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RESEARCH ARTICLE

A STUDY ON THE SOIL MICROARTHROPODS OF CULTIVATED AND UNCULTIVATED FIELDS OF PASCHIM MEDINIPUR, WEST BENGAL, INDIA

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ABSTRACT

Present study revealed that agricultural manipulations brought about significant changes in the physico-chemical properties & floral composition but failed to cause significant differences in the abundance of microarthropod groups even though their number were less in the agricultural fields. Acari was the most common group in both cultivated and uncultivated sites. Oribatida comprised about 60% of the acarofauna in the uncultivated wasteland and constituted <50% of acari in the cultivated land. Oribatida outnumbered collembola in wasteland and fodder field but in sugarcane field trend was opposite.

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INTRODUCTION

The maintenance of ecosystem functions is critically dependent on the composition of below ground communities (Wall, 2004). Microarthropods are very abundant in the upper soil layer and have functional roles ranging from detritivores to predators, thus influencing nutrient cycling and other soil processer (Coleman et al., 2004). Microarthropod abundance has been shown to change with soil type and with the depth of the organic layer (Petersen and Luxton, 1982; Schaefer and Schauermann, 1990). Fertilizer application which increases soil fertility often stimulates an increase in the total abundance of soil microarthopods (Zyromska-Rudzka, 1977; Cole et al., 2005; Sjursen et al., 2005). In the present study we tried examine the impact of agricultural practices on the density and diversity of soil microarthropods in two agricultural and one non-agricultural land.

Description of study site

The present investigation was conducted in three study sites situated in Midnapore Subdivision of Paschim Medinipur district in West Bengal, India. Two agricultural fields *viz.*, a fodder field and a sugarcane field and a wasteland were selected for the purpose. No agricultural or other human interference was in force in the wasteland. The sites were located within a radius of 5 km. aerial distance.

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Wasteland (WL)

This site (22°25′ 24.1″ N, 87°17′ 33.5″E) was almost free from any human interference. The most dominant floral component was *Evolvulus numularius.* There were 16 species of dicots and 7 species of monocots, mostly weeds and grasses.

Fodder field (FF)

This was a demonstration plot maintained by the office of the Deputy Director of Animal resource Development, Government of West Bengal where *Avena fltua* and *Zea mays* were cultivated alternately as fodder. Avena was sown between 15 November to 8 December and harvested in between January and February. This field was kept fallow till May. Maize was sown in June and harvested in August. The field was subjected to mechanical ploughing, thrice at in interval of 5 days. Farmyard manure was added to the soil at the rate of 2500 Kg/Acre the day before the 3rd ploughing. No insecticide and pesticide was used in this field. 19 species of dicots and 3 species of monocots were found mostly during fallow period.

Sugarcane field (SF)

This site was a six month old perennial sugarcane field (23°29′35.6″N, 87°41′42.7″E). Before raising the crop, the field was ploughed in the month of September. After ploughing, Aldrin @ 9 Kg/Acre, Diamonium phosphate @ 90 Kg/Acre, potash @ 50 Kg/Acre, urea @ 30 Kg/Acre and cowdung manure @ 1500 Kg/Acre, were applied to soil and the field was ploughed again. The crop was planted in row at a gap of 1ft. (30 cm.) between the row. 25 days after plantation, urea was spread in the soil at a rate of 300 kg/Acre. During the entire cropping period, urea was applied at the rate of 30 Kg/Acre once in a month. Two insecticides namely Cyper Methrin 10% EC and Parathion 50% EC were also sprayed at monthly interval. Irrigation of the field was done once in a week. The harvesting was done once in April and again in November. Such sugarcane field was maintained for 3 years. SF was subjected to more agricultural manipulation as compared to FF in the form of application of inorganic fertilizers and insecticides which were lacking in FF.

MATERIALS AND METHODS

Soil samples were collected at monthly interval on the 7th day of each month between 8.00 hrs to 9.00 hrs. from 3 sampling sites between February 2002 to January 2004. During each sampling occasion 5 soil samples of 5 cm x 5 cm size upto the depth of 10 cm were collected with the help of a hand spade from each site for extraction of microarthropods. Soil microarthropod fauna along with oribatid mites were extracted with a modified Tullgren extractor, the procedure lasting for 24 hours. Community composition was analysed with reference to abundance & relative abundance.

Physicochemical analysis of soil

Soil was analysed by following standard methods as summarised in Table-1

Statistical analysis

Statistical analyses were preceeded by the normality and homogeneity test of the data. Kolmogorov-Smirnov test was carried out for verification of normality. Homogeneity of variance was tested for using Levene's test. When the assumptions of normality and Homogeneity were not supported by these tests, results were analysed using non-parametric Kruskal-Wallis variance analysis, otherwise parametric analysis of variance was done. When a statistically significant difference ($p < 0.05$) was noted in post-hoc comparison of rank or mean Dunn's or Tukey's test was applied as applicable using statistical packages NCSS and PASS 2004 and Sigma Plot v10.

RESULTS AND DISCUSSION

Findings relating physicochemical properties of soil are shown in table- 2. The soil of the three study sites was slightly acidic in nature and light yellowish brown in colour. Physicochemical properties of the soil varied significantly between the three study sites. Dunn's multiple comparison test revealed that water holding capacity and pH significantly differed between WL & SF and between WL & FF. While electrical conductivity, available nitrogen and organic carbon significantly differed between WL & FF and between FF & SF, moisture content and available potassium differed significantly between WL & SF only and available phosphate differed significantly between FF & SF. Thus the findings clearly revealed that the three sites were distinct in their edaphic nature. The type of cultivation profoundly altered the physicochemical nature of the soil. Use of farmyard manure in the FF might have resulted into increased level of most of the edaphic factors under study. Pandit & Bhattacharya (2001) have also reported that agricultural practice altered the edaphic properties of soil. 23, 24 and 5 species of plants were recorded in WL, FF and SF respectively during the entire period of investigation. Of these only one species of grass viz., *Digitaria sanguinalis* was common in all the three sites. 9 species were common between WL & FF and only one species was common between WL & SF and FF & SF (Table – 3). The Sorensen's quotient of similarity was found to be 38%, 7%, 7% between WL & FF and WL & SF and FF & SF respectively (Table – 4). Thus all the three study sites were strongly dissimilar in the floral composition. This was obviously due to the effect of agricultural manipulation. Soil inhabiting microarthropods of the fields under consideration comprised of Arachnids, Insecta, Crustacea and Myriapod (Table – 5). While arachnids and insects were present in all the sites, no myriapod could be collected from the wasteland. Acari is the most abundant group in all the three sites followed by insecta. In sugarcane field Acari and Insecta were almost equal in abundance but in the remaining two field's mites outnumbered insects. Kruskal-Wallis variance analysis, however, revealed that the differences in number between the sites were insignificant. Acari constituted 54.57%, 54.23%, 47.95% of microarthropods in FF, WL, SF fields respectively. Insect fauna mainly comprised of Collembola which constituted 26.08%, 24.49%, 16.16% of microarthropods in SF, FF and WL respectively. Other Insect orders found were Diplura, Pscoptera, Hymenoptera, Coleoptera and Hemiptera. Of these Hemiptera was absent in FF. Among Crustacea only Isopoda was encountered in SF.

Soil inhabiting Acari in the present study belonged to 4 suborders viz., Acaridida, Actinedida, Gamasida and Oribatida. In all the three sites Oribatida was the most abundant group of Acari comprising 59.32%, 44.89%, 47.33% of acarofauna (Fig. 1) and 32.23%, 24.49%, and 22.74% of total microarthropods (Table 5) in WL, FF and SF respectively. Abundance of Acari, Orbatida, Collembolan and total microarthropods did not differ significantly among the 3 sites. On the basis of abundance of total microarthropods and that of Acari the three sites could be arranged in the descending order of WL>SF>FF. Acari was the main group of soil inhabiting microarthropods in all the sites comprising more than 48% of the total microarthropods. Predominance of Acari in Indian soil has also been previously reported by Choudhuri & Banerjee (1975), Singh & Singh (1975), Bhattacharya & Joy (1978), Choudhuri & Pande (1979, 1982), Bhattacharya *et al.* (1980), Singh & Pillai (1981), Mitra *et al.* (1981), Pai & Prabhoo (1991), Majumder & Deb (1991), Sarkar (1991), Sengupta & Sanyal (1991), Chakraborty & Bhattacharya (1992) and Pandit & Bhattacharya (2001). Contrary to these Mukharji & Singh (1970) and Reddy & Ao (1995) found that Collembola was the most predominating group in a rose garden and maize field respectively. In the present study collembola outnumbered Oribatida in the sugarcane field. Among Acari, Oribatida was the most abundant group in all the 3 study sites.

Table 1. Methodology used in analysis of physicochemical properties of soil

S.No.	Parameter	Method
1.	Soil colour	Munsell soil colour chart
2.	Moisture content	Torsion balance moisture meter
3.	Water holding capacity	Keen-Raczkowski box method (Piper, 1966)
4.	pH	Glass electrode digital pH meter (Systronics-324)
5.	Electrical conductivity	Conductivity meter (Systronics-307)
6.	Available nitrogen	Alkaline permanganate method (Subbiah and Asija, 1956)
7.	Available phosphate	Olsen's method (Jackson, 1973) using colorimeter (Systronics Balanced Cell Colorimeter-102).
8.	Available potassium	Ammonium acetate extraction method (Jackson, 1973) using flame photo meter (Systronics-MK-1)
9.	Organic Carbon	Walkley and Black's rapid titration method (Jackson, 1973).

Table 2. Physicochemical properties of the soil of study sites

Edaphic Parameters	WL	FF	SF	Kruskal- Wallis One- way ANOVA	Dunn's multiple comparison test
Colour	Light yellowish brown 10YR6/4	Light yellowish brown 10YR 6/4	Light yellowish brown 10YR 6/4		
Moisture content (%)	x ± SE (Min-Max)	x ± SE (Min-Max)	x ± SE (Min-Max)		
	8.30 ± 0.97 (3.37 – 19.27)	9.87 ± 0.94 (3.62 – 17.17)	11.87 ± 0.88 (5.07 – 19.03)	H = 8.088 P = 0.018*	WL vs FF = P > 0.05 WL vs SF = P < 0.05* FF vs SF = P > 0.05
Water holding capacity (%)	51.45 ± 0.72 (47.07 – 59.91)	51.23 ± 0.83 (44.53 – 60.23)	44.92 ± 0.77 (36.50 – 49.60)	H = 28.240 P ≤ 0.001*	WL vs FF = P < 0.05* WL vs SF = P < 0.05* FF vs SF = P > 0.05
pH	6.41 ± 0.06 (6.03 – 7.00)	6.43 ± 0.05 (5.93 – 6.97)	6.08 ± 0.08 (5.43 – 6.90)	H = 14.604 P ≤ 0.001*	WL vs FF = P < 0.05* WL vs SF = P < 0.05* FF vs SF = P > 0.05
Electrical conductivity (mmhos/cm)	0.17 ± 0.03 (0.05 – 0.66)	0.20 ± 0.02 (0.11 – 0.41)	0.13 ± 0.01 (0.03 – 0.25)	H = 11.114 P = 0.004*	WL vs FF = P < 0.05* WL vs SF = P > 0.05 FF vs SF = P < 0.05*
Available Nitrogen (ppm)	146.21 ± 6.50 (111.67 – 222.33)	172.92 ± 5.00 (134.33 – 223.67)	139.13 ± 6.17 (93.00 – 213.33)	H = 18.242 P ≤ 0.001*	WL vs FF = P < 0.05* WL vs SF = P > 0.05 FF vs SF = P < 0.05*
Available Phosphate (ppm)	23.40 ± 0.77 (18.00 – 30.60)	29.62 ± 1.88 (17.40 – 46.80)	26.91 ± 1.29 (18.00 – 42.30)	H = 6.341 P = 0.042*	WL vs FF = P > 0.05 WL vs SF = P > 0.05 FF vs SF = P < 0.05*
Available Potassium (ppm)	89.50 ± 5.64 (63.00 – 160.00)	117.29 ± 11.67 (44.00 – 300.00)	105.33 ± 3.45 (66.00 – 143.00	H = 7.612 P = 0.022*	WL vs FF = P > 0.05 WL vs SF = P < 0.05* FF vs SF = P > 0.05
Organic carbon (%)	0.63 ± 0.07 (0.24 – 1.30)	0.73 ± 0.03 (0.49 – 0.95)	0.44 ± 0.03 (0.22 – 0.72)	H = 22.433 P ≤ 0.001*	WL vs FF = P < 0.05* WL vs SF = P > 0.05 FF vs SF = P < 0.05*

WL=Wasteland, FF=Fodder field, SF=Sugarcane field, H = Kruskal-Wallis statistics. * P < 0.05

Table 3. Floral list of study sites

S.No.	Plant Species	Family	WL	FF	SF
DICOTYLEDONS					
1.	*Ruellia tuberosa* Linn.	Acanthaceae	+	–	–
2.	*Rungia parviflora* Nees.	Acanthaceae	+	–	–
3.	*Mollugo stricta* Linn.	Aizoaceae	–	+	–
4.	*Amarantus spinosus* Linn.	Amaranthaceae	–	+	–
5.	*Celosia argentea* Linn.	Amaranthaceac	–	+	–
6.	*Ageratum Conyzoides* Linn.	Asteraceae	+	+	–
7.	*Blumea lacera* DC.	Asteraceae	–	–	+
8.	*Eclipta prostrata* Linn.	Asteraceae	–	–	+
9.	*Launea sp.*	Asteraceae	–	–	+
10.	*Parthenium* hystoriphorus Linn.	Asteraceae	–	+	–
11.	*Tridax procumbens* Linn.	Asteraceae	–	+	–
12.	*Vernonia cinerea* Less.	Asteraceae	–	+	
13.	*Anagallis arvensis* Linn.	Caryophyllaceae	–	+	–
14.	*Evolvulus nummularius* Linn.	Convolvalaceae	+	–	–
15.	*Euphorbia hirta* Linn.	Euphorbiaceae	+	+	–
16.	*Phyllanthus fraternus* Webster, Contr.	Euphorbiaceae	+	+	–
17.	*Alysicarpus vaginalis* DC.	Fabaceae	+	–	–
18.	*Cassia obtusifolia* Linn.	Fabaceae	+	–	–
19.	*Desmodium triflorum* DC.	Fabaceae	+	–	–
20.	*Sida acuta* Burn.	Malvaceae	+	+	–
21.	*Sida cordifolia* Linn.	Malvaceae	+	+	–
22.	*Boerhaavia repens* Linn.	Nyctaginaceae	+	+	–
23.	*Ludwigia perviflora* Roxb.	Onagraceae	–	+	–

Continue……

24	*Peperomia pellucida* Kunth.	Piperaceae	+	–	–
25.	*Oldenlandia corymbosa* Linn.	Rubiaceae	–	+	–
26.	*Scoparia dulcis* Linn.	Scrophulariaceae	+	–	–
27.	*Physalis minima* Linn.	Solanaceae	–	+	–
28.	*Melochia corchorifolia* Linn.	Sterculiaceae	–	+	–
29.	*Corchorus aestuaus* Linn.	Tiliaceae	–	+	–
30.	*Clerodendron viscosum* Vent.	Verbenaceae	+	–	–
31.	*Vitis sp.*	Vitaceae	+	+	–
		MONOCOTYLEDONS :			
32.	*Commelina bengalensis* Linn.	Commelinaceae	+	–	–
33.	*Murdhania sp.*	Commelinaceae	+	–	–
34.	*Kyllinga monocephala* Vahl.	Cyperaceae	+	–	–
35.	*Avena fltua* Linn.	Poaceae	–	+	–
36.	*Digitaria sanguinalis* Scop.	Poaceae	+	+	+
37.	*Echinochloa Colona* Link.	Poaceae	–	+	–
38.	*Eleusine indica* Gacrtn.	Poaceae	+	+	–
39.	*Eragrostis tenella* Roem. & Schnlt.	Poaceae	+	–	–
40.	*Oplismenus* burmanni Beaux.	Poaceae	+	–	–
41.	*Saccharum officinarum* Linn.	Poaceae	–	–	+
42.	*Ziea mays* Linn.	Poaceae	–	+	–
	Total		23	24	5

WL = Wasteland, FF = Fodder field, SF = Sugarcane field, + = Present, - = absent.

Table 4. Sorensen's quotient of similarity (Q/S) between the sites with respect to plant species

Sites	Q/S value (%)	Remark
WL vs FF	38	Strongly dissimilar
WL vs SF	7	Strongly dissimilar
FF vs SF	7	Strongly dissimilar

WL = Wasteland, FF = Fodder field, SF = Sugarcane field. <50% - Strongly dissimilar

Table 5. Comparison of abundance and relative abundance of microarthropod groups of study fields

Microarthropod groups	Wasteland		Fodder field		Sugarcane field		Kruskal-Wallis One-way ANOVA
	Abundance x ± SE	Relative abundance %	Abundance x ± SE	Relative abundance %	Abundance x ± SE	Relative abundance %	
ACARI	4.64 ± 0.58	54.23	3.58 ± 0.32	54.57	3.71 ± 0.49	47.95	H = 0.419 P = 0.811
Acaridida	0.35 ± 0.09	4.09	0.27 ± 0.06	4.06	0.28 ± 0.08	3.66	
Actinedida	0.32 ± 0.07	3.70	0.61 ± 0.12	9.26	0.28 ± 0.07	3.66	H = 5.874 P = 0.053
Gamasida	1.22 ± 0.27	14.31	1.1 ± 0.10	16.75	1.39 ± 0.16	17.99	H = 4.584 P = 0.101
Oribatida	2.76 ± 0.31	32.23	1.61 ± 0.19	24.49	1.76 ± 0.41	22.74	H = 5.089 P = 0.078
ARANEIDA	0.04 ± 0.04	0.49	0.01 ± 0.01	0.13	0.11 ± 0.07	1.40	
PSEUDOSCORPIONIDA	0.07 ± 0.02	0.78	-	-	-	-	
INSECTA	2.98 ± 0.37	34.86	2.39 ± 0.29	36.42	3.26 ± 0.39	42.13	H = 2.746 P = 0.253
Collembola	1.38 ± 0.17	16.16	1.61 ± 0.26	24.49	2.02 ± 0.30	26.08	H = 0.786 P = 0.675
Diplura	0.14 ± 0.04	1.65	0.40 ± 0.08	6.09	0.16 ± 0.04	2.05	
Pscoptera	0.15 ± 0.04	1.75	0.13 ± 0.03	2.03	0.20 ± 0.04	2.59	
Hemiptera	0.04 ± 0.02	0.49	-	-	0.25 ± 0.14	3.23	
Hymenoptera	0.88 ± 0.29	10.32	0.13 ± 0.05	2.03	0.47 ± 0.17	6.03	
Coleoptera	0.38 ± 0.09	4.48	0.12 ± 0.03	1.78	0.16 ± 0.04	2.05	
CRUSTACEA	-	-	-	-	-	-	
Isopoda	-	-	-	-	0.10 ± 0.03	1.29	
MYRIAPODA	-	-	-	-	-	-	
Chilopoda	-	-	0.01 ± 0.01	0.13	0.10 ± 0.03	1.29	
Diplopoda	-	-	-	-	0.01 ± 0.01	0.11	
UNIDENTIFIED JUVENILE	0.82 ± 0.12	9.64	0.57 ± 0.10	8.76	0.44 ± 0.07	5.71	H = 4.571 P = 0.102
TOTAL MICROARTHROPODS	8.56 ± 0.83		6.57 ± 0.51		7.73 ± 0.68		H = 0.785 P = 0.675

Kruskal-Wallis one-way ANOVA for the major microarthropod groups (relative abundance > 5%) were done. H = Kruskal-Wallis statistics.

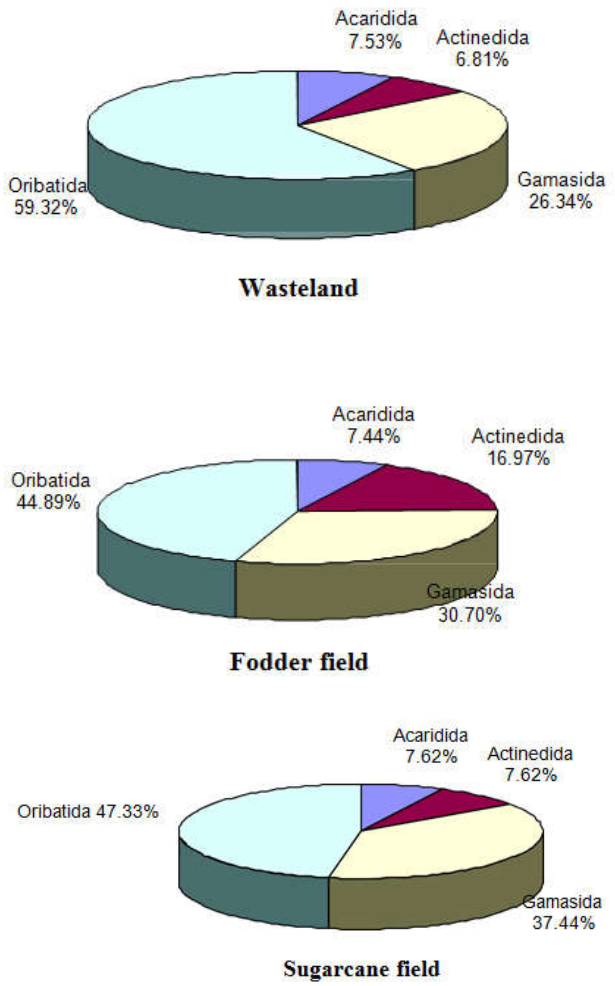

Fig.1. Relative abundance of suborders of Acari

This finding agrees with the findings of Singh, J. & Singh, U. R (1975), Choudhuri & Banerjee (1975), Prabhoo (1976), Bhattacharya & Joy (1978), Bhattacharya *et al.* (1981, 1982), Banerjee (1988), Ghatak & Ray (1981), Pai & Prabhoo (1991), Bhattacharya & Bhattacharya (1983), Alfred *et al.* (1991), Majumder & Deb (1991a), Sarkar (1991), Sanyal (1991a), Chakraborty & Bhattacharya (1992), Hattar *et al.* (1992), Reddy & Ao (1995), Nakamura *et al.* (2000), Bettiol *et al.* (2002), Roy *et al.* (2004), Oliveira *et al.* (2007) and Osler *et al.* (2008). In contrast to these Oribatida was not the most predominating acarofauna in wasteland soil Singh & Pillai (1981), paddy field Sengupta & Sanyal, (1989, 1991),Pandit&Bhattacharya(2001) and in the vegetable field Pandit & Bhattacharya, (2001). In the present study WL harboured more oribatid mites (59.3% of the total acarofauna) as compared to the agricultural sites (<50%). Predominance of oribatids in uncultivated fields and their relative scarcity in agricultural fields has also been pointed out by Wallwork (1967, 1970, 1976), Ryke & Loots (1967), Edwards & Lofty (1969), Block (1970), Fujikawa (1970), Bhattacharya *et al.* (1980), Sanyal & Sarkar (1983), Tomlin & Miller (1987), Majumder & Deb (1991) Grishina *et al.* (1995) and Vreeken and Buijs (1998).

Finally it may be inferred that although the three sites differed in their floral components and edaphic characteristic, agricultural activities failed to bring about any significant change in microarthropod abundance, even though, numbers were slightly on the lower side in the cultivated fields. Oribatids had higher relative abundance in the uncultivated soil as compared to those of cultivated land. Thus it may be concluded that contrasy to the popular belief agricultural manipulation does not always have a serious detrimental effect on the soil microarthropods. The reason may have been the perennial nature of sugarcane plantation and irrigation and fertilizer application in the FF. Wallwork (1976) also opined that although agriculture as a whole has a detrimental effect on the soil fauna, irrigation and fertilizer application has a positive role on soil fauna

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