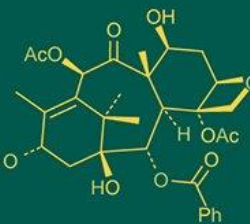
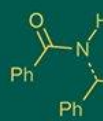


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(7): 1318-1327
www.biochemjournal.com
Received: 14-05-2026
Accepted: 18-06-2026

Krishna Kumar Bonkuri
Department of Entomology,
N.M. College of Agriculture,
Navsari Agricultural
University, Navsari, Gujarat,
India

PB Patel
Main Rice Research Centre,
Navsari Agricultural
University, Navsari, Gujarat,
India

Bhanavathu Sai
Department of Entomology,
N.M. College of Agriculture,
Navsari Agricultural
University, Navsari, Gujarat,
India

Parise Teena
Department of Entomology,
College of Agriculture,
Rajendranagar, Professor
Jayashankar Telangana
Agricultural University,
Hyderabad, Telangana, India

Upparapalli Shivaram
Department of Entomology,
College of Agriculture,
Rajendranagar, Professor
Jayashankar Telangana
Agricultural University,
Hyderabad, Telangana, India

Corresponding Author:
Krishna Kumar Bonkuri
Department of Entomology,
N.M. College of Agriculture,
Navsari Agricultural
University, Navsari, Gujarat,
India

Bioefficacy of newer insecticides against rice earhead bug, *Leptocorisa acuta* thunberg, under field conditions

Krishna Kumar Bonkuri, PB Patel, Bhanavathu Sai, Parise Teena and Upparapalli Shivaram

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i7Sp.9228>

Abstract

The present study on the Bioefficacy of newer insecticides against rice earhead bug, *Leptocorisa acuta* Thunberg, under field conditions, was conducted at the Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat, India on the rice variety, Gujarat Rice-11 during Kharif 2023. Results of the study revealed that the order of effectiveness of various treatments against *L. acuta* was found to be emamectin benzoate 5 SG (0.002%) > fipronil 5 SC (0.015%) ≥ lambda cyhalothrin 5 EC (0.0025%) > thiamethoxam 25 WDG (0.005%) ≥ dinotefuran 20 SG (0.008%) ≥ acetamiprid 20 SP (0.004%) ≥ flonicamid 50 WG (0.015%) > buprofezin 25 SC (0.04%) ≥ benzpyrimoxan 10 SC (0.02%) > control (water spray). The maximum realization (48309 ₹/ha) over control was obtained in emamectin benzoate 5 SG at 0.002 per cent followed by fipronil 5 SC at 0.015 per cent (41932 ₹/ha) and lambda cyhalothrin 5 EC at 0.0025 per cent (39184 ₹/ha). The lowest (14561 ₹/ha) realization over control was obtained in treatment with benzpyrimoxan 10 SC at 0.02 per cent. The cost-benefit ratio (ICBR) of emamectin benzoate 5 SG at 0.002 per cent was found to be the highest (1:22.06) among all the treatments followed by lambda cyhalothrin 5 EC at 0.0025 per cent (1:20.41) and thiamethoxam 25 WDG at 0.005 per cent (1:15.82). Whereas, the lowest (1:3.96) ICBR was found in the treatment of benzpyrimoxan 10 SC at 0.02 per cent.

Keywords: Bioefficacy, insecticides, rice gundhi bug, rice earhead bug, cost benefit ratio, Navsari

Introduction

Rice (*Oryza sativa* L.) is one of the world's most important cereal crops, serving as the primary staple food for over 60% of the global population, particularly across Asia. It represents a major source of dietary energy and contributes substantially to daily nutrient intake in many developing countries. On average, 100 g of edible rice contains approximately 78.2 g carbohydrates, 6.8 g protein, 0.5 g fat, 0.2 g crude fibre, 0.6 g minerals, 10 mg calcium, and 160 mg phosphorus, highlighting its nutritional significance. Beyond its nutritional contribution, rice is cultivated across a wide range of agro-climatic environments due to its remarkable adaptability, making it indispensable for sustaining global food and nutritional security. Rice is grown extensively throughout the world, occupying nearly 167.1 million hectares and producing approximately 527.7 million metric tonnes of milled rice during the 2024–25 cropping season. Among rice-producing nations, India and China dominate global production, followed by Bangladesh, Indonesia, and Vietnam. The worldwide average productivity of rice is estimated at 4.71 t ha⁻¹ (USDA, 2024) ^[1].

India is the world's leading country in terms of rice cultivation area, with approximately 51.42 million hectares under cultivation during the 2024–25 crop year. The country produced an estimated 150.0 million metric tonnes of milled rice, achieving an average productivity of 4.38 t ha⁻¹ (USDA-FAS, 2025) ^[2]. Rice is cultivated across diverse agro-ecological regions and forms an integral component of the agricultural production system in almost every state. Among the major rice-producing states, West Bengal accounts for the largest cultivated area, while Punjab consistently attains the highest levels of productivity, largely attributable to extensive irrigation infrastructure, widespread adoption of high-yielding varieties, advanced production technologies, and efficient crop management practices.

In Gujarat, rice cultivation is predominantly confined to the kharif season and is concentrated in the southern and central agro-climatic zones, where rainfall and irrigation resources are favourable for crop establishment and growth. The crop occupies nearly 0.90 million hectares, with an annual production of approximately 2.14 million metric tonnes and an average productivity of about 2.36 t ha⁻¹. The principal rice-growing districts include Navsari, Surat, Anand, Kheda, Bharuch, and Vadodara, which collectively contribute a major share of the state's rice production owing to suitable climatic conditions, fertile soils, and the availability of irrigation facilities (Directorate of Agriculture, Government of Gujarat, 2022) [3].

Among the insect pests of rice, the rice earhead bug, *Leptocorisa acuta* Thunberg, is of particular concern because it feeds directly on developing grains during the reproductive stage, resulting in grain discoloration, chaffiness, reduced grain weight, poor milling quality, and significant economic losses. Since the damage occurs at the grain-filling stage, infestations not only reduce yield but also adversely affect market value and seed quality. In recent years, the incidence and severity of *L. acuta* have increased in several rice-growing regions, including Gujarat, where recurring outbreaks have been reported over the past five to six years (Ghoghari *et al.*, 2019) [4]. This increasing pest pressure has necessitated the development of effective and sustainable management strategies.

Although several studies have evaluated the efficacy of conventional insecticides against rice earhead bug, information on the performance of recently introduced insecticide molecules under field conditions remains limited, particularly under the agro-climatic conditions of Gujarat. Generating reliable field-based information on the effectiveness of these newer insecticides is therefore essential for developing economically viable and environmentally sound management recommendations. In view of the increasing incidence of *L. acuta* and the limited availability of comprehensive field evaluation studies on newer insecticide molecules, the present investigation was undertaken to evaluate the bioefficacy of selected newer insecticides against the rice earhead bug, *Leptocorisa acuta* Thunberg, under field conditions. The findings of this study are expected to contribute to identifying effective insecticidal options for incorporation into integrated pest management programmes to minimise yield losses and promote sustainable rice production.

Materials and Methods

The field experiment was conducted during *Kharif* 2023 at the Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat, India, to evaluate the bioefficacy of newer insecticides against rice earhead bug, *leptocorisa acuta* thunberg, under field conditions. The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments comprising nine insecticidal treatments viz., Acetamiprid 20 SP @ 2 g/10 l, Benzpyrimoxan 10 SC @ 20 ml/10 l, Buprofezin 25 SC @ 16 ml/10 l, Emamectin benzoate 5 SG @ 4 g/10 l, Dinotefuran 20 SG @ 4 g/10 l, Fipronil 5 SC @ 30 ml/10 l, Flonicamid 50 WG @ 3 g/10 l, Lambda cyhalothrin 5 EC @ 5 ml/ 10 l and Thiamethoxam 25 WDG @ 2 g/10 l, along with Control (water spray), each replicated three times. The rice variety Gujarat Rice-11 was used for the study. Seeds were sown on 3 July 2023, and 23-day-old seedlings were

transplanted on 26 July 2023 at a spacing of 20 × 15 cm. The total experimental area was 544 m², with a gross plot size of 3.20 × 3.00 m and a net plot size of 2.40 × 2.40 m. A seed rate of 25–30 kg ha⁻¹ was adopted for raising the nursery. The crop was maintained by following all the recommended agronomic practices, including the application of 10 t ha⁻¹ farmyard manure (FYM) and fertilizers at the rate of 100:30:0 kg N:P:K ha⁻¹, to ensure healthy crop growth. Two insecticidal sprays were applied as per the treatment schedule, with the first spray on 25 September 2023 and the second on 10 October 2023. The crop was harvested on 10 November 2023.

The insecticidal treatments were applied at the flowering stage of the crop, coinciding with the incidence of the rice earhead bug, *Leptocorisa acuta* Thunberg. The insecticides were applied using a battery-operated knapsack sprayer, which was thoroughly cleaned before the application of each treatment to avoid cross-contamination. The population of rice earhead bug was recorded as the number of nymphs and adults per 10 hills. Observations were recorded one day before spraying (pre-treatment count) and at 1, 3, 5, 7, 10, and 14 days after each spray (DAS). For recording observations, ten hills were selected at random from each plot by following a 'W'-shaped sampling pattern. Two sprays were imposed, and observations were recorded after both the first and second applications.

Grain and straw yields were recorded separately from the net plot at harvest, expressed as kilograms per plot, and subsequently converted to kilograms per hectare (kg ha⁻¹). The percentage increase in grain and straw yield over the untreated control was computed for each treatment. To evaluate the economic feasibility of the insecticidal treatments, the Incremental Cost–Benefit Ratio (ICBR) was calculated. The total cost of plant protection included the cost of insecticides and labour charges incurred for their application. The additional returns over the untreated control were estimated based on the prevailing market prices of rice grain and straw. The realization over control was calculated by summing the monetary value of the additional grain and straw yields obtained under each treatment, and the ICBR was determined by dividing the realization over control by the corresponding cost of plant protection. The data on rice earhead bug population were subjected to square root transformation [$\sqrt{(x + 0.5)}$] before statistical analysis to stabilize the variance. The transformed data were analyzed using analysis of variance (ANOVA) appropriate for a Randomized Block Design (RBD), and treatment means were compared at the 5% level of significance.

Results and Discussion

Effectiveness of insecticides

First spray

The earhead bug population recorded in different treatments at different intervals was presented in Table 1. In the pre-treatment observations, the rice earhead bug nymphal and adult population ranged from 10.00 to 11.00 bugs per 10 hills. All the treatments were statistically at par with each other indicating a more or less uniform number of bug population on the crop under experimentation.

One day after spraying, the earhead bug population ranged from 5.00 to 11.33 bugs per 10 hills (Table 1). The crop treated with emamectin benzoate 5 SG at 0.002 per cent recorded the lowest (5.00 bugs/10 hills) bug population per 10 hills which remained at par with fipronil 5 SC at 0.015

per cent (6.67 bugs/10 hills) and lambda cyhalothrin 5 EC at 0.0025 per cent (6.67 bugs/10 hills). The next effective treatments were thiamethoxam 25 WDG at 0.005 per cent (7.67 bugs/10 hills) which remained at par with dinotefuran 20 SG at 0.008 per cent (7.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (8.00 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (8.00 bugs/10 hills). The least effective treatments were buprofezin 25 SC at 0.04 per cent (8.67 bugs/10 hills) and benzpyrimoxan 10 SC at 0.02 per cent (8.33 bugs/10 hills) which were at par with each other. The maximum (11.33 bugs/10 hills) number of earhead bug population was found in control.

Observation of bug population three days after spraying of treatments exhibited significant differences among the treatments which ranged from 2.00 to 11.67 bugs per 10 hills. Emamectin benzoate 5 SG at 0.002 per cent recorded the lowest population of bugs (2.00 bugs/10 hills) followed by fipronil 5 SC at 0.015 per cent (3.33 bugs/10 hills) and lambda cyhalothrin 5 EC at 0.0025 per cent (4.00 bugs/10 hills). The next best treatments in the order of efficacy were thiamethoxam 25 WDG at 0.005 per cent (5.33 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (5.33 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (5.67 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (5.67 bugs/10 hills) which were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (7.67 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (7.67 bugs/10 hills) which were at par with each other. The maximum (11.67 bugs/10 hills) number of earhead bug population was found in control.

On the fifth day after spraying the earhead bug population ranged from 1.00 to 13.67 bugs per 10 hills. The results revealed that emamectin benzoate 5 SG at 0.002 per cent significantly recorded the lowest (1.00 bug/10 hills) population of bugs followed by fipronil 5 SC at 0.015 per cent (2.33 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (2.67 bugs/10 hills). The next best treatments in the order of efficacy were thiamethoxam 25 WDG at 0.005 per cent (4.00 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (4.33 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (4.67 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (4.67 bugs/10 hills) which were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (6.33 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (6.33 bugs/10 hills) which were at par with each other. The maximum (13.67 bugs/10 hills) number of earhead bug population was found in control.

Seven days after spraying, the earhead bug population ranged from 0.67 to 14.00 bugs per 10 hills in which emamectin benzoate 5 SG at 0.002 per cent significantly recorded the lowest (0.67 bug/10 hills) population of bugs followed by fipronil 5 SC at 0.015 per cent (2.00 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (2.33 bugs/10 hills). The next best treatments in the order of efficacy were thiamethoxam 25 WDG at 0.005 per cent (3.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (4.00 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (4.00 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (4.33 bugs/10 hills) which were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (5.67 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (5.33 bugs/10 hills) which were at par with each other. The maximum (14.00

bugs/10 hills) number of earhead bug population was found in control.

Ten days after spraying, the earhead bug population ranged from 1.67 to 15.00 bugs per 10 hills. The crop treated with emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (1.67 bugs/10 hills) bug population per 10 hills followed by fipronil 5 SC at 0.015 per cent (3.33 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (3.67 bugs/10 hills). The next best treatments in the order of effectiveness were thiamethoxam 25 WDG at 0.005 per cent (5.33 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (5.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (6.00 bugs/10 hills), flonicamid 50 WG at 0.015 per cent (6.00 bugs/10 hills) which were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (7.67 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (7.67 bugs/10 hills) which were at par with each other. The maximum (15.00 bugs/10 hills) number of earhead bug population was found in control.

Fourteen days after spraying the earhead bug population varied from 5.33 to 17.67 bugs per 10 hills, when the crop was treated with emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (5.33 bugs/10 hills) bug population per 10 hills which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (6.00 bugs/10 hills), fipronil 5 SC at 0.015 per cent (6.33 bugs/10 hills), thiamethoxam 25 WDG at 0.005 per cent (6.67 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (7.00 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (7.33 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (7.33 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (8.33 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (8.33 bugs/10 hills) which were at par with each other. The maximum (17.67 bugs/10 hills) number of earhead bug population was found in control.

Pooled data over different periods of observation after first spray was presented in Table 1 revealed that the earhead bug population varied from 2.61 to 13.89 bugs per 10 hills (Fig. 1). Emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (2.61 bugs/10 hills) bug population per 10 hills followed by fipronil 5 SC at 0.015 per cent (4.00 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (4.22 bugs/10 hills). The next effective treatments were thiamethoxam 25 WDG at 0.005 per cent (5.44 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (5.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (5.94 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (6.00 bugs/10 hills) which were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (7.33 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (7.33 bugs/10 hills) which were at par with each other. The maximum (13.89 bugs/10 hills) number of earhead bug population was found in control (T_{10}).

The order of effectiveness of various treatments against *L. acuta* after the first spray was found to be emamectin benzoate 5 SG (0.002%) > fipronil 5 SC (0.015%) ≥ lambda cyhalothrin 5 EC (0.0025%) > thiamethoxam 25 WDG (0.005%) ≥ dinotefuran 20 SG (0.008%) ≥ acetamiprid 20 SP (0.004%) ≥ flonicamid 50 WG (0.015%) > buprofezin 25 SC (0.04%) ≥ benzpyrimoxan 10 SC (0.02%) > control (water spray).

Second spray

The earhead bug population recorded in different treatments at different intervals was presented in Table 2. In the pre-treatment observations, the rice earhead bug nymphal and adult population ranged from 5.33 to 17.67 bugs per 10 hills.

One day after spraying the earhead bug population ranged from 2.00 to 18.00 bugs per 10 hills. The crop treated with emamectin benzoate 5 SG at 0.002 per cent recorded the lowest (2.00 bugs/10 hills) bug population per 10 hills which remained at par with fipronil 5 SC at 0.015 per cent (3.33 bugs/10 hills) and lambda cyhalothrin 5 EC at 0.0025 per cent (3.33 bugs/10 hills). The next effective treatments were thiamethoxam 25 WDG at 0.005 per cent (4.00 bugs/10 hills) which remained at par with dinotefuran 20 SG at 0.008 per cent (4.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (4.67 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (5.00 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (6.33 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (6.33 bugs/10 hills) which were at par with each other. The maximum (18.00 bugs/10 hills) number of earhead bug population was found in control.

Observation of bug population three days after spraying of treatments exhibited significant differences among the treatments which ranged from 1.00 to 19.67 bugs per 10 hills. Emamectin benzoate 5 SG at 0.002 per cent recorded the lowest population of bugs (1.00 bug/10 hills) followed by fipronil 5 SC at 0.015 per cent (2.00 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (2.33 bugs/10 hills). The next best treatments in the order of efficacy were thiamethoxam 25 WDG at 0.005 per cent (3.33 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (3.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (3.67 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (4.00 bugs/10 hills) which were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (5.00 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (5.00 bugs/10 hills) which were at par with each other. The maximum (19.67 bugs/10 hills) number of earhead bug population was found in control.

On fifth day after spraying the earhead bug population ranged from 0.67 to 21.33 bugs per 10 hills. The results revealed that emamectin benzoate 5 SG at 0.002 per cent significantly recorded the lowest (0.67 bug/10 hills) population of bugs followed by fipronil 5 SC at 0.015 per cent (1.67 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (1.67 bugs/10 hills). The next best treatments were thiamethoxam 25 WDG at 0.005 per cent (3.00 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (3.00 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (3.33 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (3.33 bugs/10 hills) thus the four treatments were at par with each other. The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (4.67 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (4.33 bugs/10 hills) which were at par with each other. The maximum (21.33 bugs/10 hills) number of earhead bug population was found in control.

Seven days after spraying the earhead bug population ranged from 1.00 to 18.67 bugs per 10 hills in which emamectin benzoate 5 SG at 0.002 per cent significantly recorded the lowest (1.00 bug/10 hills) population of bugs followed by fipronil 5 SC at 0.015 per cent (2.00 bugs/10

hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (2.33 bugs/10 hills). The next best treatments in the order of efficacy were dinotefuran 20 SG at 0.008 per cent (3.33 bugs/10 hills), thiamethoxam 25 WDG at 0.005 per cent (3.33 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (3.67 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (3.67 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (5.00 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (4.67 bugs/10 hills) which were at par with each other. The maximum (18.67 bugs/10 hills) number of earhead bug population was found in control.

Ten days after spraying the earhead bug population ranged from 1.33 to 14.00 bugs per 10 hills. The crop treated with emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (1.33 bugs/10 hills) bug population per 10 hills followed by fipronil 5 SC at 0.015 per cent (2.33 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (2.67 bugs/10 hills). The next best treatments were thiamethoxam 25 WDG at 0.005 per cent (3.67 bugs/10 hills) which was at par with dinotefuran 20 SG at 0.008 per cent (3.67 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (4.00 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (4.00 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (5.67 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (5.33 bugs/10 hills) which were at par with each other. The maximum (14.00 bugs/10 hills) number of earhead bug population was found in control.

Fourteen days after spraying the earhead bug population varied from 2.33 to 9.33 bugs per 10 hills, when the crop was treated with emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (2.33 bugs/10 hills) bug population per 10 hills which was at par with fipronil 5 SC at 0.015 per cent (3.00 bugs/10 hills) and lambda cyhalothrin 5 EC at 0.0025 per cent (3.33 bugs/10 hills). The next best treatments in the order of effectiveness were thiamethoxam 25 WDG at 0.005 per cent (3.67 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (4.33 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (4.33 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (5.00 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (5.67 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (5.67 bugs/10 hills) which were at par with each other. The maximum (9.33 bugs/10 hills) number of earhead bug population was found in control.

Pooled data over different periods of observation after second spray was presented in Table 2 revealed that the earhead bug population varied from 1.39 to 16.83 bugs per 10 hills (Fig. 2). Emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (1.39 bugs/10 hills) bug population per 10 hills followed by fipronil 5 SC at 0.015 per cent (2.39 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (2.61 bugs/10 hills). The next best treatments were thiamethoxam 25 WDG at 0.005 per cent (3.50 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (3.78 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (3.94 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (4.17 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (5.39 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (5.22 bugs/10 hills) which were at par with each other. The maximum (16.83 bugs/10 hills) number of earhead bug population was found in control (T10).

The order of effectiveness of various treatments against *L. acuta* was found to be emamectin benzoate 5 SG (0.002%) > fipronil 5 SC at (0.015%) ≥ lambda cyhalothrin 5 EC at (0.0025%) > thiamethoxam 25 WDG (0.005%) ≥ dinotefuran 20 SG (0.008%) ≥ acetamiprid 20 SP 0.004%) ≥ flonicamid 50 WG (0.015%) > buprofezin 25 SC (0.04%) ≥ benzpyrimoxan 10 SC (0.02%) > control (water spray).

Pooled over sprays

Overall investigations of pooled data after both sprays were presented in Table 3 revealed that the earhead bug population varied from 2.00 to 15.36 bugs per 10 hills in different treatments. Emamectin benzoate 5 SG at 0.002 per cent recorded significantly the lowest (2.00 bugs/10 hills) bug population per 10 hills followed by fipronil 5 SC at 0.015 per cent (3.19 bugs/10 hills) which was at par with lambda cyhalothrin 5 EC at 0.0025 per cent (3.42 bugs/10 hills). The next effective treatments are thiamethoxam 25 WDG at 0.005 per cent (4.47 bugs/10 hills), dinotefuran 20 SG at 0.008 per cent (4.72 bugs/10 hills), acetamiprid 20 SP at 0.004 per cent (4.94 bugs/10 hills) and flonicamid 50 WG at 0.015 per cent (5.08 bugs/10 hills). The least effective treatments were benzpyrimoxan 10 SC at 0.02 per cent (6.36 bugs/10 hills) and buprofezin 25 SC at 0.04 per cent (6.28 bugs/10 hills) which were at par with each other. The maximum (15.36 bugs/10 hills) number of earhead bug population was found in control (T₁₀) (Fig. 3).

The order of effectiveness of various treatments against *L. acuta* was found to be emamectin benzoate 5 SG (0.002%) > fipronil 5 SC (0.015%) ≥ lambda cyhalothrin 5 EC (0.0025%) > thiamethoxam 25 WDG (0.005%) ≥ dinotefuran 20 SG (0.008%) ≥ acetamiprid 20 SP (0.004%) ≥ flonicamid 50 WG (0.015%) > buprofezin 25 SC (0.04%) ≥ benzpyrimoxan 10 SC (0.02%) > control (water spray).

The above findings were more or less similar with Girish and Balikai (2015) [5] who reported that the significantly the least number of bugs were recorded in thiamethoxam 25 WG @ 0.3 g/l (0.75 bugs/hill) followed by malathion 5 per cent dust @ 20 kg/ha (1.13 bugs/hill). Ghoghari *et al.* (2019) [4] noted that the treatment emamectin benzoate 5 WSG 0.015% @ 3 gm/l was found to be the most effective in controlling rice gundhi bug and it was at par with the treatment of imidacloprid 17.8 SL 0.05% @ 3 ml/10 l. The next best treatment was novaluron 10 EC 0.01% @ 1.0 ml/l, rynaxypyr 20 SC 0.004 @ 0.2 ml/l and profenophos 50 EC 0.05% @ 1 ml/l in terms of reduction of rice gundhi bug populations in both sprays. Sharma *et al.* (2019) [6] noted that the plots treated with fipronil 5% + buprofezin 20% SC recorded the lowest number of rice earhead bug population (2.10 and 3.51 bugs/5 sweep nets) after first and second insecticidal sprays, respectively, followed by indoxacarb 10% + thiamethoxam 10% WG (2.47 and 4.25 bugs/5 sweep nets, respectively). Whereas, application of thiamethoxam 25% WG and buprofezin 25% singly SC were recorded as third and fourth best treatments, respectively. Karibasabba *et al.* (2021) found that the insecticides in the decreasing order of their efficacy were fipronil 5 SC @ 2.0 ml/l > thiamethoxam 25 WG @ 0.30 g/l > imidacloprid 17.8 @ 0.30 ml/l > acetamiprid 20 SP @ 0.30 g/l > lambda cyhalothrin 5 @ 1.00 ml/l > dinotefuran 20 @ 0.30 g/l > deltamethrin 2.8 EC @ 1.00 ml/l > flonicamid 50 WG @ 0.25 g/l > dimethoate 30 EC @ 2.00 ml/l. The differences might be due to different concentrations and different locations with varied weather conditions.

Reduction of earhead bug population

The reduction of earhead bug population over control varied from 47.20 to 81.20 per cent during the first spray (Table 1). The maximum (81.20%) reduction of earhead bug population over control was recorded in emamectin benzoate 5 SG (0.002%) followed by 71.20 per cent in fipronil 5 SC at (0.015%) and 69.60 per cent in lambda cyhalothrin 5 EC (0.0025%). The bug reduction over the control in the treatments thiamethoxam 25 WDG (0.005%), dinotefuran 20 SG (0.008%), acetamiprid 20 SP (0.004%), flonicamid 50 WG (0.015%), buprofezin 25 SC at (0.04%), and benzpyrimoxan 10 SC (0.02%) were 60.80, 59.20, 57.20, 56.80, 47.20 and 47.20 per cent, respectively.

Similarly, the reduction of earhead bug population over control varied from 67.99 to 91.75 per cent during the second spray (Table 2). The maximum (91.75%) reduction of earhead bug population over control was recorded in emamectin benzoate 5 SG (0.002%) followed by 85.81 per cent in fipronil 5 SC at (0.015%) and 84.49 per cent in lambda cyhalothrin 5 EC (0.0025%). The bug reduction over the control in the treatments thiamethoxam 25 WDG (0.005%), dinotefuran 20 SG (0.008%), acetamiprid 20 SP (0.004%), flonicamid 50 WG (0.015%), buprofezin 25 SC at (0.04%), and benzpyrimoxan 10 SC (0.02%) were 79.21, 77.56, 76.57, 75.25, 68.98 and 67.99 per cent, respectively.

As per the pooled over data in Table 3, the reduction of earhead bug population over control ranged from 58.59 to 86.98 per cent (Fig. 4). The maximum (86.98%) reduction of earhead bug population over control was recorded in emamectin benzoate 5 SG (0.002%) followed by 79.21 per cent in fipronil 5 SC (0.015%) and 77.76 per cent in lambda cyhalothrin 5 EC (0.0025%). The order of per cent reduction of earhead bug population over control of various treatments against *L. acuta* was emamectin benzoate 5 SG (86.98%) > fipronil 5 SC (79.21%) > lambda cyhalothrin 5 EC (77.76%) > thiamethoxam 25 WDG (70.89%) > dinotefuran 20 SG (69.26%) > acetamiprid 20 SP (67.81%) > flonicamid 50 WG (66.91%) > buprofezin 25 SC (59.13%) > benzpyrimoxan 10 SC (58.59%).

The above results were more or less in accordance with Karibasabba *et al.* (2021) who found that the highest per cent reduction of earhead bug population (78.78%) over control was recorded in fipronil 5 SC @ 2.0 ml/l and this was followed by thiamethoxam 25 WG @ 0.30 g/l (76.83%) and imidacloprid 17.8 SL @ 0.30 ml/l (62.09%). Likewise, the per cent reduction of earhead bug population over control in acetamiprid 20 SP @ 0.30 g/l, lambda cyhalothrin 5 EC @ 1.00 ml/l, dinotefuran 20 SG @ 0.30 g/l, deltamethrin 2.8 EC @ 1.00 ml/l, flonicamid 50 WG @ 0.25 g/l and dimethoate 30 EC @ 2.00 ml/l was 58.53, 45.91, 40.05, 36.53, 34.60 and 30.39 per cent, respectively. Shyamrao *et al.* (2020) [8] reported that the highest per cent reduction over control was recorded in thiamethoxam 25% WG (65.76%) followed by acetamiprid 20% SP (62.60%) during 2016-17, whereas the highest per cent reduction over control was recorded in thiamethoxam 25% WG (62.89%) followed by acetamiprid 20% SP (60.13%) during 2017-18. The differences might be due to the change in locality, weather conditions and concentration of the treatments.

Economic Estimation of Different Insecticides to Control Rice Earhead Bug Grain yield

All the insecticidal treated plots produced significantly higher grain yield than the control (Table 4 and Fig. 5). The

highest (5897 kg/ha) grain yield was obtained in the plot treated with emamectin benzoate 5 SG at 0.002 per cent followed by fipronil 5 SC at 0.015 per cent (5645 kg/ha) and lambda cyhalothrin 5 EC at 0.0025 per cent (5531 kg/ha). Minimum (4089 kg/ha) grain yield was obtained in the untreated plot (control). Whereas the treatment thiamethoxam 25 WDG at 0.005 per cent, dinotefuran 20 SG at 0.008 per cent, flonicamid 50 WG at 0.015 per cent, acetamiprid 20 SP at 0.004 per cent, buprofezin 25 SC at 0.04 per cent and benzpyrimoxan 10 SC at 0.02 per cent recorded 5294, 5176, 5095, 5089, 4743 and 4644 kg/ha rice grain yield, respectively.

Straw yield

Results of the experiment revealed that all the insecticidal treatments produced significantly higher straw yield than the control (Table 4 and Fig. 5). The highest (6977 kg/ha) straw yield was obtained in the plot treated with emamectin benzoate 5 SG at 0.002 per cent followed by fipronil 5 SC at 0.015 per cent (6802 kg/ha) and lambda cyhalothrin 5 EC at 0.0025 per cent (6750 kg/ha). Minimum (5209 kg/ha) straw yield was obtained in the untreated plot (control). Whereas the treatment thiamethoxam 25 WDG at 0.005 per cent, flonicamid 50 WG at 0.015 per cent, dinotefuran 20 SG at 0.008 per cent, acetamiprid 20 SP at 0.004 per cent, buprofezin 25 SC at 0.04 per cent and benzpyrimoxan 10 SC at 0.02 per cent recorded 6458, 6410, 6365, 6188, 5774 and 5698 kg/ha rice straw yield, respectively. The present research findings were more or less similar to Ghoghari *et al.* (2019) ^[4], who reported that the highest grain yield of rice was recorded in the treatment of emamectin benzoate 5 WG 0.015% @ 3 gm/litre (6109 kg/ha) and it was at par with the treatment of imidacloprid 17.8 SL 0.05% @ 3 ml/10 litres (5882 kg/ha). The next treatment was followed by novaluron 10 EC 0.01% @ 1.0 ml/litre (5711 kg/ha) and rynaxypyr 20 SC 0.004 @ 0.2 ml/litre (5607 kg/ha). As far as straw yield considered, the treatment of emamectin benzoate 5 WSG 0.015% @ 3 gm/litre (7212 kg/ha) was recorded highest straw yield and it was at par with the treatment of imidacloprid 17.8 SL 0.05% @ 3 ml/10 litres (6998 kg/ha). Karibasabba *et al.* (2021) found that the rice grain yield was significantly varied from 39.56 to 59.33 q/ha. Among the different treatments, significantly highest grain yield was recorded in fipronil 5 SC @ 2 ml/l of 59.33 q/ha and this was followed by thiamethoxam 25 WG @ 0.30 g/l, imidacloprid 17.8 SL @ 0.30 ml/l and acetamiprid 20 SP @ 0.30 g/l which recorded 57.33, 54.67 and 53.44 q/ha, respectively and were at par with each other. The treatment, lambda cyhalothrin 5 EC @ 1.00 ml/l recorded 51.44 q/ha was at par with dinotefuran 20 SG @ 0.30 g/l recorded 44.89 q/ha. Whereas, flonicamid 50 WG @ 0.25 g/l recorded 43.67 q/ha and was at par with deltamethrin 2.8 EC @ 1.00 ml/l (41.33 q/ha), which was the next best treatment in recording grain yield. The treatment, dimethoate 30 EC @ 2.00 ml/l recorded 41.11 q/ha. However, significantly the lowest yield of 39.56 q/ha was recorded in control. Plant biomass yield did not vary significantly among different treatments in the present study. However, the highest biomass yield of 64.55 q/ha was recorded in fipronil 5 SC @ 2 ml/l followed by acetamiprid 20 SP @ 0.30 g/l and deltamethrin 2.8 EC @ 1.00 ml/l which recorded 62.00 and 60.33 q/ha. The lowest biomass yield (54.11 q/ha) was recorded in control. Differences might be due to different

concentrations of treatments and varied climatic conditions in different locations.

Incremental cost benefit ratio

Economics of various treatments was worked out considering prevailing market price of rice grain and straw. The cost of insecticidal treatments included labour charges. The yield increase over control, realization over control and incremental cost benefit ratio (ICBR) were also worked out for all the treatments and presented in Table 5 and Fig. 7. The total cost of treatment was minimum (1880 ₹/ha) in acetamiprid 20 SP at 0.004 per cent followed by lambda cyhalothrin 5 EC at 0.0025 per cent (1920/ha), thiamethoxam 25 WDG at 0.005 per cent (2058 ₹/ha), dinotefuran 20 SG at 0.008 per cent (2180 ₹/ha), emamectin benzoate 5 SG at 0.002 per cent (2190 ₹/ha), benzpyrimoxan 10 SC at 0.02 per cent (3680 ₹/ha), buprofezin 25 SC at 0.04 per cent (3909 ₹/ha) and flonicamid 50 WG at 0.015 per cent (5110 ₹/ha). The total cost of treatment was maximum (6520 ₹/ha) in fipronil 5 SC at 0.015 per cent.

All the insecticidal treated plots produced significant grain yield increase over control (Table 5 and Fig. 6). The highest (1808 kg/ha) grain yield increase over control was obtained in the plot treated with emamectin benzoate 5 SG at 0.002 per cent followed by fipronil 5 SC at 0.015 per cent (1556 kg/ha) and lambda cyhalothrin 5 EC at 0.0025 per cent (1442 kg/ha). The lowest (555 kg/ha) grain yield increase over control was obtained in the plot treated with benzpyrimoxan 10 SC at 0.02 per cent. Whereas the treatment thiamethoxam 25 WDG at 0.005 per cent, dinotefuran 20 SG at 0.008 per cent, flonicamid 50 WG at 0.015 per cent, acetamiprid 20 SP at 0.004 per cent and buprofezin 25 SC at 0.04 per cent recorded 1205, 1087, 1006, 1000 and 654 kg/ha rice grain yield increase over control, respectively.

Results of the experiment revealed that all the insecticidal treatments produced significant straw yield increase over control. The highest (1768 kg/ha) straw yield increase over control was obtained in the plot treated with emamectin benzoate 5 SG at 0.002 per cent followed by fipronil 5 SC at 0.015 per cent (1593 kg/ha) and lambda cyhalothrin 5 EC at 0.0025 per cent (1541 kg/ha). The lowest (489 kg/ha) straw yield increase over control was obtained in the plot treated with benzpyrimoxan 10 SC at 0.02 per cent. Whereas the treatment thiamethoxam 25 WDG at 0.005 per cent, flonicamid 50 WG at 0.015 per cent, dinotefuran 20 SG at 0.008 per cent, acetamiprid 20 SP at 0.004 per cent and buprofezin 25 SC at 0.04 per cent recorded 1249, 1201, 1156, 979 and 565 kg/ha rice straw yield increase over control, respectively.

The data presented in the Table 5 indicated that maximum realization over control was obtained in emamectin benzoate 5 SG at 0.002 per cent (48309 ₹/ha) treatment followed by fipronil 5 SC at 0.015 per cent (41932 ₹/ha) and lambda cyhalothrin 5 EC at 0.0025 per cent (39184 ₹/ha). In treatment of thiamethoxam 25 WDG at 0.005 per cent, dinotefuran 20 SG at 0.008 per cent, flonicamid 50 WG at 0.015 per cent, acetamiprid 20 SP at 0.004 per cent and buprofezin 25 SC at 0.04 per cent the net realization over control was 32550 ₹/ha, 29509 ₹/ha, 27966 ₹/ha, 26725 ₹/ha and 17102 ₹/ha, respectively. The lowest (14561 ₹/ha) realization over control was obtained in treatment with benzpyrimoxan 10 SC at 0.02 per cent.

The ICBR of emamectin benzoate 5 SG at 0.002 per cent was found to be the highest (1:22.06) among all the treatments followed by lambda cyhalothrin 5 EC at 0.0025 per cent (1:20.41). Whereas, the lowest (1:3.96) ICBR was found in the treatment of benzpyrimoxan 10 SC at 0.02 per cent. The treatment with, thiamethoxam 25 WDG at 0.005

per cent, acetamiprid 20 SP at 0.004 per cent, dinotefuran 20 SG at 0.008 per cent, fipronil 5 SC at 0.015 per cent, flonicamid 50 WG at 0.015 per cent and buprofezin 25 SC at 0.04 per cent were in the order of 1:15.82, 1:14.22, 1:13.54, 1:6.43, 1:5.47 and 1:4.38 ICBR, respectively (Fig. 7).

Table 1: Efficacy of different insecticides against rice earhead bug, *L. acuta* (First spray)

Tr. No.	Treatments	Conc. (%)	Average number of earhead bugs/10 hills								Reduction over control (%)	Rank
			BS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled		
T ₁	Acetamiprid 20 SP	0.004	11.00 (3.38)	8.00 (2.88) ^c	5.67 (2.48) ^{cd}	4.67 (2.27) ^{de}	4.00 (2.11) ^{de}	6.00 (2.54) ^{de}	7.33 (2.79) ^{ab}	5.94 (2.52) ^c	57.20	6
T ₂	Benzpyrimoxan 10 SC	0.02	10.33 (3.28)	8.33 (2.96) ^{cd}	7.67 (2.85) ^d	6.33 (2.61) ^f	5.67 (2.48) ^f	7.67 (2.85) ^e	8.33 (2.96) ^b	7.33 (2.79) ^d	47.20	9
T ₃	Buprofezin 25 SC	0.04	10.67 (3.32)	8.67 (3.02) ^{cd}	7.67 (2.85) ^d	6.33 (2.61) ^{ef}	5.33 (2.41) ^{ef}	7.67 (2.86) ^e	8.33 (2.96) ^b	7.33 (2.79) ^d	47.20	8
T ₄	Emamectin benzoate 5 SG	0.002	11.00 (3.38)	5.00 (2.35) ^a	2.00 (1.56) ^a	1.00 (1.22) ^a	0.67 (1.05) ^a	1.67 (1.46) ^a	5.33 (2.41) ^a	2.61 (1.67) ^a	81.20	1
T ₅	Dinotefuran 20 SG	0.008	10.33 (3.29)	7.67 (2.86) ^{ab}	5.33 (2.41) ^c	4.33 (2.20) ^d	4.00 (2.12) ^{de}	5.67 (2.48) ^{de}	7.00 (2.74) ^{ab}	5.67 (2.47) ^c	59.20	5
T ₆	Fipronil 5 SC	0.015	10.67 (3.34)	6.67 (2.67) ^{ab}	3.33 (1.95) ^{ab}	2.33 (1.66) ^{ab}	2.00 (1.58) ^b	3.33 (1.95) ^b	6.33 (2.61) ^{ab}	4.00 (2.07) ^b	71.20	2
T ₇	Flonicamid 50 WG	0.015	11.00 (3.38)	8.00 (2.92) ^c	5.67 (2.48) ^{cd}	4.67 (2.27) ^{de}	4.33 (2.20) ^{def}	6.00 (2.55) ^{de}	7.33 (2.80) ^{ab}	6.00 (2.54) ^c	56.80	7
T ₈	Lambda cyhalothrin 5 EC	0.0025	10.33 (3.29)	6.67 (2.67) ^{ab}	4.00 (2.11) ^{bc}	2.67 (1.77) ^{bc}	2.33 (1.68) ^{bc}	3.67 (2.03) ^{bc}	6.00 (2.54) ^{ab}	4.22 (2.14) ^b	69.60	3
T ₉	Thiamethoxam 25 WDG	0.005	10.00 (3.22)	7.67 (2.85) ^{ab}	5.33 (2.41) ^c	4.00 (2.12) ^{cd}	3.67 (2.04) ^{cd}	5.33 (2.41) ^{cd}	6.67 (2.67) ^{ab}	5.44 (2.42) ^c	60.80	4
T ₁₀	Control (water spray)	—	11.00 (3.38)	11.33 (3.43) ^d	11.67 (3.48) ^e	13.67 (3.76) ^g	14.00 (3.80) ^g	15.00 (3.93) ^f	17.67 (4.26) ^c	13.89 (3.78) ^e	—	—
SEm ± Treatment (T)			—	0.17	0.16	0.13	0.11	0.10	0.12	0.05	—	—
P			—	—	—	—	—	—	—	0.04	—	—
T x P			—	—	—	—	—	—	—	0.13	—	—
CD at 5 (%) Treatment (T)			—	N.S.	0.48	0.37	0.32	0.31	0.36	0.41	—	—
P			—	—	—	—	—	—	—	0.12	—	—
T x P			—	—	—	—	—	—	—	0.35	—	—
CV (%)			—	9.10	9.69	8.85	8.37	8.30	8.39	8.77	—	—

Note: 1. BS: Before spray 2. DAS: Days after spray 3. Figures in the parentheses are square root transformed ($\sqrt{(x + 0.5)}$) values and those outside are original values

Table 2: Efficacy of different insecticides against rice earhead bug, *L. acuta* (Second spray)

Tr. No.	Treatments	Conc. (%)	Average number of earhead bugs/10 hills								Reduction over control (%)	Rank
			BS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled		
T ₁	Acetamiprid 20 SP	0.004	7.33 (2.79)	4.67 (2.26) ^{bc}	3.67 (2.04) ^{de}	3.33 (1.95) ^{cd}	3.67 (2.03) ^{de}	4.00 (2.11) ^{cd}	4.33 (2.20) ^{bcd}	3.94 (2.10) ^{cd}	76.57	6
T ₂	Benzpyrimoxan 10 SC	0.02	8.33 (2.96)	6.33 (2.61) ^c	5.00 (2.34) ^e	4.67 (2.27) ^e	5.00 (2.34) ^e	5.67 (2.48) ^e	5.67 (2.48) ^d	5.39 (2.42) ^e	67.99	9
T ₃	Buprofezin 25 SC	0.04	8.33 (2.96)	6.33 (2.61) ^c	5.00 (2.34) ^e	4.33 (2.20) ^{de}	4.67 (2.26) ^{de}	5.33 (2.41) ^{de}	5.67 (2.48) ^d	5.22 (2.38) ^e	68.98	8
T ₄	Emamectin benzoate 5 SG	0.002	5.33 (2.41)	2.00 (1.56) ^a	1.00 (1.22) ^a	0.67 (1.05) ^a	1.00 (1.22) ^a	1.33 (1.34) ^a	2.33 (1.68) ^a	1.39 (1.34) ^a	91.75	1
T ₅	Dinotefuran 20 SG	0.008	7.00 (2.74)	4.67 (2.26) ^{bc}	3.67 (2.04) ^{de}	3.00 (1.87) ^c	3.33 (1.94) ^{cd}	3.67 (2.04) ^c	4.33 (2.19) ^{bcd}	3.78 (2.06) ^{cd}	77.56	5
T ₆	Fipronil 5 SC	0.015	6.33 (2.61)	3.33 (1.95) ^{ab}	2.00 (1.58) ^{ab}	1.67 (1.46) ^b	2.00 (1.58) ^{ab}	2.33 (1.68) ^{ab}	3.00 (1.86) ^{ab}	2.39 (1.68) ^b	85.81	2
T ₇	Flonicamid 50 WG	0.015	7.33 (2.80)	5.00 (2.33) ^{bc}	4.00 (2.11) ^{de}	3.33 (1.95) ^{cd}	3.67 (2.04) ^{de}	4.00 (2.11) ^{cd}	5.00 (2.35) ^{cd}	4.17 (2.15) ^d	75.25	7
T ₈	Lambda cyhalothrin 5 EC	0.0025	6.00 (2.54)	3.33 (1.95) ^{ab}	2.33 (1.68) ^{bc}	1.67 (1.46) ^b	2.33 (1.68) ^{bc}	2.67 (1.77) ^{bc}	3.33 (1.95) ^{ab}	2.61 (1.75) ^b	84.49	3
T ₉	Thiamethoxam 25 WDG	0.005	6.67 (2.67)	4.00 (2.12) ^b	3.33 (1.95) ^{cd}	3.00 (1.86) ^c	3.33 (1.95) ^{cd}	3.67 (2.04) ^c	3.67 (2.04) ^{bc}	3.50 (1.99) ^c	79.21	4
T ₁₀	Control (water spray)	—	17.67 (4.26)	18.00 (4.30) ^f	19.67 (4.48) ^f	21.33 (4.67) ^f	18.67 (4.38) ^f	14.00 (3.81) ^f	9.33 (3.13) ^e	16.83 (4.13) ^f	—	—
SEm ± Treatment (T)			—	0.14	0.13	0.11	0.10	0.11	0.11	0.05	—	—
P			—	—	—	—	—	—	—	0.04	—	—
T x P			—	—	—	—	—	—	—	0.11	—	—
CD at 5 (%) Treatment (T)			—	0.41	0.39	0.32	0.29	0.32	0.31	0.13	—	—
P			—	—	—	—	—	—	—	0.10	—	—
T x P			—	—	—	—	—	—	—	0.31	—	—
CV (%)			—	8.31	9.54	8.53	8.17	8.65	8.39	8.71	—	—

Note: 1. BS: Before spray, 2. DAS: Days after spray, 3. Figures in the parentheses are square root transformed ($\sqrt{(x + 0.5)}$) values and those outside are original values

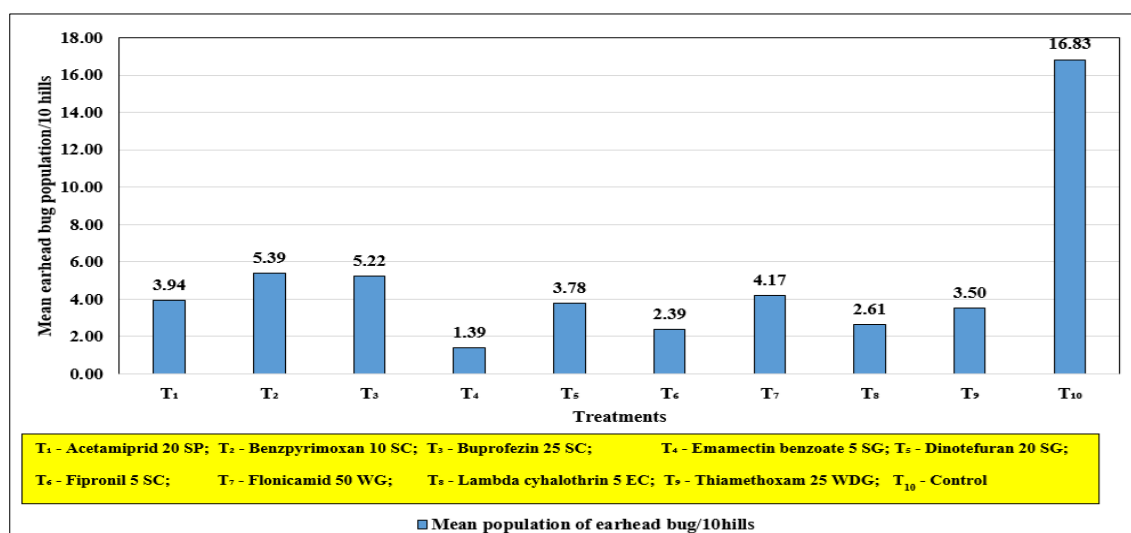


Fig 2: Mean population of rice earhead bug, *L. acuta* (After second spray)

Table 3: Efficacy of different insecticides against rice earhead bug, *L. acuta* (Pooled of first and second sprays)

Tr. No.	Treatments	Concentration (%)	Average number of earhead bugs/10 hills			Reduction of bug population over control (%)	Rank
			First spray	Second spray	Pooled over sprays		
T ₁	Acetamiprid 20 SP	0.004	5.94 (2.52) ^c	3.94 (2.10) ^{cd}	4.94 (2.31) ^d	67.81	6
T ₂	Benzpyrimoxan 10 SC	0.02	7.33 (2.79) ^d	5.39 (2.42) ^e	6.36 (2.60) ^e	58.59	9
T ₃	Buprofezin 25 SC	0.04	7.33 (2.79) ^d	5.22 (2.38) ^e	6.28 (2.59) ^e	59.13	8
T ₄	Emamectin benzoate 5 SG	0.002	2.61 (1.67) ^a	1.39 (1.34) ^a	2.00 (1.51) ^a	86.98	1
T ₅	Dinotefuran 20 SG	0.008	5.67 (2.47) ^c	3.78 (2.06) ^{cd}	4.72 (2.26) ^{cd}	69.26	5
T ₆	Fipronil 5 SC	0.015	4.00 (2.07) ^b	2.39 (1.68) ^b	3.19 (1.88) ^b	79.21	2
T ₇	Flonicamid 50 WG	0.015	6.00 (2.54) ^c	4.17 (2.15) ^d	5.08 (2.34) ^d	66.91	7
T ₈	Lambda cyhalothrin 5 EC	0.0025	4.22 (2.14) ^b	2.61 (1.75) ^b	3.42 (1.94) ^b	77.76	3
T ₉	Thiamethoxam 25 WDG	0.005	5.44 (2.42) ^c	3.50 (1.99) ^c	4.47 (2.21) ^c	70.89	4
T ₁₀	Control (water spray)	—	13.89 (3.78) ^e	16.83 (4.13) ^f	15.36 (3.95) ^f	—	—
SEm ± Treatment (T)	—	—	0.05	0.05	0.03	—	—
Season (S)	—	—	—	—	0.01	—	—
Period (P)	—	—	0.04	0.04	0.03	—	—
T x S	—	—	—	—	0.04	—	—
T x P	—	—	0.13	0.11	0.08	—	—
S x P	—	—	—	—	0.08	—	—
T x S x P	—	—	—	—	0.12	—	—
CD at 5 (%) Treatment (T)	—	—	0.14	0.13	0.10	—	—
Season (S)	—	—	—	—	0.04	—	—
Period (P)	—	—	0.12	0.10	0.07	—	—
T x S	—	—	—	—	0.12	—	—
T x P	—	—	0.35	0.31	0.24	—	—
S x P	—	—	—	—	0.24	—	—
T x S x P	—	—	—	—	0.33	—	—
CV (%)	—	—	8.77	8.71	8.21	—	—

Note: 1. BS: Before spray 2. DAS: Days after spray 3. Figures in the parentheses are square root transformed ($\sqrt{x + 0.5}$) values and those outside are original values

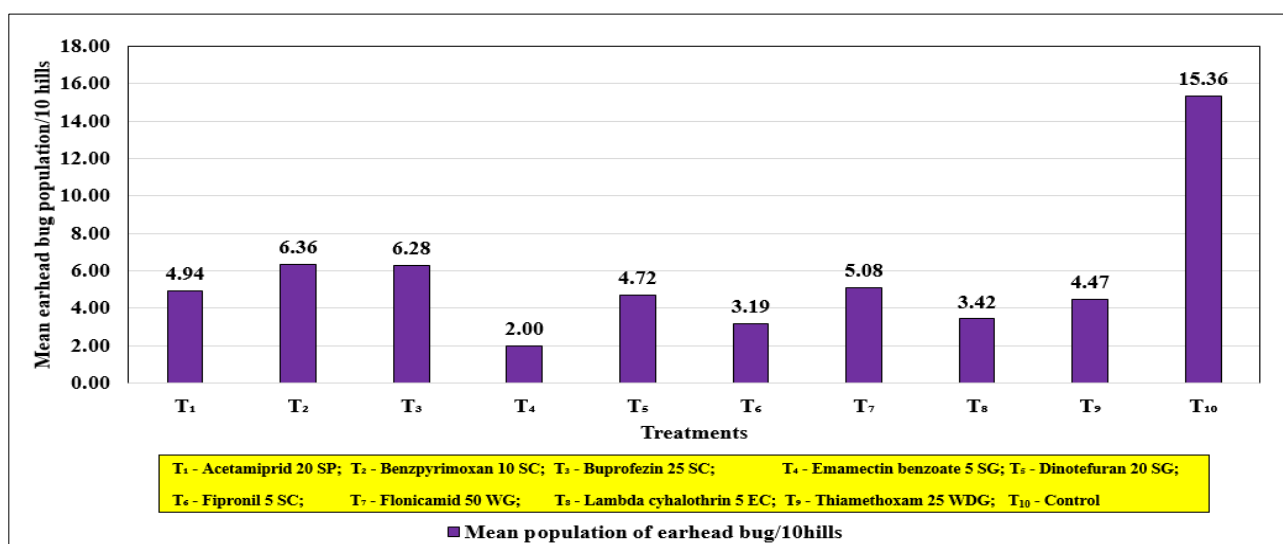
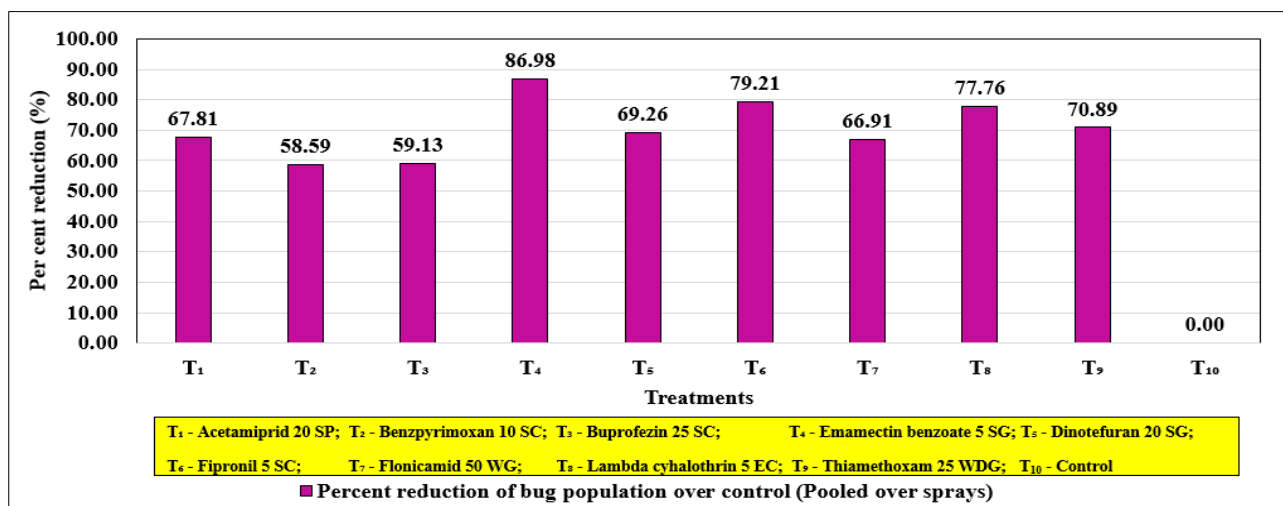
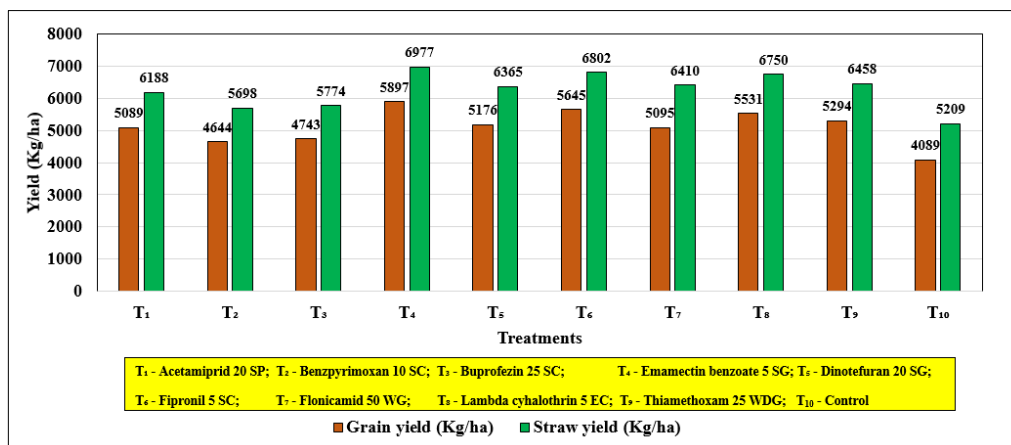
**Fig 3:** Mean population of rice earhead bug, *L. acuta* (Pooled over sprays)**Fig 4:** Per cent reduction of rice earhead bug, *L. acuta* population (Pooled over sprays)

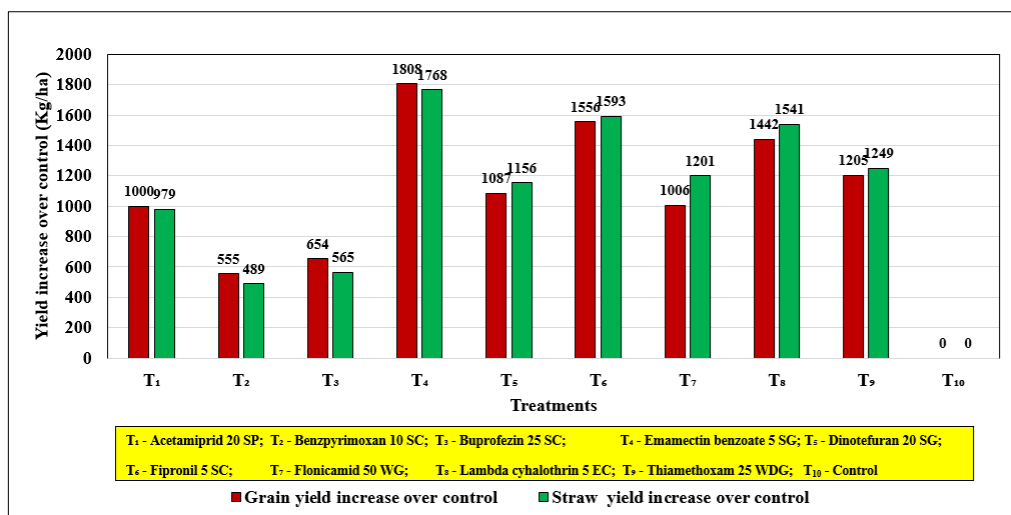
Table 4: Grain and straw yields of rice in different insecticidal treatments

Tr. No.	Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)
T ₁	Acetamiprid 20 SP (0.004%)	5089 ^{abc}	6188
T ₂	Benzpyrimoxan 10 SC (0.02%)	4644 ^{cd}	5698
T ₃	Buprofezin 25 SC (0.04%)	4743 ^{bcd}	5774
T ₄	Emamectin benzoate 5 SG (0.002%)	5897 ^a	6977
T ₅	Dinotefuran 20 SG (0.008%)	5176 ^{abc}	6365
T ₆	Fipronil 5 SC (0.015%)	5645 ^{ab}	6802
T ₇	Flonicamid 50 WG (0.015%)	5095 ^{abc}	6410
T ₈	Lambda cyhalothrin 5 EC (0.0025%)	5531 ^{abc}	6750
T ₉	Thiamethoxam 25 WDG (0.005%)	5294 ^{abc}	6458
T ₁₀	Control (water spray)	4089 ^d	5209
	S.Em ±	281.17	357.11
	CD at 5%	841.88	NS
	CV	9.51	9.88

**Fig 5:** Grain and straw yields of rice in different insecticidal treatments applied against rice earhead bug, *L. acuta***Table 5:** Economics (ICBR) of different insecticides evaluated against rice earhead bug, *L. acuta*.

Tr. No.	Treatment	Dose / 10 lit	Quantity of insecticides required for two sprays (ml or g/ha)	Cost of insecticide (₹/ha)	Labour cost (₹/ha)	Treatment cost (₹/ha)	Yield (kg/ha)		Yield increase over control (kg/ha)		Realization over control (₹/ha)	ICBR	Rank
							Grain	Straw	Grain	straw			
T ₁	Acetamiprid 20 SP (0.004%)	2 g	200	400	1480	1880	5089	6188	1000	979	26725	14.22	4
T ₂	Benzpyrimoxan 10 SC (0.02%)	20 ml	2000	2200	1480	3680	4644	5698	555	489	14561	3.96	9
T ₃	Buprofezin 25 SC (0.04%)	16 ml	1600	2429	1480	3909	4743	5774	654	565	17102	4.38	8
T ₄	Emamectin benzoate 5 SG (0.002%)	4 g	400	710	1480	2190	5897	6977	1808	1768	48309	22.06	1
T ₅	Dinotefuran 20 SG (0.008%)	4 g	400	700	1480	2180	5176	6365	1087	1156	29509	13.54	5
T ₆	Fipronil 5 SC (0.015%)	30 ml	3000	5040	1480	6520	5645	6802	1556	1593	41932	6.43	6
T ₇	Flonicamid 50 WG (0.015%)	3 g	300	3630	1480	5110	5095	6410	1006	1201	27966	5.47	7
T ₈	Lambda cyhalothrin 5 EC (0.0025%)	5 ml	500	440	1480	1920	5531	6750	1442	1541	39184	20.41	2
T ₉	Thiamethoxam 25 WDG (0.005%)	2 g	200	578	1480	2058	5294	6458	1205	1249	32550	15.82	3
T ₁₀	Control (water spray)	—	0	0	1480	1480	4089	5209	—	—	—	—	—

Price of insecticides: See appendix XI; 1: MSP of paddy grain per kg is Rs. 21.83 (MSP by CACP, Govt. of India); 2: Price of paddy straw per kg is Rs.5; 3: Charge of one labour for spraying is Rs. 370; 4: Number of sprays are 2; 5: Water required for one spray is 500 litres; 6: No of labour needed for one spraying per one hectare is 2.

**Fig 6:** Grain and straw yield increase over control in different insecticidal treatments applied against rice earhead bug, *L. acuta*

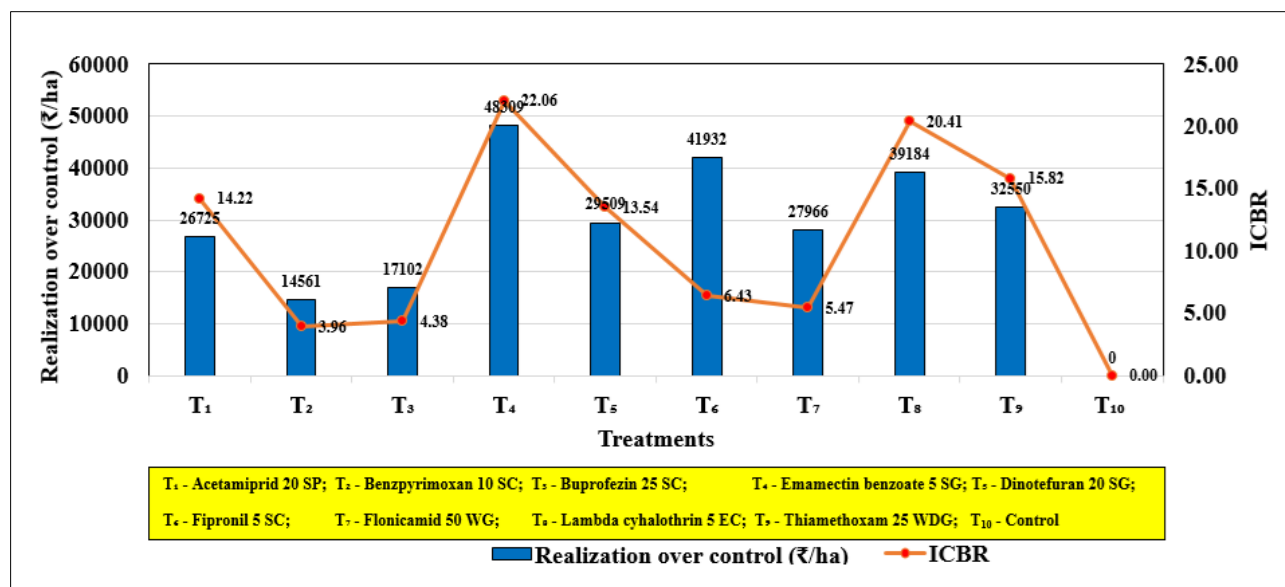


Fig 7: Economics (ICBR) of different insecticidal treatments applied against rice earhead bug, *L. acuta*

Conclusion

The order of effectiveness of various treatments against *L. acuta* was found to be emamectin benzoate 5 SG > fipronil 5 SC ≥ lambda cyhalothrin 5 EC > thiamethoxam 25 WDG ≥ dinotefuran 20 SG ≥ acetamiprid 20 SP ≥ flonicamid 50 WG > buprofezin 25 SC ≥ benzpyrimoxan 10 SC > control (water spray). The highest incremental cost-benefit ratio (ICBR) was found in emamectin benzoate 5 SG at 0.002 per cent followed by lambda cyhalothrin 5 EC at 0.0025 per cent and thiamethoxam 25 WDG at 0.005 per cent. Hence these insecticides can be evaluated further and used commercially to control rice ear head bug.

Disclaimer (Artificial intelligence)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript.

Acknowledgement

Authors are grateful to the Department of Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari and Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat, India, 396 450.

Competing interests

Authors have declared that no competing interests exist.

References

1. United States Department of Agriculture. World agricultural production, September 2024. Washington (DC): USDA Foreign Agricultural Service; 2024.
2. United States Department of Agriculture Foreign Agricultural Service. India: rice area, yield and production (2024/25) [Internet]. Washington (DC): USDA-FAS; 2025 [cited 2026 Jul 23]. Available from: <https://ipad.fas.usda.gov/countrysummary/Default.aspx?crop=Rice&id=IN>
3. Directorate of Agriculture, Government of Gujarat. Agricultural statistics at a glance, Gujarat State. Gujarat: Government of Gujarat; 2022.
4. Ghoghari PD, Kavadi NK, Patil VA. Evaluation of insecticides against rice gundhi bug, *Leptocoris acuta*

(Thunberg) in South Gujarat. Journal of Entomology and Zoology Studies. 2019;7(4):1411–1417.

5. Girish VP, Balikai RA. Efficacy of botanicals, biopesticides and insecticide molecules against ear head bug, *Leptocoris acuta* (Thunberg) in paddy and their effect on yield. Journal of Experimental Zoology India. 2015;18(2):943–946.
6. Sharma KR, Raju SVS, Singh KN, Roshan DR. Effects of environmental factors on population dynamics of rice earhead bug and their management with newer insecticide combinations and sole insecticide. Bangladesh Journal of Botany. 2019;48(4):973–979.
7. Karibasappa G, Kumar LV, Basavaraju BS, Chandrappa, Kirankumar N. Bio-efficacy of new insecticides against paddy earhead bug, *Leptocoris oratorius* (Fabricius). Journal of Rice Research. 2021;14(2):45–51.
8. Shyamrao ID, Raghuraman M, Kumar A, Gajbhiye R. Population dynamics and management of gundhi bug, *Leptocoris acuta* (Thunberg) in rice ecosystem. Journal of Experimental Zoology India. 2020;23(2):1829–1835.