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**S Malathi**  
Agricultural College, Warangal,  
Professor Jayashankar Telangana  
Agricultural University,  
Telangana, India

**A Venkat Reddy**  
Regional Agricultural Research  
Station, Warangal, Professor  
Jayashankar Telangana  
Agricultural University,  
Telangana, India

## Bio-efficacy of selected insecticides against brown planthopper, *Nilaparvata lugens* (Stål), and their safety to natural enemies in the rice ecosystem

**S Malathi and A Venkat Reddy**

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### Abstract

A field experiment was conducted to evaluate the efficacy of different insecticides against brown planthopper (BPH) and their impact on natural enemies and grain yield. The experiment was conducted on the rice variety BPT-5204 at Regional Agricultural Research Station, Warangal under Professor Jayashankar Telangana Agricultural University, Telangana, India during *Kharif* 2014. The treatments comprised of acephate 95 SG, flubendiamide 4 + buprofezin 20 SC, buprofezin 25 SC, dinotefuran 20 SG, imidacloprid 40 + ethiprole 40 WG, acephate 75 WP, and monocrotophos 36 WSC along with an untreated control. Observations on hopper population, spider population, coccinellid population were recorded at 3, 10, and 15 days after spray (DAS). All insecticidal treatments significantly reduced hopper incidence compared to the untreated control. Among the treatments, dinotefuran 20 SG proved most effective by recording the lowest hopper population at 3 DAS (35.3 hoppers hill<sup>-1</sup>) and 10 DAS (68.7 hoppers hill<sup>-1</sup>), while imidacloprid 40 + ethiprole 40 WG recorded the lowest hopper population at 15 DAS (60.3 hoppers hill<sup>-1</sup>). The populations of spiders and coccinellids were not significantly affected by the treatments, indicating their relative safety to natural enemies. The highest grain yield was recorded in acephate 75 WP (5196 kg ha<sup>-1</sup>), followed by acephate 95 SG (5045 kg ha<sup>-1</sup>) and dinotefuran 20 SG (4959 kg ha<sup>-1</sup>), whereas the untreated control recorded the lowest yield (3178 kg ha<sup>-1</sup>). Overall, dinotefuran 20 SG followed by imidacloprid + ethiprole and buprofezin provided superior suppression of BPH and did not significantly affect populations of spiders and coccinellids under field conditions.

**Keywords:** Brown planthopper, efficacy, insecticides, natural enemies, *Oryza sativa*

### 1. Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops, serving as the primary source of nutrition for a large proportion of the world's population. In India, rice occupies a prominent place in agricultural production and food security. A significant portion of potential yield of rice is lost due to both biotic and abiotic factors. Among the biotic stresses, insect pests pose a major threat to rice crop right from nursery till harvest. More than 300 insect species infest rice, among which approximately 20-25 species cause economically significant damage (Pasalu & Katti, 2006) [14]. The insect pests that are of economic importance in rice are stem borers, planthoppers, rice gall midge, leaf folders and rice bugs. The brown planthopper (BPH), *Nilaparvata lugens* (Stål) is one of the major sucking pests causing substantial yield losses under favourable environmental conditions. Both nymphs and adults feed on plant sap from the phloem tissues, resulting in yellowing, stunted growth, hopper burn and ultimately reduction in grain yield. In severe infestations, complete drying of crop patches may occur.

Management of this pest has largely relied on insecticides in most rice-producing countries (Alam, 2013 [1]; Gao *et al.*, 1987 [3]; Hasan *et al.*, 2015) [7]. Indiscriminate and continuous use of conventional insecticides has led to problems such as pest resurgence, resistance development, destruction of natural enemies and environmental contamination. BPH resurgence subsequent to application of insecticides were reported in Bangladesh (Alam, 2013) [1], India (Lakshmi *et al.*, 2010) [12], Indonesia (Oka, 1991) [13], the Philippines (Heong and Hardy, 2009) [9]. While the use of insecticides remains an important component of integrated pest management (IPM), biological control through conservation of natural enemies is also considered as an equally

**Corresponding Author:**  
**S Malathi**  
Agricultural College, Warangal,  
Professor Jayashankar Telangana  
Agricultural University,  
Telangana, India

important tool. Hence, the protection and preservation of natural enemies such as spiders, mirid bugs and coccinellids which play a vital role in regulating hopper populations in rice fields is important. These natural enemies are exposed directly to insecticides during spraying, as well as to the residual insecticides on the crop. Therefore, evaluation of newer insecticidal molecules with higher efficacy and safer effects on beneficial organisms has become essential for sustainable hopper management in rice ecosystems. In recent years, several novel insecticides with different modes of action have been introduced for hopper management in rice. However, comparative information on newer and conventional insecticides with respect to BPH suppression, safety to beneficial arthropods and yield response under field conditions is limited. Therefore, the present study was undertaken to evaluate the efficacy of selected insecticides against BPH, their impact on natural enemies and influence on grain yield of rice.

## 2. Materials and Methods

The present experiment was conducted at Regional Agricultural Research Station, Warangal, Professor Jayashankar Telangana Agricultural University, Telangana, India during *Kharif*, 2014. The experiment was conducted as per the approved technical programme under the All India Coordinated Research Project (AICRP) on Rice. The experiment was conducted using rice variety viz., BPT-5204. Nursery was sown on 19-06-2014 and transplanted on 18-07-2014 at a spacing of 20 x 15 cm and was grown following all recommended agronomic package of practices, except plant protection measures (Shaik *et al.*, 2014)<sup>[16]</sup>. The experiment was laid out in randomized block design with eight treatments including untreated control (Table 1) each replicated thrice and an individual plot size of 21 sq. m. Initially two sprays of the respective treatments were taken up in third week of August and second week of September targeting early stage pests. However, pest pressure of early stage pests like gall midge and stem borer was very low and non-significant during this period. Observations presented in this study correspond to the third spray targeting BPH infestation.

The third spray was applied during second week of October. Water was sprayed in untreated control plots when treatments were imposed. Spray volume of 500 L ha<sup>-1</sup> was used. Spraying was done using knapsack sprayer and was directed towards the basal portion of plants to target hopper populations. The sprayer was flushed thoroughly with clean water every time before spraying next insecticide. Precautions were taken to avoid spray drift from one treatment plot to another. Observations on number of brown plant hoppers were recorded at 3, 10 and 15 days after third spraying on ten randomly selected hills per plot, mean per hill was arrived and statistically analysed. Similarly, observations on number of natural enemies (spiders, coccinellids) were recorded at 3, 10 and 15 days after third spraying on ten randomly selected hills per plot, mean per hill was arrived, transformed using  $\sqrt{(x+0.5)}$  prior to analysis. Grain yield from each plot was recorded at harvest excluding border rows, converted into kg ha<sup>-1</sup> and analyzed statistically. The data were subjected to ANOVA (Gomez and Gomez, 1984)<sup>[5]</sup> and the mean values were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1951)<sup>[2]</sup> at 5% significance level.

**Table 1:** Treatment details

| Tr. No.        | Treatments                         | Dose (g a.i. ha <sup>-1</sup> ) |
|----------------|------------------------------------|---------------------------------|
| T <sub>1</sub> | Acephate 95 SG                     | 500                             |
| T <sub>2</sub> | Flubendiamide 4 + buprofezin 20 SC | 1838                            |
| T <sub>3</sub> | Buprofezin 25 SC                   | 250                             |
| T <sub>4</sub> | Dinotefuran 20 SG                  | 40                              |
| T <sub>5</sub> | Imidacloprid 40 + ethiprole 40 WG  | 100                             |
| T <sub>6</sub> | Acephate 75 WP                     | 500                             |
| T <sub>7</sub> | Monocrotophos 36 WSC               | 500                             |
| T <sub>8</sub> | Untreated control                  | -                               |

## 3. Results and Discussion

### 3.1 Efficacy against BPH

The efficacy of different insecticidal treatments against BPH was evaluated based on the mean number of BPH hill<sup>-1</sup> recorded at 3, 10, and 15 days after third spray (DAS). Significant differences among treatments were observed at all observation intervals (Table 2). At 3 DAS, the lowest BPH population was recorded in plots treated with dinotefuran 20 SG @ 40 g a.i. ha<sup>-1</sup> (35.30 hill<sup>-1</sup>), which was statistically on par with imidacloprid 40 + ethiprole 40 WG @ 100 g a.i. ha<sup>-1</sup> (40.70 BPH hill<sup>-1</sup>) and acephate 75 WP @ 500 g a.i. ha<sup>-1</sup> (46.00 hill<sup>-1</sup>). These treatments were significantly superior to the untreated control, which registered highest BPH population of 517.70 hill<sup>-1</sup>. Monocrotophos 36 WSC @ 500 g a.i. ha<sup>-1</sup> recorded comparatively higher BPH populations (116.30 hill<sup>-1</sup>) among the treated plots.

At 10 DAS, dinotefuran 20 SG continued to maintain the lowest BPH population (68.70 hill<sup>-1</sup>), followed by buprofezin 25 SC (72.30 hill<sup>-1</sup>) and imidacloprid 40 WG + ethiprole 40 WG (73.00 hill<sup>-1</sup>), which were statistically at par. The highest BPH population among treated plots was observed with monocrotophos 36 WSC (186.30 hill<sup>-1</sup>), whereas the untreated control recorded 309.70 BPH hill<sup>-1</sup>.

Similarly, at 15 DAS, imidacloprid 40 + ethiprole 40 WG recorded the lowest BPH population (60.30 hill<sup>-1</sup>), followed by dinotefuran 20 SG (78.00 hill<sup>-1</sup>) and buprofezin 25 SC (78.70 hill<sup>-1</sup>). The untreated control exhibited the highest BPH incidence (226.30 hill<sup>-1</sup>), indicating sustained pest pressure in the absence of insecticidal intervention.

Overall, dinotefuran 20 SG @ 40 g a.i. ha<sup>-1</sup> and imidacloprid 40 + ethiprole 40 WG @ 100 g a.i. ha<sup>-1</sup> were the most effective treatments in suppressing BPH populations throughout the observation period, followed by buprofezin 25 SC. These treatments resulted in substantial reduction of BPH infestation compared to untreated control, demonstrating their effectiveness in BPH management in rice. The efficacy of dinotefuran may be attributed to its rapid systemic activity, translaminar movement and prolonged residual activity against sap-feeding insects. The present results are in conformity with the findings of Jaglan *et al.* (2022)<sup>[11]</sup> who reported that spray of dinotefuran 20 SG at 40 g a.i. ha<sup>-1</sup>, when pest crosses economic threshold level is the most effective treatment for the reduction of hopper population. Ghosh, *et al.* (2014)<sup>[4]</sup> reported that dinotefuran 20 SG at 25 g a.i. ha<sup>-1</sup> was found quite effective against BPH and was also very safe to the important predators recorded to be present in rice field. Similarly, effectiveness of imidacloprid 40 + ethiprole 40 WG against BPH was also reported by Rajasekhar *et al.* (2025)<sup>[15]</sup>. Buprofezin effectiveness may be related to its insect growth regulating properties affecting hopper nymphal development. The efficacy observed with buprofezin 25 SC is also consistent with other reports. Wang *et al.* (2008)<sup>[18]</sup> reported

that buprofezin effectively controlled planthopper populations with relatively low environmental risk. Heinrichs (1984) [8] reported that buprofezin was highly selective and effective at low rates against nymphs of BPH, white-backed plant hopper and green leaf hopper. Dinotefuran exhibited comparatively more persistent efficacy than acephate treatments evaluated. In the present experiment, comparatively higher populations were observed in monocrotophos treated plots. The lower efficacy recorded with monocrotophos 36 WSC compared to newer insecticides may suggest reduced field susceptibility associated with prolonged use; however, resistance mechanisms were not investigated in the present study. Similar concerns regarding diminished effectiveness of older chemistries against rice planthoppers have been highlighted in earlier studies.

### 3.2 Effect on natural enemies

The population of natural enemies, namely spiders and coccinellids, did not differ significantly among the treatments and untreated control, at all observation intervals (3 DAS, 10 DAS and 15 DAS), indicating no adverse impact of the evaluated insecticides on beneficial fauna. Spider population ranged from 21.30 to 25.30 hill<sup>-1</sup> at 3 DAS, 21.00 to 34.00 hill<sup>-1</sup> at 10 DAS, and 23.70 to 27.00 hill<sup>-1</sup> at 15 DAS. Similarly, coccinellid population varied from 10.00 to 14.00 hill<sup>-1</sup> at 3 DAS, 13.00 to 18.00 hill<sup>-1</sup> at 10 DAS, and 14.00 to 17.00 hill<sup>-1</sup> at 15 DAS in the experimental block. The safety of insecticides to natural enemies in rice ecosystems has been widely documented. Indoxacarb 15.8 EC, chlorantraniliprole 18.5 SC, cartap hydrochloride 50 SP, and fipronil 5 SC were reported to exhibit minimal adverse effects on natural enemies in rice ecosystems (Jafar *et al.*, 2013) [10]. The present findings are in agreement with earlier reports by Wang *et al.* (2008) [18], Jaglan *et al.* (2022) [11] and Vinoth Kumar *et al.* (2010) [17]. Jaglan *et al.* (2022) [11] reported that dinotefuran 20 SG applied at 20, 30, 40, and 50 g a.i. ha<sup>-1</sup> was safe to important natural enemies including spiders, mirid bugs and coccinellids in rice ecosystem. Vinoth Kumar *et al.*, 2010 [17] reported that ethiprole 40% + imidacloprid 40% - 80 WG treatments were found to be safer to the predators found in the rice ecosystem. Though they observed an initial set back in the population of mirid bugs and spiders, it started increasing gradually in the ethiprole 40% + imidacloprid

40% - 80 WG treated plots. Further, Harika and Deole (2023) [6] observed that imidacloprid 17.8% SL @ 25 g a.i. ha<sup>-1</sup>, sulfoxaflor 24% SC @ 175 g a.i. ha<sup>-1</sup>, thiamethoxam 25% WG @ 25 g a.i. ha<sup>-1</sup>, pymetrozine 50% WG @ 150 g a.i. ha<sup>-1</sup>, dinotefuran 20% SG @ 40 g a.i. ha<sup>-1</sup>, and flonicamid 50% WG @ 75 g a.i. ha<sup>-1</sup> were comparatively safer to spiders and coccinellids. These findings collectively support the present observations that the test insecticides did not significantly reduce populations of spiders and coccinellids under field conditions.

### 3.3 Effect on Yield

The grain yield of rice varied significantly among the insecticidal treatments, ranging from 3178 to 5196 kg ha<sup>-1</sup>. The highest yield was recorded in plots treated with acephate 75 WP @ 500 g a.i. ha<sup>-1</sup> (5196 kg ha<sup>-1</sup>), which was statistically on par with acephate 95 SG @ 500 g a.i. ha<sup>-1</sup> (5045 kg ha<sup>-1</sup>), dinotefuran 20 SG @ 40 g a.i. ha<sup>-1</sup> (4959 kg ha<sup>-1</sup>), buprofezin 25 SC @ 250 g a.i. ha<sup>-1</sup> (4818 kg ha<sup>-1</sup>), imidacloprid 40 + ethiprole 40 WG @ 100 g a.i. ha<sup>-1</sup> (4417 kg ha<sup>-1</sup>), and flubendiamide 4 + buprofezin 20 SC @ 1838 g a.i. ha<sup>-1</sup> (4307 kg ha<sup>-1</sup>). The higher yield recorded with acephate treatments despite comparatively higher BPH populations indicates that yield response may also depend on suppression of other pest complexes and crop physiological recovery. As acephate is a broad-spectrum systemic insecticide, its effectiveness against other unrecorded insect pests may have indirectly contributed to improved crop performance and yield. However, since populations of other pests were not quantified in the present study, this interpretation should be considered tentative. The lowest yield among treated plots was recorded in monocrotophos 36 WSC @ 500 g a.i. ha<sup>-1</sup> (4265 kg ha<sup>-1</sup>), although it remained significantly higher than the untreated control (3178 kg ha<sup>-1</sup>). The untreated control registered minimum grain yield due to severe brown planthopper infestation, indicating the detrimental effect of uncontrolled pest populations on crop productivity. The increased yields observed under insecticidal treatments could be attributed to effective suppression of BPH populations, resulting in reduced crop damage and improved plant performance. The results demonstrate that insecticide application contributed to enhanced grain yield compared to the untreated condition.

**Table 2:** Effect of insecticides on Brown planthopper, natural enemies and grain yield in rice at RARS, Warangal during Kharif, 2014

| Treatments                            | Dose<br>(g a.i. ha <sup>-1</sup> ) | No. of BPH hill <sup>-1</sup> |                      |                       | No. of Spiders hill <sup>-1</sup> |                              |                              | No. of Coccinellids hill <sup>-1</sup> |                              |                              | Yield<br>(Kg ha <sup>-1</sup> ) |
|---------------------------------------|------------------------------------|-------------------------------|----------------------|-----------------------|-----------------------------------|------------------------------|------------------------------|----------------------------------------|------------------------------|------------------------------|---------------------------------|
|                                       |                                    | 3 DAS                         | 10 DAS               | 15 DAS                | 3 DAS                             | 10 DAS                       | 15 DAS                       | 3 DAS                                  | 10 DAS                       | 15 DAS                       |                                 |
| Acephate 95 SG                        | 500                                | 90.30 <sup>cd</sup>           | 168.00 <sup>bc</sup> | 131.30 <sup>bc</sup>  | 23.30 <sup>a</sup><br>(4.93)      | 29.30 <sup>a</sup><br>(5.51) | 27.00 <sup>a</sup><br>(5.28) | 12.00 <sup>a</sup><br>(3.54)           | 11.00 <sup>a</sup><br>(3.43) | 14.00 <sup>a</sup><br>(3.84) | 5045 <sup>ab</sup>              |
| Flubendiamide 4 +<br>buprofezin 20 SC | 1838                               | 56.30 <sup>abc</sup>          | 125.30 <sup>a</sup>  | 176.00 <sup>cd</sup>  | 22.30 <sup>a</sup><br>(4.82)      | 31.00 <sup>a</sup><br>(5.62) | 26.30 <sup>a</sup><br>(5.21) | 11.00 <sup>a</sup><br>(3.48)           | 15.00 <sup>a</sup><br>(4.04) | 16.30 <sup>a</sup><br>(4.16) | 4307 <sup>ab</sup>              |
| Buprofezin 25 SC                      | 250                                | 80.70 <sup>b</sup>            | 72.30 <sup>a</sup>   | 78.70 <sup>ab</sup>   | 25.30 <sup>a</sup><br>(5.13)      | 27.30 <sup>a</sup><br>(5.32) | 24.30 <sup>a</sup><br>(5.03) | 11.00 <sup>a</sup><br>(3.45)           | 18.00 <sup>a</sup><br>(4.30) | 15.60 <sup>a</sup><br>(4.07) | 4818 <sup>ab</sup>              |
| Dinotefuran 20 SG                     | 40                                 | 35.30 <sup>a</sup>            | 68.70 <sup>a</sup>   | 78.00 <sup>ab</sup>   | 23.30 <sup>a</sup><br>(4.92)      | 25.00 <sup>a</sup><br>(5.10) | 23.70 <sup>a</sup><br>(4.96) | 11.00 <sup>a</sup><br>(3.40)           | 13.00 <sup>a</sup><br>(3.74) | 17.00 <sup>a</sup><br>(4.24) | 4959 <sup>ab</sup>              |
| Imidacloprid 40 +<br>ethiprole 40 WG  | 100                                | 40.70 <sup>ab</sup>           | 73.00 <sup>a</sup>   | 60.30 <sup>a</sup>    | 23.00 <sup>a</sup><br>(4.90)      | 21.00 <sup>a</sup><br>(4.68) | 24.70 <sup>a</sup><br>(5.06) | 11.00 <sup>a</sup><br>(3.41)           | 13.00 <sup>a</sup><br>(3.77) | 14.00 <sup>a</sup><br>(3.87) | 4417 <sup>ab</sup>              |
| Acephate 75 WP                        | 500                                | 46.00 <sup>ab</sup>           | 108.70 <sup>ab</sup> | 120.70 <sup>abc</sup> | 24.30 <sup>a</sup><br>(5.03)      | 31.00 <sup>a</sup><br>(5.62) | 24.00 <sup>a</sup><br>(5.03) | 11.00 <sup>a</sup><br>(3.49)           | 14.00 <sup>a</sup><br>(3.91) | 15.30 <sup>a</sup><br>(4.02) | 5196 <sup>a</sup>               |
| Monocrotophos 36<br>WSC               | 500                                | 116.30 <sup>d</sup>           | 186.30 <sup>c</sup>  | 157.70 <sup>c</sup>   | 21.30 <sup>a</sup><br>(4.73)      | 34.00 <sup>a</sup><br>(5.93) | 26.00 <sup>a</sup><br>(5.19) | 10.00 <sup>a</sup><br>(3.30)           | 15.00 <sup>a</sup><br>(3.99) | 15.70 <sup>a</sup><br>(4.07) | 4265 <sup>b</sup>               |
| Untreated control                     | -                                  | 517.70 <sup>e</sup>           | 309.70 <sup>d</sup>  | 226.30 <sup>d</sup>   | 24.70 <sup>a</sup><br>(5.06)      | 29.70 <sup>a</sup><br>(5.51) | 26.30 <sup>a</sup><br>(5.23) | 14.00 <sup>a</sup><br>(3.86)           | 15.00 <sup>a</sup><br>(3.99) | 14.70 <sup>a</sup><br>(3.91) | 3178 <sup>c</sup>               |
| CD (5%)                               |                                    | 41.50                         | 62.70                | 63.30                 | NS                                | NS                           | NS                           | NS                                     | NS                           | NS                           | 925                             |
| SE (m) ±                              |                                    | 13.60                         | 20.50                | 20.70                 | (0.16)                            | (0.27)                       | (0.20)                       | (0.25)                                 | (0.23)                       | (0.27)                       | 302                             |
| CV (%)                                |                                    | 19.10                         | 25.50                | 27.85                 | 5.66                              | 8.61                         | 6.70                         | 12.54                                  | 10.16                        | 11.81                        | 11.57                           |

DAS-Days after Spray

Means followed by similar letters are not significantly different by DMRT at  $p < 0.05$ . Values in parentheses are square root transformed values.

#### 4. Conclusion

The results indicated that all insecticidal treatments significantly reduced brown planthopper (BPH) population compared to the untreated control, although differences among treatments varied over the observation periods. Among the evaluated insecticides, dinotefuran 20 SG @ 40 g a.i. ha<sup>-1</sup> and imidacloprid 40 + ethiprole 40 WG @ 100 g a.i. ha<sup>-1</sup> recorded comparatively lower BPH populations at 3, 10 and 15 DAS, demonstrating superior suppression of BPH. The abundance of natural enemies (spiders and coccinellids) did not differ significantly among treatments, indicating minimal impact of the test insecticides on these beneficial arthropods under field conditions. Although acephate treatments recorded comparatively higher grain yields, yield response did not correspond directly with BPH suppression alone, suggesting influence of additional field factors. Overall, dinotefuran 20 SG, followed by imidacloprid + ethiprole and buprofezin, demonstrated effective BPH management with limited impact on natural enemies and satisfactory grain yield under field conditions.

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