Comparison of Soil Mites (Oribatida; Acari) Between Conventional and Nature (Tillage and No-Tillage Practices) Farming Crop Fields in Japan

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Abstract *: Oribatid mites, one of the major soil fauna groups in crop fields, were compared terms of abundance and diversity between conventional fields (CT) and nature farming fields with tillage (OT) or no-tillage (ON) practices. The values of abundance, species richness, diversity and evenness were significantly larger in OT and ON than in CT, indicating that the abundance and diversity were greater in nature farming fields than in conventional farming fields. The abundance in OT was similar to that in ON, while the species richness and diversity were smaller in OT than in ON, suggesting that no-tillage practice under nature farming management might contribute to the improvement in quality of oribatid communities. Oribatid mites were classified into three feeding groups. Macrophytophages, microphytophages and panphytophages feed on dead higher plants and microorganisms, respectively. Only microphytophages were obtained in CT. The density and species richness were significantly smaller in CT than in OT and ON. All of the feeding habits were observed in OT and ON. The density and species richness in each feeding habit were larger in ON than in OT. Panphytophages were the most abundant in ON, suggesting that panphytophagous species played a significant role in decomposing soil organic matter in nature farming crop fields.*

Introduction

One important factor to keep a stable and sustainable productivity in nature farming systems is biological diversity in the soil, a balanced eco-chain including soil microorganisms, soil fauna and field crops. Soil fauna play an important role in organic matter decomposition and mineralization. Plants benefit from increased mineralization of nitrogen by soil fauna. In this study, oribatid mites, the most numerous of microarthropods, were selected for the representative of soil animals because it was very difficult to survey the whole soil fauna from so much work for identification and for various methods. The abundance of oribatid mites and the environmental conditions in crop fields were analyzed to elucidate the relation of the abundance and diversity of oribatid mites to the different field management practices, that is, conventional and nature farming and tillage practices. Moreover, the relationship between the feeding habits of oribatids and management of crop fields was evaluated.

Materials and Methods

Types of Management.

Three types of field management were selected in this study, involving conventional farming (CT), nature farming with tillage practices (OT), and nature farming with no-tillage practices (ON). For the CT management, vegetables and crops had been grown by conventional farming, and all the fields were tilled and applied with agricultural chemicals (fertilizers and pesticides). For the OT management, vegetables and crops were grown by nature farming practices with tillage but without addition of any chemical fertilizers and pesticides. Farmyard manure, which consisted of animal dung and/or plant materials such as crop residues, weeds and tree litters, was applied to the soil surface and rotary digging was practiced. The ON management was the specific case of the organic farming with no-tillage practices. The fields had been done for more than eight years until end of the study although the minimal soil disturbance was caused by seeding, transplanting and harvesting. Farmyard manure and organic mulch, which both consisted of crop residues, weeds and tree litters, were applied to the soil surface where they would decompose.

Sampling Method

Soil samples of 0-5 cm layer were obtained from 17 crop fields mainly in central Japan. Samplings were carried out in springs (April and May) of 1987 - 1995 because it was the most suitable season for sampling in a year (Fujita, 1989). The faunal trends in crop fields were evaluated with the top 0-5 cm soil where the majority of individuals generally inhabit (Fujita, 1989) although the samples of top 0-5 cm soil might miss some species that would exist in deep soil profiles. Four rectangular plots of 10 cm x 8 cm were set at random in the surveyed field, and each plot consisted of 4 continuous quadrates. A total of 16 samples were collected from each crop field. Each sample was 5 cm long, 4 cm wide and 5 cm high. All above ground plant (crop and weed) residuals and applied organic matter were left there until the end of sampling to prevent soil animals from disturbance. The collected samples were wrapped immediately in aluminum foil, placed in a portable icebox and then transported to the laboratory. The samples were used to extract oribatid mites in 100 % ethanol by modified Tullgren apparatus (Fujikawa, 1970). After the mites were extracted from the samples, the remaining soils were used for chemical analyses. Soil pH values were measured by pH-meter (Soil : Water = 1 : 2.5). Contents of total carbon and total nitrogen were measured by a carbon-nitrogen measurement equipment.

Analysis of Feeding Habits of Oribatids

Extracted oribatid mites were preserved in lactic acid. Gut contents of the oribatid mites were examined under a microscope with 400 x magnification. Adults of oribatid mites were slide-mounted and a cover-glass was gently placed on the specimen and squashed with finger pressure. Size of chelicerae was measured using a micrometer with 1000 x magnification. Oribatid mites were classified into three feeding habits that were established by the variation of gut contents and three types of chelicera (Fujita, 2001), as Macrophytophages, microphytophages and panphytophages feed on dead higher plants, microorganisms, and dead higher plants and microorganisms, respectively.

Results

Environmental Conditions.

Correlation matrices of the oribatid densities with environmental factors are shown in Table 1. The abundance of oribatids did not correlate significantly with these environmental factors ($r < 0.15$, $P>0.54$). However, the three types of field management in order of CT, OT and ON related significantly to the abundance of oribatids ($r = 0.68$, $P = 0.002$).

Table 1. Correlation Matrices of Oribatid Densities with Environmental Factors

Environmental Factor	r Probability	
Soil pH (H_2O)	0.24	ns
Soil total nitrogen	0.00	ns
Soil total carbon	-0.06	ns
Altitude	-0.13	ns
Annual mean temperature	0.15	ns
Annual precipitation	0.10	ns
Type of management	0.68	**

ns = not significant(P>0.05), **= significant(P<0.01).

Oribatid Communities

Many oribatids could be identified to morphospecies although some were unnamed. Out of the total number of 67 oribatid species, 3, 36 and 53 species were from CT, OT and ON, respectively, which showed high species diversity in OT and ON. It was also quite evident that the oribatid communities in CT were very poor. Total species number in each field ranged from 4 to 17 in OT and 17 to 20 in ON. Many species were obtained in organic farming fields.

The species richness, density, diversity and evenness in OT and ON were significantly (P<0.05) higher than those of CT (Table 2). The values of density and evenness in OT were similar to those in ON, while the species richness and diversity in OT were significantly (P<0.05) smaller. Therefore, the density and diversity between OT and ON were smaller than those between OT or ON and CT.

Table 2. Comparison of Oribatid Community Parameters in Crop Fields with Three Types of Management

Types of Management	Species Richness	Density ($x10^3$ m^{-2})	Diversity (H')	Evenness [a]
CT	0.8±0.3c[b]	0.09 ±0.03b	0.00 ±0.00c	—
OT	8.9±1.4b	3.6 ±1.1a	1.54 ±0.16b	0.72 ±0.05a
ON	18.2±0.6a	10.7 ±3.5a	2.14 ±0.09a	0.74 ±0.03a

[a)]Evenness of CT could not be calculated because species number is one.
[b)]Mean ±SE within a column followed by the same letter are not significantly different at P<0.05 using Scheffé method.

Comparison of Feeding Habits

Figure 1 shows comparisons in densities and species richness in each feeding habit of adult oribatid mites in crop fields among three types of management. Only microphytophages were obtained in CT. The microphytophagous density and species richness, however, were significantly (P < 0.05) smaller than those in OT and ON. All of the feeding habits were obtained in OT and ON. The densities of oribatids in OT and ON were the largest in microphytophages and panphytophages among feeding habits, respectively. However, the density and species richness in each feeding habit were larger in ON than in OT although some of them were not significant (P > 0.05).

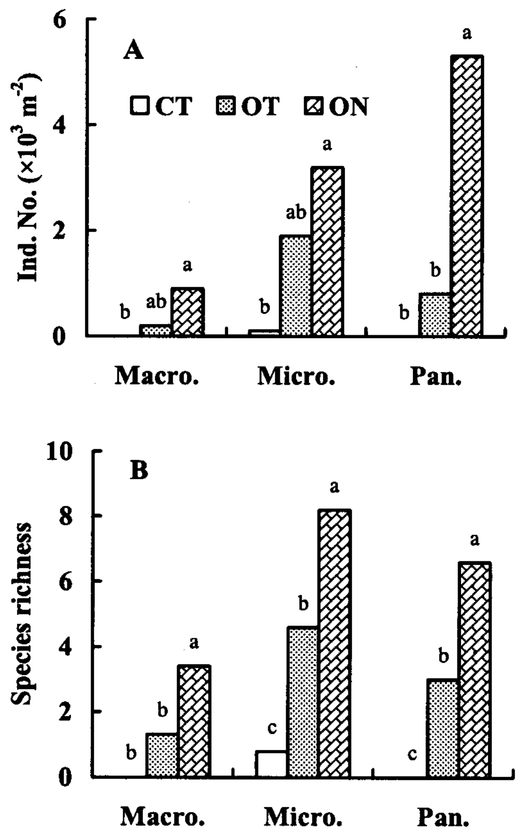

Figure 1. Comparison in Densities (A) and Species Richness (B) in each Feeding Habit of Adult Oribatid Mites in Crop Fields among Three Types of Management. CT, Crop Fields with Conventional Farming; OT, Crop Fields with Nature Farming and Tillage; ON, Crop Fields with Nature Farming and no-tillage; Macro., Macrophytophages; Micro., Microphytophages; Pan., Panphytophages.

Columns with the same letter for a given feeding habit are not significantly different at the 0.05 level, according to Scheffé method in multiple comparisons.

Discussion

The abundance of oribatid mites was compared between conventional and nature farming fields. The different values in community parameters could not be explained by meteorological, soil and other main environmental conditions at sampling times (Table 1), but the density and diversity of oribatids were extremely lower in conventional farming than in nature farming (Table 2). Thus, the richness of soil fauna was related to the difference of soil management. This is agreeable to other reports on the relation of soil fauna to soil management in Japan (Fujikawa, 1976; Nakamura, 1988; Fujita, 1989; Nakamura *et al.*, 2000).

Common conventional farming uses a large amount of chemical fertilizers and pesticides but only a little organic matter. It mainly adopts monocropping systems for crop production. Application of chemical fertilizers decreases the density of microarthropods in comparison with that of organic matter (Edwards and Lofty, 1969; Fujita, 1989) and cause soil acidification. Pesticides and monocropping greatly reduce the density and diversity of microarthropods in soil (Edwards and Lofty, 1969). In contrast, organic matter makes moderate soil pH. Specific responses of microarthropod species to different soil pH are also been reported in acidification/liming experiments (Van Straalen, 1997). Therefore, poor oribatid mites in the fields might have been caused by the effect of conventional farming practices although the primary factor could not be pointed out.

In nature farming fields, the densities were not significantly different between the two types of tillage practices although the species richness and diversity were significantly smaller in tillage than in no-tillage practices (Table 2). The difference between the two types of practices in nature farming fields was smaller than that between conventional and nature farming fields.

It is evident from the foregoing results that differences in field management strongly affected the density and diversity of soil animals. They were significantly higher in nature farming than in conventional farming management. As discussed above, the difference between two tillage types of practices in nature farming may be qualitative rather than quantitative.

Oribatid communities must be organized by structure of habitat and the abundance of food resources, and there is a change in feeding habit composition. In conventional farming fields oribatid communities divided into feeding habits were very poor (Figure 1). Oribatid mites in conventional farming fields scarcely played a role in decomposition of soil organic matter.

In nature farming fields with no-tillage practices the soil surface was covered with organic mulch. The environment of soil surface protects oribatid community in the field (Fujita and Fujiyama, 2000). Therefore, the oribatid food and habitat, especially those for panphytophagous species, might be more abundant in conventionally tilled nature farming fields without organic mulch. Thus, the difference in the oribatid communities between two tillage types of practices might be mainly affected by the organic mulch or tilling-in of organic matter.

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