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Enumeration of Arthropods Density in Context to Plant Diversity and Agricultural (Organic and Conventional) Management Systems

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ABSTRACT
Arthropods were inventoried in fields and woody hedgerows of organic and conventional agricultural fields situated in Bahour-Puducherry, India. The objective was to access the total abundance, family richness and composition of arthropods in two different agricultural systems (organic and conventional). The study was conducted twice a month from August 2008 to October 2010 by visual searching and pitfall trap methods in crop fields and adjacent hedgerows of organic and conventional fields. A total of 2,59,722 individual's arthropods belonging to 185 families were recorded during the study. The study showed that beneficial and phytophagous arthropods differed in their abundance/richness in organic and conventional sites both in visual searching and pitfall traps methods. Phytophagous arthropods were more abundant in field margins with hedgerows, while beneficial arthropods were abundant in crop fields. The study also demonstrated a strong relationship between plant composition and management strategies. The arthropod species composition was highly influenced by crop species, habitats, total hedgerow length and Shannon diversity index influence. In general, the number of beneficial arthropods was always higher in the organic plots in relation to the conventional ones, reflecting on the Shannon index diversity. Higher population was represented by the individuals belonging to the taxa/order Arachnida (mites, spiders and pseudo-spiders), Oribatida, Collembola (spring tails) and Coleoptera (insects). The prime importance is to consider both local organic management practices and marginal woody hedgerow in conserving beneficial arthropods population, to maintain soil fertility and sustainable productivity in long term.

Key words: Arthropods, diversity, agriculture, organic agriculture, soil fertility

INTRODUCTION
Soil arthropods consist of a large number of species and they play an important role in many functions like nutrient cycling, mineral element recycling and soil structure dynamics (Barros *et al.*, 2004; Mader *et al.*, 2002; Nakhro and Dkhar, 2010). These arthropod populations are sensitive soil to moisture, humidity, temperature, prey availability, fertilizers, pesticides, plant cover, quality and quantity of detritus inputs to the soil, structural stability of soil, litter habitats and other factors (Diekotter *et al.*, 2010; Gabriel *et al.*, 2010). The epigaeic arthropods which lives on/above ground, like carabids, spiders and harvestments are important predators and considered

sensitive indicators of soil fertility (Mader *et al.*, 2002). Various Coleoptera species are polyphagous predators and thus the taxonomic group as a whole could be considered as beneficial, still presence of excessive carabides in the fields is a bio-indicator of various anthropogenic activities such as urbanization, crop and forest management, overgrazing and soil pollution (Weibull *et al.*, 2003). Ground beetles (carabid beetles) are the predominant group of epigaeic (soil surface) arthropod fauna in agro-ecosystems. They are important invertebrate predators in biological pest control (Hadjicharalampous *et al.*, 2002; Diekotter *et al.*, 2010).

Several invertebrate species feed on key agricultural pests, such as aphids and slugs. Other arthropod like Acari (mites), Formicidae (ants), Heteroptera (true bugs), Centipedes, Collembola (spring tiles), Diptera (flies) and Hymenoptera are important in soil nutrient cycling, soil organic matter decomposition, thus ultimately improves soil quality and they aid weed control through seed-eating (Lund and Turpin, 1997). Spiders and harvestmans (opiliones) have been shown to be useful in controlling aphid numbers. Isopoda, Collembola and Coleoptera include saprophagous organisms, which contribute to soil organic matter decomposition influencing the amount of living and dead organic material and nutrient transfers in terrestrial ecosystems (Diekotter *et al.*, 2010). Average activity density and diversity of arthropods is considered as sensitive indicators of soil fertility, their abundance in the fields determines the soil fertility and productive capacity of the field (Mader *et al.*, 2002; Nakhro and Dkhar, 2010). They all serve as important predators on harmful insects/pests and acts as bio-control agents (Gabriel *et al.*, 2010).

Contamination of the water-soil-plant system with pesticides and fertilizers, in addition to breaking up the soil structure due to inadequate use of machinery and implements as in soil management practice are the main problems caused by intensive agriculture. All these criteria can have dramatic effects on soil invertebrate communities (Jia *et al.*, 2010) and lead to important changes in soil structure and functioning. As in case of organic cropping systems, they are sustainable productive systems in time and space, by means of management and protection of the natural resources, without the use of chemicals that are aggressive to humans and to the environment, retaining fertility increases, soil life and biological diversity. The organic farming system reduces the environmental negative-impact problems caused by intensive agriculture and it is also economically competitive (Nakhro and Dkhar, 2010; Gabriel *et al.*, 2010).

The impact of agriculture on biodiversity conservation, ranging from water quality, erosion and removal of hedges to socioeconomic issues has been widely recognized. The interaction between agriculture and biodiversity has also been analyzed in several publications (Altieri and Nicholls, 1999; Pfiffner, 2000; Mader *et al.*, 2002; Boutin *et al.*, 2009) and most concentrate on adverse changes caused by conventional agriculture (Buguna-Hoffmann, 2000; Mader *et al.*, 2002; Masto *et al.*, 2008). Organic farming can reduce the effects of conventional agricultural practices to the environment and especially to halt the decline of biodiversity in agricultural landscape (Boutin *et al.*, 2009). Thus, it was important to find out if and this was done through a about occurrence, richness and abundance of certain important taxa.

The main objective of this study was to measure the effect of overall management practices (organic and conventional farming) on arthropods richness, abundance and composition. We hypothesized that organic farming can influence arthropods biodiversity than conventional fields. This was done through comparative examination on phytophagous and beneficial arthropods in organic and conventional agroecosystems. We also tested the influence of plant species composition, crop plants and presence of non-crop habitats/woody hedgerows in the agricultural landscapes.

MATERIALS AND METHODS

Experimental site and design: Puducherry is located on the Coromandal coast 11°52' N, 79°45' E and 11°59' N and between 79°52' E covers an area of 480 km^2. The study area experiences mean annual temperature of 30°C and mean annual rainfall about 1311-1172 mm. The mean number of annual rainy days is 55, the mean monthly temperature ranges from 21.3°-30.2°C. The climate is tropical dissymmetric with the bulk of the rainfall during northeast monsoon October- December (Indian Meteorological Department-Chennai). The present study is based on the field work carried out by us at Kuruvinatham and Soriankuppam villages (Fig. 1), 24 km South on the way to Cuddalore from the Puducherry main town. These villages come under Bahour commune.

Study sites are located on the river bank/basin of Ponnaiyar River, has a clayey soil texture with major proportion of clay (55%) and fine sand (35.5%), that are more suitable and convenient (soil texture) for groundnut and vegetable cultivation. Conventional and Organic agriculture fields were chosen on the basis of the homogeneity of inherent soil characteristics. Two sets of samples were taken in this study, 15 organic fields (with a history of organic farming practice for the last 6 years) and 15 Inorganic/Green Revolution Agriculture fields (with a history of inorganic farming practice for more than 6 years) and they had a uniform crop sequence pattern as Paddy/Groundnut/Ladys finger (per year) were selected. The fields sizes varied between <1 to >5 ha.

Characteristics: A comprehensive description of the vegetation and the agricultural practices adopted during the survey are described here. In the case of Conventional fields-Urea (analyzing 46% N) at the rate of 30 kg ha^{-1}, phosphorus as single super phosphate (analyzing 16% water soluble P_2O_5) and potassium as muriate of potash (60% K_2O) each at the rate of 38 kg ha^{-1} were applied. Remaining N was applied through urea in three-split dose at fortnightly interval at

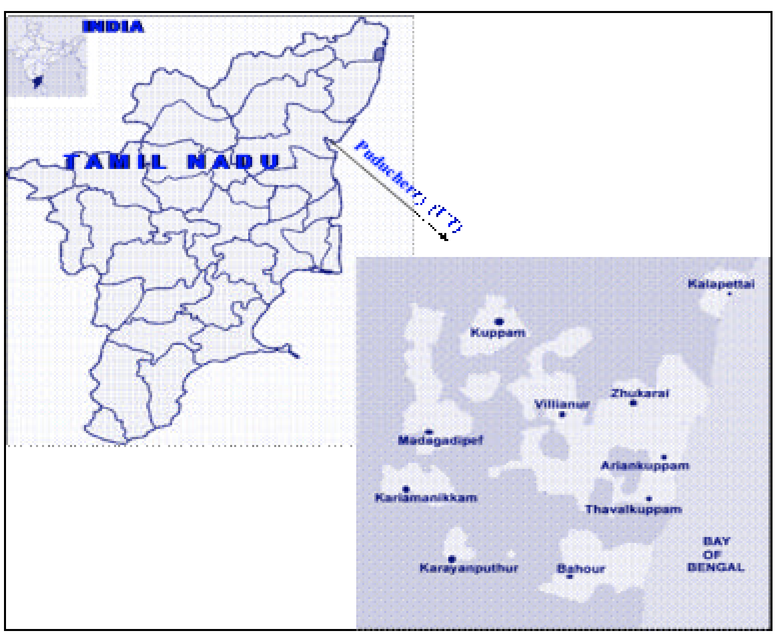

Fig. 1: Location of the study area

30 kg ha^{-1} after basal application. Insecticides Monochromotopas and Carathae (paddy), Whitmore, Carathae and Endosulphon (Lady's finger) and Endosulphon, Parisulphon and Carathae (Groundnut) were used.

In Organic fields, mulching, soil amendments (composts) and organic fertilizers i.e., Vermi composts, organic urea, effective micro organisms, Panchakavya (300 mL/10 L of water), Meein amilam (1:1), Amuthakaraisal (1:10), Flower/fruit promoters (1/10 L of water) and Organic pesticides and insecticides i.e., Puchuvirati (1/10 L of water) were prepared by farmers locally with locally available materials (Padmavathy and Poyyamoli, 2011). Mineral fertilizers were applied on conventional farms. Data are based on the information gathered from the farmers by brain storming and triangulation and on estimates of the content of organic C and nutrients of input materials applied as fertilizers. The cover crops were communities of natural weeds, retained all throughout the year disturbed and partially ploughed only when fertilizers were incorporated into the soil. Both organic and conventional farms were mostly rain fed and in absences of rainy days water was distributed by canals, at annual rates from 280 to 620 mm, i.e., mean daily water input for paddy is 11.3-14.4 mm day^{-1} and for others 9-11.5 mm day^{-1}.

Arthropods: Arthropods were sampled twice a month during the study period from August 2008 to October 2010. They were estimated by visual searching method (Latif *et al*., 2009) and Pitfall trap Method (Schmidt *et al*., 2006). A grid of 18 pitfall traps was set in each target field, comprising nine within the crop and nine within the uncropped boundary/woody hedgerows. Traps were set for 48 h before emptying. Paired target fields were always sampled at the same time. Because of seasonal variation in animal activity and trapping efficiency, separate samples were collected before and after harvest.

Characteristic of the study fields, size, crop types and adjacent woody hedgerows (length, height, width) were measured for each site. Two plot types were used; the first two followed the procedure of Smart *et al*. (2003) with one plot per field. (1) Field boundary plots recorded presence and abundance of species in plots extending 1 m from the centre of the uncultivated field boundary and 10 m parallel to the boundary. (2) Percent cover of within-crop plants was recorded in 0.5 X 0.5 m quadrates placed at distances of 2, 4, 8, 16 and 32 m from the ploughed margin on 12 transects per field. Data for the quadrates in the hedgerow edges and centers were pooled for each hedgerow, while data for fields consisted of pooled quadrates for each fields (Boutin *et al*., 2008).

All specimens were identified to the family level. Arthropods were assigned to 2 groups: (1) beneficial or neutral to crops (flower visiting, predaceous, saprophagous, parasitoids) or (2) detrimental to crops (phytophagous), depending on the predominant feeding habit of the species belonging to the group. Although, family-based classification captures less diversity than classification based on species, it is deemed necessary in this study given the large number of number of arthropods collected (Boutin *et al*., 2008, 2009).

Statistical analysis: The Mantel test was used to examine if there is relationship between total arthropod family composition, farm type, total beneficial or phytophagous family composition and plant species composition. The t-tests were conducted to assess the differences in hedgerow and fields characteristics between organic and conventional fields. Stepwise multiple linear regression were used in order to test the differences between beneficial and phytophagous arthropods richness and abundance in farm type (organic and conventional), habitat type (woody hedgerow and filed), hedgerow length, Shannon habitat diversity and sampling year. Pearson correlation used to test the correlation between the arthropod families and plant species in different farm types. Analyses were conducted separately for beneficial and phytophagous arthropods. Years are used as a covariant. CCA was used to examine the relationship between arthropods population, farm type and selected variables (hedgerow length, Shannon habitat diversity) and Years are used as a covariant. Analysis was conducted separately for the 2 field methods separately using pooled data of woody hedgerows and field habitats for each type. Arthropod families with only one occurrence were removed for this analysis. SPSS and Biodiversity-R were used for analysis of variance, t-tests, correlations, regressions, Mantel test and CCA (Boutin *et al*., 2009).

RESULTS

The Mantel test was used to examine if there is relationship between total arthropod family composition, farm type, total beneficial or phytophagous family composition and plant species composition showed a significant difference (Table 1). A total of 2,59,722 individual's arthropods belonging to 185 families were recorded during the study, 72 families in visual searching and 113 families in pitfall traps. Approximately, half of the families (93 families) inventoried were exclusively to pit fall traps, whereas remaining 25% were to visual searching method and 25% of the families shared between visual searching and pitfall trap methods. Overall hedgerow harbored larger number of arthropods families i.e., phytophagous (68) and beneficial arthropods (54) families, as in case of fields beneficial (93) and phytophagous arthropods (15) families. Families Aphididae, Arctidae, Cecidomyiidae, Cicadellidae, Noctuidae, Pyraustidae and Reduviidae were dominant phytophagous families and in beneficial arthropods families Araneae, Carabidae, Entomobryidae, Formicidae, Linyphiidae, Lycosidae, Opiliones, Oribatuloidae and Uropodidae are dominant.

Richness and abundance of arthropods: The multiple regression method showed difference between organic and conventional farm types in both phytophagous and beneficial arthropods families. However, average number of families in visual searching and pitfall trap methods was generally higher in hedgerow than in fields Table 2 and Fig. 2. Figure 2 reveals that very few families were responsible for the phytophagous arthropod abundance in the fields and hedgerows; total number of beneficial arthropods was distributed amongst a large number of families; however only limited families were very abundant (Fig. 2). Significant difference was found among farm types in both visual searching and pitfall trap method (Table 2). The phytophagous arthropods were sample more in visual searching method, whereas beneficial arthropods were found more in pitfall trap method in both farm types. The only family in beneficial arthropods-Carabidae was more abundant in conventional managed sites than in organic fields ($p>0.05$ and 0.01).

Table 1: Mantel Correlation test results between total arthropods composition and farm types and total, beneficial or phytophagous family composition and plant species composition

	Visual searching		Pitfall traps	
	Mantel r statistic	p-value	Mantel r statistic	p-value
Total Arthropod composition versus Farm type	0.12	0.01	0.21	0.01
Total Arthropod composition *versus* Plant composition	0.11	0.01	0.43	0.00
Beneficial Arthropod composition *versus* Plant composition	0.14	0.02	0.35	0.01
Phytophagous Arthropod composition *versus* Plant composition	0.31	0.01	0.16	0.02

Table 2: Stepwise multiple linear regressions showing the influence of farm types (organic and conventional), Habitat type (crop field and woody hedgerows), Hedgerows length and Shannon diversity indices and years on richness and abundance of beneficial and phytophagous arthropod families sample using visual observation and pitfall trap method. The coefficient of determination (r^2) for each regression analysis is presented

			Visual observation			Pit fall traps		
Source	Arthropod group	df	F-statistic	p-value	r^2	F-statistic	p-value	r^2
Richness	Beneficial							
Farm type		1	14.32	0.00		13.82	0.001	
Habitat type		1	12.32	0.001		11.47	0.001	
Hedgerow length		1	13.12	0.001		14.18	0.00	
Shannon diversity		1	13.82	0.001		12.80	0.001	
Years		2	10.18	0.005	0.24	9.08	0.005	0.39
Farm type	Phytophagous	1	0.73	0.399		1.33	0.181	
Habitat type		1	8.64	0.005		4.21	0.054	
Hedgerow length		1	0.68	0.413		2.18	0.214	
Shannon diversity		1	1.68	0.202		2.14	0.213	
Years		2	0.18	0.674	0.26	0.73	0.399	0.42
Abundance	Beneficial							
Farm type		1	7.32	0.00		11.82	0.004	
Habitat type		1	6.32	0.002		10.47	0.003	
Hedgerow length		1	6.12	0.001		12.18	0.001	
Shannon diversity		1	7.82	0.003		9.80	0.005	
Years		2	9.18	0.005	0.24	8.08	0.006	0.58
Farm type	Phytophagous	1	0.63	0.43		6.13	0.015	
Habitat type		1	8.17	0.006		0.19	0.652	
Hedgerow length		1	0.46	0.34		0.61	0.431	
Shannon diversity		1	1.42	0.211		0.15	0.671	
Years		2	5.42	0.012	0.22	4.72	0.032	0.25

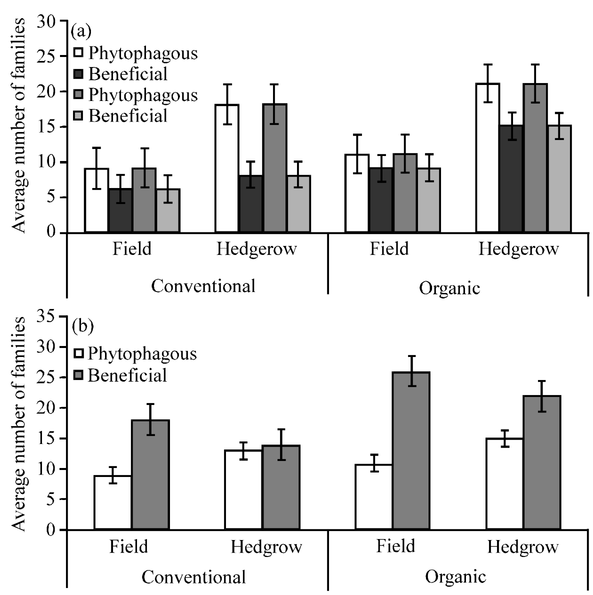

Fig. 2(a-b): Average number (±SE) of beneficial and phytophagous arthropods families in crop fields and hedgerows of organic and conventional farming systems collected in a) visual searching method and b) pitfall traps

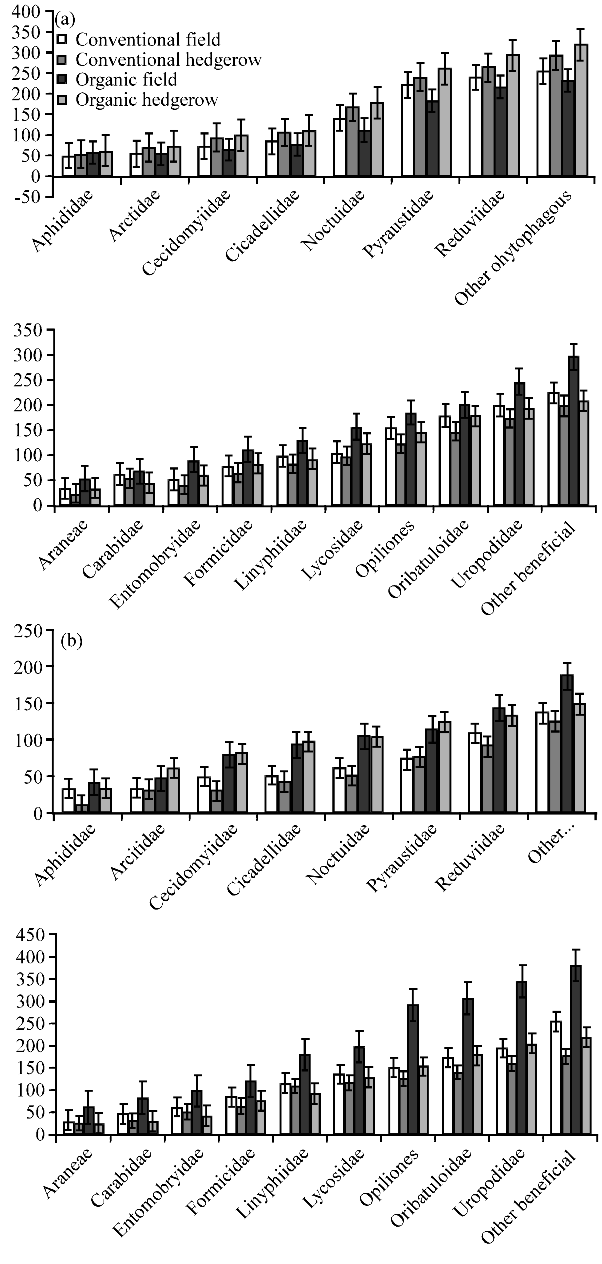

Fig. 3(a-b): Abundance (±SE) of beneficial and phytophagous arthropods in crop fields and hedgerows of organic and conventional farming systems collected in a) visual searching method and b) pitfall traps. The most abundant families were represented

Arthropods abundance was clearly different between hedgerows and its adjacent fields. In general more beneficial arthropods were found in fields, while phytophagous arthropods were predominantly located in hedgerows (Table 2, Fig. 3). Individuals of the families Cicadellidae ($p<0.05$), Chrysomelidae ($p<0.01$) and Reduviidae ($p<0.02$) in visual searching method and Carabidae ($p<0.05$), Formicidae ($p<0.05$) and Opiliones ($p<0.05$) in pitfall trap were more abundant in hedgerows, as in case of crop fields individuals of the families Aphididae ($p<0.03$) in visual

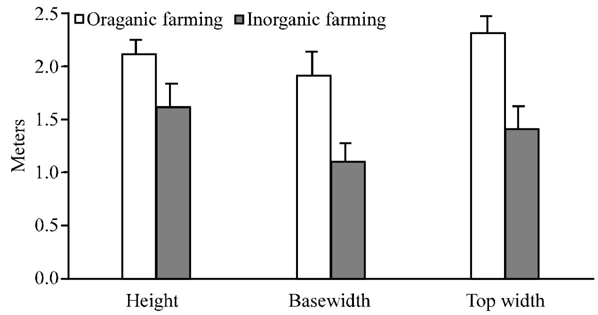

Fig. 4: Hedge parameters (m) of target fields on organic and conventional farming system (Mean±SE)

searching methods and Entomobryidae ($p<0.02$), Opiliones ($p<0.01$), Oribatuloidae ($p<0.02$) and Uropodidae ($p<0.00$) were more abundant. Phytophagous arthropods were abundant in hedgerows and beneficial arthropods were abundant in crop fields. There was a significant negative correlation between phytophagous and beneficial arthropods in both hedgerows ($r = -0.32$, $p<0.02$) and organic fields ($r = -0.42$, $p<0.02$).

Effect of plant diversity and richness on arthropods: The relationship between plant and arthropods composition were examined using Mantel test, which evaluates the correlation between 2 different matrices, in this case arthropod family composition and plant species composition. A significant correlation between plant and arthropods assemblage were noted (Table 1). This correlation was found to be much higher for visual search method then it was for pitfall traps. While examining phytophagous arthropods families and plant species richness it showed positive correlation ($r = 0.71$ $p<0.01$) in visual searching methods, this was predominant in hedgerows.

Effects of habitat, hedgerows and shannon diversity indices on arthropods composition: There was significant difference in width, height and length of the hedgerows between organic and conventional fields. The density (km ha^{-1}) of all boundaries and of hedges was higher on organic than non-organic farms (means of 0.21±0.02 and 0.17±0.01, n = 15, $p<0.05$; 0.15±0.02 and 0.10±0.01, n = 15, $p<0.05$, respectively). The proportion of land that was grass/fodder near cropped land was much higher on organic than non-organic farms (respective percentage means of 35.7±1.5 and 15.2±1.5, n = 26, $p<0.01$). Organic fields were smaller than their nonorganic fields (0.7±0.2 ha and 8.02±0.4 ha, n = 15 and 1.2±0.5 ha and 10.02±0.5 ha, n = 15 $p<0.01$). There were also marked differences in hedgerow structure around the target fields (Fig. 4). Height ($p<0.05$), base width ($p<0.05$) and top width ($p<0.01$) were greater on organic farms and there were more gaps in hedgerows ($p<0.05$) surrounding non-organic fields. There were significant differences between systems in shrub and herb species majorly like *Amaranthus blitoides*, *Amaranthus retroflexus*, *Chenopodium album*, *Convolvulus arvensis*, *Cynodon dactylon*, *Cyperus rotundus*, *Echinochloa crus-gali*, *Paspalum distichum*, *Portulaca oleracea*, *Settaria viridis*, *Solanum nigrum*, *Sorghum halepense*, *Tribolus terrestis* and *Vitex negundo* recorded in hedges/hedgerows, organic fields had mean average of 12±6 and inorganic fields 3±2, n = 30, $p<0.05$.

The CCA presented in Fig. 5 shows a clear separation between organic and conventional sites along with the Hedgerows habitat and Shannon diversity indices variables. Table 3 shows the

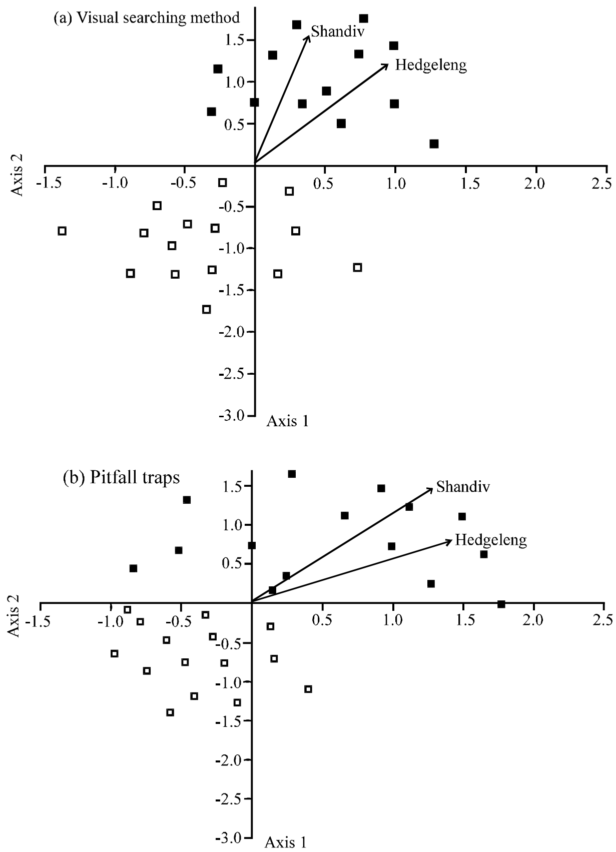

Fig. 5(a-b): Canonical correspondence analysis (based on abundance of family showing the difference in species composition between organic farming systems and conventional farming sites for a) visual searching method and b) pitfall traps. Shannon habitat diversity index (SHANDIV) and Total hedgerows length (HEDGELENG) were used as variables

Table 3: CCA results for visual observation and pitfall trap method using arthropod abundance data of families occurred more than once. p-values of Student's t-tests are presented for significance differences between scores of farm types

	Visual observation		Pit fall traps	
Analysis	Axis 1	Axis 2	Axis 1	Axis 2
Eigen values	0.041	0.04	0.081	0.043
% variance explained of the species data	6.10	3.10	9.30	7.20
% variance explained by variables	49.3	26.1	45.2	35.2
Correlation				
Hedgerows	0.42	0.69	0.02	0.73
Shannon diversity indices	0.39	0.01	0.03	0.02
p-values for different between scores	0.026	0.03	0.01	0.02

percentage variation explained in the specie data was between 3.1 and 9.3%. The fraction of variation explained by all sets of variables was comparatively more significant in Pitfall traps than that of visual searching methods.

DISCUSSION

The results revealed that farm types (organic/conventional) influences arthropods richness, composition and abundance. Arthropods population correlates to *in situ* species richness. Hedgerows and crop fields differed considerably in arthropods richness, composition and abundance. Hedgerows had more phytophagous arthropod and less number of beneficial arthropods, its might due to predation activity on beneficial arthropods like mites, collembolas, springtails and ants, as in case of fields beneficial arthropods were more than phytophagous arthropods. In fields the beneficial arthropods were more as due to more organic matter and nutrient inputs and has less number of phytophagous arthropods by use of chemicals (conventional)/organic (organic farms) insecticides and pesticides. Overall hedgerow harbored larger number of arthropods families (Boutin *et al*., 2009). Organic and conventional farming systems are characterized by different management practices in terms of usage of agrochemicals, weed and pest management and tillage practices. Organic farm fields are comparatively rich in beneficial arthropods except in carabidae (beneficial arthropods family) was more abundant in conventional managed sites than in organic fields. Presence of more carabides in the inorganic farms is a bio-indicator of various anthropogenic activities such as urbanization, crop and forest management, overgrazing and soil pollution (Weibull *et al*., 2000, 2003; Boutin *et al*., 2009), thus coincides with the present study results.

The strong and significant correlations between plants and arthropods composition in this study clearly demonstrated the relations among the first two tropic levels of agriculture ecosystems. Pit fall trap method found to be most efficient method in this study as it captures a large number of beneficial (Marasas *et al*., 2001) and comparatively less numbers of phytophagous arthropods, in Visual searching method was most efficient in phytophagous and less effective in beneficial arthropods (Latif *et al*., 2009). Plant diversity and composition has also been a factor in arthropods species determination, thus it forms as a primary producers as key determinants of the arthropods community (Boutin *et al*., 2009).

The most important factors determining arthropod abundance and diversity in agroecosystems are the availability of food, shelter and suitable microclimate (Booij and Noorlander, 1992; Hadjicharalampous *et al*., 2002; Letourneau and Bothwell, 2008). Another explanation could be the crop-arthropod interactions because they influence the amount of living and dead organic matter and nutrient dynamics in terrestrial ecosystems (Hadjicharalampous *et al*., 2002; Letourneau and Bothwell, 2008). Both arthropod orders studied consist of organisms that are known to contribute to soil organic matter decomposition. They fragment and redistribute organic residues, thereby favoring microbial activity, which enhances organic matter decomposition and nutrient availability throughout the root zone and improve soil structure (Linden *et al*., 1994; Doube and Schmidt, 1997; Letourneau and Bothwell, 2008).

Intensive agriculture and excessive use of agrochemicals have resulted in an impoverished wildlife especially reduce arthropod diversity and density in agricultural landscapes. Due to elimination of semi-natural habitats and other melioration measures, simplification of crop rotations as well as high input of fertilizers and pesticides a severe decline of biological diversity has been observed (Letourneau and Bothwell, 2008; Masto *et al*., 2008). Vast literatures exist on detrimental side effects of insecticides and other chemical treatments on arthropods (Pfiffner, 2000; Badji *et al*., 2007; Jia *et al*., 2010). Pesticides are a potential threat to polyphagous predators (spring tails, mites, carabids and spiders) either by reducing numbers directly or indirectly eliminating major food resources and (Dangerfield, 1990; Diekotter *et al*., 2010). After a long time of intensive cropping, several factors may explain the observed decrease in invertebrate density and zoological richness. Intense use of pesticides, intense cropping and heavy tillage cause soil compaction and destroy most soil and litter microhabitats (Badji *et al.*, 2007; Diekotter *et al.*, 2010).

Organic farm fields are comparatively rich in beneficial arthropods and it is mainly due to high organic and nutrient content in soils, improved soil quality, absence of chemicals, no or low level of soil disturbance/pollution and eco-friendly management techniques in organic fields, which are completely or partially absent in conventionally managed fields (Mader *et al.*, 2002; Nakhro and Dkhar, 2010). The higher biological diversity in the organic system is important because it contributes to keeping the biological equilibrium, essential in an agroecosystem. This equilibrium may bring about greater stability for the system and consequently fewer problems with diseases and pests. The higher number of species in the organic system is possibly due to the availability of organic substrates for them to breed on and the absence of pesticides (Letourneau and Bothwell, 2008). These organisms are important because they not only improve the physical properties (Lee, 1985) but also contribute to the soils ability to suppress pathogens, such as *R. solani*, among others (Stephens *et al.*, 1993; Letourneau and Bothwell, 2008).

Organic agriculture is now considered a viable option in food security discussions (Badgley *et al.*, 2006; Zanoli *et al.*, 2007; Letourneau and Bothwell, 2008; Gabriel *et al.*, 2010). Biodiversity that is conserved on organic farms promotes beneficial biological processes that compensate for practices (such as application of synthetic insecticides) that are disallowed under organic certification requirements. Organic practices might be expected to increase conservation biological control, defined as the maintenance of natural enemies of insect pests through reduced use of broad-spectrum pesticides and enhancement of natural enemies through habitat manipulation (Barbosa, 1998; Gabriel *et al.*, 2010). Pimentel (1961) related increases in the diversity of parasitoids and predators with reduced pest population outbreaks. Root (1973) predicted that herbivores would be suppressed to a greater extent in mixed vegetative stands with a higher species diversity of predators and parasitoids. Gliessman (1989) warned that, as biological diversity is reduced, trophic structures tend to become simplified and vacant niches appear, leading to increased risk of catastrophic pest outbreaks. A recent position paper cautioned that critical ecosystem services such as pollination and pest control for food production both support and depend on biodiversity (Alcamo *et al.*, 2003). The same linkages have been expressed for organic farming operations with higher biodiversity than conventional farms (Kasperczyk and Knickel, 2006; Letourneau and Van Bruggen, 2006; Gabriel *et al.*, 2010).

Bengtsson *et al.* (2005) and Hole *et al.* (2005) continue to support a positive association between organic management and on-farm biodiversity for plants (Belfrage *et al.*, 2005; Gabriel *et al.*, 2006; Kleijn *et al.*, 2006), predatory arthropods (Purtauf *et al.*, 2005; Schmidt *et al.*, 2005; Kleijn *et al.*, 2006) and non-predatory arthropods (Wickramasinghe *et al.*, 2004; Kleijn *et al.*, 2006). Bird diversity has been more strongly associated with crop or landscape diversity than with organic practices alone (Belfrage *et al.*, 2005; Jones *et al.*, 2005; Kleijn *et al.*, 2006). Oehl *et al.* (2004) found a greater diversity of soil microorganisms on organic farms than on conventional farms. Organic agriculture practices clearly promote biodiversity, especially compared to intensively-managed conventional systems (Bengtsson *et al.*, 2005; Letourneau and Bothwell, 2008; Gabriel *et al.*, 2010).

In conclusion difference in the arthropod communities among sites were determined by farming practices (organic/conventional), plant composition and by presence of wide range of diverse habitats i.e., crop fields and hedgerows. This study proves that organic farming systems were rich in plant diversity, arthropods diversity, maintains soil quality and control pests that would result in long term increased sustainable production.

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