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Population dynamics of brown planthopper *Nilaparvata lugens* stall and arthropod diversity on rice ecosystem with returned straw and different spectrum of insecticides

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Abstract. The natural ecosystem of lowland rice in Indonesia is rich in biodiversity. However, high-intensity insecticide accompanied by a lack of organic matter in the form of straw returned to the fields causes the fragile agroecosystem, decreasing the abundance and species diversity of natural enemies, causing a broken food chain, and the tremendous potential for the outbreak of rice pests. Need study to understand the impact of returned straw and different insecticide spectrums on the diversity and abundance of arthropods and the brown planthopper (BPH) in rice fields. The experiment was located in Ciwaringin, Lemahabang, Karawang, West Java, during the rainy season from January-April 2022.The field trial was conducted under a split-plot design consisting of two main plots: rice field with and without returned straw and three subplots: without insecticide, fipronil as insecticide broad-spectrum, and triflumezopyrim as insecticide narrow-spectrum. The first insecticide was applied at an economic threshold level. Arthropods were sampled biweekly by systematically using a vacuum and insect nets. Population observation of BPH was done weekly until one week before harvest. The result showed that there are 40 morphospecies, 29 families, and 9 orders of arthropods. Based on the functional roles, there were 48.6% pests, 19.2% predators, 5.8% parasitoids, and 26.4% other role arthropods. Plots with returned straw showed a 5.4% higher abundance and diversity of arthropods than those with unreturned straw. The plot treated with triflumezopyrim showed a significantly lower population of the BPH than the plot treated with fipronil and was similar arthropod diversity to the untreated plot. In conclusion, returning straw to the paddy fields provides many ecological and economic benefits.

1. Introduction

Ecosystem balance is the main objective of pest management. If the food webs in the ecosystem work, then the population outbreak, especially pests, can be avoided. The natural ecosystem of lowland rice in Indonesia is rich in biodiversity; about 765 species of insects and their arthropod relatives can be found in natural conditions [9]. In agricultural ecosystems, insect communities have many types, each showing a distinctive population characteristic [11]. The complexity and diversity of these biological agents must be utilized and developed to control pests naturally and sustainably [7].

In the case of artificial ecosystems such as lowland rice, the concept of balance is influenced by many factors. The factor considered to be the most influential is inappropriate cultivation practices, including using insecticides with high intensity and minimal organic matter in the form of straw or manure given to paddy fields. Insecticide applications aimed to control pests. However, the wrong choice of insecticide (spectrum/selectivity) and unwise application will impact not only the target pests but also many beneficial arthropods have a detrimental effect. Returned straw can potentially increase soil organic matter, a source of macro and micronutrients, and is essential in maintaining the complexity of food webs in paddy fields [13]. However, rice straw is generally considered a waste and not utilized optimally. These practices cause the agroecosystem to become fragile, have low arthropod biodiversity, low soil microbes, a broken food chain, and a vast potential outbreak of rice pests [10][13].

BPH is one of rice's main pests, which is often an outbreak condition in Indonesia. Although it does not attack every season, its population can quickly increase under favourable environmental conditions and cause severe economic damage to rice plants [3]. Need study to integrate the best techniques in pest management by combining cultivation practices, such as a returned straw in the paddy field and different insecticide spectrums for controlling BPH. The objectives of this field study were to understand the impact of both approaches on the abundance and diversity of arthropods also the dynamic population of BPH as one of rice's main pests.

2. Materials and methods

2.1. Field study

The research was located in Ciwaringin, Lemahabang, Karawang, West Java, during the rainy season from January-April 2022. The straw biomass that was returned was 5 tons/ha. Returned straw was spread after the harvest of the previous planting season. The straw was left for about one month to decompose naturally, followed by land cultivation.

The field trial was conducted under a split-plot design consisting of two main plots: rice field with and without returned straw, and three subplots: without insecticide, fipronil at 25-gram active ingredient per ha (gai/ha) as a broad-spectrum insecticide, and triflumezopyrim at 25 gai/ha as a narrow-spectrum insecticide. Each treatment measured 5 m x 8 m with rice spacing of 25 x 25 cm and four replications. Advanced cultivation techniques, which include irrigation and weeding, follow the habits of farmers and local farmers' cultivation systems. Fertilization follows the local guidelines, 300 kg Urea, 50 kg KCl and 50 kg SP-36 [2]. The first insecticide was applied at an economic threshold level (ETL) of 5-10 individuals of BPH per hill.

2.2. Arthropod samplings and population observation of BPH

Arthropods were sampled biweekly by systematically using a vacuum and insect nets. Insect vacuum to catch arthropods on the hill of rice plants was carried out in plastic cages 1 m x 1 m with a height of 1.5 m and placed at five spots in each plot [5]. The collection technique with insect nets was carried out by three swinging nets in each plot. BPH populations were observed weekly until one week before harvest by directly counting the number of nymphs and adults in 25 rice hills.

2.3. Data analysis

The arthropod community structure was analyzed using the Shannon-Wiener (H') diversity index. The experimental data in the split-plot design. The data obtained from each test will be processed using Microsoft Excel 2019 and analysis of variance (ANOVA). Furthermore, the data is processed through the R-statistics program. Significantly different treatments were tested with the Tukey test at a 0.05 significance level.

3. Results and discussion

Karawang is one of the districts in West Java, one of Indonesia's rice production centers. Generally, it is planted twice a year, during the rainy season between December-April and during the dry season from May-September. In the surrounding area used for the study, farmers generally do not do special treatment to the remaining harvested straw, some are piled up and left, and some are burned. Pesticide is applied intensively; on average, farmers spray 8-12x pesticides every planting season, i.e., 1x herbicide, 6-8x insecticides, and 2-3x fungicides. BPH and yellow stem borer (YSB) *Scripophaga incertulas* are the main problems faced by farmers in Karawang; the active ingredients of insecticides commonly used by farmers include fipronil, BPMC, imidacloprid, nitenpyram, pymetrozine and triflumezopyrim for BPH, as well as dimehypo, abamectin, chlorantraniliprole and spinetoram for YSB.

Table 1. Diversity of arthropod species occurs in a rice field during the growing season.

Order	Species abundance	Percentage (%)
Araneae	552	6.4
Coleoptera	179	2.1
Diptera	2,420	28.3
Hemiptera	4,804	56.1
Hymenoptera	501	5.8
Lepidoptera	39	0.5
Odonata	22	0.3
Orthoptera	31	0.4
Thysanoptera	17	0.2

The results showed that 40 morphospecies, 29 families, and 9 orders of arthropods were found, with an abundance of 8565 individuals. The abundances of arthropods found were 9 orders consisting of 6.5% Araneae, 2.1% Coleoptera, 28.3% Diptera, 56.1% Hemiptera, 5.8% Hymenoptera, 0.5% Lepidoptera, 0.3% Odonata, 0.4% Orthoptera, and 0.2% Thysanoptera (Table 1). Based on the functional roles, they were 48.6% pests, 19.2% predators, 5.8% parasitoids, and 26.4% other-role arthropods (Figure 1). Most species abundance occurs in Hemiptera (56.1%). BPH was the dominant species in this study, followed by white-backed planthopper (WBPH) *Sogatella furcifera* and predator *Cyrthorhinus lividipennis* (Hemiptera: Miridae).

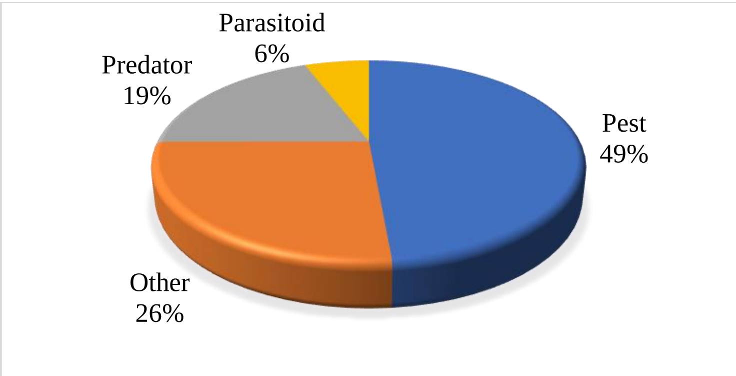

Figure 1. The functional role of arthropod species occurs during the growing season

Untreated plots (T1) showed the highest abundance, followed by fipronil plots (T2) and triflumezopyrim plots (T3). Plots with straw return provided a higher arthropod abundance, 52.7% of total arthropod species, and 5.4% higher abundance than plots without returned straw (Table 2). Plots with returned straw always showed a higher number of abundance arthropods in different treatments and sampling timing. Returned straw into the paddy field and different insecticide applications significantly impacted arthropods' occurrence.

Agriculture practices with the addition of organic matter will greatly affect the increase in species richness, evenness and heterogeneity. In addition, the farming method that includes the cultivated plant type, intensity of land management and pest management practices will also affect the abundance and types of insects occurrence [1][8].

Table 2. The abundance of arthropod species in the plot with and without straw returned dan three different treatments.

Main Plot	Vegetative stage			Reproductive stage			Ripening stage			Total	Percentage (%)
	T1	T2	T3	T1	T2	T3	T1	T2	T3		
Returned straw	331	282	241	730	609	278	961	782	299	4,513	52.7
Without returned straw	301	228	212	668	549	240	946	659	249	4,052	47.3

T1 = Untreated, T2 = Fipronil, T3 = Triflumezopyrim

Plots with a returned straw also provided a higher percentage of beneficial (predator and parasitoid), higher other functional arthropods and a lesser percentage of pests than plots without returned straw (Figure 2). Adding organic matter in rice fields not only increases species diversity but can also increase the detritivores' population, which can be an alternative feed for generalist predators. These positively impact the abundance of predators in rice fields, which is very useful in natural pest control [9].

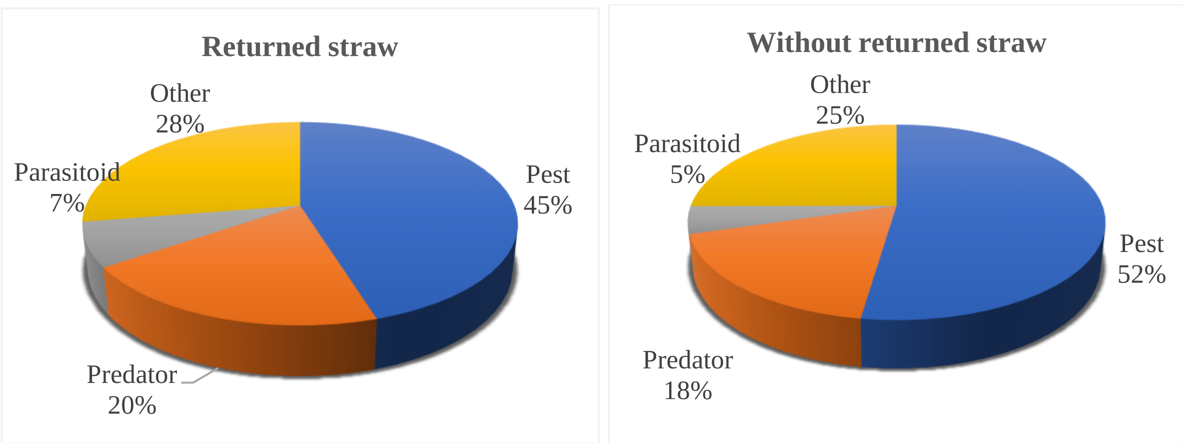

Figure 2. Functional role of arthropod species on rice with and without returned straw.

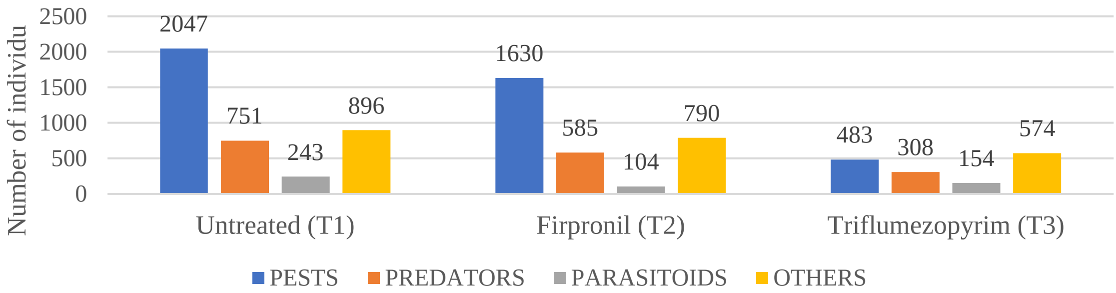

Figure 3. Functional role of arthropod species on three different treatments.

The plot treated with fipronil (T2) showed a low reduction in pest number than the untreated plot. On another side, fipronil as a broad-spectrum insecticide reduced the number of parasitoids more than triflumezopyrim. The plot treated with triflumezopyrim showed a considerably lower population of pests than the untreated plot and fipronil. Fipronil had a high contact effect toxicity and a longer residual effect against some parasitoids in the rice ecosystem [12]. Triflumezopyrim was harmless to the rice parasitoid wasps and some rice predators, *Cyrtorhinus lividipennis* and *Paederus fuscipes* [14].

The diversity plot with returned straw has a higher diversity index (H') on different treatments and sampling timing. Even though triflumezopyrim, a narrow-spectrum insecticide, has the lowest arthropod abundance, these insecticides have arthropod diversity the same as in the untreated plot. Returned rice straw and added organic materials to agricultural systems positively affect species richness and abundance of rice arthropods [4][6]. Triflumezopyrim can effectively control rice planthoppers and have minimum impact on predators and parasitoids [14]; this is one of the factors that triflumezopyrim still shows a relatively similar diversity index with the untreated plot.

Table 3. Diversity of arthropod species in the plot with and without returned straw dan three different treatments.

Main Plot	Vegetative stage			Reproductive stage			Ripening stage			Average
	T1	T2	T3	T1	T2	T3	T1	T2	T3	
Returned straw	1.68	1.52	1.55	2.01	1.76	1.92	2.04	1.67	1.86	1.78
Without returned straw	1.48	1.40	1.29	1.64	1.58	1.81	1.80	1.70	1.87	1.62

T1 = Untreated, T2 = Fipronil, T3 = Triflumezopyrim

BPH population occurred for the first time at 14 DAT and reached the ETL by 21 DAT. The peak population of BPH happen in the second generation at 70 DAT. At this time, most of the BPH founded were macropterous adults who were active in moved to another area. Plots with returned straw overall have a lower number on BPH. However, it was no significant difference compared to the plot with unreturned straw. Even though there was no difference in the number of BPH, based on arthropod sampling, that returned straw plot has a higher number of predators, parasitoids, and a lower number of general pests.

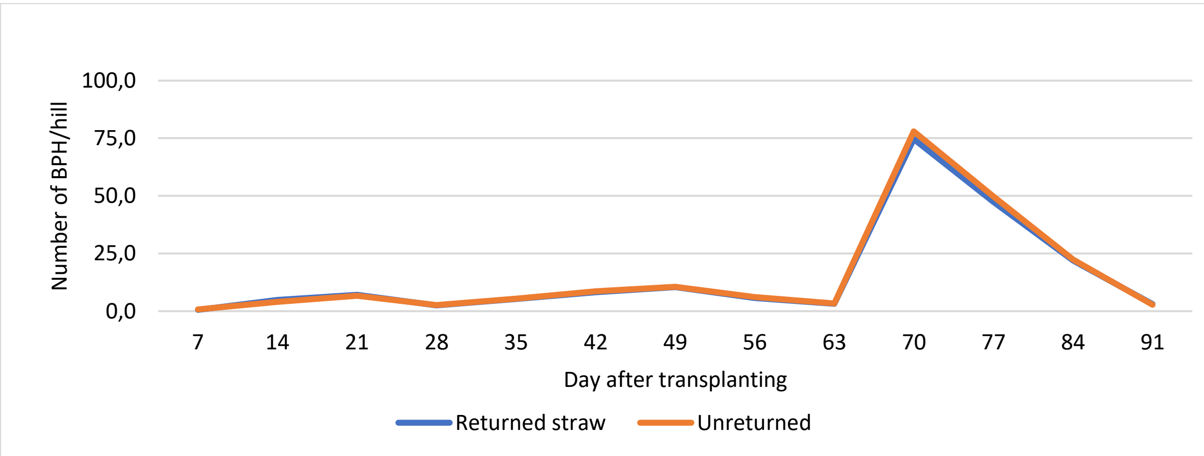

Figure 4. Dynamic population of BPH on the plot with returned and unreturned straw.

The plot treated with triflumezopyrim showed a significantly lower population of BPH than those treated with fipronil. Triflumezopyrim, a narrow-spectrum insecticide that showed a long residual efficacy effect, could suppress the BPH population under the economic threshold level during the planting season. Triflumezopyrim is the mesoionic insecticide that effectively controls the main pest in rice, planthoppers *N. lugens* and has long residual activities. Its mode of action is to inhibit the feeding activities of the insect [15].

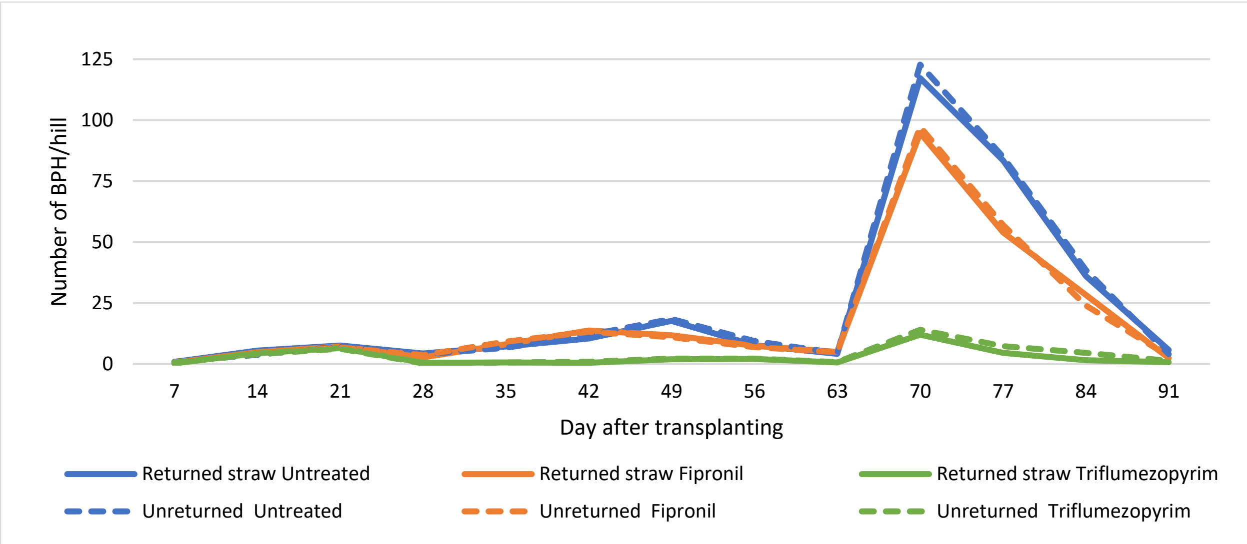

Figure 5. Population dynamic of BPH on treated plots.

4. Conclusion

Returning straw to the paddy fields provides many ecological and economic benefits. Returning straw to the paddy field and using narrow-spectrum insecticide give more advantages for a better pest management program.

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