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The impact of rice straw incorporation and insecticide application on brown planthopper, *Nilaparvata lugens* Stal. (Hemiptera: Delphacidae) population and beneficial insects

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Abstract. Integrating rice straw incorporation and insecticide application is an agricultural practice with significant implications for pest management and ecosystem health. This study explores the combined effects of these practices on the brown planthopper (BPH) population, *Nilaparvata lugens* Stal., a major rice pest, and on beneficial insects that contribute to natural pest control. Two experiments were conducted in Ciwaringin, Lemahabang, Karawang, West Java, from January to September 2022 during the rainy seasons. The field trial used a split-plot design with two main plots: rice fields with and without rice straw incorporation. Additionally, there were three subplots: no insecticide, fipronil as a broad-spectrum insecticide, and triflumezopyrim as a narrow-spectrum insecticide. The first insecticide application was triggered at the economic threshold level. BPH and beneficial insect populations were sampled every two weeks using suction devices and insect nets. Direct BPH population observations were conducted weekly to determine insecticide application timing. Incorporating rice straw alone reduced BPH populations and increased the number of beneficial insects, particularly predators. In contrast, insecticide application significantly decreased BPH populations but caused substantial mortality among beneficial insects. Specifically, fipronil use was associated with a marked reduction in parasitoid populations. Moreover, the beneficial effects of straw incorporation on BPH and predator populations were not observed when insectiside triflumezopyrim was applied.

1. Introduction

The brown planthopper (BPH), one of the main pests of rice plants in Indonesia, frequently experiences population outbreaks, leading to significant yield losses [1]. These outbreaks are supported by BPH's monophagous nature on rice plants, high fecundity, and excellent migration abilities. Additionally, BPH can quickly adapt to resistant rice varieties and several active insecticidal ingredients commonly used by farmers [2]. Previous studies have shown that rice cultivation with the addition of organic materials (such as returning straw, manure, and compost) and the appropriate use of insecticides can influence or suppress BPH populations [3-4]. However, this contrasts with the current situation, where farmers' understanding and awareness of these practices remain relatively low.

The technique of utilizing straw in Indonesia is not yet widely practiced, even though returning post-harvest straw to agricultural land has proven to potentially increase organic matter in the soil, serving as a source of macro and micronutrients beneficial for plant growth. Additionally, straw utilization is very beneficial in maintaining the complexity of the food web [5,6]. The application of insecticides aims to control pests; however, if used improperly and unwisely, it can negatively impact beneficial insects or arthropods, increasing the risks of resistance, resurgence, and residue (3R) [3,7].

Generally, current rice cultivation practices in Indonesia tend to make agroecosystems fragile, with low biodiversity of arthropods and soil microbes, disrupted food chains, and a higher potential for pest outbreaks [6]. Comprehensive analyses integrating these two factors are still limited, necessitating studies to fill this research gap and provide a holistic understanding of their combined impacts. This study aims to understand the effects of returning organic matter in the form of straw and applying insecticides with different selectivity, as well as their interactions on BPH population dynamics and their impact on beneficial insects.

2. Materials and Methods

2.1. Field study

Field research was conducted at Ciwaringin Village, Lemahabang District, Karawang Regency, West Java Province, during two different rice planting seasons: the rainy season from January to April 2022. Insect identification was performed at the Insect Biosystematics Laboratory, Department of Plant Protection, Faculty of Agriculture, IPB University.

The field testing employed a split-plot design with two main plots: fields with straw incorporation and fields without straw incorporation. Each main plot was divided into three subplots or treatments: (I1) without insecticide; (I2) with Regent 50SC insecticide, containing fipronil as a broad-spectrum insecticide at a dose of 25 g active ingredient per hectare; and (I3) with Pexalon 106SC insecticide, containing triflumezopyrim as a narrow-spectrum insecticide at a dose of 25 g active ingredient per hectare.

Five tons per hectare of straw biomass were returned to the paddy fields by spreading it after the harvest of the previous planting season. The straw was left to decompose naturally for about one month, after which the land was prepared for cultivation. The treatment plots measured 40 m² with a planting distance of 25 cm x 25 cm and had four replications. The variety used was Ciherang, one of the superior varieties resistant to rice pests (VUTW), which is widely planted in West Java.

2.2. Population observation of BPH and beneficial sampling

BPH population observations were conducted weekly by counting the number of nymphs and adults on 20 designated rice hills to determine insecticide application. The insecticide was first applied at the economic threshold level (ETL) of 5-10 BPH individuals per hill. Subsequent insecticide applications were based on weekly monitoring of the BPH population.

Samples were collected using a suction device (portable vacuum) to capture insects perching on rice plants. The suction technique was performed inside a plastic cage measuring 1 m x 1 m x 1.5 m high, placed at 5 points in each plot. In addition to the suction device, insect netting was used by swinging the net three times in each plot. Insects and spiders were sampled six times in one season, at 2, 4, 6, 8, 10, and 12 weeks after transplanting (WAT).

2.3. Data Analysis

Daily weather observations, including rainfall, temperature, and humidity, were obtained from the Environmental Monitoring System. Data collection was conducted from planting to harvest. The data were processed using Microsoft Excel 2019 and Statistical Tools for Agricultural Research (STAR) 2.0.1 for Analysis of Variance (ANOVA). Treatments that showed significant differences were further analyzed using the Least Significant Difference (LSD) test at a significance level of 0.05.

3. Results and Discussion

The recorded data indicate that the study was conducted under moderate rainfall conditions (>100 mm per month), with daily temperature and humidity remaining relatively stable. The average daily temperature was recorded at 29.5°C, with a minimum of 24.3°C and a maximum of 36.5°C. Meanwhile, the average daily humidity was recorded at 78.2%, with a minimum of 62.5% and a maximum of 97.9%. The first insecticide application in this study was done simultaneously; fipronil insecticide was applied three times in each season: at 3, 6, and 10 WAT, whereas triflumezopyrim insecticide was only applied once throughout the season, at 3 WAT (figure 1).

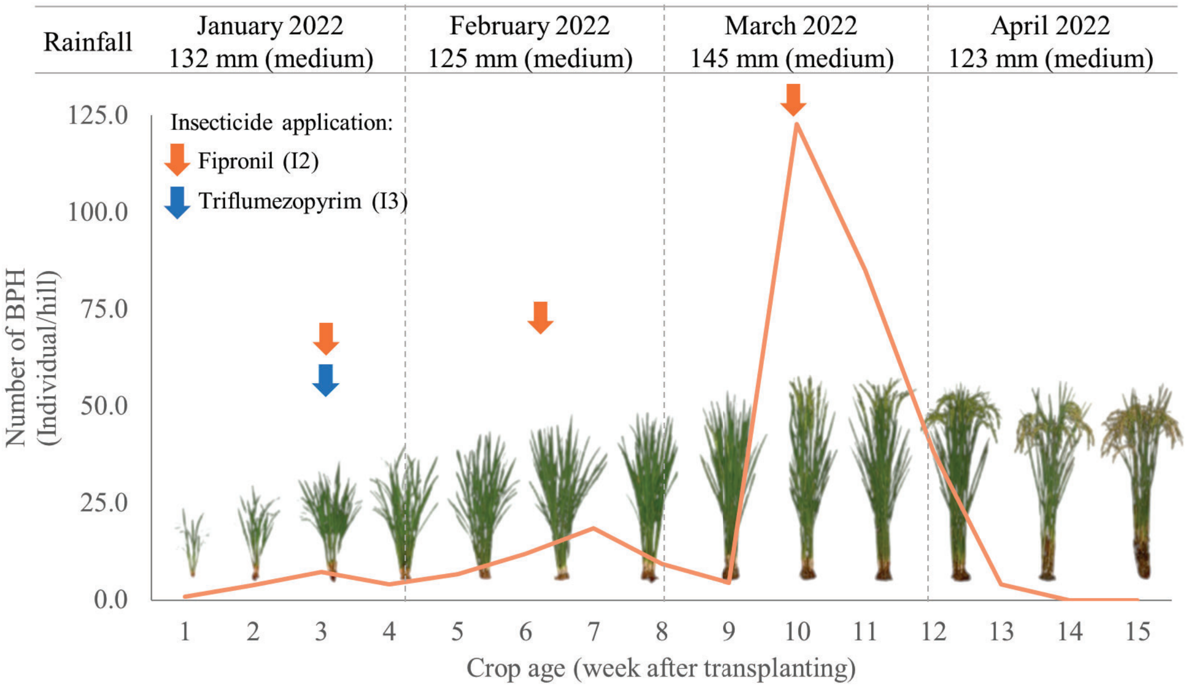

Figure 1. Population of BPH in untreated plots, rainfall category, and the timing of application of each insecticide

The BPH population was first observed at 2 WAT and reached its peak abundance during the second generation at 10 WAT (Figure 2). During this period, most of the BPH found were macropterous adults actively migrating to other areas. Plots with straw incorporation generally had a lower number of BPH, although the difference was not statistically significant compared to plots without straw incorporation. Insecticide treatments had a highly significant impact on BPH abundance. Plots treated with triflumezopyrim showed significantly lower BPH populations compared to those treated with fipronil.

Despite being applied three times in this study, fipronil insecticide did not demonstrate good efficacy against BPH. Fipronil is known for its contact toxicity and good residual effects; however, these effects often negatively impact various predators and parasitoids within the rice ecosystem [8]. In contrast, triflumezopyrim, even when applied only once, showed good efficacy and long-lasting residual effects, keeping BPH populations below economic threshold levels throughout the growing season. Triflumezopyrim is a mesoionic insecticide that effectively controls BPH by inhibiting insect feeding activity and maintaining long-lasting residual activity on rice plants [9].

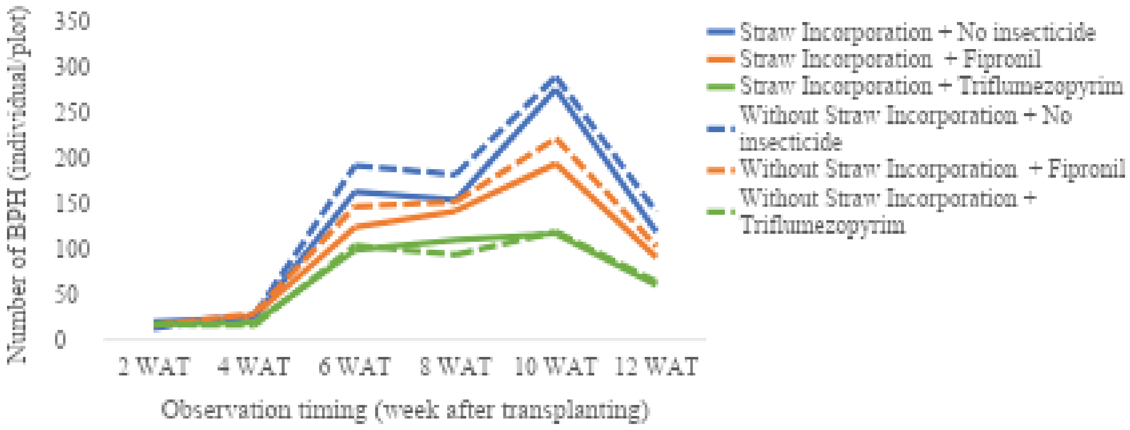

Figure 2. Abundance of BPH during growing season

Several species of predator insects and spiders commonly found in the field include the mirid bug *Cyrtorhinus lividipennis* (Hemiptera: Miridae) the hunting spider *Oxyopes* sp. (Araneae: Oxyopida), *Lycosa* sp. (Lycosidae) and the rove beetle *Paederus fuscipes* (Coleoptera: Staphylinidae), These predators are frequently reported as primary natural enemies of BPH and other major rice pests, typically preying on the eggs and nymphs of pest insects during their early instars [10]. Other predators found in this study include Coenagrionidae damselflies, *Ophionea* sp. (Coleoptera: Carabidae) and Coccinellidae beetles.

Cyrtorhinus sp. was the most dominant predator in this study, found from the beginning to the end of the observation period. The experimental results showed that, on average, its abundance was higher in plots with straw incorporation, with 26.2 individuals per plot, compared to plots without straw incorporation, which had 22.1 individuals per plot. Meanwhile, observations regarding the influence of insecticides on the number of *Cyrtorhinus* during planting seasons generally resulted in population reductions. The abundance of *Cyrtorhinus* in treatments with the triflumezopyrim active ingredient insecticide application (I3) was the lowest compared to the other two treatments, namely treatments I1 and I2. The low abundance of predatory insects and spiders in plots treated with triflumezopyrim insecticide may be due to the low number of BPH as their prey. However, further investigation is needed to prove the correlation between prey and predator abundance in the field, considering triflumezopyrim is a narrow-spectrum and selective insecticide.

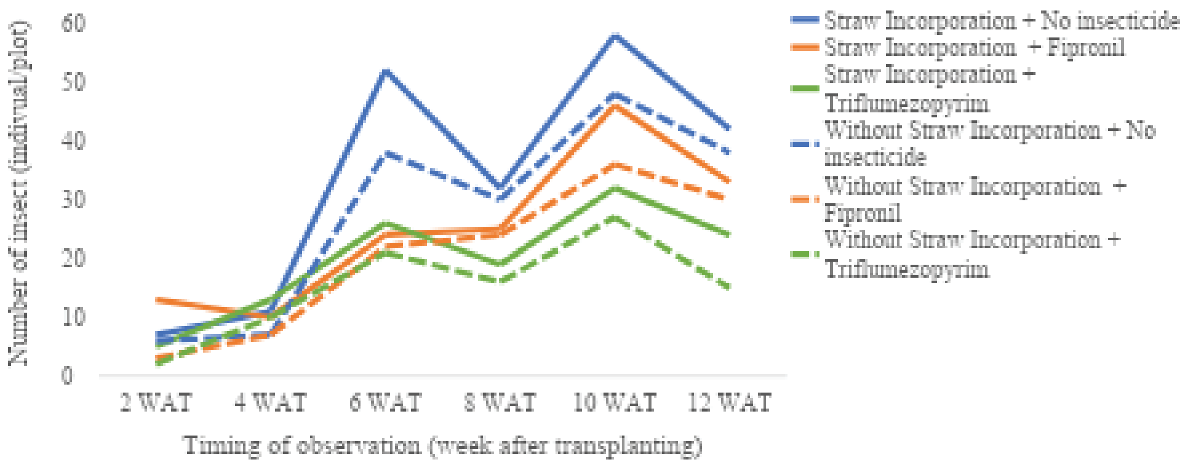

Figure 3. Abundance of *Cyrtorhinus* sp. during growing season

The predator *Cyrtorhinus* sp. generally preys on the eggs and early instar nymphs of BPH, but its population is greatly influenced by the presence of BPH as its primary prey. Its abundance will decrease as the prey population declines due to insecticide application [11]. Triflumezopyrim was found to be harmless to *Cyrtorhinus lividipennis*, and it is considered safer than thiamethoxam, chlorpyrifos, and abamectin [14]. Another study showed that insecticides like buprofezin mixed with fipronil resulted in a significant reduction in the population of *Cyrtorhinus* sp. in the field [13].

Spiders are the second most abundant predators after *Cyrtorhinus* sp., In this study, two commonly found species were *Oxyopes* sp. and *Lycosa* sp. Spiders were frequently observed from the early planting season up to 6 WAT then declined after 8 WAT (Figure 4). Generally, the average abundance of these predators was higher in plots with straw incorporation, with 12.2 individuals per plot compared to 11.1 individuals per plot in plots without straw incorporation. Although insecticide application numerically reduced spider populations, there was no significant difference between fipronil and triflumezopyrim.

Spiders, while being primary predators of BPH, can also prey on other insects, including both pests and neutral insects [14]. Several group 4 insecticides, including imidacloprid, thiacloprid, dinotefuran, and triflumezopyrim, have shown a reduction in spider populations in China [15]. Studies in Indonesia indicate that some commonly used insecticides by farmers, such as fipronil, imidacloprid, dinotefuran, and pymetrozine, do not significantly affect spider population reduction in the field [13].

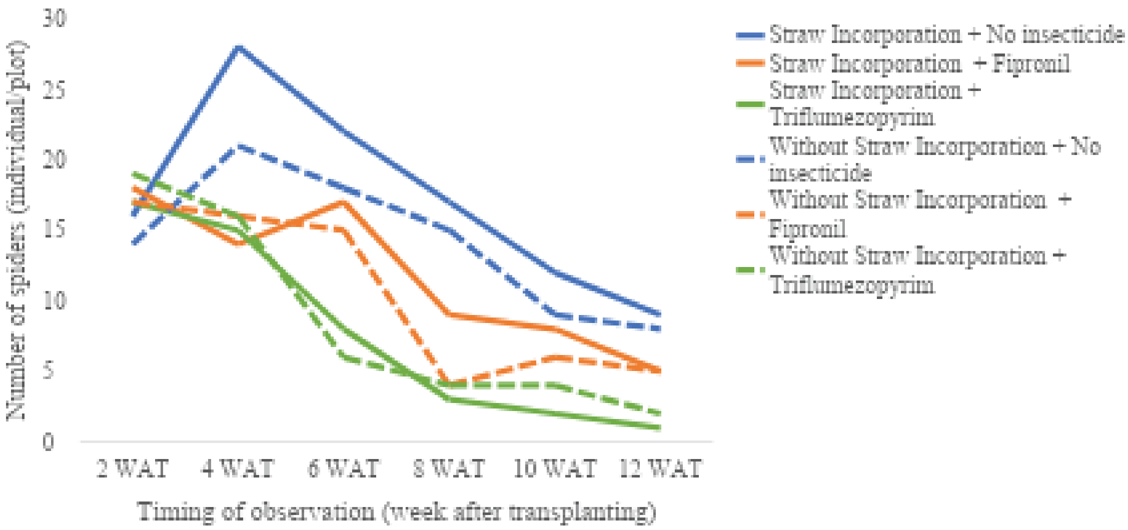

Figure 4. Abundance of spiders during growing season

In this experiment, the abundance of *Paederus* sp. was first observed at 6 and increased along with the rise in BPH populations (figure 5). Generally, the population of Paederus was higher in plots with straw incorporation, averaging 5.1 individuals per plot, compared to plots without straw incorporation, which averaged 3.5 individuals per plot. Insecticide application resulted in a reduction of Paederus abundance, but there was no significant difference between fipronil and triflumezopyrim. *Paederus* sp. is a predator that can prey on the nymphs and adults of several planthopper species, including BPH, green leafhoppers, and zigzag leafhoppers [16]. The application of several insecticides, including fipronil, imidacloprid, buprofezin, and pymetrozine, did not affect the *Paederus fuscipes* population in the field [13].

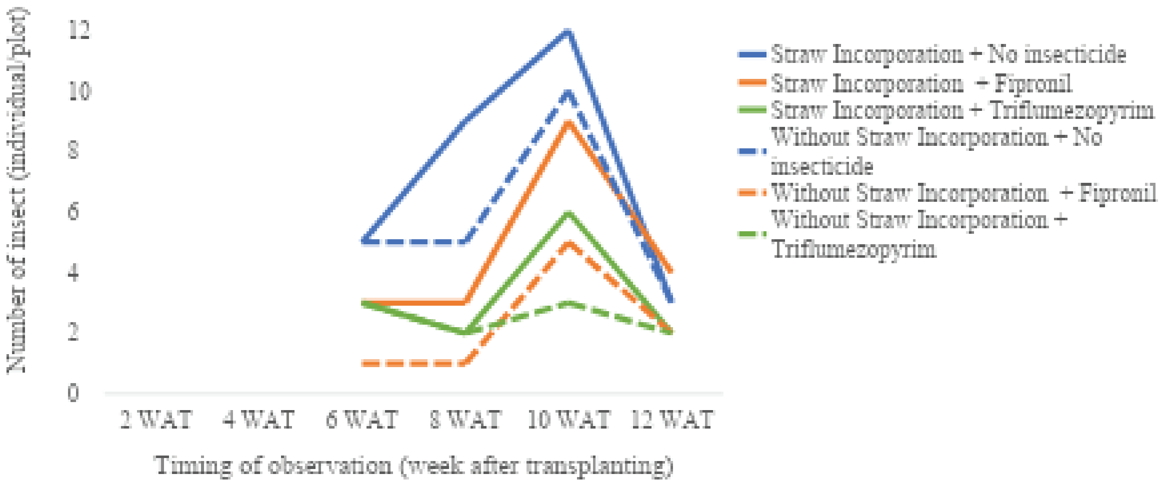

Figure 5. Abundance of *Paederus* sp. during the growing season

In this study, several parasitoid species were found, including *Anagrus* sp., which is a BPH egg parasitoid, as well as *Tetrastichus* sp. and *Telenomus* sp., which are typically known as parasitoids of rice stem borers. The incorporation of straw also positively influences parasitoid insects and shows a significant difference in abundance compared to plots without straw incorporation. On average, there were 16.2 parasitoid individuals per plot in the straw incorporation plots, while in plots without straw incorporation, the abundance of parasitoid insects was recorded at 11.8 individuals per plot. Meanwhile, insecticide applications significantly affect the reduction of parasitoid populations (figure 6). Fipronil insecticide results in a higher decrease in parasitoids compared to triflumezopyrim insecticide, attributed to the distinct characteristics of fipronil and triflumezopyrim. Fipronil is a broad-spectrum insecticide, also has contact and longer residual effect thus exerting a higher impact on non-pest insects, including parasitoids [8] Several insecticides commonly used in the field for BPH control, such as fipronil, thiamethoxam, nitenpyram, and abamectin, are known to have negative effects on parasitoids living on rice plants [17]. Another experiment showed that triflumezopyrim has no harmful effects on the parasitoid Anagrus nilaparvatae when used according to the recommended dosage [12].

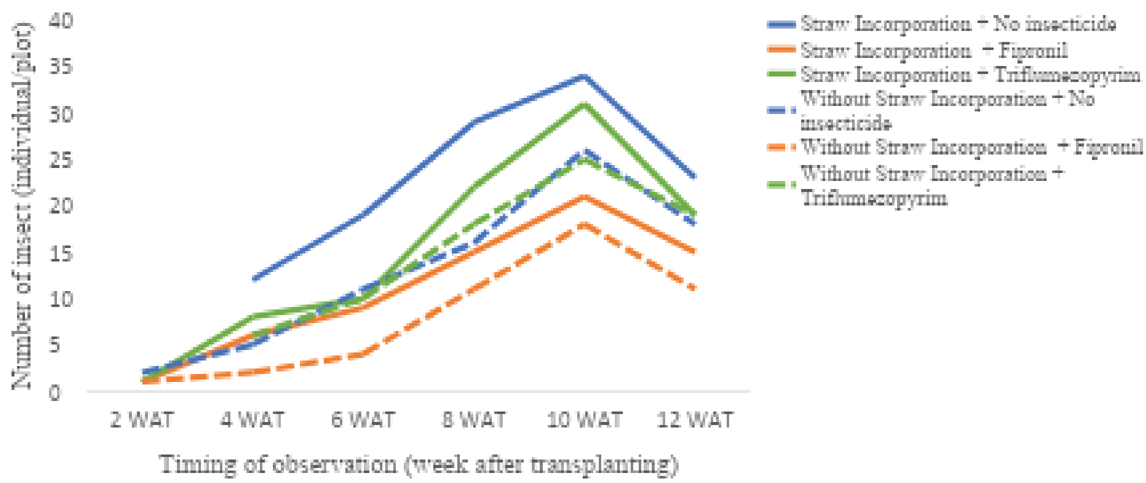

Figure 6. Abundance of parasitoids. during the growing season

4. Conclusions

The practice of incorporating straw into the soil yields positive responses by promoting an increase in natural enemies. However, incorporating straw does not notably contribute to reducing BPH pest populations. On the other hand, insecticide applications strongly influence BPH population dynamics and protect plants against BPH infestation. In particular, narrow-spectrum insecticide applications, such as triflumezopyrim, offer more effective protection against BPH than fipronil. Triflumezopyrim is relatively safe for BPH's main predators and parasitoids, while fipronil is relatively safe for spiders and Paederus but less safe for Cyrtorhinus and parasitoids. Notably, the efficacy of narrow-spectrum insecticides in controlling BPH populations remains significant across both treatment plots (with and without straw) and is not directly influenced by other biotic factors.

To strengthen similar research in the future, it is necessary to observe the initial population of natural enemies before insecticide application and continue with observations after insecticide application over a certain period. This will provide a more detailed view of the direct effects of insecticides and minimize other factors that may influence the results.

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