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Abundance of Arthropods in Organic and Inorganic Soil Habitat for Soil Health Bioindicator

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Abstract
Inventory or ecological benchmarking of functional groups of arthropods is vital in the development of sustainable management systems that become the vanguard of soil health. This study used two methods of arthropods collection: soil and leaf sifting and pitfall trapping method across organic and inorganic soil habitat. Nine sites were randomly assigned in the organic and the inorganic production area. Kwik-Key Soil Dwelling Invertebrates Guide developed by University of Illinois and Introduction to the Identification of Insects and Related Arthropods by following series question of identifiable features of different soil arthropods were used for identification. There were 14 species collected using soil and leaf sifting method in organic soil habitat while 10 in inorganic soil habitat. For the pitfall trapping method, 11 and 8 in organic and inorganic soil habitat were collected, respectively. Across sites, pitfall trapping collected more arthropods species than soil and leaf sifting method. Different sampling methods collected had an inverse proportion of arthropods collection regardless of soil habitat. Almost all individual arthropods regardless of species were collected from pitfall trapping method, only a small proportion in the sifting method. This study further showed that more species can be collected from sifting method but in case of individual collection; pitfall trapping method is an advantage to use. Soil and leaf sifting method in organic soil habitat collected more diverse species than any other method used based on the result of Shanon and Simpson indices. There were almost similarities or overlapping in the community analysis of the species in all trapping methods and soil habitats.

Keywords: arthropods, organic soil habitat, inorganic soil habitat, pitfall trapping method, soil and leafsifting method, Shanon and Simpson indices.

Introduction

Whatever features it is, land use shifting is the leading reason to loss of soil biodiversity worldwide. Somehow, conservation of biodiversity in the soil is not much emphasis and its contribution to sustainable development is not much given attention. From forest to agricultural land use, there is a tremendous loss of biodiversity due to changes at the microhabitat which makes other components lose a chance to survive the shifting. This leads further to imbalances in many essential ecosystem functions.

Environmental problems in different forms can be dealt using fronts such as: (1) soil characterization through their hydrodynamics activities; (2) monitor available nutrients; (3)

changes in physical and chemical properties; (4) plant activity and nutrient status; (5) effect os soil microbial biomass; (6) plant productivity; and (7) sustainability of the system (Cardaso et al., 2013).

Soil quality is considered as one of the most important factors in sustainability (Sthanu, 2013). Thus, soil health/quality bioindicator is further studied which now carry variety of organisms and procedures. Enzymatic activities were found to be effective for the impacts of natural and anthropogenic activities in soil (Utubo and Tewari, 2014). Nematodes can also play many processes in agricultural and natural ecosystems like that of flow of energy and soil fertility maintenance (Ilieva-Makulec et al., 2014), biological pests control by infecting host cadaver (Dillman, 2013) and bioindicator of soil health (Mekonen et al., 2017).Moreover, nematodes importance in food web is also recognized (Wang and Hooks, 2011).Another bioindicator is the presence of weeds which can be linked to soil characteristics such as soil pH and texture or to soil management like saturation, nutrient status and compaction (Carlesi & Bàrberi (2017). In the insect world, Odonata species is very sensitive to environmental changes, Heteroptera, Plecoptera, and Ephemeroptera can adapt to many environmental situations, beetles can be used in changes in forests and agriculture, and Lepidoptera and Diptera are indicators of heavy metal (de Rocha et al., 2015). Microbial community can also respond to changes in the environment by adjusting its biomass, structure, and activity rates (Wani et al., 2017). However, it further depends on the soil and functions being investigated (Morugan-Coronado et al., 2013). Furthermore, microbes can be gone unheard in new cropping systems (Bakker, 2012).

Biodiversity in soils especially the arthropods could be used as bioindicator more than using direct measurement of soil property changes. Bioindicator is defined as organisms, its part, product, or collection of diverse species that can utilized as source of information about all or part regarding with the environment (Killham, 2002). Bioindicators are component in the whole complex system based on the collected ecological information. It will then provide scientific analysis that aims in using information to make inferences about the quality of the environment at the place under which investigation is done. They are related directly or indirectly to some factors or a complex of factors which they tend to indicate in the system. It includes the study of soil health which becomes the central study of bioindicator.

The vast soil masses could house variety of component that will serve to soil health bioindicator purposes. By just looking at the presence of these organisms, one can equate primarily to the health status of the soil. There are few studies recognize the efficiency of soil organisms as bioindicator of soil health knowing that these components are somehow location specific and different organisms may thrive in a certain biogeochemical domain. Hence, there is a need to recognize their contribution to soil fertility along with its conservation for future utilization.

Objectives

1. Determine the diversity of the species in organic and inorganic soil habitat through benchmarking and inventory of soil arthropods using two collecting method used.
2. Compare the abundance of the species among the established sampling sites in two production systems.
3. Calculate the diversity index and community similarity of the arthropods in organic and inorganic soil habitat.

Methodology

Area Delineation

The study was conducted as trial site in the National Soil and Water Resources Research and Development Center for Highland Pedo-Ecological Zone defined for its different land use, slope gradient, and soil type and where sampling universe was established.

Random Sampling

Random coordinate selection was employed in the field setting. Assigning of trapping method was done after area delineation in the sampling universe to avoid spatial autocorrelation.

Sampling Techniques

Two sampling techniques were used in the experiment. These were pitfall traps, and soil and litter sifting method, all are strategically located in the field for maximum potential in collecting soil arthropods both in micro and macro habitat.

Pitfall traps: Pitfall traps which were consisted of containers that was buried in the ground so that the rim of collecting containers were flushed to the surface of the ground primarily to collect ground dwelling arthropods. Trap volume was measured 450 mm, and the diameter of opening a minimum of 8 cm.Containers was put mesh sieve (25mm) to exclude small mammals and amphibians from entering the trap. After which, a hardened cloth was used to cover the above 2cm from the ground to allow nocturnal induced environment.

Soil and litter sifting:. Soil sample was collected from the field at standard size of 0.3m x 0.3m x 0.3m and then brought to the laboratory for intensive collection process. A large pan was used to sift soil sample through series of sieve below collecting tray to collect larger arthropods while microscope examination for smaller arthropods were employed.

Method of Collection

The traps were set prior to the experiment. Weekly visitation and collection of the trapped arthropods were done. This experiment lasted for 2 months during the fallowing period.

Arthropods Identification

The identification of arthropods was done at class and order level only using Kwik-Key Soil Dwelling Invertebrates Guide developed by University of Illinois (Meyer, 1994) and Introduction to the Identification of Insectsand Related Arthropods (Choate, 2003) by following series question of identifiable features of different soil arthropods were used.

Data analysis

The data were subjected to T-test to further determine the difference among sampling sites, trapping methods, and soil habitat. Arthropods diversity index was calculated using the Shanon and Simpson diversity index (while community similarity was following the equation of Sorenson's coefficient.

Shanon Index:

$$\sum_{i=1}^{s} Pi \ln Pi$$

Simpson Index:

$$\frac{1}{\sum_{i=1}^{s} Pi2}$$

Sorenson's Coefficient:

$$\frac{2C}{S1 + S2}$$

Where C is the number of species the two communities have in common, S1 is the total number of species found in community 1, and S2 is the total number of species found in community 2.

Results and Discussion

Site Description

The soil was classified under Adtuyon clay loam subgroup of *Typic Kandiudults*. It is a soil that has undergone extensive leaching and accumulation of clays in the subsoil. It experiences sufficient moisture throughout the year, has low cation exchange capacity with andesite and basaltic rocks as parent material (BSWM, 2010).The area is situated 900 meters above sea level which further classify under highland pedo-ecological zone.

Inorganic production was planted with corn using conventional system of management. Twice cropping a year with four months of fallowing period from one cropping to another was practiced in the production site.

Recognized organic production site was used in this experiment which supported by the evidence after its conversion following the Philippine National Standards (PNS) from conventional to organic production system. The area was planted with varieties of semi-temperate vegetables strictly applied with organic inputs.

Total Number of Arthropod Species Collected

Fourteen species were collected using soil and leaf sifting method in organic soil habitat namely centipede (geophilomorpha), earwig (dermaptera), earthworm (haplotaxida), black carpenter ants (hymenoptera), soil mites (oribatida), black ground beetle (coleoptera), field crickets (orthoptera), white grub (coleoptera), fire ants (hymenoptera), cockroach (blattodea), millipede (polydesmida), springtails (collembola), termites (isoptera), and spider (aranea). For the pitfall trapping method in organic soil habitat, all were present as compare to the soil and leaf sifting method except the white grub, termite, and cockroach. There were ten species of arthropods collected using soil and leaf sifting methods from the inorganic soil habitat, namely centipede (geophilomorpha), earwig (dermaptera), earthworm (haplotaxida), black carpenter ants (hymenoptera), black ground beetle (coleoptera), field crickets (orthoptera), fire ants (hymenoptera), cockroach (blattodea), millipede (polydesmida), mites (orobatida), and spider (aranea). For pitfall trapping method in inorganic sites, eight species collected where spider and earthworm were absent relative to the soil and leaf sifting method. It was observed that soil mites, white grub, spider and springtails were among the species found in organic soil habitat and absent in inorganic soil habitat.

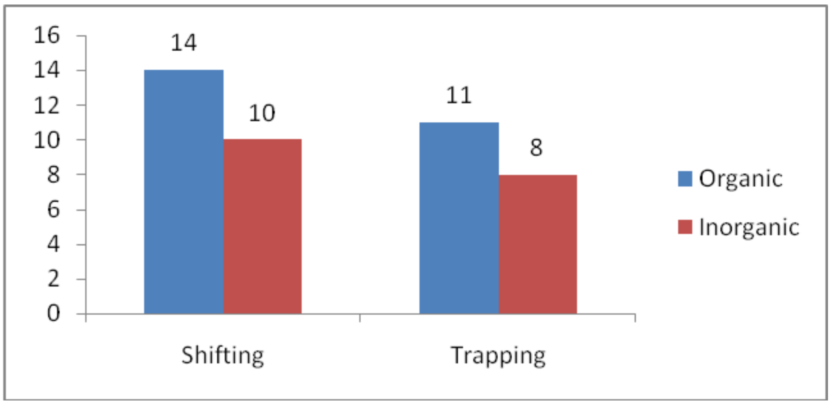

Fig. 1. Total number of arthropod species collected in organic and inorganic soil habitat of Adtuyon clay loam.

Community Similarity

In terms of the community analysis of arthropods species, Sorenson's coefficient was used which values ranges from 0 and 1. The closer the value to 1, the more the communities have in common in terms of species. Coefficient revealed that there were almost similarities or overlapping between organic and inorganic soil and litter sifting method, organic and inorganic pitfall trapping method, soil and litter sifting and pitfall trapping method in organic method and pitfall trapping method in inorganic methods.

Lowest value in the community analysis is between pitfall trapping method in inorganic and organic soil habitat while highest in soil and litter sifting and pitfall trapping method in inorganic soil habitat.

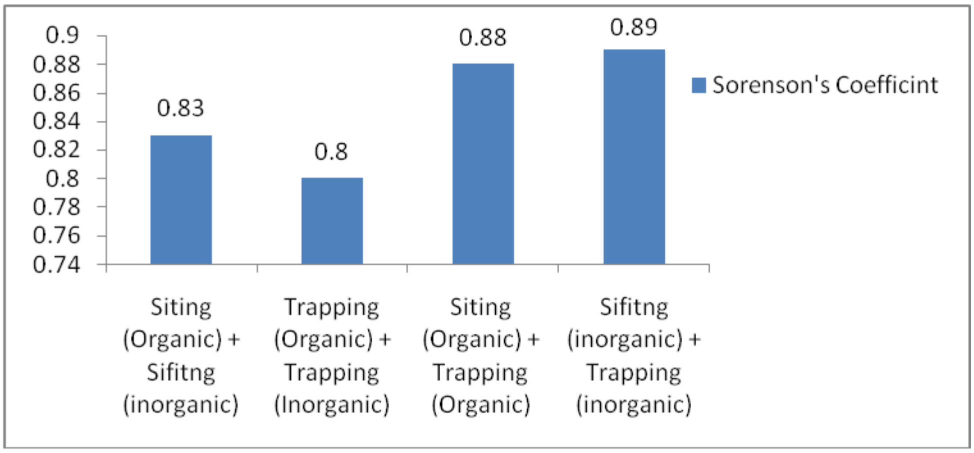

Fig 2. Community analysis of arthropod species collected in organic and inorganic soil habitat of Adtuyon clay loam using Sorenson's coefficient

Arthropods Collection across Sites

Across sites, pitfall trapping collected more arthropods species than soil and leaf sifting method. Higher arthropods species collected was found in organic than inorganic soil habitat. The same trend was observed in soil and leaf sifting method. There is no significant difference on the arthropods collected within sampling methods for organic and inorganic soil habitat. However, it was found that different sampling method has an inverse relationship on the arthropods collected which means the higher arthropod collected in pitfall trapping method, the lesser is the collection in the soil and leaf sifting method regardless of soil habitat.

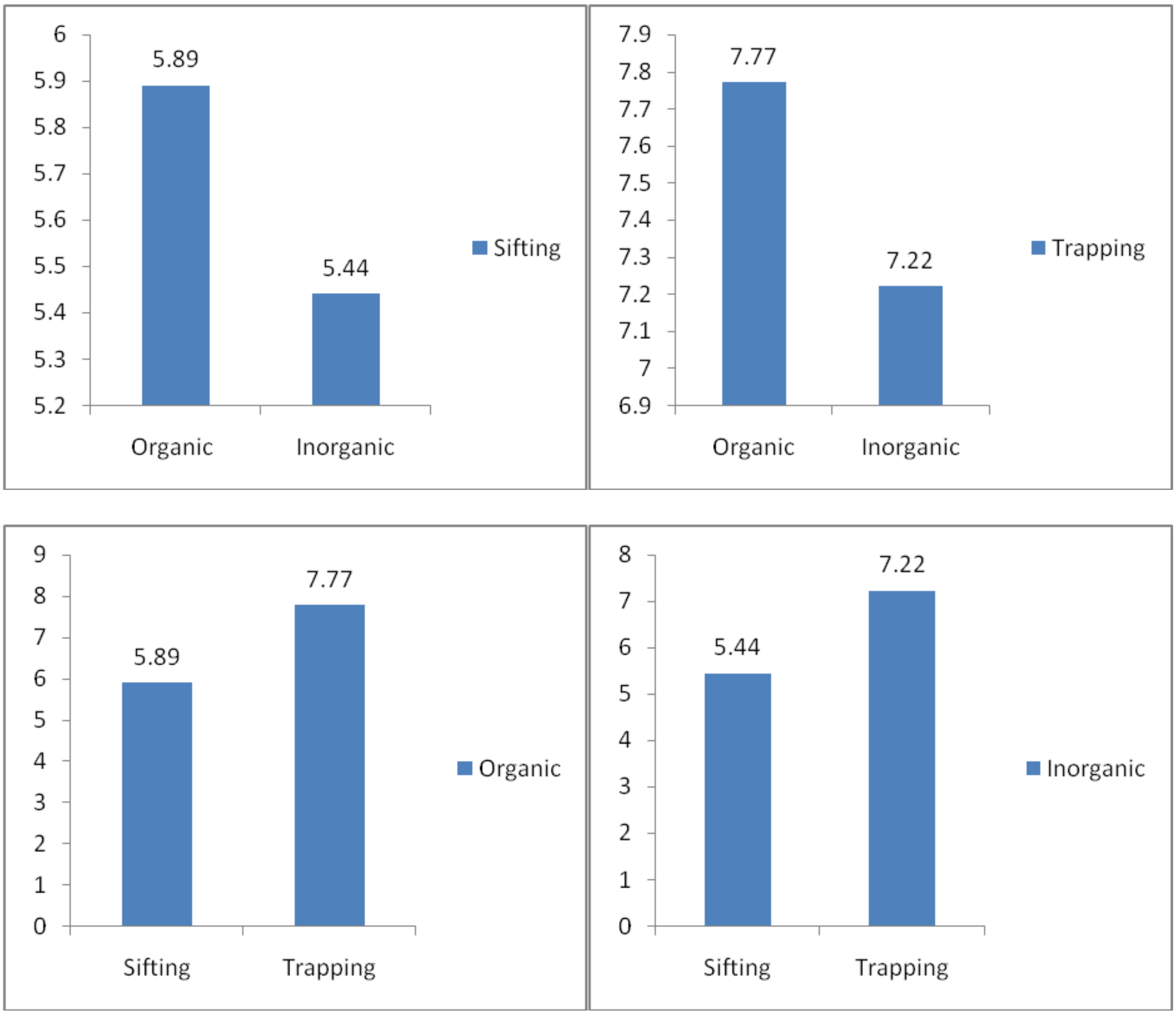

Fig. 3. Arthropod diversity in organic and inorganic soil habitat of Adtuyon clay loam

Individual Arthropod Species Collected

A significant number of individual species were collected from organic than inorganic soil and leaf sifting method. Soil and leaf sifting method in organic production site occupies about 70.57% while leaf and soil sifting method in inorganic production site had only 29.43% of the total collected individual species. For the trapping method, same trends followed the soil and leaf sifting method, a little bit higher in percentage for organic which was 76.40% while 23.60% for inorganic soil habitat.

Across collection method, a significant number of individual were collected from pitfall trapping than soil and leaf sifting method in organic soil habitat. 94.91% of individual species were collected from pitfall trapping method in organic while 5.09% in soil and leaf sifting method for organic soil habitat. The same trend for inorganic soil was observed where 93.25% in pitfall trapping and 6.75% in soil and leaf sifting method.

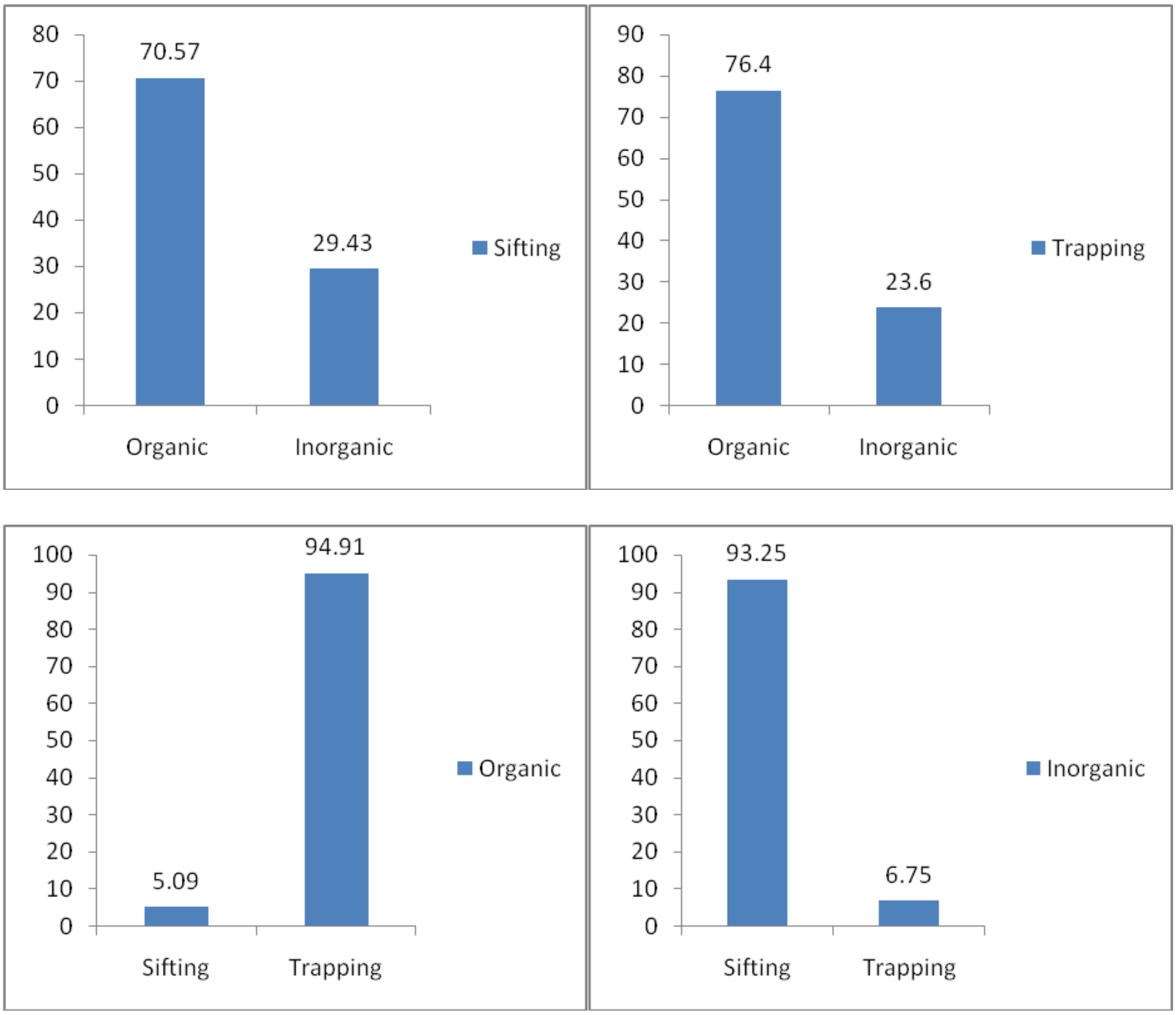

Fig. 4. Percentage of individual species collected in organic and inorganic soil habitat of Adtuyon clay loam

Arthropods Diversity

The diversity of arthropods was found highest in soil and leaf sifting method in organic soil habitat as revealed by Shanon (H) and Simpson (D) diversity indices. Soil and leaf sifting method organic, pitfall trapping method in organic and pitfall trapping method in inorganic, respectively follows.

In terms of the collection method, diverse species was collected from soil and leaf sifting than from pitfall trapping method regardless of the soil habitat.

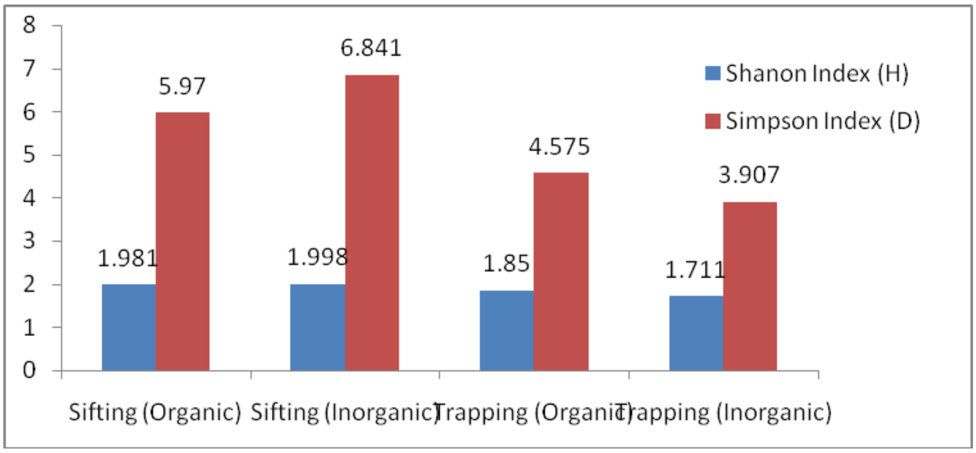

Fig. 5. Arthropods diversity across soil habitat and trapping method using Shanon and Simpson Diversity Indices

Conclusion

Soil and litter sifting methods collected more species compared to pitfall trapping methods. However, individual species were significantly higher using pitfall trapping than soil and leaf sifting method. The use of two methods has different results depending on the data that was gathered. Moreover, organic soil habitat housed more species and individual number of soil arthropods compared to inorganic soil habitat. It follows then that the more diverse the soil organism, the more it can carry its essential ecosystem functions. These arthropods had great impacts in breaking down organic materials so that the decomposition activity of the microorganisms can be easily done.

References

Choate, P. M. (2003). *Introduction to the Identification of Insects and related arthropods.* Retrieved From entnemdept.ifas.ufl.edu/choate/insectid.pdf.

Meyer, J. R. (1994). *Kwik-Key to Soil Dwelling Invertebrates.* Vision Press, Raleigh, North Carolina.

Bureau of Soils and Water Management. (2010). Soils in the Upland. *Retrieved from www.bswm.da.com.ph/soilintheupland* .

Bakker, M. G., Manter, D. K., Sheflin, A. M., Weir, T. L., & Vivanco, J. M. (2012). Harnessing the rhizospheremicrobiome through plant breeding and agricultural management. *Plant and Soil*, 360(1-2), 1-13.

Cardaso, E. J. B. N., Vasconcellos , R. L. F., Bini, B., Miyauchi, M. Y. H., Santos C. A., Alves, R. L. P., de-Paula, A. M., Nakatani, A. S., Pereira, J. M., & Nogueira, M. A. (2013). Soil health: looking for suitable indicators. What should be considered to assess the effects of use and management on soil health? *Scientia Agricola*, 70(4), 274-289.

Carlesi, S & Bàrberi, P. (2017). Weeds as bioindicators: How to sample and use data. *FertilCrop Technical Note*, Sant's Anna, 1-8.

Dillman, A. R. (2013). *Host Seeking and the Genomic Architecture of Parasitism among Entomopathogenic Nematodes.* (Unpublished Doctoral Thesis). Institute of Technology. Pasadena, California, Pp 191.

Iieva-Makulec, K., Bjarnadottir, B. & Sigurdsson, B. D. (2014). Nematode diversity, abundance and community structure 50 years after the formation of the volcanic island of Surtsey. *Bio geosciences*, 11(1), 14239–14267.

Killham, K. (2002). *Bioindicators and sensors of soil health and the application of geostatistics*. In: Burns, R.G., R.P. (eds). Enzymes in the Environment: Activity, Ecology, and Application.

Mekonen, S., Petros, I., & Hailemariam, M. (2017). The role of nematodes in the processes of soil ecology and their use as bioindicators. *Agriculture and Biology Journal of North America* , 8(4), 132-140.

Morugán-Coronado, A., Arcenegui, V., García-Orenes, F., Mataix-Solera, J., & Mataix-Beneyto, J. (2013). Application of soil quality indices to assess the status of agricultural soils irrigated with treated wastewaters, *Solid Earth,* 4(1), 119–127.

DeRocha, J. R. M., Almeida, J. M., Lins, G. A., & Durval, A. (2015). Insects as indicators of environmental changing and pollution: a review of appropriate species and their monitoring. *HOLOS Environment*, 250-262.

Sthanu, L. K., Sarasamma, J. D., Iyer, R.T., & Challepan, M. (2013). Soil quality mapping studies using nematodes as bioindicators. *Open Journal of Soil Science*, 3(7), 323-335.

Utubo, E. B., & Tewari, L. (2014). Soil enzymes as bioindicator of soil ecosystem status. *Applied Ecology and Environmental Research* , 13(1), 147-166.

Wang, K. H., & Hooks, C. R. (2011). *Managing Soil Health and Soil Health Bioindicators through the Use of Cover Crops and other Sustainable Practices*. G.E. Brust (ed.) MD Organic Vegetable Growers.

Wani, A. S., Wani, M. A., Sheikh, A. A., & Chand, S. (2017). Microbiological-indicators with potential for evaluating soil quality. *International Journal of Current Microbiology and Applied Sciences,* 6(2), 831-839.