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Effects of Persistent Insecticides on Beneficial Soil Arthropod in Conventional Fields Compared to Organic Fields, Puducherry

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Abstract: The usage of synthetic fertilizers/insecticides in conventional farming has dramatically increased over the past decades. The aim of the study was to compare the effects of bio-pesticides and insecticides/pesticides on selected beneficial non targeted arthropods. Orders Collembola, Arachinida/Opiliones, Oribatida and Coleoptera were the main groups of arthropods found in the organic fields and Coleoptera, Oribatida, Gamasida and Collembola in conventional fields. Pesticides/insecticides had a significant effect on non-targeted arthropods order- Collembola, Arachinida/Opiliones, Hymenoptera and Thysonoptera were suppressed after pesticides/insecticides spraying. Bio-insecticides in organic fields had a non-significant effect on non targeted species and they started to increase in abundance after 7 days of spraying, whereas insecticide treatment in conventional fields had a significant long-term effect on non targeted arthropods and short term effect on pests/insects, it started to increase after 21 days of the spraying. These results indicate that insecticide treatment kept non targeted arthropods at low abundance. In conclusion, organic farming does not significantly affected the beneficial-non targeted arthropods biodiversity, whereas preventive insecticide application in conventional fields had significant negative effects on beneficial non targeted arthropods. Therefore, conventional farmers should restrict insecticide applications, unless pest densities reach the thresholds and more desirably can switch to organic farming practices.

Key words: Organic farming, conventional farming, pesticides/insecticides, non-targeted species, arthropods

INTRODUCTION

In the last century, agricultural intensification resulted in significant biodiversity loss in agro-ecosystems (Robertson and Swinton, 2005; OECD, 2008; Nair, 2008; Krauss *et al*., 2011). Biodiversity and ecosystem services might be protected along with agro-ecosystems, where farmers get subsidies, partly to produce ecological benefits (Kleijn *et al*., 2001). Important agro-ecological concept in organic farming systems is the avoidance of chemical fertilization and pesticide application, whereas in conventional farming systems it is common (Krauss *et al*., 2011; Pandey and Singh, 2012). There is a considerable concern about decline in biodiversity that would influence the delivery of various ecosystem services (Hole *et al*., 2005; Hooper *et al*., 2005; FIBL, 2012).

In agricultural intensification, the most affected/ecosystem services at severe risk are biological pest control (Tscharntke *et al*., 2005, Geiger *et al*., 2010), crop pollination (Biesmeijer *et al*., 2006; MEA, 2005; Zhang *et al*., 2007) and soil fertility maintenance (Hole *et al*., 2005; Hansen *et al*., 2006; Goh, 2011; Pandey and Singh, 2012). Organic farming might decrease the biomass of crop by 25% but increases the diversity of most functional group species (Bengtsson *et al*., 2005; Letourneau and Bothwell, 2008; Kleijn *et al*., 2006). Tonhasca (1993) and Carcamo *et al*. (1995) reported that response of different arthropods to organic cultivation systems has diverse consequences for pest management, focusing only on more relevant species which improve the productive capacity in such systems.

Mites, spring tails and ants are some important arthropods used to assess environmental impacts (Joy and Chakravorty, 1991; Peck *et al*., 1998; Badji *et al*., 2007). Studies on non target impacts of pesticides on spring tails are carried out by Frampton (1994, 1997) and in ants by Samways (1981) and Peck *et al*. (1998), Perfecto (1990), Michereff-Filho *et al*. (2004). Moore *et al*. (1984) and Minor *et al*. (2004) reported that Oribatida and Gamasida mites have been used to assess the changes resulting from human activity.

Application of systematic insecticides in conventional fields is a common practice (Geiger *et al*., 2010). Studies on comparison of death of non targeted species among organic and conventional fields with

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different crops is still lacking, hence this study was conducted to assess the effects of pesticides (causing loss of beneficial arthropods) in conventional fields and a comparison was made along with organic fields.

Hymenoptera are important in soil nutrient cycling/soil organic matter decomposition; Spiders (Araneae) and Opiliones (harvestmans) are useful in controlling aphid numbers, whereas Isopoda, Collembola and certain families of Coleoptera (Carabidae, Scarabidae) that include saprophagous organisms, contribute to decomposition of soil organic matter influencing the amount of living and dead organic material and nutrient transfers in terrestrial ecosystems. The present study was focused on the pesticides/insecticides effects on the assemblage of such beneficial arthropods are selected for the study. All these families were easily collected using pitfall traps/visual searching methods and species belonging to these families were abundant in most of the habitat types under the investigation.

MATERIALS AND METHODS

Experimental site and design: Puducherry is located on the Coramandal coast 11°52' N, 79° 45' E and 11°59' N and between 79°52' E covers an area of 480 sq km. The study area experiences mean annual temperature of 30.0°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 kms

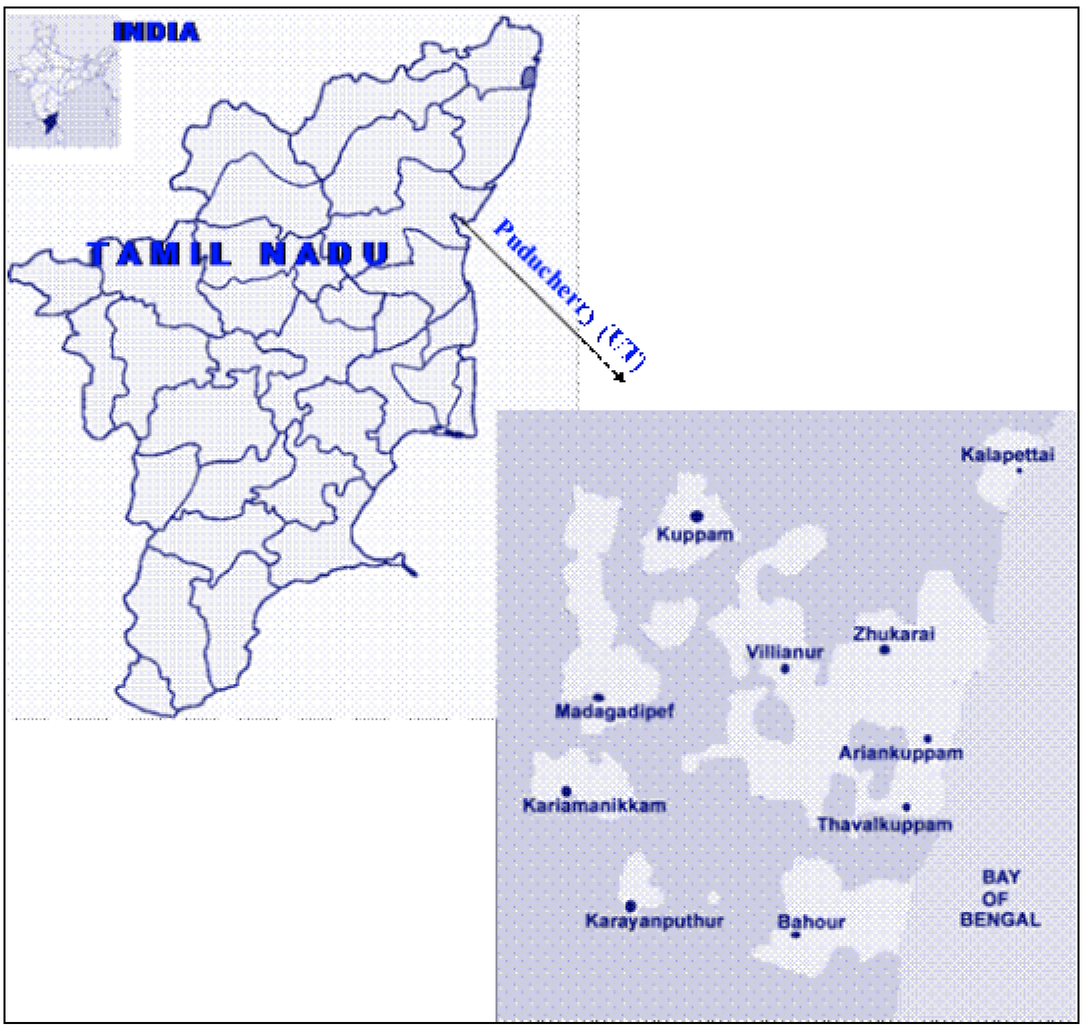

Fig. 1: Location of the study area

Table 1: Fertilizer/manures/insecticides/bio-pesticides application in organic and conventional fields

	Organic farming (ha^{-1})	Conventional farming (ha^{-1})
Paddy	50 mg cow dung compost	120-130 kg N (urea)
	11 mg green manure	80-20 kg P_2O_5 (Superphosphate)
	1.2 mg vermi compost	40-50 kg K_2O (KCl)
	100 l Panchakavya	250-500 l insecticides
	100 l Amirthakaraisal	
	80 l Meein amilam	
	50 l Thayingaipal and pulithamoor karaisal	
	55 l Vanamutham	
	90 l Bio-pesticides	
Ladys finger	40 mg cow dung compost	100-115 kg N (urea)
	9 mg green manure	60-75 kg P_2O_5 (Superphosphate)
	0.8 mg Vermi compost	35-45 kg K_2O (KCl)
	65 l Panchakavya	220-230 l insecticides
	65 l Amirthakaraisal	
	50 l Meein amilam	
	40 l Thayingaipal and pulithamoor karaisal	
	35 l Vanamutham	
	75 l Bio-pesticides	
Groundnut	50 mg cow dung compost	100-110 kg N (urea)
	11 mg green manure	50-60 kg P_2O_5 (Superphosphate)
	1.2 mg vermi compost	30-38 kg K_2O (KCl)
	50 l Panchakavya	200-210 l insecticides ha^{-1}
	50 l Amirthakaraisal	
	35 l Meein amilam	
	35 l Thayingaipal and pulithamoor karaisal	
	25 l Vanamutham	
	65 l Bio-pesticides	

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 conventional/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. 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}.

Characteristics: A comprehensive description of the fertilizers application practices adopted during the survey are described in Table 1. According to the procedures utilized by conventional local growers, a blend of pesticides/insecticides was sprayed once every month (depending upon the abundance of pests/insects) after planting. Monocrotophos chemical at 1:4 with water applied at 25/35/45 days after sowing and Karate chemical at 1:3 ratios with water applied at 55/70 days after sowing. Endosulphon at 1:4 with water applied at 25/35/45 days after sowing. These are the predominant insecticides used in paddy, lady's finger and groundnut at the local level.

As in case of organic farming, a mixture of fermented extracts of *Caltrops* leaf, *Adhatoda vasica* leaf, *Ipomoea carnea* leaf, *Vitex negundo* and *Morinda correia* are used as Bio-pesticides to control diseases and pests in the organic system. These applications were performed according to the program adopted by organic producers in the region and sprayed once every month (depending upon the abundance of pests/insects) after planting.

Sampling was carried out by pitfall traps as suggested by Schmidt *et al.* (2006) and visual searching methods by Latif *et al.* (2009). In each field 10 pitfall traps were placed in three or four parallel lines (least distance between single traps in the line: 5 m; least distance between lines: 5 m) close to the plants. Pitfall traps were left in the fields for 48 h and then specimens were collected, identified (to family level) and preserved. Samples were taken 20, 13, 6 and 1 days before spraying and 1, 6, 13, 20 and 25 days after insecticides spraying. Arthropod families/order with only one occurrence was removed from analysis as suggested by Boutin *et al.* (2009) SPSS 16 and Biodiversity-R was used for ANOVA.

Weed control was carried out by mechanical weeding and manually on post-planting in the conventional system and in the organic system weeds are encouraged till they are under threshold level and its is removed mechanically/manually, when it crosses the threshold level.

RESULTS

The density and the numbers of arthropods were higher (before and after insecticides/pesticides application) in the organic cropping system, reflecting on Shannon diversity indices, which were higher in the organic system (H' 2.5-3.5) than conventional fields H' 0.5-1.5) throughout the study (Fig. 2). Families belonging to the orders Homoptera, Pscopotera, Poudurida, Scheloribatida etc., that appeared with less frequent/less number of individuals were neglected from further analyses. Families belonging to the orders Collembola (Entomobridae/Isotomidae/Sminthuridae) Arachinida (Araneae/Oliliones), Oribatida (Oribatuloidae/Oribatida), Coleoptera (Carabidae/Scarabidae/Cicadellidae), Hymnoptera (Myrimicinae, Formicidae, Ecitoninae, Ponerinae) and Thysonoptera are the main groups of arthropods found in the organic soil during the study period, as in case of conventional farming Oribatida (Oribatuloidae/Brachichythonidadae/Galummidae), Gamasida (Rhodacaridae/Uropodidae/Ixodidae) Collembola (Symphyploena/Brachysromellidae/Ioduridae) and Coleoptera (Aphididae/Carabidae/Reduviidae/Noctuidae-pests) are the main groups of arthropods (Table 2-4).

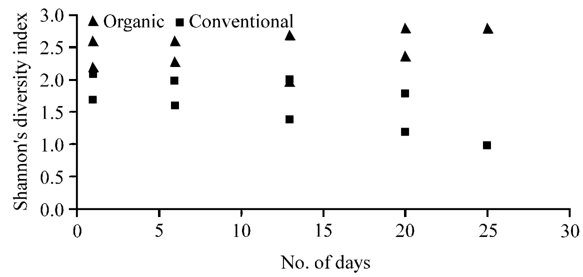

Fig. 2: A comparison of arthropod diversity index between organic and conventional fields

Table 2: An overall abundance/harvest (±standard error) of arthropods collected from conventional and organic paddy fields, without and with insecticides spraying

	Conventional field		Organic field	
Taxa/order/family	Without insecticide	With insecticide	Without insecticide	With bio insecticide
Arachnida Araneae				
Araneidae	117.67±0.37	108.67±0.42	165.20±1.94	114.67±0.34
Clubionidae	185.20±1.94	146.20±1.94	514.20±1.95	503.67±1.35
Freridae	95.67±0.38	85.06±0.43	214.20±1.96	183.57±1.36
Muturigidae	85.20±1.95	104.20±1.95	224.09±0.97	175.69±1.07
Oxyopidae	76.10±1.09	97.70±0.93	127.39±0.98	95.08±1.08
Opiliones				
Cyphophthalmi	127.67±0.37	118.47±0.42	925.36±6.54	555.10±4.60
Tropicophihalmi	256.20±1.94	147.20±1.04	476.12±3.32	346±2.26
Ogoveoudae	315.67±0.38	128.67±0.43	588.10±2.02	536.06±2.92
Stronoidae	165.20±1.05	114.20±1.95	415.20±7.93	303.30±4.93
Acaridida				
Acaridae	542.28±2.82	665.13±4.60	126.04±0.22	122.06±0.30
Actinedida				
Cunaxidae	642.38±3.80	987.13±6.20	125.06±0.22	102.37±0.30
Pygmephoridae	548.38±3.81	765.65±6.21	223.06±0.23	202.38±1.31
Scutacaridae	548.08±3.82	687.53±4.20	225.86±1.24	112.07±0.02
Gamasida				
Ascidae	442.33±2.60	687.13±2.22	325.26±1.22	262.37±0.30
Macrochilidae	348.43±2.15	547.18±1.22	188.26±1.00	154.27±0.31
Pachylaelapidae	445.43±2.61	683.43±2.02	125.06±1.24	102.37±0.32
Rhodacaridae	245.13±2.62	387.13±1.04	225.26±1.25	202.37±0.33
Ixodida				
Ixodidae	448±1.36	286.22±4.42	128.20±1.94	074.20±1.64
Oribatida				
Brachichythoridada	857±6.57	985.36±5.75	237.47±0.06	186.57±0.51
Galimmidae	1377.43±3.60	1455.46±5.32	564.20±2.93	405.28±1.64
Oribatuloidae	1756.30±7.57	1928.32±5.75	658.60±1.03	398.10±1.22
Scheloribatidae	748±3.36	886.22±4.42	228.20±1.94	184.20±1.64
Collembola				
Entomobridae	637.67±0.36	539.47±3.41	2156±8.57	2536.10±5.75
Isotomidae	337.20±1.93	218.20±2.94	1889.67±3.70	2822.67±8.62
Ioduridae	537.47±3.37	518.67±4.42	2424.00±7.62	3437.67±9.40
Symphyploena				
Sminthuridae	286.20±2.94	117.20±2.05	648.00±4.27	457.22±6.32
Podumorpha				
Brachysromellidae	743.00±2.27	765.43±9.67	1134.43±5.33	1437.05±3.91
Hypgastruridae	654.08±3.28	723.67±6.08	1026.08±5.38	1287.55±5.08

Table 2: Continue

	Conventional field		Organic field	
Taxa/order/family	Without insecticide	With insecticide	Without insecticide	With bio insecticide
Coleoptera				
Carabidae sp1	453.27±0.16	210.40±0.16	358.57±0.54	288.43±0.40
Carabidae sp2	353.17±0.16	170.40±0.16	241.67±0.24	168.43±2.40
Carabidae sp3	258.27±0.16	110.40±0.16	148.57±0.54	88.43±4.40
Noctuidae	15.67±0.06	19.33±0.06	185.33±0.13	225.32±0.20
Reduviidae	11.37±0.01	0.00±0.00	88.33±0.05	110.20±1.01
Aphididae	3.20±0.02	2.00±0.03	33.00±0.02	45.00±0.10
Hymnoptera				
Myrimicinae	44.20±0.02	33.09±0.03	111.00±0.08	78.00±0.10
Formicinae	30.00±0.02	31.00±0.01	86.00±0.02	64.08±0.02
Ecitoninae	21.00±0.00	23.33±0.02	47.05±0.08	52.33±0.06
Ponerinae	21.02±0.01	23.08±0.03	36.05±0.09	52.36±0.07
Thysanoptera				
Thysonura	50.20±0.96	35.67±1.36	85.67±1.38	55.06±0.33
Immature arthropods	270.20±1.96	115.57±1.36	455.67±3.38	335.06±0.43

Table 3: An overall abundance/harvest (±standard error) of arthropods collected from conventional and organic groundnut fields ha^{-1}, with and without insecticides spraying

	Conventional field		Organic field	
Taxa/order/family	Without insecticide	With insecticide	Without insecticide	With bio insecticide
Arachnida Araneae				
Araneidae	245.40±1.02	215.20±1.92	815.36±3.72	803.20±1.92
Clubionidae	138.67±0.41	123.57±0.08	347.57±2.32	313.45±0.92
Freridae	97.20±1.93	104.20±1.93	314.67±1.33	303.20±0.93
Muturgidae	98.57±0.02	107.67±0.37	465.60±1.34	414.52±2.94
Oxyopidae	146.20±1.94	185.20±1.94	544.67±2.36	503.85±1.95
Theriduidae	127.85±0.43	122.37±0.38	314.08±2.36	293.40±1.05
Thomisidae	104.20±1.95	184.20±2.75	414.65±3.38	403.23±1.97
Opiliones				
Cyphophthalmi	357.57±2.36	288.67±5.41	1937.22±6.75	1328±8.57
Tropicophihalmi	216.20±1.94	187.20±1.04	76.12±3.32	146±2.26
Stronoidae	234.60±1.93	198.23±2.65	1356.47±5.32	1242.38±1.80
Caddidae	345.67±0.37	343.67±0.42	1925.35±6.54	1365.08±5.60
Phalangoidae	286.20±1.94	146.20±1.94	575.22±4.32	446±3.26
Acaridida				
Acaridae	148.20±1.94	108.20±0.94	474.32±2.38	333±2.26
Gamasida				
Ascidae	942.33±2.60	1197.00±3.22	542.20±1.22	533.67±1.30
Macrochilidae	1147.33±5.60	1285.00±4.22	674.20±1.93	418.20±1.93
Pachylaelapidae	855.00±5.60	1126.20±4.54	527.67±2.37	408.67±3.42
Rhodacaridae	442±3.26	479.22±5.32	266.20±2.76	146.20±1.94
Uropodidae	632±2.16	419.22±3.12	346.20±3.76	143.20±1.04
Ixodida				
Ixodidae	348±7.26	269.22±5.32	235.20±4.76	196.20±5.94
Oribatida				
Brachichythoridida	738±8.57	885.26±6.75	437.67±0.36	286.57±2.51
Galimmidae	1287.43±3.60	1385.40±5.32	674.20±1.93	415.28±3.63
Oribatuloidae	1825.00±7.57	1726.10±4.75	777.00±1.45	298.00±1.02
Oribatellidae	846±2.36	886.22±4.42	415.20±1.94	354.20±2.64
Collembola				
Entomobridae	637.67±0.36	738.67±4.41	1636.22±3.45	1225±7.57
Isotomidae	824.20±2.94	518.20±3.93	2822.67±8.62	1756.67±7.70
Ioduridae	777.67±2.37	523.67±3.02	3285.67±6.40	2574.00±6.62
Symphyploena				
Sminthuridae	186.20±2.94	77.20±2.34	843.00±2.27	567.22±2.42
Podumorpha				
Brachysromellidae	1563.67±9.67	743.00±3.27	2337.55±7.50	1428.00±5.32
Hypgastruridae	1333.67±5.04	845.40±5.28	1887.55±5.62	1126.00±5.34
Coleoptera				
Pyraustidae	22.00±0.02	12.23±0.00	12.00±0.00	7.00±0.06
Carabidae sp 2	45.00±0.10	22.67±0.03	26.33±0.05	17.20±0.06
Carabidae sp 3	55.00±0.20	32.27±0.13	31.33±0.01	22.11±0.16
Carabidae sp 4	45.00±0.23	22.67±0.21	26.33±0.05	15.20±0.03
Staphylindae	62.00±0.02	30.00±0.00	34.00±0.01	25.00±1
Aphididae	88.67±0.03	20.00±0.04	62.00±0.02	33.00±0.02
Cecidomyiidae	71.00±0.01	42.00±0.20	51.00±0.01	21.50±0.01

Table 3: Continue

	Conventional field		Organic field	
Taxa/order/family	Without insecticide	With insecticide	Without insecticide	With bio insecticide
Hymnoptera				
Myrimicinae	52.67±4.13	45.00±0.12	96.33±0.05	77.20±0.06
Formicinae	22.67±4.13	53.00±0.50	74.33±1.05	53.20±0.06
Ecitoninae	25.67±4.13	45.00±0.06	56.33±0.05	37.20±0.12
Ponerinae	30.00±5.08	32.00±5.02	74.25±0.86	65.00±5.09
Thysanoptera				
Thysonura	70.20±0.96	29.67±1.36	95.67±5.38	75.06±0.33
Immature arthropods	270.20±1.96	115.57±1.36	347.67±2.38	135.06±0.43

Table 4: An overall abundance/harvest (±standard error) of arthropods collected from conventional and organic ladys finger fields, with and without insecticides spraying

	Conventional field		Organic field	
Taxa/order/family	Without insecticide	With insecticide	Without insecticide	With bio insecticide
Arachnida Araneae				
Araneidae	888.00±1.45	390.00±1.02	836.10±4.75	525±7.57
Clubionidae	729.20±1.22	717.67±1.30	935.00±3.22	841.33±2.60
Freridae	669.00±6.13	496.20±5.79	825.20±7.54	755.00±5.60
Muturgidae	378.00±1.32	363.00±1.75	575.22±4.32	446±3.26
Oxyopidae	115.20±1.92	145.20±1.92	215.20±2.92	203.20±1.92
Lycosidae	113.67±0.36	138.67±0.41	317.67±1.32	313.20±1.92
Linyphiidae	104.20±1.93	97.20±1.93	314.67±1.33	303.20±1.93
Pholicidae	117.67±0.37	108.67±0.42	465.67±1.34	414.20±1.94
Psechaidae	185.20±1.94	146.20±1.94	514.67±1.35	503.20±1.95
Scytodidae	115.67±0.38	127.67±0.43	314.67±1.36	283.20±1.96
Sparassidae	85.20±1.95	104.20±1.95	414.67±1.37	375.20±1.97
Opiliones				
Cyphophthalmi	227.67±0.36	138.67±0.41	876.10±4.75	625±9.57
Tropicophthalmi	114.20±1.93	98.20±1.93	285.00±4.22	241.33±2.60
Ogoveoidae	117.67±0.37	108.67±0.42	1925.20±7.54	1555.00±5.60
Stronoidae	286.20±1.94	146.20±1.94	575.22±4.32	446±3.26
Caddidae	315.67±0.38	128.67±0.43	515.20±3.92	426.20±1.92
Phalangoidae	185.20±1.95	114.20±1.95	415.20±7.93	303.20±6.93
Acaridida				
Acaridae	827.20±5.92	915.60±6.92	486.00±1.64	385.20±1.94
Actinedida				
Cunaxidae	976.22±4.32	846.00±3.26	317.67±0.37	208.67±2.42
Pygmephoridae	815.20±3.92	627.20±1.92	386.00±1.64	285.20±1.94
Scutacaridae	915.06±4.03	777.20±1.93	438.47±1.03	415.67±0.38
Gamasida				
Ascidae	882.00±9.57	836.10±4.75	237.67±0.36	218.67±2.41
Macrochilidae	1247.33±3.60	1285.00±4.22	174.20±1.93	118.20±1.93
Pachylaelapidae	1255.00±5.60	1326.20±7.54	517.67±0.37	408.67±3.42
Rhodacaridae	446.00±3.26	576.22±4.32	286.20±1.94	146.20±1.94
Uropodidae	427.20±1.92	515.20±3.92	315.67±0.38	138.67±1.43
Ixodida				
Ixodidae	308.00±7.26	203.22±5.32	135.20±4.76	69.20±5.94
Oribatida				
Brachichythoridida	932.00±6.57	936.10±5.75	337.67±0.36	238.67±3.41
Galimmidae	1387.33±3.60	1585.00±3.22	564.20±1.93	418.20±2.93
Oribatuloidae	1155.00±6.60	1326.20±7.64	517.67±0.37	408.67±3.42
Oribatellidae	746.00±3.26	886.22±4.42	366.20±1.94	246.20±1.64
Collembola				
Entomobridae	837.67±0.36	738.67±4.41	1836.10±4.75	1325±9.57
Isotomidae	727.20±1.93	518.20±3.93	2822.67±8.62	1889.67±3.70
Ioduridae	637.67±2.37	518.67±4.42	3437.67±9.40	2424.00±7.62
Symphyploena				
Sminthuridae	386.20±2.94	277.20±3.34	948.00±3.27	1457.22±4.32
Podumorpha				
Brachysromellidae	948.00±3.27	2963.67±13.60	2424.00±7.62	3437.67±9.40
Hypgastruridae	688.00±3.28	1528.67±13.61	1865.00±6.73	2437.67±7.61
Coleoptera				
Carabidae sp 1	258.67±0.14	208.33±0.40	120.67±0.16	154.20±0.16
Carabidae sp 4	55.33±0.13	60.20±0.20	15.67±0.06	19.33±0.06

Table 4: Continue

	Conventional field		Organic field	
Taxa/order/family	Without insecticide	With insecticide	Without insecticide	With bio insecticide
Carabidae sp 5	200.67±0.16	154.20±0.16	158.67±0.14	108.33±0.40
Scydonaeidae	8.33±0.05	1.20±0.01	1.67±0.01	0.00±0.00
Curculionidae	21.00±0.08	22.00±0.10	3.20±0.02	2.00±0.03
Pselaphidae	2.00±0.02	2.00±0.02	0.00±0.00	1.00±0.01
Scarabidae sp 1	17.00±0.08	11.33±0.06	0.00±0.00	3.33±0.02
Nitidulidae	16.00±0.05	1.20±0.01	12.63±0.02	16.00±0.09
Chrysomelidae	0.00±0.00	7.00±0.06	2.00±0.02	7.23±1.00
Diptera				
Dipteraadult	14.20±0.02	3.00±0.03	31.00±0.08	18.00±0.10
Dipteralarva	10.00±0.00	5.00±0.01	16.00±0.02	10.00±0.02
Hymnoptera				
Myrimicinae	4.20±0.02	3.00±0.03	11.00±0.08	18.00±0.10
Formivinae	0.00±0.00	1.00±0.01	6.00±0.02	4.00±0.02
Ecitominae	1.00±0.00	3.33±0.02	17.00±0.08	12.33±0.06
Thysonoptera				
Thysonura	63.20±0.96	49.37±1.32	85.31±2.33	65.06±0.32
Immature arthropods	170.20±1.06	95.57±2.30	247.17±3.38	185.06±0.13

These orders did show an apparent trend based on their overall abundance and they were also subjected to individual Repeated Measures ANOVA allowing the interpretation of the within subject factor for each one of them. All interactions between treatments and time (before and after insecticide spraying) were tested. Significant difference between treatments was found among the three crops.

There was a significant effect of the cultivation systems on the following orders Collembola (p = 0.103), Oribatida (p = 0.04) and Coleoptera (p = 0.003) in paddy fields (Table 1), in the groundnut fields (Table 2) Collembola (p = 0.020), Gamasida (p = 0.05) and Hymnoptera (p = 0.04) showed a significant effect in the abundance and in case of ladys finger fields (Table 3) Collembola (p = 0.12), Arachinida -Araneae and Opiliones (p = 0.034; p = 0.043) showed a significant effect in the abundance. This effect was regardless of time, orders-Collembola, Arachinida-Araneae/Opiliones, Hymnoptera and Thysonoptera has the largest populations of arthropods and the number of individuals were twofold higher (before/after insecticides/pesticides spraying) in the organic cropping system.

DISCUSSION

In conventional fields, orders- Oribatida, Gamasida and Coleoptera had the largest populations of arthropods; they showed higher number of individuals and 25% times higher (before insecticides/pesticides spraying) and remained 45% higher in the conventional cropping system (after insecticides/pesticides spraying) than in the organic fields. This results are similar to the results of several earlier workers (Cockfield and Potter, 1983; Stark, 1992; Weibull *et al*., 2000; 2003; Michereff-Filho *et al*., 2004; Boutin *et al*., 2009; Thomas *et al*., 2011) and found that these species are tolerant to insecticides and used as bio indicators of environmental stress; their presence in higher abundance in conventional fields determines such fields are under severe environmental stress like urbanization, crop and forest management, overgrazing and soil pollution .

Repeated measures ANOVA indicated a significant interaction between cultivation systems and sampling data for Collembola-(Entomobridae/Isotomidae/ Sminthuridae) (p = 0.00; p = 0.003; p = 0.04), Arachinida-Araneae/Opiliones (p = 0.010; p = 0.103; p = 0.14), Hymnoptera (Myrimicinae, Formicidae) (p = 0.020; p = 0.013; p = 0.004) and Thysonoptera (p = 0.203, p = 0.110; p = 0.214) these results indicate a significant effect of the cultivation systems with spring tails, spiders/harvestmans and ants, through time. There is a drastic decline/decrease from day 2 to 20 in the abundance on the non-targeted species after pesticides/insecticides spraying in conventional fields among the entire three crop fields, the abundance was slightly decreased (day 2) and raised after 7 days of bio-pesticides spraying in organic fields (Fig. 2). The pests/aphids population trend to increase in conventional fields after 20 day of insecticides spraying, necessitating spraying pesticides/insecticides again, as in case of organic fields, the bio-pesticides brings the insects/pests population under threshold level and it is mentioned throughout by biological pest control agents like spiders/harvestmans, mites, ants, true bugs, centipedes and flies.

These results agree with that of several earlier workers who reported that semi-natural agricultural systems in organic fields with diverse plants provide food source for several beneficial arthropods and it is a key determinant for the arthropods community, with a positive effect on the biodiversity (Oehl *et al*., 2004; Boutin *et al*., 2009; Ponce *et al*., 2011; Krauss *et al*., 2011). The weeds in organic fields serve as a habit and habitat for several predatory bugs and are present in greater density and diversity in organic fields (Fukuda *et al*., 2011; Nascimbene *et al*., 2012); whereas in conventional fields weeds are removed mechanically/manually/by using herbicides (rarely). This intern affects various beneficial insect populations (FIBL, 2012). Insecticides application and weed removal in conventional croplands usually have a stronger negative impact on arthropods and also reduce biological pest control potentials (Paoletti and Pimentel, 1992; Hendrickx *et al*., 2007; Rundlof *et al*., 2008; Boutin *et al*., 2009); Geiger *et al*., 2010; Thomas *et al*., 2011; Fukuda *et al*., 2011; Nascimbene *et al*., 2012).

In summary, the results of the present study confirm that pesticides/insecticides spraying in conventional systems results in significant (p value ranged in and between p = 0.00-, p = 0.103) effect on non-targeted arthropods order-Collembola, Arachinida-Araneae/Opiliones, Hymenoptera and Thysonoptera they were significantly suppressed after pesticides/insecticides spraying. These results are in agreement with that of El Titi and Ipach (1989), Wiggins and Curl (1979), Curl *et al*. (1985a, b), Rickerl *et al*. (1989), Lartey *et al*. (1994), Bettiol *et al*. (2002), Boutin *et al*. (2009) and Thomas *et al*. (2011), who concluded that collembolans can be found in large population densities in organic fields than in conventional fields, due to enhanced food source/reduced suppression in organic soils. They play important role in arthropod food webs, decomposition, soil nutrient dynamics and suppressing plant pathogens. Hunting spiders/Opiliones/ants play a significant role in biological pest control and serves as important bio-control agents (Batary *et al*., 2010, 2012; Dahms *et al*., 2010). Organic management enhanced the species richness of spiders/opiliones/ants, whereas conventional farming portrayed the opposite trend as it is reported by Letourneau and van Bruggen (2006), Letourneau and Bothwell (2008) and Dahms *et al*. (2010).

CONCLUSION

From this study, it may be concluded organic farming enhances arthropod groups that provide ecosystem services with benefits for farmers due to better top to down control of pest species and maintenance of soil fertility. The insecticide application in conventional fields had significant direct costs in terms of material and labour with no long term benefit for aphid control and negative effects on natural beneficial arthropods. It is therefore concluded that the application of insecticides in conventional fields increases direct management costs for farmers and indirectly decreases biological pest control effectively, thus results reduced ecosystem services.

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