International Journal of Research and Review
Vol.7; Issue: 5; May 2020
Website: www.ijrrjournal.com
Review Article E-ISSN: 2349-9788; P-ISSN: 2454-2237

Role of Earthworms for Sustainable Agriculture: A Review

Chakravarthy Thejesh

M. Sc. (Ag) Agronomy, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

ABSTRACT

Earthworms are the most commonly occur in the soil. The activities of burrowing and feeding by earthworms have many valuable effects generally on soil quality for crop production. Earthworms act as the soil conditioners by improving the physical, chemical, and biological properties of the soil. By the processes like fragmentation, aeration, breakdown of organic matter in soil helps in the release nutrients and makes them available to plants also secretes the plant growth hormones, their crucial role in nitrogen fixation, carbon dynamics, and phosphorous dynamics. Due to the rapidly improved farm machineries and increased use of synthetic fertilizers causing the huge decline in the population of the earthworms. Due to rapid industrialization and the rise of population brought a lot of change in land use, made the land inappropriate for the development and growth of earthworms. An effort was made to explain the factors affecting the population of the earthworms, effective earthworm friendly agricultural practices which improves the population dynamics of earthworms, thus improve the soil productivity and crop productivity.

Key words: Earthworms, Sustainable, Nutrients, Dynamics, Productivity.

INTRODUCTION

Soil is the most precious natural resource and is the greatest inheritance of mankind. Our connection with soil is based upon the cultivation of soil throughout human history and led to the success of civilizations. To sustain life humans in the past were dependent on hunting and gathering of food. This rapport between humans, the earth, and the food sources confirms that the soil as the foundation of agriculture. [1] Safeguard of the soil habitat is the first measure towards sustainable management of its biological properties that decide long-term quality and productivity. Sustainable agriculture is the protection of communities, the environment, and animal welfare by producing food from plants or animals using different agricultural techniques that do not harm the ecosystem. But as a result of deforestation, overgrazing, burning crop residues, unsystematic use of agrochemicals may have helped in good getting yields, but it has the efficiency to depreciate of the soil all over the world day-by-day and reduced application of organic manures and utilization of fertile land for non-agricultural purposes, soil fertility is decreasing and further declining agricultural productivity. This, at last, led to a decline in Soil Organic Matter (SOM), soil pH, major, and minor nutrients in the soil. [2] This contemporary agricultural practices has resulted in a sharp fall in the biodiversity (above and below the ground) associated with cropland ecosystems.

Earthworms are one of the most significant soil animals; they have the potential to maintain the fertility of the soil and thus play a key role in sustainability. They are also acknowledged as farmer’s friend, ecological engineers, biological indicators, intestines of the earth, and plowman of the field. Earthworms are hermaphrodites and develop slowly, except leaf litter dwellers. Depending on the species, earthworms can live for 2-8 years and produce only generation per year with a maximum of 8-12 cocoons. Sexual maturity can be identified by the "genital belt" encircling the body (Clitellum). Except Polar Regions and deserts earthworms can be found in most of the soils and worldwide there are about 3,000 species of earthworms. They desire medium-heavy to loamy sand soils. Heavy clay and dry sandy soils are not good to their growth because of high and lack of moisture respectively in soils. Maximum burrowing and reproductive activity takes place in the months of March-April and September-October in the temperate zone. During dry and hot days the earthworms move to deeper layers and aestivates. The nightcrawler (*Lumbricus Terrestris*) is capable of migrating up to 20 meters. Nutrient availability increases owing to their role in organic matter decomposition and mineralization [3] and play a vital role in the enhancement of soil fertility by recuperating soil physical, chemical, and biological properties. [4-6] By activities like burrowing, casting, and mixing, besides the mineralization they play a significant role in nutrient cycling and [7-9] and they are termed as *'ecosystem engineers'*.

A. *Role of Earthworms in Soil Fertility:*

Earthworms play a significant role in improving soil fertility in many ways. For example, earthworms bring the nutrients from deeper layers of soil and deposits them on the soil surface as castings, therefore neutralize leakage of nutrients. Earthworms blend soil layers and add organic matter into the soil. These amalgamations allow the distribution of the organic matter throughout the soil and make the nutrients be readily obtainable by plants and improve the fertility of the soil. Earthworms contribute by improving soil structure, incorporation, and tilling the soil, mounting humus formation, and increasing the available plant nutrients. [10] Bacteria present in the earthworm gut devastate detrimental chemicals ingested by worms and as well break down organic wastes. Plant growth regulator like Auxin is produced in castings of earthworm that stimulates the roots to grow more rapidly and much deeper. When compared to soil, Nitrogen fixation is higher in worm casts due to the occurrence of nitrogen-fixing bacteria in the earthworm gut as well as in worm casts. Nitrogenase activity in casts is moreover superior consequently contributing to high nitrogen fixation in casts than adjoining soil. [5-11]

a. *Earthworms for Soil Organic Matter:*

Earthworms play a chief part of preliminary breakdown and successive decomposition of organic matter to release and recycle of nutrients present in organic matter. Earthworms consume more surface organic matters when compared to all other soil animals jointly. They excrete these materials in the form of the cast which are rich in nutrients that are more water-soluble and are readily available to plants. Crop residues, plant litter and, partly decayed, are transported by the earthworms to the sub-surface layer from the soil surface are consumed, fragmented. These fecal materials of earthworms are called as cast, which are deposited on the soil surface inside their burrows or in the open spaces below the soil surface. Earthworms are the main life forms in the breakdown of organic matter and the conversion of major and minor mineral nutrients. [5]

b. *Earthworms for Soil Nitrogen:*

Earthworms improve the organic matter mineralization in the soil and consequently increase the amount of nitrogen in the soil, as of superior nitrification in earthworm casts. In terrestrial ecosystems, a major amount of nitrogen can bypass directly through earthworm biomass. Up to 60-70 kg nitrogen per ha for one year was estimated to return to the soil in the form of dead tissue by *L. Terrestris* in woodland in England. [12,5] Earthworm tissues decompose rapidly and the nitrogen is mineralized readily. Due to the presence of nitrogen-fixing bacteria in the gut of earthworm and earthworm casts the nitrogen fixation in casts is relatively better than that in soil, which increases the activity of nitrogenase enzyme.

c. ***Earthworms and Soil Phosphorous*:**

Phosphorous is a vital plant nutrient accountable for energy storage and transfer in the metabolic activities of cells. It stimulates the early vegetative growth thus, early maturity of grain crops. Though P is a necessary element for plant growth, after nitrogen it is the second most essential nutrient for plant growth. [13-15] Due to less solubility in water lack of mobile nature availability to the plants than other major nutrients in the soil is less. Earthworm casts hold a higher amount of available P than the soil lacking of earthworms. Due to increased phosphatese activity in the casts causes an increase in available P in earthworm casts. [16-17] Estimated that earthworm casts in an agroforestry system, pasture, and secondary forest could constitute 41, 38.2, and 26 kg/ha of total available P stocks respectively.

d. Earthworms for control of soil-borne pests:

Recent studies revealed that earthworm promote the growth and propagation of beneficial organisms in the soil. Earthworms distribute the insect-killing (*Steinernema sp*) and fungi (*Beauveria bassiana*) in the soil, therefore contributing to the good natural regulation of the insect and pests. A fungal spore survives even after passing through the gut of the earthworm and can regenerate after the dropping of the earthworm. Some vertical burrowing species like Nightcrawler and blackhead worm build the permanent vertical burrows.

B. Factors Affecting Earthworm's Population:

Many environmental factors influence action, population density, profusion, and distribution of earthworms. Soil organic matter content, type of soil, soil moisture content, the temperature of the soil, soil pH are the most important factors that regularly control the earthworm population. [18-20] Climatic circumstances and biotic factors strongly influence the profusion and distribution of earthworms. [20]

a. Organic Matter:

Organic matter is the most important food resource of earthworms. Many researchers found an optimistic relationship between soil organic matter content and earthworm population and biomass. Low organic matter in the soil does not promote the population, thus less number of earthworms in those particular soils. [5,21] Observed that increase in organic carbon content has increased the earthworm population during their work in Egyptian soil. Due to large amounts of root debris and other organic matter in pasture land has increased the earthworm population density, but the population density declined after the land is plowed and converted to the arable land. [22,5] Quality of organic residues is also imperative in affecting the earthworm population density. Generally high C: N ratio residues are not preferred owing to their lower palatability by earthworms.

b. Soil Type:

The soils in which earthworms live in effect their population density. Soil textures affect the earthworm populations because it influences other soil properties like moisture, nutrients, and CEC. [5] More earthworm population density is in light and medium loam soil when compared with heavy clay, sandy and alluvial soils. [5] A relationship between the silt content of the soil and earthworm was observed. [23,24] Observed the positive relationship between clay content of soil and the population density of *A. trapezoids, A. osea, and A. caliginosa*. Amongst these species, a positive correlation with clay content was shown by *A. caliginosa*.

c. Moisture:

Earthworms normally need sufficient moisture for the appropriate growth and development. 75-90% body weight of earthworms is constituted with water. Moist skin and the blood capillaries on the surface of earthworm are necessary to respire and should get an adequate amount of moisture to carry out respiratory activity. [25] The activity of earthworm is depended on the adequate availability of soil moisture. Activities of earthworms are superior in moist soil than in dry soil and therefore guard against dehydration. [26-27] Earthworms adopt diverse strategies to handle with arid soil conditions. Some go to deeper soil layers, few diapauses and few produce drought-resistant cocoons. [27] 60-70% moisture is most favorable for the growth and development of earthworms. Ample moisture with heavy rainfall is lethal to earthworms. Since anaerobic conditions are created by too much moisture and they occupy the place of dissolved oxygen to survive earthworms move to the soil surface where they are exposed to damaging ultra-violet radiation and predation.

d. Temperature:

Growth, metabolism, reproduction, and respiration of earthworms are the activities which are affected by temperature. The increase of temperature above the critical point may be fatal for earthworms. Earthworms can tolerate chilly and damp conditions better than hot and arid conditions. [26] The tolerance rate of earthworms may change from species to species. Fluctuation in temperatures will affect the fecundity, cocoon duration, time for incubation, and the growth beginning with hatching to sexual maturity in earthworms. [5] At higher temperature Cocoons tend to hatch sooner and for growth of the indigenous population of *Lumbricidae* in Europe 10-15^{0}C is the optimal temperature. [28]

e. Soil pH:

Earthworms are very susceptible to soil pH. The pH will affect the distribution of the earthworms in many species. [29] Reported that the neutral soil pH is optimal by most species of the earthworms, but they can tolerate up to 5.0-8.0 pH. Variation in soil pH may decline the population density of earthworms. [20] Reported an increase in mortality of earthworm species at pH value below 5. Reduced earthworm activity was observed at high soil pH, above 9.

C. Effective Agricultural practices to improve the earthworm population:

a. Avoid rigorous soil tillage and minimize the use of plow:

- Usage of plough and fast rotating implement should be used only if it is necessary, because 25% of loss caused due to plowing and more than 75% loss of earthworm can be caused by the use of rotating implements.
- Due to high earthworm fertilization activity during the periods of March-April and September- November the intensive tillage should be avoided.
- As the majority of earthworms are in hibernation activity during dry and cold conditions the impact of tillage will be at a minimal level.
- Compaction of soil can be reduced by the usage of on-plows and shallow plows.
- Conservation tillage reduces the risk of soil compaction, for good infiltration, reducing water runoff and evaporation, hence improves the water retention capacity.

b. Minimizing the soil compaction by less ground pressure:

- Heavier the tillage equipment more the soil compaction which will harm the earthworm population and other insects. Hence select the machinery which is light in weight.
- To avoid soil compaction, tillage activity should be done only when the soil is dry or in well-drained soils.

c. Diversified crop rotation to enhance earthworm population:

- Diversified cropping with enduring and deep-rooted plants that are rich in clover or green manure crops are selected.

- Diversified crop residues are essential for the improvement of the earthworm population.
- Incorporation of cereal residues by plowing in the soil usually increases the earthworm population by adding up of the higher amount of organic matter than a leguminous crop which decomposes rapidly and leaves less organic matter. [30]

d. *Fertilizer application concerning to soil properties and plant requirement:*

The quantity and the kind of fertilizer both can affect the earthworm population

- A soil which is well balanced and adequate as per fertilizer requirement is good for both earthworms and crops.
- It's better to use the slightly rotten compost than the ripen compost to promote the earthworm population.
- Organic residues may cause anaerobic reactions if the residues are buried at deeper depth which may be detrimental to the earthworms, so it is better to bury them in shallow depths.
- To ensure the neutral soil pH should be applied regularly based on the requirement of the soil by maintaining the soil pH not below 5.5 is important.

CONCLUSION

Earthworms are referred to as friends of farmers considering their crucial role in the ecosystem there is a need to utilize them in the agroecosystem management. They improve the soil fertility in many ways by bringing the nutrients from the deeper layers of the soil which can be easily absorbed by the plants. They also help in aeration, good root penetration, and further improving the soil fertility and crop productivity. But with the modern technologies and the human greed for better yield obtained from indiscriminate use of chemical fertilizers is degrading the ecosystem as well as agroecosystem. The degradation of soil fertility is therefore a result of a decrease in the earthworm population because of the environmental factors. Good earthworm management will maintain crop yields and also reduce the fertilizer input of farmers. Usage of sufficient organic manures despite of chemical fertilizers with fewer disturbances of soil enhances the activity of the earthworms in the soil for improving and maintaining soil health and fertility. Hence, this review article was prepared by collecting the ideas that improve earthworm activity and soil fertility.

ACKNOWLEDGMENT

The author wishes to express his sincere gratitude to researchers and authors of various review articles on Earthworms. Wikipedia and Google scholar for resources provided through online.

REFERENCES

1. Parikh SJ and James BR (2012). Soil: Found. Agr. Nat. Educ. Knowl., 3(10): 2.
2. Alfred EH and Tom VZ (2008). Land cover change and soil fertility decline in tropical regions. Turk. J. Agr., 32: 195-213.
3. Brown GG, Benito NP, Pasini A, et al (2004). No-tillage greatly increases earthworm populations in Parana State, Brazil. Pedobiol., 47: 764-771.
4. Abdul Rida AM, Bouché MB (1997). Earthworm toxicology: from acute to chronic tests. Soil Biol. Biochem., 29: 699-703.
5. Edwards CA, Bohlen PJ (1996). Biology and Ecology of Earthworms. 3rd Edition. Chapman and Hall, London.
6. Aina PQ (1984). Contribution of earthworms to porosity and water infiltration in a tropical soil under forest and long-term cultivation. Pedobiol., 26: 131-136.
7. Lee KE (1985). Earthworms-Their Ecology and Relationship with Soils and Land Use. Sydney, Academic Press.
8. McLean MA and Parkinson D (2000). Introduction of the epigeic earthworm Dendrobaena octaedra changes the oribatid community and micro arthropod abundances

in a pine forest. Soil Biol. Biochem., 32: 1671-1681.
9. Bohlen PJ, Scheu S, Hale CM, McLean MA, Groffman PM and Parkinson D (2004). Non-native invasive earthworms as agents of change in northern temperate forests. Front. Ecol. Environ., 2: 427-435.
10. Ramsay JA and Hill S (1978). Earthworms: The agriculturist's friends. Macdonald J., 39(10): 1.
11. RanchT (2006).Earthworm benefits, Available: http://mypeoplepc.com/members//arbra/bbb/id19.html. (20th November, 2013).
12. Satchell JE (1967). Lumbricidae. In: Burgess and F. Raw. Soil Biol., London: Academic Press.
13. Vance CP, Graham PH and Allan DL (2000). Biological nitrogen fixation: phosphorus Ba critical future need? In: Pederosa FO, Hungria M, Yates MG and Newton WF (Eds.). Nitrogen Fixation from Molecules to Crop Productivity. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 509-518.
14. Hinsinger P (2001). Bioavailability of soil inorganic P in the rhizosphere as affected by root-induced chemical changes: A Review. Plant Soil., 237: 173-195.
15. Vacance CP (2001). Symbiotic nitrogen fixation and phosphorus acquisition. Plant nutrition in a world of declining renewable resources. Plant Physiol., 127: 390- 397.
16. Satchell JE (1967). Lumbricidae. In: Burgess and F. Raw. Soil Biol., London: Academic Press.
17. Kuczak CN, Fernandes ECM, Lehmann J, et al (2006). Inorganic and organic phosphorus pools in earthworm casts (Glossoscolecidae) and a Brazilian rainforest Oxisol. Soil Biol. Biochem., 38: 553- 560.
18. Wood JG (1972). The distribution of Earthworms (Megascolecidae) in relation to soils, vegetation and altitude on the slope of Mt Kosciusko. Aust. J. Anim. Ecol., 43: 87-106.
19. Lee KE (1985). Earthworms-Their Ecology and Relationship with Soils and Land Use. Sydney, Academic Press.
20. Werner U, Adam C and Lwona P (2005). Earthworm activity in semi-natural and farmland soils. Pol. Agr. Univ., 8: 3- 12.
21. Schmidt O, Curry JP, Dyckmans J, et al (2004). Dual stable isotope analysis of soil invertebrates and their food sources. Pedobiol., 48: 171- 180.
22. Stehouwer RC, Dick WA and Traina SJ (1994). Sorption and retention of herbicides in vertically oriented earthworm and artificial burrows. J. Environ. Qual., 23: 286-292.
23. Hendrix PF, Muller BR, Bruce BR, et al (1992). Abundance and distribution of earthworms in relation to landscape factors on the Georgia piedmont, U.S.A. Soil Biol. Biochem., 24: 1357-1361.
24. Baker GH, Barrett VJ, Grey-Gardner R et al (1992). The life history and abundance of the introduced earthworms Aporrectodae trapezoids and Aporrectodae caliginosain pasture soils in the Mount Lofty Range, South Australia. Aust. J. Ecol., 17(2): 177-188.
25. Eckert R and Randall D (1988). Anim. Physiol. Mech. Adaptations., 3 rded.
26. Kretzschmar A and Bruchou C (1991). Weight response to the soil water potential of the earthworm Aporrectodea longa. Biol. Fert. Soils, 12: 209-212.
27. Mary A (1982). Worms can eat my garbage. Flower Press, Los Angeles. Freeman and Company, New York.
28. Holmstrup, Ostergaard MIK, Nielsen A and Hansen BJ (1991). The relationship between temperature and cocoon production time for some lumbricid earthworm species. Pedobiol., 35: 179-184.
29. Lee KE (1985). Earthworms-Their Ecology and Relationship with Soils and Land Use. Sydney, Academic Press.
30. Edwards CA (1984). Report on the second stage in the development of a standardized laboratory method for assessing the toxicity of chemical substances to earthworms. Commission of the European Communities, Brussels, Luxemburg.

How to cite this article: Thejesh C. Role of earthworms for sustainable agriculture: a review. International Journal of Research and Review. 2020; 7(5): 391-396.

******