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Efficacy and Induce Resurgence of Insecticides Mixture Pymetrozine 50% + Acetamiprid 30 g/l to Brown Planthopper, *Nilaparvata lugens* (Stål) on Higher Initial Population in Ricefield

Baehaki SE[1,2*], Hadi Suparno[3]
[1]Indonesian Center for Rice Research (ICRR), Jl. Raya No.9, Sukamandi, Subang 14256, West Java, Indonesia
[2]Entomological Society of Indonesia, Bandung Branch, Faculty of Agriculture, Padjadjaran University, Bandung-Sumedang street Km 21-Jatinangor, West Java-Indonesia
[3]PT Royal Agro Indonesia

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***Corresponding author**
Baehaki SE

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Abstract: Research of efficacy and induce resurgence of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to brown planthopper (BPH), *Nilaparvata lugens* (Stål) on higher initial population in ricefield was carried out in the wet season 2012/2013 at Ciberes-Subang District-West Java-Indonesia. The research used randomized block design with 10 treatments and three replications. The first insecticides application on a higher population of BPH more than 4 fold of economic threshold. The results showed that all of combinations insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l a little bit effectiveness to suppress BPH with general efficacy of insecticide (GEI) were 60% as a moderately efficacy catagory. Likewise pymetrozine and acetamiprid insecticides it self little bit effectiveness to suppress BPH with the GEI were 60%. The first application of insecticide mixture to macropterous brown planthopper population at 4 fold economic threshold didn't reduce the BPH population, although the BPH in the plot treatments lower significantly different from the control treatment. The low performance of insecticides mixture due to higher initial BPH population macropterous that had laid eggs and emerged a lot of nymphs after first insecticides application, so only a small part of the nymphs are affected by the insecticides deposit. In the second and third application of insecticides mixture had reduced BPH up to under and around the economic threshold; because all BPH including nymphs are exposed by insecticides spray. All combinations of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l and it's single of both insecticides were 100% highly un-induce resurgence to BPH.
Keywords: Efficacy, induce resurgence, insecticides mixture, brown planthopper, rice.

INTRODUCTION

The brown planthopper (BPH), *Nilaparvata lugens* (Stål) as a global pest have high economic value [1] damaging the rice crops until hopperburn in China, Thailand, Vietnam, Malaysia, Indonesia, Philippines, Cambodia, India, and Pakistan [2]. Baehaki *et al*., [3] reported that BPH is one of the most economically important insects and the famous planthoppers which caused a major obstacle to increase rice production. Both nymphs and adults of BPH damaging rice crops directly by sucking the cell sap in the plant tissue which causes the plant to wilt or hopperburn [4]. In the oder hand indirectly rice damages by transmitting rice grassy stunt virus (RGSV) and rice ragged stunt virus (RRSV).

In Indonesia the BPH outbreak in the 1986 covering 61,255 ha. In 1989 began to develop integrated pest management (IPM) program in response to BPH outbreak. The IPM program occurred in the the third era between 1976-1997, with pests control through ecological philosophy approach [5]. The program has brought Indonesia to be recognized internationally by successfully developing IPM. Atfter that time the pest control technology in Indonesia became an example to neighboring countries, such as in Leyte - Philippines which have been trying to implement of IPM by involving farmer participatory research [6,7]. The IPM program is important to accelerate the dissemination and adoption process as well as to preserve and establish the technology in the farmers level. The device knowledge that must be possessed by the IPM expert either researchers or technicians, among others are ecobiology of pest, ecobiology of biotypes or strains, types of pests or dominant species, population dynamics in relation to agro-climatic and host, monitoring and forecasting, dynamics of natural enemies (predators, parasitoids, microbes etc.), and the balance of biology.

BPH control is still concentrated on insecticides. The relationship of pests and insecticides almost can't be left out, and always occur at any time, any commodities, and any place. At one time the use of insecticides to be compulsory, when the BPH population is already on the economic threshold or above economic injury level, while the other control tool are not able to reduce the BPH. These pests must be overcome properly to controlled on the 1st generation, so that after the control would be reached the population below the economic threshold. Further more spraying insecticides in the 3rd generation in the increasingly high population less successful even will fail.

BPH control by insecticides often ineffective because of the type of insecticide, time of application and incorrect dosage cause the BPH resurgence. Chelliah and Heinrichs [8] reported that field application of certain pesticides has been shown to induce resurgence of the target pests. Synthetic organic insecticides provide effective insect control, but the wider use had resulted in toxicity to natural pest enemies, toxic residues in plants and the environment, and induces to insect resistance. Resurgence of some pests after insecticide application on rice is becoming common. Such an abnormal increase of pest population after insecticide application often far exceeds the economic injury level.

Resurgence due to by changes in plant physiology and thus more desirable by BPH, or there is a stimulus of insecticide against hopper to lay eggs, feeding and hatching eggs. Wu *et al*. [9] reported that pesticide-induced susceptibility of rice to BPH and Cheng *et al*. [10] reported the genes encoding plant lipid transfer protein, lignin peroxidase, and flavonol-3-O-methyltransferenase may be important responses to the IMI-induced susceptibility of rice to BPH. The treatment of imidacloprid increase the population of *Tetranychus urticae* Koch, is not caused by the absence of natural enemies, but because changes in the plant physiology [11]. The development of IPM programs, particular in insecticides mixture the Royal Agro Indonesia will release new mixed insecticides. The objective of this research to determine efficacy and induce resurgence of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH in the rice field.

MATERIALS AND METHODS

Field efficacy study of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH, was carried out in the wet season 2012/2013 at Ciberes-Subang District-West Java-Indonesia. The trial used randomized block design with 10 treatments and three replications. Efficacy of insecticide was compared to control (untreated). The insecticides in each level doses treatments as follows (Table 1):

Table- 1. Insecticide mixture of pymetrozine 50% + acetamiprid 30 g/l. Ciberes-Subang, MP 2012/2013

code	Insecticides mixture of formulated product	Level mixture	
		Pymetrozine (kg/ha)	Acetamiprid (kg/ha)
A	Pymetrozine + Acetamiprid	0.25	1.33
B	Pymetrozine + Acetamiprid	0.25	1
C	Pymetrozine + Acetamiprid	0.25	0.67
D	Pymetrozine + Acetamiprid	0.188	1.33
E	Pymetrozine + Acetamiprid	0.125	1.33
F	Pymetrozine + Acetamiprid	0.125	0.67
G	Pymetrozine	0.25	-
H	Acetamiprid	-	1.33
M	Buprofezin	Buprofezin (2.2 kg/ha)	
N	Control	-	-

Pandanwangi rice seedling of 21 days old as susceptible variety to BPH was planted with 25cm x 25cm spacing, 2-3 seedling/hole on 8m x 5 m plot size. Fertilizers recommend were used 120 kg N/ha (Urea) and 40 kg P_2O_5 (TSP). The nitrogen fertilizer was given three times before transplanting, 25 days after transplanting (dat), and at 45 dat each for 1/3 part of nitrogen dose and all P_2O_5 was given before transplanting.

First insecticides application was done if the BPH population (adults + nymphs) upper on the economic threshold level. The insecticides dose was diluted in 500 l/ha volume of water and was sprayed on rice plot by using knapsack sprayer with cone jet nozzle. Insecticides application were repeated every 2 weeks. Observation of BPH (nymph and adult) from 30 hills with systematically sampling method per plot. Timing BPH observation on 1 and 2 weeks after every application. Calculation of efficacy and induce resurgence as follows:

Efficacy of Insecticides

The data will be analyzed by Duncan's Multiple Range Test = DMRT on 5% significance level. In the other hand efficacy of insecticides (EI) in each observation was determined by Abbot formulae (1925) [12] if the data BPH population before first application insignificant (homogenous) or use Henderson-Tilton formulae (1955) [13] if the data BPH population before first application was significant (heterogenous) in one to another plots treatments. The formulae as follow:

1. Use Abbott formula when the BPH population before first application was insignificance.

$$EI = \frac{Ca - Ta}{Ca} \times 100\%$$

EI = Efficacy of insecticides (%).
Ta = BPH population in treated plot after application
Ca = BPH population at the untreated plot alter application.

2. Use Henderson and Tilton when the population of BPH before 1st application was showed significance:

$$EI = \left(1 - \frac{Ta}{Ca} \times \frac{Cb}{Tb}\right) \times 100\%$$

EI =Efficacy of insecticide (%).
Tb =BPH population in plot treated before application.
Ta = BPH population in plot treated after application.
Cb =BPH population in untreated plot before application.
Ca =BPH population in untreated plot after application.

The EI as partially efficacy of insecticides (PEI) more than 50% in each observation can be acceptable by Indonesian Commission of Insecticide (ICI). The acceptable PEI depend on ICI, may be some times more than 60% can be acceptable. To determine the efficacy of all observations (N) in one experiment was done with the calculation of General efficacy of insecticide (GEI) as follows:

$$GEI = \frac{\sum_{i=1}^{n} PEI>50\%}{N} \times 100\%$$

Where i = 1, ……….n obsevation which the PEI more than 50% , N= number of observation in one research or one season. Criteria to determine the efficacy of insecticides on BPH are GEI <25% the lowest efficacy, GEI >25-50% lower efficacy, GEI >50-60% =moderately efficacy, GEI >60-75% = higher efficacy, GEI >75-100 % the highest efficacy.

Induce Resurgence of Insecticides

Criteria of BPH resurgence due to insecticides based on LSD (least significant differences) are taken from the analysis of variance (ANOVA) with a probability of 10% and 20% for the resurgence and tend resurgence respectively.

The formula for calculating the LSD value at a certain level of significance as follows: $LSD_{10} = [t_{0.1\ (dfe)}]\ [\sqrt{(2MSE/r)}]$ and The $LSD_{20} = [t_{0.2\ (dfe)}]\ [\sqrt{(2MSE/r)}]$, where t is a tabular value of the α (10 and 20%) level of significance and with the degree of freedom of error (dfe) (distribution table of t probability), MSE is mean square of error from anova, and r is a number of replication [14]. LSD value to distinguish the BPH population on treatment (W_t) and BPH population of in controls (W_c), are determined with 6 rules as follows:

a. Rule 1: In the case the number of BPH in treatment (W_t) subtracted by BPH number in the control (W_c) is positive, the determination of the induce resurgence of insecticides should be continued to calculate with a probability test. If W_t-W_c ≥ P(10%) (=LSD_{10}), it means the insecticide had induced resurgence to BPH [15].
b. Rule 2: When the number of BPH on treatment (W_t) subtracted by the number BPH in control (W_c) is negative, it can be concluded that insecticide didn't induce resurgence to BPH [15].
c. Rule 3: If W_t-W_c is higher than P = 20% (= LSD_{20}), but lower than P (10%) (= LSD_{10}) in other words P(20%) (= LSD_{20}) <W_t-W_c< P (10%) (= LSD_{10}) that mean the insecticides tends to be induce resurgence [16].
d. Rule 4: If the BPH population in treatments (W_t) is higher than the BPH population in controls + LSD_{10} namely W_t> (W_c + LSD_{10}), it mean the insecticide had induced resurgence to BPH [15].
e. Rule 5: If the population BPH in treatments (W_t) is higher than the population of BPH in controls (W_k) + LSD20, but lower than the population of BPH in controls (W_c) + LSD_{10} in other words (W_c + LSD_{20}) <W_t <(W_c + LSD_{10}), that mean the insecticides tends to be induce resurgence.
f. Rule 6: To determine induce resurgence of insecticide from all observations (N) in one experiment was done by calculating general un-induce resurgence (GUR) as follows:

$$GUR = \frac{\sum_{i=1}^{n} UR}{N} \times 100\%$$

Where i = 1,2,3…….n obsevation which the un-induce resurgence (UR), N= number of observation in one research. Criteria to determine induce resurgence insecticide BPH to are GUR <25% highly induce resurgence, GUR >25-50 % induce resurgence, GUR >50-60 % = moderately un-induce resurgence, GUR >60-75% = un-induce resurgence, GUR >75-100 % highly un-induce resurgence.

Population increases were due to primarily to increased BPH feeding and reproductive rates, reduced nymphal periods, enhanced adult life, and killing of predators [17], but in here the induce resurgence of insecticide to BPH was measured only on the increase and decrease BPH population as above explanation.

RESULTS AND DISCUSSIONS

Efficacy of insecticides

The BPH population in the beginning observation of all plots treatment, before application was not significant different one to another. So in the future for determine efficacy insecticide value (EI) used Abbott formula. The average BPH population is 1107.4 macropterous/30 hills (= 36.9 BPH/hill). BPH population higher than 4 fold economic thresholds (ET) that was declared ET in vegetatif stage was 9 BPH/hill and in generative stage was 18 BPH/hill if the price of rice grains was US $0.1/kg [18]. The decision making for all plots was spayed by insecticides mixture of Pymetrozine 50% + Acetamiprid 30 g/l.

The observation on 1 MAA-1, the BPH population on all plots treatments of insecticides mixture pymetrozine 50% + acetamiprid 30 g/l did not different one to another, but BPH on all plots insecticide treatments were different and lower than untreated plot (Table 2). The insecticide efficacy values (EI) was still lower than 50%. In the other hand also the buprofezin (2.2) treatments showed EI value indicates lower than 50%.

Table- 2: Effect of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH on 1 weeks after application-1

Combination of formulated product (kg/ha+kg/ha)	BPH population/30 hills		EI (%)	W_t-W_c	LR
	Before application	1 WAA-1			
Pymetrozine 0.25+ Acetamiprid 1.33	1061 a	16441 b	37.0	-9669	UR
Pymetrozine 0.25+ Acetamiprid 1	1055 a	13745 b	47.4	-12365	UR
Pymetrozine 0.25+ Acetamiprid 0.67	1057 a	17052 b	34.7	-9058	UR
Pymetrozine 0.188+ Acetamiprid 1.33	1053 a	16387 b	37.2	-9723	UR
Pymetrozine 0.125+ Acetamiprid 1.33	1154 a	16583 b	36.5	-9527	UR
Pymetrozine 0.125+ Acetamiprid 0.67	1081 a	14977 b	42.6	-11133	UR
Pymetrozine 0.25	1174 a	15251 b	41.6	-10859	UR
Acetamiprid 1.33	1153 a	18000 b	31.1	-8110	UR
Buprofezine2.2	1121 a	17346 b	33.6	-8764	UR
Control	1165 a	26110 a	0.0	0	-

Remarks: Mean values in each column followed by the same letter are not significantly different at the 5% level base on DMRT for efficacy, whereas level 10% dan 20% for resurgensi and tend resurgence. EI= Efficacy of insecticide, LR= Level of Resurgence, R= induce resurgence, UR= un-induce resurgence. LSD_{10} = 5776.6, LSD_{20} = 4452.7.

The observation on 2 MAA-1, the BPH population on all plot treatments of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l did not different one to another, but BPH on all plot insecticide treatments was different and lower than untreated plot (Table 3). The insecticide efficacy values (EI) was still lower than 50%. In the other hand Buprofezine (2.2) treatments show EI value indicates lower than 50%.

Tabel-3: Effect of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH on 2 weeks after application-1

Combination of Formulated product (kg/ha+kg/ha)	BPH population/30 hills on 2 WAA-1	EI (%)	W_t-W_c	LR
Pymetrozine 0.25+ Acetamiprid 1.33	18238 b	34.7	-9675	UR
Pymetrozine 0.25+ Acetamiprid 1	14400 b	48.4	-13513	UR
Pymetrozine 0.25+ Acetamiprid 0.67	17359 b	37.8	-10554	UR
Pymetrozine 0.188+ Acetamiprid 1.33	14167 b	49.2	-13746	UR
Pymetrozine 0.125+ Acetamiprid 1.33	17246 b	38.2	-10667	UR
Pymetrozine 0.125+ Acetamiprid 0.67	17324 b	37.9	-10589	UR
Pymetrozine 0.25	16213 b	41.9	-11700	UR
Acetamiprid 1.33	17462 b	37.4	-10451	UR
Buprofezin 2.2	14225 b	49.0	-13688	UR
Control	27913 a	0.0	0	-

Remarks: Mean values in each column followed by the same letter are not significantly different at the 5% level base on DMRT for efficacy, whereas level 10% dan 20% for resurgensi and tend resurgence. EI= Efficacy of insecticide, LR= Level of Resurgence, R= induce resurgence, UR= un-induce resurgence. LSD_{10} = 3717.0, LSD_{20} = 2865.1.

After first insecticides application, in observations 1 WAA-1 and 2 WAA-1 the BPH population higher than BPH population before treatments (initial BPH population) up to the BPH population increasingly beyond EIL (Fig.1). So the application of insecticides mixture of pymetrozine 50% + acetamiprid 30 g / l and it's single insecticides didn't reduce BPH population from the initial population, although the BPH population in the insecticides treatments lower than on control. The BPH population increasingly beyond EIL due to:

- The initial BPH was higher than four fold of ET, and then the BPH population of macropterous had laid eggs and emerged a lot of nymphs after first application.
- The nymphs appear after the application, so the insecticide is not directly contact the body of BPH nymphs
- By the time the nymphs come out of the egg shell only a small part of the nymphs die from contact with the insecticidal deposit, but most of the nymphs develop as well.
- The egg period of BPH is only 9 days, so at 2 weeks after first application can be confirmed all the nymphs have been out of the egg shell or all eggs have hatched.
- At the second insecticide application (done 2 weeks after the first application) all BPH including nymphs are exposed to insecticide solution spray. Therefore, although the presence of nymphs above EIL in plots treatments can be reduced up to below the economic threshold, as will be explained later.

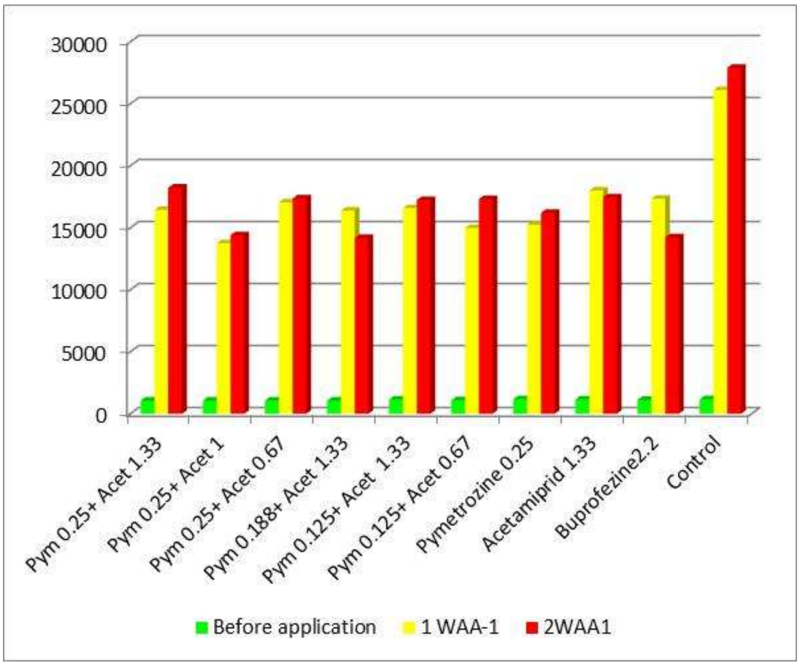

Fig-1: BPH population growth after first insecticides application, increasing up to more than EIL. Pym = pymetrozine, Aset = acetamiprid.

The observation on 1 MAA-2, the BPH population on all plot treatments of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l did not different one to another, but BPH on all plots insecticide treatments was different and lower than untreated plot (Table 4).

The insecticide efficacy values (EI) was higher more than 98%. In the other hand also buprofezine (2.2) treatments showed EI value indicates more than 97%.

The observation on 2 MAA-2, the BPH population on all plot treatments of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l did not different one to another, but BPH on all plot insecticide treatments were different and lower than untreated plot (Table 5).

The insecticide efficacy values (EI) was higher more than 88%. In the other hand also buprofezine (2.2) treatments showed EI value indicates more than 97%.

Table-4: Effect of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH on 1 weeks after application-2

Combination of Formulated product (kg/ha+kg/ha)	BPH population /30 hills on 1 WAA-2	EI (%)	W_t-W_c	LR
Pymetrozine 0.25+ Acetamiprid 1.33	154 d	99.2	-20137	UR
Pymetrozine 0.25+ Acetamiprid 1	145 d	99.3	-20146	UR
Pymetrozine 0.25+ Acetamiprid 0.67	122 d	99.4	-20169	UR
Pymetrozine 0.188+ Acetamiprid 1.33	66 d	99.7	-20225	UR
Pymetrozine 0.125+ Acetamiprid 1.33	444 cd	97.8	-19847	UR
Pymetrozine 0.125+ Acetamiprid 0.67	25 d	99.9	-20266	UR
Pymetrozine 0.25	161 d	99.2	-20130	UR
Acetamiprid 1.33	618 cd	97.0	-19673	UR
Buprofezin 2.2	469 cd	97.7	-19822	UR
Control	20291 a	0.0	0	-

Remarks: Mean values in each column followed by the same letter are not significantly different at the 5% level base on DMRT for efficacy, whereas level 10% dan 20% for resurgensi and tend resurgence. EI= Efficacy of insecticide, LR= Level of Resurgence, R= induce resurgence, UR= un-induce resurgence. LSD_{10} = 423.3, LSD_{20} = 326.3.

Table-5: Effect of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH on 2 weeks after application-2

Combination of Formulated product (kg/ha+kg/ha)	BPH population /30 hills on 2 WAA-2	EI (%)	W_t-W_c	LR
Pymetrozine 0.25+ Acetamiprid 1.33	209 b	98.1	-11050	UR
Pymetrozine 0.25+ Acetamiprid 1	174 b	98.5	-11085	UR
Pymetrozine 0.25+ Acetamiprid 0.67	238 b	97.9	-11021	UR
Pymetrozine 0.188+ Acetamiprid 1.33	209 b	98.1	-11050	UR
Pymetrozine 0.125+ Acetamiprid 1.33	258 b	97.7	-11001	UR
Pymetrozine 0.125+ Acetamiprid 0.67	289 b	97.4	-10970	UR
Pymetrozine 0.25	306 b	97.3	-10953	UR
Acetamiprid 1.33	378 b	96.6	-10881	UR
Buprofezin 2.2	297 b	97.4	-10962	UR
Control	11259 a	0.0	0	-

Remarks: Mean values in each column followed by the same letter are not significantly different at the 5% level base on DMRT for efficacy, whereas level 10% dan 20% for resurgensi and tend resurgence. EI= Efficacy of insecticide, LR= Level of Resurgence, R= induce resurgence, UR= un-induce resurgence. LSD_{10} = 1095.5, LSD_{20} = 844.4.

The observation on 3 MAA-1, the BPH population on all plot treatments of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l did not different one to another, but BPH on all plot insecticide treatments were different and lower than untreated plot (Table 6).

The EI was higher more than 77%. In the other hand also buprofezine (2.2) treatments showed EI value indicates more than 86%.

Table-6: Effect of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l to BPH on 1 weeks after application-3

Combination of Formulated product (kg/ha+kg/ha)	BPH population /30 hills on 1 WAA-3	EI (%)	W_t-W_c	LR
Pymetrozine 0.25+ Acetamiprid 1.33	766 bc	86.5	-4890	UR
Pymetrozine 0.25+ Acetamiprid 1	717 bc	87.3	-4939	UR
Pymetrozine 0.25+ Acetamiprid 0.67	626 c	88.9	-5030	UR
Pymetrozine 0.188+ Acetamiprid 1.33	786 bc	86.1	-4870	UR
Pymetrozine 0.125+ Acetamiprid 1.33	1264 b	77.7	-4392	UR
Pymetrozine 0.125+ Acetamiprid 0.67	751 bc	86.7	-4905	UR
Pymetrozine 0.25	613 c	89.2	-5043	UR
Acetamiprid 1.33	1020 bc	82.0	-4636	UR
Buprofezin 2.2	763 bc	86.5	-4893	UR
Control	5656 a	0.0	0	-

Remarks: Mean values in each column followed by the same letter are not significantly different at the 5% level base on DMRT for efficacy, whereas level 10% dan 20% for resurgensi and tend resurgence. EI= Efficacy of insecticide, LR= Level of Resurgence, R= induce resurgence, UR= un-induce resurgence. LSD_{10} = 436.5, LSD_{20} = 336.4.

To determine efficacy of insecticide from all observations (N) in one experiment was calculated with general efficacy insecticide (GEI). In all combinations of insecticide mixture of pymetrozine 50% + acetamiprid 30 g / l and buprofezine (2.2) had given GEI = 60%, likewise pymetrozine 0.125 and acetamiprid 0.67 with GEI were 60%. Based on the GEI, the insecticides mixture of pymetrozine 50% + acetamiprid 30 g / l include to moderately efficacy suppress populations of BPH (Table 7). This data was consequently on the first insecticides application in higher initial BPH population and abundance nymphs emergence after application.

Table-7: EI and GEI value over 50% of mixed insecticides pymetrozine 50% + acetamiprid 30 g/l to the BPH in the rice crop

Combination of Formulated product (kg/ha+kg/ha)	EI over 50% to the BPH					GEI proportions above 50% (%)
	1WAA-1	2WAA-1	1WAA-2	2WAA-2	1WAA-3	
Pymetrozine 0.25+ Acetamiprid 1.33	-	-	Yes	Yes	Yes	60
Pymetrozine 0.25+ Acetamiprid 1	-	-	Yes	Yes	Yes	60
Pymetrozine 0.25+ Acetamiprid 0.67	-	-	Yes	Yes	Yes	60
Pymetrozine 0.188+ Acetamiprid 1.33	-	-	Yes	Yes	Yes	60
Pymetrozine 0.125+ Acetamiprid 1.33	-	-	Yes	Yes	Yes	60
Pymetrozine 0.125+ Acetamiprid 0.67	-	-	Yes	Yes	Yes	60
Pymetrozine 0.25	-	-	Yes	Yes	Yes	60
Acetamiprid 1.33	-	-	Yes	Yes	Yes	60
Buprofezin 2.2	-	-	Yes	Yes	Yes	60
Control	-	-	-	-	-	-

Remarks: Criteria to determine the efficacy of insecticides on BPH are GEI <25% the lowest efficacy, GEI >25-50% lower efficacy, GEI >50-60% = moderately efficacy, GEI >60-75% = higher efficacy, GEI >75-100 % the highest efficacy.

Induce Resurgence of Insecticides

The emergence of insecticide induce resurgence to BPH can be determined of some rules as had declared in the methodology. In 1 MAA-1, had been described how to use of all rules to determine induce resurgence of insecticide to BPH, complete from rules 1-5. But calculation in the further observation will be determined to depend on W_t-W_c value only.

Rule 1. BPH population in insecticide treatment (W_t) minus by BPH on control (W_c) none of values $W_t-W_c \geq 5776.6$ (LSD_{10}). This indicated that all insecticides treatments did not induced resurgence to BPH.

Rule 2. All insecticides treatment did not tend induced resurgence because none of W_t-W_c between Wt-W_c > 4452,7 BPH (LSD_{20}) until $W_t-W_c \geq 5776.6$ BPH (LSD_{10}), because W_t-W_c were negative value.

Rule 3. If insecticides induce resurgence will be signed by W_t should exceed from the value of W_c + LSD_{10} was (26110 + 5776.6 = 31886.6 BPH.

Rule 4. The W_c + LSD_{20} was (26110 + 4452.7) = 30562.7 BPH and Wc + LSD_{10} was (26110 + 5776.6 = 31886.6 BPH. From Table 1 did not found W_t were between 30562.7 BPH <W_t <31886.6 BPH. From this data had cleared that the insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l, pymetrozine 50%, acetamiprid 30 g/l, and buprofezin (2.2) none treatments showed resurgence against BPH (Table 1).

Rule 5: The all W_t minus by W_c were negative, it can be concluded that insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l, pymetrozine 50%, acetamiprid 30 g/l, and buprofezin (2.2) did not induce resurgence to BPH.

In the other observation of 2 MAA-1, 1 MAA-2, 2 MAA-2, and 3 MAA-1 BPH population on all of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l and buprofezine (2.2) (W_t) minus by BPH population on untreated plot (W_c) were negative. According to rule 5, when the number of BPH on W_p-W_k were negative, it can be concluded insecticides tested showed no resurgence (Tabel 3,4,5, and 6).

Rule 6. The determination of induce resurgence of insecticide to BPH from all observations (N) in one experiment was calculated by general un-induce resurgence (GUR). All insecticides showed 100% GUR value, indicating all insecticides mixture highly un-induce insecticides resurgence (Table 8).

Table-8: UN and GUR value of mixed insecticides pymetrozine 50% + acetamiprid 30 g/l to the BPH in the rice crop

Combination of Formulated product (kg/ha+kg/ha)	UN insecticides to the BPH					GUR proportions (%)
	1WAA-1	2WAA-1	1WAA-2	2WAA-2	1WAA-3	
Pymetrozine 0.25+ Acetamiprid 1.33	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.25+ Acetamiprid 1	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.25+ Acetamiprid 0.67	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.188+ Acetamiprid 1.33	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.125+ Acetamiprid 1.33	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.125+ Acetamiprid 0.67	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.25	Yes	Yes	Yes	Yes	Yes	100
Acetamiprid 1.33	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 2.2	Yes	Yes	Yes	Yes	Yes	100
Control	-	-	-	-	-	-

Remarks: Criteria to determine induce resurgence insecticide BPH to are GUR <25% highly induce resurgence, GUR >25-50% induce resurgence, GUR >50-60% = moderately un-induce resurgence, GUR>60-75% = un-induce resurgence, GUR >75-100 % highly un-induce resurgence

In all combinations of insecticide mixture of pymetrozine 50% + acetamiprid 30 g/l and buprofezine (2.2) highly un-induce resurgence because GUR =100%, likewise pymetrozine 0.125 and acetamiprid 0.67 with GUR were 100%. Based on the GUR the insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l were very good didn't induce resurgence to BPH, although have been application on a higher initial BPH population than Economic threshold.

All combinations of insecticide mixture of pymetrozine 50% + acetamiprid 30 g/l that was applied to the both high population in the first application and low population in second and third application (in economic threshold) didn't induce resurgence to BPH. Likewise pymetrozine and acetamiprid insecticides it self had been able to suppress and didn't induce resurgence to BPH. The result of the research was similar to the result of Kirankumar (2016) [19] that the new insecticide pymetrozine 50 WG was tested against BPH and showed that pymetrozine 50 WG @350g a.i/ha found significantly superior during the Kharif season in Karnataka-India of both the year 2011 and 12 and it is at par with pymetrozine 50WG @400g.a.i/ha. The other results indicate that pymetrozine would be an effective alternative for the control of brown planthopper [20].

The values of relative toxicity when calculated in comparison to LC_{50} value of monocrotophos it was observed that acetamiprid, thiamethoxam, flubendamide, clothinidine and mixture of flubendamide + fipronil were less toxic than monocrotophos, whereas imidacloprid, chlorpyriphos and endosulfan were more toxic to BPH [21]. Efficacy of thiamethoxam (0.025 kg a.i./ha) was 72.23 per cent reduction over control followed by thiacloprid @ 0.12 kg a.i./ha (64.56%) and acetamiprid @ 0.020 kg a.i./ha (63.79%) which recorded more than 60 per cent reduction of BPH population over untreated control [22].

In 7 days after spraying, 25% pymetrozine WP (112.5 a.i. g/hm2), a percentage of 4:1 of 25% pymetrozine WP + 20% acetamipride SP (60 a.i. g / hm^2) had good controlling effects with 93.08% and 93.41% respectively. The controlling effect of 20% acetamipride SP (22.5 a.i. g/hm^2) alone in 7 days after spraying was 81.65% [23]. According to the toxicological data suggested that 25% pymetrozine+thiamethoxam SC is expected to a potential candidate insecticide [24].

Insecticides mixtures may offer a short-term solution to resistance problems, but it is essential to ensure that each component of a mixture belongs to a different insecticide MoA class, and that each component is used at its full ra [25]. Acetamiprid is group of 4A of neonicotinoids together with clothianidin, dinotefuran, imidacloprid, nitenpyram, thiacloprid, and thiamethoxam. Targeted acetamiprid is nicotinic acetylcholine receptor (nAChR) agonists namely nerve action, strong evidence that action at one or more of this class of protein is responsible for insecticidal effects. Mixing of Acetamiprid and pymetrozine was justified because, pymetrozine is group of 9B as pymetrozine with targeted selective homopteran feeding blockers to nerve action, target protein responsible for biological activity is unknown, or uncharacterized (IRAC, 2012) [26]. The above fact shows that pymetrozine or acetamiprid were better to control the BPH, even the mixture the two insecticides in various combinations can suppress BPH with a higher efficacy, and did not urge BPH resurgence.

CONCLUSIONS

The first insecticides application on the higher population of BPH about 4 fold of economic threshold had showed all of combinations insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l little bit effectiveness to suppress BPH with general efficacy of insecticide (GEI) were 60% as a moderately efficacy. Likewise pymetrozine and acetamiprid insecticides it self little bit effectiveness to suppress BPH with the GEI were 60%. The first application of insecticide mixture to brown plant hopper at the time of high population of macropterous, didn't reduce the BPH population although the BPH in the plot treatment significantly different from the control treatment. The low performance of insecticides mixture du to on the first insecticides application in the higher initial BPH population macropterous had laid eggs and emerged a lot of nymphs and only small part of BPH nymphs contact to insecticides deposit after application.

In the second and third application of insecticide mixture had reduced BPH up to under and around the economic threshold, because all BPH including nymphs are exposed to insecticide solution spray. All combinations of insecticides mixture of pymetrozine 50% + acetamiprid 30 g/l and single of both insecticides were 100% highly un-induce resurgence to BPH.

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REFERENCES

1. Baehaki SE, Mejaya IMJ. Wereng cokelat sebagai hama global bernilai ekonomi tinggi dan strategi pengendaliannya (Brown planthopper as a global rice pest of high economic value and control strategy). IPTEK Tanaman Pangan, 2014;9(1):1-12. Abstract in English.
2. Catindig JLA, Arida GS, Baehaki SE, Bentur JS, Cuong LQ, Norowi M, Rattanakarn W, Sriratanasak W, Xia J, Lu Z. Situation of planthoppers in Asia. In K.. Heong and B Hardy, Proc. Planthopper-New Threat to the Sustainability on Intensive Rice Production System in Asia. International Rice Research Institute, Los Baños, Philippines. 2009; 191-220.
3. Baehaki SE, Surahmat EC, Susetyo A, Senn R. Safety selected insecticides to predators and egg parasitoids of planthoppers in rice ecosystem. American Journal of Engineering Research (AJER), 2017; 6(6):174-182.
4. Baehaki SE. Dynamics of rice planthoppers (RPH) and natural enemies using yellow paper sticky trap and existence of rice stunt virus after outbreak as a buffer management to RPH control. International Journal of Entomology Research. 2017; 2(6):58-66. www.entomologyjournals.com
5. Baehaki SE, Heong KL. Impact of nutrient management on pest and yield of different rice varieties. Research Journal of Agriculture and Environmental Management, 2016; 5(7):243-252.
6. Escalada MM, Heong KL. Human and social constrain to the implementation of IPM programmes. 15th Session of the FAO/UNEP Panel of Experts on Integrated Pest Control, 31 August-4 September 1992, Rome, Italy.
7. Fujisaka S, Guino R, Medrano P, Obusan L. Establishing a farmer participatory pest management experi-ment. ARFSN-INSURF-IPM Joint Meeting, 12-17 October 1992, Ho Chi Minh City, Vietnam, 11p.
8. Chelliah S, Heinrichs EA. Factors affecting insecticideinduced resurgence of the brown planthopper, *Nilaparvata lugens* on rice. Environmental Entomology. 1980; 9:773–777.
9. Wu JC, Xu JX, Yuan SZ, Liu JL, Jiang YH, Xu JF. Pesticide-induced susceptibility of rice to brown planthopper *Nilaparvata lugens.* Entomologia Experimentalis et Applicata, 2001; 100:119–126.
10. Cheng Y, Shi ZP, Jiang LB, Ge LQ, Wu JC, Jahn GC. Possible connection between imidacloprid-induced changes in rice gene transcription profiles and susceptibility to the brown plant hopper *Nilaparvatalugens* Stål (Hemiptera:Delphacidae). Pestic. Biochem. Physiol. 2012; 102(3): 213–219.
11. James DG, Price TS. Fecundity in twospotted spider mite (Acari: Tetranychidae) is increased by direct and systemic exposure to imidacloprid. J. Econ. Entomol. 2002; 95(4):729-32.
12. Abbot WS. Method for computing the effectiveness of an insecticide. J. Econ. Entomol. 1925; 18:265-267.
13. Henderson CF, Tilton EW. Tests with acaricides against the brow wheat mite, J. Econ. Entomol., 1955; 48:157-161.
14. Gomez KA, Gomez AA. Statistical procedures for agricultural research with emphasis on rice. The International Rice Research Institute. Los Banos, Philippines. 1976; 294p.
15. Baehaki SE, Arifin K, Munawar D. Peran varietas tahan dalam menurunkan populasi wereng coklat biotipe 4 pada tanaman padi (Roles of resistance rice varieties on decreasing population of brown planthopper biotype 4). Penelitian Tanaman Pangan, 2011; 30(3):145-153.
16. Baehaki SE, Iswanto EH, and Hamzah A. Evaluasi sifat ovisidal dan nimfasidal insektisida buprofezin 100 G/L terhadap telur dan nimfa wereng coklat, *Nilaparvata Lugens* (Stal.) (Hemiptera: Delphacidae). Agrotrop, 2016; 6 (2): 90 – 104. Abstract in English.
17. Buenaflor HG, Saxena RC, Heinrichs EA. Biochemical basis of insecticide- induced brown planthopper resurgence. IRRN, 1981: 6(4):13-14
18. Baehaki SE. Strategi fundamental pengendalian Hama wereng batang coklat dalam pengamanan produksi padi nasional. Pengembangan Inovasi Pertanian (Fundamental strategy of controlling brown planthopper in securing national rice

production). Badan Penelitian dan Pengembangan Pertanian. 2011; 4(1):63-75.

19. Kirankumar R. Eficacy of pymetrozine 50 WG against brown planthopper *Nilaparvata lugens* (Stal) on paddy *Oryza sativa* L. International Journal of Plant Protection. 2016; 9(1):68-78).
20. Liu J, Zhang J, Qin X, Chen Y, Yuan F, Zhang R. Toxic Effects of pymetrozine on the brown planthopper, *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae). Journal of Entomological Science. 2013; 48(1):17-22.
21. Srivastava C, Chander S, Sinha SR, Palta RK. Toxicity of various insecticides against Delhi and Palla population of brown plant hopper (*Nilaparvata lugens).* Indian Journal of Agricultural Sciences. 2009; 79(12):1003–1006.
22. Shashank PR, Mallikarjuna J, Chalam MSV, Madhumathi T. Efficacy of new insecticide molecules against leaf hoppers and plant hoppers in rice (*Oryza sativa* L.). International Journal Of Plant Protection. 2012; 5(2):397-400.
23. Zhang XL, Feng Z, Xing ZF, Hong LJ. Controlling effects of mixture of pymetrozine and acetamipride on *Nilaparvata lugens*. Hubei Agricultural Sciences, http://en.cnki.com.cn/Article_en/CJFDTOTAL-HBNY20. Accessed, 2013.
24. Chen Z, Bai S, Wang Z, Zeng S, Zhu F, Zhuang JX, Guo R, Hu D. Study on twenty-five percent pymetrozine-thiamethoxam suspension concentrate as an insecticide against rice planthopper. African Journal of Agricultural Research. 2012; 7(33):4627-4633.
25. IRAC. IRAC Mode of Action Classification Scheme. Issued, 2016; 8(1):1-26.
26. IRAC. IRAC Mode of Action Classification Scheme. Issued, 2012; 7(2):1-23.