Original research paper

Abundance and diversity of soil arthropods in major plantation crops under different farming practices

ABSTRACT

Agriculture is the main source of greenhouse gas emissions. It is therefore vital to understand the role of the agricultural soil communities in maintaining the soil economic value for agriculture. Soil arthropods play a vital role in soil systems, in decomposition, nutrient cycling and regulation of microbial communities. The study on effect of farming practices (*viz*. Natural farming, Organic farming and Inorganic farming) on abundance and diversity of soil arthropods in major plantation crops (Arecanut, Coconut, Coffee) was studied under different zones *i.e*. Hilly, Central Dry and Transition zone of Chikkamagaluru, Karnataka from August 2023 to May 2024. Soil arthropods belonging to 12 different order were collected under 5 classes *viz.*,Entognatha, Arachnida, Insecta, Symphlan and Chilopoda. The highest numbers of individuals was observed in natural farming practice (1256) followed by organic farming(825) and least in inorganic farming(397). Highest number of soil arthropodsin the agro-ecological zones recorded innatural farming practice (31.90 individuals per 400g of soil)in coconut ecosystem followed by organic farming practice with 12.39 and lowest in inorganic farming practices with 5.39 individuals per 400g of soil in arecanut and coffee ecosystem respectively.Shannon weiner index shows highest species richness in natural farming system with 2.13. Whereas, the lowest diversity was recorded under Inorganic farming practices (Shannon-Wiener: 0.69). The abundance and diversity showed a significant difference between different farming practices *i.e.* natural, organic and inorganic farming practices in different zones. Natural farming practices followed by organic farming generally supported higher diversity indices and abundance of soil fauna compared to inorganic farming practices.

Keywords:Arthropods; Abundance; Diversity; Natural; Organic; Inorganic; farming system; zones

INTRODUCTION

Soil arthropods, which include classes such as Crustacea, Arachnida, Myriapoda, and Insecta, are crucial components of soil ecosystems. These organisms are characterized by features like chitinous exoskeletons, segmentation and jointed appendages, enabling them to perform vital ecological functions. They contribute significantly to organic matter translocation, decomposition, nutrient cycling, and soil structure formation, all of which are essential for maintaining soil quality and health. Diverse arthropod communities are linked to enhance ecosystem stability and resilience to disturbances, making their assessment important for effective habitat management and conservation strategies (Menta and Remelli, 2020; Nahmani*et al.,* 2005). As integral members of soil food webs, these arthropods serve as valuable indicators of soil biological activity, influencing factors such as hydrology, aeration and nutrient dynamics.

However, intensive agricultural practices pose significant threats to soil arthropod diversity and overall soil health. The conversion of natural habitats to agricultural land leads to drastic changes in soil biological and chemical properties, often resulting in biodiversity loss. These changes can negatively impact soil fauna abundance and activity due to altered temperature, moisture levels and organic matter availability (Edwards, 2004). Conventional farming methods, which heavily rely on chemical fertilizers and pesticides, disrupt natural ecosystem processes, further degrading soil quality. The widespread application of pesticides, while beneficial for crop production, has detrimental side effects, killing not only pests but also beneficial insects and other soil invertebrates, leading to environmental imbalances.

In contrast, organic and natural farming systems prioritize the enhancement of soil health and biodiversity by focusing on the management of soil organic matter and utilizing natural nutrient sources. These practices emphasize reduced soil disturbance, avoidance of synthetic chemicals, and the promotion of biodiversity through diverse planting and natural pest management strategies. Research has shown that conservation farming systems support greater arthropod abundance compared to conventional methods (Hole *et al.,* 2005). Monitoring soil arthropod diversity is critical for assessing soil stability and ensuring sustainable agricultural practices. With increasing global concern over the impacts of modern farming on soil biological activity, biodiversity, and water quality, embracing these sustainable approaches is essential for the long-term health of agro-ecosystems and the environment (Rossi *et al.,* 2006). With this background the present study was conducted on abundance and diversity of soil arthropods under different farming practices in major plantation crops

MATERIALS AND METHOD

Study area

The soil fauna study was conducted in three major plantation crop ecosystem such ascoconut, arecanut and coffee in three different zones *viz.*, hill zone (13.13°N, 75.64°E), Transition Zone (13.71°N, 75.81°E) and central dry zone (13.54°N, 76.00°E) taluks of Chikkamagaluru district. The soil samples were collected from plantations of farmers' fields practicing for > 5 yearsunder different farming practices *viz.*, natural farming, organic farming and inorganic farming during *kharif*, *Rabi* and summer season of 2023 – 2024. To know the diversity of arthropods the soil samples were randomly drawn from natural, organic and inorganic plantations of coconut, arecanut and coffee farming systems from August 2023 to May 2024.

Sampling site

Natural farming: This area is good composition of weed mulch with grasses and herbs. The practice followed with application of Jeevamritha 200 litre per acre at monthly intervals.

Organic farming: This sampling site were practiced with addition of farm yard manure/ organic manure to the soil at 2 tonnes per acre. The plantations were free from weed mulches.

Inorganic farming: The plantation were applied with inorganic fertilizers 2 splits per year and fertilizers used are urea, DAP, potash and complex form. The plots were free from weeds and no mulching practices followed.

Sampling procedure

The samples were drawn near the root zone within the radius of 45 cm from the plant. The surface litter and weeds were removed carefully from the sampling spot before sampling, soil was collected by using circular core sampler measuring 12 cm diameter and 10 cm height. The core sampler was placed on the soil surface and pressed downward to a depth of 10 cm in the sampling spot. Soil sample weighing 400 g was collected in three spots randomlyfrom each plot and were immediately transferred to aluminium cans and labels were placed into each can and closed with lid and brought to the laboratory for further analysis.

Extraction technique of Soil arthropods and processing

The soil fauna was separated from soil sample using Tullgren funnel consistedof a funnel with meshscreen,a glass vials and a light source. The glass vials were filled with 10 ml of 75 per centethyl alcohol. The vials were periodically checked to keep the alcohol at desired levels. The collected soil sampleswere placedover the meshfixed across wide end of each funnel. The electric bulbs were fixed at the top of the funnel setup thatserved as the source of light and heat energy. Light source of Berlese funnel was switched-on for48 hours to generate heat thatled the micro-arthropods to move down passing through sieve ofthe funneland get collected in glass vials.The arthropods collected were sorted using a stereo binocularmicroscope (35x magnification). Taxonomic groups sorted were identified up to order level following taxonomic keys.

Data Analysis

Recorded data on total number of individuals of all arthropods species, which appeared at the time of observation in each samples were subjected to analysis of variance with square root transformation (√X+0.5). Abundance of arthropods was compared among farming practices under different zones as well as across seasons using DMRT.

Shannon- Wiener Diversity index

Diversity index were computed using PAST prog (Hammer *et al.*, 2001).

The abundance and diversity of insect communitywas commuted usingShannon's diversity index (H) thataccountedfor both abundance and evenness of thespecies.

$$H = -\sum pi\ (\ln pi)$$

Where, H represents the index of species diversity in a given locality

Pi is the proportion of"i^{th}" species in total sample and

ln = Natural logarithm.

Relative abundance wasdetermined using the following equation

$$RA\ (\%) = \frac{Ts}{Tp} \times 100$$

Where RA = denotes the species relative abundance (%)

Ts = total number of individuals in a given area

Tp = total population of all species in the area

RESULTS AND DISCUSSION

Abundance of soil arthropods

During the study period natural farming practices exhibited the highest total abundance, with 1256 individuals followed by organic framing practices with 825 individuals and lowest in Inorganic Farming with 397 individuals. Highest individuals were recorded in classEntognatha followed by Arachnida, Insect, Symphyla and least was recorded in class Chilopoda. The main groups in these class belong to Entomobryomorpha,Diplura, Mesostigmata, Cryptostigmata, Coleoptera, Hemiptera, Blattodea, Dermaptera, Diptera, Hymenoptera, and Scutegeromorphawith the majority of soil arthropods. (Table 1).Recently these findings are supported byDeepika *et al.* (2020) where they recorded a higher population of soil arthropods (1987 individuals) in the agricultural ecosystem of which most individuals recorded are from Class Entognatha, Order Acarina, and Order Entomobryomorpha. Also Ojija (2016) reported 1,719 arthropods across 63 species in grassland and woodland ecosystems compared to thier study our study exhibited more abundance in natural farming followed by organic farming, which might be due to the availability of rich organic carbon, mulching practices and arthropods friendly soil and climatic conditions. They also observed that undisturbed habitat host more soil relative abundance than organic and inorganic practices.

Relative abundance of soil arthropods

A significant variation in the number of soil arthropods between different farming practice were observed where Entognatha, Acarina, insecta, Symphyla and Chilopoda which was most abundant in Natural farming (55.18%, 56.18%, 49.28%, 18.84% and 11.24% respectively), followed by Organic farming (33.11%, 34.98%, 32.13%, 31.88% and 40.45% respectively) and least relative abundance observed in Inorganic farming (19.38%, 15.77%, 11.50%, 18.84% and 11.24% respectively) (Table 2).These findings align with Pahari *et al.* (2007) who reported that Acari constituted 47.04%, followed by Collembola (38.68%), with other groups showing significantly lower dominance.

Abundance and diversity of soil arthropods

Soil arthropod abundance varied significantly across different farming practices in various zones. In hill zone, natural farming plantation of arecanut and coffee showed the highest arthropod populations, averaging 26.70 and 20.00 per 400 g of soil, respectively. Organic farming practices recorded with 17.23 and 15.09 individuals, while inorganic farming had the lowest numbers (8.15 for arecanut, 11.00 for coconut, and 6.76 for coffee). Similar trend was observed among farming practices in transition zone and dry zone. Overall, natural farming consistently supported the highest mean values of soil arthropods across all crops, while inorganic practices yielded the lowest abundance and diversity, highlighting the significant differences in arthropod populations linked to farming methods across zones (Table 3). In contrast to our findingsHole *et al.* (2005) found that most groups exhibited greater abundance or biomass under conservation systems than under conventional-tillage systems because the former cause less disturbance to their habitats, maintaining the structures that serve as shelter.

Organic farming practices performed better than inorganic practices, indicating that they support higher soil arthropod populations than conventional chemical inputs. Inorganic farming practices were associated with the lowest soil arthropod counts, reflecting the negative impact of chemical inputs on soil health.

In plantation crops the species diversity indices of soil arthropods recorded a significant differences across farming practices and zones.The highest diversity was noticed in the Natural farming practices in the Hill Zone(H = 2.13) in coffee followed by arecanut (H = 2.02). While, in Organic farming practices also recorded maximum diversity in the Hill Zone (H = 1.97) in arecanut. Least species richness was supported in Inorganic farming practices (H= 0.69) in transition zone(Table 3). The lower evenness is due to the enormous difference in relative from one order to another order.These results are in support fromGkisakis*et al.* (2014) also observedsoil arthropods, in conventional, organic and integrated olive orchards where Hilly orchards showed significantly higher seasonal total arthropod diversity and evenness. Selected habitats in this study was relatively undisturbed compared to organic and inorganic farming

CONCLUSION

The population abundance and diversity of soil dwelling arthropods in natural farming practices generally supported higher diversity indices and abundance of soil fauna, followed by organic farming practices and least soil arthropods were recorded in inorganic farming practices. The present study is the first time effort to investigate the abundance and diversity of soil arthropods in different farming practices. The information generated by this study would be partial base line of soil living arthropods groups. The practices with natural and organic farming showed increased soil fertility, which is due to addition of large amounts of organic residue inputs, which in turn increase the biological activity of soil arthropods due to the mulching practices followed. And also provided a more balanced and nutrient - rich environment compared to inorganic approaches, potentially leading to better crop performance and soil health.

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Table 1. Abundance of Soil arthropods as influenced by different farming practices

Class	**Order**		**Number of individuals**		
			Natural farming	**Organic farming**	**Inorganic farming**
Entognatha	Collembola	Entomobryomorpha	201	145	64
		Poduromorpha	30	12	9
	Diplura		122	89	71
Arachnida	Mesostigmata		158	135	58
	Cryptostigmata		170	98	47
Insecta	Coleopteran		48	37	14
	Hemiptera		32	18	6
	Blattodea		22	15	6
	Dermaptera		39	21	15
	Diptera		80	39	11
	Hymenoptera		137	74	21
Symphyla	Symphylan		170	110	65
Chilopoda	Scutegeromorpha		47	32	10
Total			**1256**	**825**	**397**

Table 2. Relative abundance of soil arthropods as influenced by different farming practices

Class	**Natural farming (RA %)**	**Organic farming (RA %)**	**Inorganic farming (RA %)**
Entognatha	55.18	33.11	19.38

Arachnida	49.25	34.98	15.77
Insecta	56.38	32.13	11.50
Symphyla	49.28	31.88	18.84
Chilopoda	52.81	40.45	11.24

Crops	**Farming practices**	**Hill zone**		**Transition zone**		**Central Dry zone**	
		Abundance	**H°**	**Abundance**	**H°**	**Abundance**	**H°**
Arecanut	Natural	26.70 (5.21^{a})	1.81	21.15 (4.65^{a})	2.02	17.84 (4.28^{a})	1.69
	Organic	17.23 (4.21^{b})	1.97	12.0 (3.53^{b})	1.72	7.96 (2.90^{b})	1.61
	Inorganic	8.15 (2.94^{d})	0.69	5.85 (2.51^{d})	0.81	3.50 (2.00^{d})	0.90
*****Coconut	Natural	-	-	22.44 (4.78^{a})	1.91	18.93 (4.40^{a})	1.77
	Organic	-	-	9.00	1.71	6.67	1.68

Note: RA – relative abundance

Table 3: Abundance and diversity of soil arthropods in plantation crops under different farmingpractices

				(3.08[c])		(2.67[bc])	
	Inorganic	11.0 (3.39[cd])	0.78	6.29 (2.60[c])	0.85	4.58 (2.25[cd])	0.81
**Coffee	Natural	20.0 (4.52[b])	2.13	16.00 (4.06[a])	1.86	-	-
	Organic	15.09 (3.9[c])	1.79	12.63 (3.62[b])	1.75	7.18 (2.77[bc])	1.58
	Inorganic	6.76 (2.69[e])	0.85	5.4 (2.42[cd])	0.91	4.03 (2.12[bc])	0.72
S.Em±		0.12		0.10		0.1	
CD at 5%		0.38		0.31		0.30	

Note: Figures in parentheses are $\sqrt{X+0.5}$ transformed values. Means followed by the same letter do not differ significantly by DMRT (P = 0.05)

H° □ Shannon – weiner diversity index

* Coconut plantation observed only in inorganic plantation. In hill zone non-availability of plantation with organic and natural farming practice.

****** Coffee plantation observed only in organic and inorganic plantation. In central dry zone Non availability of plantation with natural farming practice