Seasonal Dynamics and Land use Effect on Soil Microarthropod Communities in the Northern Indian State of Uttar Pradesh (India).

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Abstract
The study addressed the influence of seasons and land use on soil microarthropod communities. Soil microarthropods were grouped into four categories i.e. Pterygote, Apterygote Acari and other Nematodes. The densities of total microarthropod, Collembola, and Acari were highly significant with seasons. Highest average densities of Collembola (70%), Acari (60%), and other microarthropods (58%) were observed in the grassland as compared to teak plantation. Pearson’s correlation indicated that microarthropod population was negatively correlated with soil temperature and pH. Seasons had greater influence on biological indicators than the land use change. This research indicated that soil microarthropods appear to be consistent and potentially a good indicator for assessing the impact of land use practice and seasons on soil quality.

Keywords: Soil microarthropods, physical factors, Collembola, Acari.

INTRODUCTION
Soil is one of the most essential and diverse natural habitat of biodiversity on earth. Soil fauna constitute 23% of the total diversity of living organisms (Decaens et al., 2006). Among soil biota microarthropods are considered to be one of the very important biotic components of soil ecosystem being actively involved in decomposition, nutrient cycling, changing the soil structure, improving soil fertility, and, thus influencing the overall soil health or quality. As micro-arthropods live in
the soil, and are sensitive, as well as, dependent on its ecological conditions, and respond to disturbance of soil structure, they could be good biological indicators of soil conditions. Biological indicators of soil quality have the capacity to integrate across a range of factors that might affect soil health (Webster et al., 2001). According to the published data, soil micro arthropods are considered to be indicators of the state of soil conditions or health (Gardi et al., 2002, Lavella et al., 2006, Lee et al., 2009, Parisi et al., 2003 and 2005, Paolo et al., 2010 and Rombke et al., 2006). In soil ecosystems, the status of soil biota at local and regional scales is influenced by different driving forces, such as forestry, agriculture, urbanization and seasonal fluctuation. These forces causes changes in land use, soil moisture, temperature, bulk density, SOC and other physio-chemical factor which directly or indirectly affect density and diversity pattern of soil biota. Temperature fluctuation during different seasons commonly induces vertical movement of soil animals in the soil profile (Didden, 1993, Luxton, 1981). To avoid drought conditions soil biota move vertically deeper into the soil or redistribute to moisture patches (Didden, 1993, Verhoef, 1983). Seasonal differences in the abundance of soil arthropods have been studied by various workers (Badejo, 1990; Badejo, and Straalen, 1993, Lasebiken, 1974 and Usher, 1975). Their findings reported that microarthropods undergo enormous fluctuations in densities, due to changes in microenvironment and thus water is a primary abiotic factor influencing population size (Badejo, 1990). However, the mechanism of the population dynamics of microarthropods in the soil ecosystem is complex, often without a sole environmental factor that can explain the variation of micro arthropods population (Miyazawa et al., 2002). Modern agricultural practices, such as, use of heavy machinery for tillage operation, chemical fertilizers, and pesticides, have led to severe impacts on the soil ecosystem. Among these impacts the reduction in soil biodiversity and degradation of soil quality are often viewed as major threats for the future (Solbrig, 1991). Land use change and agricultural intensification generate severe habitat degradation or destruction for soil biota (Decaens et al., 2006).

Thus, the objectives of our study were: to evaluate the influence of land use practice and seasonal variations on soil faunal densities and diversities and to investigate the relationship among soil biological and physicochemical indicators.

MATERIALS AND METHOD:

The study was conducted in two different lands. In which first one was grassland and other was Teak plantation at Aligarh Muslim university, Aligarh (India). The climate of the area is semi arid characterized by low precipitation, high evaporation hot summer days and moderate winter temperature. The soil through the study area is clay loam. To determine the population density of soil mites found in the depth of 0-10 cm of soil, soil microarthropods were collected with the help of a corer modified by
Averbach and Crossley (1960). The soil samples were collected bimonthly for a period of two years. Extraction of microarthropods was done in a modified Tullegren-Funnel. The insects collected were preserved in 70% alcohol and identified in a stereo zoom microscope. Analysis of edaphic factors such as soil temperature, soil moisture, pH, content of organic carbon, nitrate and phosphate were done by standard laboratory methods. Temperature was measured by directly inciating the soil thermometer into the soil up to the required depth, Relative humidity by a Dial Hydrometer, pH by electric pH meter and soil moisture (water content) by Dowdeswell’s (1959) method. Organic carbon was estimated by rapid titration method as described by Walkey and Black (1934), Nitrogen content (N) by Jackson (1966) method, Phosphorus content (P) by Molybdemnum blue test and Potash content (K) by Jackson (1966) method.

RESULTS AND DISCUSSIONS

Influence of land use and seasons on microarthropod density and diversity:

During the experimental period at both the lands, the total number of Microarthropods collected from the experimental areas was grouped into the following categories: a) Pterygote, Apterygote, Acari, and Nematodes. Among Pterygote, Dipterans were found to have the highest number and among Apterygotes, the dominant order was Collembola followed by Acari and Coleoptera. This was in agreement to the work of Reddy (1984) and Adeniyi (2009) in which collembolans were observed to be the most abundant taxa. Ford (1937) had emphasized on the influence of presence or absence of grasses on the fluctuation in the populations of Collembola and Acari. The average population densities of total microarthropods (Apterygote, Pterygote, Acari and Nematode) were higher in the winter followed by post-monsoon and lowest in the pre-monsoon season (Table 1). Interaction between seasons and land use for population density was significant indicating a varied response of microarthropods to seasonal change under different land uses.

Among the soil microarthropod groups, Collembola and Acari are the most often studied group, due to their high abundance and diversity, important role in key biological processes such as, catalyzing organic matter decomposition and central role in the soil food web, making them suitable organisms for use as bioindicators of changes in soil quality, especially due to land use practice and pollution (Rombke, 2006). Collembola density was weakly significantly different according to land use (p<0.1). Average population density of Collembola was higher in grassland soils as compared to Teak plantation in all the seasons (Table 1). Acari density did not significantly vary with the land use suggesting that their response to seasonal changes differed markedly according to land use. Such differences may be due to disturbances caused by soil tillage and planting/harvesting activities on agricultural land.

Low densities and diversities of microarthropod population including Diptera,
Collembola, and Mites during the pre-monsoon month of April was probably due to low soil moisture content, higher temperature and recent tillage operations in agricultural plots. The decrease in microarthropod populations caused by tillage practices can be attributed to the destruction of microhabitat, changes in temperature, humidity, and pore size distribution, and decrease in organic matter content (Heisler and Kaiser, 1995, Loring, 1981, Perdue and Crossley, 1989). Further, environmental factors, such as water and nutrient contents, are important factors affecting the populations of soil microarthropods (Klironomos, 1995 and Tadeka, 1987). The increase in microarthropod population was also likely caused by inputs of various forms of organic matter such as manure, sewage sludge, green manure and crop residues (Alissiuty, 2000, Axelsen, 2000, Primental and Warneke, 1989 and Vreeken-Buijis, 1998).

Comparing both land use systems, mean population densities of Diptera, Collembola and Acari were highest in the grassland (Table 1). This could be attributed to higher organic content and moisture, and slightly lower temperature and bulk density in grassland soils compared to Teak plantation land (Table 1). According to Begum et al. (2011) these differences are likely relate to microhabitat, and the differences could reflect the soil abiotic factors such as differences in temperature, soil moisture, bulk density, changes in food sources and SOC.

The minima of the total microarthropod population in Teak plantation during pre monsoon, though correlated with the dry conditions, lack of moisture high atmosphere temperature but the most important reason could be scarcity of food material. As in dry conditions the humus layer becomes dry and the growth of fungal mycelia is also retarded. The absence of fungal population in the soil may be one of the causes responsible for such a minima (Wallwork 1967). In conclusion there is a strong correlation between litter animal diversity and decomposition rate suggests soil animals play an important role in litter decomposition. We also made certain inferences;

a) That thickness of leaves has a relation with the rate of decomposition.

b) That there is a tendency to increase in the numerical abundance of most of the populations of litter-dwelling species, when there is enough fungal growth on the soil surface.

Apart from seasonal variation, litter quality is also an important factor directly related to the population fluctuation of microarthropods. Because type of leaves the amount of nutrient they have and how easily the leaves are degraded after shredding by these insects is also very important. Leaves which decay rapidly are highly favored by collembolans, Dipterans and hymenopterans, as it was observed in teak plantation site. Price and Benham, 1977, Darlong and Alfred 1982, was of the opinion that the interaction of litter and soil apparently had its effect on the prevailing physico-
chemical condition of soil. The thickness of the leaf generally influences the rate of decomposition which in its turn affects the fluctuation in the population of microarthropods in general and Collembola and Acarina in particular.

**CONCLUSION:**

When compared across the seasons, soil micro arthropod population was highest in the winter, followed by post-monsoon and lowest during the pre-monsoon. The seasonal variations in soil microarthropod population groups were largely due to climatic fluctuations. Spatial and temporal variability of soil biological as well as physicochemical properties affected soil performance, ecosystem services and processes. Understanding changes in soil biological indicators is, therefore, important to minimize the environmental degradation and improve the productivity and sustainability of agro ecosystems in the northern state of Uttar Pradesh (India). Therefore, there is a need to investigate spatial and temporal variability of the dynamics soil attributes to refine the agricultural management practices for sustainable management of agro ecosystem. Long-term monitoring is required to fully understand the impact of different agricultural practices and seasons on soil faunal abundance, diversity and community structure for the conservation of soil biota, as well as, for assessment of soil quality.

**Table1:** Average densities of different soil micro arthropods in different seasons and land use system.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Monsoon</th>
<th>Post-Monsoon</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grassland</td>
<td>Grassland</td>
<td>Grassland</td>
</tr>
<tr>
<td></td>
<td>Teak plantation</td>
<td>Teak plantation</td>
<td>Teak plantation</td>
</tr>
<tr>
<td><strong>Total microarthropods</strong></td>
<td>78±20</td>
<td>112±40</td>
<td>295±125</td>
</tr>
<tr>
<td></td>
<td>58±35</td>
<td>65±32</td>
<td>190±67</td>
</tr>
<tr>
<td><strong>Dipterans</strong></td>
<td>21±11</td>
<td>43±20</td>
<td>92±40</td>
</tr>
<tr>
<td></td>
<td>18±15</td>
<td>24±12</td>
<td>64±24</td>
</tr>
<tr>
<td><strong>Collembolans</strong></td>
<td>26±11.5</td>
<td>25±16.6</td>
<td>50±27.4</td>
</tr>
<tr>
<td></td>
<td>14±8.4</td>
<td>21±12.2</td>
<td>28±12</td>
</tr>
<tr>
<td><strong>Acari</strong></td>
<td>12.4±8.4</td>
<td>27±13.6</td>
<td>32±18.4</td>
</tr>
<tr>
<td></td>
<td>10±4.8</td>
<td>19.4±7.8</td>
<td>27±15</td>
</tr>
<tr>
<td><strong>Nematodes</strong></td>
<td>7±2.5</td>
<td>12±7.8</td>
<td>13±6.8</td>
</tr>
<tr>
<td></td>
<td>4±2.2</td>
<td>9.5±3.8</td>
<td>10±6.8</td>
</tr>
</tbody>
</table>
Table 2: Pearson Correlation between soil microarthropod population and edaphic factors at Control plot during sampling year.

<table>
<thead>
<tr>
<th>Soil Microarthropods &amp; Edaphic factors</th>
<th>Grassland Pterygote</th>
<th>Grassland Acari</th>
<th>Teak plantation Pterygote</th>
<th>Teak plantation Acari</th>
<th>Teak plantation Apterygote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Temperature</td>
<td>0.240</td>
<td>-0.635*</td>
<td>0.395</td>
<td>-0.620*</td>
<td>-0.570*</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>0.356</td>
<td>0.059</td>
<td>0.072</td>
<td>0.496</td>
<td>0.276</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>-0.139</td>
<td>-0.169</td>
<td>-0.107</td>
<td>-0.207</td>
<td>-0.529</td>
</tr>
<tr>
<td>pH</td>
<td>-0.444</td>
<td>-0.264</td>
<td>*</td>
<td>0.627</td>
<td>-0.529*</td>
</tr>
<tr>
<td>Organic Carbon</td>
<td>0.436</td>
<td>0.226</td>
<td>0.630*</td>
<td>0.137</td>
<td>-0.306</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>0.428</td>
<td>0.228</td>
<td>0.620*</td>
<td>0.138</td>
<td>-0.309</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>0.265</td>
<td>0.097</td>
<td>0.374</td>
<td>0.288</td>
<td>-0.426</td>
</tr>
<tr>
<td>Available Nitrogen</td>
<td>0.032</td>
<td>0.155</td>
<td>0.081</td>
<td>0.395</td>
<td>0.098</td>
</tr>
<tr>
<td>Phosphate</td>
<td>-0.193</td>
<td>-0.254</td>
<td>-0.473</td>
<td>0.135</td>
<td>-0.168</td>
</tr>
<tr>
<td>Potassium</td>
<td>-0.182</td>
<td>0.161</td>
<td>-0.124</td>
<td>0.107</td>
<td>-0.276</td>
</tr>
</tbody>
</table>

*, Correlation is significant at the 0.05 level (2-tailed).

**, Correlation is significant at the 0.01 level (2-tailed).

REFERENCES:


“Assessment of soil quality index based on micro arthropods in corn cultivation in Northern Italy” Ecological Indicators 10, 129-135.


