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Bio-efficacy of certain insecticidal molecules against sucking pests of rice

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Abstract
Rice is one of the most important staple food crops grown worldwide. Despite of using improved agronomic practices, we cannot get optimum production and productivity. The reason behind its low productivity includes different factors, among them insect pest infestation is of prime importance. The crop is liable to attack by more than 20 species of insect pests. Among several insect pests, sucking pests such as brown plant hopper, green leaf hopper and gundhi bug cause damage at both the nymphal and adult stages by sucking sap and thereby devitalizing plants and also such insects act as vectors of some viral diseases, which are difficult to manage. Chemical control is considered as one of the most effective as well as quick method in reducing the pest population below economic injury level. So the present investigation was carried out in order to find out the efficacy of certain chemicals against sucking pests infesting rice. From the results of the experiment, it was found that the treatment Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha is most effective against *N. lugens* and *N. virescens* and against gundhi bug most effective treatment is Indoxacarb 10% +Thiamethoxam 10% WG @50 +50g a.i./ha.

Keywords: Sucking pest, brown plant hopper, green leaf hopper, gundhi bug, management, bio-efficacy

Introduction
Over half the world's population consume rice (*Oryza sativa* L.) as their staple food and is one of the mostly grown crops in the world (Khush, 1997) [6]. Approximately, 750 million of the world's poor people depend on rice to survive (Zeigler, 2006) [10]. It is grown practically in all the tropical, sub-tropical and calm nations of the world. There are different factors which affect improved yields in rice, among which insect-pests infestation is the prime and the most restraining factor in the successful cultivation of rice. It has been found that more than 100 species of insects attack rice and among them 20 have potential to cause economic damage all over the world, causing more than 30 per cent yield loss at different stages of rice crop, i.e., from seedling to maturity (Cramer, 1967; Pathak and Dhaliwal, 1981 and Athwal and Dhaliwal, 2005) [2, 7, 1]. Some of them are Yellow stem borer *(Scirpophaga incertulas)*, Leaf folder *(Cnaphalocrocis medinalis)*, Gall midge *(Orseolia oryzae)*, Brown plant hopper *(Nilpravata lugens)*, Green leaf hopper *(Nephotettix nigropictus, Nephotettix virescens)*,Gundhi bug *(Leptocorisa acuta)*, Case worm *(Nymphula depunctalis)* and several others. Among quite a few insect pests linked with rice, sucking pests cause huge damage to rice by sucking plant sap, devitalizing plants and also act as vectors of several viral diseases.
However, timely application of insecticides is the only and most commonly used measure for reducing pest population and sometimes the only practical solution to sudden outbreaks of insect pests in general. Thus it is imperative that alternate insecticides be explored for managing the pests. New molecules will be searched in the context of effective against rice pest as well as eco-friendly, selective, cost effective, bio-degradable, and safe to natural enemies and non-target organisms.

Materials and Methods
The experiment was carried out during the *kharif* season of 2018-19 at the Agricultural Research Farm, Banaras Hindu University, Varanasi (Uttar Pradesh) which is situated at latitude of 24° 56' N to 25° 35' N and longitude of 82° 14' E to 83° 24' E with an altitude of 82 m above the mean sea level (MSL). The place is situated in the centre of Indo-gangetic belt, falling under the sub-humid and sub-tropical climate zone.
Pests monitoring was done at regular intervals in the current experiment and when the economic threshold levels were reached in terms of pest population/damage, insecticides were sprayed as per the schedule laid out in two sprays:

First Spray	10th October 2018
Second Spray	30th October 2018

Treatment Details

Treatments	Technical name	Dose(g a.i./ha)	Source
T_1	Indoxacarb 10% +Thiamethoxam 10% WG	50 +50	Gharda chemicals limited
T_2	Fipronil 5% SC	75	Gharda chemicals limited
T_3	Buprofezin 25% SC	200	Gharda chemicals limited
T_4	Fipronil 40% +Imidacloprid 40% WG	50 +50	Gharda chemicals limited
T_5	Fipronil 5% +Buprofezin 20% SC	62.5 +200	Gharda chemicals limited
T_6	Thiamethoxam 25% WG	25	Gharda chemicals limited
T_7	Indoxacarb 14.5% SC	30	Gharda chemicals limited
T_8	Imidacloprid 17.8 SL	25	Gharda chemicals limited
T_9	Quinalphos 25% EC	375	Gharda chemicals limited
T_{10}	Control	-	-

Observation

Plant hoppers

From 10 randomly selected hills, the number of adults and nymphs of brown plant hopper and Green leaf hopper were recorded. The total count was averaged and stated in per hill basis.

Rice gundhi bug

The number of nymphs and adults of gundhi bug were counted by using sweep nets five times across the treated plots including the control plots in each replication.

Result and Discussion

Effect of insecticidal treatments against Brown Plant Hopper, *Nilaparvata lugens*

The outcomes of the effect of insecticidal treatments after first and second insecticidal application on brown plant hopper were represented in table-1 and table 2 respectively. The average number of insects one day before the sprays varied from 9.1 to 13.36 in various test plots, including control. A study of Table 1 indicates that a significant reduction in population was observed after spraying of test chemicals as compared to untreated control. It was observed that average number of insects per 10 hills on one day after the sprays was found to be lowest (6.56) in plots treated with Fipronil 5% SC +Imidacloprid 40% WG @50+50g a.i./ha followed by 6.93 and 7.46 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha. In contrary, the average N. lugens population per 10 hills one day after the sprays was found to be highest (12.40) in control plots followed by 8.53 and 8.46 in plots treated with Buprofezin 25% SC @200g a.i./ha and Thiamethoxam 25% WG @25g a.i./ha.

It was observed that average brown plant hopper, *N. lugens*, population per 10 hills on three days after the sprays was found to be lowest (4.2) in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha followed by 4.6 and 5.06 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha respectively. In contrary, the average brown plant hopper, N. lugens population per 10 hills three days after the sprays was found to be highest (13.23) in control plots followed by 6.56 and 6.26 in plots treated with Quinalphos 25 EC @375g a.i./ha and Buprofezin 25% SC @200g a.i./ha, respectively.

After the five days of insecticidal spray, the average brown plant hopper population per 10 hills were 3.56, 3.70 and 3.96/ten hills in Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha, Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha treated plots, respectively and was significantly low when compared to the population observed in other treatments. Buprofezin 25% SC @200g a.i./ha and Quinalphos 25% EC @375g a.i./ha treated plots recorded 5.93 and 6.00/ten hills and all the treatments differed significantly from one another in reducing brown plant hopper population. However, in control the mean brown plant hopper population after five days of sprays was as high as 14.30/ten hills and was significantly high when compared to the population in all insecticidal treated plots.

During 7 DAS, the average brown plant hopper populations per 10 hills were found to be low in all the plots applied with different insecticidal treatments and differed significantly from the mean brown plant hopper population per 10 hills recorded in control plot. It was observed that average brown plant hopper population per 10 hills during 7 DAS was found to be lowest (3.10) in plots treated with Fipronil 5% SC +Buprofezin 20% SC @62.5+250g a.i./ha followed by 3.5 and 3.6 in plots treated with Buprofezin 25% SC @200g a.i./ha and Thiamethoxam 25 WG @25g a.i./ha respectively. Quinalphos 25% EC @375g a.i./ha and Indoxacarb 14.5%SC @30g a.i./ha recorded 5.9 and 5.6/ten hills and all the treatments differed significantly from one another in reducing brown plant hopper population. However, in control, the average brown plant hopper population after seven days of sprays was as high as 13.53/ten hills and was significantly high when compared to the population in all insecticidal treated plots.

It was observed that, there was a rise in average brown plant hopper population per 10 hills during 10th and 14th days after spraying. It was observed that average brown plant hopper population per 10 hills, ten days after the sprays was found to be lowest (4.76) in plots treated with Fipronil 40% SC +Imidcloprid 40% WG @50 +50g a.i./ha followed by 5.23 and 5.76 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha. However, in control the average brown plant hopper population after ten days of sprays was as high as 14.26/ten hills and was significantly high when compared to the population in all insecticidal treated plots. The average brown plant hopper, *N. lugens*, population per 10 hills was found to be increased from 4.76 (10 DAS) to 5.73 (14 DAS) in plot treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha, from 5.23 (10 DAS) to 6.13 (14 DAS) in plot treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and from 5.76 (10 DAS) to 6.73 (14 DAS) in plot treated with Indoxacarb 14.5% SC @30g a.i./ha..

Table 3: Effect of insecticidal treatments against *N. lugens* after 1st insecticidal sprays

Treatments	Dose (g a.i./ha)	Avg. no. of adult & nymphs/hill one day before spray	Avg. no. of adults & nymphs/hill at different days after 1st insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% +Thiamethoxam 10% WG	50 +50	13.36* (3.79)**	8.03 (3.00)	5.46 (2.54)	4.53 (2.35)	4.23 (2.29)	6.13 (2.67)	7.53 (2.92)	5.98
Fipronil 5% SC	75	13.6 (3.83)	8.33 (3.05)	5.63 (2.57)	4.9 (2.43)	4.56 (2.36)	6.4 (2.72)	7.66 (2.94)	6.25
Buprofezin 25% SC	200	12.43 (3.66)	8.53 (3.09)	6.26 (2.69)	5.93 (2.63)	5.63 (2.57)	7.56 (2.93)	8.46 (3.07)	7.06
Fipronil 40% +Imidacloprid 40% WG	50 +50	13.63 (3.82)	6.56 (2.75)	4.2 (2.28)	3.56 (2.14)	3.16 (2.04)	4.76 (2.40)	5.73 (2.59)	4.66
Fipronil 5% +Buprofezin 20% SC	62.5 +200	12.66 (3.69)	6.93 (2.81)	4.6 (2.36)	3.7 (2.17)	3.56 (2.14)	5.23 (2.49)	6.13 (2.66)	5.02
Thiamethoxam 25% WG	25	11.83 (3.58)	8.46 (3.08)	5.93 (2.63)	5.33 (2.51)	5.03 (2.45)	6.66 (2.77)	8.06 (3.01)	6.58
Indoxacarb 14.5% SC	30	10.76 (3.43)	7.46 (2.91)	5.06 (2.46)	3.96 (2.23)	3.6 (2.14)	5.76 (2.60)	6.73 (2.78)	5.43
Imidacloprid 17.8 SL	25	12.4 (3.66)	7.7 (2.94)	5.26 (2.50)	4.26 (2.29)	4.06 (2.25)	6.03 (2.65)	7.2 (2.86)	5.75
Quinalphos 25% EC	375	9.1 (3.18)	8.03 (3.00)	6.56 (2.74)	6.0 (2.64)	5.93 (2.63)	7.9 (2.98)	8.8 (3.13)	7.20
Control		11.83 (3.58)	12.4 (3.66)	13.23 (3.77)	14.36 (3.92)	13.53 (3.81)	14.26 (3.90)	14.46 (3.93)	13.71
SE(m)±		0.09	0.08	0.06	0.06	0.06	0.07	0.06	-
C.D.at 5%		0.27	0.24	0.19	0.20	0.18	0.20	0.19	-

*Mean of three replications, **Figures in the parenthesis are Square root transformed values, DAS-Days after spray

Table 4: Effect of insecticidal treatments against *N. lugens* after 2nd insecticidal sprays

Treatments	Dose (g a.i./ha)	Avg. no. of adult & nymphs/hill one day before spray	Avg. no. of adults & nymphs/hill at different days after 2nd insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% +Thiamethoxam 10% WG	50 +50	8.26* (3.04)**	7.26 (2.87)	5.33 (2.52)	4.36 (2.32)	3.63 (2.15)	4.36 (2.32)	4.8 (2.41)	4.96
Fipronil 5% SC	75	8.83 (3.13)	7.33 (2.88)	5.63 (2.57)	4.63 (2.37)	3.7 (2.17)	4.83 (2.41)	5.0 (2.45)	5.19
Buprofezin 25% SC	200	8.66 (3.11)	7.56 (2.92)	5.9 (2.63)	5.0 (2.45)	4.13 (2.26)	5.53 (2.56)	5.63 (2.58)	5.62
Fipronil 40% +Imidacloprid 40% WG	50 +50	7.66 (2.94)	5.86 (2.62)	4.33 (2.31)	3.26 (2.06)	2.53 (1.88)	2.96 (1.99)	3.2 (2.05)	3.69
Fipronil 5% +Buprofezin 20% SC	62.5 +200	7.9 (2.98)	6.2 (2.68)	4.63 (2.37)	3.53 (2.13)	2.76 (1.94)	3.43 (2.10)	3.76 (2.18)	4.05
Thiamethoxam 25% WG	25	9.36 (3.22)	7.43 (2.90)	5.8 (2.61)	4.9 (2.43)	4.3 (2.30)	5.13 (2.47)	5.33 (2.52)	5.48
Indoxacarb 14.5% SC	30	9.56 (3.25)	6.8 (2.79)	4.96 (2.44)	3.96 (2.23)	3.16 (2.04)	3.76 (2.18)	4.16 (2.27)	4.47
Imidacloprid 17.8 SL	25	8.23 (3.04)	7.16 (2.85)	5.16 (2.47)	4.13 (2.26)	3.36 (2.09)	4.06 (2.25)	4.56 (2.36)	4.74
Quinalphos 25% EC	375	10.0 (3.32)	8.26 (3.04)	6.0 (2.65)	5.06 (2.46)	4.3 (2.30)	5.9 (2.63)	6.2 (2.68)	5.95
Control		15.33 (4.04)	14.53 (3.94)	12.56 (3.68)	13.13 (3.76)	12.56 (3.68)	10.5 (3.39)	8.46 (3.08)	11.96
SE(m)±		0.04	0.05	0.07	0.05	0.03	0.03	0.04	-
C.D.at 5%		0.12	0.17	0.22	0.15	0.10	0.08	0.12	-

*Mean of three replications, **Figures in the parenthesis are Square root transformed values, DAS – Days after spray

The average population of brown plant hopper per ten hills after insecticidal sprays was found to be lowest in plots treated with Fipronil 5%+Buprofezin 20% SC @62.5+250g a.i/ha (4.59) and the average insect population of remaining treatments were found to be in the following order as: Fipronil 40%+Imidacloprid 40% WG (4.66) <Fipronil 5% +Buprofezin 20% SC (5.02) <Indoxacarb 14.5% SC (5.43) <Imidacloprid 17.8 SL (5.75) <Indoxacarb 10% +Thiamethoxam 10% WG (5.98) <Fipronil 5% SC (6.25) <Thiamethoxam 25% WG (6.58) <Buprofezin 25% SC (7.06) <Quinalphos 25% EC(7.20)<Control(13.71).

The field bio-efficacy of various insecticide molecules and their combinations against rice brown plant hopper were presented in Table 2. The average population of brown plant hopper, *N. lugens* per ten hills one day before the sprays varied from 7.66 to 15.33 per 10 hills in various test plots, including control. A perusal of Table 2 indicates that a significant reduction in population was observed after spraying of test chemicals as compared to untreated control

plot. It was observed that average population of brown plant hopper per ten hills one day after the sprays was found to be lowest (5.86) in plots treated with Fipronil 40%+Imidacloprid 40% WG @50 +50g a.i./ha followed by 6.2 and 6.8 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha. In contrary, the average population of brown plant hopper per ten hills one day after the sprays was found to be highest (14.53) in control plots followed by 8.26 and 7.56 in plots treated with Quinalphos 25% EC @375g a.i./ha and Buprofezin 25% SC @200g a.i./ha.

The average population of brown plant hopper per ten hills after second insecticidal spray was found to be lowest in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i/ha (3.69) and the mean insect population of remaining treatments were found to be in increasing order as: Fipronil 40%+Imidacloprid 40% WG (3.69) <Fipronil 5% +Buprofezin 20% SC (4.05) <Indoxacarb 14.5% SC (4.47) <Imidacloprid 17.8 SL (4.74) <Indoxacarb 10% +thiamethoxam 10% WG (4.96) <Fipronil 5% SC (5.19) <Thiamethoxam 25% WG (5.48) <Buprofezin 25% SC (5.62) <Quinalphos 25% EC (5.95) < control (11.96).

Effect of insecticidal treatments against Green Leaf Hoppers, *Nephotettix virescens*

Field bio-efficacy of various insecticide molecules and their combinations against rice green leaf hopper, *N. virescens* were presented in Table 3. First observation was recorded one day before spraying of test chemicals. The mean green leaf hopper population per 10 hills one day before the sprays varied from 9.56 to 13.73 in various test plots, including control. A study of Table 3 indicates that a significant reduction in population was observed after spraying of test chemicals as compared to untreated control. It was observed that mean green leaf hopper population per 10 hills on one day after the sprays was found to be lowest (7.36) in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha followed by 7.63 and 7.73 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha respectively. In contrary, the mean green leaf hopper population per 10 hills one day after the sprays was found to be highest (12.5) in control plots followed by 8.46 and 8.36 in plots treated with Quinalphos 25 EC @375g a.i./ha and Buprofezin 25% SC @50+50g a.i./ha.It was observed that mean *N. virescen s* population per 10 hills on three days after the sprays was found to be least (5.43) in plots treated with Fipronil 40% +Imidacloprid 40% WG @50+50g a.i./ha followed by 5.83 and 5.96 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5+200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha respectively. In contrary, the mean green leaf hopper population per ten hills three day after the sprays was found to be highest (13.16) in control plots followed by 7.0 and 6.96 in plot treated with Quinalphos 25 EC @375g a.i./ha and Thiamethoxam 25% WG @25g a.i../ha respectively.After the five days of insecticidal spray, the mean green leaf hopper population per 10 hills was 3.73, 3.96 and 4.0/ten hills in Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha, Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha treated plots, respectively and was significantly low when compared to the population observed in other treatments. However, in control plots, the green leaf hopper population after five days of sprays was as high as 13.66 /ten hills and was significantly high when compared to the population in all insecticidal treated plots. The mean green leaf hopper, *N. virscens*, population per 10 hills was observed to be low in all the treatments during 7 days after spray and all the treatments were significantly different from the mean green leaf hopper, *N. virescens* population per 10 hills recorded in the control plot. It was observed that mean green leaf hopper population per 10 hills during 7 DAS was found to be lowest (3.1) in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha followed by 3.33 and 3.73 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha respectively. However, in control the mean green leaf hopper population after seven days of sprays was as high as 12.9/ten hills and was significantly high when compared to the population in all insecticidal treated plots. It was observed that, there was a rise in mean green leaf hopper population per 10 hills during 10th day and 14th days after spraying. It was observed that mean *N. virescens* population per 10 hills ten days after the sprays was found to be lowest(3.96) in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha. It was followed by 4.13 and 4.56 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha. However, in control the mean green leaf hopper population after ten days of sprayswas as high as 13.93/ten hills and was significantly high when compared to the population in all insecticidal treated plots. Among insecticides, the mean green leaf hopper population was found to be highest in plots treated with Quinalphos 25% EC (6.76). During 14th days after spraying also, least GLH population was found in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha (4.93) followed by Fipronil 5% +Buprofezin 20%SC @62.5 +200g a.i./ha (5.66) and Indoxacarb 14.5% SC @30g a.i./ha (5.96).Maximum population was found in control plot (13.4) followed by Quinalphos 25% EC (8.23).

The overall mean of green leaf hopper population per 10 hills after first insecticidal spray was found to be lowest in plots treated with Fipronil 40%+Imidacloprid 40% WG @50 +50g a.i/ha (4.75) and the average insect population of remaining treatments were shown in the following order as: Fipronil 40%+Imidacloprid 40% WG (4.75) <Fipronil 5% +Buprofezin 20% SC (5.09) <Indoxacarb 14.5% SC (5.32) <Imidacloprid 17.8 SL (5.54) <Indoxacarb 10% +thiamethoxam 10% WG (5.81) <Fipronil 5% SC (5.90) <Thiamethoxam 25% WG (6.26) <Buprofezin 25% SC (6.41) <Quinalphos 25% EC (6.68) < Control (13.26).

Field bio-efficacy of various insecticide molecules and their combinations against rice green leaf hopper, *N. virescens* were presented in Table 4. The response of various test chemicals were almost same as that of observations made after first insecticidal sprays. The mean green leaf hopper population per 10 hills one day before the sprays varied from 8.76 to 14.23 in various test plots, including control. A study of table 4 indicates that a significant reduction in population was observed after spraying of test chemicals as compared to untreated control. It was observed that mean green leaf hopper population per 10 hillson one day after the sprays was found to be lowest (6.16) in plots treated with Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha followed by 6.4 and 6.93 in plots treated with Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha and Indoxacarb 14.5% SC @30g a.i./ha. In contrary, the mean green leaf hopper population per 10 hills one day after the sprays was found to be highest (13.60) in control plots followed by 8.23 and 8.0 in plots treated with Quinalphos 25 EC @375g a.i./ha and Buprofezin 25% SC @50+50g a.i./ha.

Table 5: Effect of insecticidal treatments against *N. virescens* after 1st insecticidal sprays

Treatments	Dose (g a.i./ha)	Avg. no. of adult & nymphs/ 5 hills one day before spray	Avg. no. of adults & nymphs per 5 hills at different days after 1st insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	13.26* (3.77)**	8.26 (3.04)	6.2 (2.68)	4.53 (2.35)	4.03 (2.24)	5.1 (2.47)	6.73 (2.78)	5.81
Fipronil 5% SC	75	9.56 (3.25)	8.13 (3.02)	6.36 (2.71)	4.53 (2.35)	4.0 (2.23)	5.46 (2.54)	6.9 (2.81)	5.90
Buprofezin 25% SC	200	12.4 (3.66)	8.36 (3.06)	6.7 (2.77)	5.03 (2.46)	4.36 (2.32)	6.13 (2.67)	7.86 (2.98)	6.41
Fipronil 40% + Imidacloprid 40% WG	50 + 50	13.26 (3.77)	7.36 (2.89)	5.43 (2.54)	3.73 (2.17)	3.1 (2.02)	3.96 (2.22)	4.93 (2.43)	4.75
Fipronil 5% + Buprofezin 20% SC	62.5 + 200	10.53 (3.39)	7.63 (2.94)	5.83 (2.61)	3.96 (2.23)	3.33 (2.08)	4.13 (2.26)	5.66 (2.58)	5.09
Thiamethoxam 25% WG	25	12.53 (3.68)	8.26 (3.04)	6.96 (2.82)	4.96 (2.44)	4.26 (2.29)	5.76 (2.60)	7.36 (2.89)	6.26
Indoxacarb 14.5% SC	30	13.73 (3.84)	7.73 (2.95)	5.96 (2.64)	4.0 (2.24)	3.73 (2.17)	4.56 (2.36)	5.96 (2.64)	5.32
Imidacloprid 17.8 SL	25	11.3 (3.51)	8.03 (3.00)	6.0 (2.64)	4.2 (2.28)	3.86 (2.21)	4.93 (2.43)	6.23 (2.69)	5.54
Quinalphos 25% EC	375	11.8 (3.58)	8.46 (3.07)	7.0 (2.83)	5.13 (2.47)	4.76 (2.40)	6.76 (2.78)	8.23 (3.04)	6.68
Control		10.96 (3.46)	12.5 (3.67)	13.16 (3.76)	13.66 (3.83)	12.9 (3.73)	13.93 (3.86)	13.4 (3.79)	13.26
SE(m)±		0.03	0.04	0.03	0.06	0.04	0.03	0.03	-
C.D.at 5%		0.09	0.13	0.11	0.17	0.12	0.09	0.08	-

*Mean of three replications, **Figures in the parenthesis are Square root transformed values, DAS – Days after spray

Table 6: Effect of insecticidal treatments against *N. virescens* after 2nd insecticidal spray

Treatments	Dose (g a.i./ha)	Avg. no. of adult & nymphs /hill one day before spray	Avg. no. of adults & nymphs/hill at different days after 2nd insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% + Thiamethoxam 10% WG	50 + 50	9.63* (3.26)**	7.2 (2.86)	5.36 (2.52)	4.23 (2.29)	3.1 (2.02)	3.73 (2.18)	4.6 (2.37)	4.70
Fipronil 5% SC	75	11.23 (3.49)	7.56 (2.93)	5.6 (2.68)	4.43 (2.33)	3.43 (2.10)	3.93 (2.22)	4.96 (2.44)	4.98
Buprofezin 25% SC	200	9.86 (3.30)	8.0 (2.99)	6.13 (2.67)	4.83 (2.41)	4.1 (2.26)	4.6 (2.37)	5.7 (2.59)	5.56
Fipronil 40% + Imidacloprid 40% WG	50 + 50	8.76 (3.12)	6.16 (2.68)	4.33 (2.31)	3.1 (2.02)	2.23 (1.79)	2.8 (1.95)	3.76 (2.18)	3.73
Fipronil 5% + Buprofezin 20% SC	62.5 + 200	10.56 (3.40)	6.4 (2.72)	4.46 (2.33)	3.46 (2.11)	2.66 (1.91)	3.16 (2.03)	3.93 (2.22)	4.01
Thiamethoxam 25% WG	25	10.33 (3.37)	7.96 (2.99)	5.83 (2.61)	4.56 (2.36)	3.56 (2.14)	4.16 (2.27)	5.13 (2.47)	5.2
Indoxacarb 14.5% SC	30	10.7 (3.42)	6.93 (2.82)	4.86 (2.42)	3.93 (2.22)	2.86 (1.96)	3.46 (2.11)	4.13 (2.26)	4.36
Imidacloprid 17.8 SL	25	8.9 (3.15)	7.13 (2.85)	5.0 (2.45)	4.13 (2.26)	3.06 (2.01)	3.5 (2.12)	4.36 (2.32)	4.53
Quinalphos 25% EC	375	12.36 (3.65)	8.23 (3.04)	6.2 (2.68)	5.16 (2.48)	4.23 (2.29)	4.93 (2.43)	6.43 (2.72)	5.86
Control	50 + 50	14.23 (3.90)	13.6 (3.82)	13.96 (3.87)	14.36 (3.92)	13.86 (3.86)	13.76 (3.84)	12.83 (3.72)	13.73
SE(m)±		0.04	0.05	0.05	0.04	0.05	0.04	0.04	-
C.D.at 5%		0.11	0.14	0.15	0.14	0.15	0.13	0.13	-

*Mean of three replications, **Figures in the parenthesis are Square root transformed values, DAS – Days after spray

The overall average population of green leaf hopper per 10 hills after insecticidal spray was found to be lowest Fipronil 40%+Imidacloprid 40% WG treated plots @50 +50g a.i/ha (3.73) and the average insect population of remaining treatments were shown in the increasing order as: Fipronil 40%+Imidacloprid 40% WG (3.73) <Fipronil 5% +Buprofezin 20% SC (4.01) <Indoxacarb 14.5% SC (4.36) <Imidacloprid 17.8 SL (4.53) <Indoxacarb 10% +thiamethoxam 10% WG (4.70) <Fipronil 5% SC (4.98) <Thiamethoxam 25% WG (5.2) <Buprofezin 25% SC (5.56) <Quinalphos 25% EC (5.86) < control (13.73).

Effect of insecticidal treatments against Gundhi bug, *Leptocrosia acuta*

Field bio-efficacy of various insecticide molecules and their combinations against rice gundhi bug, *L. acuta* were presented in Table 5. The mean gundhi bug, *L. acuta*, population per 5 sweep nets one day before the sprays varied

from 10.33 to 12.67 in various test plots, including control. A study of Table 5 indicates that a significant reduction in population was observed after spraying of test chemicals as compared to untreated control. It was observed that mean gundhi bug population per 5 sweep nets on one day after the sprays was found to be lowest (6.00) in plots treated with Indoxacarb 10% +Thiamethoxam 10% WG @50+50g a.i./ha followed by 8.00 and 9.00 in plots treated with Fipronil 5% SC @75g a.i./ha and Fipronil 40% +Imidcloprid 40% WG @50+50g a.i./ha. In contrary, the mean gundhi bug, *L. acuta*, population per 5 sweep nets one day after the sprays was found to be highest (13.67) in control plots followed by 12.67 and 11.67 in plot treated with Buprofezin 25% EC @200g a.i./ha and Imidacloprid 17.8 SL @25g a.i./ha, respectively.

It was observed that *L. acuta*, population per 5 sweep nets on three days after the sprays was found to be lowest (5.00) in plots treated with Indoxacarb 10% +Thiamethoxam10% WG @50+50g a.i./ha followed by 5.66 and 7.66 in plots treated with Fipronil 5% SC @75g a.i./ha and Fipronil 40% +Imidcloprid 40% WG @50+50g a.i./ha, respectively. In contrary, the mean gundhi bug, *L. acuta*, population per 5 sweep nets one day after the sprays was found to be highest (14.00) in control plots followed by 10.66 and 10.33 in plot treated with Buprofezin 25% EC @200g a.i./ha and Quinalphos 25% EC @375g a.i./ha, respectively.

After the five days of insecticidal spray, the mean gundhi bug population per 5 sweep nets was 3.33, 4.66 and 5.33/five sweep nets in Indoxacarb 10% +Thiamethoxam 10% WG @50+50g a.i./ha, Fipronil 5% SC @75g a.i./ha and Fipronil 40% +Imidcloprid 40% WG @50+50g a.i./ha treated plots, respectively and was significantly low when compared to the population observed in other treatments. Buprofezin 25% SC @200g a.i /ha and Quinalphos 25% EC @375g a.i./ha treated plots recorded 8.00 and 8.66/five sweep nets and all the treatments differed significantly from one another in reducing gundhi bug population. However, in control the mean gundhi bug population after five days of sprays was as high as 12.66/five sweep nets and was significantly high when compared to the population in all insecticidal treated plots.

The mean gundhi bug, population per 5 sweep nets was observed to be low in all treatments during 7 days after spray and differed significantly from the mean *L. acuta*, population per 5 sweep nets recorded in control. It was observed that mean gundhi bug population per 5 sweep nets during 7 DAS was found to be lowest (3.00) in plots treated with Indoxacarb 10% +Thiamethoxam 10% WG 50 +50g a.i./ha followed by 4.00 and 5.00 in plots treated with Fipronil 5% SC @75g a.i./ha and Fipronil 40% +Buprofezin 20% SC @62.5 +200g a.i./ha respectively. Buprofezin 25% SC @200g a.i/ha and Quinalphos 25% EC @375g a.i./ha recorded 8.33 and 7.66/five sweep nets and all the treatments differed significantly from one another in reducing gundhi bug population. However, in control the mean gundhi bug population after seven days of sprays was as high as 13.00/five sweep nets and was significantly high when compared to the population in all insecticidal treated plots.

It was observed that, there was a rise in mean gundhi bug population per 5 sweep nets during 10th day and 14th days after spraying. However, the mean gundhi bug population per 5 sweep nets ten day after the sprays was found to be lowest (5.00) in plots treated with Indoxacarb 10% +Thiamethoxam 10% WG @50 +50g a.i./ha followed by 5.33 and 6.33

Table 7: Effect of insecticidal treatments against *L. acuta* after insecticidal spray

Treatments	Dose (g a.i./ha)	Avg. no. of adult & nymphs/ 5 sweep nets one day before spray	Avg. no. of adults & nymphs per 5 sweep nets at different days after 1st insecticidal spray						
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Overall Mean
Indoxacarb 10% +Thiamethoxam 10% WG	50 +50	10.33* (3.34)**	6.00 (2.64)	5 (2.44)	3.33 (2.08)	3 (2.00)	5 (2.43)	5.66 (2.57)	4.95
Fipronil 5% SC	75	11.00 (3.45)	8.00 (2.99)	5.66 (2.58)	4.66 (2.38)	4 (2.23)	5.33 (2.51)	6.33 (2.71)	5.96
Buprofezin 25% SC	200	13.00 (3.73)	12.67 (3.70)	10.66 (3.41)	8.66 (3.31)	8.33 (3.05)	9 (3.15)	9.66 (3.26)	10.04
Fipronil 40% +Imidacloprid 40% WG	50 +50	12.00 (3.60)	9.00 (3.16)	7.66 (2.94)	5.33 (2.31)	5 (2.45)	6.33 (2.70)	7 (2.82)	6.96
Fipronil 5% +Buprofezin 20% SC	62.5 +200	12.00 (3.60)	10.67 (3.41)	10 (3.31)	7.66 (2.94)	7 (2.82)	8.33 (3.05)	8.66 (3.11)	8.89
Thiamethoxam 25% WG	25	13.00 (3.74)	11.00 (3.46)	9.66 (3.26)	7 (2.99)	6.66 (2.77)	8 (2.99)	8 (2.99)	8.60
Indoxacarb 14.5% SC	30	12.67 (3.68)	9.33 (3.21)	8 (2.99)	6.33 (2.71)	5.66 (2.58)	7 (2.82)	8 (3.00)	7.62
Imidacloprid 17.8 SL	25	12.33 (3.64)	11.67 (3.56)	9.33 (3.21)	6.66 (2.76)	6.33 (2.71)	7.33 (2.88)	7.66 (2.88)	8.41
Quinalphos 25% EC	375	12.00 (3.60)	11.33 (3.51)	10.33 (3.37)	8 (2.51)	7.66 (2.94)	8.33 (3.11)	9 (3.16)	9.26
Control	50 +50	10.33 (3.36)	13.67 (3.83)	14 (3.87)	12.66 (3.69)	13 (3.74)	14 (3.86)	12 (3.51)	13.24
SE(m)±		-	0.07	0.09	0.09	0.08	0.13	0.11	-
C.D.at 5%		-	0.21	0.26	0.29	0.26	0.41	0.32	-

*Mean of three replications, **Figures in the parenthesis are Square root transformed values, DAS-Days after spray

in plots treated with Fipronil 5% SC @75g a.i./ha and fipronil 40% +Imidaclorid 40% WG @50+50g a.i./ha. In control the mean gundhi bug population after ten days of sprays was as high as 14.00/five sweep nets and was significantly high when compared to the population in all insecticidal treated plots. The mean gundhi bug, L. acuta, population per 5 sweep nets was found to be rise from 5.00 (10 DAS) to 5.66 (14 DAS) in plot treated with Indoxacarb 10% +Thiamethoxam 10% WG

@50 +50g a.i./ha, from 5.33(10 DAS) to 6.33(14 DAS) in plot treated with Fipronil 5% SC @75g a.i./ha and from 6.33(10 DAS) to 7.00(14 DAS) in plot treated with Fironil 40% +Imidacloprid 40% WG @50 +50g a.i /ha.

The average population of gundhi bug per five sweep nets after insecticidal spray was found to be lowest in plots treated with Indoxacarb 10% +Thiamethoxam 10% WG @50 +50g a.i./ha (4.95) and the mean insect population of remaining treatments were shown in the increasing order as: Indoxacarb 10% +Thiamethoxam 10% WG (4.95)<Fipronil 5% SC (5.96)<Fipronil 40%+Imidacloprid 40% WG (6.96)<Indoxacarb 14.5% SC (7.62)<Imidacloprid 17.8%SL(8.41)<Thiamethoxam 25% WG (8.60)<Fipronil 5%+Buprofezin 20% SC (8.89)<Quinalphos 25% SC (9.26)<Buprofezin 20% SC (10.04)< Control(13.24).

Conclusion

From the results of the experiment, the treatment Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha is most effective against N. lugens and is best insecticidal treatment. The second best chemical was Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha, followed by Indoxacarb 14.5% SC @30g a.i./ha and Imidacloprid 17.8% SL @25g a.i./ha. These results are in close accordance with Roshan *et al*. (2016) who confirmed that Acetamiprid +Fipronil combination was most effective against BPH. A combination of phenyl pyrazole and chitin synthesis inhibitor, Fipronil +Buprofezin has more efficacy against BPH than the sole application of Buprofezin (chitin synthesis inhibitor). However, Ghosh *et al*. (2012) reported that, the treatments Buprofezin 25 SC and Imidacloprid sole treatments were more effective in controlling brown plant hopper population.

Of the selected insecticidal assessment against GLH, combination insecticide Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha was most effective succeeded by Fipronil 5% +Buprofezin 20% SC @62.5 +200g a.i./ha, Indoxacarb 14.5% SC @30g a.i./ha and Imidacloprid 17.8% SL @25g a.i./ha. These results are in close accordance with work done by Roshan *et al*. (2016) in which they reported that combination of Acetamiprid 15% +Fipronil 60% WDG provided good result against green leaf hopper. However, Firaka *et al.* (2010) in their study reported that Imidacloprid 17.8 SL was more effective in sole treatment against GLH followed by Fipronil 5 SC. Hence, the combination of phenyl pyrazole and neonicotinoid with contact and systemic action proved to be significant at GLH control.

The findings made during the evaluation of test insecticides against gundhi bug revealed that the most effective treatment is Indoxacarb 10% +Thiamethoxam 10% WG @50 +50g a.i./ha and it is significantly better over the rest insecticidal treatments. The second best chemical was Fipronil 5% SC @75g a.i./ha. The third best treatment is Fipronil 40% +Imidacloprid 40% WG @50 +50g a.i./ha. Girish and Balikai (2015) reported that Thiamethoxam 25% WG @25g a.i./ha was found to be more effective in comparison to other treatments. All the findings made in present study are in concurrence with the results obtained by above workers. Buprofezin 25% SC was found to be least effective. However, Chaudhury and Raghuraman (2014) [9] reported that Buprofezin with Acephate combination provided significant result in controlling rice gundhi bug.

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