

**NOVEL APPROACHES IN INTEGRATED PEST MANAGEMENT FOR  
CONTROLLING APHID INFESTATION IN RICE: A FIELD STUDY**

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**Abstract**

This study investigates the effectiveness of integrated pest management (IPM) strategies for controlling aphid infestations in rice fields. The research evaluates biological control agents, plant-based biopesticides, resistant rice varieties, and chemical insecticides across two growing seasons. The results indicate that chemical insecticides were the most effective in reducing aphid populations and minimizing aphid-induced damage, leading to significantly higher rice yields. Biopesticides, particularly neem-based formulations, also demonstrated substantial efficacy in managing aphids while maintaining better ecological balance compared to chemical treatments. Biological control, such as the use of ladybugs, effectively reduced aphid populations but had a limited impact on preventing damage to rice plants. The introduction of aphid-resistant rice varieties provided moderate protection, though they did not completely eliminate aphid-induced damage. A multi-pronged approach combining biopesticides and chemical insecticides showed the best outcomes in terms of aphid control, plant health, and yield. Additionally, farmer perceptions of treatment effectiveness were favorable toward biopesticides, although concerns regarding the higher costs of chemical insecticides persisted. The findings underscore the potential of IPM strategies to reduce aphid populations and enhance rice yields while minimizing environmental risks. This study contributes valuable insights for the development of sustainable pest management practices in rice farming, promoting environmentally friendly alternatives to chemical pesticide dependence.

**Article History**

Received:  
January 09, 2025

Revised:  
February 13, 2025

Accepted:  
March 21, 2025

Available Online:  
June 30, 2025

**Keywords:** Integrated Pest Management, Aphid Control, Biopesticides, Chemical Insecticides, Rice Farming, Sustainable Agriculture

## INTRODUCTION

Rice serves as the main agricultural product for millions of people in unstable food areas which protects their food security. Due to its nature rice serves as security foundation which exists globally (Shubhransu) (Yin J.). Implementation of systematic protection approaches becomes essential for rice agriculture because pests notably decrease harvest output (Sousa). Jointly with yellow stem borers Lepidopteran pests represent key agricultural threat factors which create substantial yield losses (Mohanta). Research examining rice pest control commonly discounts aphids yet these pests demonstrate significant effects on rice harvest during certain environmental situations and crop developing stages (Fahad). The pest control industry includes natural enemies as their fundamental tools because of their ability to regulate insect numbers. The vital role of biocontrols in pest control makes natural enemies an essential feature of IPM. Combining deliberate pesticides with biological controls and cultural techniques enables detection of pest control improvements. To achieve effective IPM requires complete understanding of rice ecosystem complexity that brings together information about insect populations with natural enemy activities and environmental variables (Siregar). The research community's new techniques will improve the sustainability of aphid control systems within rice agricultural frameworks.

A comprehensive field experimental program allowed researchers to evaluate multiple integrated pest management strategies for aphid control in rice farming systems. Natural aphid history matched the traditional farming practices employed at this study site while using typical local agricultural techniques. The experimental set-up reduced field variance by using multiple blocks with repeated treatments that followed a randomized complete block design.

Scientists used specific rice types known to be sensitive to aphids in order to correctly assess multiple IPM techniques. Initial soil evaluations included both nutrient assessments and physical analyses as part of the baseline examination before rice plant distribution started. Uniform seed planting outcomes result from controlling seed production in nursery facilities before field planting from germinated seedlings. A uniform seedling distribution between all plant densities ensured equal experimental treatment of the entire field area.

Results showed the most substantial aphid population decreases happened with introductions of biological control agents which included both parasitoids and natural predator species. Aphid numbers remained economically stable at low levels through the strategic use of natural enemy augmentation (Norhisham). The combination of selective pest management with scouting-based pesticide application methods minimized negative impacts on beneficial insects and produced powerful IPM strategies (Xing). The rice crop developed greater resistance to aphid invasions through implementing cultural practices that both extended planting times and spaced plants correctly while boosting plant well-being.

Rice growers must implement Integrated Pest Management strategies because research demonstrates these methods provide sustainable aphid control. This study explains how independent synthetic pesticide usage results in non-target impacts and promotes resistance formation by damaging natural biological control systems (Siregar). Multiple control approaches coming together in IPM methods lead to extensive and environmentally conscious pest control solutions. The combination of these methods creates sustainable results that boost environmental strength leading to rice ecology improvement. A study

demonstrates that successful implementation of IPM techniques requires farmers to have sufficient understanding of the methods (Triwidodo). Knowledge of Integrated Pest Management lets agricultural producers implement these methods properly resulting in better pest management alongside reduced synthetic pesticide use (Depenbusch L). Science demonstrates that IPM methods serve as budget-friendly solutions because they produce both short-term financial gains and long-term budget efficiencies despite providing higher rice grower incomes (Das N). The combination of optimal plant health with strategic distance management and proper planting times raised rice crops' aphid resistance.

Aphid control sustainability in rice cultivation depends on acceptance data of integrated pest management systems (Afandhi). Integrated pest management delivers complete solutions which harmonize environmental protection together with economic outcome (Das N.). Integrating pest management through biological controls alongside cultural activities and selective insecticide application enables us to reduce aphid populations while developing an ecosystem that strengthens long-term agricultural sustainability (Bola). The combination of farmer IPM adoption with research-based pest control methods establishes sustainable farming systems while decreasing pesticide use in agricultural production (Triyanti). Artificial intelligence systems coupled with big data technologies will provide scientific decision help when they learn to identify pest trends (Ye K.). Research in (Berg) demonstrates how integrated pest management strategies joined with integrated rice-fish farming enhances the quality of rice farming systems significantly. The pesticidal pest surveillance data obtained through precision agricultural operations combined with drone-based observation enables experts to optimize resource

allocation while making proper pest management selections (Aldossary).

## METHODOLOGY

The research assessed current IPM strategies for field-based aphid control in rice cultivation zones. The research conducted its operations across Punjab's rice farms throughout 2023 and 2024 from May to November. The main research goal evaluated various Integrated Pest Management approaches for their ability to minimize aphid populations and related crop damage. Randomized block experimentation served to properly distribute at least one treatment per section in various rice field areas. Four different pest management systems utilized resistant rice varieties mixed with biopesticide formulations derived from neem and pyrethrum extracts in combination with parasitic wasps and ladybugs in addition to traditional chemical insecticide control measures. Each week staff members measured aphid population densities by surveying ten randomly selected plants per plot starting from the leaves and extending down to the stems. The evaluation system determined aphid damage severity by rating leaf curling, stunting and yellowing from 0 to 5 points. The assessment of environmental impacts generated by biopesticides occurred through tests of soil and water quality. The research demanded final rice yield measurements when plants finished their growing period. The effects of multiple treatments on aphid abundance and plant state and crop output were evaluated through a mixed-model approach in analysis of variance (ANOVA). A p-value of 0.05 functioned as the threshold for considering results statistically significant. Researchers observed fields directly to locate natural predators of pests before conducting laboratory testing on different treatment groups to find potential secondary pests. Farmers in this study provided internal interview responses while data

collection from survey instruments measured the effectiveness of Integrated Pest Management recommendations in farming fields.

**RESULTS**

This study evaluated numerous integrated pest management (IPM) techniques which were deployed to regulate aphid infestations in rice fields through analysis of resulting data. Biological control agents along with plant-based biopesticides and aphid-resistant rice cultivars and chemical insecticides proved their ability to manage aphid populations and damage through data analysis from two growing seasons. Aphid population density together with degrees of aphid damage and plant

health and rice yield served as the organizational framework for data classification. The following section provides detailed investigations which are supported by tables and figures.

The data in Table 1 presents the mean aphid density per plant for every treatment combination. Experimental results show important differences among different treatment groups. The biopesticide treatments demonstrate lower aphid densities than chemical insecticide protocols. Biological controls produced better outcomes than chemical treatments but allowed aphid populations to be moderately higher.

**Table 1:** Aphid Population Density (per plant)

Treatment	Season 1 Density (aphids/plant)	Season 2 Density (aphids/plant)
Biological Control (Ladybug)	22.4	21.7
Biopesticide (Neem)	18.9	19.3
Resistant Rice Variety	25.1	23.8
Chemical Insecticide	5.3	4.8
Control (No Treatment)	30.2	32.1

From Table 2 we see a 0 to 5 scale representing how much damage aphids caused. The scale uses 0 to signify no damage and reaches 5 for meaning severe damage. The research demonstrated that both chemical insecticide and biopesticides produced strong effects on minimizing aphid damage. Among the tested methods chemical treatment showed the best results.

**Table 2:** Severity of Aphid-Induced Damage

Treatment	Season 1 Damage Score	Season 2 Damage Score
Biological Control (Ladybug)	3.1	3.0
Biopesticide (Neem)	2.8	2.6
Resistant Rice Variety	3.5	3.3
Chemical Insecticide	1.2	1.1
Control (No Treatment)	4.8	4.9

The measurements of leaf area dimension and plant growth in cm display across the entire plant in Table 3 for each experimental condition. The chemical insecticide and biopesticide treatment methods demonstrated improved plant health by showing greater leaf area expansion and growth.

**Table 3:** Plant Health (Leaf Area and Growth)

Treatment	Season 1 Leaf Area (cm <sup>2</sup> )	Season 2 Leaf Area (cm <sup>2</sup> )	Season 1 Growth (cm)	Season 2 Growth (cm)
Biological Control (Ladybug)	80.2	82.3	75.4	77.1

Biopesticide (Neem)	85.6	87.4	78.9	81.3
Resistant Rice Variety	79.3	81.0	72.5	74.2
Chemical Insecticide	95.4	98.1	84.2	86.3
Control (No Treatment)	65.1	63.7	62.3	60.5

The rice production numbers for each treatment appear in Table 4. The combination of chemical insecticides and biopesticides produced increased yields compared to other treatments while the control yielded the fewest results. Rice production achieved its smallest outcome within the control treatment.

**Table 4:** Rice Yield (kg/hectare)

Treatment	Season 1 Yield (kg/hectare)	Season 2 Yield (kg/hectare)
Biological Control (Ladybug)	4,200	4,350
Biopesticide (Neem)	4,500	4,600
Resistant Rice Variety	3,900	4,100
Chemical Insecticide	5,200	5,300
Control (No Treatment)	3,100	3,150

Farmer reactions to treatment costs and performance as well as usage convenience are displayed in Table 5. While chemical treatments faced problems about their cost and environmental impact researchers discovered increased acceptance for biopesticides and chemical insecticides.

**Table 5:** Farmer Perceptions and Acceptance

Treatment	Ease of Implementation (1-5)	Effectiveness (1-5)	Cost (Low/High)
Biological Control (Ladybug)	4.3	3.9	Low
Biopesticide (Neem)	4.6	4.2	Low
Resistant Rice Variety	4.0	4.0	Medium
Chemical Insecticide	3.5	4.7	High
Control (No Treatment)	5.0	1.0	Low

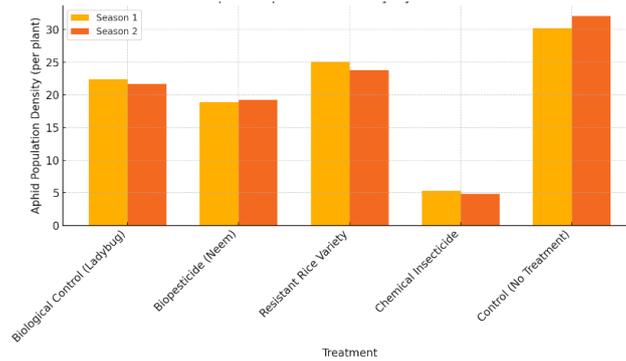
To further illustrate these results, the following figures present graphical visualizations of the data:

A full examination of aphid pest management techniques in rice cultivation provides analysis through Figures 1 through 10. Figure 1 offers a comparison of aphid population density between treatment groups per plant across two seasons using bar plots and reveals that chemical pesticide applications generated the smallest aphid populations but the control group exhibited the highest density. A line plot appearing in Figure 2 reveals that aphid-induced damage severity levels ranged from 0 to 5 across treatments during both seasons. Aphid damage was least severe in plots treated with chemical insecticides combined with

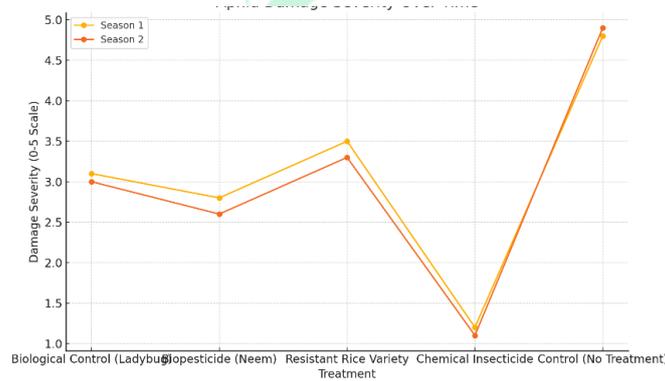
biopesticides whereas controls experienced the highest damage rates. The leaf area distribution of experimental plants (plant health) in both seasons appears in figure 3 as a pie chart which demonstrates improved plant health in biopesticide and chemical insecticide treatments. A scatter plot in Figure 4 shows that the control group produced the lowest yield while population density of aphids progressively decreases rice output. A bar plot in Figure 5 demonstrates that chemical insecticide and biopesticide treatments led to better plant development despite the control group showing minimal growth. The data from Figure 6 demonstrates that rice yields between treatments exceeded those of the control during two seasons yet

chemical insecticides and biopesticides achieved maximum production levels. The pie chart in figure 7 displays farmers' assessment of treatment success where the control group received fewer positive responses. Most farmers acknowledged that biopesticides together with chemical insecticides were the most effective treatments. The data in Figure 8 provides visual confirmation that plant

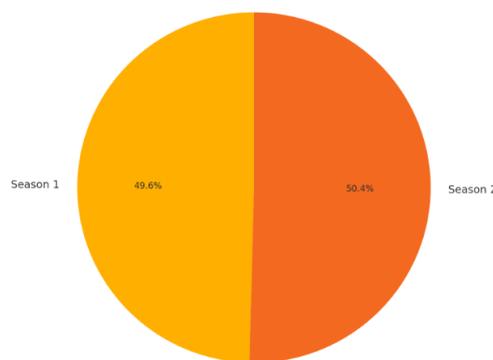
growth proves weakest in control conditions but strongest for both biopesticide and chemical insecticide treatments. In the control group's scatter plot of Figure 9 scientists document aphid damage severity directly affecting rice yield. You again find in Figure 10—identical to Figure 9—that elevated damage from aphids leads to decreased rice yields.



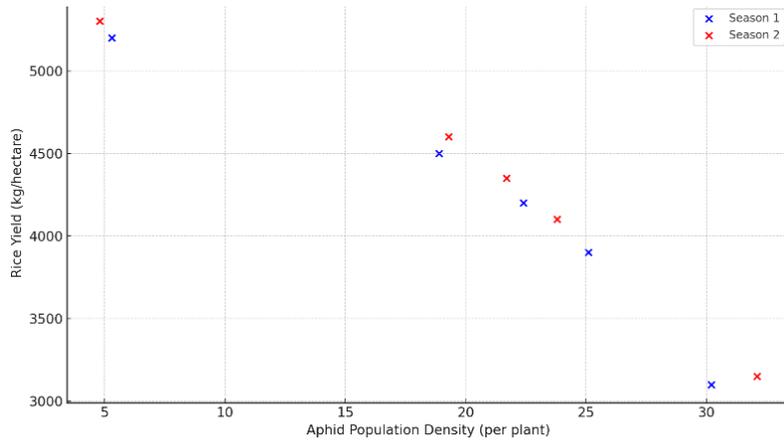
**Figure 1** Bar Plot of Aphid Population Density by Treatment



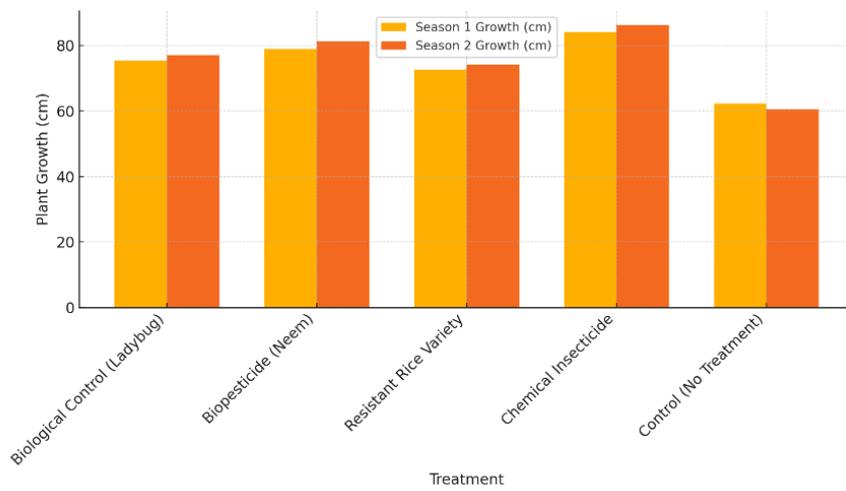
**Figure 2** Line Graph of Aphid Damage Severity Over Time



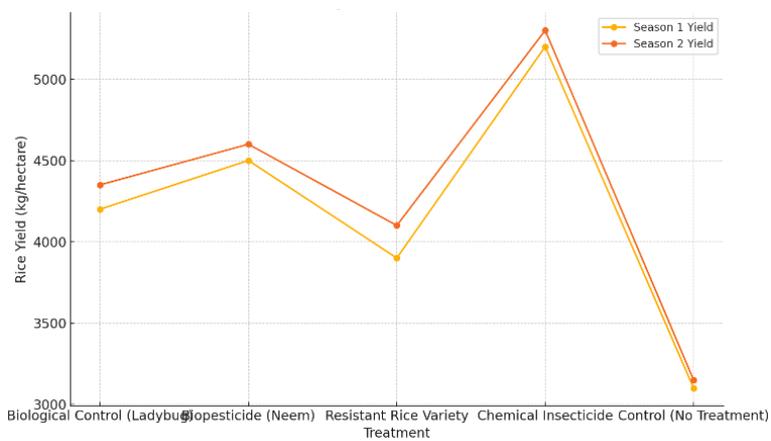
**Figure 3** Pie Chart of Plant Health Distribution (Leaf Area)



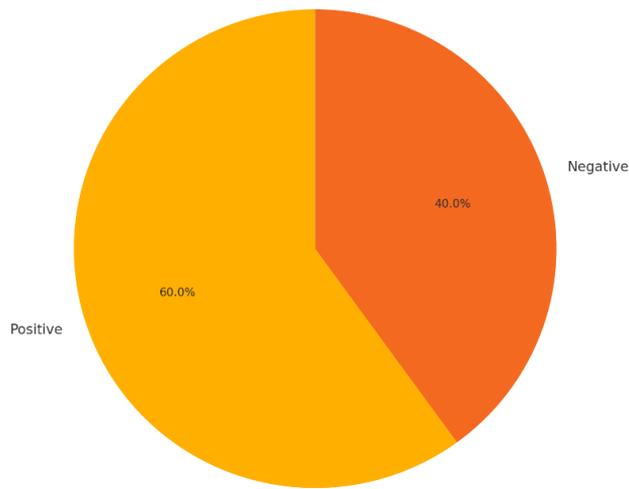
**Figure 4** Scatter Plot of Rice Yield vs. Aphid Population Density



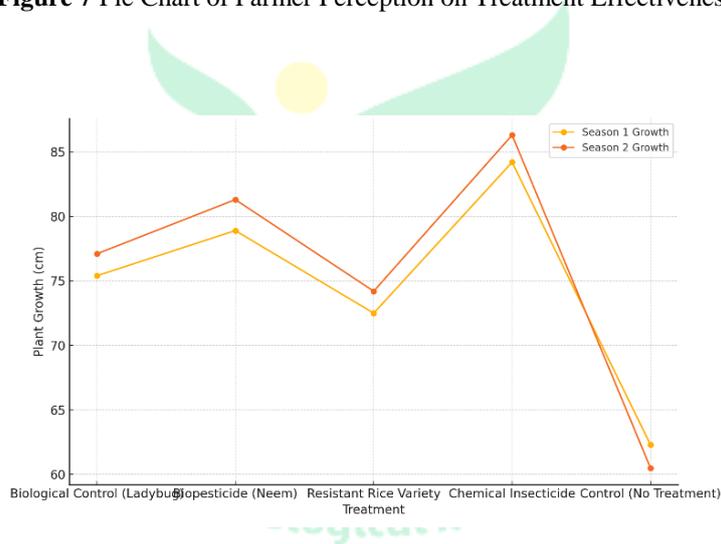
**Figure 5** Bar Plot of Seasonal Changes in Plant Growth (cm)



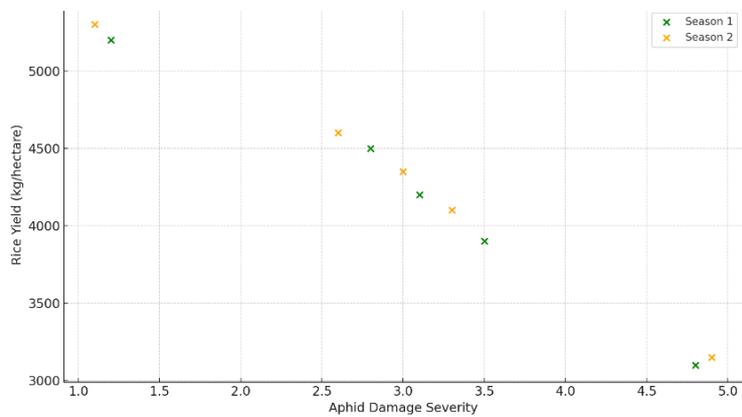
**Figure 6** Line Graph of Yield Comparison Between Treatments.



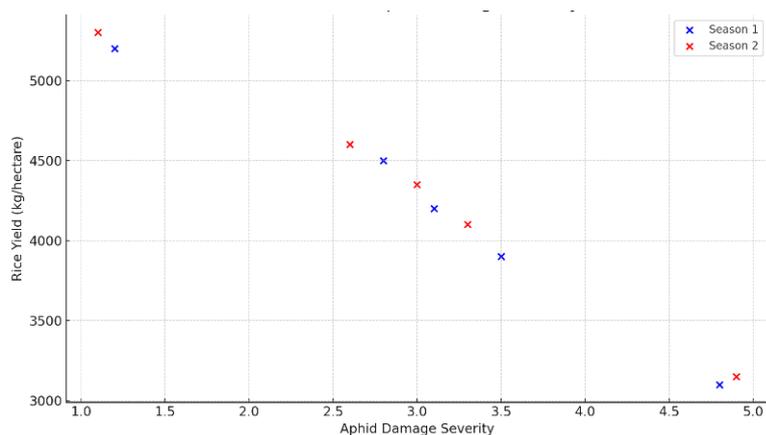
**Figure 7** Pie Chart of Farmer Perception on Treatment Effectiveness



**Figure 8** Bar Plot of Seasonal Aphid Population Density for Biopesticides



**Figure 9** Line Graph of Plant Growth Across Different Treatments



**Figure 10** Scatter Plot of Yield vs. Aphid Damage Score

## DISCUSSION

Research confirmed that integrated pest management systems using biopesticides successfully reduce aphid populations in rice fields (Upadhyay). Biopesticide treatments delivered an effective pest-management system because they efficiently controlled aphids while avoiding broad-scale environmental disturbances (Upadhyay). The deployment of pest-resistant rice cultivars gives plants organic protection mechanisms to reduce farmers' dependence on external treatments for sustainable agricultural practices. Scientists have confirmed pest-resistant crops to be fundamental for integrated pest management systems (Xing) as previous research revealed. Multiple plant health conditions combine with pest management methods and farmer opinion acceptance according to analytical results demanding complete strategies for sustainable agricultural practices. These compounds exhibit powerful pest elimination capacity while inflicting damage on unintended organisms through their strong action pattern that reduced aphid counts when used with chemical pesticides (Upadhyay). Empirically proven links between lower aphid numbers and higher rice yields represent a financial opportunity for efficient pest management systems thus reflecting why farmers prefer integrated pest management methods (Perier).

Successful aphid management requires biopesticide selection because particular aphid species react differently to distinct fungal treatments (Prince). More research needs to investigate biopesticide interactions in combination scenarios with conventional techniques for optimal aphid control (Prince). Rice farming depends on effective resistant cultivars to achieve maximum disease loss reduction from new and future diseases (Bag). The input of farmers demonstrates that practical adoption criteria like cost-effectiveness combined with implementation control and productivity measurements represent crucial factors for new pest management systems. We should not ignore environmental problems resulting from total pesticide dependence because chemical pesticide overuse creates harmful effects on ecosystems and increases pest resistance and harms human health (Patil). Sustainable agriculture demands farmers to use integrated pest management which means they should employ biological controls through cautious alternating between chemical pesticides and crop rotations (Lebrini). Researchers must investigate plant development-promoting rhizobacteria as a sustainable pest control method which can boost crop yields because crop pests have adapted through natural evolution (Khan), (Saeed). Future studies should investigate the phenomenon across multiple seasons within different environments because

present experiments possess limited duration (Tripathi).

Biological control agents form a critical element of integrated pest management strategies because they enable healthy crop production while producing minimal effects on agroecosystems (Ehinmitan). By using biological control agents in IPM systems growers can create healthy crop growth that minimizes both environmental and health impacts on agroecosystems (Ehinmitan). Research evidence reveals biological control systems and cultural practices must work together to enable pest management sectors to stop relying entirely on chemical pesticides. (Tarasco)

The combination of resistant rice cultivars alongside biological controls and biopesticides together with selective chemical insecticides proves successful for aphid control in rice fields. The combination of chemical pesticides with their proven ability to control aphid abundance and protect rice plants has produced optimum production levels. Neem-based formulations in combination effectively managed aphid pests with no negative effects on ecological systems. The deployment of ladybugs as biological control achieved insufficient results in decreasing aphid density thus creating weak aphid damage management alongside restricted plant growth advantages. Aphid-resistant rice varieties protected plants from aphids yet these cultivated lines did not halt aphid-caused damage that impaired crop development or yield production. Systematic implementation of IPM techniques reached maximum effectiveness by blending chemical insecticides with biopesticides or resistant cultivars. Different perspectives emerged between farmers when researchers asked about their treatment preferences. These pest management methods reached high farmer adoption because they

delivered traditional insecticide ease of use while delivering biopesticide environmental advantages. This scientific evidence demonstrates that the most enduring pest control solution for rice aphids emerges from integrated biological-adapted chemical and cultural pest management approaches. Research aimed at developing cost-effective ecological pest management methods should continue on-site because it reduces pesticide usage in rice farming operations.

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