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Efficacy and induce resurgence of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% to brown planthopper, *Nilaparvata lugens* (Stål) on higher initial population in the ricefield

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Abstract
Efficacy and induce resurgence research of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% to brown planthopper, *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 trial 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 insecticides mixture of buprofezin 100 g/l + pymetrozine 50% was highly efficacy to reduce BPH, although was sprayed in higher population or in the population is being increased development. The general efficacy of insecticide (GEI) of insecticide mixture in all combination were 80-100% as a highly efficacy. In the other hand both buprofezin and pymetrozine insecticides it self had been able to reduce BPH, but the GEI were 60% as moderately efficacy. Base on general un-induce resurgence (GUR), all combinations of insecticides mixture of buprofezin 100 g/l + pymetrozine 50%, buprofezin and pymetrozine showed GUR=100% as highly un-induce resurgence category to the BPH.

Keywords: efficacy, induce resurgence, insecticides mixture, brown planthopper, rice

1. Introduction

The Brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) is a famous pest on rice, which caused a major problem of rice production in the Asian country. BPH destroyed rice crops every year in several hectare up to hundreds thousand hectares of rice plantation and almost did not be stopped, especially in the damage level up to hopperburn. Rice plant damage on 1960-1970 decade reached 52,000 ha and on 1970-1980 decade was 2,510,680 ha. Since 1981-1990 was recorded only 54,770 ha rice damage and on 1991-2000 decade reached 250,000 ha. In the decade 2001-2010, BPH had attacked about 360,778 ha and among of them about of 11,372 ha was hopperburn. Almost in a half decade of 2011 to 2020 rice plant attacked by BPH was 445,594 ha**.** Among of yearly damage, the BPH have outbreak rhythm in every 12 years occurred in 1986, 1998, and 2010 had destroyed about 61,255; 115,484 and 137,768 ha respectively [1].

In Indonesia the BPH was called as executive-major rice pest [2], because in the history of the BPH outbreak was always followed by a Presidential Instruction No. 3 in 1986 that banded 57 insecticides formula and at the BPH outbreak in 2010 followed by Presidential Instruction No. 5 in 2011 which one of the content was a rules to help farmers whose their rice crops damaged by BPH. Jena *et al*., 2006 [3] called this BPH as one of the most destructive phloem-sap-sucking insect pest of tropical and temperate rice in Asia. The BPH as r-strategic insect has be able change to new biotype rapidly which are capable to breakdown rice varieties that resistant previously. Based on this fact will be more difficulty to BPH control, and therefore is required how to manage this insect.

From the data above, the BPH as a latent pest and very difficult to be reduced up to below of economic threshold, because the BPH have unique characteristic. Baehaki (2007) [4] reported the characteristic of BPH as follows: a) the BPH as a r-strategic pest that have exponential development, b) the BPH as a small insect pest, quickly development, used source of food in the short time before competition with the another pests, c) the BPH quickly dispersal to find out new habitat before the old habitat useless, to escape from the catastrophic, d) BPH development as a biological clock pattern, because BPH will be developed at dry and wet season depend on the environment proverb on both wet and dry season especially increased in La Nina (dry season with more precipitation), e) the BPH be able to weakness insecticides that good efficacy previously, f) the BPH as a latent pest be able outbreak any times, g) the BPH as the vector for ragged stunt virus (RSV) and grassy stunt virus (GST), h) BPH with high genetic plasticity, easy changed to new biotype, especially if the BPH against monogenic (vertical) rice resistance compared to polygenic (horizontal) rice resistance, and i) the BPH as a miracle pest is easy to integrated with various environment.

The priority of BPH control use the agronomic technique among of this technique had planted resistance rice varieties. In the other hand insecticides was used only if the BPH population reach to economic threshold, although some times did not effective to reduce BPH in the field due to some case. To complement insecticide in the field the Royal Agro Indonesia will release new mixed insecticides. The objective of this research to determine efficacy and induce resurgence of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% to BPH in the rice field.

2. Materials and Methods

Efficacy and induce resurgence of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% to BPH in the rice field 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. Efficacy and induce resurgence of insecticides was compared to control (untreated). The insecticides in each level doses dilution in volume 500 l water/ha. The treatments as follows (Table 1):

Table 1: Insecticide mixture of buprofezin 100 g/l + pymetrozine 50%

Code	Insecticides mixture	Level doses mixture of formulated product	
		Buprofezin (kg/ha)	Pymetrozine (kg/ha)
A	Buprofezin + Pymetrozine	2.2	0.25
B	Buprofezin + Pymetrozine	2.2	0.188
C	Buprofezin + Pymetrozine	2.2	0.125
D	Buprofezin + Pymetrozine	1.65	0.25
E	Buprofezin + Pymetrozine	1.1	0.25
F	Buprofezin + Pymetrozine	1.1	0.125
G	Buprofezin	2.2	-
H	Pymetrozine	-	0.25
I	Buprofezin + Acephate	2.2	Acephate (1.0 kg/ha)
J	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, but P_2O_5 was given before transplanting. First insecticides application was done if the population abundance of BPH (adults + nymphs) upper on the economic threshold level. The insecticides 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 resurgence as follows:

2.1 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) [5] if the data BPH population before first application insignificant (homogenous) or use Henderson-Tilton formulae (1955) [6] 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) > 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%. 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. Baehaki and Suparno, (2017) [7] give a criteria to determine the efficacy of insecticides on BPH as follows 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.

2.2 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 [8]. Population increases were due to primarily to increased BPH feeding and reproductive rates, reduced nymphal periods, enhanced adult life, and killing of predators [9], but in here the induce resurgence of insecticide to BPH was measured only on the increase and decrease BPH population use LSD value. The LSD value to distinguish the BPH population on treatment (W_t) and BPH population of in controls (W_c), are determined with 6 rules [7] 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 [10].
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 [10].
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 [11].
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 [10].
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 [7].
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,……….n obsevation which the un-induce resurgence (UR), N= number of observation in one research. Baehaki and Suparno, (2017) [7] give a criteria to determine induce resurgence insecticide BPH to as follows 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.

3. Results and Discussions

3.1 Efficacy of Insecticides

The population of BPH before application insignificantly different among the plots treatments. So in the future to determine efficacy of insecticide (EI) used Abbott formula. The average population before application was 1159.7 BPH macropterous/30hills (38.7/hill), this BPH population higher than economic threshold (ET) that was declared ET in vegetatif stage was 9 BPH/hill or in generative stage was 18 BPH/hill if the price of rice grains was US $0.1/kg [12]. The decision making for all plots was spayed by insecticides mixture of buprofezin 100 g/l + pymetrozine 50%.

The observation on one week after first application (1WAA-1), the BPH population in all plots treatments of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% did not different one to another, but BPH on all plot insecticide treatments were different and lower than untreated plot (Table 2). Although the BPH population in the insecticides mixture was lower than in control, were still upper of the economic threshold level, because the BPH population continues to increase beyond the current population before application. The efficacy of insecticide (EI) was still low, less than 50%. Only in insecticides mixture of buprofezin 100 g/l + pymetrozine 50% in combination C (2.2: 0.125), D (1.65: 0.25), and F (1.1: 0.125) have EI value more than 50%. In the other hand buprofezin 2.2 + acephate 1.0 treatments show EI value indicates greater than 50%.

Table 2: Effect of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% to BPH on 1 week 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			
Buprofezin 2.2+ Pymetrozine 0.25	1085 a	7443 b	47.1	-6635	UR
Buprofezin 2.2+ Pymetrozine 0.188	1111 a	7291 b	48.2	-6787	UR
Buprofezin 2.2+ Pymetrozine 0.125	1259 a	6418 b	54.4	-7660	UR
Buprofezin 1.65+ Pymetrozine 0.25	1159 a	6815 b	51.6	-7263	UR
Buprofezin 1.1+ Pymetrozine 0.25	1326 a	7050 b	49.9	-7028	UR
Buprofezin 1.1+ Pymetrozine 0.125	1140 a	6940 b	50.7	-7138	UR
Buprofezin 2.2	1117 a	7314 b	48.0	-6764	UR
Pymetrozine 0.25	1153 a	7110 b	49.5	-6968	UR
Buprofezin 2.2 + Acephate 1.0	1114 a	6896 b	51.0	-7182	UR
Control	1133 a	14078 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} = 1276.1, LSD_{20} = 983.6.

The observation on 2 WAA-1, the BPH population in all plots treatments of insecticides mixture did not different one to another, but BPH on all plots insecticide treatments were different and lower than untreated plot (Table 3). Although the BPH population in the insecticides mixture lower than on control, but the population still above of the economic threshold level, even above of economic injury level.

Almost all the EI was still low less than 50%, but only in insecticides mixture of buprofezin 100 g/l + pymetrozine 50% by combinations A (2.2:0.25), B (2.2:0.188), C (2.2: 0.125), D (1.65: 0.25), E (1.1:0.25), and F(1.1: 0.125), given EI value more than 50%. In the other hand buprofezin (2.2) + acephate (1.0) treatment show EI value lower than 50%.

Table 3: Effect of mixed insecticides buprofezin 100 g/l + pymetrozine 50% 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
Buprofezin 2.2+ Pymetrozine 0.25	9732 b	57.4	-13108	UR
Buprofezin 2.2+ Pymetrozine 0.188	11054 b	51.6	-11786	UR
Buprofezin 2.2+ Pymetrozine 0.125	10969 b	52.0	-11871	UR
Buprofezin 1.65+ Pymetrozine 0.25	9238 b	59.6	-13602	UR
Buprofezin 1.1+ Pymetrozine 0.25	8498 b	62.8	-14342	UR
Buprofezin 1.1+ Pymetrozine 0.125	10231 b	55.2	-12609	UR
Buprofezin 2.2	12064 b	47.2	-10776	UR
Pymetrozine 0.25	11540 b	49.5	-11300	UR
Buprofezin 2.2 + Acephate 1.0	12625 b	44.7	-10215	UR
Control	22840 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} = 3982.1, LSD_{20} = 3069.4.

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), the BPH population increasingly beyond EIL. So the application of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% 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 (Fig 1). Baehaki and Suparno, (2017) [7] had explained the increasingly BPH population as follows:

a. 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.
b. The nymphs appear after the application, so the insecticide is not directly contact the body of BPH nymphs.
c. 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.
d. 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.
e. 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.

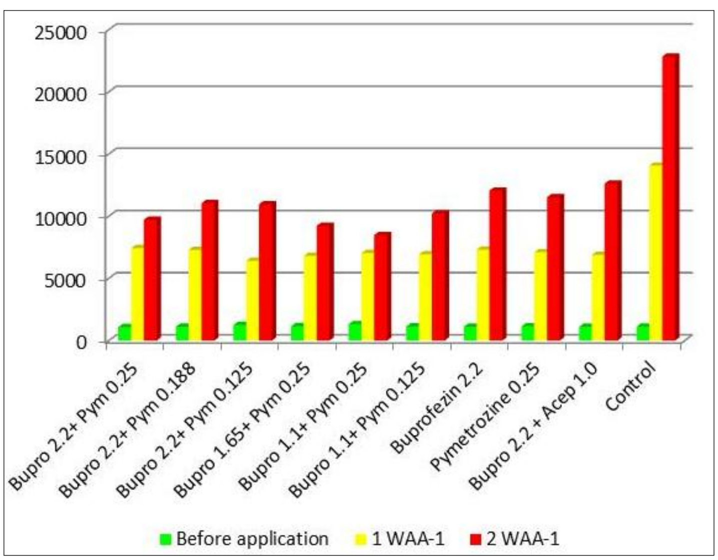

Fig 1: BPH population after first insecticides application was increasingly beyond EIL.

The observation on 1 WAA-2, showed that BPH population in all plots treatments of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% did not different one to another, except BPH on all plots insecticide treatments were different and lower than untreated plot (Table 4).

The EI of insecticides mixture of buprofezin 100 g/l + pymetrozine 50% was very higher more than 98%, even buprofezin 100 g/l + pymetrozine 50% treatment in combination A(2.2:0.25), B(2.2: 0.188), D (1.65: 0.25), and E (1.1:0.25) reach to 100%. In the other hand buprofezin (2.2) + acephate (1.0) treatments show EI value was 99.3%.

Table 4: Effect of mixed insecticides Buprofezin 100 g/l + Pymetrozine 50% 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
Buprofezin 2.2+ Pymetrozine 0.25	11 b	100.0	-24073	UR
Buprofezin 2.2+ Pymetrozine 0.188	3 b	100.0	-24081	UR
Buprofezin 2.2+ Pymetrozine 0.125	19 b	99.9	-24065	UR
Buprofezin 1.65+ Pymetrozine 0.25	6 b	100.0	-24078	UR
Buprofezin 1.1+ Pymetrozine 0.25	11 b	100.0	-24073	UR
Buprofezin 1.1+ Pymetrozine 0.125	23 b	99.9	-24061	UR
Buprofezin 2.2	62 b	99.7	-24022	UR
Pymetrozine 0.25	144 b	99.4	-23940	UR
Buprofezin 2.2 + Acephate 1.0	169 b	99.3	-23915	UR
Control	24084 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} = 1166.2, LSD_{20} = 898.9.

Observation on 2 WAA-2 showed that BPH population in all plots treatments of insecticides mixtue of buprofezin 100 g/l + pymetrozine 50% did not different one to another. The BPH on all plots insecticide treatments were different and lower than untreated plot (Table 5).

The EI of all insecticides mixture of buprofezin 100 g/l + pymetrozine 50% was very higher more than 98%. In the other hand buprofezin (2.2) + acephate (1.0) treatments show little bit EI value was 97.3%.

Table 5: Effect of mixed insecticides buprofezine 100 g/l + pymetrozine 50% 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
Buprofezin 2.2+ Pymetrozine 0.25	46 b	99.2	-6046	UR
Buprofezin 2.2+ Pymetrozine 0.188	39 b	99.4	-6053	UR
Buprofezin 2.2+ Pymetrozine 0.125	46 b	99.2	-6046	UR
Buprofezin 1.65+ Pymetrozine 0.25	33 b	99.5	-6059	UR
Buprofezin 1.1+ Pymetrozine 0.25	34 b	99.4	-6058	UR
Buprofezin 1.1+ Pymetrozine 0.125	41 b	99.3	-6051	UR
Buprofezin 2.2	68 b	98.9	-6024	UR
Pymetrozine 0.25	51 b	99.2	-6041	UR
Buprofezin 2.2 + Acephate 1.0	168 b	97.2	-5924	UR
Control	6092 a	0.0	0	-

Remaks: 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} = 581.1, LSD_{20} = 447.9.

Observation on 1 WAA-3, show that BPH population in all plots treatments of insecticides buprofezin 100 g/l + pymetrozine 50% mixed did not different one to another. The BPH population in all plots insecticide treatments were different and lower than untreated plot (Table 6). The EI of all insecticide mixture of buprofezin 100 g/l + pymetrozine 50% was very higher, more than 73%. In the other hand buprofezin (2.2) + acephate (1.0) treatments show EI value was 78%.

To determine efficacy of insecticide from all observations (N) in one experiment was calculated with general efficacy insecticide (GEI). The GEI values of all combination insecticides mixture of buprofezin 100 g/l + pymetrozine 50% to BPH reach 80-100% were highly efficacy. In the other hand Buprofezin 2.2 and Pymetrozine 0.25 it self with GEI only 60% were moderately efficacy (Table 7). Based on the GEI the insecticides mixture of buprofezin 100 g/l + pymetrozine 50% of all combination were effectively suppress populations of BPH.

3.2 Induce Resurgence of Insecticides

The induce resurgence of insecticide 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 ≥ 1276.1 (LSD_{10}). This indicated that all insecticides treatments did not induced resurgence to BPH.

Table 6: Effect of mixed insecticides buprofezin 100 g/l + pymetrozine 50% 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
Buprofezin 2.2+ Pymetrozine 0.25	1283 b	77.8	-4501	UR
Buprofezin 2.2+ Pymetrozine 0.188	673 b	88.4	-5111	UR
Buprofezin 2.2+ Pymetrozine 0.125	686 b	88.1	-5098	UR
Buprofezin 1.65+ Pymetrozine 0.25	999 b	82.7	-4785	UR
Buprofezin 1.1+ Pymetrozine 0.25	843 b	85.4	-4941	UR
Buprofezin 1.1+ Pymetrozine 0.125	1446 b	75.0	-4338	UR
Buprofezin 2.2	861 b	85.1	-4923	UR
Pymetrozine 0.25	741 b	87.2	-5043	UR
Buprofezin 2.2 + Acephate 1.0	1230 b	78.7	-4554	UR
Control	5784 a	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, TR= un-iduce resurgence. LSD_{10} = 843.7, LSD_{20} = 650.3.

Table 7: PEI and GEI value over 50% of mixed insecticides buprofezin 100 g/l + pymetrozine 50% to the BPH in rice crop

Combination of Formulated product (kg/ha+kg/ha)	PEI more than 50% to the brown planthopper					GEI (%)
	1WAA-1	2WAA-1	1WAA-2	2WAA-2	1WAA-3	
Buprofezin 2.2+ Pymetrozine 0.25	-	Yes	Yes	Yes	Yes	80
Buprofezin 2.2+ Pymetrozine 0.188	-	Yes	Yes	Yes	Yes	80
Buprofezin 2.2+ Pymetrozine 0.125	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 1.65+ Pymetrozine 0.25	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 1.1+ Pymetrozine 0.25	-	Yes	Yes	Yes	Yes	80
Buprofezin 1.1+ Pymetrozine 0.125	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 2.2	-	-	Yes	Yes	Yes	60
Pymetrozine 0.25	-	-	Yes	Yes	Yes	60
Buprofezin 2.2 + Acephate 1.0	Yes	-	Yes	Yes	Yes	80
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.

Rule 2. All insecticides treatment did not tend induced resurgence because none of W_t-W_c between W_t-W_c > 983.6 BPH (LSD_{20}) until W_t-W_c ≥ 1276.1 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 (14078 + 1276.1) = 15354,1 BPH.

Rule 4. the W_c + LSD_{20} was (14 078 + 983.6) = 15061.6 BPH and W_c + LSD_{10} was (14078 + 1276.1) = 15354,1 BPH. From Table 1 did not found W_t were between 15061.6 BPH <W_t <15354,1 BPH. From this data had cleared that the insecticide mixture of buprofezin 100 g/l + 50% pymetrozine, buprofezin (2.2) + acephate (1.0), buprofezin and pymetrozine none treatments showed induce resurgence against BPH.

Rule 5: The all W_t minus by W_c were negative, it can be concluded that insecticides 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 W_c were negative. It concluded that insecticides did not induce resurgence to BPH (Table 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).

In all combinations of insecticide mixture of buprofezin 100 g/l + pymetrozine 50% highly un-induce resurgence because GUR =100%, likewise Buprofezin (2.2), Pymetrozine (0.25), and Buprofezin 2.2 + Acephate 1.0 with GUR were 100%. Based on the GUR the insecticides mixture of buprofezin 100 g/l + pymetrozine 50% were very good didn't induce resurgence to BPH, although had been application on the higher initial BPH population more than Economic threshold.

All combinations of insecticide mixture of buprofezin 100 g/l + pymetrozine 50% that was applied to the both high population in the first application and low population in second and third application (in ET) did not induced resurgence to BPH. The first application of insecticide mixture to brown plant hopper in the high population of macropterous (at 4 fold ET), didn't reduce the population up to under ET although significantly different from the control treatment. This is due to the high populations of BPH macropterous had laid eggs and emerged very much nymphs. The second and third application of insecticide mixture, had been able to reduce BPH up to under and around the ET.

Baehaki dan Suparrno, 2017 [7] reported 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 itself 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 of pymetrozine 50% + acetamiprid 30 g/l 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% + aceamiprid 30 g/l and it's single of both insecticides were 100% highly un-induce resurgence to BPH.

Table 8: UN and GUR value of mixed insecticides buprofezin 100 g/l + pymetrozine 50% 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	
Buprofezin 2.2+ Pymetrozine 0.25	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 2.2+ Pymetrozine 0.188	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 2.2+ Pymetrozine 0.125	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 1.65+ Pymetrozine 0.25	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 1.1+ Pymetrozine 0.25	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 1.1+ Pymetrozine 0.125	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 2.2	Yes	Yes	Yes	Yes	Yes	100
Pymetrozine 0.25	Yes	Yes	Yes	Yes	Yes	100
Buprofezin 2.2 + Acephate 1.0	Yes	Yes	Yes	Yes	Yes	100
Control	-	-	-	-	-	-

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

Chaudhary and Raghuraman (2014) [13] reported that among all the treatments, Buprofezin 15 per cent + Acephate 35 per cent WP was most effective against both the sucking pests (BPH and rice stink bug) and conversely protected the crop. Buprofezin 25% SC (800 ml/ha) followed by acephate (1000 ml/ha) were found most effective among all the treatments after 3 DAS. They showed reduction of BPH population from 58.00 to 28.31 and 58.10 to 30.29 per 5 hills after 3 DAS, respectively [13]. The efficacy of buprofezin, which is a chitin synthesis inhibitor, in combination with acephate has been reported by Mesquita *et al*. (2007) [14]. Similar results are also obtained by Bhavani *et al*. (2005) [15] reported that application of acephate was more pronounced in restricting the planthopper population to a minimum level at its peak activity period.

The buprofezin was a good insecticide to reduced rice planthoppers, this clearly indicated that buprofezin 25 SC @ 1 ml/l recorded the lowest plant hopper population at 10 days after spray. The next best treatment was buprofezin 25 SC @ 0.75 ml/l which recorded lower planthopper population and was at par with standard check thiamethoxam 25 WG @ 0.2 g/l, while imidacloprid 17.8 SL @ 0.3 ml/l was on par with buprofezin 25 SC @ 0.75 ml/l and significantly superior to all the remaining treatments [16]. The BPH populations from Gangavati, Kathalagere and Kollegala exhibited higher resistance to some of the old insecticides and low resistance to new molecules, but acephate (1.34- to 5.32-fold) and buprofezin (1.06- to 5.43-fold) insignificantly different [17]. In field efficacy of buprofezin 25 SC @ 625, 750 and 875 ml/ha against BPH and whitebacked planthopper (WBPH), infesting paddy crop revealed that after 3 days of spray, BPH and WBPH count in all buprofezin doses were significantly inferior as compared to standard checks, imidacloprid 17.8 SL and chlorpyriphos 20 EC [18]. Buprofezin 25 SC @ 200 g a.i./ha was more effective after 3 days up to the 14 days in reducing BPH, followed by thiamethoxam 25 WG @ 25 g a.i./ha and Imidacloprid 200 SL @ 25 ga.i./ha [19]. Eficacy of buprofezin to BPH was urge by low resistance as Wang *et al*., (2008) [20] reported that BPH field population indicated had developed medium resistance level to fipronil (up to 10.5-fold), and some field populations had evolved a low resistance level to buprofezin.

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 [21]. The other results indicate that pymetrozine would be an effective alternative for the control of brown planthoppe [22]. The above discussion shows that pymetrozine and buprofezin were better to control the BPH, likewise the mixture of two insecticides in various combinations can suppress BPH with a higher efficacy.

4. Conclusions

The first application of insecticide mixture to brown plant hopper in a higher population of macropterous (> 4 fold ET), had been able to reduce the population although this reducing didn't up to under ET. This is due to the high populations of BPH macropterous had laid eggs and emerged very much nymphs. The second and third application of all combination insecticide mixture in the normal population, had been able to reduce BPH up to under and around the economic threshold.

The GEI values of all insecticide mixture of buprofezin 100 g/l + pymetrozine 50% to BPH reach 80-100% were highly efficacy. In the other hand Buprofezin 2.2 and Pymetrozine 0.25 itself with GEI only 60% were moderately efficacy. Based on the GEI the insecticides mixture of buprofezin 100 g/l + pymetrozine 50% were effectively suppress populations of BPH.

In all combinations of insecticide mixture of buprofezin 100 g/l + pymetrozine 50% highly un-induce resurgence because GUR were 100%, likewise Buprofezin (2.2), Pymetrozine

(0.25), and Buprofezin 2.2 + Acephate 1.0 with GUR were 100%. Base on general un-induce resurgence (GUR), all combinations of insecticides mixture of buprofezin 100 g/l + pymetrozine 50%, buprofezin and pymetrozine showed GUR=100% as highly un-induce resurgence category to the BPH, although had been application on the higher initial BPH population more than 4 fold Economic threshold.

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