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Research Article

SCREENING OF LOCAL VARIETIES AND EVALUATION OF NEWER MOLECULES ON THE INCIDENCE OF RICE WHORL MAGGOT (*Hydrellia philippina*) IN RICE CROP ECOSYSTEM OF MANIPUR VALLEY

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Abstract: Two sets of field trials were experimented during Kharif, 2014 at the research farm of College of Agriculture, Central Agricultural University, Imphal to investigate the susceptibility of promising rice varieties and new molecules on the incidence of rice whorl maggot (*Hydrellia philippina*) in rice-crop-ecosystem of Manipur valley. The results on the resistant reaction of fifteen rice varieties to *H. philippina* revealed that though none of screened varieties showed immune or high degree of resistance to the pest, all the varieties significantly reacted against the test insect pests. However, lowest incidence of *H. philippina* was noticed in the var. CAU-R1 of minimum leaf infestation 9.85 per cent followed by in varieties RC-MANI-PHOU-11 (10.07%) which were at par with each other. Among the various new molecular insecticides field evaluated against the pest, Fipronil 5 SC @ 100 ml a.i. ha^{-1} was found effective. The pooled mean data on extent of leaf damage of two sprays showed that Fipronil 5 SC @ 100 ml a.i. ha^{-1} proved as the most effective compound with minimum leaf damage of 4.78 per cent as against 11.60 percent in untreated control.

Keywords: *Hydrellia philippina, Fipronil, CAU-R1, RC-MANI-PHOU-11*

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Introduction

Rice (*Oryza sativa* L.) belonging to the family Graminae is the staple food for around one third world's population and occupies almost one fifth of the total land area covered under cereals. It is grown under diverse cultural conditions and over wide geographical range. Most of the world's rice is cultivated and consumed in Asia constituting more than half of the global population. Approximately 11% of the world's arable land is planted annually to rice, and next to it ranks wheat. India accounts for 43.95 million ha in area of rice cultivation, 103.61 million tonnes of production and productivity of 2462 kg/h [1]. Rice, being the staple food for more than 70 percent of the population and the source of livelihood for 120-150 million rural households, is the backbone of the Indian agriculture. Rice is mainly grown during the Kharif season in Manipur covering an area of 2, 44,000 hectares, producing 645 thousand tones with a productivity of 2413.52 Kg/ha [2]. The prime causes of low productivity of rice in Manipur, as compared to the production in nationwide states are due to inappropriate adoption of agronomical practices, limited irrigation, lack of improved varieties suitable to different ecosystems and lack of extension services. More than 100 species of insect have been recorded to infest the paddy crop but only about 20 of them are of major economic significance, out of these 20-insect pest are of major economic significance [3], a few are widely distributed with great potential to create a havoc the paddy crop, brown planthopper is such that type of insect. The rice whorl maggot (RWM), *Hydrellia philippina* Ferino, belonging to the fly family Ephydridae is a pest of rice under irrigated condition [4], this may be attributed due to the fact that the adults have high preference for oviposition in the flooded field [5]. It was first reported in the literature feeding on rice in Khon Kaen, Thailand during the 1961 wet season by Somporn Patanakamjorn of Kasetsart University [6-7]. The diagnostic key characters of RWM are 8-12 spines in the ventral portion of femur I, absence of a spine in the subcosta of forewing, absence of strong dorsal spines on tibia III, small body size (2- 2.6mm long), and the gray body color [8].

The common host that has been recorded to be infested by RWM are *Echinochloa crusgalli, Echinochloa colona, Brachiaria distachya, Cynodon dactylon, Leersia hexandra*, *Leptochloa chinensis, Panicum repens, Paspalum scrobiculatum, Pennisetum clandestinum, Eleusine indica, Fimbristylis miliacea, Cyperus difformis*. The pest feeds on the developing leave tissues from the apical meristem exhibiting a unique symptom hence they are referred to as rice whorl maggot. In this way, its injury is more like that of a stemborer than a defoliator [9]. Keeping the present scenario of the above pest, two protocols were carried out to test the efficacy of various new molecules and varietal screening of resistant varieties against *Hydrellia philippina*

Material and Method

Two sets of field experiments were carried-out during Kharif season of 2014 in the Rice research farm of the College of Agriculture, Central Agricultural University, Iroisemba, Imphal to investigate the effect of certain rice varieties and new molecules on the incidence of whorl maggot (*Hydrellia philippina* Ferine). The Rice Research Farm, College of Agriculture, Central Agricultural University, Imphal, is situated at 24 045' N latitude and 93 0 56' E longitude with an elevation of 790 m above the mean sea level. The seedlings were raised in the properly prepared nursery beds for all the experiments Before sowing, the seeds were soaked for two days and kept in shade after treating with Anokhi (Carbendazim 12% + Mancozeb 63%) 75 WP @ 2 g per kg of seeds in order to make the seeds disinfected from fungal diseases and the seeds for insecticides evaluations trials also treated with insecticides Gaucho(Imidacloprid 600 FS) @ 7 ml per kg of seeds then treated seeds were allowed to sprout by keeping in gunny bag for 24 hours. The sprouted seeds were sown on the prepared seed beds and the seedlings were uprooted when they attained 4-5 leaf stage (30 days old). The experimental field was ploughed two times to a depth of 20-25 cm by tractor one

month ahead of transplanting and was followed by power tillering for four times. The field was kept flooded for one week and puddling was done by running tractor drawn puddler three to four times in standing water followed by leveling. One month prior to transplanting, the well decomposed Farm Yard Manure @ 10 tonnes per hectare was thoroughly incorporated into the soil. The N, P_2O_5 and K_2O were applied in the form of Urea, Single Super Phosphate and Muriate of Potash @ 60:40:30 kg per hectare, respectively. Half of the recommended quantity of Urea, and full dose of Single Super Phosphate and Muriate of Potash were applied uniformly them to all the plots as basal dose at the time of final puddling and incorporated properly with the soil. The remaining half dose of Urea was applied as top-dressing in two equal splits at 30 days (active tillering) and 65 days (panicle initiation stage) after transplanting. The thirty days old seedlings were transplanted with the inter and intra-row spacing of 15 x 10 cm at the rate of three seedlings per hill. Considering the fact that assured and timely provide of irrigation water has a great influence on the crop growth and yield, timely irrigation was given to the experimental fields by maintaining water level of 5 cm in the field upto dough stage of the crop. Water was drained out from the field eleven days before harvest to encourage uniform maturity of the grains. The crop field was kept weed free through hand weedings twice, first at 20 days after transplanting (DAT) and second at 55 DAT. The chemical method of weed control was not adopted throughout the crop growth period.

Screening of certain rice varieties on the incidence *H. philippina*.

For the field study, the experiment was laid-out in Randomized Block Design (RBD) with three replications. Fifteen Rice varieties including one check were field-tested for their resistance reaction against the pests. One-month-old seedlings of each variety were transplanted in the plot size of 3 x 2 m^2 at 15 x 20 cm spacing. No pest control measures were followed in the experimental crop. Observation on whorl maggot will be recorded after 30, 50 and 70 DAT from 10 randomly selected hills per plot. The percentage infestation will be determined by Heinrichs *et al.* Genetic evaluation for insect resistance in rice [10]

Scale	Damage
0	None
1	One leaf/hill with feeding lesions
3	Two or more leaves/hill but not more than 33% of the leaves with feeding lesions
5	33-50% of the leaves with feeding lesions
7	More than 50% of leaves with feeding lesions but no broken leaves
9	More than 50% of leaves with feeding lesions with some broken leaves

Evaluation of new molecular insecticides against *H. philippina* in Rice var. "Leimaphou (KD-2-6-3)"

A separate field experiment was laid-out in Randomized Block Design (RBD) replicating thrice with a plot size of 3 x 2 m^2 and spacing of 15 x 20 cm. The high yielding susceptible variety 'Leimaphou (KD-2-6-3)' was used for the experiment. Seven new molecules and one synthetic organic insecticide were tested. There was an untreated control in each replication.

Details of treatment

Treatment	Insecticides	Dose a.i./ha
T_1	Rynaxypyr 18.5 SC	150 ml
T_2	Dinotefuran 20 SG	200 g
T_3	Flubendiamide 39.35 SC	50 g
T_4	Thiamethoxam 25 WG	25 g
T_5	Thiacloprid 21.7 SC	50 g
T_6	Imidacloprid 17.8SL	250 ml
T_7	Imidacloprid 20 SL	100 ml
T_8	Imidacloprid 70 WG	30 g
T_9	Fipronil 5 SC	100 ml
T_{10}	Acephate 75 SP	500 g
T_0	Untreated / control	Water spray

Two rounds of foliar application of the test insecticides were made first at 30 DAT (days after transplanting) and second at 50 DAT with a high volume hand compression knapsack sprayer at spray volume of 500 liters per hectare. In order to determine the relative efficacy of the test insecticides, observations on the incidence of *H. philippina* were recorded five days and ten days after each application. Observation on whorl maggot infestation was recorded 5 days and 10 days after each insecticide application from 10 randomly selected hills/plot in each plot. The percent of infestation was determined by recording total number of leaves as well as infested leaves by using the following formula:

$$Infestation\ (\%) = \frac{No.\ of\ damage\ leaves/hill}{Total\ no.\ of\ tillers\ per\ hill} \times 100$$

Results

Effect of certain rice varieties

The results of present field investigation on the effect of certain rice varieties on the incidence of whorl maggot (*Hydrellia philippina* Ferine) conducted during Kharif, at the research farm of the College of Agriculture, Central Agricultural University, Imphal are briefly outlined. A significant variation in percent leaf damage due to *H. philippina* was observed in the test varieties at all the three different observation intervals *viz*., 30, 50, and 70 days after transplanting during the study period. The mean percent leaf damage data of three observation time intervals presented in [Table-1] indicated that the CAU-R1 resulted the minimum leaf infestation of 9.85 percent followed by in varieties RC-MANI-PHOU-11 (10.07%) which were at par with each other. The mean leaf damage recorded in varieties RCM-9(10.62 %), CAU-R4 (11.37 %), WR-1-9-1-1 (11.69%), KD-6-18-7-1(11.74%) and CAU-R3 (11.91%) which did not show significant difference from one another. The maximum percent leaf damage (16.53%) recorded in susceptible check variety Leimaphou (KD-2-6-3). The mean percent leaf damage of rest of the varieties was varied from 12.13 – 14.13, the minimum of 12.13% in WR-15-6-1 variety to the maximum of 14.13% in Lamyanbaphou variety. However, the variety Matamphou (12.50 %) was at par with the variety WR-3-2-6-1(13.56 %). Mean leaf infestation data further revealed that none of the screened rice varieties was found to be resistant though considerable variability existed in their reaction to *H. philippina*. Out of fifteen rice varieties tested, only two varieties CAU-R1 and RC-MANI-PHOU-11 exhibited moderate susceptible reaction. The ten varieties *viz*., WR-15-6-1, WR-1-9-1-1, CAU-R2, CAU-R3, KD-5-3-14, Matamphou, CAU-R4, RCM-9, KD-6-18-7-1 and RC-Maniphou-6-RC-5 categorized as susceptible, whereas the rest three varieties *viz*., Lamyanbaphou, WR-3-2-6-1, and Leimaphou(KD-2-6-3) rated as highly susceptible to *H. philippina* infestation.

Field efficacy of certain new molecules on Rice var. "Leimaphou (KD-2-6-3)"

Insecticidal treatments consisting of seven new molecules *viz*., Rynaxypyr, Dinotefuran, Flubendiamide, Thiamethoxam, Thiacloprid, Imidacloprid, Fipronil and one synthetic organic insecticide, Acephate were field evaluated against *H. philippina* on Rice var. "Leimaphou (KD-2-6-3)" during Kharif, 2014. The insecticides were applied twice as post transplanting treatment first at 30 DAT and second at 50 DAT. The information generated on the effect of the insecticidal treatments on the infestation of these insect pests, yield and extent of yield loss are presented in the following paragraphs.

Extent of leaf damage at 1 DBA

The whorl damage on leaf counts made 1 day before spraying revealed the leaf damage 13.18 -14.46 percent in different plots without any significant difference between them [Table-2].

Extent of leaf damage at 5 DAA

At 5 DAA, the percentage of leaf damage significantly varied from 6.50 to 13.85 percent in various plots treated with insecticides as against 14.70 percent LD in untreated control plot. However , minimum leaf damage incidence (6.50% LD) was observed in the treatment with Fipronil 5 SC, followed by Thiamethoxam 25 WG (8.90% LD), Flubendiamide 39.35 SC (9.09% LD), Imidacloprid 20 SL (9.24% LD) and Rynaxypyr 18.5 SC (9.44% LD) treated plots which showed non-significant difference one another. The maximum incidence of silver shoot 13.85 percent was exhibited by the plots treated with Thiacloprid 21.7 SC. The mean percentage leaf damage recorded in the plots treated with the rest of insecticides varied from 11.64 to 13.80 percent [Table-2].

Table-1 *Effect of certain rice varieties on the incidence of H. philippina during Kharif, 2014*

Variety	Mean leaf damage at			Pooled mean	D- Value	Damage score	Rating
	30 DAT	50 DAT	70 DAT				
WR-15-6-1	17.75(4.27)	13.03(3.66)	5.60(2.46)	12.13(3.46)	73.38	7	S
WR-1-9-1-1	17.75(4.27)	11.60(3.60)	5.73(2.48)	11.69(3.41)	70.72	7	S
CAU-R2	23.33(4.87)	11.09(3.37)	5.20(2.38)	13.21(3.54)	79.91	7	S
Lamyanbaphou	23.33(4.88)	13.14(3.69)	5.91(2.51)	14.13(3.69)	85.48	9	HS
WR-3-2-6-1	23.33(4.87)	11.22(3.41)	6.12(2.64)	13.56(3.62)	82.03	9	HS
CAU-R3	16.08(4.06)	13.14(3.66)	6.51(2.64)	11.91(3.45)	72.05	7	S
KD-5-3-14	21.08(4.64)	14.08(3.81)	4.89(2.31)	13.35(3.59)	80.76	7	S
CAU-R1	16.66(4.13)	8.37(2.96)	4.52(2.23)	9.85(3.11)	59.59	5	MS
RC-MANI-PHOU-11	18.50(4.36)	7.60(2.84)	4.12(2.14)	10.07(3.11)	60.92	5	MS
MATAMPHOU	19.06(4.41)	12.57(3.61)	5.84(2.84)	12.50(3.62)	75.62	7	S
CAU-R4	18.67(4.37)	10.28(3.28)	5.17(2.76)	11.37(3.47)	68.78	7	S
RCM-9	15.53(3.99)	10.86(3.32)	5.46(2.79)	10.62(3.37)	64.25	7	S
KD-6-18-7-1	16.03(4.06)	12.94(3.65)	6.25(2.56)	11.74(3.42)	71.02	7	S
RC- ANIPHOU-6-RC-5	16.67(4.14)	15.43(3.98)	6.66(2.67)	12.92(3.60)	78.16	7	S
Leimaphou (KD-2-6-3) (check)	24.40(4.99)	16.00(4.05)	9.20(3.11)	16.53(4.05)	100.00	9	HS
CD(P=0.05)	0.41	0.64	0.32	0.79			

Figures in parentheses are √(X+0.5) transformed values

Table-2 *Effect of different insecticidal treatments on the incidence of H. phillippina in Rice var. 'Leimaphou' (KD-2-6-3) during Kharif, 2014*

Treatments	Dose	Mean leaf damage at					Pooled mean
		1st spray			2nd spray		
		1DBA	5 DAA	10DAA	5DAA	10DAA	
T_1	150 ml	13.18(3.70)	9.44(3.14)	7.60(2.83)	5.34 (2.41)	3.40(1.97)	6.44(2.59)
T_2	200 g	13.24(3.71)	12.00(3.52)	8.96(3.02)	5.82 (2.51)	3.50(1.99)	7.57(2.76)
T_3	50 g	13.00(3.67)	9.09(3.08)	5.78(2.47)	5.09 (2.35)	3.22(1.93)	5.79(3.28)
T_4	25 g	13.28(3.71)	8.90(3.01)	6.87(2.69)	4.54 (2.24)	2.69(1.78)	5.75(2.45)
T_5	50 g	13.12(3.69)	13.85(3.78)	10.60(3.33)	6.82 (2.69)	3.87(2.07)	8.78(2.97)
T_6	250 ml	13.09(3.69)	11.64(3.45)	7.14(2.74)	6.79 (2.68)	3.63(2.03)	7.30(2.72)
T_7	100 ml	13.23(3.71)	9.24(3.11)	8.10(2.93)	5.88 (2.48)	4.42(2.21)	6.91(2.68)
T_8	30 g	13.43(3.73)	13.80(3.74)	11.96(3.51)	8.04(2.91)	4.12(2.14)	9.48(3.07)
T_9	100 ml	13.24(3.71)	6.50(2.59)	5.75(2.49)	4.41 (2.21)	2.46(1.72)	4.78(2.25)
T_{10}	500 g	13.46(3.75)	12.70(3.57)	12.12(3.55)	8.62 (3.02)	5.63(2.47)	9.77(3.15)
T_0		14.46(3.87)	14.70(3.89)	13.70(3.75)	10.01(3.23)	7.98(2.91)	11.60(3.44)
CD(P=0.05)	-	NS	0.74	0.47	0.44	0.28	0.22

Figures in parentheses are √(X+0.5) transformed values

Extent of leaf damage at 10 DAA

The mean leaf damage due to whorl maggot (WM) recorded 10 days after application (DAA) of insecticides varied from 5.75 to 12.12 percent as against 13.70 percent in untreated control. The minimum leaf damage incidence (5.75% LD) was observed in Fipronil 5 SC treated plots as against 13.70 percent in untreated check [Table-1]. The lower LD incidence also found in Flubendiamide 39.35 SC (5.78% LD), Thiamethoxam 25 WG (6.87% LD), Imidacloprid 17.8 SL(7.14% LD)and Rynaxypyr 18.5 SC(7.60% LD) treatments which were not significantly differ from one another. However, maximum mean leaf damage incidence was recorded in the plots treated with Acephate 75 SP (12.12% LD).

Effect of insecticides, on the incidence of *H. philippina* during 2nd spray

Extent of leaf damage at 5 DAA

The mean percentage leaf damage data [Table-2] observed at 5 DAA during 2nd spray revealed that the untreated control plots recorded significantly highest leaf damage incidence (10.01% LD) as compared to 4.41 to 8.62 percent in insecticides treated plots, the lowest being in the plots treated with Fipronil 5 SC (4.41% LD) which was closely followed by Thiamethoxam 25 WG (4.54% LD) and Flubendiamide 39.35 SC (5.09% LD) treatments having non-significant difference between one another. The highest leaf damage incidence (8.62% LD) was resulted by the plots treated with Acephate 75 SP.

Extent of leaf damage at 10 DAA

During the observation on the extent of leaf damage due to *H. philippina* recorded at 10 DAA, the plots treated with Fipronil 5 SC showed lowest damage of 2.46 percent as against 7.98 percent in untreated control and found significantly superior to other insecticides tested [Table-2]. The second most effective insecticide was Thiamethoxam 25 WG with a record of 2.69 percent leaf damage but did not show significant difference from the plots treated with Flubendiamide 39.35 SC(3.22% LD), Rynaxypyr 18.5 SC(3.40% LD), Dinotefuran 20 SG(3.50% LD), Imidacloprid 17.8 SL(3.63% LD) and Thiacloprid 21.7 SC. The maximum leaf damage incidence recorded in Acephate 75 SP (5.63% LD).

Mean extent of leaf damage over two sprays based on 5 DAA and 10 DAA

The pooled mean data on extent of leaf damage of two sprays [Table-2] showed that Fipronil 5 SC @ 100 ml a.i. ha^{-1} proved as the most effective compound with minimum leaf damage of 4.78 percent as against 11.60 percent in untreated control. The minimum mean leaf damage also recorded in Thiamethoxam 25 WG @ 25 g a.i. ha^{-1} (5.75% LD), Flubendiamide 39.35 SC @ 50 g a.i. ha^{-1} (5.79% LD) which did not differ significantly. Maximum mean extents of leaf damage (9.77% LD) were recorded in plots treated with Acephate 75 SP @ 500 g a.i. ha^{-1}. While, the rest of plots mean leaf damage varied from 6.44 - 9.48 percent which differed significantly from one another.

Discussion

The mean percentage leaf damage data of three observation indicated that the CAU-R1 resulted the minimum leaf infestation of 9.85% followed by in varieties RC-MANI-PHOU-11 (10.07 %) which at par with each other. The mean leaf damage recorded in varieties RCM-9 (10.62 %), CAU-R4 (11.37%), WR-1-9-1-1 (11.69%), KD-6-18-7-1 (11.74%) and CAU-R3 (11.91%) which did not show significant difference from one another. The maximum percentage leaf damage 16.53 recorded in susceptible check variety Leimaphou (KD-2-6-3). The mean percentage leaf damage of rest of the varieties was varied from 12.13-14.13, the minimum of 12.13 in WR-15-6-1 variety to the maximum of 14.13 in Lamyanbaphou variety. Mean leaf infestation data of the three times observation revealed that none of the screened rice varieties was found to be resistant though considerable variability existed in their reaction to *H. philippina*. Out of fifteen rice varieties tested, only two varieties CAU-R1 and RC-MANI-PHOU-11 exhibited

moderate susceptible reaction. The ten varieties *viz*., WR-15-6-1, WR-1-9-1-1, CAU-R2, CAU-R3, KD-5-3-14, Matamphou, CAU-R4, RCM-9, KD-6-18-7-1 and RC-MANIPHOU-6-RC-5 categorized as susceptible, whereas the rest three varieties *viz*., Lamyanbaphou, WR-3-2-6-1, and Leimaphou (KD-2-6-3) rated as highly susceptible to *H. philippina* infestation. Singh [11] also reported a similar finding whereby varieties like CAU-R1, RCM-9 produced higher yield and lower infestation as compared to control plot. It was also concluded that both the varieties significantly showed moderately resistant to the incidence of *Hydrellia phillippina*. The results of the efficacy of various insecticidal treatments against whorl maggot revealed that the plots treated with Fipronil 5 SC @ 100 ml a.i. ha^{-1} proved as the most effective compound with minimum leaf damage of 4.78 percent as against 11.60 percent in untreated control. The minimum mean leaf damage also recorded in Thiamethoxam 25 WG @ 25 g a.i. ha^{-1} (5.75% LD), Flubendiamide 39.35 SC @ 50 g a.i. ha^{-1} (5.79% LD) which did not differ significantly. Maximum mean extent of leaf damage (9.77% LD) was recorded in plots treated with Acephate 75 SP @ 500 g a.i. ha^{-1}. While, the rest of plots mean leaf damage varied from 6.44 - 9.48 percent which differed significantly from one another. The present results obtained here on the effectiveness of Flubendiamide against whorl maggot is in accordance with Sharma and Srivastava [12] who observed that Flubendiamide was the effective treatments against whorl maggot with 11.04 percent damaged leaves as compared to 24.00 percent in untreated control. Similarly, in the subsequent cropping season, the leaf damage by whorl maggot was 8.98 percent in Flubendiamide treated plots as against 23.03 percent in untreated control. The effectiveness of Fipronil, Flubendiamide and Thiamethoxam, might be attributed to their inherent toxicity to the whorl maggot. Moreover, these new molecules have systemic action through the properties of which the toxicants might be available in all the plant tissues for exerting toxic action to the pest. The least effectiveness of Thiacloprid and Acephate were probably due to their slow knockdown action and lower persistence.

Application of research: Research is applicable for farmers and extension workers so as to emphasize in employing newer effective molecules against the pest

Research Category: Cultural and chemical method of RWM

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References

[1] Anonymous (2015) *International Rice Research Institute, Annual Report, 2015. Los Banos, Philippines*, 131-148.
[2] Anonymous (2016) *Department of Agriculture, Government of Manipur.*
[3] Pathak M.D. and Khush G.S. (1979) *Studies of varietal resistance in rice to the brown planthopper at the International Rice Research Institute. Brown planthopper: Threat to rice production in Asia. Los Banos, Philippines,* 285-301.
[4] Litsinger J.A. (2009) *When is a rice insect a pest: Yield loss and the Green Revolution, p. 391-498. In: R Peshin, AK Dhawan editors, Integrated Pest Management: Innovation-Development Process. Berlin: Springer 1573 Science + Media B.V., Volume* 1, 670.
[5] Viajante V.D. and Heinrichs E.A. (1985) *International Rice Research Newsletter*, 10(1), 24-25.
[6] Patanakamjorn S. (1964) *Review of Applied Entomology*, 55 (9), 515, 1967.
[7] Patanakamjorn S. and Rangdang Y. (1968) *Thai Journal of Agricultural Science*, 1,1-18.
[8] Barrion A.T. and Litsinger J.A. (1994) *Taxonomy of rice insect pests and their arthropod parasites and predators, p. 13-359. In: EA Heinrichs editor, Biology and Management of Rice Insects, Wiley Eastern Ltd., New Delhi,* 779.
[9] Litsinger J.A., Canapi B.L., Bandong J.P., Lumaban M.D., Raymundo F.D and Barrion A.T. (2009) *International Journal of Pest Management*, 55, 221-242.
[10] Heinrichs E. A., Medrano F. G. and Rapusas H. R. (1985) *Genetic evaluation for insect resistance in rice. International Rice Research Institute. Los Banos, Philippines.*
[11] Singh H.R. (2010) *Effect of Certain Varieties and New Molecules on the Incidence of Major Insect Pests under Rice-Crop-Eco-System of Manipur Valley. M. Sc. Thesis. College of Agriculture, Central Agricultural University, Imphal.*
[12] Sharma P.K. and Srivastava A. (2010) *Oryza*, 47(4), 340-341.