International Journal for Modern Trends in Science and Technology, 7(11): 215-218, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0711036
Available online at: http://www.ijmtst.com/vol7issue11.html

Sustainable soil management in agroecosystems of India : A Review

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To Cite this Article
Dr. Anil Kumar. Sustainable soil management in agroecosystems of India : A Review. *International Journal for Modern Trends in Science and Technology* 2021, *7*, pp. 215-218. https://doi.org/10.46501/IJMTST0711036

Article Info
Received: 15 October 2021; Accepted: 25 November 2021; Published: 28 November 2021

ABSTRACT

One of the most pressing concerns is maintaining long-term sustainable agroecosystem productivity through wise use of natural resources, which necessitates a thorough understanding of soil biodiversity and ecological functioning. One of the elements in strengthening the resilience of any agroecosystem might be the impact of soil biodiversity on soil quality, such as nutrient availability, physical structure change, and water holding capacity. Because of the potential function of earthworms in improving soil fertility, they should be considered in agroecosystem management decisions, and they could thus increase land use sustainability in natural, degraded, and agroecosystem settings.The reliance on inorganic fertiliser input in agroecosystems could be reduced due to their involvement in nutrient cycling and providing adequate substrate for bacteria. This would ensure that the soil habitat is protected while also allowing for long-term control of its biological features, determining its long-term quality and production.

Key Words: Agroecosystems, soil biodiversity, nutrient cycling, earthworms

I.INTRODUCTION

As the world's population and food production demands grow, it's more important than ever to keep our soil healthy and productive. More and more farmers are boosting their soil's organic matter and improving microbial activity by farming employing soil health concepts and techniques such as no-till, cover cropping, and diversified rotations. Farmers are sequestering more carbon, enhancing water penetration, and improving wildlife and pollinator habitat as a result, all while reaping higher earnings and yields.

Earthworms as bioindicator for sustainable agriculture

Sustaining agricultural output for future generations is currently a global challenge. Today's new technologies have increased crop productivity, but they are becoming unsustainable over time owing to socioeconomic and environmental variables. The use of chemicals pesticides and mechanical tillage has resulted in the death and decline of biomass and quantity of organisms engaged in decomposing and mineralizing nutrients, leading in a reduction in plant ability to absorb nutrients. This has also resulted in changes in soil physicochemical qualities as a result of the loss of natural tillers such as earthworms and termites, as well as the widespread use of fertilizer and pesticides, which has diminished the soil system's ability to gather organic matter for nutrient absorption.Due to changes in soil characteristics, changes in land use patterns for agricultural reasons have a significant impact on the number and quality of soil biota (Bhadauria *et.al.* 2016).

Soil health is characterized by its ecological characteristics, which include the diversity, quality, and ability of soil biota to influence soil productivity as evaluated by sustained crop productivity over a longer time period for long-term use. The term "soil health" refers to the soil's ecological characteristics, which go beyond its quality or ability to grow a certain crop. These characteristics are mostly related to the soil biota, such as its biodiversity, food web organization, productivity, and variety of services.Soil heterogeneity, for example, is not a necessary soil quality for the development of a specific crop, but it is a characteristic which may be crucial for the topsoil ability to produce that crop. Self-sustaining farming methods are those which make a contribution to soil nutrients and production efficiency by synchronising soil nutrients and crop growth, recycling plant residues, using biocontrol agents to control crop pests, recognising low tillage practises, and utilising soil biota proficiently for nutrient management, soil consistency, and structural characteristics (Oberc,2020).

Land management techniques and soil biota

The positive effects of below ground macrofauna on agrarian and ecological structure and function may be altered as a result of changes in residue management practices, for example, by altering the amount of degradation of organic matter, nitrogen nutrient uptake, or nutrient absorption by microorganisms in plant available forms. Decision makers have paid less attention to soil as nothing more than a living unit, regardless of the fact that its health and texture are critical for agricultural production, environmental quality, and thus plant, animals, and people's health. Land use and strategic planning choices that reflect the multifarious functions of soil rather than attention on a specific function such as production can help to increase the resilience of an agricultural ecosystem to some extent. Environmental and chronological variability lead to alterations in agricultural and land management patterns should indeed be regulated to compensate for the altered soil characteristics and re-establish fertility. If soil biodiversity is not handled appropriately, soil resilience to recuperate from anthropogenic and natural perturbations will worsen (Matthey and Bieri, 1990). Operational procedures associated with nutrient cycling and organic matter breakdown must be effectively maintained for the soil to be a sustainable unit enabling crop growth over a longer duration. Under various land planning processes, this would assure the continued operation of soil as an essential biological system in an environment, while supporting bioaccumulation and thereby ensuring good fertility status" (Barrios *et.at*.,2015).

Changes in land use land cover, soil diversification, and ecological processes

It is in need of global data upon that impact of different land management practices on soil faunal biodiversity, as this data might be beneficial in strengthening ecological systems and boosting the viability of deteriorated and marginal lands, along with preserving naturalistic observation. Due to differences in the quantity and quality of inputs used, varying farming techniques change the established ratio of numerous soil organisms and their interactions. For example, a sustainably grown or farmyard manure-based agro - based system that includes crop rotation and mixes will have a richer soil biota interaction than an intensive agricultural ecosystem, whereas an agroecosystem encompassing integrated inputs is best for the soil. Earthworms can be regarded keystone species because of their higher biomass, lower dispersal rate, and specialized ecological niche utilization, and therefore can be regarded as biomonitors of several agroecological aspects. The composition and structure of earthworm assemblages, as well as species diversity and dispersal patterns, are significantly impacted by changes in landscape management practices (Bhadauria *et. al*. 2012). Several investigations have shown that earthworms can be used as a gauge to measure the severity of variations in soil habitats, such as contaminants and management strategies (pesticides remnants, plowing impacts, compaction, organic matter (Buckerfield*et.Al*. 1997).The use of defoliant for pest and vegetation management in intensive agricultural determines the optimal influences earthworm activity, which can then be leveraged to track effects on soil attributes and perform necessary modifications (Bhadauria et al 2015).

Nutrient management using earthworms

Increased fertiliser application has culminated with only 50% absorption by the crop, whereas the surplus nutrients are dissipated through infiltration of water or as top runoff water, generating water and soil pollution thus decreasing the faunal richness of the soil Paoletti (1999). It will lead to potential depletion of certain essential soil nutrients, such as phosphate, over the next 50-100 years (Cordell *et. al.* 2009). As a consequence, we should look at farming methods those are sustained over extended periods of time.Prudent utilisation of existing resources, including improved agricultural production whilst minimizing negative impacts on the environment..Nutrient interception by AMF roots systems will increase nutrient intake from the soil more efficiently by synchronising nutrient mineralization by soil fauna and crop uptake. (Marcel and Franz ,2015;Asghari and Cavagnaro,2011)

Earthworms play a crucial part in biogeochemical cycles in soils since their foraging activity raises the soil ph., providing an appropriate platform for microbial activity to thrive. Earthworm activity varies based on ecological categories and agricultural systems type in both natural as well as in agroecosystems. They have a variety of activities in soils, including bioturbation, pollutant breakdown, disintegration, biogeochemical cycles, carbon capture and storage, and pest extermination.Bioactive structures, also known as earthworm casts, are collections of mineral and organic assemblages that are highly stable and have an influence on organic matter kinetics and nutrient availability, and also on crop production (Bhadauria 2009)Due to the incorporation of composed matter in th e soil, the involvement of earthworms becomes much m ore beneficial in degraded soil conditions and intensivel y managed agricultural systems (Curry and Schmidt 2007). Earthworm Casts a re 1.5 and 1.3 times richer in C and N than standard soil s (Sinha et. al. 2005), bringing to light the importance of earthworms in carbon sequestration in worm casts and therefore carbon stocks consistency (Zhang et. al. 2003). Work done by us in Northeast India on earthworms in nitrogen cycling during cropping period of shifting agriculture, showed that plant available soil nitrogen was higher in soils with earthworms than that of total nitrogen input in soil with lopped vegetation fertilizer, organic manure, weeds and recycled crop by products but without earthworms (Bhadauria and Ramakrishnan 1996) and which was corelated to be due to presence of mucus, urine, coelomic fluid and through the death and decay of tissues (Padmavathiamma, 2008).

The significance of earthworms in crop nutrient management is largely determined by prevailing cultivation practices, and also the kinds of inputs used, either inorganic or biological and ecological categories of species, and interaction with other species or organisms. In comparison to the surrounding soil, earthworms affect the accessibility of phosphate-phosphorus, calcium, and potassium within the casts (Chen *et. al.* 2008, Bhadauria and Ramakrishnan 1989). Consequently, earthworms play a catalyst role in just about any ecosystem, providing a favourable environment for microbes to deliver organic nutrients to the plant for assimilation.

Poorly articulated farmers' prolonged agricultural production with lower organic material addition to soils on the very same patch of land resulted in variations in soil communities, crop productivity, and fertility, especially in the pea crop. Due to differences in the biological system, there must have been significant differences in the final substrates attributes comparing manure and vermicompost treatment (Vivas*et al* 2009,Lazcano*et. al.* 2008). Similar fluctuations also were detected in overall influence upon crop morphological traits.

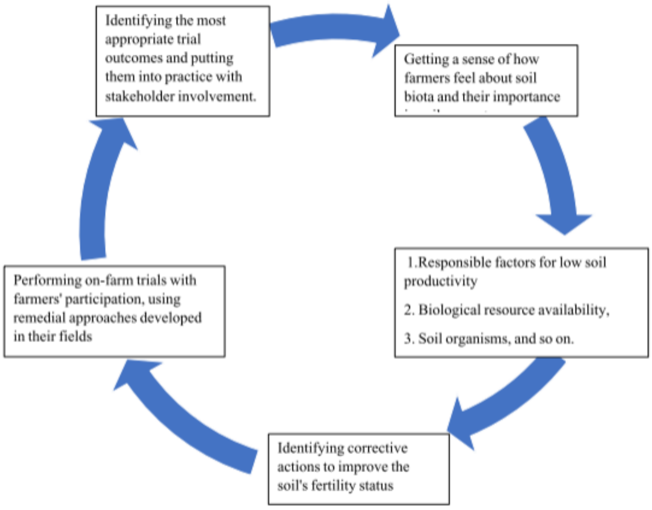
When compared to traditional compost, vermicompost boosted pea crop production along with soil quality and also had a positive impact on soil biota, which then in consequence had such a positive impact on peas crop production (Brussard*et.al*. 1997).

Therefore, the utilization of earthworms as agents for ecosystem conservation planning has gained significance in areas wherein farmers depend on forest vegetation for feed and compost. As a consequence, they concentrate on physiological systems of soil along with biological inputs to promote crop productivity or manage soil health.

2. CONCLUSION

Implementing sustainable procedures may reduce crop yields when especially in comparison to intensive farming techniques, however the long-term advantages will indeed outweigh the economic loss, as improved nutritional efficiency augmented by better overall soil biotic characteristics will indeed result in a reduction in fertiliser contribution, be ecologically responsible, and therefore be a cost-effective scheme for marginal and small farmers. Farm owners will be in a stronger place to effectively contribute advantageous procedures to provide a self-sustaining agroecosystem if they have been educated to investigate the positive impacts of management strategies on species diversity,including such earthworms, and also their own capabilities, and also recognise how to establish what really is occurring in the soil attributed to the prevalence of this soil biota.

Monitoring soil sustainable biological management:



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