Biological Forum – An International Journal **16(8): 178-183(2024)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Abundance and Diversity of Hemipteran Predators in Different Organic Rice Regimes and Efficiency of Different Sampling Methods

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(Received: 29 May 2024; Revised: 22 June 2024; Accepted: 16 July 2024; Published: 14 August 2024)
(Published by Research Trend)

ABSTRACT: Rice (*Oryza sativa* L.) is a major food crop of the world. As it is affected by many insect pests, organic farming and natural control are the tactics for sustainable management of insect pests. An experiment was conducted during *rabi* 2020 at the research fields of the Indian Institute of Rice Research, Hyderabad to know the impact of organic treatments in rice crop *viz*., *Trichoderma*, *Pseudomonas,* and farmers' practice on the abundance, diversity, and density of Hemipteran predators of rice pests. Various sampling methods such as visual counts, sweep net, yellow pan traps, yellow sticky traps and D-net collection were used. Results revealed that, among all these methods visual count and yellow sticky traps were found more effective for sampling of Hemipteran predators which together have collected 84 % of insects. Thirteen families of predators belong to Hemipteran order were recorded among which Miridae was the most abundant. There was no significant difference in abundance of predators among different treatments, however, the diversity indices showed considerable variations. The rice plots with seeds treated *Pseudomonas* and *Trichoderma* harboured relatively more predators than other treatments, however, it was on par with other treatments in most of the cases.

Keywords: Organic rice, Predators abundance, Diversity indices, Sampling methods.

INTRODUCTION

Rice (*Oryza sativa* L.) is a major food crop of the world and 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 a total harvested area of approximately 165.25 M ha, producing more than 503.27 MT annually. Asia, representing 90% of global production. Yields range from less than 1t/ha under very poor rainfed conditions to more than 10t/ha in intensive temperate irrigated systems. India's total rice production during 2021-22 crop year is estimated at a record 130.29 million tonnes (Production statistics, 2023). Insect pests are a major causative factor in yield loss, either directly eating plant tissue or as a vector of plant pathogens. Pesticides are commonly used to control crop pests and diseases and ensure maximum yield with high market value. However, the accumulation of these chemical in crop fields increases risks to biodiversity and human health (Ali *et al*., 2019) which necessitates the safe alternate methods to tackle pest problems. Use of natural enemies to suppress crop pests has the potential to reduce chemical pesticide inputs in rice production systems. Understanding the diversity of insects associated with rice cultivation can provide information about the composition and structure of such ecosystems, which can be applied to integrated pest management (Sonico, 2022). Ecologically diversified agro-ecosystem supports conservation of natural enemies which is not only helps in managing insect pests but also helps in rescuing the environment from ill effects of hazardous pesticides which otherwise are used to manage the insect pests (Sree Latha *et al*., 2022). Different agricultural practices, such as the System of Rice Intensification (SRI), have been shown to support higher insect diversity (Siregar *et al*., 2017). Similarly, organic farming has been recognised as the primary alternative to lessen the environmental impact of agriculture by restricting the use of synthetic inputs and enhancing crucial ecological services like biological pest management. The natural enemies are biotic components that regulate pest insect populations in the agroecosystem, which consists of predators and parasitoids and their diversity has very important impact on stability in the rice ecosystem (Hendrival *et al*., 2017). Among natural enemies, hemipteran predators, such as *Cyrtorhinus lividipennis*, are significant natural enemies of rice pests like plant hoppers and leafhoppers (Zhou *et al*., 2023). They help control pest populations, which is essential for maintaining rice yield and quality. This natural predation reduces the reliance on chemical pesticides, promoting a more sustainable agricultural practice. For biological pest management, semi-aquatic crops like rice heavily rely on macro invertebrate predators. There are several natural predators in the rice fields that if conserved, can play an effective role in decreasing the pest population density (Bonhof *et al*., 1997). *Trichoderma* seed treatment can indirectly benefit insect predators by promoting plant health and vigor.

Healthier plants are better able to withstand pest attacks, reducing the need for insecticides and creating a more stable environment for predators to thrive (Prakash *et al*., 2014). However, the impact of organic inputs as a part of biointensive pest management practices which include the use of *Trichoderma*, *Pseudomonas*, vermicompost, farm yard manure, rise husk and neem cake on arthropod communities in rice crop has hardly been explored. With this view, the present study has been conducted to study the abundance and diversity Hemipteran predators in different organic rice regimes.

MATERIAL AND METHODS

This study was conducted in the fields of Indian Institute of Rice Research, Rajendranagar, Hyderabad during *rabi*, 2020. The rice variety, BPT 5204 (Samba Mahsuri) was grown in plots of 900 sq. m. for each treatment. There were four treatments and an untreated control plot. The treatments include: T1) BIPM Organic rice treatment with *Trichoderma* (seed treatment and soil application): In nursery, seed treatment with *Trichoderma* @ 10g per kg + rice husk and vermicompost @ 5kg per nursery. In 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. T2) BIPM Organic rice with *Pseudomonas* (seed treatment and sprays): In nursery, seed treatment with *Pseudomonas* @ 10g per kg seed +rice husk and vermicompost @ 5kg per nursery. Inmain field, pray of *Pseudomonas* -10g per litre at 30,60 and 90 DAT; Neem cake @ 80kg per acre + FYM @ 6 tons per acre. T3) Farmer's Practices: In nursery, Carbofuran 3 G granules @ 200g per nursery. In main field, foliar sprays with Cartap Hydrochloride @ 2g per litre when YSB or Leaf folder cross ETL, spray of Chlorpyriphos @ 2.5 ml per litre for Hispa beetle. T4) Organic rice without seed treatment: Innursery, rice husk and @ 5kg each per nursery bed of 8-10 sq. m. In main field, Neem cake @ 80kg per acre + FYM@ 6 tons per acre. T5) Untreated control. Observations on Hemipteran predators were made at 30, 45, 60, 90, and 120 DAT during morning hours. Various methods such as yellow pan traps (YPT) (3 traps per plot), visual counts (VC) and collections from randomly selected 20 hills in 1 m² quadrats (5 quadrats per plot), sweep netting (SN) (five sweeps at five points), yellow sticky traps (YST) (5 traps per plot), and D-Net for collection of aquatic insects were used. After collection, insects were sorted into respective orders and families. Identification of Hemipteran families was done based on keys given by Thirumalai and Kumar (2005). The biodiversity indices such as Shannon - Wiener diversity Index (H′), True diversity (Effective no. of species), and Simpson Diversity index (D) were calculated by using BPMSG biodiversity calculator. The density of the beneficials: The number of insects per sq. meter area was also worked out. After compiling data on insect abundance, one way analysis of variance was performed to check the significance of differences among the treatments using OPSTAT software (Sheoran *et al*., 1998).

RESULTS AND DISCUSSION

In the current study, thirteen families of predators belong to Hemipteran order were recorded. The order of abundance of these families as follows: Miridae (2430) > Pentatomidae (162) > Veliidae (144) >Mesoveliidae (110) >Gerridae (58)>Notonectidae(35)>Geocoridae (33)> Corixidae(18)>Saldidae(7)>Hydrometridae(4)=Nebidae (4) >Reduviidae(2)>Coreidae (1). In the visual count method, a total of 1588 predator specimens belonging to 7 families were recorded. Abundance of none of these families were significant among different treatments, however, untreated control and *Pseudomonas* treatments harbored relatively more predators as compared to other treatments. Among the different predator families recorded in visual count, Miridae was found to be most abundant followed by Pentatomidae (Table 1). Further, in yellow pan traps, four predator families were collected. Abundance of none of these families were significant among different treatments (Table 2). Similarly, using Sweep nets total of 227 Hemipteran predators belonging to 4 families (Pentatomidae, Geocoridae, Nabidae, and Coreidae) were collected, but abundance of none of these families were significant among different treatments. Among the four families, Pentatomids dominated the collection (Table 3). Furthermore, in yellow sticky traps, a total of 1190 individuals of predators belonging to two families (Miridae and Pentatomidae) were collected. The abundance of Miridae was significant across the treatments with *Pseudomonas* treatment harbored significantly greater Mirids followed by organic rice without seed treatment, *Trichoderma* treatment, untreated control and farmers' practice (Table 4). A total of 287 individuals of aquatic Hemipteran predators were collected using D-net belonging to 7 families, among which Veliidae and Mesoveliidae were more abundant (Table 5). Thongphak and Iwai (2016) compared the diversity between organic and conventional rice field and reported that there was no significant in diversity or abundance of aquatic insects between organic and conventional rice field. They reported 17 species belongs to 16 families of 6orders of which order Hemiptera was the highest in abundance groups. Mahendra *et al*. (2024) has evaluated the efficiency of various sampling methods and reported that the yellow sticky traps were most effective for sampling of hemipteran predators followed by sweep nets and visual count methods. An increase in predator abundance enhances chances of natural biological control and maintains pests under an economic threshold level for most time in the field. Wakhid *et al.* (2020) collected a total of 3,306 individuals representing 45 species of aquatic insects belonging to 30 genera, 20 families, and 7 orders and Hemiptera was found to be most abundant comprising 28.89 per cent of the total collected insects.

The abundance of predators among the treatments was not much varied. However, *Pseudomonas* treatment and organic rice without seed treatment harbored relatively more predators than other treatments (Table 6). Among all the methods of collection, visual count and yellow sticky traps were found more effective for collection of Hemipteran predators which together have collected 84 % of insects (Fig. 1). A total of 3,307 predators were observed and the predatory guild consisted of Miridae (73.48 per cent), Pentatomidae (13.15 per cent), Geocoridae (0.99 per cent), Reduviidae (0.06 per cent), Veliidae (4.35 per cent), Mesoveliidae (2.54 per cent), Corixidae (0.54 per cent), Notonectidae (1.99 per cent), Gerridae (2.36 per cent), Hydrometridae (0.12 per cent), Coreidae (0.03 per cent), Nabidae (0.12 per cent) and Saldidae (0.24 per cent) (Fig. 2). The mirid insect *Cyrtorhinus lividipennis* Reuter (Hemiptera: Miridae) is an economically and ecologically important enemy of insect pests of rice (Zhou *et al*., 2023). Manipulating habitat for natural enemies in rice landscapes enhances pest suppression and maintains equal yields while reducing the need for insecticide use in crop fields. For instance, the abundance of predators and parasitoids and parasitism rates increased significantly in the eco-engineering plots compared to the insecticide-treated and control plots (Ali *et al*., 2019). Yadav *et al*. (2018) reported that among the several species of predators, Mirid bug (*Cyrtorhinus lividipennis*) was the major one on rice pests. Parasappa *et al*. (2017) recorded spiders and Mirid, *C. lividipennis* as the most important natural enemies in rice.

The presence of Hemipteran predators contributes to the overall biodiversity of rice ecosystems. A diverse predator community can provide more stable pest control, reducing the likelihood of pest outbreaks due to the presence of multiple natural enemies (Ali *et al*., 2019). In our study, even though there was no much significant difference in abundance of predators among different treatments, the diversity indices showed considerable variations. Shannon -Wiener diversity Index was highest in untreated control (1.31) followed by farmers' practices (1.16), *Trichoderma* treatment (0.75), organic rice without seed treatment (0.75) and *Pseudomonas* treatment (0.62) highlighting the negative effects of treatments (inorganic or organic) on predator diversity. Likewise, lesser values of Simpson Diversity index in farmers' practice (0.38) and untreated control (0.39), indicated good diversity of predators. Organic rice without seed treatment (0.67), *Trichoderma* treatment (0.65) and *Pseudomonas* treatment (0.72) recorded higher values indicating lesser diversity and lesser evenness in the spread of species in the ecosystem than untreated control and farmers' practice plots. True diversity was highest for untreated control (3.7) > farmers' practices (3.2) >*Trichoderma* plots and organic rice without seed treatment (2.1) >*Pseudomonas* treatment (1.9). Untreated control plot besides recording higher diversity of predators recorded the highest density also (0.91 per sq. m.) followed by *Pseudomonas* treatment (0.90 per sq. m.), Organic rice without seed treatment plots (0.75 per sq. m.), *Trichoderma* treatment (0.66 per sq. m.) and farmers' practice plots (0.43 per sq. m.) which recorded least density among the treatments (Table 7).

Treatment applications whether organic or inorganic had a pronounced impact on the diversity and density of predators, moreover, chemical treatments especially have damaging effects on natural enemies. Diversity in untreated control was moderate indicating mediocre stability of the predatory guild. This could be because the Shannon diversity index depends on the richness of species recorded and in the present study, Mirids and Pentatomids were in high numbers in all the treatments, while Coreids, Nabids, Saldidids were in low numbers. Ovawanda *et al*. (2017) compared insect biodiversity indices by measuring species richness, species evenness and heterogeneity in organic and inorganic rice farming ecosystem. Higher species richness (7 to 13 species) in inorganic rice field during April–May and higher species richness (22 to 33 species) was found in the organic rice. Jauharlina *et al*. (2019) used a sweep net to collect insects in the rice ecosystem at three growth stages and found that Shannon-Wiener diversity index (H') was significantly higher (0.88 ± 0.11) at the vegetative stage, while Simpson Dominance (C) and Species Evenness (E) indices were not significantly different among the three observed stages. Amzah *et al*. (2018) calculated diversity in conventional and ecological engineering plots and reported Simpson Index(D) of arthropods in the conventional plot was lower than that in the ecological engineering plot (1.27 < 1.94). Shannon-Wiener Index(H), also recorded similar results which was 0.42 < 1.19. In terms of species density, the conventional plot showed a low Margalef Index compared to ecological engineering plot (0.51 < 2.52). Rajna and Chander (2013) reported that the Mirid bug population dominated during the post-flowering period. Based both on species richness and equitability, the Simpson index and Shannon-Wiener index found that the predator community was the most diverse between 39-51 days after transplanting (8.074) and least diverse at 79 DAT (1.153).

Table 1: Abundance of Hemipteran predators in visual count method.

Family	Abundance of Hemipteran predators in different treatments*					
	Trichoderma	***Pseudomonas***	**Farmers' practice**	**Organic rice without seed treatment**	**Untreated control**	**CD**
Miridae	44.40(5.13)	63.60(6.18)	28.04(5.00)	49.40(5.59)	63.40(7.35)	N/A
Hydrometridae	0.00(1.00)	0.80(1.24)	0.00(1.00)	0.00(1.00)	0.00(1.00)	N/A
Pentatomidae	6.00(2.19)	7.40(2.30)	7.60(2.38)	7.20(2.30)	15.80(3.14)	N/A
Gerridae	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	11.60(2.78)	N/A
Veliidae	1.20(1.32)	0.00(1.00)	0.00(1.00)	0.00(1.00)	3.40(1.83)	N/A
Notonectidae	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	7.00(2.00)	N/A
Reduviidae	0.40(1.14)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	N/A

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

Table 2: Abundance of Hemipteran predators in yellow pantraps.

Family	Abundance of Hemipteran predators in different treatments*					
	Trichoderma	*Pseudomonas*	Farmers' practice	Organic rice without seed treatment	Untreated control	CD
Miridae	0.20(1.08)	0.20(1.08)	0.20(1.08)	0.00(1.00)	0.20(1.08)	N/A
Saldidae	0.20(1.08)	0.20(1.08)	0.20(1.08)	0.40(1.14)	0.40(1.14)	N/A
Geocoridae	0.00(1.00)	0.00(1.00)	0.60(1.20)	0.00(1.00)	0.00(1.00)	N/A
Veliidae	0.00(1.00)	0.00(1.00)	0.20(1.08)	0.00(1.00)	0.00(1.00)	N/A

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

Table 3: Abundance of Hemipteran predators in sweep net.

Family	Abundance of Hemipteran predators in different treatments*					
	Trichoderma	*Pseudomonas*	Farmers' practice	Organic rice without seed treatment	Untreated control	CD
Pentatomidae	6.80(2.77)	5.60(2.52)	9.60(3.09)	6.80(2.74)	9.60(3.19)	N/A
Geocoridae	1.00(1.22)	0.60(1.36)	0.80(1.65)	1.00(1.36)	2.60(1.45)	N/A
Coreidae	0.00(1.00)	0.20(1.08)	0.00(1.00)	0.00(1.00)	0.00(1.00)	N/A
Nabidae	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.60(1.20)	0.20(1.08)	N/A

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

Table 4: Abundance of Hemipteran predators in yellow sticky traps.

Family	Abundance of Hemipteran predators in different treatments*					
	Trichoderma	*Pseudomonas*	Farmers' practice	Organic rice without seed treatment	Untreated control	CD
Miridae	51.60(6.90)[c]	74.40(8.59)[a]	14.00(3.83)[e]	59.80(7.66)[b]	33.60(5.86)[d]	2.00
Pentatomidae	0.60(1.22)	1.00(1.36)	0.20(1.08)	1.20(1.41)	1.60(1.49)	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: Abundance of Hemipteran predators in D-net collection.

Family	Abundance of Hemipteran predators in different treatments*				
	Trichoderma	*Pseudomonas*	Farmers' practice	Organic rice without seed treatment	Untreated control
Veliidae	9.0	20.0	71.0	13.0	7.0
Mesoveliidae	26.0	22.0	6.0	16.0	14.0
Corixidae	1.0	3.0	3.0	6.0	5.0
Notonectidae	2.0	0.0	0.0	4.0	25.0
Gerridae	0.0	0.0	0.0	1.0	19.0
Saldidae	1.0	0.0	0.0	0.0	0.0
Miridae	0.0	0.0	2.0	7.0	4.0

*Total of two counts at 30 DAT and 45 DAT

Table 6: Total abundance of Hemipteran predators.

Family	Abundance of Hemipteran predators in different treatments*				
	Trichoderma	*Pseudomonas*	Farmers' practice	Organic rice without seed treatment	Untreated control
Miridae	96.20(6.88)	138.20(8.11)	43.00(4.90)	110.60(7.57)	98.00(7.09)
Pentatomidae	13.40(3.09)	14.00(3.20)	17.40(3.33)	15.2(3.32)	27.00(4.18)
Geocoridae	1.00(1.29)	0.60(1.20)	1.40(1.44)	1.60(1.49)	2.60(1.54)
Reduviidae	0.40(1.14)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)
Veliidae	3.00(1.76)	4.00(1.71)	14.40(2.58)	2.60(1.54)	4.80(2.01)
Mesoveliidae	5.20(1.83)	4.40(1.75)	1.20(1.32)	3.20(1.62)	2.80(1.57)
Corixidae	0.20(1.08)	0.60(1.20)	0.60(1.20)	1.20(1.32)	1.00(1.29)
Notonectidae	0.40(1.14)	0.00(1.00)	0.00(1.00)	0.80(1.24)	12.00(2.82)
Gerridae	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.20(1.08)	15.40(3.03)
Hydrometridae	0.00(1.00)	0.80(1.24)	0.00(1.00)	0.00(1.00)	0.00(1.00)
Coreidae	0.00(1.00)	0.20(1.08)	0.00(1.00)	0.00(1.00)	0.00(1.00)
Nabidae	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.60(1.20)	0.20(1.08)
Saldidae	0.40(1.16)	0.20(1.08)	0.20(1.08)	0.40(1.14)	0.40(1.14)

Table 7: Diversity indices and density of Hemipteran predators in various organic rice regimes.

Diversity Index	Treatments				
	Trichoderma	Pseudomonas	Farmers' practice	Organic rice without seed treatment	Untreated control
Shannon - Wiener	0.75	0.62	1.16	0.75	1.31
Simpson	0.65	0.72	0.38	0.67	0.39
True Diversity (Effective no. of species)	2.10	1.90	3.20	2.10	3.70
Density (per sq. m)	0.66	0.90	0.43	0.75	0.91

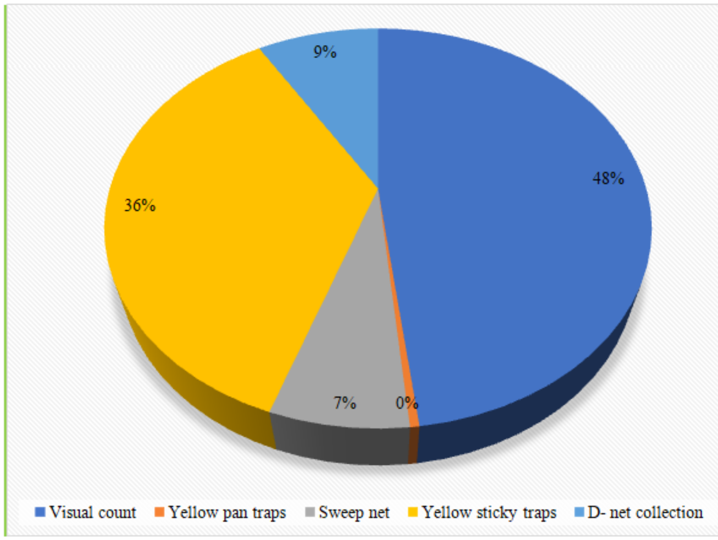

Fig. 1. Contribution of different methods for sampling of Hemipteran predators.

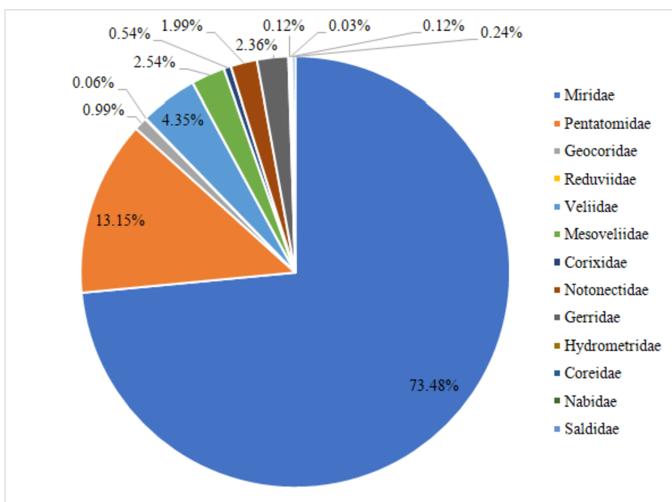

Fig. 2. Per cent contribution of different families to total abundance of Hemipteran predators.

CONCLUSIONS

The diversity of Hemipteran predators in organic rice crops is a fundamental component of natural pest control. The individual treatments with the above-mentioned treatments may be less effective. An effective combination of different treatments might provide outstanding results in terms of enhanced abundance and diversity compared to traditional rice cultivation.

FUTURE SCOPE

Despite the benefits, managing insect predator diversity in organic rice systems poses challenges. One of the primary challenges is the variability in predator populations due to environmental factors, such as weather conditions and landscape composition. As mentioned earlier, the studies on effect of combination of different treatments rather than individual treatment should be made in the future research to arrive at the real effect of these treatments on the abundance of insect predators in the organic rice ecosystems.

Acknowledgements. The authors thank the Head, the Department of Entomology, College of Agriculture, Rajendranagar, Hyderabad and the Director of the Indian Institute of Rice Research, Hyderabad for their help and support during this study.

Conflict of Interest. None.

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How to cite this article: M. Chaitanya, G. Anitha and K.R. Mahendra (2024). Abundance and Diversity of Hemipteran Predators in Different Organic Rice Regimes and Efficiency of Different Sampling Methods. *Biological Forum – An International Journal, 16*(8): 178-183.