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Diversity studies on insect communities in organic, conservation and conventional farming systems under rain-fed conditions

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Abstract
The study was conducted in conventional, conservation farming (six year old block) and organic (10 year block) farming crop systems at UAS, Dharwad for assessing the impact of agricultural practices on insect diversity. The results indicated greater insect diversity in organic and conservation crop blocks as compared to conventional system. Simpson's diversity index ranged from 0.335 (conventional farming) to 0.444 (organic farming) while Shannon-Wiener index varied from 0.422 (organic farming) to 0.627 (conventional farming). Organic farming practices registered significantly higher Simpson’s and Shannon indices (0.376 and 0.445, respectively) for beneficial arthropods compared to conventional farming (0.263 and 0.339 respectively).

Keywords: Diversity, organic farming, conservation agriculture, conventional farming, Shannon-wiener index, Simpson’s index

Introduction

Agriculture is extremely vulnerable to climate change with higher temperatures and changes in precipitation proliferating pest populations leading to short-run crop failures and long-run production declines. At the same time, modern agricultural practices *viz*., mechanization, tillage, mono-cropping, use of hybrids coupled with indiscriminate use of synthetic fertilizers, pesticides and weedicides have resulted into loss of biodiversity in crop ecosystems. However, crop ecosystems being rich in arthropod diversity have greater resilience and will be able to recover more rapidly from the environmental stress. The pesticide usage influences the insect-communities significantly, ranging from pest density reduction to resurgence and loss of beneficial arthropods (Croft and Brown, 1975; Aebischer, 1991; Berry *et al*., 1996; Wilby and Thomas 2002; Mone, *et al*., 2011 and Aune *et al*., 2012) [5, 1, 4, 14, 2].

In agri-horticultural ecosystems insect-pests and beneficial fauna such as pollinators, predators, parasitoids, etc co-exist and conventional cultivation practices in crops often disrupt insect community structure leading to pest outbreaks, loss of insect natural enemies and pollinators. The literature suggests that among various factors, the pesticides usage and its degree influence the insect-communities of crop ecosystems significantly (Bommarco *et al*., 2011 and Dey, 2016) [3, 6]. This ranges from pest density reduction to resurgence and sometimes elimination of certain insect communities from the crop ecosystem though temporarily. This sort of imbalance in arthropod communities leads to reduction in crop yields, keeping this as focus the present study was undertaken to assess the effects of organic and conservation agriculture practices on insect communities and compare it to the conventional chemical based agriculture systems.

Materials and Methods

The study was conducted during 2016-2018 in soybean, wheat, groundnut and sorghum crop ecosystems located at the University of Agricultural Sciences, Dharwad, Karnataka, Southern India. Three types of crop ecosystems *viz*., conventional, conservation and organic farming systems were selected for assessing the impact of farming system practices on insect diversity. Conventional farming is characterized by high degree usage of synthetic fertilizers, pesticides and weedicides with intensive tillage. Conservation agriculture system comprised minimum or no tillage, use of surface mulch, less usage of fertilizers and pesticides, while organic farming practices included use of organic composts, green manuring, plant protection inputs consisting of bio and botanical pesticides. The trials were laid out in RCBD design under assured rainfed conditions and weekly observations were taken during the cropping period. Shannon wiener index and Simpson evenness index indicating arthropod richness and evenness were applied to make interpretations.

Results and Discussion

Simpson index diversity in the present study ranged from 0.335 in conventional farming) to 0.444 in organic farming while Shannon Weiner index varied from 0.422 (organic farming) to 0.627 (conventional farming). With respect to beneficial arthropods and others, organic farming practices registered significantly higher Simpson and Shannon indices (0.376 and 0.445 respectively) compared to conventional farming (0.263 and 0.339 respectively) (Table 1). Conservation agriculture practices scored index values lesser than organic practices but higher than conventional agriculture practices. The arthropods noticed in organic and conservation crop ecosystems included crop pests and beneficials such as Coccinellidae, Chrysopidae, Hemerobidae, Pentatomidae, Ichnemonidae, Braconidae, Chalcididae, Syrphidae, etc. Though same communities were noticed in conventional agriculture the richness and evenness of insect community were at lower side. The soil arthropods observed in the study are Mites, Collembolans, Beetles, Spiders, Ants and other arthropods

Shannon's weaver index (H) and Simpson index (D) of general insect diversity were calculated and analysed for above ground insect diversity. Among the farming systems, organic farming recorded higher diversity index (H=0.627, D= 0.444) followed by four conservation treatments T_1, T_2, $T_3$and T_4 (H=0.575, 0.572, 0.574 and 0.572) and (D= 0.405, 0.400, 0.404, 0.393 and 0.335) and less in conventional farming (H=0.422, D=0.335). In all the crops, *viz.*, soybean, groundnut, *rabi* sorghum and wheat, highest diversity index (both richness and evenness) were observed in organic farming (H=0.857, D= 0.544) (H=0.748, D= 0.507)(H=0.552, D= 0.465) and (H=0.352, D= 0.259)respectively) followed by conservation treatments (H= 0.633, D=0.433),(H= 0.565, D= 0346) and least diversity index was recorded in conventional farming (H= 0.317, D= 0.383) and (H=0.174, D= 0.178) (Table 2).

Across the crops, soybean recorded the higher diversity index of H= 0.755and D= 0.492 followed by groundnut (H= 0.701, D= 441), *Rabi* sorghum (H= 0.483, D= 421) and least in wheat (H= 0.289, D= 232). The insect-pest noticed on groundnut were *Spodoptera litura* (Fabricius, 1775), *Agrius convolvuli* (Linnaeus, 1758), *Aphis craccivora* (Koch, 1854) *Chrysodeixis chalcites* (Esper, 1789), *Frankliniella schultzei (Trybom), Thysanoplusia orichalcea* (Fabricius, 1775), *Aproaerema modicella* (Deventer, 1904, *Eocanthecona furcellata* (Wolff, 1811), *Cheilomenes sexmaculata* (Fabricius, 1781), *Coccinella transversalis* (Fabricius, 1781) and *Campoletis chlorideae* (Uchida, 1958) and *Spodoptera sp. Atherigona soccata* (Smith, 1797), *Chilo partellus* (Swinhoe, 1885), *Aphis sacchari* (Linnaeus, 1758), *Cheilomenes sexmaculata (Fabricius), Cheilomenes sexmaculata (Fabricius), Odontomantis planiceps* (Giglio, 1913), *Hirudula sp.* and *Micromus sp.* in *Rabi* sorghum.

Shannon weaver and Simpson's indices of general diversity were calculated and analysed for soil arthropod diversity. Among different farming systems, organic farming recorded the higher diversity index (H: 0.60 and D: 057) followed by conservation farming system T_1, T_3, T_2 and T_4 (H: 0.55 & D: 0.53, H: 0.52 & D: 0.50, H: 0.55 & D: 0.52, H: 0.50 & D: 0.52) and conventional farming system (H: 0.44 & D: 0.40) (Table 3). The stability of communities results in taxa richness which would be represented by those groups which adopt to organic management (Santigo *et al.*, 2009). Organic fields are rich in soil arthropods which are mainly due to high organic and nutrient content improving soil quality. Absence of chemicals, no or low levels of soil disturbance and eco friendly management techniques in organic fields which are completely or partially absent in conventionally managed fields, resulted in the build-up of beneficial arthropods (Nakhro and Dkhar, 2010) [11]. It may be due to non usage of chemical pesticides and fertilizers in organic farming and higher usage in conventional farming system which has deleterious effect on these organisms (Salavuddin, 2014) [12]. In conventional farming less population of soil arthropods was recorded. It may be due to intensive agriculture and excessive use of agrochemicals that might have resulted in an impoverished bio-life especially reduced arthropod diversity and density in agriculture ecosystem. Because of high input of chemical fertilizers and pesticides, a severe decline of biological diversity of insects has been observed (Letourneau and Goldstein, 2001) [9], and mechanical and chemical perturbations produced by conventional agricultural management practices and by particular abiotic soil conditions present in the intensively managed sites are found to be unfavourable for collembolans, pauropods and mites densities (Jose *et al.*, 2006a and Jose *et al.*, 2006b) [7, 8]. Land use pattern, irrigation, indiscriminate use of chemical agri-inputs, etc are the causes for reduction in diversity and density of insect communities.

Table 1: Diversity studies on beneficial insects in organic, conservation and conventional farming systems

Beneficial Insect	Soybean						Wheat						Groundnut						Sorghum						Overall pooled diversity	
Ecosystems	2016-17		2017-18		Pooled		2016-17		2017-18		Pooled		2016-17		2017-18		Pooled		2016-17		2017-18		Pooled			
	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D
Organic	0.57	0.32	0.53	0.39	0.55	0.36	0.26	0.18	0.28	0.79	0.27	0.48	0.56	0.48	0.54	0.35	0.55	0.42	0.37	0.22	0.45	0.29	0.41	0.25	0.45	0.38
Conservation T1	0.52	0.31	0.48	0.36	0.50	0.34	0.22	0.17	0.25	0.62	0.24	0.40	0.46	0.47	0.48	0.33	0.47	0.40	0.29	0.20	0.43	0.25	0.36	0.23	0.39	0.34
Conservation T2	0.54	0.31	0.47	0.35	0.51	0.33	0.24	0.17	0.23	0.62	0.24	0.39	0.48	0.49	0.48	0.34	0.48	0.41	0.22	0.21	0.42	0.23	0.32	0.22	0.38	0.34
Conservation T3	0.52	0.31	0.50	0.33	0.51	0.32	0.23	0.16	0.25	0.63	0.24	0.40	0.42	0.42	0.49	0.33	0.46	0.38	0.22	0.20	0.43	0.21	0.32	0.20	0.38	0.32
Conservation T4	0.54	0.54	0.51	0.34	0.53	0.44	0.22	0.16	0.24	0.64	0.23	0.40	0.40	0.45	0.41	0.33	0.40	0.39	0.27	0.21	0.44	0.24	0.36	0.22	0.38	0.36
Conventional	0.44	0.48	0.39	0.26	0.42	0.37	0.12	0.10	0.18	0.37	0.15	0.23	0.75	0.32	0.33	0.23	0.54	0.28	0.19	0.17	0.31	0.17	0.25	0.17	0.34	0.26

H: Shannon Wiener Index
D: Simpson Index Evenness
Conservation T_1: Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface.
Conservation T_2: Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues.
Conservation T_3: Conservation tillage with Flat bed with crop residues retained on the surface.
Conservation T_4: Conservation tillage with Flat bed with incorporation of crop residues.

Table 2: Diversity studies on insect communities in organic, conservation and conventional farming systems

Pest	Soybean						Wheat						Groundnut						Sorghum						Overall pooled diversity	
Ecosystems	2016-17		2017-18		Pooled		2016-17		2017-18		Pooled		2016-17		2017-18		Pooled		2016-17		2017-18		Pooled			
	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D
Organic	0.89	0.57	0.82	0.51	0.86	0.54	0.38	0.29	0.32	0.23	0.35	0.26	0.76	0.53	0.74	0.48	0.75	0.51	0.64	0.49	0.46	0.44	0.55	0.46	0.63	0.44
Conservation T1	0.77	0.52	0.73	0.49	0.75	0.51	0.33	0.27	0.28	0.21	0.31	0.24	0.74	0.48	0.72	0.42	0.73	0.45	0.59	0.42	0.43	0.42	0.51	0.42	0.58	0.41
Conservation T2	0.75	0.51	0.74	0.46	0.75	0.48	0.34	0.27	0.29	0.22	0.31	0.25	0.73	0.47	0.73	0.43	0.73	0.45	0.57	0.40	0.43	0.43	0.50	0.42	0.57	0.40
Conservation T3	0.76	0.53	0.76	0.45	0.76	0.49	0.32	0.26	0.27	0.21	0.30	0.23	0.72	0.49	0.73	0.44	0.73	0.47	0.58	0.42	0.45	0.43	0.52	0.43	0.57	0.40
Conservation T4	0.79	0.52	0.78	0.46	0.78	0.49	0.33	0.26	0.25	0.21	0.29	0.24	0.70	0.42	0.72	0.43	0.71	0.43	0.57	0.41	0.44	0.42	0.50	0.42	0.57	0.39
Conventional	0.62	0.44	0.64	0.42	0.63	0.43	0.22	0.21	0.13	0.15	0.17	0.18	0.54	0.39	0.59	0.31	0.56	0.35	0.32	0.38	0.31	0.39	0.32	0.38	0.42	0.33

H: Shannon Wiener Index
D: Simpson Index Evenness
Conservation T_1: Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface.
Conservation T_2: Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues.
Conservation T_3: Conservation tillage with Flat bed with crop residues retained on the surface.
Conservation T_4: Conservation tillage with Flat bed with incorporation of crop residues.

Table 3: Diversity studies on soil arthropods in organic, conservation and conventional farming systems

Natural Enemies	Soybean						Wheat						Groundnut						Sorghum						Overall pooled diversity	
Ecosystems	2016-17		2017-18		Pooled		2016-17		2017-18		Pooled		2016-17		2017-18		Pooled		2016-17		2017-18		Pooled			
	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D	H	D
Organic	0.62	0.54	0.64	0.52	0.63	0.53	0.58	0.54	0.60	0.64	0.59	0.59	0.60	0.55	0.54	0.53	0.57	0.54	0.62	0.56	0.59	0.64	0.61	0.60	0.60	0.57
Conservation T1	0.58	0.48	0.60	0.47	0.59	0.48	0.48	0.50	0.54	0.62	0.51	0.56	0.58	0.50	0.48	0.50	0.53	0.50	0.58	0.55	0.54	0.59	0.56	0.57	0.55	0.53
Conservation T2	0.54	0.44	0.58	0.47	0.56	0.46	0.47	0.51	0.51	0.62	0.49	0.56	0.58	0.48	0.48	0.52	0.53	0.50	0.50	0.54	0.50	0.62	0.50	0.58	0.52	0.52
Conservation T3	0.56	0.47	0.59	0.45	0.58	0.46	0.45	0.50	0.57	0.63	0.51	0.57	0.57	0.52	0.49	0.48	0.53	0.50	0.57	0.55	0.57	0.53	0.57	0.54	0.55	0.52
Conservation T4	0.52	0.46	0.54	0.49	0.53	0.48	0.45	0.48	0.52	0.60	0.49	0.54	0.54	0.47	0.41	0.55	0.47	0.51	0.52	0.50	0.51	0.60	0.52	0.55	0.50	0.52
Conventional	0.41	0.38	0.39	0.34	0.40	0.36	0.48	0.42	0.44	0.50	0.46	0.46	0.52	0.46	0.33	0.49	0.42	0.48	0.48	0.50	0.47	0.44	0.48	0.47	0.44	0.44

H: Shannon Wiener Index
D: Simpson Index Evenness
Conservation T_1: Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface.
Conservation T_2: Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues.
Conservation T_3: Conservation tillage with Flat bed with crop residues retained on the surface.
Conservation T_4: Conservation tillage with Flat bed with incorporation of crop residues.

Conclusion

The present study indicated that eco-friendly organic and conservation agriculture practices exhibit greater bio-diversity (both, species richness and evenness) than in farming systems characterized by heavy usage of fertilizers and pesticides.

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