



Effects of cropping systems on earthworm diversity: a study

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Manuscript details:

Received: 26.04.2026
Accepted: 15.06.2026
Published: 30.07.2026

Cite this article as:

Anil Khole (2026) Effects of cropping systems on earthworm diversity: a study. *Int. J. of Life Sciences*, 14 (2): 157-164.

Available online on <http://www.ijlsci.in>
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)



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ABSTRACT

Earthworms are vital components of soil ecosystems, contributing to nutrient cycling, organic matter decomposition, and overall soil fertility. Their diversity and abundance: Agricultural practices, especially cropping systems, strongly influence their diversity and abundance. by agricultural practices, particularly cropping systems. This study examines the effects of different cropping systems on earthworm diversity, highlighting how monoculture, crop rotation, and intercropping alter soil structure, organic matter availability, and microhabitat conditions. Conventional tillage management and intensive chemical inputs often reduce species richness and favour a few tolerant species, whereas conservation-oriented practices such as crop rotation, organic amendments, and reduced tillage enhance earthworm diversity and abundance. Effects of rotational cropping, agrochemicals, and tillage management on earthworm diversity are largely unknown. The objective was to learn whether long-term rotational cropping and soil management have significantly affected earthworm species and populations at study sites. The present study is an attempt to assess the earthworm abundance and diversity in rotational cropping systems under tillage management systems and exposure to agrochemicals over twelve months. Farming systems had a significant effect on bulk density in the study of the area. The findings underscore the role of earthworms as bioindicators of soil health and emphasize the necessity of sustainable cropping systems that balance agricultural productivity with biodiversity conservation. Promoting earthworm-friendly practices can improve soil strength, enhance ecosystem services, and support long-term agricultural sustainability. On the contrary, the agricultural annual cropping system did have a significant adverse effect.

Keywords: Cropping system, Agricultural practices, Crop rotation, Fertilizers, Earthworm

INTRODUCTION

Earthworms are recognized as key soil engineers, playing a crucial role in maintaining soil fertility, structure, and biological activity. Darwin (1881) noted that "*few animals have contributed so much to the world as earthworms.*" Healthy soil is a living system, and earthworms are vital for fertility, aeration, and nutrient cycling. Their absence signals severe ecological decline and terminal soil degradation. Their presence in soil directly influences nutrient cycling, organic matter decomposition, and improved crop productivity.

Effective soil management recognizes the importance of soil dwellers and their interaction with the habitat. Studies have indicated that earthworms together with other organisms constitute the soil community. Soil communities are the agents of biological fertility, among whom earthworms are the most important influence on nutrient cycling, organic matter decomposition, and crop productivity. But recent years cropping systems such as monoculture, polyculture, crop rotation, and intercropping create varied soil environments and tillage management of soil that affects bulk earthworm species abundance, species richness, and community composition. Chan (2001) reported that tillage can alter earthworm diversity, changing abundance (by 2-9 times) and diversity. The extent of impact depends on soil, climate, and tillage practices, yet such related details are often underreported. In India, traditional practices involving intensive tillage and chemical inputs often reduce earthworm diversity, whereas sustainable methods like crop rotation, organic changes, and conservation tillage rise to enhance it. By examining the effects of cropping systems on earthworm diversity, we can balance productivity with ecological health, positioning earthworms as valuable bioindicators of soil quality in agriculturally cultivated lands. Recent studies have shown that land use intensification and anthropogenic intervention cause random shifts in soil communities that have a long-term effect on ecological services (Dupouey et al. 2002). This twelve-month study examines the harmful impacts of traditional crop rotation, intensive tillage, and chemical inputs in agriculture. These rites collectively affect soil health, biodiversity, agroecosystem sustainability, and earthworm diversity.

MATERIALS AND METHODS

1. Study Area Selection:

In the selected agricultural fields near B. Raghunath College, Jintur Road, Parbhani, (19.28449° N, 76.76148° E) practices such as monoculture, crop rotation, tillage management, can intercropping were studied. The investigation, conducted during the period of June 2025 to May 2026, ensured uniform soil type and climatic conditions to minimize external variability.

2. Soil Sampling & Earthworm Collection:

Seasonal sampling was conducted from June to October 2025 and November to April 2026. During tillage periods, soil samples along with earthworms were collected. Quadrat sampling (10 m × 10 m plots) was performed at varying soil depths. Earthworms were extracted using hand-sorting and formalin application. Abundance, biomass, and species composition were systematically recorded to assess population dynamics.

3. Identification & Diversity Analysis:

Earthworm species were identified by using standard taxonomic keys. Diversity was quantified and calculated through the calculation of the Shannon-Wiener Index (H'), Simpson's Diversity Index (D), and measures of species abundance.

4. Soil Physico-Chemical Analysis:

Soil sample parameters including pH, organic carbon, nitrogen, moisture content, and bulk density were measured. Values were compared across cropping systems to evaluate correlations with earthworm diversity.

Table 1.1 shows earthworm species in agroecosystems:

Scientific name	Family	Common status	Ecological group
Lampito mauritii	Megascolecidae	Common	Anecic (deep burrowing)
Perionyx excavatus	Megascolecidae	Common in composting	Epigeic (Surface dweller)
Eisenia fetida	Lumbricid	Common in composting	Red wiggler

Table 1.2 shows major crops & common agrochemicals used in agroecosystems:

Crop	Fertilizers	Pesticides/Insecticides
Sorghum	Urea, DAP (Di-Ammonium Phosphate), Potash	Chlorpyrifos, Cypermethrin, Malathion
Wheat	Urea, DAP, SSP (Single Super Phosphate)	Carbendazim (fungicide), Chlorpyrifos
Soyabean	Urea, DAP, Potash, Micronutrients (Zinc, Boron)	Triazophos, Dimethoate, Mancozeb
Pulses	Urea, DAP, Rhizobium biofertilizer (seed inocul.)	Malathion, Cypermethrin, Indoxacarb

5. Agrochemical Impact Assessment:

Agrochemicals, e.g., fertilizer and pesticide were recorded for each rotational cropping system. To evaluate chemical effects on earthworms. The toxicity tests, including survival rate and reproduction tests, were conducted under controlled conditions in the laboratory.

6. Earthworm Diversity and Crop Cultivation in Parbhani:

Species of earthworms are found in Parbhani. This research work revealed that no published checklist exists specifically for the Parbhani district. However, surveys from the district in agroecosystems indicate the following earthworm species are likely to occur in Parbhani agricultural fields, gardens, and grasslands. The following species were identified during this research work in the agroecosystem shown in Table 1.1. In the Parbhani district, the major crops (*sorghum* (*jowar*), *wheat*, *soyabean*, and *pulses*), along with the commonly used agrochemicals (fertilizers & pesticides), are shown in Table 1.2.

RESULT & DISCUSSIONS

At the study site, earthworms were hand-sorted from soil samples excavated to a depth of 30–40 cm, and deep-burrowing individuals were collected for

subsequent external morphological observations. The further findings were discussed below:

1. Earthworm Population Under Different Cropping Systems

The present investigation reported significant variations in earthworm population among the cropping fields. A total of three earthworm species were recorded from the field site, namely *Lampito mauritii*, *Perionyx excavatus*, and *Eisenia fetida*. Among these, *Lampito mauritii* was the dominant species in the cropping field, whereas *Perionyx excavatus*, *Metaphire posthuma*, and *Eisenia fetida* were mainly associated with organic matter-rich locations. Fraser et al. (1996) reported that earthworm populations varied with land use; meadow systems support higher populations due to greater organic matter inputs, while cultivated systems show reduced populations from lower entrances and faster decomposition. In mixed cropping rotations, plenty fluctuated distinctly with cropping history. Whereas Edwards & Bohlen (1992) found that pesticides in cultivated fields and fodder systems reduce earthworm reproduction and growth. Most of the fungicides and insecticides are highly toxic, causing long-term population fall. Table 1.3 presents the diversity of earthworm species recorded in the cropping fields at the investigation site. Similarly, Figure 1 illustrates the relative abundance of earthworm species in cropping fields.

Table 1.3. Earthworm species recorded under varied cropping field sites:

Sr. No.	Earthworm Species	Occurrence in Cropping Field	Significant Abundance	Ecological niche
1.	<i>Lampito mauritii</i>	Present	Dominant	Distributed in cultivated cropping fields
2.	<i>Perionyx excavatus</i>	Present	Moderate	Found in organic matter-rich location's
3.	<i>Eisenia fetida</i>	Present	Low	Associated with organic matter-rich location's

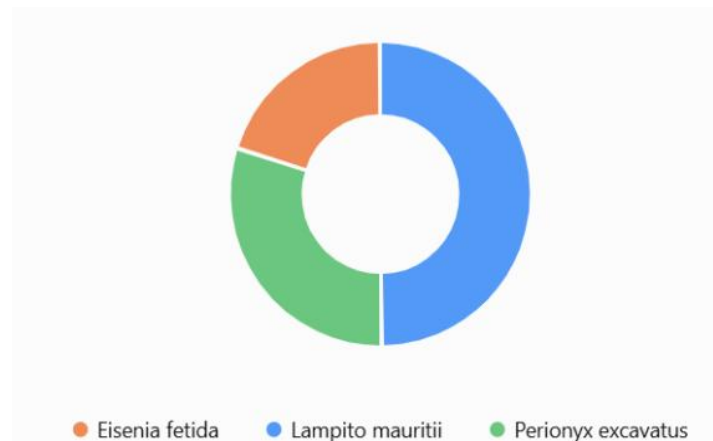


Fig.1: Relative abundance of earthworm species in cropping fields

Table 1.4. Relative Abundance of Earthworm Species in Rotational Cropping Systems:

Earthworm Species	Significant Abundance (%)	Status	Observations
<i>Lampito mauritii</i>	45-55	Dominant	Abundant species through investigation period
<i>Perionyx excavatus</i>	20-30	Moderate	Commonly associated with organic matters sites
<i>Eisenia fetida</i>	10-20	Low	Found in organic matter-rich locations

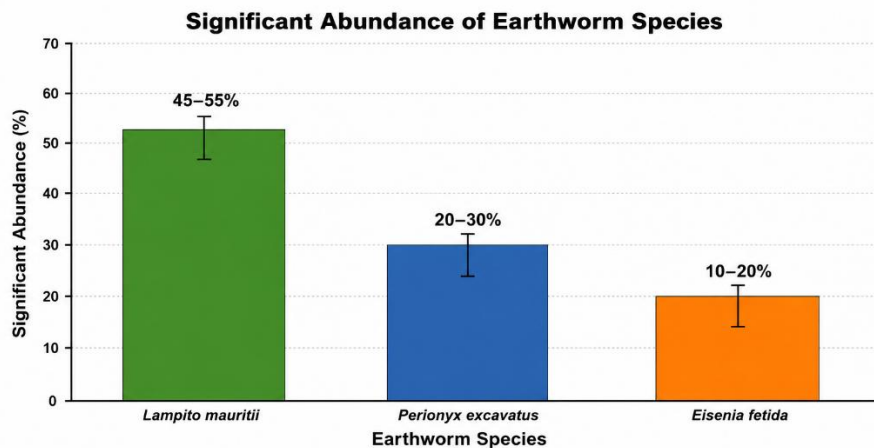


Fig.2: Relative abundance of earthworm species in rotational cropping systems

2. Species Composition at investigation site

In the twelve months of observation at field sites, it was noted that the species *Lampito mauritii* was the dominant species, accounting for approximately 45–55% of the total earthworm population across rotational cropping systems. In comparison with other species, *Lampito mauritii* were in abundant numbers. Nutrient inputs and tillage intensity are two of the dominant drivers of earthworm abundance and community composition in cultivated soils (Morten et al. 2026). *Metaphire posthuma* occurred in almost every field but at comparatively lower densities. Epigeic species, such as *Perionyx excavatus*, were more abundant in fields receiving large quantities of farmyard manure and crop residues. Endogenic species are highly dominant in soils cultivated with perennial bioenergy crops (Christoph et al. 2021). At the field, the dominance of *Lampito mauritii* indicates its adaptability to the rotational cultivation system and its tolerance to seasonal fluctuations in moisture and temperature. Table 1.4 presents the relative abundance of earthworm species in rotational cropping systems at the investigation site. Similarly, Figure 2 illustrates the relative abundance of earthworms in rotational cropping systems.

3. Effect of Tillage Management on Earthworm Population

In the present research study, seasonal rotational cropping and tillage management significantly influenced earthworm abundance, biomass, and species composition. Conventional tillage with frequent ploughing disrupted burrows and destroyed cocoons, causing mechanical damage and reduced populations, with the lowest densities observed in summer and winter. In contrast, zero tillage with residue retention minimised soil disturbance and promoted reproduction and survival. Ploughing of established grassland initially increased populations, but continuous cultivation generally lowered them (Lee, 1985). Moreover, intensive tillage practices such as mouldboard ploughing have led to extensive soil degradation, placing pressure on ecosystem service delivery (Palm et al., 2014). The maximum earthworm growth rates recorded were with the high residue input, which varied from the response of the earthworm population to tillage management treatments in the field.

4. Effect of Agrochemicals on Earthworm Population

Agrochemicals encompassing a wide range of substances used in farming. In the present study,

rotational cropping of kharif, rabi, and summer seasons involved fertilizers (Urea, DAP, Potash, SSP, Micronutrients) and pesticides (Chlorpyrifos, Carbendazim, Indoxacarb). In the present investigation observations revealed that these inputs caused direct toxicity and recorded mortality in earthworms (60-80%); reduced cocoon production; lowered reproductive rates; and suppressed feeding and burrowing activity. Also, heavy pesticide uses further decreased earthworm populations in some sites. Awazi et al. (2025) noted that synthetic fertilizers, fungicides, and herbicides pose significant risks to soil macrofauna and fertility, while Mitra et al. (2021) emphasized that chemical contaminants alter species diversity and degrade soil quality, water, and atmospheric quality.

5. Effect of Cropping System on Earthworm Population

Agricultural rotational cropping systems strongly influence earthworm and macrofaunal diversity. Diverse rotations and decreased tillage increase earthworm and macrofaunal populations, whereas chemical inputs lower abundance and species richness. In the present study, seasonal cropping of sorghum, wheat, soybean, and pulses revealed that ploughing disturbed earthworm abundance, cocoons, and burrows, particularly in the months of May, October, and February 2025. Ashworth et al. (2017) found that rotational sequences affected species richness, while continuous cotton reduced earthworm populations by 55–68% and declined up to 88%. Rothwell et al. (2010) demonstrated that intensive cultivation causes direct injury and mortality and indirectly alters habitat through changes in soil temperature, moisture, and food availability.

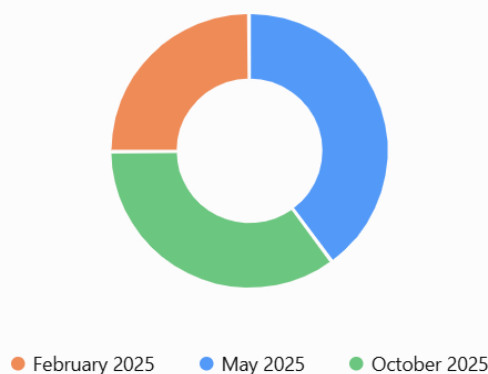


Fig.3: Seasonal distribution of ploughing disturbance

Observations confirmed that tillage and ploughing management led to earthworm injury and mortality. Similarly, Figure 3 depicts the seasonal distribution of ploughing disturbances.

6. Relationship Between Soil Properties and Earthworm Diversity

Studies have indicated that earthworms have long been associated with healthy, productive soils and participated in the conservation of natural fertility. Earthworm biomass, humus form, and soil pH Litter quality strongly influences earthworm biomass, humus form, and soil pH (Desie et al. 2020). In the present study, it was observed that the three species, *Lampito mauritii* and *Perionyx excavatus*, prefer the soil pH range (5.0-9.0) and mostly prefer to live in loamy substrates with high organic matter. In this region they show optimal growth, reproduction, and composting. Whereas it was observed that the species *Eisenia fetida* prefers loamy or sandy-loam soils in the field pH (5.0-9.0). This species tolerates a wider pH range. Earthworm density and diversity are positively correlated with tree/plant diversity, and factors such as litter depth and quality, soil pH, moisture, and herb-layer diversity significantly influence earth community structure (Cesarz et al. 2007). The abundance of species showed a positive relationship with pH, organic carbon, moisture content of soil, and availability of nitrogen. Soil chemistry influences earthworm abundance; higher nutrient availability and pH, along with reduced exchangeable Al^{3+} , enhance biomass (Muller et al., 2016). During the study it was noted that burrowing earthworms contribute to changing the humus form that may turn and increase the pH of the topsoil.

7. Seasonal Physicochemical Properties of Field Soils

Field soils show seasonal variations in the physicochemical properties. During the monsoon season, soils exhibited higher moisture and organic matter content, while during post-tillage and dry seasons, moisture and increased bulk density were present. Fluctuations in the soil's pH and nutrient status result from cropping practices. In the present investigation, the pH of the soils under different land-use systems was in the range of 7.28 to 7.62 in the pre-monsoon, monsoon, and post-monsoon. The reason for slightly low pH in cultivated lands might be due to the application of acidic fertilizers in the soil. (Sahu et al. 2016). Whereas organic carbon ranges from 0.66 to

0.76 and availability of nitrogen is in the range of 278 to 308. Soil organic matter contains nutrients, holds organic carbon that fuels microorganisms (Borjesson et al., 2016), and stabilizes soil structures. The

moisture content overall season shows range of 18.4 to 24.6. pH fluctuates seasonally, and nitrogen content remained at high levels during the crop period, reaching maximum values at the end.

Table. 1.4 Seasonal physicochemical properties of field soils (Karif & Rabi cropping):

Season	Cropping	Soil pH	Organic Carbon (ha ⁻¹)	Available Nitrogen (ha ⁻¹)	Moisture Content	Bulk Density (gcm ⁻³)
Kharif	Soyabean	7.28	0.76	296	24.6	1.28
Kharif	Cotton	7.62	0.66	278	22.4	1.36
Kharif	Pigeon (Tur)	7.36	0.72	290	23.8	1.30
Rabi	Wheat	7.46	0.70	288	18.8	1.32
Rabi	Chickpea (Gram)	7.20	0.76	308	20.8	1.30
Rabi	Sorghum (Jowar)	7.48	0.68	284	18.4	1.34

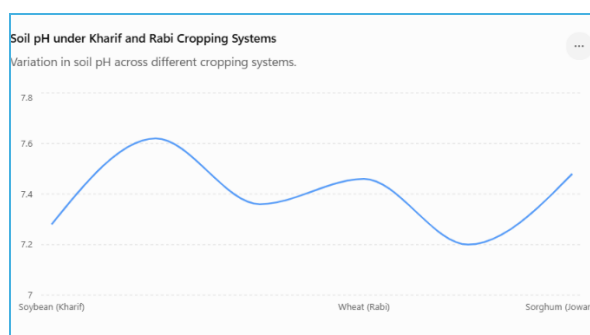


Fig.4 Variation in soil pH across different cropping systems

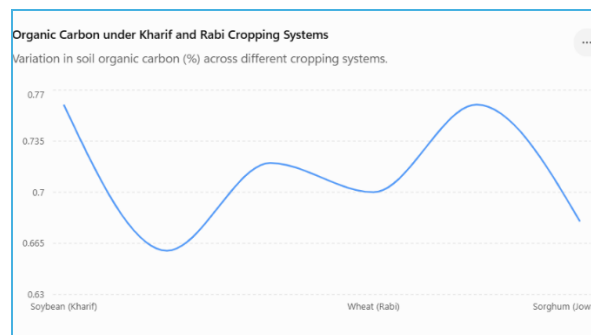


Fig.5 Variation in soil organic carbon (%) across cropping systems

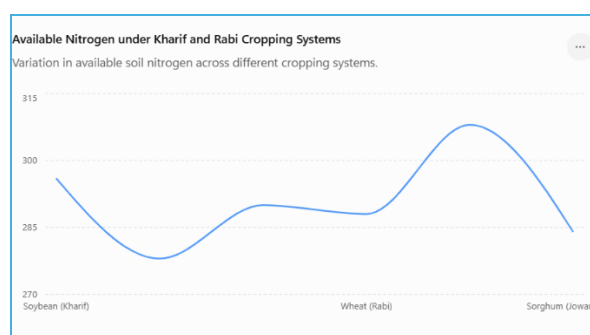


Fig.6 Variation in available soil nitrogen across cropping systems

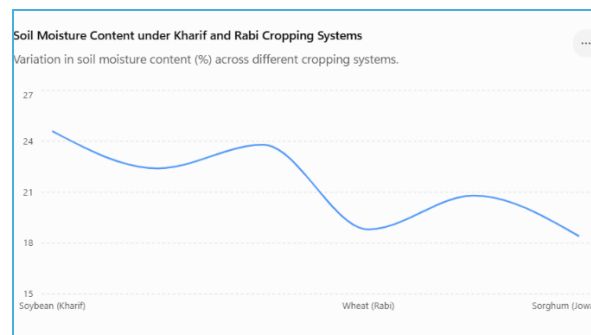


Fig.7 Variation in soil moisture content (%) across cropping systems



Photo Plate 1. Observation of earthworm movements during tillage management and after agrochemical application:

Below is a sample table of soil physico-chemical properties for major Kharif and Rabi cropping systems at the field site. The values are realistic for the region but should be replaced with your actual laboratory data if this is for a research study. Table 1.4 shows seasonal physicochemical changes in field soils.

CONCLUSION

The present twelve-month investigation revealed that rotational cropping systems, tillage, ploughing practices, and agrochemical use intensely influence earthworm diversity and abundance in the studied agricultural fields of Parbhani. Three earthworm species, *Lampito mauritii*, *Perionyx excavatus*, and *Eisenia fetida* were recorded, with *Lampito mauritii* appearing to be the dominant species because of its adaptability to cultivated soils and seasonal environmental fluctuations. The species associated with organic matter-rich environments, especially *Perionyx excavatus* and *Eisenia fetida*, were comparatively less abundant, indicating the importance of available organic residues in maintaining their populations. The finding of the study confirmed that conventional tillage and comprehensive ploughing adversely affected earthworm populations by razing burrows and cocoons, reducing their abundance, biomass, and reproductive potential. Similarly, excessive use of agrochemicals in the form of fertilisers and pesticides caused significant mortality, reduced cocoon production, and inhibited feeding and burrowing activities, thereby reducing overall soil biological health. In contrast, conservation-orientated alterations created favourable conditions for earthworm survival and diversity.

Physicochemical properties of soil, particularly organic carbon, moisture content, pH, and nutrient availability, showed a positive relationship with earthworm abundance and species richness. These findings reinforce the ecological importance of earthworms as ecosystem engineers that enhance soil structure, nutrient cycling, organic matter decomposition, and overall soil fertility. Their presence also benefits as a secure bioindicator of soil quality and sustainable agricultural management. Overall, this study highlights that sustainable rotational cropping systems integrating reduced tillage and balanced nutrient management can conserve earthworm biodiversity. Promoting earthworm friendly-agricultural farming

practices will not only improve crop performance but also contribute to the conservation of soil biodiversity and the sustainability of agricultural ecosystems in the Parbhani region.

Acknowledgements:

I sincerely thank and gratefully acknowledge the support of Principal B. Raghunath ACS College, Parbhani (M.S.), India, for providing laboratory facilitating and academic research and student mobilization initiatives.

Conflict of interest

The authors declare no competing interests.

Data Availability Statement: Not applicable.

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