Effect of Temperature on the Population of Soil Microarthropods in Different Land Use Systems

Mohammad Jalaluddin Abbas[1], Hina Parwez[2]

[1,2]Laboratory of Ecology, Department of Zoology,d, Aligarh Muslim University, Aligarh-202002

Abstract
Soil ecosystems support a large diversity of its inhabitants of which soil microarthropods contribute a very significant proportion as soil biological resource. Utilization of soil resources is crucial for agricultural production as well as soil biodiversity conservation. Biodiversity varies widely with the composition of soil. This is due to that, ecological factors critically affect on the diversity of soil inhabiting microarthropods. *Fluctuation in soil temperature consequently affects microarthropods population*. To confirm this hypothesis, an experiment has been carried out at Aligarh. Soil samples have been carried out from four different sites at weekly intervals for two consecutive years. Soil temperature found statistically negative significant with reference to soil microarthropods in both agricultural sites (in first year, $p<0.05$, –0.768 and in second year $p<0.05$, –0.573 in AQS; in first year, $p<0.01$, –0.759 and in second year, $p<0.01$, –0.705 in APS) whereas, it found statistically positive significant in Mango orchard sites only in second year of study ($p>0.05$, 0.578). These observations indicate that, fluctuation in temperature regimes leading to microarthropods population might depend on vegetation and field conditions. Apart from microarthropods, Collembolans are much more sensitive to variation in soil temperature than compare to Acarina (mites). Diversity patterns of microarthropods, responses to stress caused by temperature which affect sustainable management and ultimately productivity of soil ecosystems which are finally discussed in this paper.

Keywords: microarthropods, diversity, temperature, effect, collembolans, mites

Introduction

Utilization of land use systems or soil resource is crucial for agricultural production as well as for soil biodiversity conservation. Biodiversity varies widely with the composition of soil. On the other hand, the impact of soil edaphic factors on the diversity of soil microarthropods is an important aspect that one should focus because edphic factors affect the survival and diversity of soil inhabitants. However, the knowledge of distributions and diversity patterns of soil microarthropods species and their influence on ecosystem processes is currently inadequate, partially due to the high species richness and complexity of ecosystems underneath the ground surface (Brussaard et al. 1997). It is now widely accepted that climatic and edaphic factors can substantially influence soil microarthropods and their populations. Therefore, knowledge of different factors influencing the population of soil microarthropods is essential for enabling one to study their impact on population and for environmental conservation which could play an important role in making sustainable agriculture.

Microarthropods play various roles in processes undergoing inside the soil such as decomposition, nutrient cycling, and energy flow; although their direct contributions might be subtle (Seastedt 1984;

Hunt et al. 1987; Hunter et al. 2003). Moreover, soil edaphic factors such as soil temperature, soil moisture, relative humidity and organic carbon contents of soil may significantly affect the diversity and biology of soil microarthropods. Thus, soil microarthropods are likely to have both direct and indirect impacts on soil systems (Reth et al. 2005). Because the responses of microarthropods to edaphic factors are often nonlinear and can fluctuate across seasons, it is difficult to extrapolate the net effect of edaphic factors and fluctuating environment controls the soil microarthropods. Thus, an insight to their impact on soil requires a detailed assessment of temporal patterns of soil microarthropods diversity and their responses to changing soil edaphic conditions.

Apart from other edaphic factors, soil temperature and soil moisture are the most important edaphic factors affecting populations of soil microarthropods. In general, Collembola development and reproduction are so strongly regulated by temperature (Choi et al. 2002) that population dynamics have often been related to simple indexes of heat accumulation (Diekkrüger and Röske 1995; Choi and Ryoo 2003). Choi and Ryoo (2003) also studied on *Paronychiurus kimi* (Lee) populations in rice fields of Ichon, South Korea and included the effects of both soil moisture as well as soil temperature. The aim of this study was to elucidate the impact of soil temperature on the diversity and population dynamics of soil microarthropods in different land use systems.

Methods

(a) Area and sites of study

The area selected for study is situated at Aligarh-INDIA. It is a flat topographical area, located in western part of UP, India at latitude 27-54’N, longitude 78-05E’ and altitude 187.45 meter above sea level. It is a subtropical zone with fluctuating climatic conditions consisting of four different seasons characterized by extreme winter and summer followed by medium to heavy rainfall during monsoon months and a post winter sweet spring. In hot dry summer, the temperature rises up to 48 ºC sometimes near 50 ºC, while in winter cold, the temperature goes drops up to 0-2 ºC. Such widely varying climatic conditions provide a variety of ecological niche to soil dwelling animals and interesting for ecological studies on microarthropods in this region.

Four different study sites have been selected to collect the soil samples for the population study of soil microarthropods, namely Agriculture Quarsi Site (AQS), Agriculture Panjipur Site (APS), Mango Orchard Site (MOS) and Un Arable Site (UAS). AQS and APS were agriculturally well managed sites with the difference that AQS was totally organic managed site whereas APS was conventionally managed site. On the other hand, MOS was the orchard site which was less managed and UAS was unmanaged site without any human interference in field site.

Agriculture Quarsi Site

Wheat (*Triticum aestivum*)	Mung been	Arhar (*Cajanus cajan*)

Agriculture Pangipur Site

Mango Orchard Site

Un Arable Site

Tullgren's Funnel Apparatus

Figure 1. Sampling sites and Apparatus for Extraction of soil microarthropods.

(b) Sampling, Extraction, Preservation and Identification of microarthropods

Samples have been taken from all study sites at regular weekly intervals in every month for two consecutive years (384 samples). Modified Tullgren's funnel apparatus (Abbas and Parwez 2020) has been used for extraction of soil microarthropods. All microarthropods have collected inside a beaker which contained 70% ethyl alcohol with few drops of glycerol for due course of microarthropods are not getting dried. Microarthropods were separated and mounted directly in DPX. A binocular stereomicroscope (OLYMPUS, CX-21) has been used to identify soil microarthropods.

(c) Measurement of Edaphic factors

The edaphic factors include soil temperature, relative humidity, and moisture content of the soil. Temperature of the soil has been measured by directly inserting the thermometer into the soil up to the required soil depth and relative humidity on soil surface was determined by Dial Hydrometer.

(d) Statistical Analysis

We analyzed the correlation among the population of soil microarthropods and soil temperatures. SPSS version 20.0 has been used to carry out the statistical analysis. Mean±SD along with correlation between soil temperature and population of soil microarthropods have been analyzed for significant responses and stability of populations. Along with temperature regimes, we also calculated soil humidity because of humidity directly related to system temperature.

We also estimated population density of soil microarthropods. Density is actually the total population of soil microarthropods correspond to the total number of samples. Therefore, it may expressed mathematically by following expression -

$$d = \frac{\sum_{i=1}^{|S|} p_i}{|S|}$$

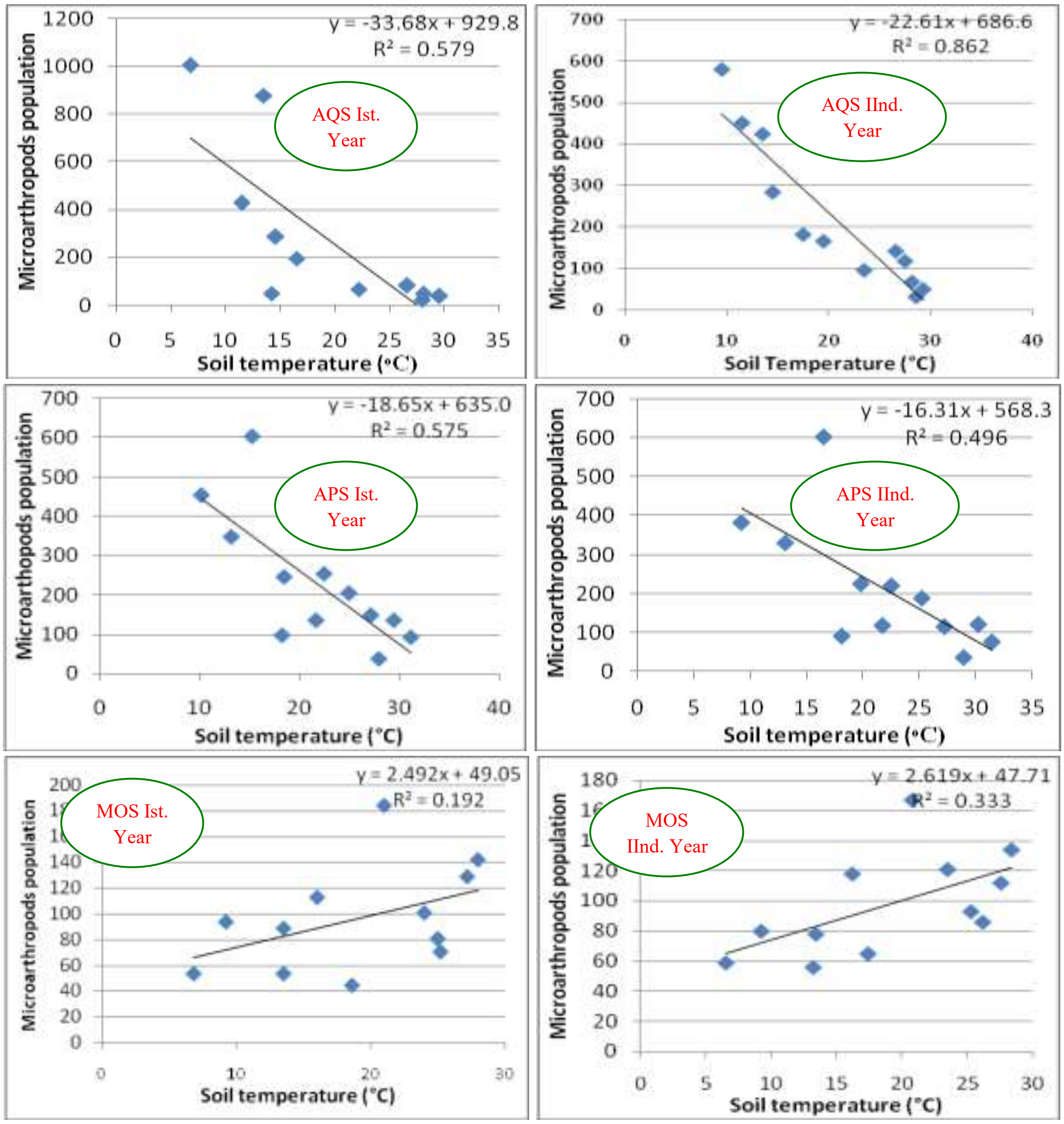
Where, d denotes the density and |S| denotes the total number of samples examined.

Results

In Agricultural Quarsi Site, soil temperature varied significantly as it was recorded critically with the average mean ± standard deviation 19.93±7.92 in first year and 20.80±7.34 in second year of study (Table 1). Soil temperature always observed statistically negative significant in the first year ($p<0.05$, –0.768) as well as in second year ($p<0.05$, –0.573) of the study with reference to the population of soil

International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

microarthropods. In Agricultural Panjipur Site, soil temperature always found statistically negative significant with reference to the population of soil microarthropods as recoded in first year ($p<0.01$, –0.759) and in second year ($p<0.01$, –0.705) of study (Table 1) which can be seen very clearly in regression Figure 2.



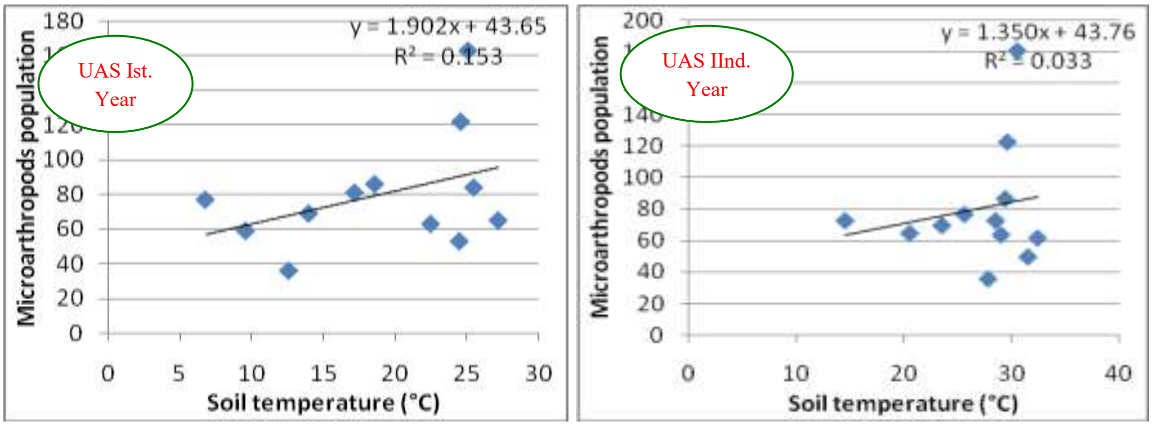


Figure 2. Correlation between soil temperature and population of soil microarthropods.

In Mango Orchard Site, soil temperature showed much more interesting results as soil temperature found statistically slight positive correlation in first year ($p>0.05$, 0.439) whereas it showed strong positive correlation in second year of study ($p>0.05$, 0.578) with reference to soil microarthropods population (Table 1). This is much clearly shown in linear regression presented in Figure 2. In Un Arable Site, soil temperature observed statistically insignificant correlated with reference to soil microarthropods population both in first year and in second year of study.

Table 1. Correlation between edaphic factors and population of soil microarthropods in different study sites of Aligarh

Parameters → ***Sites*** ↓	**Soil temperature (°C)** Mean±SD	**Soil temperature (°C)** Correlation	**Relative Humidity (%)**
AQS Ist year	19.93±7.92	-0.768**	0.282
AQS IInd year	20.80±7.34	-0.573*	0.425
APS Ist year	21.71±6.74	-0.759**	0.723**
APS IInd year	21.98±6.96	-0.705*	0.718**
MOS Ist year	19.00±7.17	0.439	-0.075
MOS IInd year	18.97±7.41	0.578*	0.052
UAS Ist year	19.01±6.92	0.391	0.344
UAS IInd year	26.90±5.16	0.183	0.394

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Discussion

The ecological research on soil microarthropods is supplemented in last two decades with new modified methods in soil ecological studies; however, idea of introducing new techniques does not submit on the edaphic dependent nature of soil microarthropods communities. This is possibly due to the fact that one of the crucial challenge of ecology is the problem of climate change and it is well known fact that climate is the precursor for all animals which live on the earth’s surface. Therefore, there is clear evidence that the rate of alteration of the species depends on the suitability to the environment in which they live. Every change in the climate or in climatic factors will affect the species concerned. Thus, the rate of climatic variation may affect the rate of alteration in species that may be the natural way.

The close relationship of climatic variations, its affect on the species concern and resistibility of species affected are inseparable. Generally, if the resistance power of species is lower than the effect, their condition may be changed or affected and if the power of their resistance is equal to the effect concern, this may be called as suitable environment (unaffected conditioning) and if the power of resistance is higher than the effect, this may be called as perfect environment for living beings. The condition changed may be physiological, anatomical or morphological. Thus, the alteration of species cannot be a random process because the climate undergoes dynamic changes at every time. Same aforesaid words, the population of soil microarthropods cannot be same at all time in an ecosystem; however it is well known that key environmental variables influence soil microarthropods populations. Thus, we hypothesized that the alteration of soil animal species depends on the climatic interference.

Among the edaphic factors studied by Pedobiologists, it has been noted that temperature showed a marked variation with the range of seasons and sudden abrupt changes during the prevailing climatic conditions or seasons. Present study agreed with the observation of Maclagen (1932), and Jucevica & Melecis (2006) as they also reported, soil temperature pronounced effect on the growth, development and fecundity of soil microarthropods mostly Collembola. In our study we found, soil temperature effects on the population of soil microarthropods in varied manner. It has been observed from this study as per the noted differences in dispersal rates of soil microarthropods species which might likely to be strongly correlated with the differences in soil temperature between different land use systems. Relative humadity reported the close factor effects on one of the major agricultural site (APS Ist. & IInd Year-table-1 and figure- 2).

The types of vegetation tend to affect on the gradient of temperature in soil. Dowdy (1965) also reported that, habitat has abrupt effect on the life cycle of microarthropods and enhances their population diversity. Some other researchers reported that temperature is an important factor, regulates many aspects of their life (Christiansen 1964, Butcher et al. 1971, Hopkins 1997). It can be interestingly considered that gradual losses of species of soil microarthropods as abiotic or edaphic conditions begin to exceed tolerance limit could result in random losses of soil microarthropods directly dependent on temperature regimes through which functional activities varied and ultimately productivity of soil may disturb. Hence, manager or farmers need to be aware of the loss of soil microarthropods diversity which might be due to affect of edaphic factors specifically soil temperature and humid conditions in agricultural soil ecosystems.

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