dunn's test at $P \leq 0.05$ showed that different italicized lowercase letters on top of bars in each of the images (A–F) denote significant difference in 'mean±SE' values of numbers of nematodes between treatments across plots.

Bacteria feeding nematodes across plots

In Figure 1A, italicized lowercase letters *a*, *b* and *c* on top of bars were used to compare mean±SE values of numbers of bacteria feeding nematodes (BFNs) between plots that had different treatments. The numbers of BFNs in soil samples from the plot that had glyphosate alone were similar to those observed in soil samples from the plot that had paraquat alone (Figure 1A). Similarly, the numbers of BFNs in soil samples from the plot that had 'glyphosate +

paraquat' were not significantly ($P > 0.05$) different from those observed in soil samples from the plot that had 'weeding, using a cutlass' (Figure 1A). However, the mean±SE- values of numbers of BFNs in soil samples from plots that had either 'weeding, using a cutlass', glyphosate alone, glyphosate + paraquat and/or paraquat alone were significantly ($P \leq 0.05$) lower than those observed in soil samples from the plot that had regrowing weeds (Figure 1A).

Omnivorous nematodes across plots

In Figure 1B, italicized lowercase letters *d* and *e* on top of bars were used to compare mean±SE values of numbers of omnivorous nematodes (OMNs) between plots that had different treatments. In fact, OMNs were observed in soil samples from plots that had either paraquat alone or 'weeding, using a cutlass' (Figure 1B). In effect, no OMNs were observed in soil samples from the remaining plots (Figure 1B).

Fungi feeding nematodes across plots

In Figure 1C, italicized lowercase letters *f* and *g* on top of bars were used to compare mean±SE values of numbers of fungi feeding nematodes (FFNs) between plots that had different treatments. Numbers of (FFNs) were only observed in soil samples from plot that had 'weeding, using a cutlass' (Figure 1C). Thus, no FFNs were observed in soil samples from the remaining plots (Figure 1C).

Plant feeding nematodes across plots

In Figure 1D, italicized lowercase letters *h* and *i* on top of bars were used to compare mean±SE values of numbers of plant feeding nematodes (PFNs) between plots that had different treatments. The 'mean ±SE' values of numbers of PFNs observed in soil samples from different plots that had glyphosate alone, 'glyphosate + paraquat', paraquat alone and 'weeding, using a cutlass' were similar (Figure 1D). Similarly, the numbers of PFNs in soil samples from the plot that had glyphosate alone were not significantly ($P > 0.05$) different from those observed in soil samples from plot that had 'regrowing weeds' (Figure 1D). Nevertheless, the numbers of PFNs in soil samples from plots that had paraquat alone, glyphosate ± paraquat, and 'weeding, using a cutlass', were significantly ($P \leq 0.05$) fewer than those observed in soil samples from the plot that had regrowing weeds (Figure 1D).

Tylenchus species that feeds on protoctists, algae or mosses

In Figure 1E, combinations of italicized lowercase letters *j*, *k* and *l* on top of bars were used to compare mean±SE values of numbers of *Tylenchus* species between plots that had different treatments. The numbers of *Tylenchus* species observed in soil samples from plots that had glyphosate alone, 'glyphosate + paraquat', paraquat alone and 'weeding by zero-tillage' were similar (Figure 1E). However, the numbers of *Tylenchus* species observed in soil samples from the plot that had 'regrowing weeds' was the lowest, when compared to the remaining plots (Figure 1E).

Overall nematodes pooled from all feeding groups

In Figure 1F, combinations of italicized lowercase letters *m*, *n*, *o* and *p* on top of bars were used to compare mean±SE values of numbers of overall nematodes (OVNs) between plots that had different treatments. The numbers of OVNs observed in soil samples from the plot that had glyphosate alone or paraquat alone were significantly ($P \leq 0.05$) lower than those observed in soil samples from the plot that had 'weeding, using a cutlass' (Figure 1F). However, the numbers of OVNs in soil samples from the plot that had 'glyphosate + paraquat' were not significantly ($P \geq 0.05$) different from those observed in soil samples from the plot that had 'weeding, using a cutlass' (Figure 1F). Similarly, numbers of OVNs observed in soil samples from the plots that had glyphosate alone were not significantly ($P \geq 0.05$) different from those observed in soil samples from the plot that had 'glyphosate + paraquat' (Figure 1F). Notwithstanding, the numbers of OVNs in soil samples from the plot that had 'regrowing weeds' were significantly ($P \leq 0.05$) the highest, when compared to the remaining plots (Figure 1F).

Diverse soil nematode communities belonging to genera of diagnosed plant feeding groups

Observations in Figure 2 covered soil nematode communities that feed on plants only. All pieces of information in Figure 2 were derived from Figure 1D. Consequently, the analyzed data were for the identified phytonematodes that belong to *Pratylenchus* (Figure 2A), *Meloidogyne* (Figure 2B), *Tylenchorhynchus* (Figure 2C) and *Amplimerlinius* (Figure 2D).

Migratory endoparasitic plant root-lesion nematodes belonging to Pratylenchus across plots

In Figure 2A, combinations of italicized lowercase letters *a*, *b* and *c* on top of bars were used to compare mean±SE values of numbers of *Pratylenchus* species between different treatments across plots. The 'mean ±SE' value of numbers of root lesion *Pratylenchus* species in soil samples from the plot that had paraquat alone was similar to that observed in soil samples from the plot that had 'glyphosate + paraquat' (Figure 2A). Also, the 'mean ±SE' values of numbers of *Pratylenchus* species observed in soil samples from the plots that had glyphosate alone, 'regrowing weeds' and 'weeding, using a cutlass' were similar (Figure 2A). However, the 'mean ±SE' value of numbers of *Pratylenchus* species in soil samples from the plot that had paraquat alone was significantly ($P \leq 0.05$) less than those observed

in soil samples from the plots that had glyphosate alone, 'regrowing weeds' and 'weeding, using a cutlass' (Figure 2A).

Sedentary endoparasitic root-knot nematodes belonging to Meloidogyne across plots

In Figure 2B, italicized lowercase letters *d* and *e* on top of bars were used to compare mean±SE values of numbers of *Meloidogyne* species between different treatments across plots. The numbers of second stage juveniles (J2) of root-knot nematodes (*Meloidogyne* spp.) observed in soil samples from the plots that had glyphosate alone, paraquat alone, 'glyphosate + paraquat' and 'weeding, using a cutlass' were similar (Figure 2B). Also, the numbers of J2 of *Meloidogyne* spp. observed in soil samples from the plot that had paraquat alone were not significantly ($P > 0.05$) different from those observed in soil samples from the plot that had regrowing weeds (Figure 2B). However, the 'mean ±SE' value of numbers of J2 of *Meloidogyne* spp. in soil samples from the plot that had regrowing weeds was significantly ($P \leq 0.05$) more than those observed in soil samples from plots that had glyphosate alone, 'glyphosate + paraquat' and

'weeding, using a cutlass' (Figure 2B).

Plant feeding migratory ectoparasitic nematodes belonging to Tylenchorhynchus across plots

In Figure 2C, italicized lowercase letters *f* and *g* on top of bars were used to compare mean±SE values of numbers of *Tylenchorhynchus* species between different treatments across plots. Few plant feeding nematodes belonging to *Tylenchorhynchus* were only observed in soil samples from the plot that had 'weeding, using a cutlass' (Figure 2C). Thus, no *Tylenchorhynchus* species was observed in soil samples from the remaining plots (Figure 2C).

Plant feeding migratory ectoparasitic nematodes belonging to Amplimerlinius across plots

In Figure 2D, italicized lowercase letters *h* and *i* on top of bars were used to compare mean±SE values of numbers of *Amplimerlinius* species between different treatments across plots. Few *Amplimerlinius* species were only observed in soil samples from the plot that had regrowing weeds (Figure 2D). Hence, no *Amplimerlinius* spp. were observed in soil samples from the remaining plots (Figure 2D).

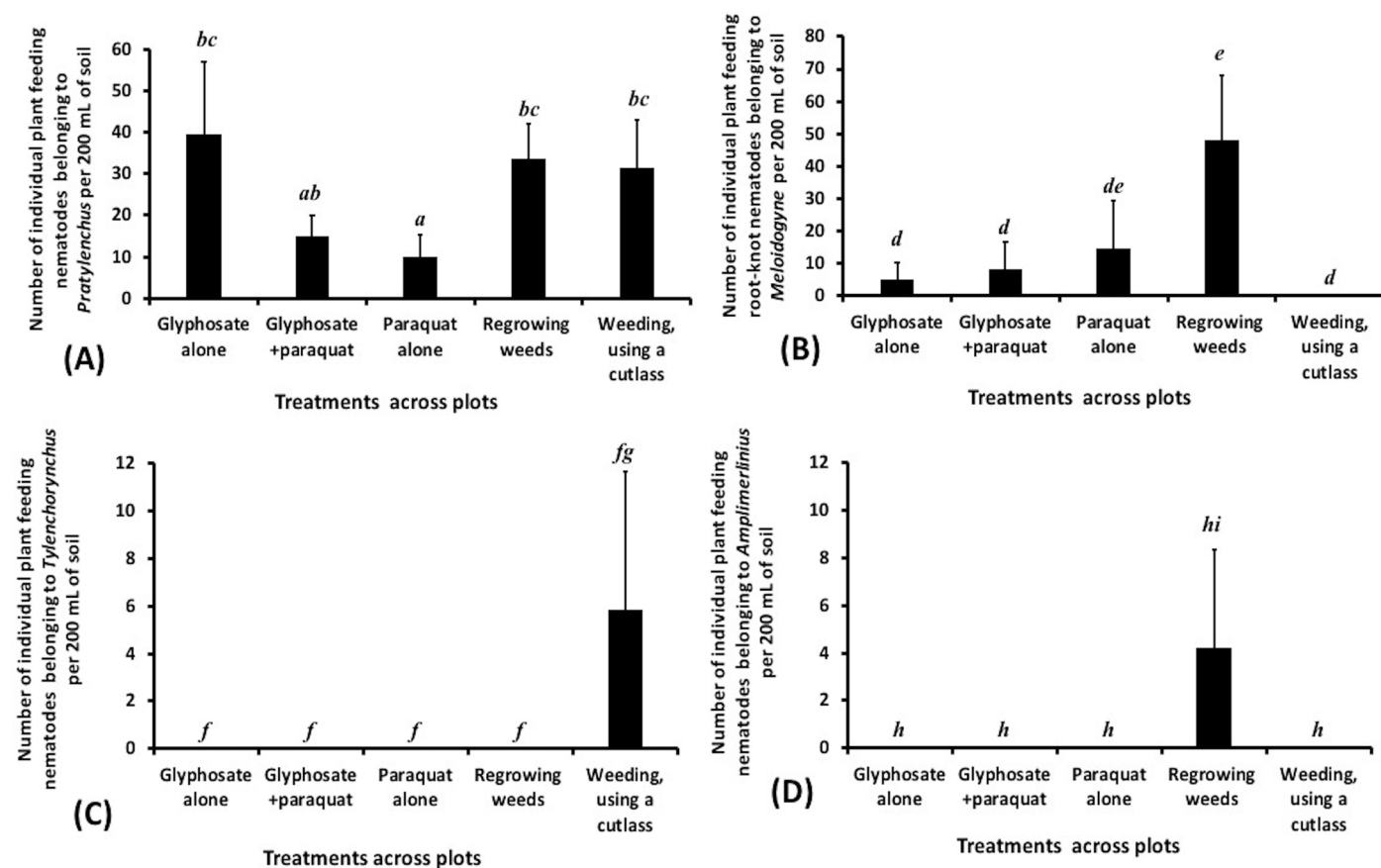


Figure 2: Soil-borne communities of plant feeding nematodes that belong to the genus: (A) *Pratylenchus*; (B) *Meloidogyne*; (C) *Tylenchorhynchus*; (D) *Amplimerlinius*. According to Dunn's test at $P \leq 0.05$, different italicized lowercase letters on top of bars in each of the images (A–D) represent significant difference in 'mean ±SE' values of numbers of nematodes between treatments across plots.

Discussion

Likely adverse effects of zero-tillage weed control treatments on food resources of soil nematode communities

Plant roots are known for stimulating diverse root-colonizing microorganisms (Beauregard, 2015; Gentry *et al.*, 2021). In effect, vegetation cover on soil surface mostly enhances high amount of diverse soil microorganisms, which include bacteria, protoctists, fungi, rotifers, ribbon worms and nematodes, among others (Zhou *et al.*, 2024). These soil microbes, soil-dwelling arthropods and plant roots, among others in the field are potential food resources that support survival and persistence of diverse feeding groups of soil nematode communities in soil ecosystems (Fourie *et al.*, 2017; Blanco-Pérez *et al.*, 2022; Perry *et al.*, 2024). In the current study, amount of measured rainfall at the study site showed that soils across plots had mesic conditions to satisfactorily support survival of the various feeding groups of soil nematode communities. Nonetheless, after applying different zero-tillage weed control (ZWC) treatments, we observed that abundance of bacteria feeding, omnivorous, protoctist-feeding, fungi-feeding and plant feeding nematodes differentially varied across plots. Possibly, the ZWC treatments, which controlled weeds in plots, could significantly reduce potential soil-borne food resources for the various feeding groups of soil nematodes at the study site.

Foliar applications of salicylic acids, 2,6-dichloro-isonicotinic acid, acibenzolar-*s*-methyl or isotianil trigger systemic resistance in plant root systems against soil-borne pathogenic bacteria and fungi, among others (Bektas and Eulgem, 2015; Conrath *et al.*, 2015; Faize and Faize, 2018; Tripathi *et al.*, 2019). Moreover, the use of synthetically-produced salicylic acids for drenching soil often elicits systemic resistance in plant roots against diverse plant root-damaging microbes in soil ecosystems (Bektas and Eulgem, 2015; Faize and Faize, 2018; Tripathi *et al.*, 2019). Possibly, foliar application of weedicides to control weeds in plots might induce systemic inconveniences that could reduce abundance of bacteria, fungi and other microbes, which are food resources to bacteria-feeding, fungi-feeding, protoctist-feeding, omnivorous and predatory nematodes, among others.

Of course, root systems of weeds are food resources to numerous groups of plant root feeding nematodes in the field (Perry *et al.*, 2024). Consequently, diverse

groups of nematodes often colonize weeds in either cultivated farmlands or uncultivated fields (Archidona-Yuste *et al.*, 2018; Asiedu *et al.*, 2019). Therefore, the use of ZWC treatments to suppress weed growth in the field will obviously reduce quantity of root systems of weeds, which are potential food resources to plant root-feeding nematodes, in soil ecosystems.

Implication for lack of sustaining soil biodiversity

Soil nematodes are largely diverse in soil ecosystems, thereby forming numerous communities (Smart and Nguyen, 1988; Fourie *et al.*, 2017; Heve, 2021; Perry *et al.*, 2024). Consequently, their abundance, survivability and persistence have often been integrated into nematode-based soil ecosystem models that generate numerous ecological parameters (Wang *et al.*, 2019, 2022; Liu *et al.*, 2021; Preez *et al.*, 2022; Mokuah *et al.*, 2023). Some of the parameters, which are often used for predicting unfavorable changes in soil environment, include soil enrichment index, channel ratio and structural trajectory, among others (Wang *et al.*, 2022; Preez *et al.*, 2022; Mokuah *et al.*, 2023). The enrichment index is used to predict soil nutrient quality status, whereas channel ratios are used to determine whether decomposition of organic matter in soil environment at a given location is dominantly due to bacteria or fungi (Wang *et al.*, 2019, 2022; Liu *et al.*, 2021; Preez *et al.*, 2022; Mokuah *et al.*, 2023). Structural index becomes very important in predicting the degree of stresses on diverse soil organisms during food web cycling of organic matter into nutrients in soil ecosystems (Liu *et al.*, 2021; Wang *et al.*, 2022; Preez *et al.*, 2022; Mokuah *et al.*, 2023). Some of the causes of the stresses on soil nematode communities often include application of soil tillage techniques and agrochemicals in agricultural fields (Alasmay *et al.*, 2020; Pothula *et al.*, 2022). In this study, we observed a differential decline in abundance of soil nematode communities in plots that had different zero-tillage weed control (ZWC) treatments. Thus, the suppression of soil nematodes could be an indication that the ZWC treatments might have increased level of stresses (or disturbances) on soil living things in plots, to some extent. In effect, none of the ZWC strategies can sustain soil biodiversity.

Short-run beneficial effects of zero-tillage weed control treatments against plant root-feeding nematodes in the field

In this study, 'weeding a plot, using a cutlass effectively suppressed *Meloidogyne* and *Amplimerlinius* species.

Foliar application of glyphosate alone on weeds in a plot was effective in reducing abundance of *Meloidogyne*, *Tylenchorhynchus* and *Amplimerlinius* species. Nonetheless, foliar application of either paraquat alone or 'glyphosate + paraquat' on weeds in the field was effective in suppressing *Pratylenchus*, *Meloidogyne*, *Tylenchorhynchus* and *Amplimerlinius* species. Thus, the use of weedicides for zero-tillage weed control (ZWC) treatments in plots appeared to suppress more genera of plant root-feeding nematodes in the field than 'using a cutlass for a ZWC treatment' could achieve. Difference in the mode of action between systemic glyphosate and non-systemic paraquat mostly causes a variation in the performance of weedicides against weed growth in the field (Tzvetkova *et al.*, 2019). Moreover, Adegaye *et al.* (2023) recently observed that non-systemic paraquat effectively suppressed soil microbial activities better than the systemic glyphosate could do. In this case, our observation in the current study was in agreement with the report of Adegaye *et al.* (2023). This is because foliar application of either paraquat alone or 'glyphosate + paraquat' on weeds suppressed more genera of plant-parasitic nematodes in the field, whereas the remaining ZWC treatments suppressed fewer genera of plant parasitic nematodes in this study.

Conclusions

Systemic glyphosate, non-systemic paraquat and 'weeding by zero-tillage' significantly reduced densities of soil nematodes in similar manner. Moreover, these zero-tillage weed control (ZWC) techniques, employed in the current study, significantly suppressed plant parasitic nematodes across plots. Sedentary endoparasitic root-knot nematodes (i.e., *Meloidogyne* spp.) were more controlled across plots by all the ZWC strategies. However, treatments involving paraquat alone or 'glyphosate + paraquat' suppressed more genera of plant-feeding nematodes better than the use of glyphosate alone or 'weeding, using a cutlass' could achieve in the field.

Acknowledgement

Authors are thankful to the University of Environment and Sustainable Development (UESD) for access to the University's laboratory facilities for this study.

Novelty Statement

This study demonstrates that although zero tillage weed control (ZWC) practices hardly disturb soil ecosystem, they modulate soil nematode biodiversity, which is used as bio-indicators to monitor adverse influences of climate change and anthropogenic activities on soil environment at any geographical locations.

Author's Contribution

William K. Heve (PhD) conceptualized the study, supervised the collection of data, diagnosed the various groups of soil nematodes in suspensions, analyzed the data using R software, wrote the manuscript and carefully edited it for publication. Isaac D. Otabil carried out the experiments in plots, collected soil samples and then used the modified Baermann funnel method to extract diverse soil nematodes from soil samples in to suspensions, under the auspices of William K. Heve (PhD).

Funding

This study received no grant and no support from any commercial institutions, funding agencies in the not-for-profit, or public sector. Nonetheless, the first author contributed his small resources to fund this study.

Human and animal rights

Authors did not use animals or humans as objects for the study.

Conflict of interest

The authors declare that they have no conflicting interest.

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