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# Effect of pre-mix combination of Acephate and Imidacloprid on insect pests of rice and their natural enemies

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**Abstract**
Field experiments were carried out during *kharif* and *rabi* seasons of 2014-15 to test the efficacy of pre-mix combination, Acephate 50%+ imidacloprid 1.8% SP at four different doses against insect pests of rice along with Acephate 75% WP (750 g.a.i $ha^{-1}$), imidacloprid 17.8% SL (25 g.a.i $ha^{-1}$) and Chlorpyrifos 50% + cypermethrin 5% EC (375+38 g.a.i $ha^{-1}$) at Baronda research farm, ICAR-National Institute of Biotic Stress Management Raipur. Acephate 50% + imidacloprid 1.8% SP @ 621.6 g.a.i $ha^{-1}$ was proved to be significantly superior over all other treatments with lowest% dead hearts,% white ear,% leaf damage by leaf folder and lowest incidence of brown planthopper and green leafhopper during both seasons of 2014-15. Maximum grain yield (50.14 and 51.02 $qha^{-1}$) with highest cost benefit ratio (3.1 and 3.3) observed in Acephate 50% + imidacloprid 1.8% SP @ 621.6 g.a.i $ha^{-1}$ respectively during *kharif* and *rabi* 2014-15. All the doses of Acephate 50%+ imidacloprid 1.8% SP were found safer to natural enemies in rice ecosystem i.e. *Cyrtorhinus lividipennis* and spiders. Acephate 50% + imidacloprid 1.8% SP was found to be effective against both borers and sucking pests.

**Keywords:** Acephate, Rice, imidacloprid, Stem borer, Leaf folder

## 1. Introduction
"Rice is Life" describes the importance of rice in human diet. It is grown worldwide over an area of 153 million hectares with annual production of more than 600 million tonnes. In India, it is cultivated in an area of 44.80 million hectares with an annual production of 89.31 million tonnes and productivity over two tonnes of milled rice per hectare (CMIE). [1] Insect pests are the severe constraints to rice production throughout the world (Dale) [2] where more than 100 species of insect pests attack and damage rice (Pathak). [13]
Among the insect pests, yellow stem borer, *Scirpophaga incertulas* (Walker) is the major stem borer accounting 30-80% yield losses (Lal) [10] followed by leaf folder pest, *Cnaphalocrocis medinalis* causes 60 to 70 per cent leaf damage (Kushwaha and Singh). [9] Among sucking pests, Brown planthopper, *Nilaparvata lugens* (Stal) is the major which causes hopper burn symptom due to sucking of sap from later stage of rice crop accounting for yield losses up to 20-60% (Varma *et al*.). [21] Green leafhopper, *Nephotettix virescens* (Dist.) often assumes serious status in several rice growing tracts of India due to its notorious nature of being a vector of 'Tungro' virus disease of rice besides causing leaf damage (Rai and Khan). [14]
Insecticide spray is the only viable option for the management of these notorious pests and farmers depend heavily on insecticides for pest management. Insecticides with different mode of action are required to control borers and sucking pests as their nature of damage is entirely different from each other. So, farmers always need to spray more insecticide molecules to control insects of different feeding nature, which is economically not viable and increases cost of cultivation. Hence, we made an attempt to evaluate the bio-efficacy of pre-mix combination of Acephate 50% + imidacloprid 1.8% SP against rice pests of varied nature and also studied the effect of this molecule on natural enemy complex of rice ecosystem.

## 2. Materials and Methods
### 2.1 Experimental location
Field experiments were carried out at ICAR-National Institute of Biotic Stress Management, Baronda, Raipur, Chhattisgarh. The farm is located at an altitude of 281.8 m, latitude of 21° 22' 59.79'' N and longitude of 81° 49' 37.28'' E. This location receives an annual average rainfall of 1150 mm.

### 2.2 Nursery raising and transplanting

Swarna (MTU-7029, medium stature with 145 days duration), a popular rice variety among farmers was sown in well prepared seed beds of size 10.0 m × 1.0 m. The nursery was raised as per standard package of practices without any plant protection measures. Twenty five days old seedlings were transplanted at the rate of 2 seedlings hill$^{-1}$ in well prepared plots of 5 m × 5 m in main field. The main crop was raised as per recommended package of practices except plant protection measures.

### 2.3 Field efficacy of insecticides

Bio-efficacy of insecticides under field conditions was carried out during *kharif* and *rabi* seasons of 2014-15. The experiment was laid out in randomized block design with seven treatments and three replications. The treatments were; 1. Acephate 50% + imidacloprid 1.8% SP @ 414.4 g a.i ha$^{-1}$; 2. Acephate 50% + imidacloprid 1.8% SP @ 518 g a.i ha$^{-1}$; 3. Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i ha$^{-1}$; 4. Acephate 75% SP @ 750 g a.i ha$^{-1}$; 5. Imidacloprid 17.8% SL @ 25 g a.i ha$^{-1}$; 6. Chlorpyrifos 50% + cypermethrin 5% EC @ 413 g a.i ha$^{-1}$ and 7. Untreated control. All the treatments were applied using high volume knapsack sprayer fitted with hollow cone nozzle and spray solution was 375-500 L ha$^{-1}$. First spraying was done at 45 days after transplanting (DAT) and second spray was done at 60 DAT. The observations on stem borer damage was recorded as per cent dead hearts (DH) at one day before spray, 10 days after first spray and 10 days after second spray and per cent white ears (WE) at 15 days before harvest on 10 randomly selected hills. Leaf folder damage was recorded as per cent damaged leaves and total number leaves per 10 randomly selected hills. BPH and GLH were counted number per 10 randomly selected hills at one day before spray, 5, 10 and 15 days after spray. The calculations were made using following relations:

$$\% \text{ dead hearts} = \frac{\text{Number of dead hearts/hill}}{\text{Total number of tillers/hill}} \times 100$$

$$\% \text{ white ears} = \frac{\text{Number of white ears/hill}}{\text{Total number of panicle bearing tillers/ hill}} \times 100$$

$$\% \text{ damaged leaves} = \frac{\text{Number of leaves damaged/hill}}{\text{Total number of leaves per hill}} \times 100$$

Observations on impact of insecticides on natural enemies of rice ecosystem *viz*, *Cyrtorhinus lividipennis* and spider populations were also taken as number per 10 hills for *C. lividipennis* and number m$^{-2}$ for spider populations.

### 2.4 Benefit: Cost ratio

Economics of insecticide applications was computed on the basis of economic returns from grain and straw yields and cost of insecticidal treatments. Thus, B: C ratio was worked out for judging economics of insecticide treatments.

### 2.5 Statistical analysis

Experimental data was transformed with suitable transformation method before analysis (Gomez and Gomez). [4] The data pertaining to per cent dead hearts, per cent white ears, per cent leaf damage and incidence of BPH and GLH was analysed using General Linear Model (GLM) technique using SAS 9.2 (SAS) [17] statistical software package. The means were compared by Tukey's HSD test at P=0.05.

## 3. Results and Discussion

### 3.1 Yellow stem borer (YSB)

All the insecticidal treatments were given superior control of YSB except Imidacloprid 17.8% SL and untreated control during both seasons. Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i ha$^{-1}$ was found to be best treatment with less% dead heart damage at 10 days after first (1.08) and second spray (0.65) followed by Acephate 50% + imidacloprid 1.8% SP @ 518 g a.i ha$^{-1}$ during *kharif* 2014-15. The least% white ear damage was recorded in Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i ha$^{-1}$ which was significantly superior over other treatments. During *rabi* 2014-15, similar observations were noticed but the% dead heart at 10 days after second spray was slightly increased from previous observation. It might be due to rainfall soon after the spraying of insecticides and other abiotic stress conditions (Table 1). This is the first study on efficacy testing of Acephate 50% + Imidacloprid 1.8% SP against rice pests. However, many researchers have tried different insecticide combinations for the control of YSB. Kartikeyan *et al*. [6] reported that flubendiamide (4%) + buprofezin (20%) @ 875 ml ha$^{-1}$ was the best treatment in controlling rice insect pests. Karthikeyan and Christy [5] proved that chlorantraniliprole @ 150 ml ha$^{-1}$ was the most effective treatment against major rice pests like yellow stem borer, leaf folder and case worm. Krishnamoorthy *et al*. [8] reported that Buprofezin 20% + acephate 50% WP was the most effective treatment for the management of BPH, stem borer and leaffolder in rice.

### 3.2 Rice leaf folder (RLF)

Efficacy of different doses of Acephate 50% + imidacloprid 1.8% SP along with traditional insecticides against RLF is presented in Table 2. All the insecticides were superior in controlling the RLF damage except Imidacloprid 17.8% SL and untreated control during both seasons. One day before treatment imposition, RLF infestation was uniform and above ETL in all the treatments. Ten days after first application of treatments, Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i ha$^{-1}$ was found to be best treatment with lowest% leaf damage (0.25%) and similar trend was noticed during second spray also. Chlorpyrifos 50% + cypermethrin 5% EC was found next best treatment with 0.51% and 0.98% leaf damage respectively during ten days after first and second spray. Similar observations were recorded during *rabi*, 2014-15. These results were corroborated with the findings of Sharma and Srivastava [19] who reported the Flubendiamide + fipronil @ 33 g a.i ha$^{-1}$ was found to be effective for the control of leaffolder with 1.95% damaged leaves. Kartikeyan *et al*. [6] found flubendiamide (4%) + buprofezin (20%) @ 875 ml ha$^{-1}$ was the best treatment with lowest leaf folder damage compared to monocrotophos. Veeravel and Ravivarman [22] reported that bifenthrin 10EC @ 75g a.i ha$^{-1}$ was the most effective against rice leaf folder both at 10 days after first and second spray.

### 3.3 Brown planthopper (BPH)

Field efficacy of Acephate 50% + imidacloprid 1.8% SP at different doses along with other check insecticides against BPH was presented Table 3. One day before application, BPH incidence was above ETL in all the treatments. Five days after application of treatments, Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i ha$^{-1}$ was found significantly superior over other treatments with lowest BPH incidence (25 per 10 hills) followed by Acephate 50% + imidacloprid 1.8% SP @ 518 g a.i ha$^{-1}$ with an incidence of 33.33 BPH per 10 hills during

first spray of *kharif* 2014-15. The same trend was observed at 10 and 15 days after spray. Similar results were noticed during second spray. During *rabi* 2014-15, overall incidence of BPH is low compared to *kharif* season. Results were similar to that of *kharif* season wherein Acephate 50% + Imidacloprid 1.8% SP @ 621.6 g a.i $ha^{-1}$ was found to be best statistically best treatment with lowest incidence of BPH. Ghosh *et al*. [3] reported that buprofezin 25 SC @ 200 g.a.i. $ha^{-1}$ and imidacloprid 17.8 SL @ 50 g a.i. $ha^{-1}$ showed superiority over other insecticides by reducing the BPH population by 99.13 and 94.97%, respectively. Sarkar and Debashis Roy [16] reported the efficacy of pre-mix combination of fenobucarb 20% EC + buprofezin 5% SC at 1500, 2000 and 3000 ml $ha^{-1}$ which performed significantly superior in controlling BPH. Subhash Chander *et al*. [20] reported that combination product, Buprofezin 20% + Acephate 50% @ 595 g a.i $ha^{-1}$ was found effective in controlling both BPH and RLF.

### 3.4 Green leafhopper (GLH)

GLH incidence was uniform at one day before spray of insecticides in all the treatments. During *kharif* 2014-15, Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i $ha^{-1}$ was found significantly superior over other treatments with incidence of 8.67, 1.67 and 4.33 GLH per 10 hills respectively at 5, 10 and 15 days after first spray. The next best treatment was Acephate 50% + imidacloprid 1.8% SP @ 518 g a.i $ha^{-1}$. Similar trend was observed during second spray also. During *rabi* 2014-15, the overall incidence of GLH was found low compared to *kharif* season (Table 4). The insecticide efficacy results were found similar to that of *kharif* 2014-15. The results are in conformity with the findings of Manjunatha and Shivanna, [11] Reddy and Krishnaiah.[15] Seetha Ramu *et al*. [18] reported that imidacloprid @ 0.25 ml $L^{-1}$ was found very effective against the sucking pests of rice *viz*., BPH, GLH and WBPH followed by ethofenprox @ 1.5 ml $L^{-1}$.

### 3.5 Economics of insecticides application

Highest grain yield was obtained in Acephate 50% + imidacloprid 1.8% SP @ 621.6 g a.i $ha^{-1}$ (50.14 and 51.02 q $ha^{-1}$) with benefit: cost ratio of 3.1 and 3.3 followed by Acephate 50% + imidacloprid 1.8% SP @ 518 g a.i $ha^{-1}$ (47.36 and 48.22 q $ha^{-1}$) with benefit: cost ratio of 2.7 and 2.9, respectively during *kharif* and *rabi* 2014-15 (Table 5).

### 3.6 Effect of insecticides on natural enemies

All the tested doses of Acephate 50% + imidacloprid 1.8% SP along with other insecticides were found safer to natural enemies of rice ecosystem *viz*., *Cyrtorhinus lividipennis* and spiders (Table 6). No adverse effects of tested insecticides were noticed during study period and activity of natural enemy population was at par across all the treatments. These findings were corroborated by Misra [12] who reported the no significant effect on natural enemies of rice ecosystem due to application of imidacloprid 17.8% SL and thiamethoxam 25% WG both @ 25g a.i. $ha^{-1}$. Kharbade [7] reported that the buprofezin 25 SC, thiamethoxam 25 WG and imidacloprid 17.8 SL, acetamiprid 20 SP and *Metarhizium anisopliae* WP were found safer to natural enemies in rice ecosystem.

**Table 1:** Efficacy of insecticides against yellow stem borer (YSB), *Scirpophaga incertulas* damage in rice during *kharif* and *rabi* 2014-15.

| Treatments | Dosage of chemical (g a.i.ha$^{-1}$) | Formulation (g or ml ha$^{-1}$) | *Kharif* 2014-15 | | | | *Rabi* 2014-15 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | % Dead heart | | | % WE | % Dead heart | | | % WE |
| | | | 1 DBS | 10 Days After 1st Spray | 10 Days After 2nd Spray | 15 DBH | 1 DBS | 10 Days After 1st Spray | 10 Days After 2nd Spray | 15 DBH |
| Acephate 50% + Imidacloprid 1.8% SP | 414.4 | 800 | 4.65a (2.27) | 4.12c (2.15) | 3.26e (1.94) | 3.06d (1.89) | 5.23a (2.39) | 2.65d (1.77) | 3.65d (2.04) | 3.10c (1.90) |
| Acephate 50% + Imidacloprid 1.8% SP | 518.0 | 1000 | 4.52a (2.24) | 1.17b (1.29) | 0.90b (1.18) | 1.84b (1.53) | 4.95a (2.33) | 1.29b (1.34) | 2.36b (1.69) | 2.08a (1.61) |
| Acephate 50% + Imidacloprid 1.8% SP | 621.6 | 1200 | 4.84a (2.31) | 1.08a (1.26) | 0.65a (1.07) | 1.67a (1.47) | 4.68a (2.28) | 1.01a (1.23) | 2.10a (1.61) | 1.98a (1.57) |
| Acephate 75% SP | 750.0 | 1000 | 4.97a (2.34) | 2.57b (1.75) | 2.16d (1.63) | 2.15c (1.63) | 5.02a (2.35) | 2.25c (1.66) | 3.00c (1.87) | 2.56b (1.75) |
| Imidacloprid 17.8% SL | 25.0 | 125 | 4.70a (2.28) | 7.51d (2.83) | 8.15f (2.94) | 5.67e (2.48) | 5.12a (2.37) | 7.24e (2.78) | 8.97e (3.08) | 7.45d (2.82) |
| Chlorpyrifos 50% + Cypermethrin 5% EC | 413.0 | 750 | 4.80a (2.30) | 1.15b (1.28) | 1.18c (1.30) | 1.81b (1.52) | 4.75a (2.29) | 1.30b (1.34) | 2.10a (1.61) | 2.10a (1.61) |
| Untreated control | | | 4.91a (2.33) | 7.74d (2.87) | 8.00f (2.92) | 6.15f (2.58) | 4.56a (2.21) | 7.50e (2.83) | 10.26f (3.22) | 7.50d (2.83) |
| $F_{(2, 6)}$ value | | | 0.94 | 23.15 | 34.56 | 28.54 | 1.04 | 54.31 | 64.26 | 34.52 |
| P r>F value | | | 0.549 | <0.0001 | <0.0001 | <0.0001 | 0.469 | <0.0001 | <0.0001 | <0.0001 |

Note: DBS- Day before spray; WE- White earhead; DBH- Days before harvest;
Figures in parentheses indicate √(x+0.5) transformed value; in columns, means followed by the same letter are not significantly different at $P<0.001$ as determined by Tukey's HSD test.

**Table 2:** Efficacy of insecticides against leaf folder, *Cnaphalocrocis medinalis* damage in rice during *kharif* and *rabi* 2014-15

| Treatments | Dosage of chemical (g a.i. ha$^{-1}$) | Formulation (g or ml ha$^{-1}$) | *Kharif* 2014-15 | | | *Rabi* 2014-15 | | |
|---|---|---|---|---|---|---|---|---|
| | | | % Damaged leaves | | | % Damaged leaves | | |
| | | | 1 DBS | 10 Days After 1st Spray | 10 Days After 2nd Spray | 1 DBS | 10 Days After 1st Spray | 10 Days After 2nd Spray |
| Acephate 50% + Imidacloprid 1.8% SP | 414.4 | 800 | 5.36a (2.42) | 1.14d (1.28) | 1.38d (1.37) | 8.04a (2.92) | 1.71c (1.49) | 2.07d (1.60) |
| Acephate 50% + Imidacloprid 1.8% SP | 518.0 | 1000 | 4.75a (2.29) | 0.35b (0.92) | 1.00b (1.22) | 7.13a (2.76) | 1.15ab (1.28) | 1.50b (1.41) |
| Acephate 50% + Imidacloprid 1.8% SP | 621.6 | 1200 | 5.12a (2.37) | 0.27a (0.88) | 0.85a (1.16) | 7.68a (2.86) | 1.10a (1.26) | 1.28a (1.33) |
| Acephate 75% SP | 750.0 | 1000 | 4.85a (2.31) | 1.14d (1.28) | 1.20c (1.30) | 8.28a (2.96) | 1.71c (1.49) | 1.80c (1.52) |
| Imidacloprid 17.8% SL | 25.0 | 125 | 5.34a (2.42) | 6.78e (2.70) | 7.15e (2.77) | 8.01a (2.92) | 10.17 (3.27) | 10.73 (3.35) |
| Chlorpyrifos 50% + Cypermethrin 5% EC | 413.0 | 750 | 4.67a (2.27) | 0.51c (1.00) | 0.98b (1.22) | 7.01a (2.74) | 1.00a (1.22) | 1.47b (1.40) |
| Untreated control | - | | 5.26a (2.40) | 7.58f (2.84) | 8.45f (2.99) | 7.89a (2.90) | 11.37d (3.45) | 10.68e (3.34) |
| $F_{(2, 6)}$ value | | | 1.01 | 45.26 | 53.21 | 0.86 | 26.54 | 43.26 |
| P r>F value | | | 0.478 | <0.0001 | <0.0001 | 0.514 | <0.0001 | <0.0001 |

Note: DBS- Day before spray; Figures in parentheses indicate √(x+0.5) transformed value
In columns, means followed by the same letter are not significantly different at $P<0.001$ as determined by Tukey's HSD test

**Table 3:** Efficacy of insecticides against brown plant hopper (BPH), *Nilaparvata lugens* in rice during *kharif* and *rabi* 2014-15

| Treatments | Dosage of chemical (g a.i. ha$^{-1}$) | Formulation (g or ml ha$^{-1}$) | *Kharif* 2014-15 | | | | | | | *Rabi*-2014-15 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. of BPH 10 hills$^{-1}$ | | | | | | | No. of BPH 10 hills$^{-1}$ | | | | | | |
| | | | 1 DBS | 1st Spray | | | 2nd Spray | | | 1st Spray | | | | 2nd Spray | | |
| | | | | 5 DAS | 10 DAS | 15 DAS | 5 DAS | 10 DAS | 15 DAS | 1 DBS | 5 DAS | 10 DAS | 15 DAS | 5 DAS | 10 DAS | 15 DAS |
| Acephate 50% + Imidacloprid 1.8% SP | 414.4 | 800 | 129.00a (11.38) | 38.67c (6.26) | 12.67c (3.63) | 33.00c (5.79) | 16.33b (4.10) | 4.67b (2.27) | 16.67c (4.14) | 86.33a (9.32) | 37.33c (6.15) | 20.67c (4.60) | 35.00c (5.96) | 14.33c (3.85) | 7.67b (2.86) | 14.00b (3.81) |
| Acephate 50% + Imidacloprid 1.8% SP | 518.0 | 1000 | 125.00a (11.20) | 33.33b (5.82) | 7.33b (2.80) | 25.67b (5.12) | 8.00a (2.92) | 0.00a (0.71) | 6.67b (2.68) | 83.67a (9.17) | 32.00b (5.70) | 11.33b (3.44) | 33.67b (5.85) | 5.33b (2.41) | 1.67a (1.47) | 5.67a (2.48) |
| Acephate 50% + Imidacloprid 1.8% SP | 621.6 | 1200 | 120.67a (11.01) | 25.00a (5.05) | 5.67a (2.48) | 18.33a (4.34) | 7.00a (2.74) | 0.00a (0.71) | 3.33a (1.96) | 80.00a (8.97) | 25.67a (5.12) | 9.67a (3.19) | 28.33a (5.37) | 4.67a (2.27) | 1.67a (1.47) | 5.00a (2.35) |
| Acephate 75% SP | 750.0 | 1000 | 126.00a (11.25) | 63.00e (7.97) | 36.00e (6.04) | 45.00e (6.75) | 29.00d (5.43) | 20.00c (4.53) | 37.33d (6.15) | 85.33a (9.26) | 42.00d (6.52) | 24.33d (4.98) | 44.00 (6.67) | 26.33d (5.18) | 20.00c (4.53) | 38.33c (6.23) |
| Imidacloprid 17.8% SL | 25.0 | 125 | 120.33a (10.99) | 57.00d (7.58) | 18.00d (4.30) | 35.00d (5.96) | 18.00c (4.30) | 4.67b (2.27) | 15.33c (3.98) | 80.00a (8.97) | 38.00c (6.20) | 19.67c (4.49) | 36.00d (6.04) | 15.00c (3.94) | 7.67b (2.86) | 13.67b (3.76) |
| Chlorpyrifos 50% + Cypermethrin 5% EC | 413.0 | 750 | 123.00a (11.11) | 98.67f (9.96) | 120.00f (10.98) | 134.67f (11.63) | 148.00e (12.19) | 110.00d (10.51) | 126.67e (11.28) | 82.00a (9.08) | 95.33e (9.79) | 85.00e (9.25) | 110.67e (10.54) | 98.67e (9.96) | 111.33d (10.57) | 90.00d (9.51) |
| Untreated control | - | | 121.00a (11.02) | 100.33g (10.04) | 133.00g (11.55) | 140.00g (11.85) | 165.00f (12.86) | 115.33d (10.76) | 128.00f (11.34) | 80.67a (9.01) | 100.33f (10.04) | 88.67f (9.44) | 115.67f (10.78) | 110.00f (10.51) | 114.67e (10.73) | 95.33e (9.79) |
| $F_{(2, 6)}$ value | | | 0.78 | 21.35 | 43.51 | 26.54 | 44.65 | 33.21 | 31.54 | 1.14 | 23.25 | 54.26 | 35.15 | 26.45 | 22.15 | 32.14 |
| P r>F value | | | 0.346 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.415 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

Note: DBS- Day before spray; Figures in parentheses indicate √(x+0.5) transformed value

In columns, means followed by the same letter are not significantly different at $P< 0.001$ as determined by Tukey's HSD test

**Table 4:** Efficacy of insecticides against green leafhopper (GLH), *Nephotettix virescens* in rice during *kharif* and *rabi* 2014-15

| Treatments | Dosage of chemical (g a.i. ha$^{-1}$) | Formulation (g or ml ha$^{-1}$) | *Kharif* 2014-15 | | | | | | | *Rabi*-2014-15 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. of GLH 10 hills$^{-1}$ | | | | | | | No. of GLH 10 hills$^{-1}$ | | | | | | |
| | | | 1 DBS | 1st Spray | | | 2nd Spray | | | 1st Spray | | | | 2nd Spray | | |
| | | | | 5 DAS | 10 DAS | 15 DAS | 5 DAS | 10 DAS | 15 DAS | 1 DBS | 5 DAS | 10 DAS | 15 DAS | 5 DAS | 10 DAS | 15 DAS |
| Acephate 50% + Imidacloprid 1.8% SP | 414.4 | 800 | 30.33a (5.55) | 11.00c (3.39) | 5.67b (2.48) | 8.33b (2.97) | 2.67b (1.78) | 0.00a (0.71) | 5.67c (2.48) | 22.67a (4.81) | 9.00b (3.08) | 5.67c (2.48) | 7.00b (2.74) | 2.00b (1.58) | 0.67b (1.08) | 3.33b (1.96) |
| Acephate 50% + Imidacloprid 1.8% SP | 518.0 | 1000 | 34.00a (5.87) | 9.33b (3.14) | 1.67a (1.47) | 4.67a (2.27) | 0.00a (0.71) | 0.00a (0.71) | 3.00b (1.87) | 22.67a (4.81) | 7.00a (2.74) | 3.00b (1.87) | 5.00a (2.35) | 0.00a (0.71) | 0.00a (0.71) | 0.67a (1.08) |
| Acephate 50% + Imidacloprid 1.8% SP | 621.6 | 1200 | 33.33a (5.82) | 8.67a (3.03) | 1.67a (1.47) | 4.33a (2.20) | 0.00a (0.71) | 0.00a (0.71) | 1.67a (1.47) | 25.00a (5.05) | 6.67a (2.68) | 2.00a (1.58) | 4.67a (2.27) | 0.00a (0.71) | 0.00a (0.71) | 0.67a (1.08) |
| Acephate 75% SP | 750.0 | 1000 | 32.67a (5.76) | 16.33d (4.10) | 7.33c (2.80) | 9.33c (3.14) | 6.67c (2.68) | 4.67b (2.27) | 13.67d (3.76) | 24.67a (5.02) | 12.00c (3.54) | 6.67d (2.68) | 8.00c (2.92) | 4.67c (2.27) | 3.00c (1.87) | 8.00c (2.92) |
| Imidacloprid 17.8% SL | 25.0 | 125 | 33.00a (5.79) | 11.33e (3.44) | 5.00b (2.35) | 8.67b (3.03) | 3.00b (1.87) | 0.67a (1.08) | 6.00c (2.55) | 24.00a (4.95) | 9.00b (3.08) | 3.67b (2.04) | 7.33b (2.80) | 2.00b (1.58) | 1.00b (1.22) | 3.00b (1.87) |
| Chlorpyrifos 50% + Cypermethrin 5% EC | 413.0 | 750 | 33.67a (5.85) | 35.67f (6.01) | 30.67d (5.58) | 25.33d (5.08) | 28.67d (5.40) | 44.00c (6.67) | 42.67e (6.57) | 25.33a (5.08) | 26.00d (5.15) | 23.00e (4.85) | 26.00d (5.15) | 24.00d (4.95) | 33.00d (5.79) | 32.00d (5.70) |
| Untreated control | - | | 34.67a (5.93) | 38.33g (6.23) | 32.33e (5.73) | 30.00e (5.52) | 35.33e (5.99) | 45.67d (6.79) | 45.00f (6.75) | 26.00a (5.15) | 25.67e (5.12) | 26.00f (5.15) | 28.00e (5.34) | 26.50e (5.20) | 34.25e (5.90) | 33.75e (5.85) |
| $F_{(2, 6)}$ value | | | 0.85 | 22.56 | 24.26 | 53.14 | 54.35 | 55.21 | 36.54 | 1.03 | 41.26 | 35.15 | 26.51 | 35.26 | 45.21 | 44.30 |
| P r>F value | | | 0.526 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.422 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

Note: DBS- Day before spray; Figures in parentheses indicate √(x+0.5) transformed value

In columns, means followed by the same letter are not significantly different at $P<0.001$ as determined by Tukey's HSD test

**Table 5:** Effect of insecticides on yield and economics of insect pest management of rice during *kharif* and *rabi* 2014-15

| Treatments | Dosage of chemical (g a.i. ha$^{-1}$) | Formulation (g or ml ha$^{-1}$) | *Kharif* 2014-15 | | *Rabi* 2014-15 | |
|---|---|---|---|---|---|---|
| | | | Yield (Q ha$^{-1}$) | B: C ratio | Yield (Q ha$^{-1}$) | B: C ratio |
| Acephate 50% + Imidacloprid 1.8% SP | 414.4 | 800 | 45.15bc | 2.3 | 45.26c | 2.4 |
| Acephate 50% + Imidacloprid 1.8% SP | 518.0 | 1000 | 47.36b | 2.7 | 48.22b | 2.9 |
| Acephate 50% + Imidacloprid 1.8% SP | 621.6 | 1200 | 50.14a | 3.1 | 51.02a | 3.3 |
| Acephate 75% SP | 750.0 | 1000 | 44.26c | 2.5 | 44.14c | 2.4 |
| Imidacloprid 17.8% SL | 25.0 | 125 | 40.12d | 2.0 | 39.86d | 1.9 |
| Chlorpyrifos 50% + Cypermethrin 5% EC | 413.0 | 750 | 42.58e | 2.1 | 42.45e | 2.1 |
| Untreated control | | | 35.44f | - | 36.17f | - |
| $F_{(2, 6)}$ value | | | 25.45 | - | 32.15 | - |
| P r>F value | | | <0.0001 | - | <0.0001 | - |

*Mean of 3 replications; In columns, means followed by the same letter are not significantly different at $P<0.001$ as determined by Tukey's HSD test.

**Table 6:** Effect of insecticides on important natural enemies of insect pests in rice ecosystem during *kharif* and *rabi* 2014-15

| Treatments | Dosage of chemical (g a.i. ha$^{-1}$) | Formulation (g or ml ha$^{-1}$) | *Kharif*, 2014-15 | | | | | | *Rabi*, 2014-15 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. of *C. lividipennis* 10 hills$^{-1}$ | | | No. of Predatory spiders m$^{-2}$ | | | No. of *C. lividipennis* 10 hills$^{-1}$ | | | No. of Predatory spiders m$^{-2}$ | | |
| | | | 1 DBS | 10 Days after 1st Spray | 10 Days after 2nd Spray | 1 DBS | 10 Days after 1st Spray | 10 Days after 2nd Spray | 1 DBS | 10 Days after 1st Spray | 10 Days after 2nd Spray | 1 DBS | 10 Days after 1st Spray | 10 Days after 2nd Spray |
| Acephate 50% + Imidacloprid 1.8% SP | 414.4 | 800 | 3.67 (2.04) | 6.33 (2.61) | 9.33 (3.14) | 2.00 (1.58) | 3.33 (1.96) | 4.00 (2.12) | 6.33 (2.61) | 11.00 (3.39) | 16.00 (4.06) | 4.00 (2.12) | 5.67 (2.48) | 7.00 (2.74) |
| Acephate 50% + Imidacloprid 1.8% SP | 518.0 | 1000 | 4.00 (2.12) | 6.67 (2.68) | 9.00 (3.08) | 2.00 (1.58) | 3.67 (2.04) | 4.33 (2.20) | 7.00 (2.74) | 11.33 (3.44) | 15.00 (3.94) | 3.67 (2.04) | 6.33 (2.61) | 7.33 (2.80) |
| Acephate 50% + Imidacloprid 1.8% SP | 621.6 | 1200 | 4.33 (2.20) | 5.67 (2.48) | 9.00 (3.08) | 2.00 (1.58) | 3.33 (1.96) | 4.67 (2.27) | 7.33 (2.80) | 10.67 (3.34) | 15.33 (3.98) | 4.33 (2.20) | 6.00 (2.55) | 7.00 (2.74) |
| Acephate 75% SP | 750.0 | 1000 | 3.67 (2.04) | 6.33 (2.61) | 8.67 (3.03) | 2.33 (1.68) | 3.00 (1.87) | 3.67 (2.04) | 6.33 (2.61) | 10.00 (3.24) | 14.67 (3.89) | 3.67 (2.04) | 5.00 (2.35) | 6.67 (2.68) |
| Imidacloprid 17.8% SL | 25.0 | 125 | 4.00 (2.12) | 6.00 (2.55) | 9.33 (3.14) | 1.67 (1.47) | 3.00 (1.87) | 4.00 (2.12) | 7.33 (2.80) | 10.00 (3.24) | 16.00 (4.06) | 3.33 (1.96) | 5.33 (2.41) | 6.67 (2.68) |
| Chlorpyrifos 50% + Cypermethrin 5% EC | 413.0 | 750 | 4.67 (2.27) | 4.33 (2.20) | 6.00 (2.55) | 2.33 (1.68) | 2.67 (1.78) | 3.67 (2.04) | 8.00 (2.92) | 9.67 (3.19) | 15.67 (4.02) | 4.00 (2.12) | 4.67 (2.27) | 6.33 (2.61) |
| Untreated control | - | | 4.00 (2.12) | 6.67 (2.68) | 9.33 (3.14) | 2.00 (1.58) | 3.67 (2.04) | 4.33 (2.20) | 7.00 (2.74) | 11.33 (3.44) | 16.00 (4.06) | 3.67 (2.04) | 6.67 (2.68) | 7.33 (2.80) |
| $F_{(2, 6)}$ value | | | 1.12 | 0.89 | 1.30 | 1.04 | 1.24 | 1.05 | 0.95 | 0.75 | 1.10 | 1.45 | 2.01 | 1.36 |
| P r>F value | | | 0.451 | 0.526 | 0.456 | 0.415 | 0.441 | 0.365 | 0.425 | 0.455 | 0.444 | 0.514 | 0.653 | 0.354 |

Note: DBS- Day before spray; Figures in parentheses indicate √(x+0.5) transformed value

## 4. Conclusion

Integrated Pest Management practices invariably depend upon use of insecticides for the successful management of insect pests. Farmers always rely on more than one insecticide to save their crops from insect pest attack of diverse nature of damage. Acephate 50% + imidacloprid 1.8% SP is a solution to manage both sap sucking and borer pests in rice. Effective and timely application of Acephate 50% + imidacloprid 1.8% SP @ 621.6 g.a.i $ha^{-1}$ was found excellent in controlling major insect pests of rice with highest returns and no harmful effects on beneficial insects.

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## 6. References

1. CMIE: Centre for Monitoring Indian Economy. Statistical database, 2013.
2. Dale D. Insect pests of rice plants-their biology and ecology. In: Biology and Management of Rice Insects (Eds.: E.A. Heinrichs). IRRI. Wiley Eastern Ltd, 1994, 363-485.
3. Ghosh A, Samanta A, Chatterjee ML. Evaluation of some insecticides on brown plant hopper *Nilaparvata lugens* (Stal.) and its predators in rice. Environment and Ecology. 2010; 27(4A):1653-1656.
4. Gomez KA, Gomez AA. Statistical procedures for Agricultural Research. John Wiley and Sons, New York, 1984, 680.
5. Karthikeyan K, Christy MM. Efficacy of Chlorantraniliprole 18.5 EC against major pests of rice. Indian Journal of Plant Protection. 2014; 42(4):379-382.
6. Karthikeyan K, Purushothaman SM, Smitha SG, Ajish PG. Efficacy of new insecticide combination against major pests of Paddy. Indian Journal of Plant Protection. 2012; 40:276-279.
7. Kharbade SB, Chormule AJ, Karade VM. Field efficacy of insecticides against Brown plant hopper. Annals of Plant Protection Sciences. 2016; 24(1):38-41.
8. Krishnamoorthy SV, Kuttalam S, Karuppuchamy P. Buprofezin 20% + acephate 50% WP for the management of BPH, stem borer and leaf folder in rice ecosystem. In: International symposium on 100 years of rice science and looking beyond, 9-12th January 2012. TNAU, Coimbatore, 2012a, 667-668.
9. Kushwaha KS, Singh R. Leaf folder (LF) outbreak in Haryana. International Rice Research Newsletter. 1984; 9:20.
10. Lal OP. Recent Advances in Entomology, (Ed). Lal, O.P. APC Publications Pvt. Ltd, New Delhi, 1996, 392.
11. Majunatha M, Shivanna BK. Field evaluation of RIL - 18, 20 SL (imidacloprid) against rice brown planthopper and green leafhopper. Insect Environment. 2001; 6(4):177-178.
12. Misra HP. Safer novel insecticide molecule for the management of rice brown planthopper, *Nilaparvata lugens* (Stal.). Indian Journal of Entomology. 2009; 71(3):232-235.
13. Pathak MD. Ecology of rice pests. Annual Review of Entomology. 1968; 13:257-294.
14. Rai AK, Khan MA. Light trap catch of rice insect pest, *Nephotettix virescens* (Distant) and its relation with climatic factors. Annals of Plant Protection Sciences. 2002; 10:17-22.
15. Reddy CS, Krishnaiah NV. Compatibility of new fungicides and insecticides in rice. Pestology. 2003; 27(2):23-26.
16. Sarkar PK, Debashis Roy. Bio-effectiveness vis-a-vis non-target toxicity of pre-mix formulation, fenobucarb 20% EC + buprofezin 5% SC against sucking pests of rice under Gangetic alluvial plain of West Bengal. Journal of Entomological Research. 2016; 40(1):81-89.
17. SAS: Statistical Analysis System (SAS) Institute Inc, 2003.
18. Seetha Ramu P, Punnaiah KC, Ramachandra Rao G, Srinivasa Rao V. Bioefficacy of certain new insecticides against sucking insect pests of rice. Journal of Entomological Research. 2005; 29(3):211-213.
19. Sharma PK, Srivastava A. Field evaluation of new insecticides and combinations against rice whorl maggot, *Hydrellia philippina* and leaffolder, *Cnaphalocrocis medinalis*. Oryza. 2009; 46(4):335-336.
20. Subhash Chander, Sujithra M, Palta RK. Efficacy of a novel insecticide and combination product against rice insect pests. Pesticide Research Journal. 2012; 24(2):235-237.
21. Varma NR, Bhanu KV, Reddy DR. Forecasting population of brown plant hopper, *Nilaparvata lugens* (Stal.). Journal of Agrometeorology. 2008; 10:197-200.
22. Veeravel R, Ravivarman B. Bioefficacy evaluation of bifenthrin 10 EC against major pests of rice. Madras Agricultural Journal. 2010; 97(4-6):164-167.