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Research Article

IMPACT OF EDAPHIC FACTORS ON THE DIVERSITY OF SOIL MICROARTHROPODS IN AN AGRICULTURAL ECOSYSTEM AT ALIGARH

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ABSTRACT
Uttar Pradesh, the largest state of India is one of biodiversity hotspot. The present study is based on samples collected from Aligarh district in Uttar Pradesh located at latitude 27 °-54' N and longitude78 °-05' E and altitude 187.45 masl. It is flat topographical area with rich and varied in agriculture as well as faunal diversity. Total, 48 soil samples were collected at random points inside the agricultural field having different types of crops in different seasons within a year. Among soil microarthropods examined, Collembola represent the highest density and abundance (13.54 & 19.70) followed by 14. 83 % Hymenopterans and 13.22 % Acari(mites). Soil temperature was negatively correlated ($r = -0.932$, $P<0.05$) with reference to Collembolans population, whereas soil moisture ($r = 0.502$, $P>0.05$) as well as available nitrogen ($r = 0.656$, $P>0.05$) both were positively correlated. A very close positive correlation was recorded between Collembolans population with reference to soil organic carbon (SOC). The highest (93.75 %) absolute frequency represented by Acari(mites) in arable soils of this region. The decreasing level of soil organic carbon contents in agricultural soils of this region is a serious concern that affects our agricultural food production.

Key Words*: *Diversity, Soil microarthropods, Collembola, Impact, Edaphic factors

INTRODUCTION
In agro-based country such as India, the importance of soil ecosystem in terms of soil productivity cannot be ignore and this productivity in agricultural areas is directly or indirectly related with soil microarthropods population and its change because the interaction of soil microarthropods population has its profound affect on the nature and fertility of soil. However, soil microarthropods are enormously diversified in agricultural soils. On the other hand, soil physical and chemical factors significantly affect the diversity of soil microarthropods.

The relatively distinct combination of temperature and precipitation determine the assemblage of species capable of surviving and defining the characteristics of community type (Mac Mahon 1981). Although impacts of physio-chemical (edaphic) factors on soil microarthropods or, other species may be more subtle but equally significant from the stand -point of the long- term ecosystem structure and functioning. Soil microarthropods are the important biotic component of soil ecosystem, represents a picture of ecological change all the time (day/night, weather/season/years etc.) and the necessity for competence in species determination of very diverse soil fauna such as Collembolans and Acari(mites). Thus, soil microarthropods are the vital source of soil quality and productivity in our agro-ecosystem with out these soil organisms, soil would be sterile medium that could not sustain crop production (Fox 2003).

No substantial study has been directed towards agricultural soils, in relation to the productivity and population dynamics of soil micro arthropods from this region. In the present study, seasonal variation and population dynamics of soil microarthropods in an agriculture environment along with concomitant changes in a variety of physio-chemical factors have been investigated.

MATERIALS AND METHODS
We selected a site at Quarsi village that is situated at the outskirts of Aligarh and is a non-urban site approximately 3 km. from AMU campus. Soil samples were collected throughout the year @ of 4

samples per month regularly and the points selected within a site distributed randomly. The soil of this site was medium course textured, a mixture of sand, silt and clay high enough to hold water and plant nutrients.

For extraction of soil microarthropods, we used modified Tullgren's Funnel apparatus. All soil microarthropods were identified up to the level of their order using a range of taxonomic keys (see O'Connell 1994). For identifying them, we used a stereo zoom microscope. Relative humidity of soil surface was measured by a Dial Hydrometer. Soil moisture was determined by the method of Dowdeswell's (1959) and soil pH measured by electric pH meter. The alkaline permanganate method was employed to estimate the available nitrogen of soil and soil organic carbon was estimated by rapid titration method as described by Walkley and Black (1934).

Statistical Analysis

Strong statistical significant correlation was calculated at 5 % level of significance. Regression (y) calculated according to the formula described by S. Prasad (2007). Non-metric multidimensional scaling (NMS) was used for ordination of density and abundance as stated previously (Abbas and Parwez, 2009).

RESULTS

Soil microarthropods Population

Sampling revealed an unexpected abundance and diversity of Collembola and Hymenoptera. The species richness of Collembola was very low while the individual population was high in most of the sampling cases specifically in spring and winter months. Collembola holds the highest 61.38% population in agriculture site while Acarina (mites) has 13.22% population. The least population in Apterygotes was of Diplura only 0.66% in this site (table-2). Both Collembola and Acari(mites) showed similar trend of population fluctuation; however, Collembola constituted a better population than compare to Acari (Table-3).

Pterygotes and Apterygotes abundance and density were recorded 6.25, 18.08 and 14.06 respectively. The highest abundance of Collembola recorded in the month of January (51.50) while the least abundance in the month of April. Collembolans were totally absent in the month of June. The average abundance and density of collembolans was recorded 19.69 and 13.54 respectively (table-1). The highest (53.54%) collembolans recorded in spring while the lowest 4.30% in rainfall. The highest (93.75 %) absolute frequency represented by Acari(mites) during investigation period (table-2). The higher mean density along with its standard deviation was represented in winter and spring season both by Collembolans as well as Acari (Table-3).

Results pertaining to edaphic factors

Temperature has a profound impact on the seasonal variation of population dynamics of soil microarthropods. Seasonally, there were several variations in temperature recorded during the investigation period. The maximum average temperature of open environment (32.3^{0}C) recorded in the month of May (20.5 to 44.0^{0}C) and minimum (20.4^{0}C) average environment temperature in the month of January (13.3 to 27.5^{0}C). Soil moisture content least (1.44%) recorded in the month of April and maximum (5.12 to 5.53%) in the month of July and January simultaneously in agriculture site. Relative humidity is one of the important environmental factors recorded in our study. The higher humidity recorded in the month of July (81.0% on an average) while the minimum recorded in the month of April (61.5% on an average). Precipitation is the key environmental factor that provides a regulation for other environmental factors, such as temperature and moisture. During the investigation period, the minimum precipitation was recorded in the month of February (10mm) and the maximum (317.4mm) in the month of July followed by August (240.0mm). There was no precipitation in the months of October, December and January; however, the total precipitation (1054.6mm) recorded in a year was 29.9% more than the normal rainfall with in a year (figure-2).

During the investigation period, total organic carbon was recorded in which the higher (0.25%) value was recorded in the month of January and the minimum in June (0.18%). The pH value was not very significant; however it was recorded higher in rainfall season and lower in spring season varies between 7.0 - 7.7 only. Soil temperature was negatively correlated (r = -0.932, P<0.05) with reference to Collembolans population, whereas soil moisture (r = 0.502, P>0.05) as well as available nitrogen (r = 0.656, P>0.05) both were positively correlated. A very close positive correlation was recorded between Collembolans population with reference to soil organic carbon (SOC).

Table 1: Density and abundance of soil Collembola and Acari(mites).

Month	Collembola		Acari (mites)	
	Density	Abundance	Density	Abundance
April08	0.25	1.00	1.75	3.50
May-08	7.00	14.00	4.25	4.25
June-08	---	---	1.25	1.25
July-08	2.00	4.00	2.50	2.25
Aug.08	4.00	8.00	4.50	4.50
Sept. 08	1.00	1.33	3.75	3.75
Oct.-08	7.00	9.33	0.75	1.00
Nov. 08	22.75	22.75	2.00	2.00
Dec. 08	31.50	31.50	5.00	5.00
Jan. -09	51.50	51.50	4.25	4.25
Feb. 09	27.50	27.50	3.25	3.25
Mar. 09	8.00	8.00	1.75	1.75
Average	**13.54**	**19.69**	**2.91**	**3.11**

Table 2: Relative density and Absolute Frequency of soil microarthropods.

Soil microarthropods	Relative Density%	Absolute Frequency%
Collembola	61.38	68.78
Protura	0.75	22.92
Diplura	0.66	12.50
Acari (mites)	13.22	93.75

Table 3: Mean ±SD of seasonal population dynamics of Collembola and Acari(mites).

Season	Collembola	Acari(mites)
Summer	9.67±15.99	9.67±6.43
Fall	9.33±6.11	14.33±4.04
Winter	81.67±49.66	10.33±8.74
Spring	116.00±87.16	12.33±5.03

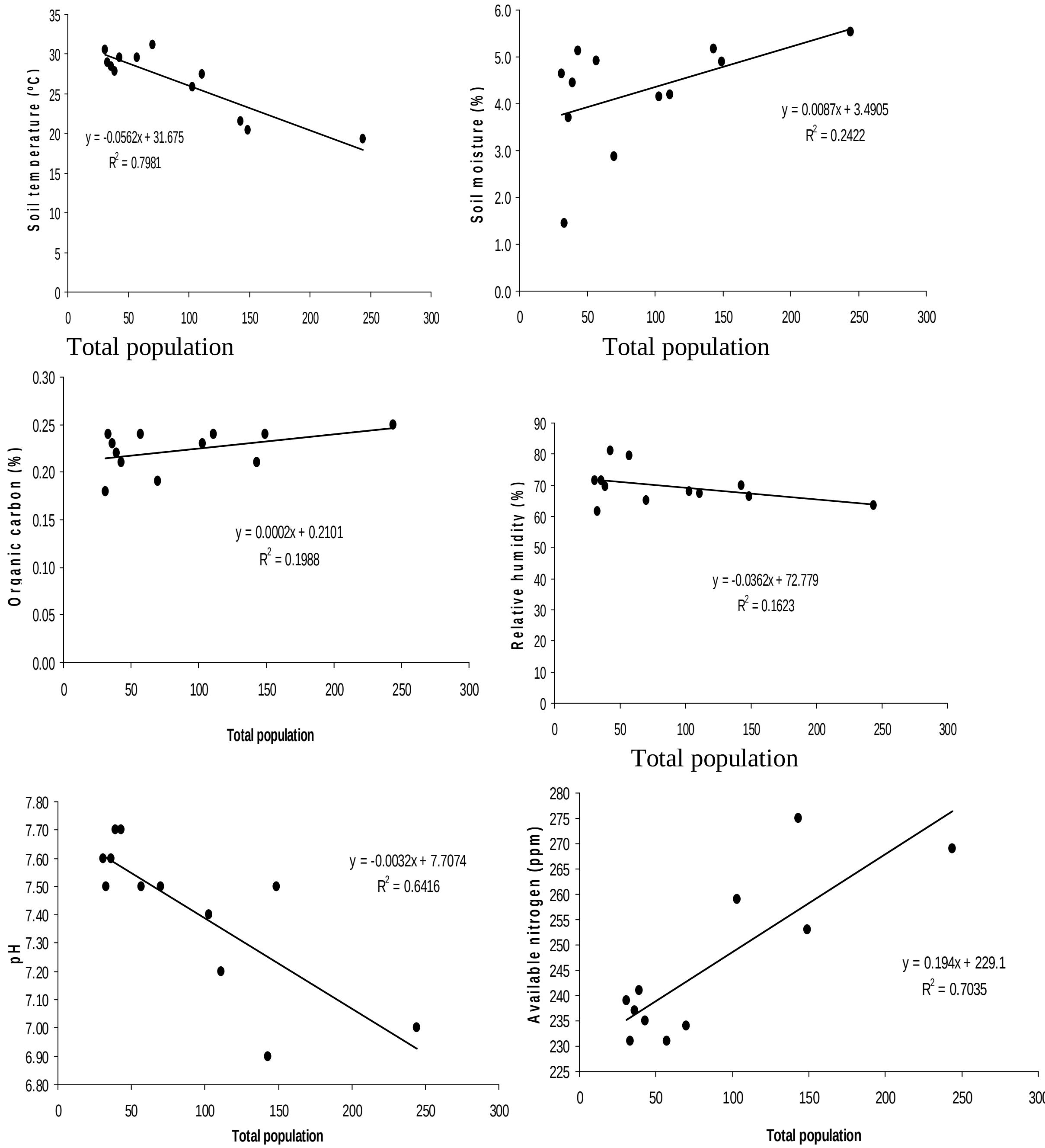

Figure 1: Regression of edaphic factors with total population of soil microarthropods.

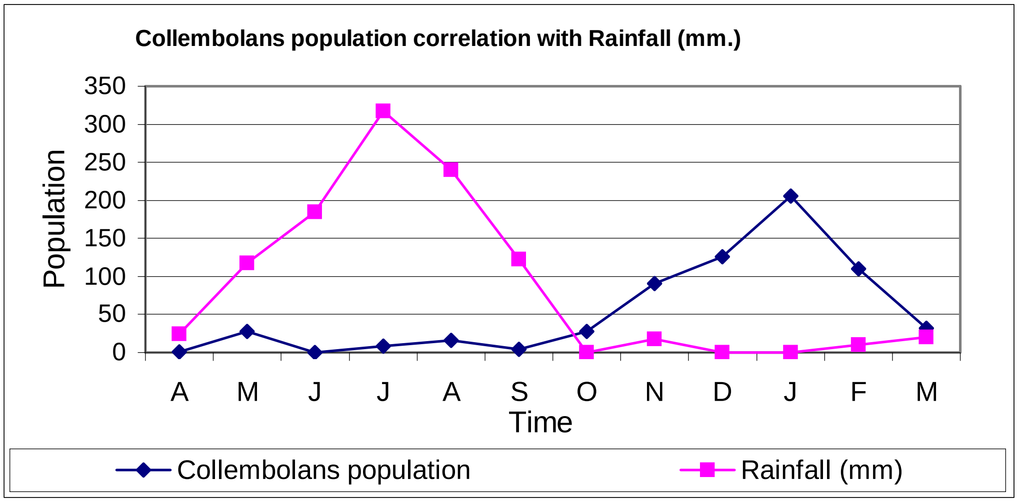

Figure 2: Correlation between Collembolans population and Rainfall (mm.).

DISCUSSIONS

Agriculture soil is an important natural resource that needs a careful management for various purposes such as plant production, cycling of soil organic carbon (SOC) content, nitrogen availability and other nutrients found in soil. Under soil ecological study, soil microarthropods are the indicators of soil quality and productivity and this is due to their interaction with abiotic factors of soil. Thus, soil biodiversity can be evaluated by means of maximizing the number of reliable soil microarthropods in an agro-ecosystem such as Collembolans and mites.

Apart from terrestrial ecosystems, agro-ecosystem is the important part for study of 'C' cycling that is closely related to the atmospheric Co2 and soil quality, because the interaction between global climate change and the dynamics of soil carbon is coexistent in an agro-ecosystem (Qiuli Zhuang et. al. 2007). In agro-ecosystem, ploughing leads to dramatic losses of SOC content through intensive soil disturbance that disrupts soil moisture and enhance decomposition (S.M. Ogle et al. 2005). However, many other studies have proved that the scientific agricultural management practices can increase SOC pool in farmland soils (Lal, 2004). Present study clearly indicates the fluctuation of diversity due to fluctuation of soil organic carbon contents. Thus, it may establishes that concentrations of SOC contents directly affect the density and abundance of soil microarthropods

The abiotic conditions of soil observed in our study were suitable for the development of high density of soil microarthropod communities. The soil was medium coarse textured, a mixture of sand, silt and clay high enough to hold water and plant nutrients. In addition to organic substances increases, the fertility and water holding capacity of this soil keeping sufficient moisture. However, the low population of Collembolans and Acari (mites) recorded in our study indicates the low amount of SOC content and available nitrogen in soil. The population of Collembola in agriculture soils is more dependent on the food availability because most of them are fungal feeder; however the 'durational stability' is more important in order to fungivores feeder. Local biodiversity of Collembola can be very high (Rusek, 1998). Thus, it can be concluded that the application of organic manures or, compost increases the population of soil microarthropods in arable soil.

We agree with the statement of other researchers that seasonal variability of microarthropods can be extremely high, reflecting period, food supplies or environmental changes such as rainfall (Den linger, 1980) and, temperature (Mani, 1968). The community responses of soil Collembola population are strongly controlled by both temperature and precipitation (E. Jucevica and V. Melecis 2006). So, it cannot be overemphasized that environmental (seasonal) stability is another important factor in terms of species richness in an agricultural soil environment. The extra use of chemical fertilizers and mechanical tillage may also affect the population of soil microarthropods in agriculture soils.

Collembolans play an important role in maintaining the Agricultural ecosystem profitable by plant litter decomposition and in formation of soil microstructure. Additionally, they are host of many parasitic Protozoan, Nematodes and Pathogenic harmful bacteria. They utilize fungi, bacteria, algae, plant litter, live plant tissues and some plant pathogens as food. Soil acidification, nitrogen availability in soil, temperature fluctuations, absence of food and intensive farming has greatly impacted collembolan diversity in agricultural soils. A strong positive affect of SOC content and available nitrogen was recorded in our study; however these soil nutrients were less recorded than their normal values. The decreasing level of SOC content in agricultural soils of this region is a serious problem that affects our agricultural food production.

Spring and winter both are the favorable seasons for the growth of soil Collembolans in agriculture soils. Little population of soil Acari (mites) recorded in our study, but having more than 93% absolute frequency in agriculture soils. In this study, the factors underlying seasonal population variability and dynamics of soil microarthropods in soil are largely unknown and clearly deserve more investigation; however the population density tended to be relatively low, in sample receiving extra rainfall (approximately 29.9 %, extra rainfall during the year, April-2008 to March-2009), and it is a general trend that rainfall is a key component that affect the population of soil microarthropods.

Soil physio-chemical properties were usually examined with soil cores; but soil cores inherently certain information limited to one random point and only one instant of time. So, it is necessary to check the soil by using tree-ring analysis, so that it may reveals different information about soil of agriculture land. However, it seems to be ideal for experimental studies of seasonal variation on the population dynamics of soil microarthropods and their roles in an agro-ecosystem. Further more research is required for the study of different parameters such as the soil chemistry, edaphic factors and their effect on the diversity of soil microarthropods in relation to soil quality.

Conclusions

Following are the significant contributions of our study that-

- In terms of numbers of soil microarthropods, Collembola apparently constituted a better population than the other diverse group of soil microarthropods such as Acari(mites).
- Both, Collembolans and Acari(mites) showed a consistent but similar trend of fluctuations with time as a function of climate.
- A very close correlation of soil organic carbon contents with soil microarthropods diversity was recorded in this study.
- The factors like soil moisture, temperature, relative humidity, pH of soil, and food resources, all have the cumulative affect on the density of soil microarthropods. Thus, both edaphic properties and seasonal patterns are the responsible factor for the population buildup of soil microarthropods.

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