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Comparative Efficacy of Modern Insecticides for Controlling Rice Leaf Folder (*Cnaphalocrocis medinalis*) Under Field Conditions

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Abstract

Rice, a critical cash crop and secondary staple in Pakistan, faces significant yield losses due to the rice leaf folder (*Cnaphalocrocis medinalis*), a major pest causing up to 80% crop damage. This study, conducted during the Kharif season of 2024 at the Maize and Millets Research Institute, Yusafwala-Sahiwal, evaluated the efficacy of five insecticides—Virtako 40 WG, Proaxis 60 SC, Karate 2.5 EC, Advantage 20 SC, and Flubendiamide 48 SC—against rice leaf folder on Super Basmati rice under a randomized complete block design with three replications. Insecticides were applied at five concentrations when infestation reached

3%, with pest scouting performed using a 1-square-foot iron ring at 3, 7, and 14 days after spray (DAS). Virtako 40 WG exhibited the highest efficacy, significantly reducing infestation to 0.926% at 14 DAS with the highest concentration (26.667 g/ha), followed by Proaxis (0.926%), Karate (1.573%), Advantage (1.852%), and Flubendiamide (1.575%). All insecticides showed dose-dependent efficacy, with higher concentrations consistently outperforming lower ones. Control plots recorded the highest infestations (6.493–7.447%). These findings align with previous studies advocating timely chemical interventions and highlight Virtako's potential in integrated pest management (IPM). The study underscores the need for sustainable pest control strategies combining new chemistry insecticides with biocontrol and resistant varieties to enhance rice yield and environmental safety in Pakistan.

Keywords: Pesticide efficacy, Stem borer, Rice, New generation pesticide, Leaf folder

Introduction

Rice, a vital cash crop and secondary staple food in Pakistan, plays a significant role in the nation's economy and food security (Memon et al., 2013). Globally, rice serves as the primary staple for over half of the world's population, ranking fifth in importance among crops from the *Graminae* family (Vaughan, 1994). In Pakistan, rice cultivation occupies approximately 10.5% of the total cultivated area, contributing 1.1% to the GDP and accounting for about 6% of annual foreign exchange earnings, making it the second-largest export earner after cotton (Anonymous, 2002). The crop is grown extensively in regions like Gujranwala, Sheikhupura, Hafizabad, and Sialkot, known as the rice Kallar tract, where the aromatic rice varieties hold a strong international market presence (Sherawat et al., 2007). Despite its economic importance, rice production in Pakistan faces significant challenges, particularly from biotic stresses such as insect pests, which necessitate advanced management strategies to ensure sustainable yields.

Rice cultivation spans diverse agroecological zones, from tropical and subtropical to temperate regions, and is grown at altitudes up to 2500 meters above sea level (Khush, 1997). In Asia, which produces and consumes approximately 92% of the world's rice, the crop is critical for food security and economic stability (Khush, 1997). In Pakistan, rice follows wheat in terms of area and production, with an annual output of around 4325 thousand tons (Anonymous, 1999). However, the average yield remains lower than in other developing countries, primarily due to biotic factors like insect pests, which cause up to 52% yield losses, with 21% attributed specifically to insect damage (Heinrichs et al., 2017). Among these pests, the rice leaf folder *(Cnaphalocrocis medinalis)* stands out as a major and sporadic threat, capable of causing up to 80% crop losses in severe infestations, particularly in Punjab during August and September (Zhang et al., 2014).

The rice leaf folder, a prevalent pest across Asian rice ecosystems, has become increasingly problematic in Pakistan and India due to its adaptability and biotic potential (Ahmad et al., 2016). Its larvae cause conspicuous foliar damage by folding and scraping leaves, reducing photosynthetic activity and leading to significant yield reductions (Gangwar, 2015). Despite the rice plant's ability to compensate for early-season foliar damage, farmers often resort to early-season pesticide applications due to the visible defoliation caused by *C. medinalis*. These applications, typically involving broad-spectrum insecticides, disrupt natural biological control by eliminating beneficial predators and parasitoids, locking farmers into a cycle of pesticide dependency known as the "pesticide treadmill". This practice not only fails to deliver economic benefits but also triggers ecological imbalances, fostering secondary pest outbreaks like brown plant hoppers.

In Pakistan, the reliance on chemical pesticides, particularly granular formulations, has been a common but problematic approach to managing rice pests, including the leaf folder (Iqbal et al., 2016; Wakil et al., 2001). These pesticides often lead to resistance development, environmental contamination, and the destruction of natural enemy populations, compromising food quality and ecosystem health (Horgan & Kudavidanage, 2020). Alternative strategies, such as resistant rice varieties and integrated pest management (IPM) practices, have shown promise in conserving natural enemies and reducing pest populations sustainably (Gurr et al., 2011). However, their adoption remains limited due to farmer risk aversion and the aggressive marketing of chemical pesticides (Gurr et al., 2012). Recent advancements in pest management, including biopesticides and insect growth regulators (IGRs), offer target-specific solutions that minimize ecological disruption while controlling pest populations effectively (Kiran & Veeranna, 2012).

Given the critical role of rice in Pakistan's economy and the significant threat posed by the rice leaf folder, there is an urgent need to develop sustainable pest management strategies. This study aims to evaluate the efficacy of new chemistry insecticides, including IGRs, for managing *C. medinalis* under field conditions in Pakistan. By exploring these innovative approaches, the research seeks to reduce reliance on broad-spectrum pesticides, enhance biological control, and improve rice yields, contributing to the sustainability of Pakistan's rice industry and global food security.

Materials and Methods

Study Area and Experimental Design

The study was conducted at the Entomological Research Area, Maize and Millets Research Institute, Yusafwala-Sahiwal (MMRI), Pakistan, during the Kharif season of 2024. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each experimental plot measured 5 × 5 square meters, ensuring sufficient space for accurate pest scouting and data collection.

Land Preparation, Nursery Sowing, and Transplantation

The rice variety Super Basmati was selected for the experiment. The field was prepared following standard agronomic practices, including land leveling, plowing, and irrigation, to ensure optimal crop growth. Fertilizer applications were made according to the recommended rice production plan. The nursery was sown in June 2024 and transplanted to the experimental field in July 2024, approximately one month after sowing, to establish a uniform crop stand.

Insecticide Application and Pest Scouting

Five insecticides were evaluated for their efficacy against the rice leaf folder *(Cnaphalocrocis medinalis):* Virtako 40 WG, Proaxis 75, Karate 200 SC, Advantage 500 SC, and Flubendiamide 10 SC, alongside a control treatment (water spray). Each insecticide was applied at five different concentrations: Virtako 40 WG (26.667, 13.333, 6.667, 3.333, 1.667 g/ha), Proaxis 75 (50, 25, 12.5, 6.25, 3.125 mL/ha), Karate 200 SC (133.33, 66.667, 33.333, 16.667, 8.333 mL/ha), Advantage 500 SC (333.33, 166.667, 83.333, 41.667, 20.833 mL/ha), and Flubendiamide 10 SC (6.667, 3.333, 1.667, 0.833, 0.417 mL/ha). Pest scouting was initiated one week after transplantation using a 1-square-foot (12-inch) iron ring, randomly placed at four locations within each plot. The total number of plants and the number of infested or folded plants within the ring were recorded. Percent infestation was calculated using the formula:

$$\%\ infestation = \frac{number\ of\ infested/folded\ plants}{number\ of\ total\ plants} \times 100$$

Insecticide applications were triggered when the infestation level reached 3%. Data on leaf folder infestation were recorded at 3, 7, and 14 days after spraying (DAS).

Experimental Layout

The experimental layout followed the RCBD with the following treatment assignments:

- T0: Control (water spray)
- T1: Virtako 40 WG
- T2: Proaxis 75
- T3: Karate 200 SC
- T4: Advantage 500 SC
- T5: Flubendiamide 10 SC

Statistical Analysis

Raw data were compiled using Microsoft Excel. Statistical analysis was performed using Statistix 8.1 software. Microsoft Excel was used for the graphical representation of the data using mean values.

Results and Discussion

Efficacy of Virtako 40WG on Rice Leaf Folder Infestation

Pretreatment data showed no significant differences in rice leaf folder (Cnaphalocrocis medinalis) infestation across Virtako 40WG concentrations and control plots, with the highest infestation in the 6.667 g/ha plot and the lowest in the 13.333 g/ha plot (Figure 1a-e). Three days after spray (DAS), infestation levels remained statistically similar, with the control plot at 6.29% and the 26.667 g/ha concentration showing the lowest infestation at 4.782% (Figure 1a-e).

At 7 and 14 DAS, Virtako 40WG significantly reduced infestation compared to the control ($p < 0.05$), with the control plot recording the highest infestations at 6.26% and 6.562%, respectively (Figure 1a-e). Among treated plots, the 1.667 g/ha concentration showed the highest infestations (3.419% at 7 DAS, 2.230% at 14 DAS), while the 26.667 g/ha concentration consistently had the lowest (2.493% at 7 DAS, 0.926% at 14 DAS) (Figure 1a-e). Overall, post-treatment data confirmed a dose-dependent reduction in infestation, with the control at 6.493% and the 26.667 g/ha concentration at 2.734% (Figure 1a-e).

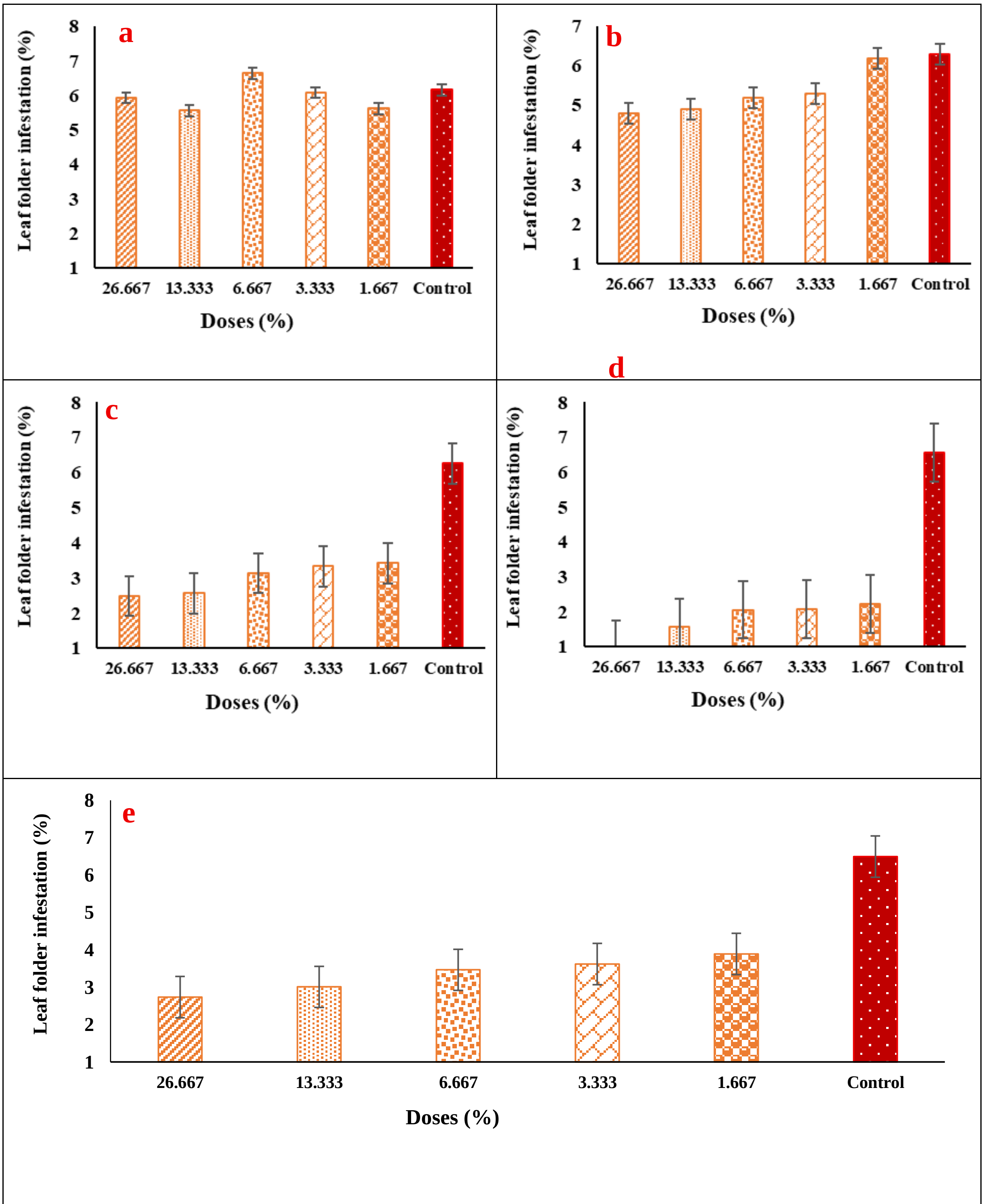

Figure 1a-e: Percent mean infestation of rice leaf folder **(a)** before Virtako spray **(b)** 03 days after Virtako spray **(c)** 07 days after Virtako spray **(d)** 14 days after Virtako spray **(e)** after Virtako post spray

Efficacy of Proaxis 60 SC on Rice Leaf Folder Infestation

Pretreatment data for Proaxis 60 SC showed no significant differences in rice leaf folder (*Cnaphalocrocis medinalis*) infestation across doses and control plots, with the highest infestation in the 6.667 mL/ha plot, followed by the control and 3.333 mL/ha plots, and the lowest in the 13.333 mL/ha plot (Figure 2a-e). Three days after spray (DAS), infestation levels remained statistically similar, with the control plot at 6.29%, followed by the 1.667 and 3.333 mL/ha plots, and the lowest at 4.782% in the 26.667 mL/ha plot (Figure 2a-e).

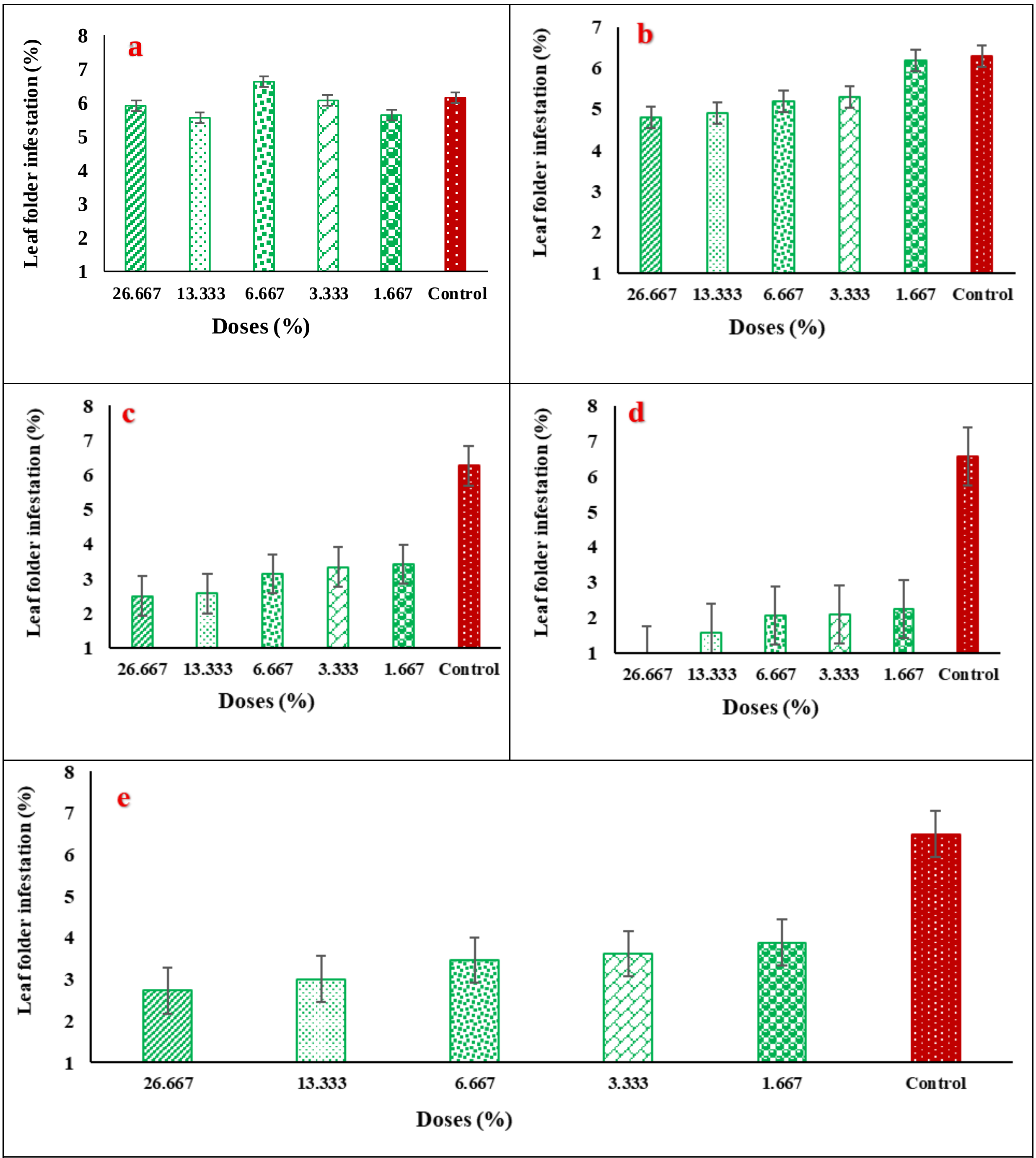

Figure 2a-e: Percent mean infestation of rice leaf folder **(a)** after Proaxis spray **(b)** 03 days after Proaxis spray **(c)** 07 days after Proaxis spray **(d)** 14 days after Proaxis spray **(e)** after Proaxis post spray

At 7 and 14 DAS, Proaxis 60 SC significantly reduced infestation compared to the control ($p < 0.05$), with the control plot showing the highest infestations at 6.26% and 6.562%, respectively (Figure 2a-e).

Among treated plots, the 1.667 mL/ha dose had the highest infestations (3.419% at 7 DAS, 2.230% at 14 DAS), followed by the 3.333 mL/ha dose (3.335% at 7 DAS, 2.077% at 14 DAS), while the 26.667 mL/ha dose showed the lowest (2.493% at 7 DAS, 0.926% at 14 DAS) (Figure 2a-e). Overall post-treatment data confirmed a dose-dependent reduction, with the control at 6.493% and the 26.667 mL/ha dose at 2.734% (Figure 2a-e)

Efficacy of Belt 48 SC on Rice Leaf Folder Infestation

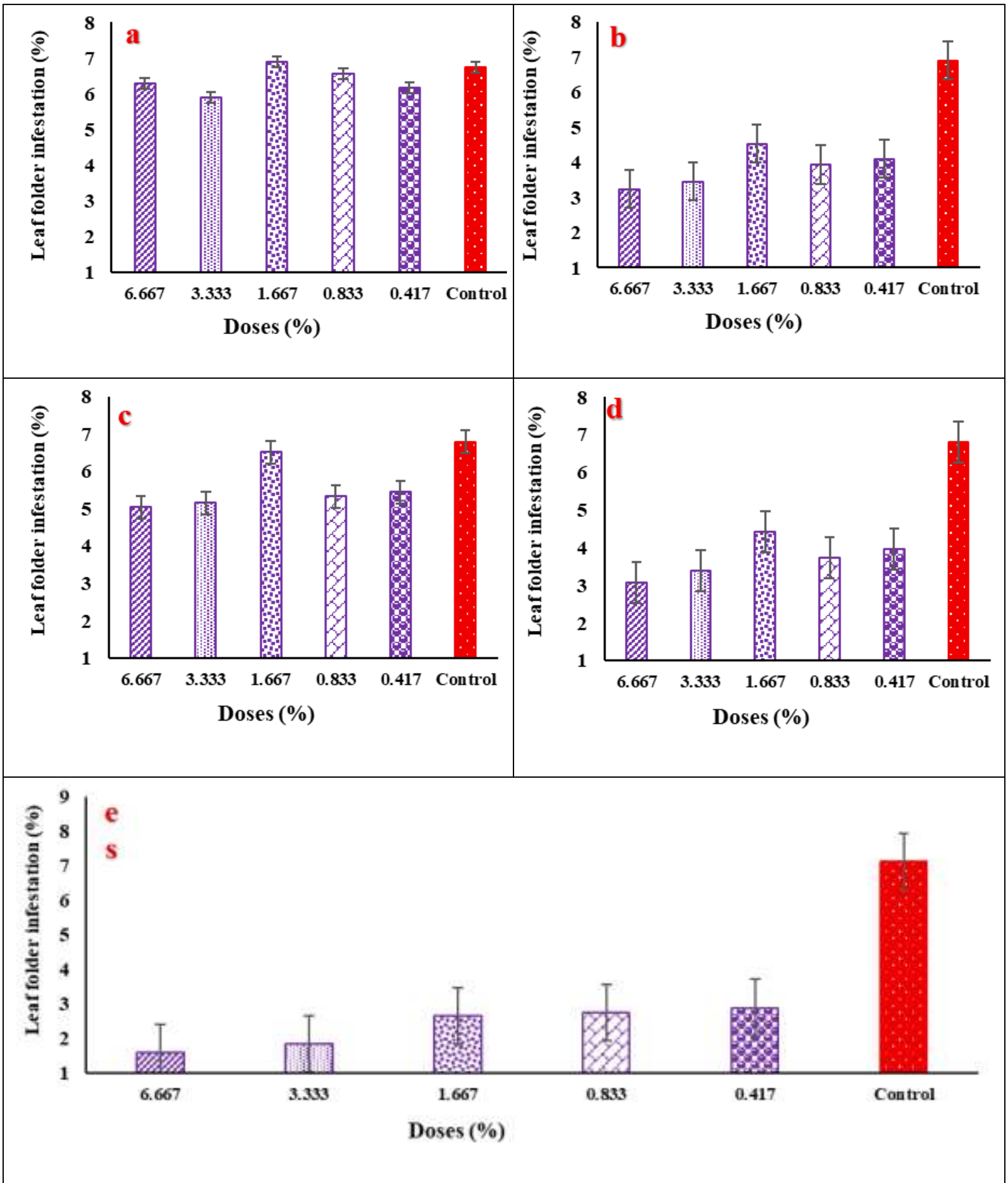

Figure 3a-e: Percent mean infestation of rice leaf folder **(a)** after Belt spray **(b)** 03 days after Belt spray **(c)** 07 days after Belt spray **(d)** 14 days after Belt spray **(e)** after Belt post spray

Pretreatment data for Belt 48 SC showed no significant differences in rice leaf folder (*Cnaphalocrocis medinalis*) infestation across doses and control plots, with the highest infestation in the control plot, followed by the 26.667 mL/ha plot, and the lowest in the 13.333 mL/ha plot (Figure 3a-e).

Three days after spray (DAS), infestation levels remained statistically similar, with the control plot at 6.800%, followed by the 6.667 and 1.667 mL/ha plots, and the lowest at 5.044% in the 26.667 mL/ha plot (Figure 3a-e).

At 7 and 14 DAS, Belt 48 SC significantly reduced infestation compared to the control ($p < 0.05$), with the control plot showing the highest infestations at 6.794% and 7.114%, respectively (Figure 3a-e). Among treated plots, the 6.667 mL/ha dose had the highest infestation at 7 DAS (4.432%), followed by 1.667 mL/ha (3.978%), while at 14 DAS, the 1.667 mL/ha dose was highest (2.881%), followed by 3.333 mL/ha (2.739%). The 26.667 mL/ha dose consistently showed the lowest infestations (3.087% at 7 DAS, 1.575% at 14 DAS) (Figure 3a-e). Overall post-treatment data confirmed a dose-dependent reduction, with the control at 6.903% and the 26.667 mL/ha dose at 3.236% (Figure 3a-e).

Efficacy of Karate 2.5 EC on Rice Leaf Folder Infestation

Pretreatment data for Karate 2.5 EC showed no significant differences in rice leaf folder (*Cnaphalocrocis medinalis*) infestation across doses and control plots, with the highest infestation in the 6.667 mL/ha plot, followed by the control and 3.333 mL/ha plots, and the lowest in the 13.333 mL/ha plot (Figure 4a-e). Three days after spray (DAS), infestation levels remained statistically similar, with the control plot at 7.164%, followed by the 6.667 and 3.333 mL/ha plots, and the lowest at 5.228% in the 26.667 mL/ha plot (Figure 4a-e).

At 7 and 14 DAS, Karate 2.5 EC significantly reduced infestation compared to the control ($p < 0.05$), with the control plot showing the highest infestations at 7.074% and 7.114%, respectively (Figure 4a-e). Among treated plots, the 3.333 mL/ha dose had the highest infestation at 7 DAS (4.546%), followed by 1.667 mL/ha (4.161%), while at 14 DAS, the 1.667 mL/ha dose was highest (2.881%), followed by 3.333 mL/ha (2.672%). The 26.667 mL/ha dose consistently showed the lowest infestations (3.149% at 7 DAS, 1.573% at 14 DAS) (Figure 4a-e). Overall post-treatment data confirmed a dose-dependent reduction, with the control at 7.117% and the 26.667 mL/ha dose at 3.318% (Figure 4a-e).

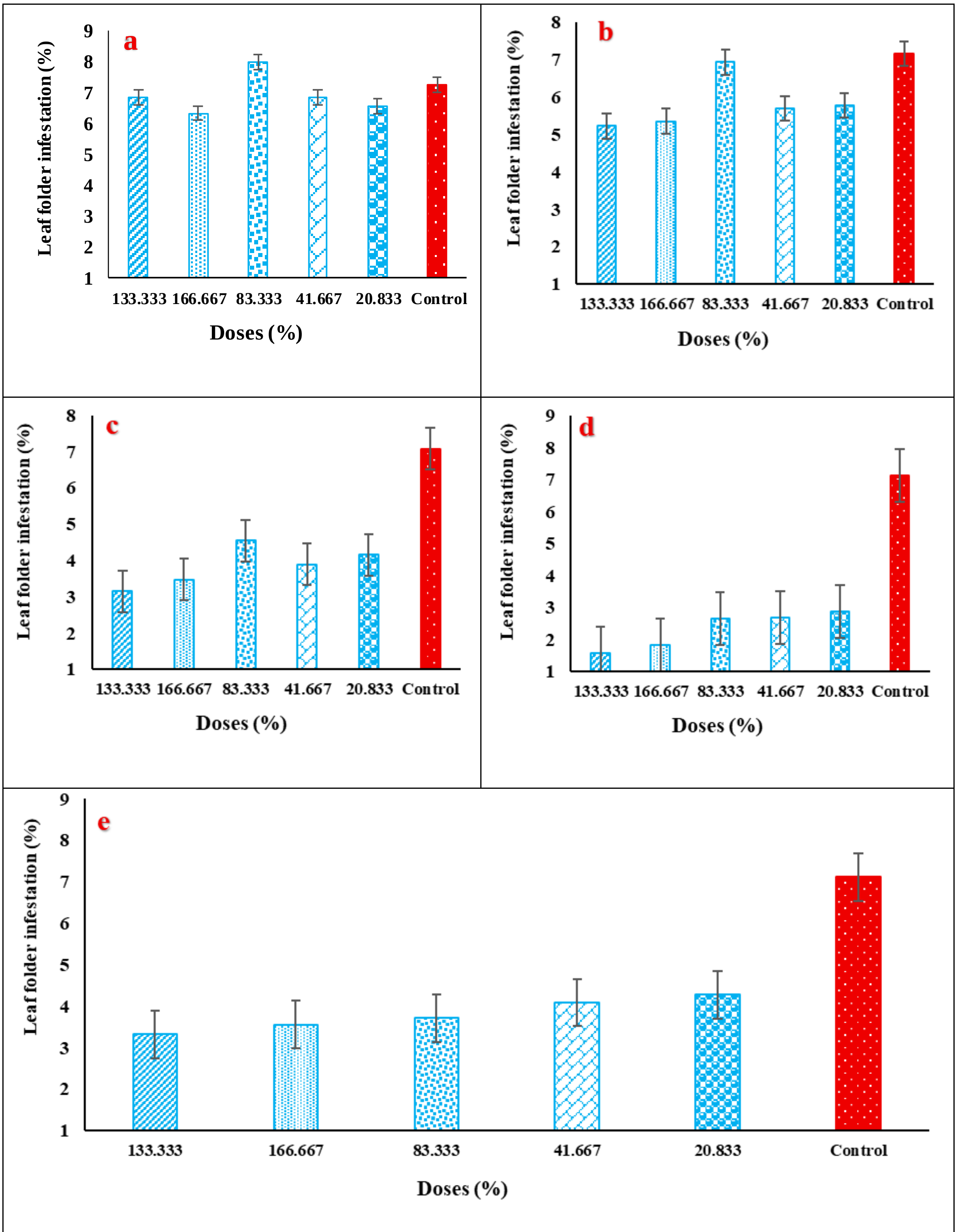

Figure 4a-e: Percent mean infestation of rice leaf folder **(a)** after Karate spray **(b)** 03 days after Karate spray **(c)** 07 days after Karate spray **(d)** 14 days after Karate spray **(e)** after Karate post spray

Efficacy of Advantage 20 SC on Rice Leaf Folder Infestation

Pretreatment data for Advantage 20 SC showed no significant differences in rice leaf folder (Cnaphalocrocis medinalis) infestation across doses and control plots, with the highest infestation in the 6.667 mL/ha plot, followed by the control and 26.667 mL/ha plots, and the lowest in the 13.333 mL/ha plot (Figure 5a-e). Three days after spray (DAS), infestation levels remained statistically similar, with the control plot at 7.222%, followed by the 6.667 and 1.667 mL/ha plots, and the lowest at 5.495% in the 26.667 mL/ha plot (Figure 5a-e).

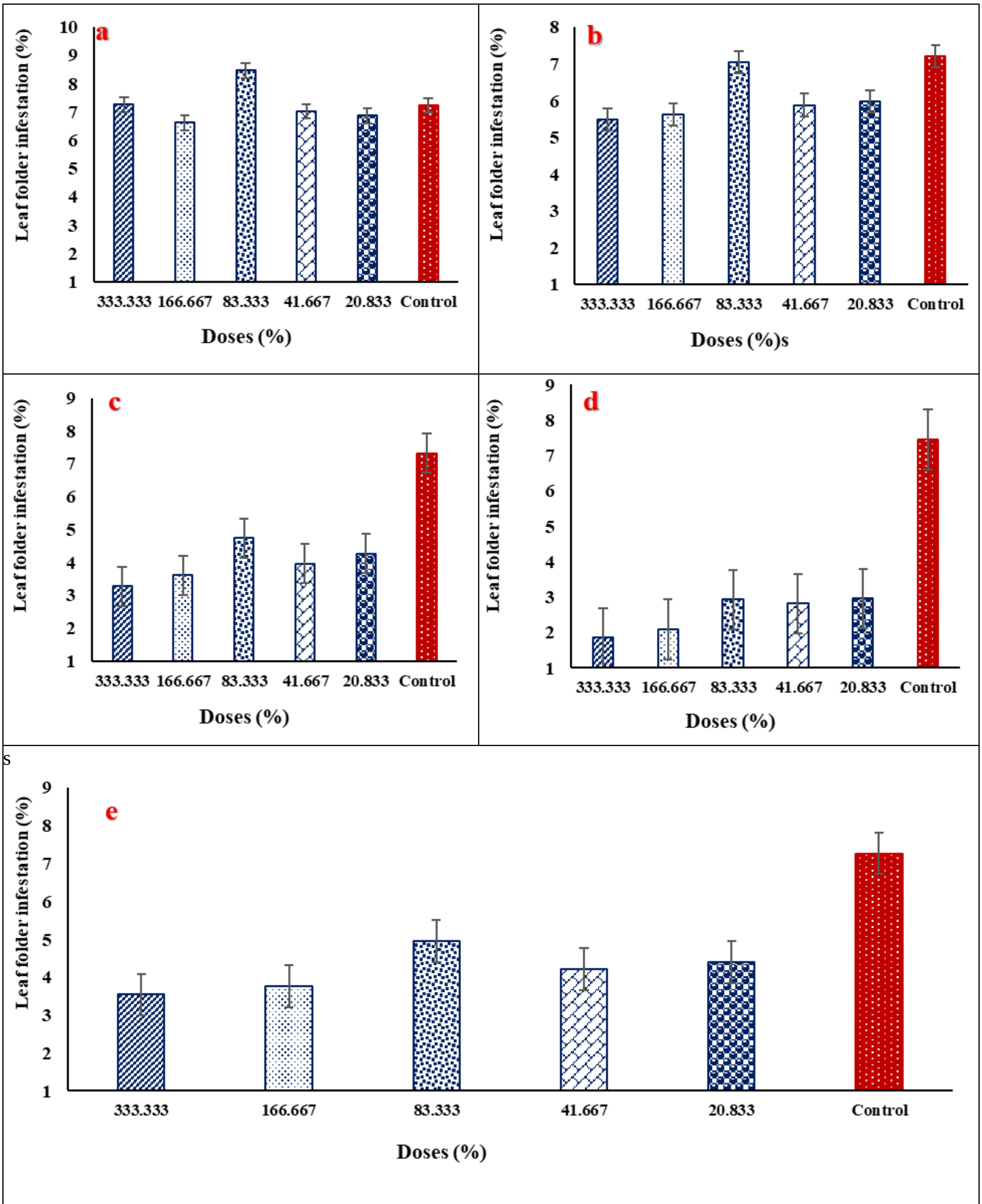

Figure 4a-e: Percent mean infestation of rice leaf folder **(a)** after Advantage spray **(b)** 03 days after Advantage spray **(c)** 07 days after Advantage spray **(d)** 14 days after Advantage spray **(e)** after Advantage post spray

At 7 and 14 DAS, Advantage 20 SC significantly reduced infestation compared to the control ($p < 0.05$), with the control plot showing the highest infestations at 7.321% and 7.447%, respectively (Figure 5a-e). Among treated plots, the 6.667 mL/ha dose had the highest infestation at 7 DAS (4.745%), followed by 1.667 mL/ha (4.267%), while at 14 DAS, the 1.667 mL/ha dose was highest (2.962%), followed by 6.667 mL/ha (2.930%). The 26.667 mL/ha dose consistently showed the lowest infestations (3.280% at 7 DAS, 1.852% at 14 DAS) (Figure 5a-e). Overall post-treatment data confirmed a dose-dependent reduction, with the control at 7.274% and the 26.667 mL/ha dose at 3.542% (Figure 5a-e).

The study, conducted at MMRI Yusafwala, Sahiwal during Kharif 2024, evaluated the efficacy of five insecticides (Virtako 40 WG, Proaxis 75, Karate 200 SC, Advantage 500 SC, and Flubendiamide 10 SC) against rice leaf folder (*Cnaphalocrocis medinalis*) on Super Basmati rice under a randomized complete block design. The results demonstrated that Virtako 40 WG achieved the highest mortality, significantly reducing leaf folder infestation at 3, 7, and 14 days after spray (DAS) compared to Proaxis and Karate, with Advantage showing intermediate efficacy and Flubendiamide the least. Higher concentrations of each insecticide consistently outperformed lower doses, aligning with the dose-dependent suppression observed in previous studies (Iqbal et al., 2000; Wakil et al., 2001).

The superior performance of Virtako 40 WG corroborates earlier findings by Iqbal et al. (2000) and, who reported effective control of rice leaf folder and stem borer using granular insecticides like Padan and Furadan in Pakistan. These studies highlighted the cost-benefit advantages of granular formulations, which also reflected in higher yields. Similarly, Alvi et al. (2003) identified August to October as peak infestation months for leaf folder in Sialkot, with Malathion outperforming other insecticides like Arrivo and Nuvacron, supporting the effectiveness of timely chemical interventions during critical infestation periods.

Recent trials with newer insecticides, such as Solomon and Cartap, have shown promising results against leaf folder and other rice pests like Tryporyza incertulas (Mamoon-ur-Rashid et al., 2013; Farooq et al., 2014). Cartap, in particular, was noted for maximizing yield, while Fipronil showed limited efficacy in Gujranwala (Farooq et al., 2014). In contrast, Ahmad et al. (2021) found Flubendiamide superior to Fipronil and Lambda Cyhalothrin in Lahore, suggesting regional variations in insecticide performance, possibly due to differences in pest resistance or environmental factors.

Bioinsecticides, such as Azadirachtin (neem-derived) and Bacillus thuringiensis, have also been explored, with Azadirachtin showing significant potential in reducing leaf folder populations compared to other bioagents (Ashfaq et al., 2019). However, Bilal et al. (2019) emphasized the necessity of chemical insecticides like Fertera (*Chlorantraniliprole*) for managing escalating leaf folder populations, with Virtako and Padan supporting biocontrol survival. These findings suggest that integrating chemical and biological controls could enhance sustainability in pest management.

The study also aligns with global research indicating that leaf folder infestations peak 45–55 days after transplantation, with the flowering stage being particularly vulnerable (Satish et al., 2007; Selvaraj et al., 2012). Insecticides like Chlorantraniliprole and Endosulfan have been effective when applied strategically during this period (Kumar et al., 2018; Sharmah, 2015). Additionally, combining Trichogramma chilonis releases with Monocrotophos sprays has shown synergistic effects, reduced infestation and boosting yields (Sharmah, 2015). These integrated pest management (IPM) strategies could be further refined for Pakistan’s rice ecosystems.

The dose-dependent efficacy observed in this study underscores the importance of precise insecticide application timing and concentration. Regular pest scouting, as implemented using a 1-square-foot iron ring, is critical for early detection and intervention when infestations reach the 3% threshold. Future research should focus on optimizing IPM approaches, incorporating resistant varieties and biocontrol agents alongside new chemistry insecticides like Virtako to minimize environmental impacts and enhance rice yield sustainability in Pakistan.

Conclusion

This study demonstrated that Virtako 40 WG was the most effective insecticide for managing rice leaf folder (*Cnaphalocrocis medinalis*) on Super Basmati rice, achieving significant reductions in infestation (down to 0.926% at 14 DAS) compared to Proaxis, Karate, Advantage, and Flubendiamide, which also showed dose-dependent efficacy but lesser impact. The consistent superiority of higher concentrations across all insecticides emphasizes the importance of precise application rates. These results align with prior research in Pakistan, where granular insecticides like Padan and Furadan outperformed others, and highlight regional variations in insecticide performance, as seen with Flubendiamide’s efficacy in Lahore. The reliance on chemical controls, however, poses risks of resistance and ecological disruption, as evidenced by the "pesticide treadmill". Integrating new chemistry insecticides like Virtako with bioinsecticides (e.g., Azadirachtin) and biocontrol agents (e.g., *Trichogramma chilonis*) offers a promising path for sustainable pest management. Regular pest scouting, as implemented here, proved critical for timely interventions at the 3% infestation threshold. Future research should focus on optimizing IPM strategies, evaluating resistant rice varieties, and assessing the long-term ecological impacts of insecticide use to ensure sustainable rice production in Pakistan, supporting both economic stability and global food security.

Author's Contribution

Saeed, Ghani, Ibrar, Shoaib, *Conceptualization, Validation, Supervision, Planning, Execution of Experiment;* Akhtar, Hanif, Shah, Mehboob, Ahmad, Hussain *Writing – original draft;* Nayab, Anwar, Ali *Writing – review & editing;* Saeed, Ghani, Khanum, Shah, Ali, Farooq *Formal analysis, Resources, Funding acquisition, Statistical Analysis, Graphic improvement.*

References

- Ahmad, M., Z. Ahmad, T. Hassan, M. Latif, M. Hussain, M.F. Iqbal, M.J. Shahzad, M. Farooq, A.R. Sajjid and M.A. Ali. 2016. Entomological survey of pests of rice nursery and crop in district Sialkot Punjab-Pakistan. Int. J. Adv. Res. Biol. Sci. 3(3):159-164.
- Alvi, S.M., M.A. Ali, S. Chaudhary and S. Iqbal. 2003. Population trends and chemical control of rice leaf folder, *Cnaphalocrocis medinalis* on rice crop. Inter. J. of Agri. and Bio. 5(4):615–617.
- Anonymous. 1999. Agriculture Statistics of Pakistan, Ministry of food, Agriculture and Livestock. Food, and Agric. Division (Economic Wing) Islamabad.13-14.
- Anonymous. 2002. Crop area production (By Districts). Government of Pakistan, Ministry of Food, Agriculture and Livestock (Economic wing). Islamabad. 16.
- Ashfaq, M., M. Ali, M. Shahzad, M.A. Anjum, M. Sajjad, Muhammad, S. Haider and U. Mubashar. 2019. Efficacy assessment of bio-pesticides against rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: *Pyralidae*) using DNA quantification method. Int. J. Biol. and Biotech. 16(2):391-399.
- Farooq, M., F. Ahmad, M. Latif, M. Ahmad, Rukhsana N. Bhutta, A. R. Sajjid, G. M. Shad, M. F. Iqbal, M. Hussain and A. H. Abid. 2014. Share of farmers using different

insecticides against leaf folder attack in transplanted rice. Int. J. Adv. Res. Biol. Sci. 1(5):05-07.

- Gangwar, R.K. 2015. Life Cycle and Abundance of Rice Leaf Folder, *Cnaphalocrocis medinalis* (Guenee) - A Review. J. Nat. Sci. Res. 5:15.
- Gurr, G.M., J. Liu, D.M.Y. Read, J.L.A. Catindig, J.A. Cheng, L.P. Lan and K.L. Heong. 2011. Parasitoids of Asian rice plant hopper (Hemiptera: Delphacidae) pests and prospects for enhancing biological control by ecological engineering. Ann. Appl. Biol. 158:149–176.
- Gurr, G.M., M.Y.R. Donna, L.A.C. Josie L.A. Catindig, J. Cheng, J. Liu, L. P. Lan and K. L. Heong. 2012. Parasitoids of the rice leaf folder *Cnaphalocrocis medinalis* and prospects for enhancing biological control with nectar plants. Agri. Forest Entomol. 14:1–12.
- Heinrichs E.A., F.E. Nwilene, M.J. Stout, B. Hadi, T. Frietas. 2017. Rice Insect Pests and Their Management. Cambridge: Burleigh Dodds Science. Publishing: 277.
- Horgan, F.G. and E.P. Kudavidanage. 2020. Use and avoidance of pesticides as responses by farmers to change impacts in rice ecosystems of southern Sri Lanka. Environ. Manag. 65:787–803.
- Iqbal, M. F. and M. Hussain. 2016. Efficacy of different insecticides for controlling leaf folder in transplanted rice. Int. J. Curr. Res. Biol. Med. 1(6):12-15.
- Khush, G.S. 1997. Origin, dispersal, cultivation and variation of rice. Plant Mol. Biol. 35(12):25-34.
- Kiran, R. and R. Veeranna. 2012. Evaluation of bio-pesticide *Metarhizium anisopliae* against brown plant hopper (*Nilaparvatha lugens*) and its efficiency on the improvement of the productivity of paddy. Int. J. Plant Prot. 5:81-83.
- Kumar, K.A., A.S.R. Sarma, T. Madhumathi and V.P. Kumari. 2018. Study on Efficacy of pesticide mixtures as foliar sprays for the management of rice leaf folder (*Cnaphalocrocis medinalis*) and leaf blast (*Pyricularia oryzae*) on Paddy. Int. J. Curr. Microbiol. App. Sci 7(11): 2163-2175.

- Mamoon-ur-Rashid, M., R. Bibi, M.K. Khattak, A. Momin, M. Amir and A. Latif, 2013. Misra, H.P., 2008. Management of the rice leaf folder, C*naphalocrocis medinalis* (Guenee) by newer insecticides. Oryza. 45(3):252-254.
- Memon, N.A. 2013. Rice important cash crop of Pakistan. Pak. Food J. 21-23.
- Satish, D., S. Chander and G. Reji, 2007. Simulation of economic injury levels for leaf folder (*Cnaphalocrosis medinalis* Guence) on rice (*Oryza sativa* L.). J. Sci. Ind. Res. 66:905-911.
- Selvaraj, K., S. Chander, M. Sujithra. 2012. Determination of multiple-species economic injury levels for rice insect pests. Crop prot. 32:150-160.
- Sharmah, D. 2015. Eco-friendly management of rice leaf folder (*Cnaphalocrocis medinalis*) Guenee (Pyralidae: *Lepidoptera)* in South Tripura, India. International Journal in Physical and Applied Sciences. 2 (9):1-7.
- Sherawat, S.M., M. Inayat, T. Ahmad and M.K. Maqsood. 2007. Determination of economic threshold levels (ETL) for the chemical control of rice stem borers. J. Agric. Res., 45(1): 55-59.
- Vaughan, D.A. 1994. The wild relatives of rice (A genetic resources handbook). IRRI, Manila, Philippines. 137.
- Wakil, W., Mansoor-ul-Hasan, R. Akbar and A. Gulzar. 2001. Evaluation of different insecticides against rice stem borer and rice leaf folder. Pak. J of Agri. Sci. 38(3-4):49-50.
- Zhang, K., W. Zhang, S. Zhang, S.F. Wu, L.F. Ban, J.Y Su, and C.F. Gao. 2014. Susceptibility of *Sogatella furcifera* and *Laodelphax striatellus* (Hemiptera: Delphacidae) to six insecticides in China J. Econ. Entomol. 107:1916-1922.