**Original Research Article**

**Efficacy of Ethiprole 40% + Imidacloprid 40% WG on brown planthopper (BPH), Nilaparvata lugens (Stal) and the whitebacked planthopper (WBPH), Sogatella furcifera (Horvath) in paddy crop**

**Abstract**

Rice (*Oryza sativa*) is a major food crop of India, covering a large area in the country. It is also the most important staple food for more than half of the global population. Nearly 300 species of insect pests damage crops at different stages, and among them, only 23 species cause notable damage. Among the sucking pests, two species of planthoppers infest rice crops and cause severe damage. The brown planthopper (BPH), *Nilaparvata lugens* (Stal) and whitebacked planthopper (WBPH), *Sogatella furcifera* (Horvath). The study aims to explore the efficacy of ethiprole 40% + imidacloprid 40% WG on brown planthopper (BPH), *Nilaparvata lugens* (Stal) and the whitebacked planthopper (WBPH), Sogatella furcifera (Horvath) in paddy crop. An experimentation was conducted for two seasons, *i.e. Kharif,* 2021-22 and 2022-23, to evaluate the bio-efficacy of Ethiprole 40% + Imidacloprid 40% WG at different dosages against brown Planthopper (BPH) Nilaparvata lugens (Stal) and the white backed planthopper (WBPH), Sogatella furcifera (Horvath) at Agricultural Research Station (ANGRAU), Amadalavalasa, Srikakulam District of Andhra Pradesh. The data thus obtained from a field experiment in a Randomised Block Design (RBD) was analysed statistically by the ANOVA technique, duly converting the data into suitable transformations (square root). In case of brown plant hopper Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 156.25 g/ha was found more effective and stood first in bringing down the BPH population with 9.22 number per hill and 2.44 number per hill after 1st spray and 2nd spray during *kharif*, 2021-22 and 12.00 and 2.67 number per hillduring *kharif*, 2022-23 respectively. The results of white backed planthopper revealed that, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @156.25 g/ha showed more effective by recording lowest mean population of 4.33 and 1.78 number per hill after 1st and 2nd spray during *kharif*, 2021-22 and 6.56 and 2.11 numbers per hill after 1st and 2nd spray during *kharif*, 2022-23 which is followed by Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @125g/ha and Ethiprole 40% + Imidacloprid 40% WG (market sample)@125g/ha which were statistically on par with each other. It is concluded that the bio-efficacy studies with Ethiprole 40% + Imidacloprid 40% WG @ 93.75 and 125 g/ha have shown efficient control of planthoppers (BPH and WBPH) in paddy crop.

**Keywords: Rice, paddy crop, white backed planthopper, Ethiprole, insecticide**

1. **Introduction:**

Rice (*Oryza sativa*) is the vital staple food crop of the world, supports the livelihood of more than 100 million farm families, providing the energy requirement of billions of people and playing a pivotal role in the agro-ecosystem and biodiversity. Global requirements of rice are expected to be about 280 million tonnes produced in the next 30 years, and feeding more than 9 billion people by 2050 will require doubling of production on a sustainable basis (Midya et al., 2021). It is a major food crop of India, covering a large area in the country. India has the largest area of 45 million ha with production of 122 mMT which ranks second in production next to China and contributing 25% of global production of total food grain production and continues to play a vital role in the national food grain supply and the total food grain production in India which accounts for 308.65 million tonnes (Anonymous, 2021).

It is also the most important staple food for more than half of the global population (Kulagod *et al*., 2011). It is the source for dietary energy for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. (FAO, 2004). But the rice production is limited by both biotic and abiotic stresses, of which insect pests alone cause about 25 per cent losses (Katti *et al*., 2019). Nearly 300 species of insect pests damage at different stages, and among them, only 23 species cause notable damage (Pasalu and Katti, 2006). Among the sucking pests, there are two species of planthoppers that infest rice crops and cause severe damage. The brown planthopper (BPH), Nilaparvata lugens (Stal) and whitebacked planthopper (WBPH), Sogatella furcifera (Horvath). Over 100 insect species have been reported in India to feed on rice plants at various stages of growth and complete their life cycle. However, not all of these may be termed pests from the point of economic yield loss. Of these, six groups may be termed as major insect pests in terms of their widespread distribution and intensity of damage to cause economic loss (Konda & Chandar, 2022; Kumar et al., 2022). These pests occur in rainfed and irrigated wetland environments. It is also seen in areas with continuous submerged conditions in the field, high shade, and humidity. Closed canopy of the rice plants, densely seeded crops, excessive use of nitrogen, and early-season insecticide spraying also favour insect development.

Nymphs and adults of planthoppers cause direct damage to the crop. These pest sucks the sap from the phloem and xylem. Under favourable conditions, they multiply very fast. The feeding damage caused by planthoppers results in the yellowing of the plants. At high population density, hopperburn or complete drying of the plants is observed. At this level, crop loss may be 100%. Abiotic factors such as temperature, relative humidity and prevailing wind direction determine the severity of incidence and spread of BPH. A lot of research efforts need to be put into understanding and quantifying the basic ecological factors that are responsible for survival, multiplication and perpetuation of the insect throughout the rice growing regions. The other reason is that brown planthopper (BPH) and white backed planthopper (WBPH) are known for their resistance to commonly used insecticides, including the neonicotinoids. In view of this, an experiment is planned to evaluate a new chemical molecule at various concentrations to know the efficacy in reducing the brown planthopper (BPH) and white backed planthopper (WBPH) populations. Different chemical pesticides were advised to manage BPH; however, their negligent use resulted in their revival, the development of insecticide resistance, and a negative influence on natural enemies. An alternate strategy for controlling brown planthopper to improve host plant resistance (Shilpakala et al., 2024).

1. **METHODOLOGY:**

The field trial was conducted for two seasons, *i.e. Kharif,* 2021-22 and 2022-23, to evaluate the bio-efficacy of Ethiprole 40% + Imidacloprid 40% WG at different dosages against brown planthopper (BPH) and white Backed Planthopper (WBPH), at Agricultural Research Station (ANGRAU), Amadalavalasa, Srikakulam District of Andhra Pradesh. The experiment was laid out in randomised block design consisting of three replications. The varieties, MTU 1224 and MTU 7029, were used during *kharif* 2021-22 and 2022-23 seasons, respectively. Eight treatments, including untreated control, were evaluated, and each treatment was replicated thrice. Seedlings were transplanted 30 days after sowing with inter and intra row spacing of 20 cm x 15 cm. The experiment was implemented as per standard agronomic practices recommended by Acharya N. G. Ranga Agricultural University for the North Coastal region of Andhra Pradesh. Insecticidal spray solutions were prepared as per the treatments and were imposed twice at 15-day interval through spraying using a knapsack sprayer.

**Chart 1. Treatment details:**

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Treatment** | **Formulation dose (g/ha)** |
| 1 | Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 62.50 |
| 2 | Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 93.75 |
| 3 | Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 125 |
| 4 | Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 156.25 |
| 5 | Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 93.75 |
| 6 | Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 125 |
| 7 | Thiamethoxam 25% WG | 100 |
| 8 | Untreated control | -- |

**Brown Planthopper(BPH) and White backed Plant Hopper (WBPH):**

The data on population of BPH and WBPH were recorded on 10 randomly selected and tagged hills from each plot at one day before, 3, 7 and 14 days after imposition of the insecticidal treatments and the population was expressed as number per hill (Stanley et al., 2022).

The per cent reduction for BPH and WBPH over control was calculated using the following Abbott's formula.

% pest reduction = 1 – No. of insects in Treatment after treatment X 100

No of insects in Control after treatment

**Grain yield**

Grain yield was calculated by leaving two border rows in all treatments and expressed as kg ha-1.

**Statistical Analysis**

The data thus obtained from a field experiment in a Randomised Block Design (RBD) was analysed statistically by the ANOVA technique duly converting the data into suitable transformations (square root).

1. **Results:**

**Brown Planthopper (BPH):**

The results on the efficacy of Ethiprole 40% + Imidacloprid 40% WG against brown planthopper during *kharif*, 2021-22 and 2022-23 are shown in Tables 1 and 3. There is no significant difference in the population of brown planthopper among the treatments before application of insecticides during both the seasons of *Kharif*, 2021-22 and 2022-23. It is evident from Tables 1 and 3, all the treatments, *i.e.* Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 62.5, 93.75, 125 and 156.25 g/ha, Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 93.75 and 125 g/ha and thiamethoxam 25% WG @100g/ha, were significantly superior over the control in controlling BPH population during both seasons of *kharif*, 2021-22 and *kharif*, 2022-23. Among the treatments, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 156.25 g/ha was found more efficacious and stood first in bringing down the BPH population at all the post treatment counts made at 3, 7 and 14 days after 1st and 2ndsprays during both seasons of *kharif*, 2021-22 and *kharif*, 2022-23 which is followed by Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 125 g/ha and Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 125 g/ha and were on par with each other with mean population in the respective treatments is 9.22, 10.56 and 10.89 number per hill, respectively after 1st spray and 2.44, 2.99 and 3.45 number per hill, respectively after 2nd spray during *kharif*, 2021-22; 12.00, 13.22 and 14.33 number per hill, respectively after 1st spray and 2.67, 4.56 and 4.78 number per hill, respectively after 2nd spray during *kharif*, 2022-23.

The treatment, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 93.75g/ha also efficient against BPH and recorded mean population of 11.78 and 4.89 number per hill after 1st and 2nd spray, respectively during *kharif*, 2021-22, and 15.11 and 6.00 number per hill after 1st and 2nd spray, respectively during *kharif*, 2022-23 which is on par with Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 93.75g/ha (12.78 and 5.22 no./hill after 1st and 2nd spray, respectively during *kharif*, 2021-22 and 15.22 and 6.89 no./hill after 1st and 2nd spray, respectively during *kharif*,2022-23), Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 125 g/ha (10.56 and 2.99 no./hill after 1st and 2nd spray, respectively during *kharif*, 2021-22 and 13.22 and 4.56 no./hill after 1st and 2nd spray, respectively during *kharif*, 2022-23) and Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 125 g/ha (10.89 and 3.45 no./hill after 1st and 2nd spray, respectively during *kharif*,2021-22 and 14.33 and 4.78 no./hill after 1st and 2nd spray, respectively during *kharif*,2022-23).

In terms of per cent reduction over untreated control, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 156.25 g/ha recorded highest reduction in BPH population with 57.23 and 84.07 at first and second spray, respectively during *kharif*, 2021-22 and 58.14 and 87.03 at first and second spray, respectively during *kharif*, 2022-23 which is followed by Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 125 g/ha (51.03 and 80.52 at first and second spray, respectively during *kharif*, 2021-22 and 53.87 and 77.83 at first and second spray, respectively during *kharif*, 2022-23) and Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 125 g/ha (49.48 and 77.52 at first and second spray, respectively during *kharif*, 2021-22 and 50.00 and 76.75 at first and second spray, respectively during *kharif*, 2022-23) (Table 1 and 3).

**White Backed Planthopper:**

The results on the efficacy of Ethiprole 40% + Imidacloprid 40% WG against white backed planthopper during *kharif*, 2021-22 and 2022-23 were shown in Tables 2 and 4. It was observed that the initial population of WBPH in different treatments are non-significant before the 1st spray during both the seasons of *Kharif*, 2021-22 and 2022-23. After imposition of the treatments *viz*., Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 62.5, 93.75, 125 and 156.25 g/ha, Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 93.75 and 125 g/ha and thiamethoxam 25% WG@100g/ha, insect population was significantly low in all the treated plots when compared to untreated control at all the post treatment count made at 3, 7 and 14 days after 1st and 2nd sprays during both the seasons of *Kharif*, 2021-22 and 2022-23. It is evident from the table 2 and 4, the highest dose of test insecticide, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @156.25 g/ha showed more effective against WBPH by recording of lowest mean population of 4.33 and 1.78 number per hill after 1st and 2nd spray during *kharif*, 2021-22 and 6.56 and 2.11 number per hill after 1st and 2nd spray during *kharif*, 2022-23 which is followed by Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @125g/ha (4.45 and 2.11 number per hill after 1st and 2nd spray, respectively during *kharif*, 2021-22 and 7.33 and 2.78 number per hill after 1st and 2nd spray, respectively during *kharif*, 2022-23) and Ethiprole 40% + Imidacloprid 40% WG (market sample)@125g/ha (4.67 and 2.33 number per hill after 1st and 2nd spray, respectively during *kharif*, 2021-22 and 7.89 and 3.00 number per hill after 1st and 2nd spray, respectively during *kharif*, 2022-23 ) and were statistically on par with each other.

The performance of test insecticide, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 93.75g/ha, was also good in arresting the development of WBPH population during both seasons of *kharif*, 2021-22 and 2022-23 and at par with higher dosages of Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @125 g/ha and Ethiprole 40% + Imidacloprid 40% WG (market sample) @125 g/ha.

In terms of per cent reduction over untreated control, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 156.25 g/ha recorded highest reduction in WBPH population with 58.95 and 81.15 at first and second spray, respectively during *kharif*, 2021-22 and 60.40 and 82.89 at first and second spray, respectively during *kharif*, 2022-23 which is followed by Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 125 g/ha (57.88 and 77.66 at first and second spray, respectively during *kharif*, 2021-22 and 55.71 and 77.46 at first and second spray, respectively during *kharif*, 2022-23) and Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 125 g/ha (55.79 and 75.29 at first and second spray, respectively during *kharif*, 2021-22 and 52.37 and 75.68 at first and second spray, respectively during *kharif*, 2022-23) (Table 2 and 4).

**Grain Yield**

The data on rice grain yield were presented in Table 5, and results showed that there was a significant difference observed in grain yield among the treatments. The test insecticide, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @156.25 g/ha recorded the highest grain yield of 6330.00 kgs per ha (33.54% increase over control) and 5840.00 kgs per ha (33.94% increase over control) during *kharif*, 2021-22 and 2022-23, respectively which is followed by Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 125 g/ha (6036.37 and 5680.00 kg/ha during *kharif*, 2021-22 and 2022-23, respectively) and Ethiprole 40% + Imidacloprid 40% WG (market sample) @ 125 g/ha (5866.67 and 5556.67 kgs /ha during *kharif*, 2021-22 and 2022-23, respectively) and were statistically on par with each other. Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 93.75 g/ha was next best treatment and recorded 5743.33 (21.17 % increase over control) and 5320.00 (22.02 % increase over control) kgs per ha during *kharif*, 2021-22 and 2022-23, respectively which is on par with Ethiprole 40% + Imidacloprid 40% WG (Market sample) @ 93.75 g/ha, Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) @ 125 g/ha and Ethiprole 40% + Imidacloprid 40% WG (Market sample) @ 125 g/ha.

1. **Discussion:**

The present results varied when different concentrations of Ethiprole 40% + Imidacloprid 40% WG were tested against rice brown planthopper (BPH), *Nilaparvata lugens*, whitebacked planthopper (WBPH), *Sogatella furcifera*, and green leafhopper (GLH). The present results are in agreement with the research work done by Lakshmi *et al* (2010) on rice brown planthopper (BPH), *Nilaparvata lugens*, whitebacked planthopper (WBPH), *Sogatella furcifera*, green leafhopper (GLH) and *Nephotettix virescens*, in which it was proved that Ethiprole+imidacloprid and thiamethoxam+lambdacyhalothrin have shown promising initial and persistent toxicity against BPH, WBPH and GLH. In a study conducted to evaluate the combination product ethiprole 40% + imidacloprid 40% - 80 WG as foliar application for its bioefficacy against plant and leaf hoppers of rice, it was noticed that, ethiprole 40% + imidacloprid 40% - 80 WG @ 125 g a.i./ha recorded more than 90 per cent reduction in the population of leafhopper and plant hopper in the rice crop. The highest yield of 4.03 ton/ha was recorded in ethiprole 40% + imidacloprid 40% - 80 WG @ 125 g a.i./ha treated plots (Vinothkumar *et al*., 2010).

In a field evaluation of bio-efficacy against brown planthopper (BPH) and white backed planthopper (WBPH) in rice by Bhanu and Reddy (2012), it was observed that Imidacloprid 40% + ethiprole 40% -80 WG @ 50, 75 and 100 g a.i./ha. recorded more than 98 per cent reduction in the population of both BPH and WBPH over the untreated control and superior to neonicotinoid insecticides like imidacloprid @ 25 and 50 g a.i./ha, thiamethoxam 25 g a.i./ha and ethiprole 10 SC @ 50 g a.i./ha. The highest grain yield of 5300 kg/ha was recorded in imidacloprid @ 50 g a.i./ha treated plots and followed by imidacloprid 40% + ethiprole 40% -80 WG @ 75 g a.i./ha (4678 kg/ha).

Insecticides play a critical role in controlling the spread of insect-borne diseases and preserving crop health. These chemical substances are specifically formulated to kill or manage insect populations. Over the years, various types of insecticides have been developed, including organophosphates, carbamates, pyrethroids, and neonicotinoids, each with unique modes of action, physiological targets, and efficacy. Despite the advantages that insecticides offer, it is imperative to recognise the potential consequences on non-target species, the environment, and human health (Araújo et al., 2023). An investigation was undertaken with the objective to study relative efficacy of insecticides viz., Acephate 75 WP, Thiamethoxam 25 WG, Acetamipride 20 SP, Emamectin benzoate 5 SG, Buprofezin 25 SC, Thiacloprid 240 SC, Clothianidin 50 WDG, Ethiprole 10 SC and *Metarhizium anisopliae* WP against rice brown plant hopper by Gajare (2018). Among the evaluated insecticides based on mean population and per cent reduction control, it was revealed that treatment Buprofezin 25 SC recorded 1.68 hoppers per hill, was found to be most effective and significantly superior over all treatments and recorded 89.08 per cent reduction over control. This was followed by Clothianidin 50 WDG (2.05 hopper per hill) with 86.67 per cent reduction over control, Thiamethoxam 25 WG, Ethiprole 10 SC, Thiacloprid 240 SC, Acetamiprid 20 SP, Emamectin benzoate 5 SG, Acephate 75 WP, and Metarhizium anisopliae WP, in which 2.21, 2.27, 2.42, 2.56, 2.61, 2.89 and 3.37 hoppers per hill were noticed, respectively, as against 15.38 hoppers population in untreated control.

Six insecticides viz., ethiprole 40 + imidacloprid 40 WG, etofenprox 10 EC, buprofezin 25 SC, pymetrozine 50 WG, acephate 75 SP and monocrotophos 36 SL were evaluated against rice brown plant hopper BPH in Paddy (Shankar *et al*., 2018). The population was significantly lower with pymetrozine 50 WG @ 250 g/ha, followed by ethiprole 40 + imidacloprid 40 W.G @ 125 g/ha, etofenprox 10 EC @ 750 ml/ha, acephate 75 SP @ 667g/ha, monocrotophos 36 SL @ 1390 ml/ha and buprofezin 25 SC @ 825 ml/ha at all the counting days of after spray in both 2014 and 2015.

1. **CONCLUSION:**

The treatments Ethiprole 40% + Imidacloprid 40% WG @ 93.75, 125 and 156.25 g/ha were effective in controlling brown planthopper (BPH) and white backed planthopper (WBPH) population significantly and resulted in higher yield of 5743.33, 6036.67 and 6330.00 kgs per ha, respectively during *kharif*, 2021-22 and 5320.00, 5680.00 and 5840.00 kgs per ha, respectively during *kharif*, 2022-23. Ethiprole 40% + Imidacloprid 40% WG @ 62.50, 93.75, 125, 156.25 and 250 g/ha. It is concluded that the bio-efficacy studies with Ethiprole 40% + Imidacloprid 40% WG @ 93.75 and 125 g/ha have shown efficient control of planthoppers (BPH and WBPH) in paddy crop.

**Table 1: Bio-efficacy evaluation against brown plant hopper (BPH) on paddy crop during *kharif* 2021-22**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose**  **(g/ha)** | **Before first spray** | **BPH population per hill** | | | **Mean** | **Reduction over control (%)** | **BPH population per hill** | | | **Mean** | **Reduction over control (%)** |
| **Days after first spray** | | | **Days after second spray** | | |
| **3** | **7** | **14** | **3** | **7** | **14** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 62.50 | 19.67  (4.44) | 15.00  (3.93) | 12.67  (3.62) | 15.00  (3.93) | **14.22**  **(3.84)** | **34.04** | 9.33  (3.12) | 7.00  (2.73) | 5.33  (2.39) | **7.22**  **(2.78)** | **52.90** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 93.75 | 18.33  (4.33) | 12.00  (3.52) | 9.33  (3.12) | 14.00  (3.8) | **11.78**  **(3.50)** | **45.37** | 6.67  (2.68) | 4.67  (2.26) | 3.33  (1.93) | **4.89**  **(2.32)** | **68.11** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 125 | 20.33  (4.54) | 10.67  (3.33) | 8.67  (3.02) | 12.33  (3.56) | **10.56**  **(3.32)** | **51.03** | 4.33  (2.18) | 2.67  (1.73) | 2.00  (1.56) | **2.99**  **(1.85)** | **80.52** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 156.25 | 19.67  (4.47) | 9.00  (3.07) | 7.33  (2.78) | 11.33  (3.43) | **9.22**  **(3.11)** | **57.23** | 2.67  (1.78) | 2.33  (1.68) | 2.33  (1.68) | **2.44**  **(1.71)** | **84.07** |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 93.75 | 18.67  (4.37) | 13.00  (3.65) | 10.33  (3.29) | 15.00  (3.93) | **12.78**  **(3.64)** | **40.73** | 6.33  (2.61) | 5.00  (2.34) | 4.33  (2.18) | **5.22**  **(2.39)** | **65.96** |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 125 | 19.00  (4.41) | 11.00  (3.22) | 9.00  (3.07) | 13.67  (3.76) | **10.89**  **(3.37)** | **49.48** | 4.67  (2.27) | 3.00  (1.86) | 2.67  (1.74) | **3.45**  **(1.98)** | **77.52** |
| Thiamethoxam 25% WG | 100 | 19.33  (4.45) | 14.33  (3.84) | 13.00  (3.67) | 16.67  (4.14) | **14.67**  **(3.89)** | **31.96** | 9.00  (3.08) | 8.00  (2.91) | 6.67  (2.68) | **7.89**  **(2.89)** | **48.54** |
| Untreated control | -- | 21.00  (4.63) | 22.33  (4.77) | 23.67  (4.91) | 18.67  (4.37) | **21.56**  **(4.69)** | **0.00** | 17.67  (4.26) | 16.00  (4.04) | 12.33  (3.57) | **15.33**  **(3.97)** | **0.00** |
| F-test |  | NS | Sig. | Sig. | Sig. | Sig. |  | Sig. | Sig. | Sig. | Sig. |  |
| S.Em± |  | 0.21 | 0.22 | 0.18 | 0.17 | 0.11 |  | 0.13 | 0.18 | 0.20 | 0.13 |  |
| CD (P=0.05) |  | 0.62 | 0.65 | 0.53 | 0.52 | 0.32 |  | 0.40 | 0.54 | 0.60 | 0.38 |  |
| CV (%) |  | 7.04 | 8.39 | 7.77 | 6.80 | 4.38 |  | 7.34 | 11.10 | 13.66 | 7.66 |  |

Figures in parentheses are square root transformed values NS – Non significant Sig. - Significant

**Table 2: Bio-efficacy evaluation against white backed plant hoper (WBPH) population on paddy crop during *kharif* 2021-22**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose**  **(g/ha)** | **Before first spray** | **WBPH population per hill** | | | **Mean** | **Reduction over control (%)** | **WBPH population per hill** | | | **Mean** | **Reduction over control (%)** |
| **Days after first spray** | | | **Days after second spray** | | |
| **3** | **7** | **14** | **3** | **7** | **14** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 62.50 | 10.33  (3.29) | 7.33  (2.79) | 4.67  (2.26) | 7.33  (2.78) | 6.44  (2.63) | 38.96 | 5.67  (2.47) | 4.33  (2.20) | 5.67  (2.48) | 5.22  (2.39) | 44.69 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 93.75 | 9.00  (3.07) | 5.33  (2.40) | 3.67  (2.04) | 6.33  (2.59) | 5.11  (2.37) | 51.59 | 3.67  (2.02) | 2.00  (1.56) | 3.33  (1.93) | 3.00  (1.85) | 68.23 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 125 | 11.67  (3.48) | 4.67  (2.27) | 3.00  (1.86) | 5.67  (2.47) | 4.45  (2.22) | 57.88 | 2.33  (1.68) | 1.67  (1.44) | 2.33  (1.64) | 2.11  (1.60) | 77.66 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 156.25 | 11.33  (3.43) | 5.33  (2.40) | 2.67  (1.78) | 5.00  (2.33) | 4.33  (2.19) | 58.95 | 2.67  (1.78) | 1.00  (1.22) | 1.67  (1.46) | 1.78  (1.51) | 81.15 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 93.75 | 9.33  (3.12) | 5.00  (2.54) | 3.33  (1.93) | 7.00  (2.72) | 5.44  (2.44) | 48.44 | 4.00  (2.11) | 2.67  (1.78) | 3.00  (1.86) | 3.22  (1.93) | 65.87 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 125 | 11.00  (3.38) | 5.33  (2.41) | 3.67  (2.04) | 5.00  (2.23) | 4.67  (2.26) | 55.79 | 3.00  (1.86) | 1.67  (1.46) | 2.33  (1.64) | 2.33  (1.68) | 75.29 |
| Thiamethoxam 25% WG | 100 | 10.67  (3.33) | 7.33  (2.79) | 5.67  (2.47) | 7.67  (2.83) | 6.89  (2.72) | 34.73 | 5.33  (2.38) | 3.67  (2.04) | 5.67  (2.48) | 4.89  (2.32) | 48.22 |
| Untreated control | -- | 09.67  (3.18) | 10.33  (3.29) | 11.67  (3.48) | 09.67  (3.18) | 10.56  (3.32) | 0.00 | 10.33  (3.29) | 9.33  (3.13) | 8.67  (3.02) | 9.44  (3.15) | 0.00 |
| F-test |  | NS | Sig. | Sig. | Sig. | Sig. |  | Sig. | Sig. | Sig. | Sig. |  |
| S.Em± |  | 0.18 | 0.14 | 0.15 | 0.29 | 0.10 |  | 0.18 | 0.09 | 0.13 | 0.10 |  |
| CD (P=0.05) |  | 0.53 | 0.42 | 0.46 | 0.87 | 0.30 |  | 0.56 | 0.28 | 0.41 | 0.29 |  |
| CV (%) |  | 8.18 | 8.15 | 10.42 | 16.51 | 5.99 |  | 12.72 | 7.53 | 9.88 | 7.16 |  |

Figures in parentheses are square root transformed values NS – Non significant Sig. – Significant

**Table 3: Bio-efficacy evaluation against brown plant hopper (BPH) on paddy crop during *kharif* 2022-23**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose**  **(g/ha)** | **Before first spray** | **BPH population per hill** | | | **Mean** | **Reduction over control (%)** | **BPH population per hill** | | | **Mean** | **Reduction over control (%)** |
| **Days after first spray** | | | **Days after second spray** | | |
| **3** | **7** | **14** | **3** | **7** | **14** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 62.50 | 27.00  (5.23) | 20.33  (4.56) | 16.67  (4.12) | 15.00  (3.93) | 17.33  (4.22) | 39.53 | 11.33  (3.42) | 9.00  (3.02) | 6.00  (2.50) | 8.78  (3.03) | 57.31 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 93.75 | 28.67  (5.40) | 18.33  (4.33) | 14.33  (3.83) | 12.67  (3.62) | 15.11  (3.94) | 47.29 | 8.33  (2.96) | 6.00  (2.54) | 3.67  (2.00) | 6.00  (2.54) | 70.81 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 125 | 26.67  (5.21) | 15.67  (4.02) | 12.67  (3.59) | 11.33  (3.43) | 13.22  (3.70) | 53.87 | 6.67  (2.67) | 4.67  (2.26) | 2.33  (1.60) | 4.56  (2.25) | 77.83 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 156.25 | 28.00  (5.33) | 15.00  (3.93) | 11.33  (3.43) | 9.67  (3.17) | 12.00  (3.53) | 58.14 | 3.33  (1.94) | 2.67  (1.78) | 2.00  (1.56) | 2.67  (1.77) | 87.03 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 93.75 | 28.33  (5.36) | 17.33  (4.16) | 15.67  (3.97) | 12.67  (3.62) | 15.22  (3.94) | 46.90 | 9.00  (3.06) | 7.33  (2.78) | 4.33  (2.18) | 6.89  (2.71) | 66.50 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 125 | 27.33  (5.26) | 18.00  (4.29) | 14.33  (3.84) | 10.67  (3.32) | 14.33  (3.85) | 50.00 | 7.00  (2.71) | 4.67  (2.27) | 2.67  (1.78) | 4.78  (2.29) | 76.75 |
| Thiamethoxam 25% WG | 100 | 28.67  (5.40) | 22.33  (4.78) | 19.00  (4.41) | 16.33  (4.10) | 19.22  (4.44) | 32.95 | 13.67  (3.71) | 10.33  (3.26) | 8.67  (3.02) | 10.89  (3.35) | 47.02 |
| Untreated control | -- | 28.00  (5.33) | 29.33  (5.46) | 29.67  (5.49) | 27.00  (5.24) | 28.67  (5.40) | 0.00 | 25.33  (5.04) | 20.67  (4.57) | 15.67  (3.94) | 20.56  (4.56) | 0.00 |
| F-test |  | NS | Sig. | Sig. | Sig. | Sig. |  | Sig. | Sig. | Sig. | Sig. |  |
| S.Em± |  | 0.20 | 0.17 | 0.26 | 0.19 | 0.15 |  | 0.25 | 0.27 | 0.24 | 0.17 |  |
| CD (P=0.05) |  | 0.60 | 0.51 | 0.79 | 0.56 | 0.45 |  | 0.77 | 0.83 | 0.74 | 0.52 |  |
| CV (%) |  | 5.72 | 5.76 | 9.72 | 7.42 | 5.52 |  | 12.07 | 14.82 | 15.92 | 9.24 |  |

Figures in parentheses are square root transformed values NS – Non significant Sig. - Significant

**Table 4: Bio-efficacy evaluation against white backed plant hopper (WBPH) on paddy crop during *kharif* 2022-23**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose**  **(g/ha)** | **Before first spray** | **WBPH population per hill** | | | **Mean** | **Reduction over control (%)** | **WBPH population per hill** | | | **Mean** | **Reduction over control (%)** |
| **Days after first spray** | | | **Days after second spray** | | |
| **3** | **7** | **14** | **3** | **7** | **14** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 62.50 | 13.33  (3.70) | 11.00  (3.38) | 9.67  (3.18) | 8.33  (2.97) | 9.67  (3.19) | 41.61 | 6.33  (2.61) | 5.00  (2.34) | 4.00  (2.11) | 5.11  (2.37) | 58.57 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 93.75 | 14.00  (3.80) | 10.67  (3.34) | 8.00  (2.91) | 7.00  (2.73) | 8.56  (3.01) | 48.32 | 5.33  (2.40) | 3.67  (2.02) | 2.33  (1.65) | 3.78  (2.06) | 69.38 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 125 | 16.67  (4.12) | 9.33  (3.07) | 7.00  (2.73) | 5.67  (2.47) | 7.33  (2.78) | 55.71 | 4.00  (2.11) | 2.67  (1.74) | 1.67  (1.46) | 2.78  (1.81) | 77.46 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 156.25 | 15.00  (3.93) | 8.00  (2.89) | 6.67  (2.67) | 5.00  (2.34) | 6.56  (2.65) | 60.40 | 3.33  (1.93) | 1.67  (1.44) | 1.33  (1.34) | 2.11  (1.59) | 82.89 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 93.75 | 14.33  (3.84) | 11.33  (3.43) | 8.33  (2.97) | 7.33  (2.80) | 9.00  (3.08) | 45.66 | 5.67  (2.45) | 4.33  (2.19) | 2.67  (1.76) | 4.22  (2.17) | 65.76 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 125 | 15.67  (4.01) | 10.33  (3.28) | 8.33  (2.96) | 5.00  (2.34) | 7.89  (2.89) | 52.37 | 4.67  (2.26) | 3.00  (1.86) | 1.33  (1.34) | 3.00  (1.87) | 75.68 |
| Thiamethoxam 25% WG | 100 | 16.00  (4.05) | 12.67  (3.60) | 10.33  (3.28) | 9.67  (3.18) | 10.89  (3.37) | 34.23 | 8.00  (2.86) | 6.67  (2.68) | 5.67  (2.48) | 6.78  (2.69) | 45.03 |
| Untreated control | -- | 15.67  (4.02) | 16.67  (4.14) | 17.33  (4.22) | 15.67  (4.02) | 16.56  (4.13) | 0.00 | 14.33  (3.85) | 12.00  (3.53) | 10.67  (3.34) | 12.33  (3.58) | 0.00 |
| F-test |  | NS | Sig. | Sig. | Sig. | Sig. |  | Sig. | Sig. | Sig. | Sig. |  |
| S.Em± |  | 0.21 | 0.25 | 0.14 | 0.13 | 0.12 |  | 0.14 | 0.18 | 0.15 | 0.09 |  |
| CD (P=0.05) |  | 0.62 | 0.74 | 0.41 | 0.38 | 0.35 |  | 0.43 | 0.55 | 0.46 | 0.28 |  |
| CV (%) |  | 7.93 | 11.02 | 6.60 | 6.76 | 5.60 |  | 8.50 | 12.51 | 11.94 | 6.14 |  |

Figures in parentheses are square root transformed values NS – Non significant Sig. - Significant

**Table 5: Paddy yield and per cent increase in yield over control during *kharif* 2021-22 and *kharif* 2022-23**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Dose**  **(g/ha)** | **Yield (kgs/ha)** | | **Per cent yield increase over control** | | |
| ***kharif* 2021-22** | ***kharif* 2022-23** | ***kharif* 2021-22** | ***kharif* 2022-23** |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 62.50 | 5380.00 | 5020.00 | 13.50 | 15.14 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 93.75 | 5743.33 | 5320.00 | 21.17 | 22.02 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 125 | 6036.67 | 5680.00 | 27.36 | 30.28 |
| Ethiprole 40% + Imidacloprid 40% WG (Rainbow sample) | 156.25 | 6330.00 | 5840.00 | 33.54 | 33.94 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 93.75 | 5566.67 | 5246.67 | 17.44 | 20.34 |
| Ethiprole 40% + Imidacloprid 40% WG (Market sample) | 125 | 5866.67 | 5556.67 | 23.77 | 27.45 |
| Thiamethoxam 25% WG | 100 | 5540.00 | 5186.67 | 16.88 | 18.96 |
| Untreated control | -- | 4740.00 | 4360.00 | 0.00 | 0.00 |
| F-test |  | Sig. | Sig. |  |  |
| S.Em± |  | 149.13 | 161.84 |  |  |
| CD (P=0.05) |  | 449.44 | 487.73 |  |  |
| CV (%) |  | 4.00 | 4.65 |  |  |

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Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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**References:**

Anonymous (2021). Third advance estimates of production of food grains, oil seeds and other commercial crops for 2020-21. Press Information Bureau, Government of India.

Katti, G., Padmavathi, C. and Shanker, C. (2019). Advances in rice IPM Indian scenario.

Food and Agriculture Organisation of the United States of America.

Lakshmi, V. J., Krishnaiah, N. V., Katti G. R. (2010). Potential toxicity of selected insecticides to rice leafhoppers and planthoppers and their important natural enemies. Journal of Biological Control. Vol: 24 (3) 244-252.

Shankar, M., Bhadru, D., Kumar, M. P., Naik, V. R., N. Naik, R. B., Sivaprasad, G., Sumalini, K.

(2018). Evaluation of new insecticides against rice brown plant hopper Indian Journal of Entomology. Vol: 80(4),1300-1303.

[Gajare, C. K.](https://krishikosh.egranth.ac.in/browse/author?startsWith=Gajare%20Chetan%20Kantilal) (2018). Efficacy of new molecules of insecticides against brown plant hopper , *Nilaparvata lugens* (stal.) (homoptera : delphacidae ) infesting rice”.

[Bhanu](https://www.researchgate.net/scientific-contributions/KV-Bhanu-2090113429?_sg%5B0%5D=IMDNCX8Iq-7A2MMJuRrB6ZbphtzKRxKHpq4rK1PQ9Z9Lh_EX-JpypCnX7Gjq6wk07lKdyLg.2-QiqJdarOcGJ1FUNmomAQ8h5PDDbdYTXal2j1_sIVOFArMesANRMZB53FRPlVJkVuaEcsDtCQQ-3uGY6yt5QQ&_sg%5B1%5D=6QrHR3wSX6zZlxLbKXrsThcoCTaiII5NQWA6LFEmEKN9Y-z9HtM5Bi4_AC0QTCcuT9r8F6I.tvS_bf5WhzuMvLLrNb47-MyNnZ6HOOpNBkzEJyPDYEqizJPmAA2jidJAFnCCdAp8MXw02ZXb-39KJjP-9Oa1Yg), K. V. and [Reddy](https://www.researchgate.net/scientific-contributions/PS-Reddy-2090200854?_sg%5B0%5D=IMDNCX8Iq-7A2MMJuRrB6ZbphtzKRxKHpq4rK1PQ9Z9Lh_EX-JpypCnX7Gjq6wk07lKdyLg.2-QiqJdarOcGJ1FUNmomAQ8h5PDDbdYTXal2j1_sIVOFArMesANRMZB53FRPlVJkVuaEcsDtCQQ-3uGY6yt5QQ&_sg%5B1%5D=6QrHR3wSX6zZlxLbKXrsThcoCTaiII5NQWA6LFEmEKN9Y-z9HtM5Bi4_AC0QTCcuT9r8F6I.tvS_bf5WhzuMvLLrNb47-MyNnZ6HOOpNBkzEJyPDYEqizJPmAA2jidJAFnCCdAp8MXw02ZXb-39KJjP-9Oa1Yg&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIiwicHJldmlvdXNQYWdlIjoic2VhcmNoIiwicG9zaXRpb24iOiJwYWdlSGVhZGVyIn19), P. S. (2012). Evaluation of field efficacy of imidacloprid 40% + ethiprole 40% - 80 wg against planthoppers in rice. [Pestology](https://www.researchgate.net/journal/Pestology-0970-3012) 36(12):29-34.

[Vinothkumar, B.,](https://www.researchgate.net/profile/Vinothkumar-Bojan?_sg%5B0%5D=GEsS662zxnl2Pm8C3mZnxbI_stqwMIUw2zaJaeY_fzJias1NBr6jmYDrgQ-e3s5VXb2YzrI.waCb3rGd-utDfqUZsG9JoneGVBQMT8mLN3i-ux_bk8ds-6kf6QTT3B5Xc8LOkICFJGA5AM50uljzFf3PoNb9IQ&_sg%5B1%5D=BsvRVxHfC1yj64b2j09LpdR4ANjc00FKTih3Q8yU6Ygi3wtzSrCbHWhya6rec9PEo2MUh6U.2tM5pG8bkNA5cN_VoS2xfiTtxBo71nhYH-6hci_mFr3A7rUlQoguq8XzNkglwm8oz05QwXVjXmcGRqrhvmawCQ&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIiwicHJldmlvdXNQYWdlIjoic2VhcmNoIiwicG9zaXRpb24iOiJwYWdlSGVhZGVyIn19) [Kumaran, N.,](https://www.researchgate.net/profile/Kumaran-Nagalingam?_sg%5B0%5D=GEsS662zxnl2Pm8C3mZnxbI_stqwMIUw2zaJaeY_fzJias1NBr6jmYDrgQ-e3s5VXb2YzrI.waCb3rGd-utDfqUZsG9JoneGVBQMT8mLN3i-ux_bk8ds-6kf6QTT3B5Xc8LOkICFJGA5AM50uljzFf3PoNb9IQ&_sg%5B1%5D=BsvRVxHfC1yj64b2j09LpdR4ANjc00FKTih3Q8yU6Ygi3wtzSrCbHWhya6rec9PEo2MUh6U.2tM5pG8bkNA5cN_VoS2xfiTtxBo71nhYH-6hci_mFr3A7rUlQoguq8XzNkglwm8oz05QwXVjXmcGRqrhvmawCQ&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIiwicHJldmlvdXNQYWdlIjoic2VhcmNoIiwicG9zaXRpb24iOiJwYWdlSGVhZGVyIn19) Kubendran, D. and [Subapriya, K.](https://www.researchgate.net/profile/Subapriya-Kuttalam?_sg%5B0%5D=GEsS662zxnl2Pm8C3mZnxbI_stqwMIUw2zaJaeY_fzJias1NBr6jmYDrgQ-e3s5VXb2YzrI.waCb3rGd-utDfqUZsG9JoneGVBQMT8mLN3i-ux_bk8ds-6kf6QTT3B5Xc8LOkICFJGA5AM50uljzFf3PoNb9IQ&_sg%5B1%5D=BsvRVxHfC1yj64b2j09LpdR4ANjc00FKTih3Q8yU6Ygi3wtzSrCbHWhya6rec9PEo2MUh6U.2tM5pG8bkNA5cN_VoS2xfiTtxBo71nhYH-6hci_mFr3A7rUlQoguq8XzNkglwm8oz05QwXVjXmcGRqrhvmawCQ&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIiwicHJldmlvdXNQYWdlIjoic2VhcmNoIiwicG9zaXRpb24iOiJwYWdlSGVhZGVyIn19) (2010). Evaluation of new combination product ethioprole 40% + imidacloprid 40% - 80 WG against rice hopers. [Pestology](https://www.researchgate.net/journal/Pestology-0970-3012?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIiwicHJldmlvdXNQYWdlIjoic2VhcmNoIiwicG9zaXRpb24iOiJwYWdlSGVhZGVyIn19). Vol: 34(1):21-25

Kulagod, S. D., Hegde, M., Nayak, G. V., Vastrad, A. S., Hugar, P. S. and Basavanagoud, K. (2011). Evaluation of insecticides and biorationals against yellow stem borer and leaf folder on rice crop. Karnataka Journal of Agricultural Sciences. Vol: 24(2):244 –246.

Pasalu, I. C., Katti, G. (2006). Advances in ecofriendly approaches in rice IPM. Journal of Rice Research. Vol:1(1):83 –90.

Food and Agricultural Organization of the United Nations. (2004). The state of food security in the world, FAO, Rome, Italy. Pp- 30-31.

Midya, A., Saren, B. K., Dey, J. K., Maitra, S., Praharaj, S., Gaikwad, D. J., ... & Hossain, A. (2021). Crop establishment methods and integrated nutrient management improve: Part i. crop performance, water productivity and profitability of rice (Oryza sativa L.) in the lower indo-gangetic plain, India. Agronomy, 11(9), 1860.

Konda, J. S. D., & Chandar, A. S. (2022). Major insect pests in paddy crop and their management. Just Agriculture e-newsletter, 3(3), 1-16.

Kumar, S., Singh, H., Patel, A., Patel, J. N., & Kant, C. (2022). Brown plant hopper, Nilaparvata lugens (Stal)(Insecta: Delphacidae) a major insect of rice in India: A review. J. Entomol. Res, 46(2), 333-38.

Araújo, M. F., Castanheira, E. M., & Sousa, S. F. (2023). The buzz on insecticides: a review of uses, molecular structures, targets, adverse effects, and alternatives. Molecules, 28(8), 3641.

Stanley, J., Subbanna, A. R. N. S., Mahanta, D., Paschapur, A. U., Mishra, K. K., & Varghese, E. (2022). Organic pest management of hill crops through locally available plant extracts in the mid‐Himalayas. Annals of Applied Biology, 181(3), 379-393.

Shilpakala , V., Lakshmi, V. J., Venkatesarulu , N., Madhav , M. S., Tamilmurugan , R., & Devi , R. S. J. (2024). Probing Behaviour of Brown Planthopper Nilaparvata lugens (Stal.) in the Resistant Germplasm Accessions. Journal of Experimental Agriculture International, 46(3), 26–34.