International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2012 Vol. 2 (2) May-August, pp.206-217/Parwez and Mohammad
Research Article

SEASONAL DIVERSITY, HABITAT QUALITY AND SPECIES SPECIFIC DIFFERENCES OF MICRO ARTHROPODS ABUNDANCE IN TWO DIFFERENT MANAGED AGRO-ECOSYSTEMS AT ALIGARH

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ABSTRACT
Present study is based on seasonal diversity, habitat quality and species specific differences of micro arthropods abundance in two different managed agro ecosystems at Aligarh. Total 48 samples have been collected from each site at weekly intervals. Soil micro arthropods have been collected with the help of Modified Tullgren's Funnel apparatus and identified by a binocular stereomicroscope. Interestingly, it has been observed from results of this study that, organic farming leads to faunal diversity and it also enhance the level of soil organic carbon that may contribute to long term functional approach in an agro-ecosystem. On the other hand, conventional farming is depend on highly cost effective input amendments which behave as precursor of temporary (short-term) increased abundance of soil micro arthropod communities along with low carbon content in soil. Climatic interference and edaphic properties are also affecting the diversity and species specific structure of soil micro arthropods community. Thus, habitat quality may serve for static nature of soil micro arthropods diversity. Hence, this study clearly establishes that, diversity of soil micro arthropods is affected by various properties in an agro-ecosystem including qualitative and quantitative nature of external inputs, habitat quality, edaphic properties and regional climatic interferences.

Key Words: *Micro arthropods, Collembola, Seasonal Diversity, Habitat Quality, Climatic Interference*

INTRODUCTION
Soil fauna such as micro arthropods enhance ecosystem services by accelerating key determinants of an ecosystem for primary productivity including decomposition of organic matter, soil mineralization, energy flow, nutrient cycling and maintaining of soil physical structure (Hofer *et al.,* 2001, Moore *et al.*, 2002, Coleman *et al.,* 2004, Gladys *et al.,* 2007, Palacios-Vargas *et al.,* 2007, Yang and Chen 2009). Thus, their diversity and abundance may used as the indicators of soil stress, soil quality, pollution and environmental changes (Kuperman 1996, Lobry de Bruyn 1997, Hofer *et al.*, 2001, Warren and Zou 2002, Lindberg *et al.*, 2002 and Parisi *et al.*, 2005).
Interestingly, it has been shown that the management practices carried out in organic agriculture increase the population as well as functional diversity of soil micro arthropods (Paoletti and Pimentel 1992, Mader *et al.,* 2002, Bengtsson *et al.*, 2005 and Diepeningen *et al.*, 2006) as compared with conventional practices (Lara *et al.*, 1986, Doles *et al.*, 2001 and Peredo *et al.*, 2002). Organic farming does not harm to soil fauna and it preserves soil fertility (Hadjicharalampous *et al.*, 2002). Organic farming is becoming a major consideration for sustaining soil quality damaged by intensive use of synthetic chemicals to enhance crop production (Srivastava *et al.,* 2007). On the other hand, modern system of conventional cultivation that is mainly based on chemical fertilizers, pesticides and herbicides; however these all are detrimental to soil organisms (Bengtsson *et al.*, 2005).
Little information is available on diversity and community structure of soil micro arthropods from Indian agricultural soils. No substantial study has been done on soil micro arthropods subjected to seasonal diversity, population dynamics and impact of agricultural practices on the diversity of soil micro arthropods though organic or conventional. However, this natural currency is more important in relation to various functional approaches in agricultural soils as well as for their conservational means. Therefore, we decide to carry out a research experiment on micro arthropods diversity. In the present study, we

investigate, seasonal diversity, habitat quality and species specific differences of micro arthropods abundance in two different managed agro-ecosystems at Aligarh. Within this context, one interesting question has been addressed in this study that-
To what extent do the responses of soil micro arthropods diversity to conventional and organic farming, edaphic properties and seasonal climatic interference?

MATERIALS AND METHODS

(a) Study Sites

Following two study sites have been selected to collect the soil samples-

(i) Agricultural organic farming site

We selected a site at Raja Nagar village that is situated at the outskirts of Aligarh city. It is a non urban site approximately 3 km. from AMU Campus. Different crops considered with in a year such as Maize (*Zea mays*), Indian Jwar and Wheat (*Triticum aestivum*) etc. The soil of this site is course textured a mixture of sand, silt and clay. In addition of organic substances in soil increases the fertility and water holding capacity of this soil, so that it keeps sufficient moisture especially in wheat crop. Thus, this soil is more fertile and able to produce more crops. Every crop was well managed by its farmer in terms of ploughing, irrigation and care taking during crop time.

(ii) Agricultural conventional farming site

Another site has been selected at Pangipur village that is situated near University Quila at Aligarh. It is just approximately 1 km. from AMU Campus. Different crops considered with in a year such as Mung been, Paddy (*Oryza sativa*) and Wheat (*Triticum aestivum*) etc. The soil of this site is also course textured a mixture of sand, silt and clay and alluvial in nature. Rest of information about this site of soil type has been same recorded as aforesaid agricultural soil.

(b) Sampling and extraction of soil micro arthropods

Samples have been taken regularly at weekly intervals and the points selected within the plots distributed randomly. Total, 96 samples have been taken from both sites during the investigation period. Each sample consists of 4 corers of 5 cm. size. Modified Tullgren's funnel apparatus has been used for extraction of soil micro arthropods. All micro arthropods have collected inside a beaker which contained 70 % alcohol with few drops of glycerol so that micro arthropods are not getting dried. They were preserved in a series of alcohol (70%→ 80%→90%) having each of series for an hour of time period and finally 10-20 minutes preserved in 100% alcohol. After that they were separated and mounted with DPX.

(c) Identification

All soil micro arthropods have been identified up to the level of their order or, family using a range of taxonomic keys (O' Connell and Bolger 1994). A binocular stereomicroscope (OLYMPUS, CX-21) has been used for identification of soil micro arthropods.

(d) Analysis of edaphic factors

Temperature of the soil was measured by directly inserting the thermometer into the soil up to the required soil depth and Relative Humidity was determined by Dial hydrometer. Soil Moisture has been determined by using the gravimetric method as described by Dowdswell (1959). For the purpose of soil matrix analysis, the soil samples were cored from the same plots from where the soil samples were collected for population analysis. Soil pH, Organic Carbon, and Nitrogen, all were examined by standard laboratory methods.

(e) Statistical Analysis

To study the diversity of soil micro arthropods in different study sites, various parameters considered such as density, abundance, and fractional population as stated previously (Abbas and Parwez, 2009). One way ANOVA was used to determine the correlation between population of soil micro arthropods with reference to various edaphic and soil chemical parameters. Diversity (H) calculated as directed by Shannon and Wiener diversity index (1949) and Evenness (J) (Pielou, 1966) based on the following formula:

$$\bar{H} = -\sum_{i=1}^{N} P_i \log_2 P_i$$ Where, $\bar{H}$ = Species diversity, P_i = Ni/N is the probability of an individual to belong to a species, N_i = no of individual in i[th] species, N = Total number of individuals in samples, S= Number of Species

Evenness $$J = \bar{H} / H_{max}$$ Where, J= Evenness, $\bar{H}$ = Diversity index, H_{max}= log_2S, and S= Number of Species.

RESULTS

We have collected 2,318 individuals during study in which 1,259 individuals (54.3 %) from agriculture organic farming (AOF) and remaining (45.7 %) from agriculture conventional farming (ACF) site. Thus, compared to ACF site, approximately 9 % more population was recorded in AOF site. Apart from soil micro arthropods, eight orders were collected, Collembola, Protura, and Diplura which consist the part of Apterygotes and Hymenoptera, Coleoptera, Diptera, Isoptera and Pscocoptera which consist of Pterygotes. Acarina was another group of soil micro arthropods that collected in our study. More than half of the specimens were Collembolaas as shown in figure 3. Thus, the proportion of Collembola in samples from each habitat type varied considerably as listed 57.8% in AOF and 61.4% in ACF site (figure 3). Collembola and Acari (mites) were significantly more abundant in post monsoon months than in dry season across both habitat types (table1, 2 and figure 1). Densities of Collembola (15.2 ind/samples) and Acari (3.4 ind/samples) were always higher in AOF than in ACF (13.5 and 2.9ind/samples) site whereas, abundance of Collembola (19.7 ind/samples) was higher and Acari (3.1 ind/samples) was lower in ACF site (table 1 and 2).

Table1: Temporal dynamics of soil micro arthropods in an agricultural organic farming site.

	Collembola		**Acarina (Mites)**		**Pterygotes**	
Month	**Density**	**Abundance**	**Density**	**Abundance**	**Density**	**Abundance**
Apr.10	6.25	8.33	0.50	**1.00**	13.25	13.25
May	**1.00**	1.33	1.75	3.50	**22.00**	**22.00**
June	4.75	6.33	2.00	2.67	14.75	14.75
July	4.25	8.50	1.00	1.33	13.00	13.00
Aug	5.25	10.50	1.75	1.75	12.00	12.00
Sept	1.25	**1.25**	2.25	2.25	3.00	3.00
Oct	9.50	12.67	**0.25**	**1.00**	---	---
Nov	5.50	5.50	4.00	4.00	3.25	4.33
Dec	14.25	14.25	3.75	3.75	1.50	1.50
Jan-11	31.75	31.75	5.75	5.75	3.00	6.00
Feb	37.75	37.75	7.75	7.75	1.25	5.00
Mar	**60.50**	**60.50**	**10.00**	**10.00**	2.75	3.67
Average	**15.17**	**18.20**	**3.39**	**4.18**	**7.48**	**9.70**

Regarding this study, 13 families were presented from six orders as following: order Collembola, four families (Entomobryoidae, Isotomidae, Hypogastruridae and Sminthuridae), order Diplura, single family (Japygidae), order Protura, single family (Eosentomidae), order Coleoptera, four family (Carabidae, Coccinellidae, Scarabaeidae and Staphylinidae), order Diptera, two families (Tipulidae and Corethrelidae), and order Hymenoptera, one family (Formicidae). Under conventional management, the most abundant taxa were Oribatids & prostigmata and Entomobryomorpha among the Collembola.

Temperature (r = -0.931, P<0.05) and pH (r = -0.708, P<0.05) both were negatively correlated with reference to Collembolans population, whereas Potash (r = 0.588, P>0.05) as well as available nitrogen (r = 0.656, P>0.05) both were positively correlated in ACF site. In AOF site, soil pH (r = -0.783, P<0.05) was negatively correlated where as Available Nitrogen (r = 0.903, P>0.05) was positively correlated with reference to Collembolans population (figure 2). Fractionally, population of both Collembola and Acari (mites) were higher in ACF site whereas overall the populations of all taxa were higher in AOF site (figure 3). Seasonally, population fluctuation of soil micro arthropods was temperature dependent as recorded in our study.

Table 2: Temporal dynamics of soil micro arthropods in an agricultural conventional farming site

	Collembola		**Acarina (Mites)**		**Pterygotes**	
Month	**Density**	**Abundance**	**Density**	**Abundance**	**Density**	**Abundance**
Apr.10	**0.25**	**1.00**	1.75	3.50	5.75	5.75
May	7.00	14.00	4.25	4.25	6.25	6.25
June	---	---	1.25	1.25	6.50	6.50
July	2.00	4.00	2.50	2.25	6.25	6.25
Aug	4.00	8.00	4.50	4.50	5.00	5.00
Sept	1.00	1.33	3.75	3.75	2.75	2.75
Oct	7.00	9.33	**0.75**	**1.00**	1.75	1.75
Nov	22.75	22.75	2.00	2.00	0.75	3.00
Dec	31.50	31.50	**5.00**	**5.00**	**0.50**	**1.00**
Jan-11	**51.50**	**51.50**	4.25	4.25	2.75	5.50
Feb	27.50	27.50	3.25	3.25	4.75	9.50
Mar	8.00	8.00	1.75	1.75	**18.0**	**18.00**
Average	**13.54**	**19.69**	**2.92**	**3.11**	**5.08**	**6.26**

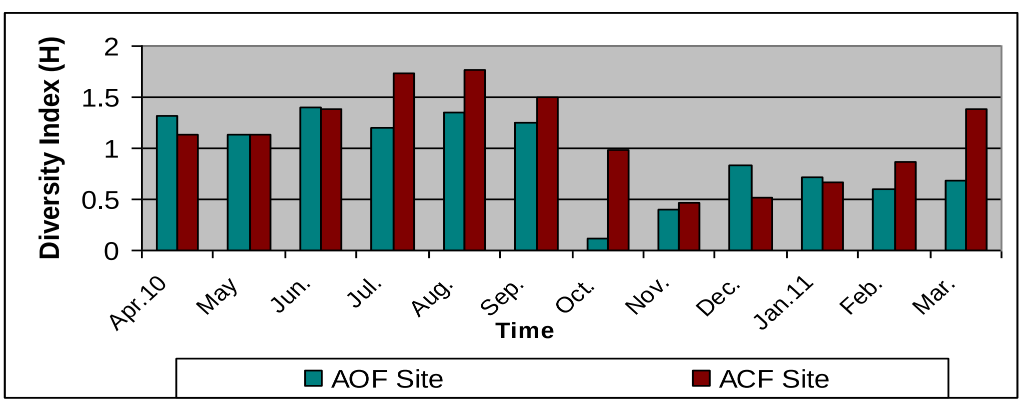

Figure1: Diversity of soil micro arthropods between two different farming systems at Aligarh

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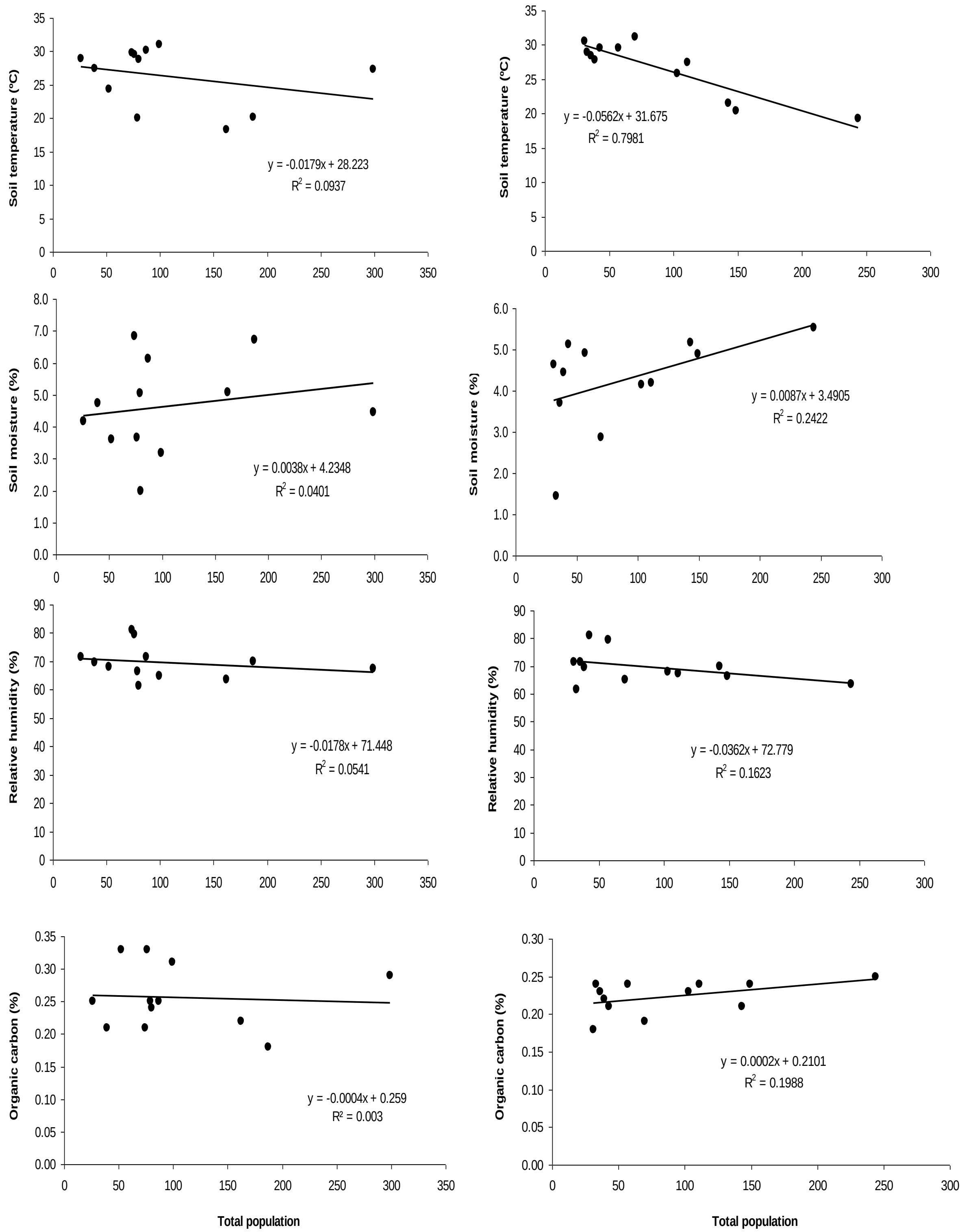

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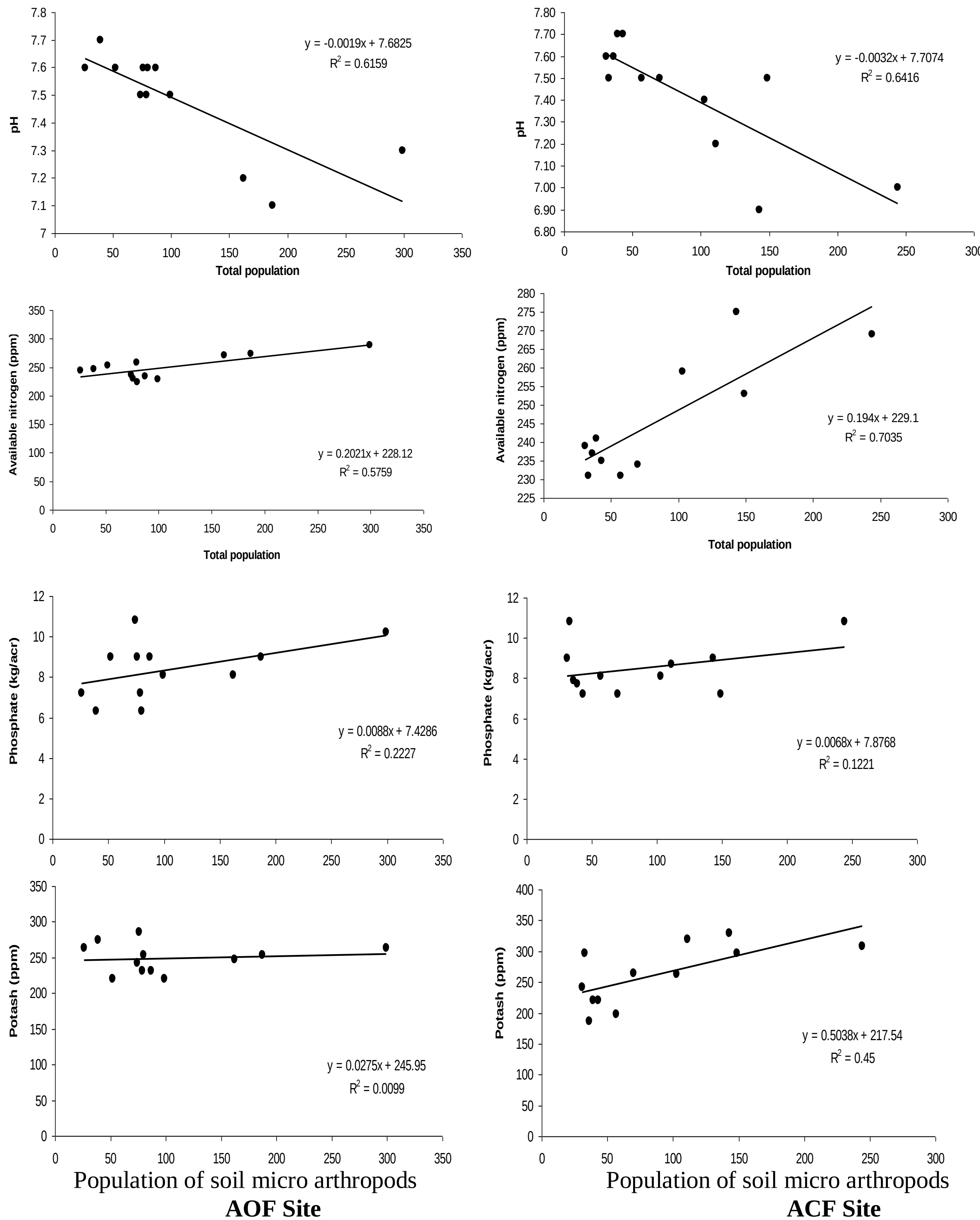

Figure 2: Regression between various physio-chemical parameters of soil and population of soil micro arthropods.

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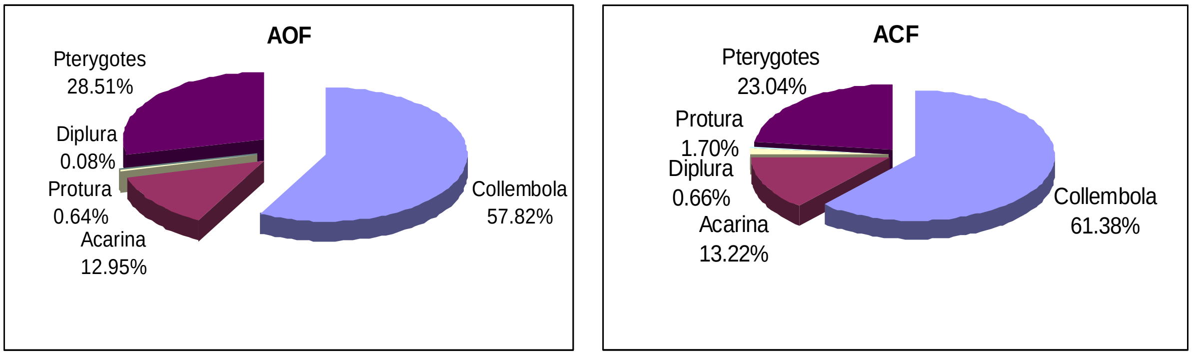

Figure 3: Community structure of soil micro arthropods population in two different managed agro-ecosystems

Table 3: Mechanical Analysis of soil

SOIL TEXTURE			
Name of Site	**% of Sand**	**% of Silt**	**% of Clay**
Agriculture conventional farming site	61.5	20.4	18.1
Agriculture organic farming site	59.5	19.7	20.8

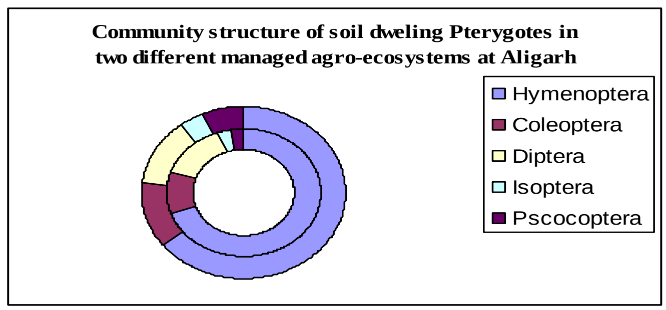

Figure 4: Community structure of soil dwelling Pterygotes in two different managed agroecosystems

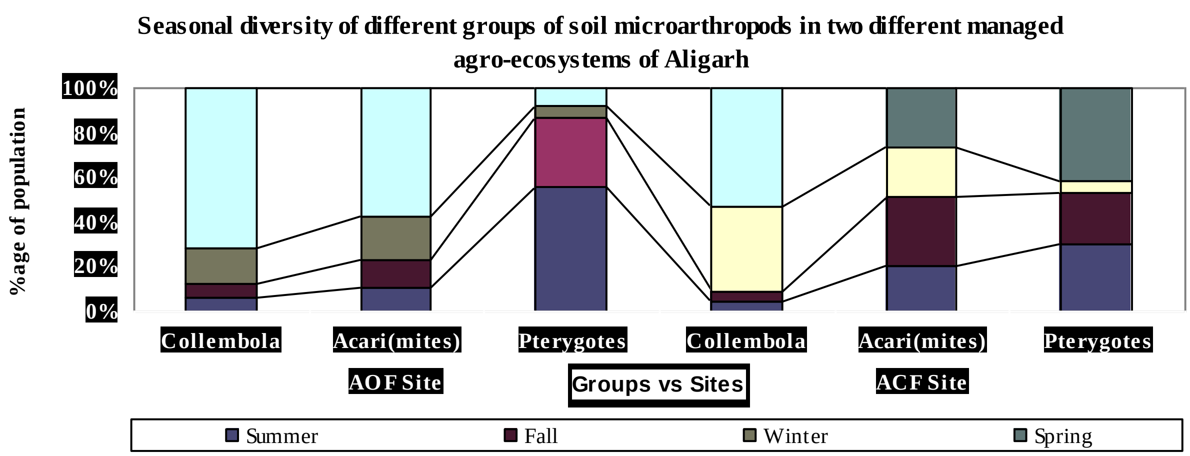

Figure 5: Seasonal diversity of soil micro arthropods in two different managed agro-ecosystems

An interesting observation has been collected in our study is the soil temperature was statistically less negative significant or insignificant with reference to Collembola population in AOF ($r = -0.489$, $P<0.05$) site compared to ACF ($r = -0.931$, $P<0.05$) site whereas, in case of Acarina population, soil temperature was statistically more negative significant in AOF($r = -0.557$, $P<0.05$) than in ACF ($r = -0.393$, $P<0.05$) site that was statistically insignificant. In our study, results were more satisfactory found in ACF site however, total diversity varied considerably in both study sites although this has clearly demonstrate the meaningful differentiation between study sites.

DISCUSSION

Modern method of agricultural cultivation is only one dimensional because of more and more demand of food productivity. This is due to perhaps explosive human population growth. However, this has led to global environmental problems including increased pollution, soil degradation and desertification, decreasing soil quality and fertility and ultimately the loss of biological diversity in soil ecosystems. Thus, soil physical structure and soil quality altogether affected by frequently using highly effective chemicals, fertilizers, pesticides and herbicide amendments employed in modern conventional agriculture. Although, this management system has played a major role in improvement of fiber and food quality as well as productivity, however, it has raised various public health problems and environmental concerns (Horrigan *et al.,* 2002).

In the present study, we observed the highly qualitative as well as quantitative similarities between communities of both types management (organic and conventional). Thus, similarities of both management types have clearly indicated that, both habitats were similar in terms of type of soil, climatic conditions and in terms of ecosystem homogeneity. The high diversity of soil micro arthropods found in AOF site; however, more satisfactory results expressed in conventional management. Thus, organic farming practices are known to alleviate the native effect on agriculture as a result of increasing its biological diversity.

The density and abundance of soil micro arthropods were greater in wet season than in dry season which is similar to other studies (Reddy and Venkataiah 1990, Wiwatwitaya 1996, and Wichaikam *et al.,* 2010). More population of total soil micro arthropods as well as group abundance was observed in AOF site than in ACF site. In view of this observation, There are two possible reasons, firstly, the high concentration of organic carbon contents of soil found in AOF may exert the faunal population and agrochemical consumables of pre-existing conventional management are being replaced by other low energy alternatives, allowing a greater inward movement of different edaphic groups in search of food thus increasing biodiversity (Altieri 1999). Secondly, the accumulation of organic material provides a substrate, which releases nutrients and appropriate maintenance of the soil structure. This stability results in taxa richness which would be represented by those groups which adapt best to organic management (Santiago *et al.,* 2009) than compare to conventional management. Thus, organic agricultural practices may increase the functional diversity of soil biota.

Collembola population was extremely higher in AOF site due to that Collembola assist the degradation of organic matter more rapidly than in conventional cultivated areas which was poorly organized or temporary nutrient reservoir. Ants (Hymenoptera) were more abundant during wet and dry seasons than the spring and winter which corroborate the results of Watanasit *et al.,* (2000). This is because of humidity plays an integral role in softening the soil which presumably enables them to build nests more easily (Watanasit *et al.,* 2000).

A marked negative impact of temperature has been recorded during study in both sites. This may be attributed that, increase temperature or warming may indirectly alter the soil micro arthropods communities by causing a shift of abundance vertically or in abundance and composition of soil organisms upon which they prey (Kardol *et al.,* 2011). Soil pH was negatively correlated in both site of study that corroborate the results of some other numerous researchers as they stated that, agricultural intensification leads to alteration of soil pH which disrupts niches of soil fauna (Moreira *et al.,* 2006).

An interesting observation has been collected in our study is the soil temperature was statistically less negative significant with reference to Collembola population in AOF site compared to ACF site. This highly negative significant correlation of soil temperature may be attributed due to fertilizers or other amendments those were applied in ACF site. On the other hand, less negatively significant soil temperature found in AOF may be due to higher soil organic matter and soil moisture. Because the organic matter of soil keeps cool to soil by increasing soil moisture contents. In conventional farming, fertilizers, pesticides and herbicides disrupts the soil labile carbon and enhance nitrogen available in soil due to that soil organic carbon level is decreasing day by day. Thus, decreasing level of SOC content in soils of this region is a serious problem that affects our food production (Abbas and Parwez 2012). Extra increasing level of available nitrogen in soils is also detrimental to human health because of higher leaching of nitrogenous compounds (such as nitrate nitrogen) through soil into ground water may increase the lungs problem.

In case of Acarina population, soil temperature was statistically more negative significant in AOF than in ACF site that was statistically insignificant. In view of this observation, we conclude that, this may be beneficial; because of most of Acari populations have pathogenic affect on farming soil. Thus, organic farming may reduce the growth of pathogenic developing soil organisms in arable soils due to that high concentration of organic matter keep warms to soil against pathogenic growing organisms. Some numerous researchers have also stated previously that, organic amendments in general are though to suppress soil pathogens, in part due to enhance competition between soil microorganisms for 'C' and 'N' and have long been used as a method of bio-control (Cook and Baker 1983).

In the present study, number of factors have influence our results and making complicate their interpretation. However, the clear evidence is that, the soil microarthropos population found higher in rich nutrient habitat along with moist and suitable soil environment. Harsh climatic conditions could lead to gradual losses of species specific. Such losses could be random with respect to species effect on any given ecosystem processes, leading to patterns of process response to changes in diversity similar to those observed in ramdomly assembled communities (Loreau *et al.*, 2001) as we observed a varied nature of Collembola community in our experiment. Thus, static environmental conditions of climate are beneficial for rich diversity of soil micro arthropods. Interestingly, it could be hypothesized that, diversity of soil micro arthropods is affected by various properties in an agro-ecosystem including qualitative and quantitative nature of external inputs, habitat quality, edaphic properties and regional climatic interferences.

Although, no comparative study has been recorded on diversity of soil micro arthropods from North Indian Indo-gangetic Alluvial plains. Despite this study suggest that, the agro-ecosystems of North India region are rich in springtails community and strongly dominated over the population of soil micro arthropods. Apart from Collembolans, Isotomidae species are dominant and represented a high reproductive rate as well as adaptive ability. Therefore, *Folsomia candida* was the dominant species in terms of richness and diversity among Isotomidae. This is first time investigated in our study.

A greater environmental heterogeneity below the soil surface provided by the plant roots would ensure a greater edaphic biological diversity and the existence of all the functional groups, especially those taxa which have no equivalent trophic role (Santiago *et al.*, 2009). Thus, diversity could be increased by increasing competitive interactions between different functional attributes and ultimately biodiversity does increase.

June and September pattern is somewhat counterintuitive as water stress was higher both in dry and flooding seasons. Hence, winter and spring both seasons have high density, abundance as well as taxa richness. Therefore, Collembola community reflected the integrated response to climate interference and it may severe when soil moisture conditions were higher or expected to very less in soil environment. Thus, micro arthropods may be used as Quality based Bio-indicaters technology (Q-Bit) in an agro-ecosystem because of their community structure as well as their densities are highly sensitive to management practices.

Clearly, the presence of faunal species in the soil may provides the information about its functional potential, where as actual soil functioning depends on various factors such as climatic conditions and soil complex medium along with microbial activities as well as micro arthropods decomposing and recycling activities. So, the exact status of soil functioning may not be detect; however it requires more investigation. Further investigation could be initialized on quality parameters of soil that may contribute to plant productivity and soil fertility. Collembola and its diversity patterns could be used as reliable bio-indicators for this approach.

Conclusions

Some important contributions of this study are as follows-

- One of the interesting observations of this study is that, the organic farming leads to faunal diversity along with the level of soil organic carbon that may contribute to long term functional approach in an agro-ecosystem.
- This study clearly establishes that, diversity of soil micro arthropods is affected by various properties in an agro-ecosystem including qualitative and quantitative nature of external inputs, habitat quality, edaphic properties and regional climatic interferences.
- June and September pattern is somewhat counterintuitive as water stress was higher both in dry and flooding seasons. Hence, winter and spring both seasons have high density, abundance as well as taxa richness.
- Thus, it could be hypothesized that, static environmental conditions of climate are beneficial for rich diversity of soil micro arthropods.

This ecological study on soil micro arthropods may provide valuable information about diversity patterns and, biotic and abiotic interactions that can be used as an applied research to maximize crop productivity and to minimize environmental degradation in agricultural ecosystems.

ACKNOWLEDGEMENTS

The authors are grateful to UGC, New Delhi for financial support in the form of a major research project no. 34-423/2008 (SR).

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