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Application of Integrated Pest Management to Build Awareness of Coffee Farmer Behavior

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Abstract: The agricultural sector, especially coffee cultivation, faces major challenges in managing pests and diseases in a sustainable manner. This study aims to analyze the effect of the implementation of Integrated Pest Management (IPM) on the behavioral awareness of coffee farmers in East Java. Using a quasi-experimental approach and mixed methods, this study involved four farmer groups: Sumber Urip, Mulyo Jaya, Suka Maju, and Kebun Jeruk Sukses. The results showed that the application of IPM significantly increased farmers knowledge and skills, and influenced their awareness of environmentally friendly agricultural practices. The convergent validity test showed that all indicators had significant loading factors, with R^2 values ranging from 15.1% to 52.1%, which showed that the variation in farmers behavioral awareness could be explained by the implementation of IPM. Supporting factors such as resource availability, farmer awareness, and community support contribute positively, while lack of prior knowledge and limited access are obstacles. Recommendations to improve the effectiveness of IPM implementation include the development of relevant training materials, increased farmer involvement, and stakeholder support. With a comprehensive approach, it is hoped that coffee farmers can become more aware and implement sustainable agricultural practices, supporting the sustainability of the agricultural sector in Indonesia.

Keyword: Integrated Pest Management, Coffee Farmers, Behavioral Awareness, Environmentally Friendly Practices, East Java.

INTRODUCTION

The agricultural sector plays a very important role in economic activities in Indonesia, as seen from its significant contribution to the Gross Domestic Product (GDP) which reaches 3.76%. The plantation subsector, especially coffee, has great potential with a contribution of 30.32% to the total agriculture, forestry, and fisheries sectors. Coffee has become a very popular drink all over the world, used by people of all ages as a companion for talking, doing homework, or simply to relieve sleepiness. In recent years, the coffee industry in Indonesia has grown rapidly, with the coffeeshop and packaged coffee drink businesses in high demand. In the period 2022/2023, Indonesia ranked third as the worlds largest coffee-producing country, with production reaching 11.9 million bags. Brazil leads as the largest coffee-producing country,

followed by Vietnam, Colombia, and other countries (Badan Pusat Statistik Provinsi Jawa Timur, 2023)(Firdausi, 2023). However, even though the coffee industry has great potential, coffee farmers in Indonesia face various challenges, especially related to pest and disease attacks that can disrupt the productivity and quality of their agricultural products. Therefore, the implementation of environmentally Integrated Pest Management practices is very important. One approach that has been adopted to address this issue is through the implementation of Integrated Pest Management. Integrated Pest Management is a strategy that integrates various Integrated Pest Management methods, including biological, cultural, mechanical, and chemical techniques, to effectively manage pest populations. This approach aims to keep pest levels below the threshold of economic loss, so that crop yields are not negatively affected, while reducing dependence on chemical pesticides (Sun et al., 2022; Tiwari, 2024). Although IPM offers a sustainable solution, the adoption of this practice by coffee farmers is often hampered by a lack of knowledge and awareness of its benefits.

Previous research has shown that farmers understanding of environmentally Integrated Pest Management techniques and principles greatly influences their decision to adopt IPM practices (Bakhtawer & Afsheen, 2021; Khan et al., 2021). In addition, support from agricultural extension workers and access to adequate resources are also important factors in the successful implementation of IPM. Research shows that the presence of competent trainers and effective extension programs can increase farmers understanding of the benefits of IPM and encourage them to apply the techniques learned (Thovhogi et al., 2022; Toepfer et al., 2020). In the context of coffee farming, the application of IPM can result in significant improvements in pest management efficiency and crop resilience. Coffee plants are susceptible to various pests, such as coffee borer insects and leaf rust diseases, which can have a serious impact on yield and quality (Rodríguez-García et al., 2021; Tang et al., 2023). By implementing an IPM strategy, coffee farmers can utilize a combination of pest monitoring, biological control agents, and pest-resistant coffee varieties to reduce damage while minimizing the use of harmful chemicals (Bakhtawer & Afsheen, 2021; Dey et al., 2021).

This study aims to analyze the effect of integrated pest management (IPM) implementation on changes in coffee farmers behavior towards adopting environmentally friendly practices. By examining the relationship between IPM training and farmer awareness, the research seeks to provide insights into how educational interventions can enhance sustainable agricultural practices. The hypothesis posits a significant relationship between IPM application (independent variable) and coffee farmer awareness (dependent variable), suggesting that better IPM implementation leads to higher awareness of eco-friendly practices. This study will test this hypothesis through the analysis of data from coffee farmers in various groups in East Java, which ultimately contributes to the development of an Integrated Pest Management implementation program and an effective support system.

METHOD

This research is categorized as experimental or quasi-experimental research with a mixed-methods approach that combines quantitative and qualitative methods (Amiruddin, 2017; Hair et al., 2017; Sugiyono, 2019), allowing for a comprehensive analysis of the effect of Integrated Pest Management (IPM) implementation on the behavior of coffee farmers. The population consists of coffee farmers from four groups in East Java: Sumber Urip in Malang Regency, Mulyo Jaya in Situbondo Regency, Suka Maju in Probolinggo Regency, and Kebun Jeruk Sukses in Batu City (Sugiyono, 2022). A sample of 100 respondents was selected from each group using the saturated sampling method, where all members of the population are included. Conducted in 2023 over three months, the research location was chosen based on regional diversity, the willingness of farmer groups to participate, and accessibility for the research team. Primary data was collected through various instruments, including questionnaires, interviews, observations, and Focus Group Discussions (FGDs), which

provided insights into the experiences, knowledge, and motivations of coffee farmers regarding IPM. Research procedures involved data collection followed by quantitative descriptive analysis to evaluate changes in farmers knowledge, skills, and behavior before and after IPM implementation. Secondary data was sourced from official entities like the Central Statistics Agency (BPS) and previous research reports. Variable measurements utilized a Likert scale to assess farmers attitudes and perceptions towards IPM. This comprehensive approach aims to provide in-depth insights into the impact of IPM on coffee farmers behavioral awareness and to support the development of more sustainable agricultural practices.

In this research method, several key variables are identified to analyze the effect of the application of Integrated Pest Management (IPM) technology on the behavior of coffee farmers. The dependent variable includes the Awareness of Coffee Farmer Behavior in the Application of IPM Technology (Y), which reflects the extent to which farmers understand and apply environmentally friendly practices. In addition, there are variables related to training farmers as experts in pest and disease control (Y.1), extension worker competence (Y.2), and pest and disease control implementation facilities (Y.3). The development of farmers as experts in Integrated Pest ManagementIntegrated Pest Management(Y.4) is also a focus. Independent variables include the application of pest and disease control (X) to coffee plants, which consists of healthy plant cultivation practices (X.1), conservation and utilization of natural enemies (X.2), routine plant observation (X.3), and question and answer practices (X.4). This study aims to explore the relationship between these variables and their impact on the awareness and behavior of coffee farmers in applying pest and disease control technology.

RESULTS AND DISCUSSION

Sumber Urip Farmer Group, Malang Regency

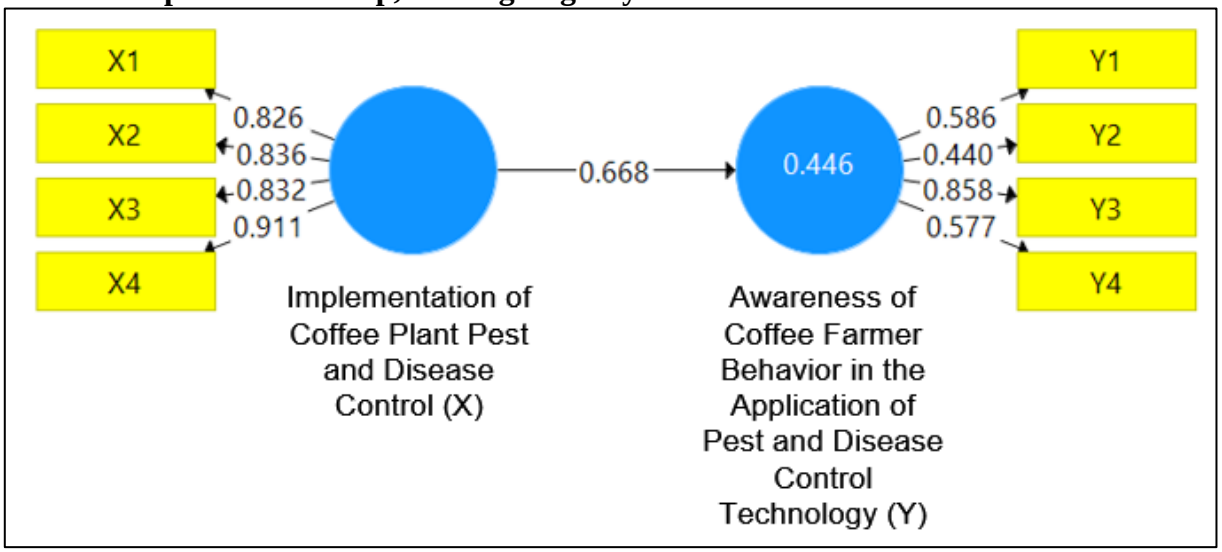

Figure 1. Path Diagram of the Effect of the Implementation of the Farmer Group Pest and Disease Management Sumber Urip, Malang Regency

Source: Primary Data Processed by SEM-PLS, 2024

Based on Figure 1, the path diagram presented in this study provides a clear visual picture of the relationship between the implementation of Integrated Pest Management and the awareness of coffee farmers' behavior in the application of technology. In this context, the concept of Convergent Validity is important to ensure that the indicators used in measuring the two variables accurately reflect the intended construct. The high loading factor and significant P-value indicate that convergent validity has been met, meaning that the indicators are effective in measuring the intended variables.

Mulyo Jaya Farmer Group, Situbondo Regency

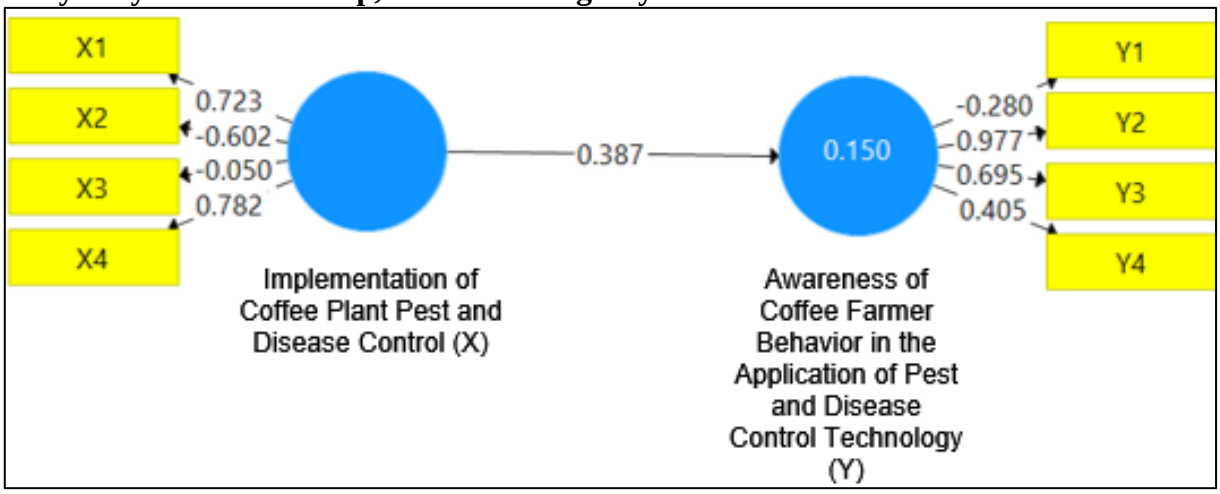

Figure 2. Path Diagram of the Effect of the Implementation of the Farmer Group Pest and Disease Management Mulyo Jaya Farmer Group, Situbondo Regency

Source: Primary Data Processed by SEM-PLS, 2024

Based on Figure 2, the path diagram presented in this study illustrates the relationship between the implementation of Integrated Pest Management and the behavioral awareness of coffee farmers in the application of Integrated Pest Management technology. The direction of influence is indicated by the arrow in the diagram, while the numbers on the arrow reflect the path coefficient, which illustrates the strength and direction of the relationship between the variables. Based on the diagram, it can be concluded that the implementation of integrated pest management as a whole has a positive effect on the behavioral awareness of coffee farmers.

Suka Maju Farmer Group, Probolinggo Regency

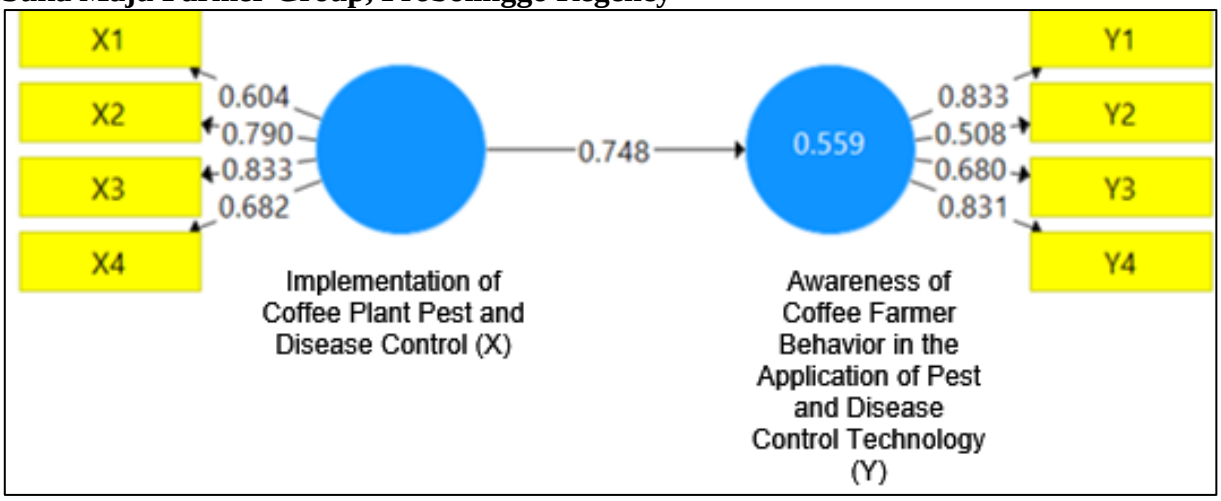

Figure 3. Path Diagram of the Effect of the Implementation of the Farmer Group Pest and Disease Management Suka Maju Farmer Group, Probolinggo Regency

Source: Primary Data Processed by SEM-PLS, 2024

Based on Figure 3. The path diagram presented in this study provides a clear visual representation of the relationship between the implementation of integrated pest management and the behavioral awareness of coffee farmers in the application of Integrated Pest Management technology. The positive path coefficient between the two variables indicates a positive effect; the better the implementation of Integrated Pest Management, the higher the level of awareness of coffee farmers. In addition, the generally high loading factor indicates

that the indicators used to measure the two variables are quite reliable and able to reflect the intended construct.

Kebun Jeruk Sukses Farmer Group, Batu City

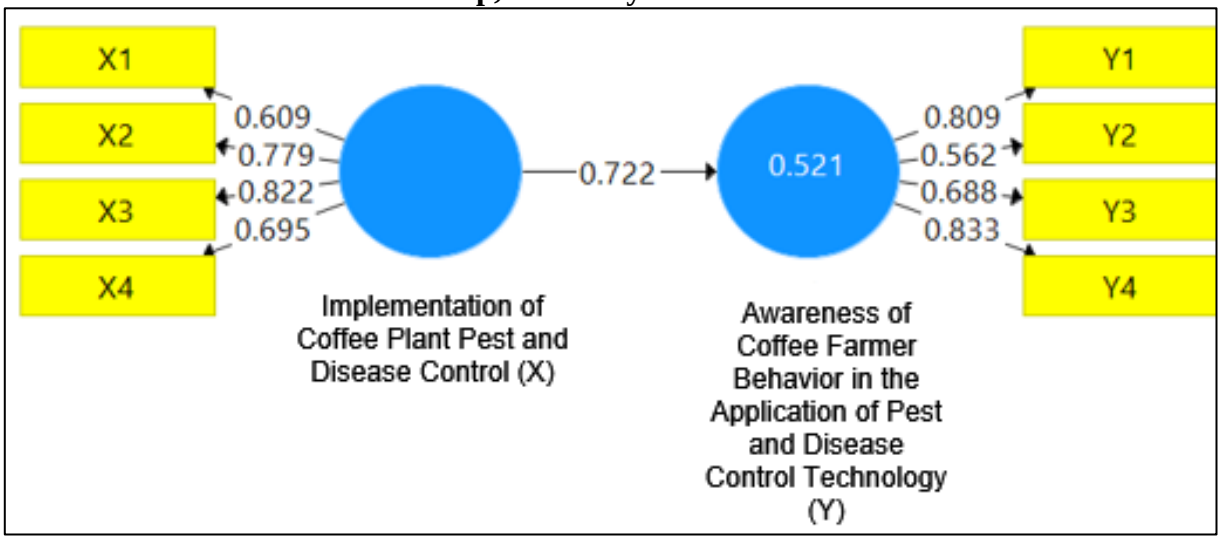

Figure 4. Path Diagram of the Effect of the Implementation of the Farmer Group Pest and Disease Management Kebun Jeruk Sukses Farmer Group, Batu City

Source: Primary Data Processed by SEM-PLS, 2024

Based on Figure 4. The path diagram presented in this study illustrates the relationship between the implementation of IPM (Integrated Pest Management) and the behavioral awareness of coffee farmers in the application of IPM technology. The positive path coefficient between the two variables indicates a significant effect, which means that the better the training implementation, the higher the level of farmer awareness in implementing IPM technology. The generally high loading factor value reflects that the indicators used to measure the two variables have sufficient reliability, so they can be relied on for this analysis.

Outer Loading Test

Table 1. Outer Loading Test Result

	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
Sumber Urip Farmer Group, Malang Regency					
(X.1) <- (X)	0.867	0.857	0.123	7.020	0.000
(X.2) <- (X)	0.791	0.725	0.234	3.386	0.001
(X.3) <- (X)	0.795	0.739	0.224	3.549	0.000
(X.4) <- (X)	0.917	0.905	0.102	9.024	0.000
(Y1) <- (Y)	0.689	0.625	0.298	2.315	0.021
(Y.3) <- (Y)	0.955	0.937	0.113	8.463	0.000
Mulyo Jaya Farmer Group, Situbondo Regency					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X.1) <- (X)	0.825	0.715	0.371	2.226	0.026
(X.4) <- (X)	0.722	0.632	0.366	1.972	0.049
(Y.2) <- (Y)	0.969	0.908	0.264	3.666	0.000
(Y.3) <- (Y)	0.769	0.705	0.295	2.602	0.010
Suka Maju Farmer Group, Probolinggo Regency					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X.1) <- (X)	0.621	0.624	0.208	2.988	0.003
(X.2) <- (X)	0.801	0.751	0.207	3.872	0.000
(X.3) <- (X)	0.849	0.812	0.155	5.475	0.000

Sumber Urip Farmer Group, Malang Regency					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X.4) <- (X)	0.641	0.633	0.197	3.252	0.001
(Y1) <- (Y)	0.882	0.878	0.050	17.751	0.000
(Y.3) <- (Y)	0.748	0.757	0.093	8.056	0.000
(Y.4) <- (Y)	0.791	0.778	0.104	7.572	0.000
Kebun Jeruk Sukses Farmer Group, Batu City					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X.2) <- (X)	0.836	0.790	0.183	4.558	0.000
(X.3) <- (X)	0.870	0.836	0.146	5.941	0.000
(X.4) <- (X)	0.708	0.710	0.162	4.365	0.000
(Y.1) <- (Y)	0.860	0.841	0.114	7.539	0.000
(Y3) <- (Y)	0.730	0.729	0.104	7.028	0.000
(Y.4) <- (Y)	0.813	0.809	0.081	9.988	0.000

Source: Primary Data Processed by SEM-PLS, 2024

From the Table 1. presents the results of loading tests for various variables related to the application of Integrated Pest Management (IPM) technology in several farmer groups in East Java. Each farmer group, namely Sumber Urip, Mulyo Jaya, Suka Maju, and Kebun Jeruk Sukses Farmer Group, shows the values of Original Sample (O), Sample Mean (M), Standard Deviation (STDEV), T Statistics, and P Values for each indicator. T Statistics values greater than 1.96 and very small P Values (below 0.05) indicate that all indicators have a significant effect on the measured variables. For example, in the Sumber Urip Farmer Group, indicator (X.1) has an O value of 0.867 with a T Statistics of 7.020 and a P Value of 0.000, indicating a very significant effect. Similarly, in the Kebun Jeruk Sukses Farmer Grouping Group, indicator (Y.1) shows an O value of 0.860 with a T Statistics of 7.539 and a P Value of 0.000, indicating that farmers behavioral awareness is also significantly influenced. Overall, these results show that the application of pest and disease management provided to farmers have a strong positive impact on their behavior and awareness in managing pests and diseases in coffee plants.

Construct Validity

Table 2. Construct Validity Test Result

Sumber Urip Farmer Group, Malang Regency				
	Cronbach's Alpha	*rho_A*	*Composite Reliability*	*Average Variance Extracted* (AVE)
(Y)	0.615	0.967	0.815	0.694
(X)	0.876	0.961	0.908	0.713
Mulyo Jaya Farmer Group, Situbondo Regency				
	Cronbach's Alpha	*rho_A*	*Composite Reliability*	*Average Variance Extracted* (AVE)
(Y)	0.740	1.252	0.865	0.765
(X)	0.339	0.347	0.750	0.601
Suka Maju Farmer Group, Probolinggo Regency				
	Cronbach's Alpha	*rho_A*	*Composite Reliability*	*Average Variance Extracted* (AVE)
(Y)	0.732	0.736	0.849	0.654
(X)	0.705	0.717	0.822	0.540
Kebun Jeruk Sukses Farmer Group, Batu City				
	Cronbach's Alpha	*rho_A*	*Composite Reliability*	*Average Variance Extracted* (AVE)
(Y)	0.724	0.734	0.844	0.645
(X)	0.730	0.738	0.848	0.652

Source: Primary Data Processed by SEM-PLS, 2024

From the Table 2. presents the results of the construct validity test for various farmer groups in East Java, including Sumber Urip, Mulyo Jaya, Suka Maju, and Kebun Jeruk Sukses Farmer Group. This validity test includes several indicators, namely Cronbach's Alpha, rho_A, Composite Reliability, and Average Variance Extracted (AVE) for the dependent (Y) and independent (X) variables. In the Sumber Urip Farmer Group, the Cronbach's Alpha value for variable Y is 0.615, which indicates adequate internal consistency, although it is still below the ideal threshold of 0.70. However, the rho_A, which reaches 0.967, indicates very high reliability. For variable X, the higher Cronbach's Alpha value of 0.876 indicates good internal consistency. The Mulyo Jaya Farmer Group shows a Cronbach's Alpha value for Y of 0.740, which reflects good reliability, while for X, a value of 0.339 indicates that this construct is less reliable. The Suka Maju Farmers Group and Kebun Jeruk Sukses Farmer Group also show good Cronbach's Alpha values for the Y variable, 0.732 and 0.724 respectively, as well as a fairly good value for the X variable. Overall, these results indicate that most of the constructs tested have good validity and reliability, supporting further analysis in this study.

Discriminant Validity Test

Table 3. Discriminant Validity Test Result

Sumber Urip Farmer Group, Malang Regency		
	Awareness of Coffee Farmer Behavior in the Application of IPM Technology	Implementation of IPM Application for Coffee Plants
(Y)	0.833	
(X)	0.643	0.844
Mulyo Jaya Farmer Group, Situbondo Regency		
	Awareness of Coffee Farmer Behavior in the Application of IPM Technology	Implementation of IPM Application for Coffee Plants
(Y)	0.875	
(X)	0.388	0.775
Suka Maju Farmer Group, Probolinggo Regency		
	Awareness of Coffee Farmer Behavior in the Application of IPM Technology	Implementation of IPM Application for Coffee Plants
(Y)	0.809	
(X)	0.722	0.735
Kebun Jeruk Sukses Farmer Group, Batu City		
	Awareness of Coffee Farmer Behavior in the Application of IPM Technology	Implementation of IPM Application for Coffee Plants
(Y)	0.803	
(X)	0.646	0.808

Source: Primary Data Processed by SEM-PLS, 2024

From the Table 3. presents the results of the discriminant validity test for the two main constructs in this study: Awareness of Coffee Farmers Behavior in the Application of Pest and Disease Management Technology (Y) and Implementation of Pest and Disease Management for Coffee Plants (X) in various farmer groups in East Java. Discriminant validity is measured by comparing the root value of the Average Variance Extracted (AVE) for each construct. In the Sumber Urip Farmer Group, the AVE value for construct Y is 0.833, indicating that this variable has a good ability to distinguish itself from other constructs. The AVE value for construct X is 0.844, which also indicates strong discriminant validity. The Mulyo Jaya Farmer Group shows an AVE value for Y of 0.875, which reflects good validity, while the AVE value for X is 0.775, indicating that these constructs can also be distinguished well. The Suka Maju Farmers Group has an AVE value for Y of 0.809 and for X of 0.735, both of which indicate adequate discriminant validity. Finally, at Kebun Jeruk Sukses Farmer Group, the AVE value for Y is 0.803 and for X is 0.808, which indicates that the two constructs have good discriminant

validity. Overall, these results indicate that the constructs tested can be distinguished from each other, supporting the reliability of the analysis in this study.

R^2 Test Result

Table 4. R^2 Test Result

Sumber Urip Farmer Group, Malang Regency		
	R Square	*R Square Adjusted*
(Y)	0.413	0.387
Mulyo Jaya Farmer Group, Situbondo Regency		
	R Square	*R Square Adjusted*
(Y)	0.151	0.114
Suka Maju Farmer Group, Probolinggo Regency		
	R Square	*R Square Adjusted*
(Y)	0.521	0.500
Kebun Jeruk Sukses Farmer Group, Batu City		
	R Square	*R Square Adjusted*
(Y)	0.418	0.392

Source: Primary Data Processed by SEM-PLS, 2024

From the Table 4. presents the R^2 (R Square) test results for the construct of Coffee Farmers Behavior Awareness in the Application of Pest Management Technology (Y) in various farmer groups in East Java. The R^2 value shows the proportion of variation in farmer behavior awareness that can be explained by the independent variables in the research model. In the Sumber Urip Farmer Group, the R^2 value is 0.413, which means that around 41.3% of the variation in farmer behavior awareness can be explained by the factors studied. The adjusted R-squared of 0.387 shows that after considering the number of predictors in the model, around 38.7% of the variation can still be explained. The Mulyo Jaya Farmer Group shows a lower R^2 value of 0.151, which indicates that only 15.1% of the variation in farmer behavior awareness can be explained by this model. The Adjusted R Square of 0.114 indicates that this model is less effective in explaining the variation. On the other hand, the Suka Maju Farmer Group has the highest R^2 value, which is 0.521, which indicates that 52.1% of the variation in farmers behavioral awareness can be explained by the variables in the model. The Adjusted R Square of 0.500 indicates that this model is quite good at explaining the variation. Finally, at Kebun Jeruk Sukses Farmer Group, the R^2 value is 0.418, indicating that 41.8% of the variation in farmer behavior awareness can be explained, with an Adjusted R Square of 0.392. Overall, these results show a significant variation in the model's ability to explain farmer behavior awareness in each farmer group.

Significance Test Result

Table 5. Significance Test Result

Sumber Urip Farmer Group, Malang Regency					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X) > (Y)	0.643	0.677	0.140	4.602	0.000
Mulyo Jaya Farmer Group, Situbondo Regency					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X) > (Y)	0.388	0.408	0.196	1.984	0.048
Suka Maju Farmer Group, Probolinggo Regency					
	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X) > (Y)	0.722	0.761	0.065	11.034	0.000
Kebun Jeruk Sukses Farmer Group, Batu City					

	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	*T Statistics* (|O/STDEV|)	*P Values*
(X) > (Y)	0.646	0.691	0.091	7.125	0.000

Source: Primary Data Processed by SEM-PLS, 2024

From the Table 5. presents the results of the significance test for the effect of the implementation of Integrated Pest Management (IPM) (X) on the behavioral awareness of coffee farmers in the application of IPM technology (Y) in various farmer groups in East Java. The results of the analysis show the values of the Original Sample (O), Sample Mean (M), Standard Deviation (STDEV), T Statistics, and P Values for each farmer group. In the Sumber Urip Farmer Group, the O value is 0.643 with a T Statistics of 4.602 and a P Value of 0.000, indicating a very significant effect of the application of Integrated Pest Management on farmers behavioral awareness. The Mulyo Jaya Farmer Group showed an O value of 0.388, T Statistics 1.984, and P Value 0.048, which also showed a significant effect, although lower than other groups. The Suka Maju Farmers Group had the highest O value of 0.722, with a T-Statistic of 11.034 and a P-Value of 0.000, indicating a very significant effect of the implementation of the IPM on the awareness of farmers behavior. Finally, at Kebun Jeruk Sukses Farmer Group, the O value was 0.646, with T Statistics 7.125 and P Value 0.000, indicating a very significant effect. Overall, these results indicate that the application of Integrated Pest Management has a significant positive impact on the behavioral awareness of coffee farmers in all farmer groups studied, supporting the hypothesis that this intervention can increase understanding and application of environmentally friendly technology among farmers.

Goodness-of-Fit Test Result

Table 6. Goodness-of-Fit Test Result

Farmer Group Sumber Urip, Malang Regency		
	Saturated Model	*Estimated Model*
SRMR	0.174	0.174
d_ULS	0.633	0.633
d_G	0.217	0.217
Chi-Square	31.651	31.651
NFI	0.653	0.653
Mulyo Jaya Farmer Group, Situbondo Regency		
	Saturated Model	*Estimated Model*
SRMR	0.142	0.142
d_ULS	0.203	0.203
d_G	0.083	0.083
Chi-Square	12.378	12.378
NFI	0.242	0.242
Suka Maju Farmer Group, Probolinggo Regency		
	Saturated Model	*Estimated Model*
SRMR	0.142	0.142
d_ULS	0.203	0.203
d_G	0.083	0.083
Chi-Square	12.378	12.378
NFI	0.242	0.242
Kebun Jeruk Sukses Farmer Group, Batu City		
	Saturated Model	*Estimated Model*
SRMR	0.131	0.131
d_ULS	0.362	0.362
d_G	0.168	0.168
Chi-Square	22.722	22.722
NFI	0.627	0.627

Source: Primary Data Processed by SEM-PLS, 2024

From the Table 6. presents the results of the goodness-of-fit test for the model used in this study, which includes several farmer groups in East Java. This test aims to assess the extent to which the proposed model fits the observed data. Some of the indicators used in this analysis include SRMR (Standardized Root Mean Square Residual), d_ULS (Squared Euclidean Distance), d_G (Geodesic Distance), Chi-Square, and NFI (Normed Fit Index). In the Sumber Urip Farmer Group, the SRMR value is 0.174, which indicates that the model does not fully fit the data. The Chi-Square value of 31.651 also indicates model mismatch. On the other hand, the NFI of 0.653 indicates that the model has a low fit. The Mulyo Jaya and Suka Maju Farmer Groups show the same SRMR value of 0.142, which indicates a better model fit compared to Sumber Urip. However, the same Chi-Square value of 12.378 and NFI of 0.242 indicate that this model also has a low fit. The Kebun Jeruk Sukses Farmer Grouping Group shows the lowest SRMR value of 0.131, which indicates a better model fit. Although the Chi-Square value of 22.722 indicates a mismatch, the NFI of 0.627 indicates that this model is better than the other groups. Overall, the goodness-of-fit test results show that although there are several indicators that show model fit, there is still room for improvement in the proposed model to better fit the observed data.

Relevance to Previous Research

The implementation of Integrated Pest Management (IPM) is a strategic step to increase the awareness and skills of coffee farmers in implementing environmentally friendly agricultural practices. The implementation of integrated pest management is designed to provide in-depth knowledge of Integrated Pest Management techniques that are not only effective but also sustainable. In this context, the analysis of the impact of the implementation of integrated pest management on the behavior of coffee farmers can be seen through several aspects, including increased knowledge, changes in attitude, and the application of more sustainable agricultural practices.

One of the main results of the implementation of integrated pest management is the increase in farmers knowledge of environmentally Integrated Pest Management techniques and principles. Data obtained from the Sumber Urip Farmer Group shows that the implementation of integrated pest management contributes significantly to increasing farmers knowledge. The loading factor for variables related to the implementation of integrated pest management shows a high value, ranging from 0.867 to 0.917, which indicates that the implementation of integrated pest management has succeeded in broadening farmers understanding of IPM techniques. Previous research has also shown that the effective implementation of integrated pest management can increase farmers knowledge of sustainable agricultural practices (Wati, 2022). Thus, this increase in knowledge is an important foundation for farmers to adopt more environmentally friendly agricultural practices.

The application of integrated pest management not only focuses on increasing knowledge, but also affects farmers attitudes towards more sustainable agricultural practices. The results of the analysis show that there is a significant relationship between the implementation of integrated pest management and farmers behavioral awareness. For example, in the Sumber Urip Farmer Group, the T Statistics value of 4,602 with a very low P Value (0.000) indicates that the application of integrated pest management significantly influences farmers awareness of implementing IPM technology (Zakil et al., 2017). Other studies have also shown that positive changes in attitudes towards the use of environmentally Integrated Pest Management methods can be achieved through the proper implementation of Integrated Pest Management (Suprihanti et al., 2023). This reflects the fact that the implementation of integrated pest management not only serves as a transfer of knowledge, but also as a tool for building awareness and positive attitudes among farmers.

After attending extension, farmers are expected to apply the knowledge gained in daily practice. The results show that the implementation of integrated pest management contributes

to behavior change in the application of pest management technology. In the Suka Maju Farmer Group, R^2 reached 52.1%, indicating that more than half of the variation in farmer behavior can be explained by the implementation of integrated pest management (Maulana, 2022). This shows that farmers are more likely to adopt environmentally Integrated Pest Management techniques after following the implementation of integrated pest management.

Previous research also indicates that effective extension can increase the adoption of sustainable agricultural practices among farmers (Hasan et al., 2024). However, the effectiveness of integrated pest management implementation is uneven among farmer groups. For example, the Mulyo Jaya Farmer Group showed a lower R^2, which was 15.1%, compared to the Suka Maju Farmer Group. This can be caused by various factors, including the level of education of the farmers, their farming experience, and the support from the farmer groups. Therefore, it is important to consider the local context and characteristics of the farmers when designing this program of activities. Previous research has also shown that socioeconomic factors can affect the effectiveness of training among farmers (Hariyani, 2022).

Despite positive changes in farmers behavior, challenges remain in changing long-established habits. Some farmers may still be bound by traditional practices that have been carried out for years. Therefore, it is important to take a more holistic approach, including ongoing mentoring and evaluation to ensure that the knowledge gained can be applied effectively. Other research shows that ongoing support after the implementation of integrated pest management can increase the successful adoption of new practices among farmers (Wastutiningsih et al., 2024).

To increase the effectiveness of the implementation of integrated pest management, several recommendations can be proposed. First, post-implementation assistance is essential to provide ongoing support to farmers after they have followed the implementation of Integrated Pest Management. Research shows that assistance can increase the successful implementation of new practices among farmers (Sitorus, 2024). Second, improving the IPM implementation materials relevant to local conditions is also necessary to increase understanding and application. Previous research shows that integrated pest management implementation materials that are appropriate to the local context can increase the effectiveness of training (Harmet, 2021). Third, the integration of case studies and field practices in the implementation of integrated pest management can provide direct experience to farmers, which has been proven to increase understanding and application of knowledge among farmers (Apreliani et al., 2023).

Overall, the implementation of Integrated Pest Management (IPM) has had a positive impact on increasing knowledge, changing attitudes, and implementing sustainable agricultural practices among coffee farmers. However, to achieve optimal results, it is important to continuously evaluate and adjust the integrated pest management program to meet the needs and challenges faced by farmers in the field. With the right approach, it is hoped that coffee farmers will be more aware and committed to implementing environmentally friendly agricultural practices, thus contributing to environmental sustainability and improving their quality of life.

The results of this study are relevant to similar studies (Limbong et al., 2020; Sardin, 2020; Yuliandri & Rachmi Alnido, 2023).

CONCLUSION

The implementation of integrated pest management has a significant influence on the behavioral awareness of coffee farmers. The results of the convergent validity test show that all indicators for the implementation of integrated pest management and farmer behavior awareness have significant loading factors, while the reliability test shows Cronbach's Alpha and Composite Reliability values above 0.7, indicating that the constructs tested have high reliability. The obtained R^2 value varies between 0.151 to 0.521, indicating that The implementation of Integrated Pest Management can explain between 15.1% to 52.1% of the

variation in farmer behavior awareness. The significance test results confirm that the implementation of IPM contributes positively to increasing farmer awareness, with a very low P-value. In addition, the goodness-of-fit test results show a good match between the proposed model and the observed data. To ensure that the implementation of IPM can optimally explain the variation in farmer behavior awareness, it is important to continuously monitor and evaluate the indicators used in the implementation of integrated pest management. The implementation of integrated pest management must be designed taking into account the results of high validity and reliability tests, and balanced with the development of relevant and interesting materials for participants. Providing constructive feedback during the implementation of integrated pest management can also help increase farmers awareness and understanding.

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