Uttar Pradesh Journal of Zoology

Volume 45, Issue 18, Page 140-147, 2024; Article no.UPJOZ.4044
ISSN: 0256-971X (P)

Evaluating Hymenopteran Parasitoid Communities Across Varied Organic Rice Cultivation Practices

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i184432

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/4044

Original research Article

Received: 25/06/2024
Accepted: 31/08/2024
Published: 03/09/2024

ABSTRACT

The abundance and biodiversity of parasitoids are important parameters in organic rice's natural regulation of insect pests. The present study was carried out in the fields of the Indian Institute of Rice Research, Rajendranagar in *rabi* 2020 to know the impact of various treatments (*Trichoderma*, *Pseudomonas*, farmer's practice, organic rice without seed treatments, and untreated control) on the abundance and diversity of Hymenopteran parasitoids. Various methods such as visual count, sweep net, yellow pan traps, and yellow sticky traps were used to collect the parasitoids at 30,45, 60, 90, and 120 DAT of rice across all the treatments. It was revealed that a count of total 12,573 parasitoids collected, the contribution of Eulophidae was higher (64.33 percent) followed by Scelionidae (13.92 percent) and Trichogrammatidae (11.38 percent). *Pseudomonas* treatment

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***Cite as:** Chaitanya, M., K. R. Mahendra, and G. Anitha. 2024. "Evaluating Hymenopteran Parasitoid Communities Across Varied Organic Rice Cultivation Practices". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (18):140-47. https://doi.org/10.56557/upjoz/2024/v45i184432.*

supported the higher abundance (25%) and density of parasitoids (3.81 per sq. m) while *Trichoderma* recorded a higher diversity of parasitoids with the highest Shannon - Wiener diversity index (H´= 1.11) and lower Simpson diversity index (D= 0.46). Yellow sticky traps and yellow pan traps were found as effective methods for the collection of Hymenopteran parasitoids. The higher abundance and diversity of parasitoids in organic treatments indicated the impact of organic amendments and bioagents in supporting the biodiversity of the rice ecosystem.

Keywords: Parasitoids; Trichoderma; Pseudomonas; organic rice; diversity indices.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is a major food crop of the world. Its cultivation has been carried out in all regions with warm and abundant moisture weather conditions, mainly in the subtropical regions. It is grown in more than a hundred countries, with India's estimated rice production of over 135 million metric tons in 2023 [1]. Conventional rice cultivation has often accomplished high yields and stable crop production but has been heavily dependent on continuous and excessive inputs of chemical pesticides, which lead to pest resistance, resurgence, pesticide residue, groundwater contamination, and risk to human health and animal habitats [2,3]. The ecological intensification through organic farming is known to have an influence on plant communities and the diversity of insects associated with them signifying the conservation of these natural enemies for a sustainable system of rice insect pest management [4]. It is an environmentally safe and efficient means of reducing pests using natural enemies and naturally available pathogens. The natural enemy is an effective population regulator because it is density-dependent, if there is an increase in the pest insect population, it will be followed by an increase in the natural enemy population (numerical response) and functional response, i.e., increase in feeding power [5].

An important principle of organic farming is to maximize natural control and therefore, temporal changes in arthropod abundance, diversity, species richness, and community structures are important considerations in designing pest management strategies. Organic farming and biodiversity conservation work hand in hand to ensure natural pest suppression. The diversity of Hymenopteran natural enemies has a high impact on stability in the rice ecosystem in maintaining ecological balance. The impact of organic inputs as a part of biointensive pest management practices which include the use of *Trichoderma*, *Pseudomonas*, vermicompost, farm yard manure, rice husk, and neem cake on arthropod communities in rice crop has hardly been worked upon. With this point of view, the present study was conducted to study the abundance and diversity of pests and natural enemies belonging to Hymenoptera in different regimes of organic rice cultivation and compare it with farmers' practices and untreated control.

2. MATERIALS AND METHODS

The experiment was carried out in *rabi* 2020 in plots of 900 sq. m. for each treatment in the fields of the Indian Institute of Rice Research, Rajendranagar by using a variety BPT 5204 (Samba Mahsuri). The main field was transplanted with 25-day-old seedlings at a spacing of 20 × 10 cm. Treatments consisted of five regimes of organic amendments as below: - A) BIPM Organic rice treatment with *Trichoderma* (seed treatment and soil application), in nursery, seeds treated with *Trichoderma* @ 10g per kg seed was sown and rice husk @ 5kg per nursery bed of 8-10 sq. m + vermicompost @ 5kg per nursery bed of 8-10 sq. m was applied. In the main field: soil application with *Trichoderma* @ 10kg per ha at 30,60 and 90 DAT; Neem cake @ 80kg per acre + FYM @ 6 tons per acre was carried out. B) BIPM Organic rice with Pseudomonas (seed treatment and sprays): In nursery: Seed treatment with *Pseudomonas* @ 10g per kg seed; rice husk @ 5kg per nursery bed of 8-10 sq. m + vermicompost @ 5kg per nursery bed of 8-10 sq. m was done, In main field, spraying of *Pseudomonas* -10g per liter at 30,60 and 90 DAT; Neem cake @ 80kg per acre + FYM @ 6 tons per acre was carried out. C) Farmer's Practices: In the nursery, Carbofuran 3 G granules @ 200g percent bed were applied, In main field: Foliar sprays with Cartap Hydrochloride @ 2g per liter when YSB or Leaf folder cross ETL, Spray of Chlorpyriphos @ 2.5 ml per liter for Hispa beetle was carried out. D) Organic rice without seed treatment: The nursery was applied with rice husk @ 5kg per nursery bed of 8-10 sq. m + vermicompost @ 5kg per nursery bed of 8-10 sq. m. The main field was supplied with Neem cake @ 80kg per acre + FYM@ 6 tons per acre. E) Untreated control – without any amendments in the nursery and main field.

Collection of Hymenopteran natural enemies was done in the treatments at 30,45, 60, 90, and 120 days after transplanting (DAT) between 7.00 a.m. and 9.00 a.m. through different methods of collection viz., visual counts and collection, yellow pan traps, sweep net and yellow sticky traps. After collection, insects were segregated into families using keys [6]. The number of individual counts in each family was recorded and used to work out the following diversity indices using an online bpmsg diversity calculator [7].

A) Shannon-Wiener Diversity Index of diversity or species diversity (H')
B) Simpson's Diversity Index (D)
C) True diversity (Effective no. of species) and
D) The density of the beneficials i.e., the number of insects per sq. m. area was worked out.

Statistical analysis of data: One-way ANOVA was performed to test the significance of differences among the treatments within the families of Hymenoptera using WASP software.

3. RESULTS AND DISCUSSION

Abundance of parasitoids collected in different methods in various organic rice regimes: A total of 12,573 Hymenopteran parasitoids were collected using different methods and the order of abundance of parasitoids was Eulophidae (8088) > Scelionidae (1750) > Trichogrammatidae (1432) > Mymaridae (1041) > Diapriidae (83) > Ichneumonidae (47) > Braconidae (35) > Dryinidae (26) > Platygastridae (22) > Chalcididae (15) > Torymidae (13) > Ceraphronidae (7) > Formicidae (6) > Eurytomidae (3) > Bethylidae (1) = Cynipidae (1). A total of 45 parasitoids were recorded in the visual count belonging to families Ichneumonidae and Dryinidae, but no significant differences were observed among the treatments (Table 1). However, in yellow pan traps a total of 730 parasitoids were trapped which belong to 15 families of which Eulophidae, Scelionidae, Trichogrammatidae, Mymaridae, Diapriidae and Ceraphronidae have differed significantly among different organic regimes. Eulophidae was the most abundant family in the rice regime treated with *Pseudomonas* and *Trichoderma* (Table 2). Further, 37 parasitoids of 4 families were caught in the sweep net of which Ichneumonidae differed significantly among treatments but was absent in farmer's practice (Table 3).

A total of 11,761 individuals of parasitoids were trapped in yellow sticky traps. They belonged to 6 families of Hymenoptera *viz*., Eulophidae, Scelionidae, Trichogrammatidae, Mymaridae, Ichneumonidae, and Braconidae, but the abundance of Scelionidae and Mymaridae was found to differ significantly among regimes, but highest mean abundance was recorded in *Pseudomonas* treatment (Table 4). Finally, the overall abundance of parasitoids was highest in *Pseudomonas* treatment (25%) (Fig. 1). However, when different methods of collection were evaluated for the collection of parasitoids, the yellow sticky traps (93.54%) followed by yellow pan traps (5.81%) and visual count (0.36%) were found effective (Fig. 2). Similar findings were reported in studies by [8,9,10].

Additionally, the percent contribution of individual families to the overall abundance of parasitoids followed the order of Eulophidae (64.33 percent) >Scelionidae (13.92 percent) >Trichogrammatidae (11.38 percent) (Fig. 3). Like our findings, Lakshman and colleagues [11] recorded 5 species of parasitoids belonging to order Hymenoptera during a survey in insecticide-free rice fields. In the same way, *Ischnojoppaluteator* (Fabricius), *Xanthopimpla punctuate* (Fabricius), *Xanthopimpla* sp. (larval and pupal parasitoid of leaf folder) *Charops bicolor* (Szepligeti) *(Ichneumonidae)* (larval parasitoid of skipper) *and Stenobracon nicevillei* (Bingham) and *Apanteles sp.* (Braconidae) were the Hymenopterans recorded [12]. Parasitoids are considered to be of major component in food webs in rice ecosystem and are useful in indicating the complexity of trophic relationships in pest/natural enemy system [11]. Further, the abundance of natural enemies in organically as well as conventionally (chemical control) grown aromatic rice was studied. A total of 9 parasitoid species were recorded of which 3 were egg parasitoids, 3 were larval parasitoids, and 3 were pupal parasitoids. However, natural parasitism by these parasitoids was significantly higher in organic than conventional rice. *T. chilonis* in the eggs of stem borer was significantly higher organic (5.96 percent) as compared to conventional (1.75 percent) [4]. Likewise, in a study, of 377 species of Hymenopterans, only 6 percent (22 Nos.) were represented by Aculeata and 94 percent (355 Nos.) were parasitica. These parasitoids fell under 206 genera belonging to 11 super families and 28 families [13]. Further, the most abundant families in rice crop were Platygastridae, Mymaridae, Encyrtidae, Eulophidae and Trichogrammatidae. Parasitoid average abundance was significantly higher in organically managed rice (25.38 ± 6.85) than in conventionally managed areas (8.41 ± 3.40) [14].

Diversity of parasitoids in various organic rice regimes: In the present study, among various treatments, the Shannon – Wiener diversity index (H´) was highest for *Trichoderma* treatment (1.11) followed by farmers' practice (1.02), while untreated control had the least parasitoid (0.96). Simpson Index recorded was highest in Untreated control and Organic rice without seed treatment (0.56 each) followed by *Pseudomonas* treatment (0.53). However, the True diversity of Farmers' practice was highest (2.8) and was moderate in organic rice without seed treatment (2.7) and *Pseudomonas* treatment (2.7) and was least in the *Trichoderma* treatment (2.2). Further, the density of parasitoids peaked in the *Pseudomonas*-treated plot (3.81 per sq. m), followed by untreated control plots (3.07 per sq. m.). However, Organic rice without seed treatment recorded a minimum density of parasitoids (2.44 per sq. m) (Table 5).

Though *Trichoderma* treatment recorded the highest Shannon index among the treatments tested, a value of 1.11 could be said to signify moderate parasitoid diversity, the reason being that the parasitoid guild in the organic ecosystems studied consisted of Eulophids, Scelionids, Trichogrammatids, and Mymarids were recorded in very huge numbers in the treatments, while Cynipids, Ceraphronids, Torymids, and Bethylids were found to occur in very fewer numbers and Shannon index relies to a large extent on the even spread of the genera in the field. It also indicates that parasitoid guild in the ecosystem had mediocre stability and could incline towards the unfavorable side with a small change in the management practices, natural calamities, agronomical practices, etc. leading to acute loss in parasitoid numbers and thereby a decline in natural biological control. Such a guild must be conserved carefully to reap maximum benefits out of the wide parasitoid spectrum recorded in the treatments.

Similar studies reported altogether 40 species of egg parasitoids in 23 genera belonging to 5 families (Platygastridae, Mymaridae, Encyrtidae, Eulophidae and Trichogrammatidae), of which 29 belonged to 16 genera of family Platygastridae. Higher number of species were found in organic (32) than conventional ecosystems (22). Simpson's diversity index was also higher (0.978) in the organic ecosystem compared to the conventional paddy ecosystem (0.878) [15]. The Ichneumonid fauna of 604 parasitoid individuals representing 14 subfamilies, 24 genera, and 33 species in the rice ecosystem were recorded in a study by [16]. The diversity indices (Simpson's index, Shannon-Wiener index, Pielou's index) revealed the western zone as the most diverse zone with 0.92, 1.15, and 0.39 while the Cauvery delta zone being the least diverse with 0.83, 0.89, and 0.38 values respectively. *Leptobatopsis indica* was the dominant Ichneumonid species in the rice ecosystem with a relative abundance of 8.1 percent. They found 12 percent similarity between the Western and Cauvery delta zones no similarity between high rainfall and Cauvery delta zones and a 25 percent similarity between high rainfall and western zones. Likewise, 4,701 individuals consisting of 39 families and 319 species of Hymenoptera were reported in a trial. Results shown that species diversity and evenness of Hymenoptera parasitoids and predators were higher in Keritang (2,032) than in Batang Tuaka (1,584) and Reteh (1084). Families Formicidae, Braconidae, Ichneumonidae, and Scelionidae had the highest number of species, while Formicidae (1815), Scelionidae (811), Diapriidae (319), and Braconidae (300) had the highest number of individuals [17]. Jauharlina et al. [18] also reported that the Shannon-Wiener diversity index (H') of parasitoids in rice was significantly higher (0.88 ± 0.11) at the vegetative stage than those at the remaining stages, while Simpson Dominance (C) and Species Evenness (E) indices were not significantly different among the three observed stages.

Table 1. Abundance of Hymenopteran natural enemies in visual count method

Family	Abundance of Hymenopteran natural enemies in different treatments*					
	Trichoderma	***Pseudomonas***	**Farmers' practice**	**Organic rice without seed treatment**	**Untreated control**	**CD**
Ichneumonidae	0.20(1.08)	0.60(1.20)	0.00(1.00)	0.00(1.00)	2.80(1.73)	N/A
Dryinidae	1.20(1.32)	1.80(1.43)	0.00(1.00)	2.20(1.49)	0.00(1.00)	N/A

** Mean of 5 counts*
Figures in parenthesis are square root transformed values

Table 2. Abundance of Hymenopteran natural enemies in yellow pan traps

Family	Abundance of Hymenopteran natural enemies in different treatments*					
	Trichoderma	***Pseudomonas***	**Farmers' practice**	**Organic rice without seed treatment**	**Untreated control**	**CD**
Eulophidae	8.00(2.91)^{b}	10.00(3.17)^{a}	2.60(1.84)^{e}	6.40(2.69)^{c}	4.40(2.26)^{d}	0.82
Scelionidae	8.20(2.94)^{a}	5.60(2.53)^{c}	1.80(1.61)^{e}	6.80(2.69)^{b}	3.80(2.10)^{d}	0.84
Trichogrammatidae	5.60(2.52)^{b}	4.80(2.39)^{d}	3.80(2.16)^{e}	5.40(2.42)^{c}	12.00(3.53)a	0.73
Mymaridae	9.80(3.21)^{a}	6.40(2.66)^{b}	1.40(1.54)^{e}	4.80(2.29)^{c}	3.60(1.98)^{d}	0.97
Ichneumonidae	0.40(1.16)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	N/A
Braconidae	0.40(1.16)	0.40(1.14)	0.00(1.00)	0.20(1.08)	0.20(1.08)	N/A
Diapriidae	4.20(2.19)^{ab}	3.00(1.95)^{bc}	1.00(1.39)^{c}	2.00(1.72)^{bc}	6.40(2.69)^{a}	0.62
Eurytomidae	0.40(1.14)	0.20(1.08)	0.00(1.00)	0.00(1.00)	0.00(1.00)	N/A
Platygastridae	0.20(1.08)	0.60(1.20)	1.00(1.29)	1.40(1.41)	1.20(1.42)	N/A
Bethylidae	0.20(1.08)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	N/A
Torymidae	0.00(1.00)	0.60(1.22)	0.20(1.08)	0.80(1.31)	1.00(1.37)	N/A
Ceraphronidae	0.00(1.00)^{b}	0.00(1.00)^{b}	0.20(1.08)^{b}	0.40(1.16)^{ab}	0.80(1.33)^{a}	0.18
Cynipidae	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.20(1.08)	N/A
Chalcididae	1.00(1.33)	0.60(1.24)	0.20(1.08)	0.20(1.08)	1.00(1.34)	N/A

**Mean of 5 counts*
Values in parenthesis are square root transformed values
Values in a row with the same alphabet are not statistically different

Table 3. Abundance of Hymenopteran natural enemies in sweep net method

Family	Abundance of Hymenopteran natural enemies in different treatments*					
	Trichoderma	***Pseudomonas***	**Farmers' practice**	**Organic rice without seed treatment**	**Untreated control**	**CD**
Eulophidae	0.0(1.00)	0.2(1.08)	0.0(1.00)	0.00(1.00)	0.00(1.00)	N/A
Ichneumonidae	0.4(1.16)^{bc}	0.6(1.22)^{bc}	0.0(1.00)	2.40(1.73)^{a}	1.60(1.53)^{ab}	0.49
Braconidae	0.0(1.00)	0.6(1.20)	0.2(1.08)	0.60(1.22)	0.00(1.00)	N/A
Formicidae	0.0(1.00)	0.0(1.00)	0.2(1.08)	0.60(1.22)	0.00(1.00)	N/A

**Mean of 5 counts*
Values in parenthesis are square root transformed values
Values in a row with the same alphabet are not statistically different

Table 4. Abundance of Hymenopteran natural enemies in yellow sticky traps

Family	Abundance of Hymenopteran natural enemies in different treatments*					
	Trichoderma	**Pseudomonas**	**Farmers' practice**	**Organic rice without seed treatment**	**Untreated control**	**CD**
Eulophidae	278.2(16.57)	428.0(20.59)	290.2(16.76)	302.4(17.38)	287.2(16.69)	N/A
Scelionidae	77.8(8.45)^{ab}	80.4(8.73)^{ab}	109.0(10.11)^{a}	30.6(5.49)^{bc}	26.0(5.12)^{c}	3.30
Trichogrammatidae	40.2(6.30)	54.0(7.14)	70.2(8.01)	35.6(5.83)	54.8(7.43)	N/A
Mymaridae	35.8(6.05)^{ab}	51.4(7.13)^{a}	19.6(4.34)^{c}	26.0(5.09)^{bc}	49.4(6.95)^{a}	1.58
Ichneumonidae	0.2(1.08)	0.0(1.00)	0.0(1.00)	0.6(1.22)	0.2(1.08)	N/A
Braconidae	0.8(1.31)	1.0(1.36)	0.4(1.16)	0.6(1.20)	1.6(1.59)	N/A

**Mean of 5 counts*
Values in parenthesis are square root transformed values
Values in a row with the same alphabet are not statistically different

Table 5. Diversity indices and density of Hymenopteran natural enemies in different organic rice regimes

Diversity Index	Treatments				
	Trichoderma	***Pseudomonas***	**Farmers' practice**	**Organic rice without seed treatment**	**Untreated control**
Shannon - Wiener Diversity Index	1.11	0.97	1.02	0.99	0.96
Simpson Diversity Index	0.46	0.53	0.46	0.55	0.55
True Diversity (Effective no. of species)	2.20	2.70	2.80	2.70	2.60
Density (per sq. m)	2.80	3.81	3.03	2.44	3.07

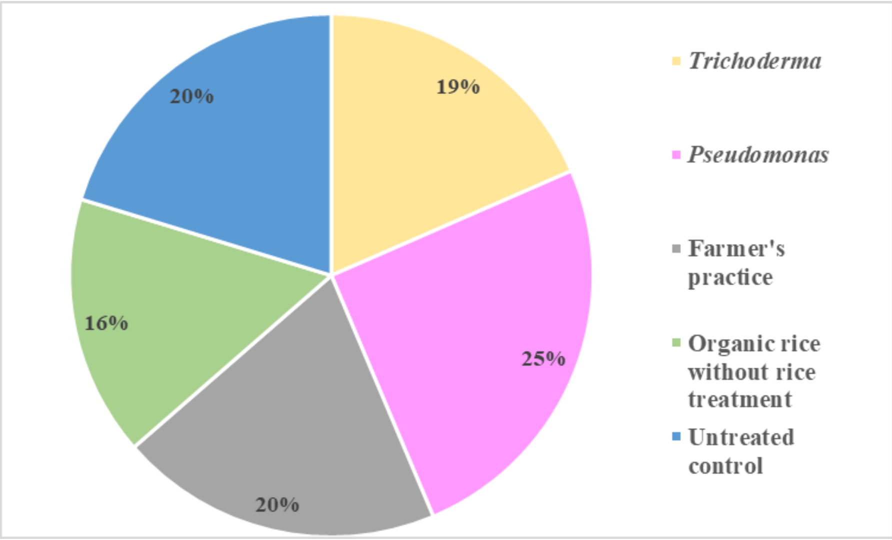

Fig. 1. Abundance of Hymenopteran parasitoids in various organic rice regimes

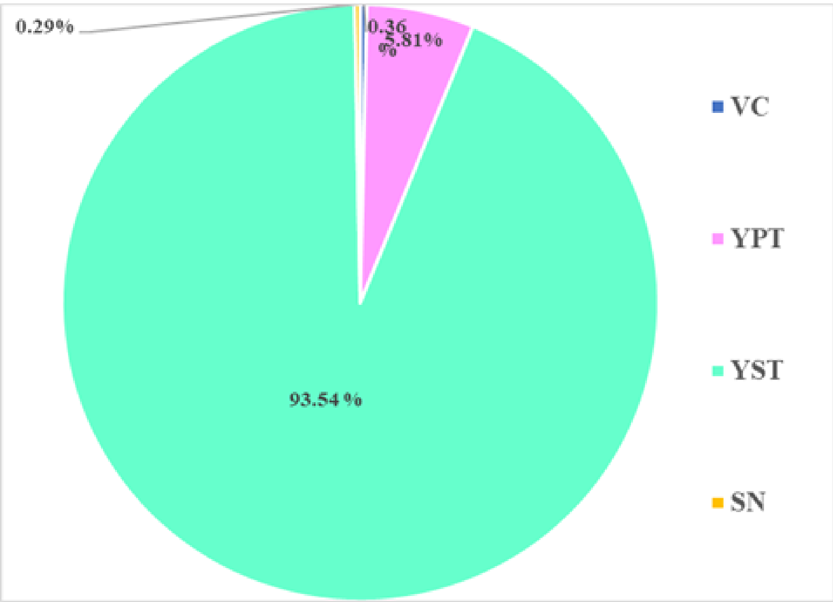

Fig. 2. Contribution of different methods of collection to abundance of Hymenopteran parasitoids

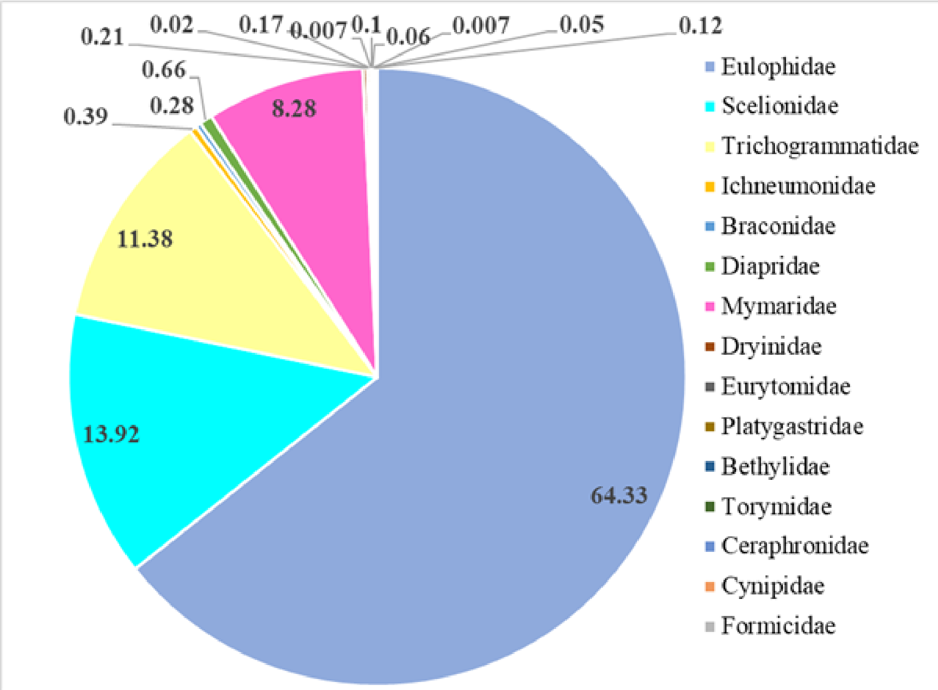

Fig. 3. Contribution (%) of each family to the total abundance of Hymenopteran parasitoids

4. CONCLUSION

In our present study, organic treatments especially *Trichoderma* and *Pseudomonas* supported the abundance and diversity of Hymenopteran parasitoids which indicates the impact of organic amendments on beneficial fauna. As all these amendments are available at a cheaper cost, they could be easily adopted by the farmers, which in turn leads to reduced usage of hazardous chemical pesticides and, consequently, a safer environment.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Statista, India: production volume of rice; 2023. Available:https://www.statista.com/statistics/1140236/india-production-volume-of-rice/.
2. Nagata T. Insecticide resistance and chemical control of the brown planthopper, *Nilaparvata lugens* Stal. The Bulletin of the Kyushu National Agricultural Experiment Station. 1982;(22):49-164.
3. Hirai K. Recent trends of insecicide susceptibility in the Brown plant hopper, *Nilaparvata lugens* Stal (Hemipteara : Delphacidae) in Japan. Applied Entomology and Zoology. 1993;28(3):339-346.
4. Sharma S, Parminder S, Shera, Kamaldeep S, Sangha. Species composition of parasitoids and predators in two rice agro-farming systems-Effect of ecological intensification. International Journal of Tropical Insect Science. 2019; 40(2):233-238.
5. Untung K. Pengantar pengelolaan hama terpadu Kedua Yogyakarta Gadjah Mada University Press. 2006;348.
6. Goulet H, Huber JT. Hymenoptera of the World: An identification guide to families. Agriculture Canada Publication, Ottawa, Ontario; 1993. ISBN 06601 49338.
7. Goepel KD. Diversity calculator online (BPMSG). 19.08.2024. (bpmsg.com/tools/div-calc.php); 2017.

8. Chaitanya M, Anitha G, Mahendra KR. Diversity and relative abundance of insect pests and natural enemies in organic rice. Uttar Pradesh Journal of Zoology. 2024;45(15):573-580. Available:https://doi.org/10.56557/upjoz/2024/v45i154274.
9. Chaitanya M, Mahendra KR, Manjunatha B, Jayanth BV. Diversity and relative abundance of insect pests and natural enemies in *Bacillus* treated rice. Journal of Experimental Agriculture International. 2024;46(8):451-a57. Available:https://doi.org/10.9734/-jeai/2024/v46i82723.
10. Mahendra KR, Anitha G, Chitra Shanker. Impact of soybean on natural enemy guilds in intercropping cotton and suitability of trapping methods for various insects. Indian Journal of Ecology. 2024;51(1):211-217. Available:https://doi.org/10.55362/-ije/2024/4219
11. Lakshman LHDS, Wijayagunashekara HNP, Mandanayake MARA. Some parasitoids of rice pests collected from insecticide – free fields in Sri Lanka. International Symposium on Agriculture and Environment. University of Ruhuna Sri Lanka. 2013;253 -256.
12. Parasappa HH, Reddy NG, Neelakanth. Rice insect pests and their natural enemies complex in different rice ecosystem of Cauvery command areas of Karnataka. Journal of Entomology and Zoology Studies. 2017;5(5):335- 338.
13. Daniel JA, Ramaraju K, Kumar S, Jeyaprakash MP, Chitra N. Influence of weather on the parasitoid catches in three rices growing agroclimatic zones of Tamil Nadu. Indian Journal of Entomology. 2019;81(1): 55-60.
14. Silva GS, Jahnke SM, Johnson NF. Riparian forest fragments in rice fields under different management: differences on Hymenopteran parasitoid diversity. Brazilian Journal of Biology. 2020;80(1): 122-132.
15. Gnanakumar M, Rajmohana K, Bijoy C, Balan D, Nishi R. Diversity of Hymenopteran egg parasitoids in organic and conventional paddy ecosystems. Tropical Agricultural Research. 2012;23(4): 300–308.
16. Daniel JA, Ramaraju K, Sudheer K, Vishnu K. Ichneumonid fauna associated with rice ecosystems of Tamil Nadu, India. Journal of Biological Control. 2020;34(1):15-25.
17. Ikhsan Z, Hidrayani Y, Hamid H. The diversity and abundance of Hymenoptera insects on tidal swamp rice field in Indragiri Hilir District, Indonesia. Biodiversitas. 2020;(21):1020-1026.
18. Jauharlina J, Hasnah H, Ikram TM. Diversity and community structure of arthropods in the rice ecosystem in aceh. AGRIVITA Journal of Agricultural Science. 2019;41(2):316–324.

Peer-review history:
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