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Assessing the impact of tillage practices on soil mesofaunal biodiversity

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Abstract- Soil is a habitat for number of organisms and play crucial role in various edaphic processes. They play significant role in the stability of the ecosystem. Soil mesofauna functions as bioindicators of soil quality. Management practices such as soil tillage and application of chemicals affect soil characteristics. The soil mesofauna are sensitive to any kind of disturbances of the environment, as they affect its abundance and diversity. In the present study, we took into consideration the impact of tillage on the mesofaunal population at two different sites comprising of Natural Sal forest (Site 1) and Rose Garden (Site 2) of Biodiversity Park, Ranchi. Abiotic factors viz. temperature, moisture, organic carbon content, and N, P, K composition of both sites were also measured. It was found that mesofaunal diversity was higher at Site 1(2.12) as compared to Site 2(1.60). The abiotic factors also affect the distribution pattern of mesofauna. A positive correlation was seen between the population of species and moisture content at both sites, 0.93 and 0.90 respectively. Tillage disrupts the soil structure and microclimate which makes it difficult for mesofauna to survive and reproduce. It leads to a decrease in abundance and diversity. Its effect varies depending on the soil type, and mesofaunal community.

Key words: Mesofauna, tillage, abiotic factors, correlation

INTRODUCTION

Soil fauna constitute a large part of world's biodiversity and regulate important processes in the ecosystem.[1] Mesofauna are one of the important organisms that play a crucial role in organic matter decomposition and nutrient cycling.[2] Out of all the mesofauna present, springtails and mites play a functional role by affecting microbial activity and regulating fluxes between organic matter pools.[3] They also influence other belowground works such as N mineralisation, leaching of dissolved organic carbon[4] and soil respiration that were shown to impact plant performance.[5]

Soil tillage represents the most influential manipulations of soil structure and one of the main practices that affects biodiversity.[6] Tillage is done to temporarily reduce bulk density, increase water retention and also gas diffusion and convection.[7] They also exert great pressure in ecosystem, modifying the habitat of important groups of edaphic arthropods.[8,9] The short-term effects of tillage are slowly reversed after rainfall when soil consolides.[10] The tillage affects the soil both qualitatively (i.e., species composition and diversity) and quantitatively (i.e., population densities).[11] Changes in soil physical environment and food resources are observed due to tillage.[12] The physical and mechanical disturbances destroy the habitat of some mesofaunal groups.[13] Under no tillage, the litter layer stabilizes temperature and soil moisture for soil organisms.[13,14] Due to this the nutrient resources remain at the soil surface for longer period of time. These nutrients are released slowly and is more efficient in terms of nutrient cycling.

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The present study is carried out at two different sites of Biodiversity Park, Ranchi, Jharkhand. One site having Natural Sal Forest where no tillage is observed while the other site consists of Rose Garden where tillage is observed more frequently and also application of fertilizers and pesticides is also observed. Ranchi has sub-tropical type of climate. Here, the temperature ranges between 2-20°C during winter and 20°C to 39°C during summer. The annual rainfall is about 1530mm. These climatic conditions are well suited for the growth of many plants that are present in the park.

METHODOLOGY

Collection of soil sample

Soil samples were collected from both sites once a month and placed in labelledzip-lock bags before being transported to the laboratory for extraction and analysis.

Physico-chemical analysis of the soil

The soil physico-chemical parameters were determined using standard procedures.[15,16]

Extraction of Soil arthropods

According to Crossley and Blair, (1991)[17], the Tullgren funnel is an integral part of the extraction process. The Tullgren funnel was invented by Berlese to gather soil arthropods from soil samples.[18] One 60- watt light bulb was utilized for 48-72 hours as a heat and light source. We gathered the separated species in vials, subjected them to 70% ethanol and a few drops of glycerol, and then examined them using compound microscope.[19]

Soil arthropod identification

The collected species were examined for basic identification using a Compound Microscope. The prepared slides were sent to the Zoological Survey of India, Kolkata, for identification of species and categorized using a variety of taxonomic keys at the order or family level.

Statistical analysis

Shannon Weiner's Species Diversity was calculated using formula

$$H' = -\sum p_i \ln(p_i) \quad \text{or} \quad H' = -\sum (Ni/N) \times \ln(Ni/N)$$

Where,

H' = The Shannon-Weaver Diversity Index

p_i = the relative abundance of each group of organisms

The index of evenness or equitability (J) were estimated using the formula as given by Krebs (1976)

$$J = H'/H'_{max} \qquad \text{when } H'_{max} = \text{Log}S \times 1/\text{Log } 2$$

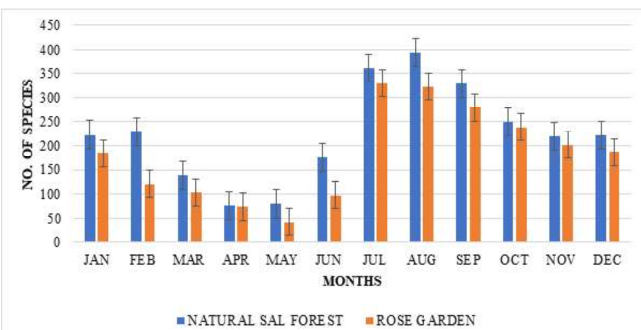

Fig. 1- Monthly population fluctuation of collembolans at two different sites.

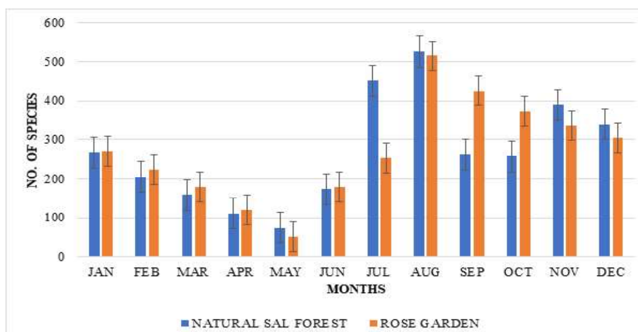

Fig. 2- Monthly population fluctuation of acari at two different sites.

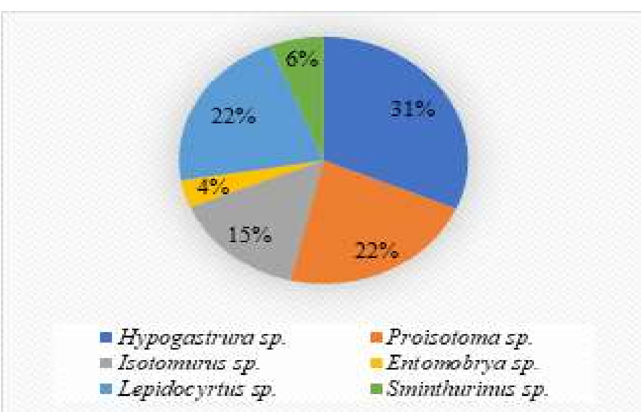

Fig. 3. Relative abundance of collembola at Natural Sal Forest.

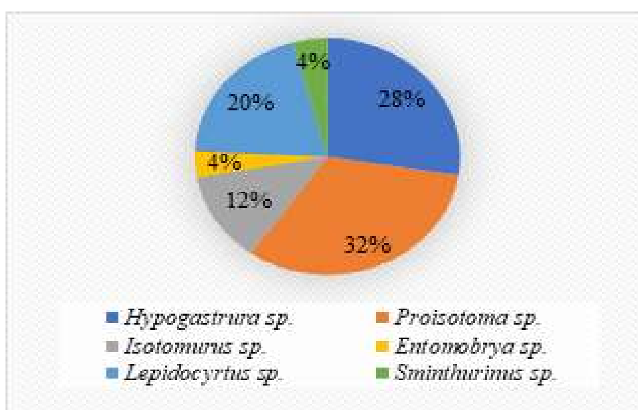

Fig. 4- Relative abundance of collembola at Rose Garden.

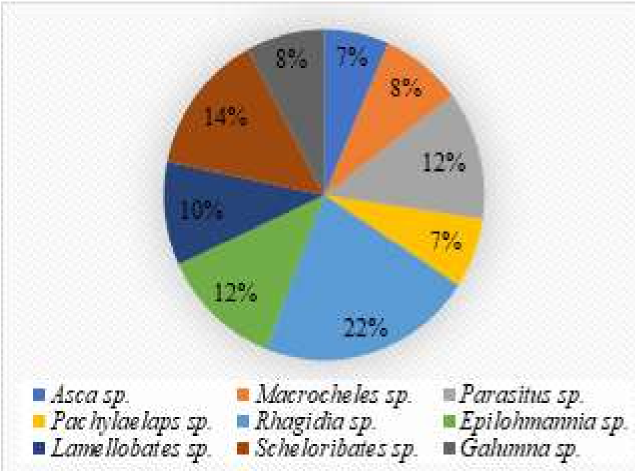

Fig. 5- Relative abundance of acari at Natural Sal Forest.

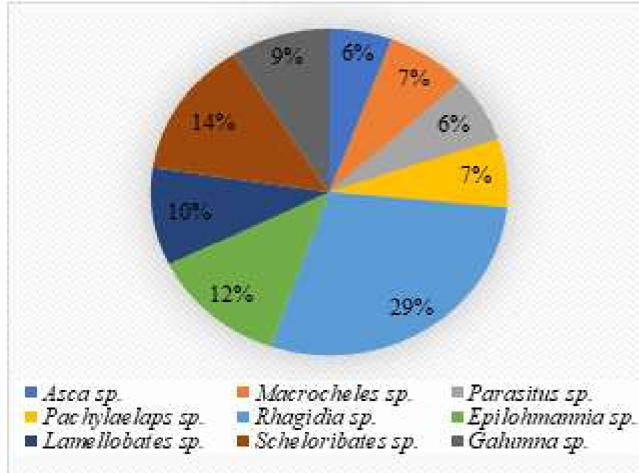

Fig. 6- Relative abundance of acari at Rose Garden.

Table 1- Seasonal diversity for collembola at two different sites.

SEASONS	NATURAL SAL FOREST	ROSE GARDEN
Summer	1.562	1.411
Monsoon	1.612	1.545
Post Monsoon	1.609	1.564
Winter	1.571	1.546

Table 2- Seasonal diversity for acari at two different sites.

SEASONS	NATURAL SAL FOREST	ROSE GARDEN
Summer	2.042	2.027
Monsoon	2.083	2.088
Post Monsoon	2.124	2.052
Winter	2.071	1.988

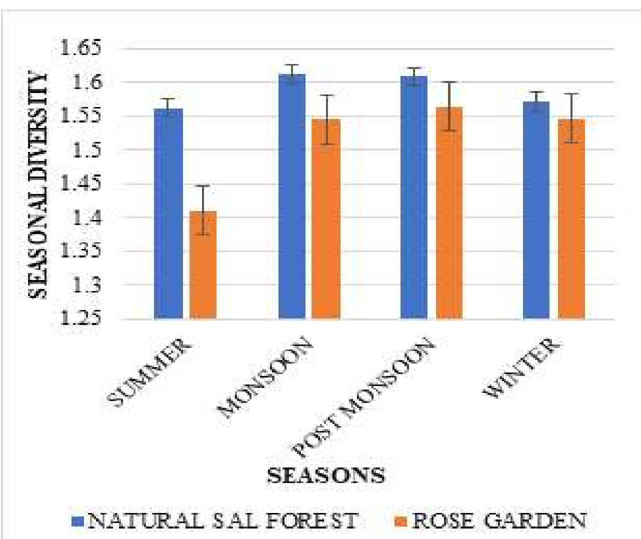

Fig. 7- Seasonal diversity for collembola at two different sites.

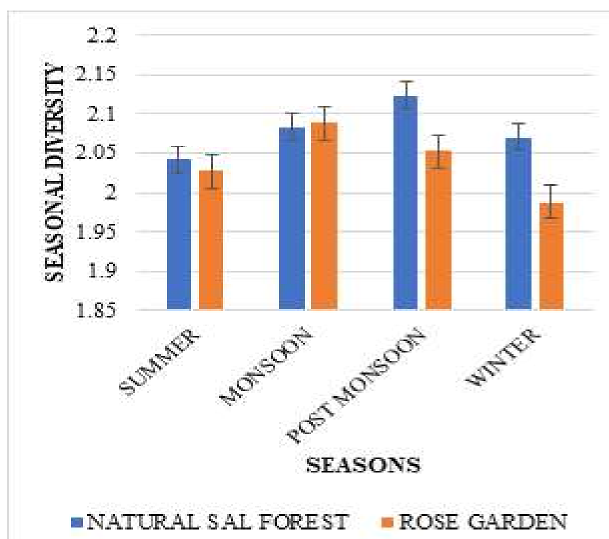

Fig. 8- Seasonal diversity for acari at two different sites.

Table 3- Correlation between various factors.

Correlation Between Factors	Natural Sal Forest (Collembola)	Rose Garden (Collembola)	Natural Sal Forest (Acari)	Rose Garden (Acari)
Population Vs Temperature	-0.084	-0.002	-0.228	-0.168
Population Vs Moisture	0.927	0.967	0.837	0.903
Population Vs Organic carbon content	0.876	0.826	0.757	0.597
Temperature Vs Moisture	-0.325	-0.095	-0.324	-0.095
Temperature Vs Organic carbon content	0.243	0.293	0.243	0.293
Moisture Vs Organic carbon content	0.757	0.689	0.757	0.689

RESULT & DISCUSSION

The soil edaphic factors such as temperature, moisture content, organic carbon content, pH, N, P, and K showed similar variations at both the sites. In the month of May, maximum temperature was observed having 26.1°C and 26.6°C at both the sites respectively. Minimum temperature was recorded in the month of January (14°C) at Natural Sal Forest and in December (14.1°C) at Rose Garden. The soil pH was recorded to be between 6.5-7.1 at both the sites. The pH tends to decrease with an increase in moisture content of soil. The soil moisture content was observed highest during August having 24% at site 1 and 23% at site 2 while a minimum was observed during May having 9.5% at site 1 and 9.7% at site 2 respectively. A fluctuation in the mesofaunal population was recorded as the soil moisture content varies.

The mesofauna comprises of both collembola and acari species. In our study, 6 species of collembola and 9 species of acari were found. The collembolan species comprises of *Hypogastrura* sp., *Proisotoma* sp., *Isotomurus* sp., *Entomobrya* sp., *Lepidocyrtus* sp., and *Sminthurinus* sp. Out of them, *Hypogastrura* sp. was found to be most abundant 31.45% at site 1 and *Proisotoma* sp. with 32.28% at site 2 while Entomobrya sp. was least abundant having 3.57% and 3.53% at both the sites respectively (Fig 3 and 4). The acari species comprises of *Asca* sp., *Macrocheles* sp., *Parasitus* sp., *Pachylaelaps* sp., *Rhagidia* sp., *Epilohmannia* sp., *Lamellobates* sp., *Scheloribates* sp., and *Galumna* sp. Out of them, *Rhagidia* sp. was found most abundant having 21.26% at site 1 and 28.19% at site 2 while *Asca* sp. was found to be least abundant with 6.41% at site 1 and 5.56% at site 2 respectively (Fig 5 and 6). There is more fluctuation in collembolan population as compared to acari population as collembolan ae more sensitive to any change in environmental conditions.

The Natural Sal Forest (Site 1) has high organic carbon content as compared to Rose Garden (Site 2) because of no tillage observed there. A complex food chain was observed at site 1 mainly due to higher litter accumulation that resulted in lower soil losses and accumulation of carbon in the soil surface layers that could serve as food to diverse soil organisms.[20,21] At site 2, tillage and fertilizer application was observed which increased the phosphorus(P) levels compared to site 1 that has higher potassium(K) content.

A higher diversity of mesofaunal population was observed in Natural Sal Forest than Rose Garden. These invertebrates take advantage of the pores and cracks to move inside the soil.[22,23] A higher density in forest is due to higher diversity of habitats and niches that allows more richness and uniformity of mesofauna species as compared to Rose Garden. Soils under forests are low in nutrients and have high acidity, as fertilizers are not applied. A strong positive correlation was seen under mesofaunal population and organic carbon content. Also, collembolans prefer fresh organic matter as food source.[23.24] Different carbon sources deposited at various stages of decomposition may lead to the development of a more diversified and richer community of soil mesofauna at site 1 than at site 2.[25,26] The soil covered by leaf litters supports higher soil moisture and lower temperature in Natural Sal Forest than in Rose Garden.[27] This explains the higher percentage of collembolans at site 1 than at site 2, since these conditions favour collembolan development and reproduction.[22]

Studies indicate that no tillage may cause long term soil compaction and depth stratification of nutrients.[28] Also, the frequency of tillage has different effects on the soil mesofauna. If the tillage is performed less frequently, the mesofaunal community get ample of time to recover between two successive diturbances. This is not possible if the tillage is done frequently at short interval of time.[29] This could be the reason for the mesofaunal population to flourish in Natural Sal Forest as compared to Rose Garden.

CONCLUSION

The present study indicates that tillage has a significant impact on mesofaunal population. Tillage leads to a decrease in mesofaunal abundance and diversity. This is because tillage disrupts the soil structure and microclimate, which can make it more difficult for mesofauna to survive and reproduce. Tillage disturbs and fragments the soil habitat. It leads to increased temperature fluctuations and moisture loss, which negatively impacts mesofauna adapted to specific moisture and temperature conditions. There are a number of ways to mitigate the negative effects of tillage on mesofauna. One way is to use conservation tillage practices such as no-tillage and reduced tillage. By taking these steps, we can help protect mesofauna and improve soil health.

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