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Comparative diversity of pests and their natural enemies in organic and conventional farming systems of tomato

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ABSTRACT: Comparative biodiversity of insects and mites was studied in organic and conventional farming systems (FS) of tomato at certified organic farming unit of ASPEE College of Horticulture and Forestry (ACHF) and conventional farm of N. M. College of Agriculture (NMCA), Navsari Agricultural University, Navsari, Gujarat during 2018 – 2020, respectively. Total 1016 insect and mite individuals belonging to 9 insect and 1 mite orders, 14 insect and 2 mite families of 20 species of insects and 2 mites were recorded at organic farm (FS) against 967 individuals belonging to 8 insect and 1 mite orders, 13 insect and 2 mite families containing 17 insect and 2 mite species at conventional farm (FS). The diversity of insect and mites was higher in organic as compared to conventional FS. Higher species richness (22), species abundance (1016), species evenness (J= 0.76), species richness index (R= 3.03) and Shannon diversity index (H= 2.36) was observed at organic FS against lower species richness (19), species abundance (967), species evenness (0.69), species richness index (2.62) and Shannon diversity index (2.04) in conventional FS. Insect order Hemiptera and mite order Acarina were more represented at conventional farm (49.63 and 30.50 %) as compared to organic farm (46.99 and 24.17 %). Insects of Coleoptera order were more abundant at organic FS as compared to conventional FS. Relative abundance of herbivores was higher (82.10 %) with lower species evenness (0.71), species richness (1.20) and Shannon diversity index (1.55) in conventional FS as compared to lower relative abundance (69.68 %) with higher species evenness (0.74), species richness (1.37) and Shannon diversity index (1.71) in organic tomato FS. Similarly, 288 insect and mite predators were recorded at organic farm as compared to 161 individuals of insect and mite predators in conventional tomato FS. The relative abundance of predators was higher (28.30 %) with higher species evenness (0.70), species richness (1.59) and Shannon diversity index (1.64) at organic farm whereas, relative abundance (16.55 %), species evenness (0.67), species richness (1.59) and Shannon diversity index (1.64) remained lower at conventional farm. Similarly, higher parasitoids (21), relative abundance (2.02 %), species evenness (0.96), species richness (0.37) and Shannon weiner index (0.67) was observed in organic FS as compared to conventional FS (15, 1.52, 0.91, 0.34 and 0.63). In the present investigation, no pollinators were observed in both the farming systems.

Keywords: Biodiversity, conventional farming system, herbivores, insect, mite, tomato organic farming system, parasitoids, predators.

INTRODUCTION

There are about 1.7 million species of plants and animals living on the earth. Of these, about 0.25 million are plants and the rest being animals and amongst these, nearly one million are insects. However, there are many that remain unidentified (Anonynous, 1992).

The Arthropoda, which includes insects, spiders, mites, and their relatives, is the most successful and diverse group of organisms on the planet. Insects alone account for nearly 55 per cent of all the species (Barrowclough, 1992). Agricultural ecosystems that are rich in biodiversity possess greater resilience and are, therefore, able to recover more readily from biotic and abiotic stresses such as drought, environmental degradation, pests, diseases, epidemics, among others (Wilsey & Polley, 2002; Wittebolle *et al*., 2009). The so-called "conventional" agricultural model was largely adopted after the green revolution. Its intensification and expansion represent a threat to global biodiversity because it causes homogenization of agricultural landscapes, habitat loss and reduction, and increased use of pesticides and synthetic chemical fertilizers (Bengtsson *et al.,* 2005). Thus, there is an increasing search for alternative crop systems based on ecological principles that would allow agriculture to benefit from biodiversity. Within this tendency, organic agriculture, which began around 1970s, became an alternative based in safer and sustainable principles for the environment and human societies (Anonymous, 2009).

Many studies in the recent past have suggested that organic farming enhances the biodiversity in agricultural landscapes as compared to conventional farming. Though organic system enhances species richness and abundance, its effects are likely to differ between organism groups and landscapes (Hole *et al.*, 2005; Bengtsson *et al.,* 2005). It has been established that "organic farming" can lead to higher populations and species diversity of predators, parasitoids as compared to conventional farming (Booij & Noorlander 1992; Gnanakumar *et al.,* 2012). A meta-analysis of biodiversity on organic versus conventional farms indicate 30 per cent higher species richness on organic farms. Positive effects of organic farming in the meta-analysis were measured for plants, arthropods, carabid beetles, predatory insects and birds (Bengtsson, *et al.,* 2005). A review of 76 studies on organic and conventional farms showed a positive effect of organic agriculture on species abundance and/or richness in 66 cases; 25 had neutral or mixed outcomes, and only eight showed a negative effect on biodiversity (Hole *et al.,* 2005) whereas, a majority of the studies showed an increase in abundance, richness or both, on organic compared to conventional farms.

Gujarat is the sixth largest state in India having 9.89 million hectares agricultural land contributing to 6.23 per cent of the total Indian agricultural land, of which 47775.62 ha. is organic. The major vegetable crops grown in south Gujarat are okra, tomato, brinjal, Indian bean. Amongst them, tomato (*Lycopersicon esculentum* Mill.) is grown in almost every district of south Gujarat (Anonymous, 2014). Butani and Verma (1976) listed as many as 16 species of insect and non-insect pests infesting tomato crop from germination to harvesting stage. Amongst them, tomato fruit borer, *Helicoverpa armigera* (Hub.), jassid, *Amrasca biguttula biguttula* (Ishida) and *Empoasca punjabensis* (Pruthi), tobacco caterpillar, *Spodoptera litura* (Fab.), thrips, *Thrips tabaci* (Linn.), aphids, *Aphis gossypii* (Glover), *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulzer), whitefly, *Bemisia tabaci* (Genn.) and epilachna beetle, *Epilachna dodecastigma* (Wiedemann), etc. occur regularly. Fruit borer, *H. armigera* is the most destructive insect pest causing considerable losses in quantity as well as quality of tomato fruits (Tiwari and Krishnamoorthy, 1984; Reddy and Zehr, 2004). Srinivas and Sushil Kumar (2025) recorded incidence of fruit borer, whitefly and red spider mite in both the farming systems (organic and conventional) of tomato cv. GT-2. The incidence of these pests was higher in the late stages of the crop.

Aleksandar Ivezic *et al*. (2025) revealed that conventional reliance on chemical pesticides as the primary pest control method has led to various adverse outcomes, impacting pest management effectiveness and reducing product quality. Information on diversity of insects and mites in a particular farming system is a pre-requisite, which helps in designing a successful pest management strategy. However, no systematic efforts have been made to study the diversity of insects and mites in both conventional and organic farming systems of tomato in south Gujarat.

Therefore, the study on comparative biodiversity of insects and mites in organic and conventional farming systems of tomato was undertaken at Navsari Agricultural University, Navsari, Gujarat during 2018-2020.

MATERIALS AND METHODS

Studies on comparative biodiversity of insects and mites in organic and conventional farming systems of tomato were carried out under field conditions at certified organic farming unit of ASPEE College of Horticulture and Forestry and conventional farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India during 2018-2020 with tomato cv. GT-2.

Sampling Procedure

Insects and mite pests on tomato were collected at fortnightly interval on 25 randomly selected plants (5 plants/spot in "W" shape) of middle rows, leaving the border row plants in both the farming systems by visual observation and plant inspection method as suggested by Southwood, 1978. The above ground insect species were trapped in sweep nets (32 cm dia. and 70 cm long) and were monitored. Five sweeps were done and fortnightly data (average of two standard weeks) (Table 1) on the number of individuals of each species obtained by net sweeping was used to formulate the biodiversity of insects.

Observations on pollinators were made using Ad-libitum sampling of flower visitors for a sampling time of ten minutes with a time interval of 60 min. However, no pollinator was identified in both the farming systems of tomato in this investigation. The population of sucking pests were visually recorded on 3 leaves (top, middle and bottom leaves).

The insects collected by various methods were brought to the laboratory and killed by placing a small cotton swab dipped in ethyl acetate inside the polythene bags. The identification of the collected specimens from both the farming systems was confirmed taxonomically. The data were used to calculate species abundance, species richness, evenness; Shannon-Weaver diversity index (often called Shannon-Weiner index) for each taxonomic order in both organic and conventional fields and then biodiversity was compared between the two farming-based ecosystems.

Statistical Analysis

PAST software was used to calculate the diversity indices.

Species Diversity: Shannon and Wiener diversity index (H') is the most popular and widely used index in community ecology. It is the average degree of 'uncertainty' and if this average 'uncertainty' increases as the number of species increase, distribution of individuals among the species also become even. Insect and mite diversity in both the farming systems were assessed using Shannon-Weaver diversity formula and is as under:

$$\mathbf{H = \Sigma\, p_i \log_2 p_i} \quad \text{.............. (Shannon – Weiner, 1963)}$$

Where, H = Diversity index

$P_i = n_i / N$

P_i= Proportion of individuals of i^{th} species.

n_i = Number of individuals of each species in the sample.

N = Total number of individuals of all species in the sample.

Species Evenness: How equally abundant the species are. There are many measures of evenness proposed. One of the most common approaches has been to scale one of the heterogeneity measures such as the Shannon-Weaver diversity measure, relative to its maximum theoretical value when each species in the sample was represented by the same number of individuals.

$$J = \frac{H}{\log \lambda S} \quad \text{................................ (Pielou, 1969)}$$

Where, 'H' is the Shannon-Weaver diversity and 'S' is the number of species in the community.

Species Richness: In order to assess how the diversity of the population is distributed or organised among the particular species, this index was calculated.

$$R = \frac{S-1}{\log \lambda N} \quad \text{............................ (Margalef, 1958)}$$

Where, 'S' is the total number of species collected and 'N' is the total number of individuals in all the species.

Relative Abundance: The relative abundance of different species was calculated in terms of percentage.

% Relative abundance (RA) =n/N*100

Where, n = Total number of individuals of species 'a'

N = Total number of individuals of all species.

Pest wise observational methodology in organic and conventional farming systems

Tomato

Twenty-five randomly selected plants in 5 spots. Five plants/spot in "W" shape in both organic and conventional farming systems.

Fruit borer, *H. armigera* and Fruit damage

During vegetative stage of the crop, number of fruit borer larvae was counted on 25 randomly selected plants in each farming systems. During fruiting stage, *H. armigera* was considered as a fruit borer. Therefore, at every picking, damaged and healthy marketable fruits were sampled from 25 selected plants of each farming systems and their numbers were counted. Percent fruit infestation was worked out using the formula (Rahman *et al.,* 2009).

$$\text{Percent Fruit infestation} = \frac{\text{Number of damaged Fruits}}{\text{Total no. of healthy fruits}} \times 100$$

Sucking pests

Observations on whitefly, *B. tabaci* population were counted from three (top, middle and bottom) leaves whereas; Red spider mite, *T. urticae* population was recorded from the same leaves of 2 cm^2 area on randomly selected 25 plants from each farming systems. The counts were continued from transplanting to harvest of the crop.

RESULTS AND DISCUSSION

The present investigation based on **"Comparative biodiversity of insects and mites in organic and conventional farming systems of tomato"** was undertaken in two different farming systems of tomato

Table 1. Details of standard week and crop stages of tomato during the study period at organic and conventional systems during 2018 - 20

Sr. No.	SMW	Standard Period	Crop Stage (Tomato)
1	50	10 Dec - 16 Dec	Vegetative Stage
2	51	17 Dec - 23 Dec	Vegetative Stage
3	52	24 Dec - 31 Dec	Vegetative Stage
4	1	01 Jan - 07 Jan	Vegetative Stage
5	2	08 Jan - 14 Jan	Flowering Stage
6	3	15 Jan - 21 Jan	Flowering Stage
7	4	22 Jan - 28 Jan	Flowering Stage
8	5	29 Jan - 04 Feb	Fruiting Stage
9	6	05 Feb - 11 Feb	Fruiting Stage
10	7	12 Feb - 18 Feb	Fruiting Stage
11	8	19 Feb - 25 Feb	Fruiting Stage
12	9	26 Feb - 04 Mar	Fruiting Stage
13	10	05 Mar - 11 Mar	Fruiting Stage

SMW- Standard Meteorological Week

i.e. Certified Organic Farming Unit, ASPEE College of Horticulture and Forestry (organic FS) and Conventional farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (conventional FS) for a period of two years from 2018 to 2020. Year wise observations were recorded in both the farming systems of tomato cv. GT-2. The major aspects such as species richness, abundance, relative abundance and diversity indices have been studied in the designated crop and compared for both the farming systems and the results obtained are presented hereunder:

Insect and mite diversity at organic and conventional farming systems of tomato during 2018-20

In the present investigation, total number of 1016 insect and mite individuals belonging to 9 insect and 1 mite orders, 14 insect and 2 mite families comprising of 20 insect and 2 mite species were recorded in organic farming system (FS) of tomato while, 967 individuals belonging to 8 insect and 1 mite orders, 13 insect and 2 mite families representing 17 insect and 2 mite species were observed in conventional FS. The diversity of insect and mites was higher in organic FS as compared to conventional FS. Higher species richness (S=22), species abundance (N=1016), species evenness (J= 0.76), species richness index (R= 3.03) and shannon diversity index (H= 2.36) were observed at organic FS in comparison to lower species richness (19), species abundance (967), species evenness (0.69), species richness index (2.62) and shannon diversity index (2.04) at conventional tomato FS (Table 2).

Similar observations were made by Bengtsson *et al.* (2005), Hole *et al*. (2005), Barros *et al.* (2018) who collected a total of 56,955 insects from 25 families from the organic tomato system and 10,660 from 22 families in the conventional tomato FS. They further recorded significantly higher insect diversity and relative abundance (AR) in organic tomato FS as compared to conventional FS. The average diversity indices were as follows: For the organic system: Shannon- Wiener, 2.97; Simpson, 0.79; Simpson Dominance, 0.19; Margalef, 5.13; and Pielou, 2.27, respectively. For the conventional system, the indices were 3.49; 0.86; 0.12; 6.93; and 2.56; respectively. Youngberg *et al*. (1984) have compared the biodiversity of natural enemies and phytophagous insects between organic and chemical farming systems in the Sacramento Valley. They found higher richness (61 species) in organic samples as compared to chemical field samples (35 species) which supports the current investigation.

Table 2. Insect and mite diversity in organic and conventional farming systems of tomato

Sr. No.	Order	Family	Scientific name	2018-19		2019-20		Pooled (2018-20)	
				Organic	Conventional	Organic	Conventional	Organic	Conventional
1	Hemiptera	Pentatomidae	*Nezara viridula*	10	7	8	5	9	6
			Eucanthecona furcellata	7	0	3	0	5	0
			Geocoris tricolor	8	6	4	3	6	5
		Miridae	*Dicyphus hesperus*	147	102	139	87	143	95
		Aleyurodidae	*Bemisia tabaci*	129	161	134	153	132	157
		Aphididae	*Myzus persicae*	176	227	183	203	180	215
2	Lepidoptera	Noctuidae	*Helicoverpa armigera*	39	20	33	17	36	19
			Spodoptera litura	16	10	16	10	16	10
			Otheris materna	4	3	7	3	6	3
3	Coleoptera	Coccinellidae	*Harmonia octomaculata*	12	0	4	0	8	0
			Cheilomenes sexmaculata	42	13	46	17	44	15
			Coccinella transversalis	34	15	26	19	30	17
4	Diptera	Agromyzidae	*Liriomyza trifoli*	25	18	16	11	21	15
		Syrphidae	*Ischidon scutellaris*	10	6	7	4	9	5
		Tachinidae	*Carcelia* sp.	15	9	12	9	14	9
5	Hymenoptera	Braconidae	*Apanteles* sp.	8	5	6	6	7	6
6	Orthoptera	Acrididae	*Cyrtacanthacris tatarica*	3	0	1	0	2	0
7	Mantodea	Mantidae	*Mantis religiosa*	5	3	2	2	4	3
8	Neuroptera	Chrysopidae	*Chrysoperla zastrowii*	33	14	25	11	29	13
9	Thysanoptera	Thripidae	*Thrips tabaci*	69	76	68	83	69	80
10	Acarina	Tetranychidae	*Tertanychus urticae*	260	308	211	263	236	286
		Phytoseiidae	*Amblyseius orientalis*	10	8	9	8	10	8
			No. of species (S)	22	19	22	19	22	19
			No. of Families	16	15	16	15	16	15
			No. of Orders	10	9	10	9	10	9
			N	1062*	1011*	960*	914*	1016*	967*
			J	0.77	0.69	0.75	0.69	0.76	0.69
			R	3.01	2.60	3.06	2.64	3.03	2.62
			H	2.38	2.03	2.31	2.04	2.36	2.04

S- No. of species, N- Total no. of individuals in all species, J- Species evenness, R- Species Richness, H- Shannon-Wiener index *Number of insects per 300 plants and 12 sampling dates, mites recorded on 2cm^2 leaf area

Rundlof and Smith (2006) studied the effect of farming practice on insect species richness and abundance on organic and chemical farms in homogeneous and heterogeneous landscape diversity. They found that organic farming and landscape heterogeneity significantly increased insect species richness and abundance. Maria *et al.* (2014) revealed that species richness and abundance were significantly higher in organic crops and insects were thirty-four per cent more abundant on organic crops compared to conventionally grown crops. Comparing studies at different landscape scales (plot, farm, and landscape matrix), organic crops had a positive effect, with greatest effect at the plot level which supports the present findings.

During the study period, the relative abundance of individual phytophagous insect and mite species (herbivores) were found higher in both organic and conventional tomato farming systems. However, relative abundance of natural enemies (predators and parasitoids) was higher in organic tomato farming system as compared to conventional farming system. The present findings are more or less similar with Drinkwater *et al.* (1995) reported that abundance of arthropod herbivores was similar in organic and conventional tomato farms whereas patterns of species richness and abundance of predators and parasitoids were significantly different in organic and conventional farms. Species richness of predators and parasitoids was more than 75 per cent greater, and natural enemies were 80 per cent more abundant, on organic tomato farms than on conventional farms.

The relative abundance of aphid, *M. persicae* (17.82 and 22.37 %), phytophagous mite, *T. urticae* (23.23 and 29.67 %), whitefly, *B. tabaci* (13.05 and 16.36 %) and thrips, *T. tabaci* (6.79 and 8.31 %) was higher in organic than conventional tomato FS. Likewise, relative abundance of natural enemies like ladybird beetle *C. sexmaculata* (4.37 and 1.58 %), *C. transversalis* (2.95 and 1.78 %) and mirid bug, *D. hesperus* (14.16 and 9.82 %) were higher at organic farms as compared to conventional tomato FS (Table 3).

This finding is very well in line with the result of a similar study conducted by Yardim and Edwards (2003) who also reported that predatory anthocorids were higher on tomato plants with high aphid populations in the organic than in the conventional plots. They concluded that increased natural enemy population might be due to presence of nontoxic environment and in turn resulted in faster multiplication rate.

In the present investigation, insects of order Hemiptera were relatively more abundant followed by mite order Acarina and insect order Thysanoptera at conventional farm (49.63, 30.50 and 8.31 %) as compared to organic farm (46.99, 24.17 and 6.79 %). However, insects of order Coleoptera (8.10 and 3.36 %) and Lepidoptera (5.69 and 3.28 %), were relatively more abundant at organic farm as compared to conventional farm, respectively followed by Diptera, Neuroptera, Hymenoptera and Mantodea. On the other hand, insects of order Orthoptera were not recorded at conventional tomato farm which might be due to absence of weed flora around the field and ill effects of pesticide spray (Table 4).

Table 3. Relative abundance (%) of insects and mites in organic and conventional farming systems of tomato

Sr. No.	Order	Family	Scientific name	2018-19		2019-20		Pooled (2018-20)	
				Organic	Conventional	Organic	Conventional	Organic	Conventional
1	Hemiptera	Pentatomidae	*Nezara viridula*	0.94	0.69	0.83	0.55	0.89	0.62
			Eucanthecona furcellata	0.66	0.00	0.31	0.00	0.49	0.00
			Geocoris tricolor	0.75	0.59	0.42	0.33	0.58	0.46
		Miridae	*Dicyphus hesperus*	13.84	10.09	14.48	9.55	14.16	9.82
		Aleyurodidae	*Bemisia tabaci*	12.15	15.92	13.96	16.79	13.05	16.36
		Aphididae	*Myzus persicae*	16.57	22.45	19.06	22.28	17.82	22.37
2	Lepidoptera	Noctuidae	*Helicoverpa armigera*	3.67	1.98	3.44	1.87	3.55	1.92
			Spodoptera litura	1.51	0.99	1.67	1.10	1.59	1.04
			Otheris materna	0.38	0.30	0.73	0.33	0.55	0.31
3	Coleoptera	Coccinellidae	*Harmonia octomaculata*	1.13	0.00	0.42	0.00	0.77	0.00
			Cheilomenes sexmaculata	3.95	1.29	4.79	1.87	4.37	1.58
			Coccinella transversalis	3.20	1.48	2.71	2.09	2.95	1.78
4	Diptera	Agromyzidae	*Liriomyza trifoli*	2.35	1.78	1.67	1.21	2.01	1.49
		Syrphidae	*Ischidon scutellaris*	0.94	0.59	0.73	0.44	0.84	0.52
		Tachinidae	*Carcelia* sp.	1.41	0.89	1.25	0.99	1.33	0.94
5	Hymenoptera	Braconidae	*Apanteles* sp.	0.75	0.49	0.63	0.66	0.69	0.58
6	Orthoptera	Acrididae	*Cyrtacanthacris tatarica*	0.28	0.00	0.10	0.00	0.19	0.00
7	Mantodea	Mantidae	*Mantis religiosa*	0.47	0.30	0.21	0.22	0.34	0.26
8	Neuroptera	Chrysopidae	*Chrysoperla zastrowii*	3.11	1.38	2.60	1.21	2.86	1.30
9	Thysanoptera	Thripidae	*Thrips tabaci*	6.50	7.52	7.08	9.11	6.79	8.31
10	Acarina	Tetranychidae	*Tertanychus urticae*	24.48	30.46	21.98	28.87	23.23	29.67
		Phytoseiidae	*Amblyseius orientalis*	0.94	0.79	0.94	0.88	0.94	0.83
		Total		**100**	**100**	**100**	**100**	**100**	**100**

Table 4. Relative abundance (%) of insect and mite orders in organic and conventional tomato farming systems

Order	2018-19		2019-20		Pooled (2018-20)	
	ORG	CONV	ORG	CONV	ORG	CONV
Hemiptera	44.92	49.75	49.06	48.06	46.99	49.63
Orthoptera	0.28	0	0.10	0	0.19	0
Mantodea	0.47	0.30	0.21	0.22	0.34	0.26
Coleoptera	8.29	2.27	7.92	3.95	8.10	3.36
Hymenoptera	0.75	0.49	0.63	0.66	0.69	0.58
Thysanoptera	6.50	7.52	7.08	9.11	6.79	8.31
Lepidoptera	5.56	3.26	5.83	3.29	5.69	3.28
Diptera	4.71	3.26	3.65	2.63	4.18	2.95
Neuroptera	3.11	1.38	2.60	1.21	2.86	1.30
Acarina	25.42	31.26	22.92	29.75	24.17	30.50

In the present investigation, species abundance and relative abundance of herbivores was higher in conventional FS (791 and 82.10%) as compared to organic farming system FS (707 and 69.68 %) (Table 5). However, species abundance and relative abundance of predators and parasitoids was higher in organic farm (N= 288 and 21) (RA= 28.30 and 2.02 %) as compared to conventional tomato FS (N= 161 and 15) (RA = 16.55 and 1.52%) (Table 6,7). The results of Culliney and Pimentel (1986) and Dialoke *et al.* (2013) where phytophagous insect populations were lower in organic farms than chemical fertilizer applied field supports the present findings.

Letourneau and Goldstein (2001) reported that arthropod damage to leaves and fruit was similar in commercial tomatoes produced under organic and conventional management. However, higher abundance of natural enemies and greater species richness of all functional arthropod groups was observed in organic systems than conventional farming system. Scarlato *et al*. (2023) indicated that organic farms had yields comparable to conventional farms, a lower abundance of pests, less pest injury, and a higher abundance of natural enemies. The cumulative pest: natural enemies ratio was 9 for organic and 38 for conventional management. In the present study, the abundance (N=791) and relative abundance (82.10 %) of herbivores was higher with lower species evenness (J= 0.71), species richness (R= 1.20) and Shannon diversity index (H= 1.55) at conventional farm while, it was lower abundance (707) and relative abundance of herbivores (69.68 %) with higher species evenness

Similarly, 288 insect and mite predators comprising of 9 insect predator species and 1 predatory mite species were recorded at organic farm as compared to 161 individuals comprising of 7 insect and 1 mite predator species at conventional farm. The relative abundance of predators was higher (28.30 %) with higher species evenness (J= 0.70), species richness (R= 1.59) and Shannon diversity index (1.64) at organic tomato farm while, lower relative abundance (16.55 %) with lower species evenness (J= 0.67), species richness (R= 1.38) and Shannon diversity index (H= 1.39) were assessed at conventional tomato farm (Table 6).

Crowder *et al.* (2010) reported higher activity of natural enemies in organic tomato farming systems which can be attributed to reduced use of broad-spectrum pesticides. Sean Clark (2001) also recorded greater predator abundance and species richness in organic tomato compared to conventional farming system. In the present investigation, species abundance and relative abundance of parasitoids were higher in organic as compared to conventional tomato FS. Higher species abundance (21), relative abundance (2.02 %), species evenness (0.96), species richness (0.37) and Shannon diversity index (0.67) were observed in organic tomato as compared to lower species abundance (15), relative abundance

Table 5. Species abundance, relative abundance and diversity indices for herbivores in organic and conventional tomato farming systems

Taxon	Herbivores					
	2018-19		2019-20		Pooled (2018-20)	
	ORG	CONV	ORG	CONV	ORG	CONV
S	10	9	10	9	10	9
N	731	830	677	748	707	791
RA (%)	68.83	82.10	70.52	82.11	69.68	82.10
J	0.74	0.70	0.74	0.71	0.74	0.71
R	1.37	1.19	1.38	1.21	1.37	1.20
H	1.71	1.55	1.70	1.55	1.71	1.55

ORG: Organic Farming System   CONV: Conventional Farming System
S- No. of species, N- Total no. of individuals in all species, RA- Relative abundance,
J- Species evenness, R- Species Richness, H- Shannon-Wiener index

(J= 0.74), species richness (1.37) and Shannon diversity index (H= 1.71) at organic tomato farm (Table 5).

(1.52 %), species evenness (0.91), species richness (0.34) and Shannon diversity index (0.63) of parasitoids at conventional tomato farming systems. The lower Shannon diversity values indicate very low parasitoid diversity in both organic and conventional tomato FS (7)(Table 7). This finding is very well in line with the results of a similar study conducted by Anbalagan *et al.* (2015), Gnanakumar *et al.* (2012) who also compared species diversity and richness of hymenopteran egg parasitoids between organic and conventional paddy ecosystems. They recorded higher Simpson's diversity index (H= 0.978) in organic ecosystem as compared to conventional paddy ecosystem (H= 0.878).

Berry *et al.* (2010) recorded significantly higher Hymenopteran parasitoids (9/0.1m^2 area), Staphylinidae (Coleoptera) (2/0.1m^2 area) and Hemerobiidae (Neuroptera) (1.5 /0.1m^2 area) in organic carrot crop as compared to conventional fields in New Zealand. Species richness, abundance and relative abundance of predators and parasitoids were higher in organic tomato systems as compared to conventional farm. Similar observations were reported by Reddy and Giraddi (2019) and Mazzei *et al.* (2021) who found greater insect diversity in organic and conservation crop blocks as compared to conventional system. Subhash Singh (2020) revealed that the organic farming system had an holistic approach in performing better than the conventional farming system with advantages like no chemicals, safety to human and animal health, species richness, abundance of insect predators and the pollinators.

Summarizing the entire study on insect and mite biodiversity in organic and conventional farming systems of tomato, it is evident that higher species richness, species abundance, species evenness and shannon diversity indices were recorded in organic farming systems as compared to conventional farming system. It has also been proved that organic farming practices can help in the population build-up of natural enemies like predators and parasitoids in tomato. The relative abundance of herbivores (phytophagous insects and mites) was lower in organic farming systems. So, it may be concluded that organic farming practices may encourage diversity of natural enemies and may not be favourable for pests. Additionally, the organic farming system methods promote the conservation of species of arthropods in all functional groups, which increases the abundance of natural enemies, compared to the conventional farming system. Bengtsson *et al.* (2005) in a meta-analysis on organic versus conventional farms reported a thirty per cent higher biodiversity on organic farms. Positive effects of organic farming in the meta-analysis were measured for plants, arthropods, carabid beetles, other predatory insects, and birds, but not for non-predatory arthropods or soil microorganisms.

Table 6. Species abundance, relative abundance and diversity indices for predators in organic and conventional tomato farming systems

Taxon	Predators					
	2018-19		2019-20		Pooled (2018-20)	
	ORG	CONV	ORG	CONV	ORG	CONV
S	10	8	10	8	10	8
N	308	167	265	151	288	161
RA (%)	29.00	16.52	27.60	16.58	28.30	16.55
J	0.74	0.66	0.66	0.67	0.70	0.67
R	1.57	1.37	1.61	1.40	1.59	1.38
H	1.70	1.38	1.52	1.40	1.64	1.39

Table 7. Species abundance, relative abundance and diversity indices for parasitoids in organic and conventional tomato farming systems

Taxon	Parasitoids					
	2018-19		2019-20		Pooled (2018-20)	
	ORG	CONV	ORG	CONV	ORG	CONV
S	2	2	2	2	2	2
N	23	14	18	15	21	15
RA (%)	2.17	1.38	1.88	1.65	2.02	1.52
J	0.93	0.89	0.98	0.92	0.96	0.91
R	0.36	0.32	0.37	0.35	0.37	0.34
H	0.65	0.62	0.68	0.64	0.67	0.63

ORG: Organic Farming System   CONV: Conventional Farming System
S- No. of species, N- Total no. of individuals in all species, RA- Relative abundance,
J- Species evenness, R- Species Richness, H- Shannon-Wiener index

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