Journal of Agricultural Innovation and Food Security Global
Volume 1, Number 2, 2025. pp. 56-61
e-ISSN 3109-385X
e-journal.nusantaraglobal.ac.id/index.php/jaifsg/index

Evaluating Integrated Pest Management Effects on Corn Resistance and Productivity Against Major Insect Pests in Indonesia

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Article Info

Article history:

Received: 20-11- 2025
Revised: 15-12- 2025
Accepted: 25-12- 2025

ABSTRACT

Integrated Pest Control (PHT) is a strategic approach in corn cultivation to suppress major pest attacks effectively, sustainably, and environmentally friendly. Corn plants in Indonesia are susceptible to various pests such as armyworms (Spodoptera frugiperda), stem borers (Ostrinia furnacalis), and aphids (Aphis maidis) which can significantly reduce productivity. Evaluation of the implementation of PHT is needed to determine the effectiveness of control techniques such as pest monitoring, the use of resistant varieties, agroecosystem management, and the use of natural enemies. This study aims to examine the implementation of PHT in corn fields and assess its impact on the level of pest attacks and increasing plant resilience. The results of the evaluation showed that the combination of intensive monitoring, release of biological agents, land sanitation, and the use of selective pesticides based on economic thresholds was able to reduce pest attacks by more than 45% and increase productivity by 15–25% compared to conventional methods. This study confirms that PHT is an effective and sustainable approach in pest control in corn plants.

Keywords: Corn crops, crop resistance, corn main pests

How to cite: Marlina (2025). Evaluating Integrated Pest Management Effects on Corn Resistance and Productivity Against Major Insect Pests in Indonesia. *Journal of Agricultural Innovation and Food Security Global*, *1*(2), 56–61. https://doi.org/10.55681/jaifsg.v1i2.126

INTRODUCTION

Corn (*Zea mays* L.) is one of the most strategic food crops in Indonesia, playing a crucial role in national food security and the livestock feed industry. As the second most important source of carbohydrates after rice, maize has high economic value, with demand increasing steadily due to rapid expansion of the poultry and animal feed sectors. Globally, more than 60% of maize production is utilized for animal feed, reflecting similar trends in Indonesia where feed industries absorb the majority of domestic maize output (Shiferaw et al., 2011; Ranum et al., 2014). Ensuring sustainable maize production is therefore essential to support food systems and rural livelihoods.

Despite its importance, maize cultivation in tropical regions faces significant constraints, particularly from insect pest infestations. Major pests such as the fall armyworm (*Spodoptera frugiperda*), Asian corn borer (*Ostrinia furnacalis*), and seed flies pose serious threats due to their high reproductive capacity, adaptability, and increasing resistance to synthetic insecticides. *Spodoptera frugiperda*, an invasive and highly destructive pest, has spread rapidly across Asia since its first detection and is capable of causing yield losses exceeding 70% under severe infestation levels (Goergen et al., 2016; Day et al., 2017). In Indonesia, the continued expansion of fall armyworm populations has intensified production risks and challenged conventional pest management practices.

Farmers' heavy reliance on chemical pesticides has resulted in several negative consequences, including pest resistance, environmental contamination, disruption of natural enemy populations, and health risks to applicators. Numerous studies have demonstrated that indiscriminate pesticide use often leads to pest resurgence and secondary pest outbreaks, ultimately reducing the long-term effectiveness of pest control strategies (Geiger et al., 2010; Pretty & Bharucha, 2015). These challenges underscore the need for more sustainable and ecologically sound pest management approaches.

Integrated Pest Management (IPM) has been widely recognized as an effective and sustainable strategy for managing crop pests worldwide. IPM integrates multiple control methods, including the use of resistant varieties, biological control agents, cultural practices, pest monitoring, and the judicious application of pesticides only when pest populations exceed economic thresholds. The primary objective of IPM is not the complete eradication of pests, but rather the maintenance of pest populations below economically damaging levels while preserving agroecosystem stability (Kogan, 1998; Dent, 2021).

In maize production systems, IPM is particularly relevant due to the complex pest dynamics and the availability of diverse biological control options. Studies have shown that natural enemies such as *Telenomus* spp. and *Trichogramma* spp. parasitoids play a significant role in suppressing early-stage populations of armyworms and stem borers (Hruska, 2019; Kenis et al., 2019). Additionally, the use of pheromone traps and routine field monitoring has been proven to reduce insecticide applications by up to 40% while maintaining yield stability in Southeast Asian maize systems (Sarina & Singh, 2020).

The effectiveness of IPM, however, is highly dependent on farmers' knowledge and skills in pest identification, monitoring techniques, and decision-making based on economic thresholds. Limited understanding of pest biology and natural enemies often leads to inappropriate control measures and excessive pesticide use. Furthermore, restricted access to biocontrol agents, pheromone traps, and resistant maize varieties continues to hinder widespread adoption of IPM among smallholder farmers (Parsa et al., 2014; Horgan et al., 2016).

Although IPM has been promoted in Indonesia for several decades, its implementation at the farm level remains inconsistent. Variations in agroecological conditions, extension services, and farmers' capacity contribute to uneven adoption rates. Evaluating the implementation of IPM in maize cultivation is therefore essential to identify the most effective control components, understand constraints faced by farmers, and develop context-specific recommendations for improving pest management efficiency and sustainability.

Given the increasing pressure from invasive pests such as *Spodoptera frugiperda* and the growing demand for maize, a systematic evaluation of IPM practices is urgently needed. Such evaluation can provide critical insights into pest population dynamics, pesticide use patterns, the effectiveness of biological control agents, and the overall impact of IPM on maize productivity. Ultimately, strengthening IPM implementation is expected to enhance the resilience of maize production systems and support environmentally sustainable agricultural development.

METHODS

This study uses a descriptive-analytical approach with field study methods and literature studies to evaluate the effectiveness of the application of Integrated Pest Control (PHT) in corn crop cultivation in the face of major pest attacks. This method was chosen because it allows researchers to obtain an empirical picture of PHT strategies implemented at the farmer level, as well as compare them with the findings of previous research. The research was conducted on corn production centers that consistently face major pest threats such as *Spodoptera frugiperda* (Laughter) *Helicoverpa armigera*, and *Ostrinia furnacalis*. The sampling technique uses the purposive sampling method by selecting agricultural land that has applied PHT for at least the last two planting seasons, so that the data obtained has a high level of relevance to the research objectives.

Primary data was collected through direct observation of plant conditions, the presence of pests, attack intensity, and control techniques used by farmers. Semi-structured interviews were conducted with farmers, agricultural extension workers, and farmer group leaders to gain an in-depth understanding of PHT implementation, implementation barriers, and success rates. In addition, secondary data was obtained through scientific journals, research reports, publications of the Food and Horticulture Crop Protection Center, and official government documentation regarding PHT guidelines. All data were analyzed using descriptive analysis techniques by examining the relationship between the application of PHT components—such as the use of resistant varieties, crop rotation, monitoring of pest populations, and selective pesticide use and changes in the intensity of pest attacks.

Data analysis is carried out systematically through the stages of data reduction, data presentation, and conclusion drawn. Each finding was compared between research locations to see variations in the effectiveness of PHT implementation. The results of the analysis were then combined with literature data to produce a comprehensive picture of the role of PHT in increasing corn resistance to major pest attacks. With this method, the research is expected to provide scientific recommendations that can be used by farmers, extension workers, and policymakers in strengthening pest control strategies that are more environmentally friendly and sustainable.

RESULT AND DISCUSSION

The results of the study on the evaluation of Integrated Pest Control (PHT) on corn plants show that the implementation of the PHT strategy is able to increase plant resistance and significantly reduce the intensity of major pest attacks. In the context of corn cultivation in various production center areas in Indonesia, the existence of pests such as *Ostrinia furnacalis* (rod borer), *Spodoptera frugiperda* (Fall Armyworm/FAW), *Helicoverpa armigera* (fruit caterpillar), and aphids (*Aphis maidis*) is often a limiting factor in production because it has the potential to reduce productivity by up to 30–70% if not managed properly. Therefore, the implementation of PHT is an approach that is not only ecological, but also economical and sustainable, because it integrates various control techniques ranging from monitoring, the use of resistant varieties, biological control, to the selective use of pesticides.

The results of observations in the field showed that farmers who applied routine monitoring used pheromone traps to monitor the presence of stem borer pests and *Spodoptera frugiperda* have a faster control response than farmers who rely only on visual forecasts on the land. Daily and weekly monitoring provide an overview of the pest population so that control actions can be carried out according to economic thresholds. In several regions such as Lampung, East Java, and Gorontalo, the implementation of organized monitoring has succeeded in suppressing FAW attacks from the severe category to the medium to light category. The data obtained showed that the intensity of leaf damage due to FAW can be reduced by up to 40% only with a combination of effective monitoring and the application of biological control based *Bacillus thuringiensis*.

The use of resistant varieties is also an important part of the PHT system. Corn varieties such as BISI-18, Pioneer P32, and some local hybrid varieties have been shown to have better tolerance to stem borer and leafworm attacks. In experimental land in Central Java, the use of resistant varieties was able to increase the rate of leaf photosynthesis during the vegetative period and reduce the damage to the growth point by up to 60%. This has a direct impact on increasing the weight of the cob, the number of seed rows, and the weight of 1000 seeds. The combination of resistant and monitoring varieties proved to be two basic components in the PHT system that contributed greatly to improving plant resilience.

In addition, biological control through the utilization of natural enemies shows an effective role in keeping pest populations below economic thresholds. Predators such as beetles *Coccinellidae*, soil spiders, and parasitoids *Trichogramma spp.* Proven to help suppress egg populations and larvae of major pests. In some study locations, the release of *Trichogramma* periodically increase the parasitization rate of stem borer eggs by up to 70%, so that the pest development cycle can be interrupted before entering the destructive larval phase. This biological control also shows a positive impact on the health of the agroecosystem because it does not cause chemical residues that are harmful to the environment or non-target organisms. In addition, biological approaches can increase the biodiversity of soil microorganisms which ultimately strengthens sustainable farming systems.

The use of pesticides remains part of PHT, but its application must be carried out selectively based on the concept of economic threshold and rotation of active ingredients. The results of the study show that pesticide spraying carried out without considering the pest population threshold actually accelerates pest resistance, decreases the effectiveness of biological control, and increases production costs. Therefore, pesticides are only recommended in conditions where the pest population has exceeded the threshold of action, for example the intensity of FAW damage has reached more than 20% in the initial vegetative phase. The use of active ingredients such as chlorantraniliprol and spinetoram is still considered effective for FAW control when applied appropriately and in turn to slow down the pest resistance process. In some plot demonstration sites, the combination of biological control and selective pesticide application was able to reduce the intensity of FAW attacks by up to 65% compared to the use of a single pesticide.

The results of the evaluation also highlight the importance of land cultivation and sanitation as an integral part of PHT. Simultaneous planting in one area (area-wide management) has been shown to reduce the migration and reproduction of pests, especially FAW and stem borers, because uniform planting cycles inhibit the continuous development of pest populations. Clearing up plant debris, weeds, and damaged cobs at the end of the growing season is also an important step in minimizing inoculum sources and pest hiding places. In some research areas, intensive land sanitation reduced the initial pest population by 30–40% in the next planting season. Healthy cultivation such as the use of balanced fertilization, regular irrigation, and soil management also make a significant contribution to improving plant resilience.

In addition to the technical component, the results of this study also emphasize the importance of the role of extension and education of farmers. Many farmers in corn-centered areas do not fully understand the concept of PHT and tend to rely on pesticides as the main step. Extension programs carried out through field schools, plot demonstrations, and technical training have been proven to improve farmers' ability to identify pests, implement monitoring, and carry out control according to PHT recommendations. In some assisted villages, the adoption rate of PHT increased from 40% to more than 80% after intensive counseling. This increase in farmers' ability is directly correlated with an increase in crop yields of 1–1.5 tons per hectare.

Overall, the results of the study show that the comprehensive implementation of PHT is able to increase the resistance of corn plants to major pest attacks while maintaining the balance of the agricultural ecosystem. An integrative approach that involves monitoring, resistant varieties, biological control, healthy cultivation, and selective pesticides is the key to the success of effective and environmentally friendly pest control. The implementation of PHT not only increases crop yields but also reduces production costs and environmental pollution risks, so that it can be a strategic solution to improve the sustainability of corn farming businesses. The findings of this study also show that the success of PHT is greatly influenced by the consistency of farmers in implementing each component. When the components are partially executed, the effectiveness of the control decreases significantly. Therefore, PHT must be understood not as a series of separate actions, but as an integrated system that requires cooperation between farmers, extension workers, and agricultural agencies.

CONCLUSION

Integrated Pest Control (PHT) in corn plants has proven to be an effective, sustainable, and adaptive approach in increasing plant resistance to various major pest attacks such as *Ostrinia furnacalis*, *Spodoptera litura*, and *Helicoverpa armigera*. Various components of PHT, including biological control, the use of pest-resistant varieties, agroecosystem management, pest population monitoring, and the application of pesticides based on economic thresholds, complement each other in creating a more efficient plant protection system. Based on the study of research results and application in the field, the combination of PHT techniques can significantly reduce the intensity of pest attacks, improve plant health, and reduce farmers' dependence on synthetic chemical pesticides that have often been used excessively.

In addition, the application of PHT not only contributes to increasing corn productivity, but also provides ecological benefits such as the preservation of natural enemies, increased land biodiversity, and the reduction of chemical residues that are harmful to soil health and the environment. Thus, PHT is an important strategy in supporting sustainable agricultural systems, especially in corn production center areas. However, the successful implementation of PHT is highly dependent on farmers' knowledge and skills, the availability of supporting technology, and government policy support in the form of counseling, training, and the provision of biological control facilities. Therefore, strengthening the capacity of farmers and increasing collaboration between researchers, extension workers, and other stakeholders is key to ensuring that PHT can be applied optimally and have a real impact on the resilience of corn crops in the future.

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