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Effectiveness of biopesticides in enhancing paddy growth for yield improvement

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ABSTRACT

There is an urgent need to enhance the productivity of irrigated paddy fields to increase the rice production that meets population growth. The focus of this study is to investigate the effectiveness of biopesticides in enhancing the paddy growth for yield improvement after controlling the pest and rice diseases. This study aims to determine either one or two types of biopesticides should be used in paddy cultivation. Thus, three conditions were adopted in paddy cultivation at the insect house as follows; T1 where the paddy was sprayed using BV500WS and BV612EC to study the effectiveness of the biopesticides, T2 where the paddy was sprayed using BV500WS only and C1 where the paddy was cultivated following the conventional technique as a control. BV500WS was sprayed into T1 and T2 on the first day of paddy growth while BV612EC was sprayed later into T1, at 55 and 67 days of paddy cultivation a week after releasing the brown planthopper (BPH). Based on the analysis of correlation obtained for each growth, application of BV500WS and BV612EC of T1 resulted in better performance in terms of height of plant, number of tillers, width of leaves, and number of leaves compared to T2 and C1. The excellence performance of plant growth at T1 produced the highest paddy yield of 2304.20 ± 491.42 g^{-2}, while T2 produced comparable yield as C1 which are 663.88 ± 128.41 g^{-2} and 665.42 ± 183.30 g^{-2} respectively. Hence, organic plants based biopesticides are successful in enhancing the plant growth of paddy and ultimately increase the paddy yield.

1. Introduction

Malaysia warm and humid climate attracts a number of pests and rice diseases that severely reduce the productivity and yield of paddy fields. Approximately over 800 herbivore insect species inhabit the ecosystem. Thus, there is an urgent need to enhance the productivity of irrigated paddy fields in order to increase the production of rice to meet the population growth (Prabhu, 2010). In addition, the brown planthopper (BPH) also causes serious damage to the rice by sucking rice sap, ovipositing in the rice tissues and transmitting rice diseases, especially during tillering stage thus causing less production (Zakaria et al., 2016; Xiaolei Zhang et al., 2016). Rice diseases like bacterial blight (BB), leaf blast, brown spot and sheath blight frequently affected the paddy growth and yield. BB, caused by Xanthomonas oryzaepv. oryzae (Xoo), caused yield reductions of 20–50% at the tiller stage in severe cases; while rice blast, caused by the fungal pathogen Magnaporthe oryzae, is responsible for large yield losses (Ni et al., 2015; Kim et al., 2015; Ji Zhi-juan et al., 2016).

Besides, there is a growing interest worldwide in alternative agricultural practices that can help farmers reduce their dependence on synthetic fertilizers and pesticides. The excessive use and misuse of the synthetic chemicals have raised serious questions regarding their long-term effects on human health, soil quality, and the environment (Ephraums, 1990; Samy et al., 1995).

For the improvement of grain yield, the knowledge of the association between grain yield and its component characters such as number of effective tillers per plant, plant height, and number of grains per panicle will be helpful (Lakshmi et al., 2014). The relative contribution of different traits on yield determination can be explained by correlation studies. The existence of correlation is attributed to the

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environmental effect or genetic effect of genes such as grain yield in rice, is significantly correlated with total tillers, flag leaf length, flag leaf width, number and grain weight (Ranawake et al., 2014).

Biopesticides are employed in agricultural uses to control the insect, disease, nematode and weed. They also can improve plant physiology and productivity. As biopesticides commonly are biodegradable, they are able to decompose quickly and do not negatively impact surface water and groundwater (Alliance, 2015). The BV500WS, which has high azadirachtin (A + B) content with proprietary water soluble concentrates is formulated for root feeding, drip and foliar for crop protection and growth enhancement (Okada Ecotech, 2014). Santos, M.S. also reported that azadiracthin which can be found abundantly in neem has high insecticide and rapid degradation in the environment (Santos et al., 2015). Besides that, BV612EC is a series of environmental friendly insecticidal formulations based on a unique and extremely safe active ingredient known as Etofenprox. It has high insecticidal activities which provide a very quick killing action against a broad spectrum of crop insect pests including lepidoptera, hemiptera, coleopteran, diptera and orthoptera, and yet has remarkably weak toxicity to mammals (Okada Ecotech, 2014). Moreover, Etofenprox was reported to be highly toxic to the insect including BPH but relatively safe to non-target organisms (Xiaolei Zhang et al., 2016; Trisyono et al., 2017).

The main focus of the study is to determine either one or two types of biopesticides should be used in paddy cultivation to control the pest and reduce the rice diseases for enhancing the paddy growth for yield improvement. This research also aimed to study the efficacy of new biopesticides in playing their roles as crop protection and growth enhancement for BV500WS and as insecticide for BV612EC in paddy cultivation. The correlation study on paddy growth and development were carried out at every stage of cultivation by focusing on plant height, number of tillers, number of leaves, and width of leaves. The efficacy of biopesticides was evaluated by analyzing the yield components using analysis of variance (ANOVA) during the harvesting stage.

2. Material and method

2.1. Experimental site

The experimental site was located at Plant Biosecurity Unit of Agriculture Department, Titi Serong, Parit Buntar, Perak, Malaysia.

2.2. Insect house experiment

BV500WS and BV612EC were obtained from Bio-X Techno Sdn. Bhd. as a part of collaborative research. The application of BV 500WS is for crop protection and growth enhancement at the early stage of cultivation while BV612EC as insecticide to protect the paddy during pest infestation (Okada Ecotech, 2014). Three conditions were adopted in paddy cultivation at the insect house as follows which are T1 where the paddy was sprayed using BV500WS and BV612EC to study the effectiveness of both types of biopesticides, T2 where the paddy was sprayed using BV500WS only and C1 where the paddy was cultivated following the conventional technique as a control. Three different conditions with five replications each were performed in the Insect House.

All pots (9 cm diameter) were filled with 15 cm depth of soil collected from paddy field at the Rice of Excellence Centre of Agriculture Department, Titi Serong, Parit Buntar, Perak, Malaysia.

2.2.1. Cultivation of paddy

The rice variety of MR 219 has been used in this experiment. The seeds for T1 and T2 were immersed in the BV500WS solution with ratio of 1:1000 to the purified water while the seeds for C1 were immersed in purified water only. All the seeds were immersed for 24 h before filtered. All the floated seeds were eliminated. Then, the seeds were dried under room temperature for another 24 h before seedling in the pot. The remaining water was used to spray in the pot during cultivation.

Only the growing seeds were selected to be planted in the pots. The seeds were sowed in the pots by adopting the paddy transplantation cultivation. The BV500WS solution was diluted in the remaining water with ratio of 1:2500 and was sprayed onto the T1 and T2. While the C1 were sprayed with the balance purified water from the curing process. The BV612EC was applied onto T1 only during 55 and 67 days of cultivation which is a week after the BPH population was released onto the paddy plants of T1 and T2. The BPH were not released to C1 as to maintain the standard cultivation and to study how the BPH infest the paddy naturally.

2.2.2. Paddy growth development

The plant growths were observed in every cultivation stage. The observation was focused on plant diseases, color of leaves, weeds and pest problems. In addition, the correlation study of paddy growth was also conducted by taking record on the plant height, number of tillers, number of leaves, and width of leaves of all samples. The stages of paddy cultivation are as per stated below (Malaysia and Padi, 2008):

- Stage 1: Plantation Day 1–5 days)
- Stage 2: Tillering Stage 15–40 days)
- Stage 3: Panicle Initiation Stage 40–69 days)
- Stage 4: Heading Stage 70–89 days)
- Stage 5: Ripening Stage 90–104 days)
- Stage 6: Harvest Stage 105–112 days)

2.3. One way ANOVA analysis

One way ANOVA is used to determine whether there are any statistically significant differences between T1, T2 and C1. The data were transformed using various algorithms so that the frequency distributions are normally distributed (Ltd, 2013).

The mean with standard error, the minimum and maximum values, and the standard deviation of all recorded data were calculated and treated using ANOVA. The degree of freedom, the F-value and P-value were obtained from the analysis.

2.3.1. Yield component calculation

$$\textbf{mass of 1000 productive spikelets}(\textbf{g}) = \frac{mass\ of\ 800\ productive\ spikelets}{800} \times 1000 \quad (1)$$

$$\textbf{acurate mass of 14\% moisture content, MC}(\textbf{g}) = \frac{100-\text{actualMC}}{86} \times [1] \quad (2)$$

$$\textbf{mass of 1 productive spikelet } (\textbf{g}) = \frac{(2)}{1000} \quad (3)$$

$$\%\ \textbf{Productives spikelets} = \frac{Total\ productive\ spikelets}{Total\ spikelets} \times 100\% \quad (4)$$

$$\textbf{Number of panicle per } \textbf{m}^2 = Total\ panicles\ \times area\ of\ sampling \quad (5)$$

$$\textbf{Gain yield } (\textbf{gm}^{-2}) = \frac{Total\ spikelets}{Total\ panicles} \times (4) \times (3) \times (5) \quad (6)$$

All calculations were performed according to standard protocol from Agriculture Department (Malaysia and Padi, 2008).

3. Results and discussion

3.1. Paddy growth observation

The observation of paddy growth is to study the effectiveness of