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Evaluation of Insecticide Strategies for Gall Midge and Yellow Stem Borer Management in Rice in Coastal Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Efficient pest control in rice cultivation plays a vital role in sustaining crop yields and minimizing financial losses in agriculture. In recent times, delayed transplanting has led to a gradual increase in gall midge infestations, particularly in specific areas of Andhra Pradesh. Therefore, it is essential to assess the performance of various insecticides for managing gall midge outbreaks in rice crops. This research was conducted during the Kharif 2023 and Rabi 2023-24 seasons at the Agricultural Research Station in Ragolu, situated in the North Coastal Zone of Andhra Pradesh, with the objective of examining the efficacy of selected insecticides and their combinations against major insect pests in rice. The study comprised nine treatments viz., T1 – Carbofuran 3% CG at 10

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kg/acre, T2 – Fipronil 0.3 GR at 10 kg/acre, T3 – Chlorpyriphos granules at 4 kg/acre, T4 – Chlorpyriphos 20 EC at 2.5 ml/litre, T5 Fipronil 5 SC at 2 ml/litre, T6 – Chlorantraniliprole 0.4 GR at 4 kg/acre, T7 – Chlorantraniliprole 18.5% SC at 0.3 ml/litre, T8 – Cartap hydrochloride 4% GR at 7.5 kg/acre, T9 – Untreated control.

The goal was to optimize insecticide usage, avoiding redundant soil applications and foliar sprays, thereby reducing pest management costs for farmers. Among the tested options, fipronil 0.3 GR (T2) applied in the main field proved to be the most effective against gall midge, showing a significant reduction in silver shoot incidence when compared to other treatments. It was followed by carbofuran 3% CG (T1) and fipronil 5 SC (T5). For yellow stem borer control, chlorantraniliprole 0.4 GR (T6) showed the best performance in minimizing the occurrence of dead hearts and white ear symptoms, with chlorantraniliprole (T7) and cartap hydrochloride (T8) also showing positive effects. All treated plots recorded higher grain yields compared to the untreated control, with the highest yield observed in plots treated with fipronil 0.3 GR (T2) at 10 and 30 days after transplanting, followed by carbofuran application.

Keywords: Gallmidge; insectidies; rice; yellow stemborer; yield.

1. INTRODUCTION

Rice ranks among the top three staple cereal crops globally and plays a pivotal role in ensuring food security now and in the future. It serves as the primary food source for nearly 50% of the world's population (Satyanarayana et al*.,* 2024). In Asia alone, more than two billion people depend on rice for up to 80% of their daily caloric intake, as it provides approximately 80% carbohydrates, 7–8% protein, 3% fat and 3% fiber (Chaudhari et al*.,* 2018). However, increasing production costs and competition from alternative crops are reducing the land area available for rice cultivation, limiting its overall output (Bandumula, 2018).

Global food production has seen an 18% surge due to the development of adaptable, high-yielding rice varieties that are resistant to pests and diseases, along with advancements in breeding technologies and biotechnology applications (Duppala et al*.,* 2023). To meet the rising future demand for rice, scientists have launched numerous programs focusing on crop production, genetic improvement and protection strategies, also addressing biotic and abiotic stress factors (Fahad et al*.,* 2019).

Presently, rice production is facing severe challenges due to climate change and pest infestations. Pest and disease outbreaks alone are responsible for yield reductions ranging between 24% and 41% across Asia (Jena et al*.,* 2018). Insect damage is a significant constraint to productivity. Environmental changes such as rising global temperatures, irregular rainfall, elevated CO_2 levels and extreme weather events influence pest development, behavior, and interactions with rice plants and natural enemies. These factors collectively impact yield outcomes. Climate-related pest outbreaks are becoming more frequent, adversely affecting production and food availability, thus threatening food security (Subedi et al*.,* 2023).

Rice serves as a host to a wide range of insect pests throughout its lifecycle from sowing to harvest. Although more than 800 insect species have been associated with rice, only about 20 species in tropical Asia are considered economically significant (Sharma et al*.,* 2017). Among these, pests like stem borers, gall midges, leafhoppers and planthoppers have become major threats to rice farming (Shivappa et al*.,* 2023). Gall midge is widely prevalent across India's rice-growing states, except in Western Uttar Pradesh, Punjab, Uttarakhand, Himachal Pradesh, Haryana and Jammu & Kashmir (Bentur et al*.,* 2016). The infestation leads to the formation of characteristic 'silver shoots' or 'onion shoots,' which are hollow, pale, cylindrical structures with reduced leaf blades. This pest has been a persistent problem in coastal rice-growing regions since the early 1900s, and it is now recognized as a major threat. Yield losses attributed to gall midge in coastal, southern, and central India vary from 10% to 100%. In India alone, the annual economic loss due to this pest is estimated at around USD 80 million (Kumar et al*.,* 2024).

Granular insecticides are solid formulations applied directly to the soil are widely used in rice pest control. These act either through direct contact or ingestion by the pests (Meena et al*.,* 2024). However, precision in application is critical, as overuse can result in harmful residues that negatively impact the soil, non-target organisms, and the broader environment. Correct application timing and methods are essential to achieve effective control while minimizing ecological damage (Zhao et al*.,* 2021). Although chemical insecticides remain a key strategy for pest control in rice, many traditional products have shown limited success (Hurali et al*.,* 2023). As a result, new-generation insecticides are under development to improve pest management and reduce environmental impact. In Andhra Pradesh, gall midge outbreaks have been increasing due to delayed transplanting practices in certain areas (Rao et al*.,* 2020). This ongoing challenge underscores the need for assessing the effectiveness of both traditional and recently developed granular insecticides. Thus, the current study is focused on evaluating the performance of different insecticidal treatments, with the aim of improving control of key rice pests, especially gall midge.

2. MATERIALS AND METHODS

The research was carried out at the Agricultural Research Station, Ragolu, situated at 83.240° E longitude and 18.240° N latitude, with an altitude of 27 meters above mean sea level. The site, representative of the North Coastal Zone of Andhra Pradesh, typically receives an annual rainfall of about 1111 mm over 57 rainy days. The experimental design included nine treatments viz., T1. Carbofuran 3% CG @ 10 kg /acre, T2. Fipronil granules 0.3 GR @ 10 kg/acre, T3. Chlorpyriphos granules @ 4 kg/acre, T4. Chlorpyriphos 20 EC @ 2.5 ml/lit, T5. Fipronil 5 SC @ 2 ml/lit, T6. Chlorantraniliprole granules 0.4 GR @ 4 kg/acre, T7. Chlorantraniliprole 18.5 % SC @0.3ml/lit, T8. Cartap hydrochloride 4% GR 7.5 Kg/acre and T9. Untreated control.

The planting schedule was aligned with the anticipated peak incidence of insect pests to ensure maximum exposure for treatment assessment. The experiment was designed as a randomized block design (RBD) using the rice variety MTU 1318, and conducted over two crop seasons, Kharif 2023 and Rabi 2023–24. Each of the nine treatments was replicated thrice. Plot sizes varied between 20 and 25 square meters, maintaining a plant spacing of 20 × 15 cm. Fertilizer application followed standard recommendations: 120 kg of nitrogen (N), 60 kg of phosphorus (P_2O_5), 50 kg of potassium (K_2O), and 50 kg of zinc sulfate ($ZnSO_4$) per hectare. To accurately assess pest dynamics, insect populations were monitored every 10 days using light traps and field surveys. These observations helped determine the most suitable timing for insecticide applications. The following parameters were recorded for analysis. The collected data was analyzed statistically, and an F-Test was conducted using R software version 4.5.0 to determine the best-performing treatment combinations.

2.1 Main Field at 50, and 65 DAT: (Per hill, in 10 Hills at Random in Each Replication)

i. Number of tillers
ii. Number of silver shoots
iii. Number of dead hearts (DH) at 50 DAT.

2.2 Main Field at Maturity: (Per Hill, in 10 Hills at Random in Each Replication)

i. Number of panicle bearing tillers
ii. Number of white ears
iii. Number of natural enemies per hill, in 10 hills at random at 50, and 65 DAT.
iv. Grain yield per plot.

Table 1. Treatment details of the efficacy experiment

Trt No.	Insecticide	Dosage
T_1	Carbofuran 3% CG	10 kg /acre
T_2	Fipronil granules 0.3 GR	10 kg/acre
T_3	Chlorpyriphos granules	4 kg/acre
T_4	Chlorpyriphos 20 EC	2.5 ml/lit
T_5	Fipronil 5 SC	2 ml/lit
T_6	Chlorantraniliprole granules 0.4 GR	4 kg/acre
T_7	Chlorantraniliprole 18.5 % SC	0.3ml/lit
T_8	Cartap hydrochloride 4% GR	7.5 Kg/acre
T_9	Untreated control	

3. RESULTS AND DISCUSSION

Insecticides continue to play a pivotal role in managing rice pests, and assessing the performance of new formulations, especially those involving combinations, is vital for effective pest control strategies (Rathee and Dalal, 2018). The present investigation aimed to determine the efficacy of novel insecticidal compounds, with an emphasis on low-dose applications targeting specific pests. The focus this year was on evaluating both individual and combination products for enhanced pest suppression (Chander et al., 2020).

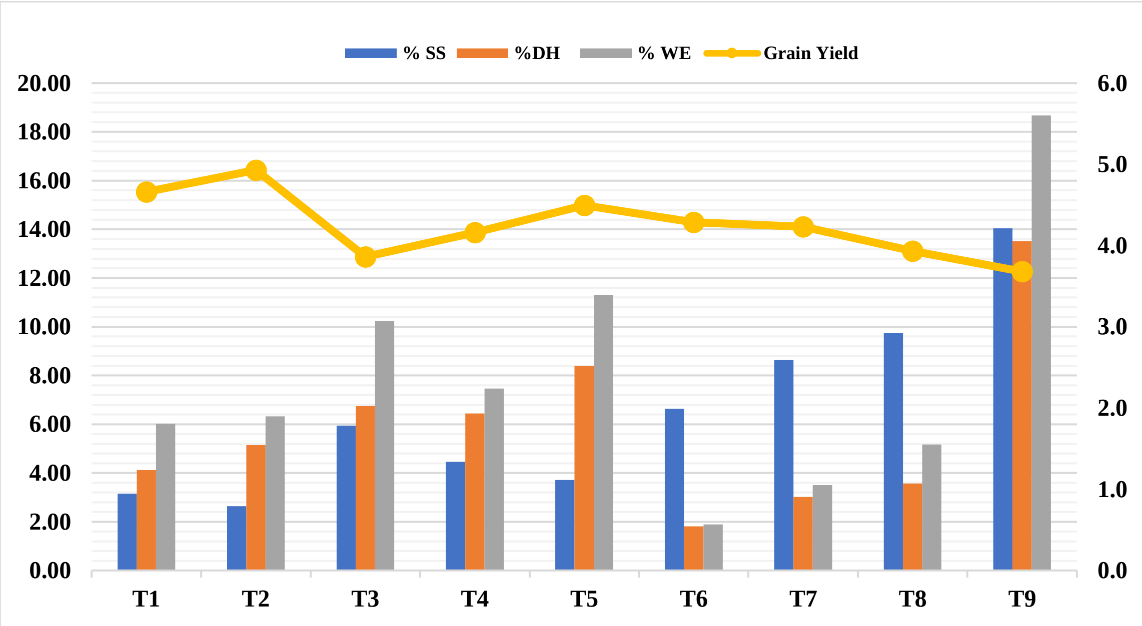

Fig. 1. Efficacy of insecticides on paddy pest complex and relatioship with yield

Table 2. Evaluation of insecticides against rice gall midge during Kharif 2023

Tr. No	Mean data of 50 DAT		% WE at pre-harvest (YSB)	Grain Yield (q/ha)
	% SS	%DH (YSB)		
T1	3.69 (6.45)	3.52 (6.32)	5.31 (7.84)	4560
T2	2.22 (4.98)	4.70 (7.35)	5.75 (8.18)	4820
T3	5.09 (7.67)	6.06 (8.41)	9.35 (10.66)	3813
T4	3.49 (6.30)	5.58 (8.05)	6.63 (8.83)	4113
T5	3.02 (5.84)	7.06 (9.14)	10.72 (11.52)	4440
T6	6.16 (8.49)	1.31 (3.82)	1.44 (4.0)	4253
T7	7.51 (9.45)	1.82 (4.50)	3.01 (5.83)	4186
T8	8.37 (10.03)	2.73 (5.55)	4.09 (6.84)	3920
T9	12.46 (12.56)	11.33 (11.89)	16.41 (14.85)	3640
F- test	Sig.	Sig.	Sig.	Sig.
CD (p=0.05)	2.76	3.07	5.89	660.06
CV%	17.58	12.60	8.86	9.09

In recent years, delayed transplanting has led to a noticeable year-on-year increase in gall midge infestations in select regions of Andhra Pradesh. This trend necessitates a reevaluation of current pest control strategies targeting this pest. According to Mardi et al*.,* 2009, the lowest gall midge incidence was recorded in plots treated with Carbofuran 3G, followed by Chlorpyriphos 40 EC and Phorate 10G. Similarly, Nath et al*.,* 2015 reported effective gall midge suppression with Carbosulfon 25% EC (800–1000 ml/ha), Fipronil 0.3 GR (16,670–25,000 g/ha), and Fipronil 5% SC (1000–1500 g/ha). Despite current recommendations advocating soil application of Carbofuran 3G at 10 kg/acre or Phorate 10G at 5 kg/acre, farmers have reported limited effectiveness. Moreover, with Phorate and Carbofuran now banned, alternative granular formulations must be explored. This study thus aimed to validate the performance of various insecticides against rice pests, especially gall midge, under both nursery and field conditions (Tables 2–4 & Fig. 1).

3.1 Kharif 2023 Observations

Among the tested treatments, Fipronil 3% GR (T2) emerged as the most effective against gall midge, resulting in the lowest silver shoot incidence (2.22%). This was followed by Fipronil 5 SC @ 2 ml/litre (T5) with 3.02% and Chlorpyriphos 20 EC @ 2.5 ml/litre (T4) with 3.49%. The untreated plots showed the highest infestation, with 12.46% silver shoots. These findings align with earlier work by Rani and Venkatesh (2018) for Fipronil and Kumari and Prasad (2020) for Chlorpyriphos. For yellow stem borer, the most effective treatment was Chlorantraniliprole 0.4 GR (T6), which reduced dead heart (DH) incidence to 1.31% and white ear (WE) formation to 1.44%, in contrast to 11.33% DH and 16.41% WE in untreated plots. This was followed by Chlorantraniliprole 18.5% SC @ 0.3 ml/litre (T7) with 1.82% DH and 3.01% WE, and Cartap hydrochloride 4% GR @ 7.5 kg/acre (T8) with 2.73% DH and 4.09% WE. These results are consistent with findings from Omprakash et al*.,* 2017 and Reddy et al*.,* 2019. In terms of yield, all treated plots outperformed the untreated control (3640 kg/ha). The highest yield was achieved with Fipronil 3% GR applied at 10 and 30 DAT (4820 kg/ha), followed by Carbofuran (4560 kg/ha). Singh and Hasan (2017) previously reported that Fipronil contributed to higher yields through effective pest suppression.

Table 3. Evaluation of insecticides against rice gall midge during Rabi, 2023-24

Tr. No	Mean data of 50 DAT		% WE at pre-harvest (YSB)	Grain Yield (q/ha)
	% SS	%DH (YSB)		
T1	2.62 (5.36)	4.72 (7.32)	6.73 (8.90)	4760
T2	3.05 (5.79)	5.60 (8.04)	6.90 (9.04)	5040
T3	6.80 (8.97)	7.43 (9.40)	11.14 (11.77)	3907
T4	5.43 (7.89)	7.30 (9.28)	8.30 (9.97)	4207
T5	4.40 (7.04)	9.71 (10.88)	11.90 (12.23)	4547
T6	7.11 (9.13)	2.30 (5.06)	2.35 (5.08)	4320
T7	9.76 10.90)	4.22 (6.93)	4.00 (6.74)	4280
T8	11.10 (11.77)	4.40 (7.11)	6.25 (8.51)	3947
T9	15.61 (14.39)	15.71 (14.47)	20.93 (17.48)	3720
F- test	**Sig.**	**Sig.**	**Sig.**	**Sig.**
CD (p=0.05)	**3.09**	**2.99**	**5.07**	**549.01**
CV%	**14.51**	**15.35**	**13.80**	**7.37**

Table 4. Evaluation of insecticides against rice gall midge two seasons pooled data of Kharif 2023 and Rabi, 2023-24

Tr. No	Mean data of 50 DAT		% WE at pre-harvest (YSB)	Grain Yield (q/ha)
	% SS	%DH (YSB)		
T1	3.16 (5.94)	4.12 (6.84)	6.02 (8.38)	4660
T2	2.64 (5.40)	5.15 (7.70)	6.33 (8.62)	4930
T3	5.95 (8.30)	6.75 (8.91)	10.25 (11.22)	3860
T4	4.46 (7.13)	6.44 (8.68)	7.47 (9.41)	4160
T5	3.71 (6.47)	8.39 (10.03)	11.31 (11.87)	4494
T6	6.64 (8.81)	1.81 (4.48)	1.90 (4.57)	4287
T7	8.64 (10.19)	3.02 (5.83)	3.51 (6.30)	4234
T8	9.74 (10.92)	3.57 (6.37)	5.17 (7.71)	3934
T9	14.04 (13.48)	13.52 (13.20)	18.67 (16.16)	3680
F- test	**Sig.**	**Sig.**	**Sig.**	**Sig.**
CD (p=0.05)	**2.78**	**2.71**	**5.23**	**599.90**
CV%	**20.62**	**16.70**	**18.56**	**8.16**

3.2 Rabi 2023–24 Observations

During the Rabi season, Carbofuran 3% CG (T1) recorded the lowest gall midge infestation (2.62%), followed by Fipronil 0.3 GR (T2) at 3.05% and Fipronil 5 SC @ 2 ml/litre (T5) at 4.40%. The untreated plots again recorded the highest infestation (15.61%). These outcomes corroborate the work of Kumar et al., (2011) for Carbofuran and Paul et al*.,* 2018 for Fipronil. For yellow stem borer, Chlorantraniliprole 0.4 GR (T6) showed superior performance with just 2.3% DH and 2.3% WE, as compared to 15.7% DH and 20.9% WE in untreated plots. Chlorantraniliprole 18.5% SC @ 0.3 ml/litre (T7) and Cartap hydrochloride 4% GR (T8) recorded 4.22% and 4.40% DH, respectively, and 4.00% and 6.25% WE. These findings are in line with those of Rahaman and Stout, 2019 and Kinjale et al*.,* 2021. All treatments significantly improved yields compared to the untreated control (3720 kg/ha). Fipronil 3% GR at 10 and 30 DAT yielded the highest grain output (5040 kg/ha), followed by Carbofuran (4760 kg/ha). Similar benefits of Fipronil and Carbofuran for pest management and yield enhancement were noted by Parmar et al*.,* 2019 and Borkar et al*.,* 2018, respectively.

Pooled data over the two years of experiment reveals- the effective management for gall midge application of fipronil 3% GR (T2) in the main field was most effective with significantly lower SS (2.64%) as compared to other treatments and most effective in preventing silver shoots formation, followed by 3.16 percent silver shoots in application of carbofuran 3% CG (T1) and 3.71 percent silver shoots in fipronil 5 SC @ 2 ml/lit (T5) treatments, whereas in the untreated control highest percent of silver shoots (14.04%) was noted. In case of yellow stem borer, application of Chlorantraniliprole 0.4 GR (T6) in the main field was most effective in preventing DH formation (1.81 %) and also preventing white ear formation (1.90 %) over control (13.56%DH and 18.68%WE) similar report was noted by Udayababu et al*.,* 2023, followed by chlorantraniliprole 18.5 % SC @0.3ml/lit (T7) with 3.02 percent dead hearts and 3.51 percent white ears, cartap hydrochloride 4% GR 7.5 Kg/acre (T8) with 3.57 percent dead hearts and 5.17 percent white ears. With respect to yield, treatment effects were significant and in all the treatments higher yield was recorded as compared to untreated control (3680 kg/ha). Application of fipronil 3% GR (T2) at 10 DAT& 30 DAT in main field was the best treatment with significantly higher yield (4930 kg/ha) as compared to remaining treatments followed by application of carbofuran (4660 kg/ha) similar results of fipronil efficacy in gallmidge management and yield improvement was reported by Rani and Padmalatha, 2019 and Udayababu et al*.,* 2025.

4. CONCLUSIONS

The two-year experimental trials assessing nine granular insecticide treatments revealed that for gall midge control, application of fipronil 3% GR (T2) in the main field was most effective with significantly lower SS (2.59 %) as compared to other treatments and most effective in preventing silver shoots formation. In case of yellow stem borer, application of Chlorantraniliprole 0.4 GR (T6) in the main field was most effective in preventing DH formation (1.80 %) and also preventing white ear formation (1.87 %) over control (13.56(DH%) and 18.68 WE%). With respect to yield, treatment effects were significant and in all the treatments higher yield was recorded as compared to untreated control (3680 kg/ha). Application of fipronil 3% GR (T2) at 10 DAT& 30 DAT in main field was the best treatment with significantly higher yield (4930 kg/ha) (R Core Team, 2025).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Bandumula, N. (2018). Rice production in Asia: Key to global food security. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, *88*, 1323–1328.

Borkar, V. S., Gokhale, N. B., More, S. S., Khobragade, N. H., & Dhopavkar, R. V. (2018). Influence of phorate and carbofuran insecticides on phosphorous availability and its residues in soil and rice. *IJCS*, *6*(1), 238–242.

Chander, S., Mohan, B. R. I. J., & Poddar, N. (2020). Efficacy of pesticides against rice plant hoppers, and insecticide and fungicide compatibility. *Indian Journal of Entomology*, *82*, 143–146.

Chaudhari, P. R., Tamrakar, N., Singh, L., Tandon, A., & Sharma, D. (2018). Rice nutritional and medicinal properties: A. *Journal of Pharmacognosy and Phytochemistry*, *7*(2), 150–156.

Duppala, M. K., Srinivas, T., Rao, L. S., Suneetha, Y., Sundaram, R. M., Kumari, V. P., Bhuvaneswari, V., & Ganesh, B. (2023). Screening of recombinant inbred lines for resistance to bacterial leaf blight pathotypes in rice (*Oryza sativa* L.). *Plant Science Today*, *10*(3), 343–353.

Fahad, S., Adnan, M., Noor, M., Arif, M., Alam, M., Khan, I. A., ... & Wang, D. (2019). Major constraints for global rice production. In *Advances in rice research for abiotic stress tolerance* (pp. 1–22). Woodhead Publishing.

Hurali, S., Prasad, P. R. B., Basavanjali, Shiralli, H., Honnayya, Gowdar, S. B., Mahantashivayogayya, K., & Masthanareddy, B. G. (2023). Evaluation of efficacy of new combi insecticides against lepidopteran pests of rice and its impact on natural enemies. *Journal of Experimental Zoology, India*, *26*, 869–874. https://doi.org/10.51470/jez.2023.26.1.869

Jena, M., Adak, T., Rath, P. C., Gowda, G. B., Patil, N. B., Prasanthi, G., & Mohapatra, S. D. (2018). Paradigm shift of insect pests in rice ecosystem and their management strategy. *ORYZA – An International Journal on Rice*, *55*(spl), 82–89.

Kinjale, R. S., Jalgaonkar, V. N., Naik, K. V., Hatwar, N. K., & Lad, S. S. (2021). Evaluation of the efficacy of some insecticides against rice yellow stem borer, *Scirpophaga incertulas* (Walker). *Journal of Entomology and Zoology Studies*, *9*(1), 123–125.

Kumar, L. V., Patil, S. U., Prasannakumar, M. K., & Chakravarthy, A. K. (2011). Bioefficacy of insecticides in nursery against Asian rice gall midge, *Orseolia oryzae* (Wood-Mason). *Current Biotica*, *5*(3), 323–329.

Kumar, R. S., Reddy, A. V., Chandra, B. S., Prasad, K. R., Hari, Y., Nagabhushanam, U., ... & Reddy, R. U. (2024). Field evaluation of rice cultures for resistance against gall midge, *Orseolia oryzae*.

International Journal of Bio-Resource & Stress Management, *15*(11).

Kumari, A., & Prasad, R. (2020). Bio-efficacy of botanical insecticides against rice gall midge (*Orseolia oryzae*) in Ranchi, Jharkhand. *International Journal of Chemical Studies*, *8*, 364–368.

Mardi, G., Pandey, A. C., & Kumar, S. S. (2009). Occurrence and management of rice gall midge in transplanted rice (*Orseolia oryzae* Wood Mason). *Ecology Environment and Conservation*, *15*(2), 361–365.

Meena, R. S., Kumar, P., & Prerana, S. B. (2024). Bio-efficacy of newer insecticides on major insect pests of rice (*Oryza sativa* L.). *Asian Journal of Environment and Ecology*, *23*(5), 41–47.

Nath, P., Nath, S., Kumar, M. U., & Prasad, J. P. (2015). Insecticides induced resurgence of sucking pests in paddy: A review. *International Journal of Advances in Agricultural Science and Technology*, *2*(2), 49–64.

Omprakash, S., Venkataiah, M., & Laxman, S. (2017). Comparative efficacy of some new insecticides against rice yellow stem borer, *Scirpophaga incertulas* Walker under field conditions. *Journal of Entomology and Zoology Studies*, *5*(5), 1126–1129.

Parmar, A. B., Sharma, P. K., & Zala, S. U. (2019). Yield enhancement in paddy through frontline demonstrations on integrated pest management. *International Journal of Farm Sciences*, *9*(2), 40–42.

Paul, B., Samanta, S., Sen, K., Manger, A., & Samanta, A. (2018). Evaluation of bioefficacy and phytotoxicity of fipronil 5% SC and acetamiprid 20% SP on rice insect pest complex. *Journal of Entomology and Zoology Studies*, *6*(4), 1410–1416.

R Core Team. (2025). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org

Rahaman, M. M., & Stout, M. J. (2019). Comparative efficacies of next-generation insecticides against yellow stem borer and their effects on natural enemies in rice ecosystem. *Rice Science*, *26*(3), 157–166.

Rani, D. S., & Padmalatha, Y. (2019). Field evaluation of insecticides against gallmidge infesting rice. *Journal of Entomology and Zoology Studies*, *7*(6), 886–889.

Rani, D. S., & Venkatesh, M. N. (2018). Relative efficacy of insecticides in the management of rice gallmidge, *Orseolia oryzae*. *Chemical Science Review and Letters*, *7*(26), 397–401.

Rao, A. U., Murthy, K. R., Kumar, K. M., Visalakashmi, V., Satyanarayana, N. H., & Rao, S. G. (2020). Alternate crop establishment methods for water-saving and high rice productivity in north coastal Andhra Pradesh. *Current Agriculture Research Journal*, *8*(3).

Rathee, M., & Dalal, P. (2018). Emerging insect pests in Indian agriculture. *Indian Journal of Entomology*, *80*(2), 267–281.

Reddy, L. P. V., Rao, S. R. K., Krishna, T. M., Rao, C. S., Padmodaya, B., & Naidu, G. M. (2019). Bio-efficacy of certain insecticides against rice yellow stem borer, *Scirpophaga incertulas* (Walker). *Journal of Pharmacognosy and Phytochemistry*, *8*(4), 2625–2628.

Satyanarayana, P. V., Kumar, K. M., Babu, P. U., Srinivas, T., & Manojkumar, D. (2024). Genetic architecture, studies to identify the selection criteria for yield in long duration rice lines (*Oryza sativa* L.). *International Journal of Environment and Climate Change*, *14*(4), 842–851.

Sharma, S., Kooner, R., & Arora, R. (2017). Insect pests and crop losses. In *Breeding insect resistant crops for sustainable agriculture* (pp. 45–66).

Shivappa, R., Navadagi, D. B., Baite, M. S., Yadav, M. K., Rathinam, P. S., Umapathy, K., ... & Rath, P. C. (2022). Emerging minor diseases of rice in India: Losses and management strategies. *IntechOpen*. https://doi.org/10.5772/intechopen.99898

Singh, H., & Hasan, W. (2017). Bioefficacy of chlorpyrifos and fipronil insecticides against insect pests of paddy. *International Research Journal of Natural and Applied Sciences*, *4*(6), 22–32.

Subedi, B., Poudel, A., & Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *Journal of Agriculture and Food Research*, *14*, 100733.

Udayababu, P., Satyanarayana, P. V., Kumar, K. M., Rao, M. S., Sreenivas, G., & Kumar, D. M. (2025). Evaluation of the bio-efficacy of granular insecticides in managing paddy pest infestations. *Journal of Advances in Biology & Biotechnology*, *28*(5), 70–83.

https://doi.org/10.9734/jabb/2025/v28i52270

Udayababu, P., Satyanarayana, P. V., Kumar, K. M., & Kumar, D. M. Efficacy of biorational insecticides against major insect pests of rice. *Biological Forum – An International Journal*, *15*(6), 966–971.

Zhao, Q., Ye, L., Wang, Z., Li, Y., Zhang, Y., Keyhani, N. O., & Huang, Z. (2021). Sustainable control of the rice pest, *Nilaparvata lugens*, using the entomopathogenic fungus *Isaria javanica*. *Pest Management Science*, *77*(3), 1452–1464. https://doi.org/10.1002/ps.6164

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