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Influences on Farmer Behavior in Integrated Pest Management: IPM Knowledge, Local Wisdom, and Motivation in Palu City

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ABSTRACT

This study investigated the impact of Integrated Pest Management (IPM) knowledge, local wisdom, and farmer motivation on farmer behavior in IPM within Palu, Central Sulawesi. A causative multivariate analysis method was employed, incorporating path analysis for explanatory purposes, and an expost facto correlational research design was executed. Data were systematically and standardly collected via structured questionnaires and observational tests. Both descriptive and inferential analysis techniques were employed for the evaluation of the collected data. A sample of 115 horticultural farmers across six villages in Palu City was selected through a simple proportional sampling method. The study findings suggest a direct influence on farmer behavior in IPM from IPM knowledge (2.43%), local wisdom (2.13%), and farmer motivation (37.45%). Furthermore, evidence was found of significant increases in IPM behavior via motivation, from 2.43% to 4.24% with respect to IPM knowledge and from 2.13% to 6.10% concerning local wisdom. The study concludes that enhancements in IPM behavior could be achieved through bolstering IPM knowledge, local wisdom, and farmer motivation. These findings have implications for the improvement of integrated pest control practices among farmers.

1. INTRODUCTION

Efforts to increase agricultural production are frequently equated solely with yield optimization, with environmental considerations often overlooked, despite the continued use of pesticides in agricultural practices [1-3]. Pesticides have been the preferred choice due to substantial crop losses caused by pests and plant diseases, despite their conceptual positioning as a last resort in pest control, supported by regulatory measures.

This reliance on pesticides is observed in urban farming practices in Palu, the capital of Central Sulawesi. Despite shrinking agricultural land, horticultural crop production persists, often leveraging chemicals such as fertilizers and pesticides intensively. This production augmentation occurs without due consideration of environmental impacts, leading to observable damage to agricultural environments in recent years due to unsustainable farming practices. This perspective treats the agricultural environment as an unlimited resource with high chemical input, essential for achieving desired production levels.

Pesticides are commonly employed to control Plant Pest Organisms (PPOs) as they are perceived as a guarantee against yield loss due to PPO attacks [4-7]. However, the government has gradually shifted its pest control policy from a unilateral approach to a comprehensive one, as outlined in Law Number 12 in 1992, further reinforced by Government Regulation Number 6 in 1995. This integrated approach, known as the Integrated Pest Management System (IPM), is based on ecological considerations and economic efficiency and is part of overall agro-ecosystem management. The IPM offers a distinct approach from conventional pest control methods that heavily rely on pesticides. The IPM is recognized as an effective means to reduce synthetic pesticide use and minimize their adverse effects on the environment and human health [8-10].

Effective pest control is a crucial aspect of agricultural productivity and agro-ecosystem sustainability. Farmers play a pivotal role in pest control method implementation, and IPM knowledge can significantly influence their pest control behavior [11-13]. This knowledge includes understanding how to integrate and utilize all selective pest control methods, such as employing predators and parasitoids, using pest-resistant varieties, adopting appropriate farming techniques, and using pesticides.

Implementation of IPM, especially in horticulture, can enhance agricultural production and quality while promoting a sustainable farming system that does not compromise environmental sustainability, thus improving farmer income and welfare [14].

Beyond IPM knowledge, local wisdom also significantly influences farmer behavior in integrated pest control. Local wisdom refers to community-developed knowledge, practices, and values for managing their agricultural environment. This knowledge is often passed down through generations and deeply rooted in empirical experience [15-18]. Farmers with strong local wisdom can implement sustainable and environmentally friendly pest control methods, including selecting pest-resistant plant varieties and employing suitable cultivation techniques based on local experience.

Furthermore, farmer behavior is intrinsically linked to motivation. Motivated farmers are observed to be more diligent and involved in implementing integrated pest control measures [19-21]. Factors affecting farmer motivation include confidence in IPM strategies, economic benefits, and support from related parties, including the government [22-24].

In light of the above, examining the factors influencing the behavior of farmers in integrated and sustainable pest control—particularly the interpretation of IPM principles—is crucial. This study aims to determine and analyze the direct influence of IPM knowledge, local wisdom, and farmer motivation on farmer behavior in integrated pest control in Palu City. It addresses the knowledge gap that contributes to the suboptimal implementation of IPM at the farm level, providing deeper insights into the factors influencing farmers' behavior in integrated pest control and offering a strong foundation for the development of more effective and sustainable pest control strategies.

2. MATERIALS AND METHODS

This research was conducted in Palu City for five months, from November 2022 to March 2023. The research targets were horticulture farmers in Palu City.

The population in the study were farmers who cultivate horticultural crops in Palu City. While the reachable population is farmers in Boyaoge, Duyu, Poboya, Petobo, Birobuli Selatan and Layana Indah Sub-districts. Determination of the sample by selecting 115 farmers spread across six urban villages using the probability sample method with the principle of simple proportional sampling. So that the total sample is 115 farmers. This study uses a causal multivariate analysis method with path analysis (Path analysis). In accordance with the research objectives that have been made, this study uses a pattern of explanation (level of explanation), namely the research is intended to explain the position of the variables studied and the relationship between one variable and another. Thus, this study explains the influence of IPM knowledge variables, local wisdom, farmer motivation on farmer behavior in integrated pest management. Based on the relationship between variables, this is a correlational study. Then based on the data collected, it is an *expost facto* study. Data collection is done carefully, standardized and systematic. Technic data collection used by giving a set of written questions in a structured manner (questionnaire) and test with observation which is a method of data collection by direct observation of the activities of farmers in the field. Questions and answers directly with the respondent farmers in order to obtain information that reinforces the answers from the questionnaire and is a control of the answers obtained. Confidentiality of respondent farmer data is guaranteed in accordance with applicable statistical laws in Indonesia.

The unit of analysis used in the study is the individual (affordable farmer). The individual in question is a horticultural farmer in Palu. The research design is a research plan and structure that is made in such a way as to obtain answers to research questions. The research design is described as follow:

Data analysis used descriptive analysis techniques and inferential analysis techniques. Descriptive analysis techniques used for data presentation, data size and data distribution size. Inferential analysis was used to examine direct and indirect effects used path analysis. The direct and indirect effects of exogenous (independent variables) on an endogenous (dependent variable) can identified in the path coefficients.

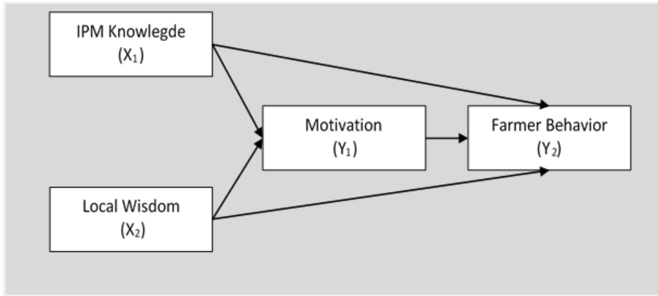

Figure 1. Research design

3. RESULTS AND DISCUSSION

The results showed that the age average of the respondent farmers 41 years old, the youngest farmers 26 years old and the oldest 61 years old. Based the productive age has the range between 15 - 64 years [25], then all farmers in the productive age. Furthermore, based on the farmers education level, the respondent ever in the high school or above level. About 53% generally admitted they had attended high school or its equivalent but did not graduate, only 0.86% of respondent had never attended school. The data mean the description of the level of education of farmers can determine the level of knowledge of IPM. Farming experience is generally more than 2 years or 97.39%. In the land ownership, relatively not much different from farmers rent the land around 53.91% and owner 46.09%. Furthermore, the characteristics of the respondent farmers can be seen in Table 1.

Table 1. Characteristics of respondent farmers in Palu City

General Information	Respondent Farmers (n = 115)	
	Total	(%)
Farmer Age		
>20 Years	5	4.35
>30 Years	27	23.47
>40 Years	58	50.44
>50 Years	25	21.74
Formal Education Level		
Without School	1	0.86
Elementary School	16	13.92
Junior High School	37	32.18
≥ Senior High School	61	53.04
Farming Experience		
<2 Years	3	2.61
2 - 5 Years	34	29.57
5 - 10 Years	41	35.65
>10 Years	37	32.17
Farmer Status		
Owner	53	46.09
Tenant	62	53.91

Source: Primary data in 2023

Furthermore, based on the result of the multivariate causal analysis method with path analysis and two-way equation model. The analysis used two models is the substructural model 1 and model 2 (Figure 1). The results of the path analysis model used as the basis for the research analysis are known to have five direct effects. The result obtained data according to the results of data analysis used path analysis system.

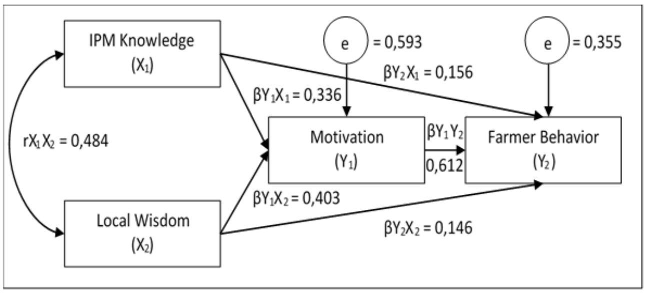

Figure 2. Path analysis model of hypothesis testing results

Based on the results of the analysis based on the path diagram above (Figure 2), the path coefficient X_1 to Y_1 (βY_1X_1) is 0.336 with t_{count} = 4.041 and $t_{table} = t_{(0.05;113)}$ = 1.982. Because the value of $t_{count} > t_{table}$, thus there is a positive direct effect of IPM knowledge on motivation. The contribution made by variable X_1 to $Y_1 = (0.336)^2 \times 100 = 11.29\%$.

The coefficient of path X_2 to Y_1 (βY_1X_2) is 0.403 with t_{count} = 4.845 and $t_{table} = t_{(0.05;113)}$ = 1.982. Because the value of $t_{count} > t_{table}$, thus there is a positive direct influence of local wisdom on motivation. The contribution made by variable X_2 to $Y_1 = (0.403)^2 \times 100 = 16.24\%$.

The coefficient of path X_1 to Y_2 (βY_2X_1) is 0.156 with t_{count} = 2.254 and $t_{table} = t_{(0.05;113)}$ = 1.982. Because the value of $t_{count} > t_{table}$, thus there is a positive direct effect of IPM knowledge on farmer behavior. The contribution made by variable X_1 to $Y_2 = (0.156)^2 \times 100 = 2.43\%$.

The coefficient of path X_2 to Y_2 (βY_2X_2) is 0.146 with t_{count} = 2.050 and $t_{table} = t_{(0.05;113)}$ = 1.982. Because the value of $t_{count} > t_{table}$, thus there is a positive direct influence of local wisdom on farmer behavior. The contribution made by variable X_2 to $Y_2 = (0.146)^2 \times 100 = 2.13\%$.

The path coefficient Y_1 to Y_2 (βY_2Y_1) is 0.612 with t_{count} = 8.335 and $t_{table} = t_{(0.05;113)}$ = 1.982. Because the value of $t_{count} > t_{table}$, thus there is a positive direct influence of motivation on farmer behavior. The contribution of the variable Y_1 to $Y_2 = (0.612)^2 \times 100 = 37.45\%$.

Furthermore, based on the analysis model formed, there are two substructure equations that are formed respectively, namely:

Substructure 1: The structural equation formed by X_1 and X_2 to Y_1 is:

$$Y_1 = 0.336X_1 + 0.403X_2 + \beta Y_1 e_1$$

The coefficient of determination R_{square} = 0.407 or 40.7% and the magnitude of the influence of other variables $e_1 = \sqrt{(1 - 0.407)} = 0.770;\ (0.770)^2 = 0.593 = 59.3\%$.

Substructure 2: The structural equation formed by X_1, X_2 and Y_1 against Y_2 is:

$$Y_2 = 0.156X_1 + 0.146X_2 + 0.612Y_1 + \beta Y_2 e_2$$

The coefficient of determination R_{square} = 0.645 or 64.5% and the magnitude of the influence of other variables $e_2 = \sqrt{(1 - 0.645)} = 0.596;\ (0.596)^2 = 0.355 = 35.5\%$.

The indirect effect of variable X_1 on Y_2 through Y_1 is 0.336 × 0.612 = 0.206. The contribution given is = $(0.206)^2 \times 100$ = 4.24%. Meanwhile, the indirect effect of variable X_2 on Y_2 through Y_1 is 0.403 × 0.612 = 0.247. The contribution given is = $(0.247)^2 \times 100$ = 6.10%.

The total effect of X_1 on Y_2 is 0.948. The contribution given is = $(0.948)^2 \times 100$ = 89.87%. The total effect of X^2 on Y^2 is 1.015. The contribution given is 100% perfect.

The following Table 2 summarizes the results of calculating the direct effect, indirect effect and total effect.

Table 2. Path coefficient, direct effect, indirect effect and total effect of exogenous variables on endogenous variables

Variable Influence	Path Coefficient			Contribution (%)
	Direct Influence	Indirect Influence	Total Impact	
X_1 to Y_1	0.336	-	0.336	11.29
X_1 to Y_2	0.156	0.206	0.362	13.10
X_2 to Y_1	0.403	-	0.403	16.24
X_2 to Y_2	0.146	0.247	0.393	15.44
Y_1 to Y_2	0.612	-	0.612	37.45
e_1	0.770	-	-	
e_2	0.596	-	-	

Source: Primary data in 2023

The results showed that farmer based IPM knowledge had a positive and significant effect on farmer behavior in integrated pest management. This mean that good or high farmer behavior in integrated pest control was explained by IPM knowledge. The magnitude of the direct contribution of IPM knowledge to farmer behavior in pest control around 2.43%. Therefore, it is important for farmers IPM knowledge to continue and improved. The formation of changes in behavior due to the process of interaction between individuals and the environment through the learning process [26]. Therefore, behavior change and the learning process related very closely. Changes in farmer behavior in the pest control is the result of learning outcomes or knowledge gained.

Furthermore, IPM knowledge must be placed as an integral part of overall agro-ecosystem management [27]. By studying the structure of ecosystems such as the composition of plant species, pests, natural enemies and other biotic groups, as well as the dynamic interactions between biotic components, IPM principles become very relevant for maintaining pest populations at a non-detrimental level. Farmers who have a good understanding of pest life cycles, identification techniques, and pest monitoring are more likely to be able to implement IPM strategies effectively [28]. In addition, knowledge of appropriate control techniques can also assist farmers in selecting the most suitable methods for dealing with pests in their crops.

In Indonesia, efforts have been made to increase farmer IPM knowledge through the Integrated Pest Management Field School Program. It is intended to train farmers to be able to understand the principles of IPM. The Integrated Pest Management Field School Program is a participatory training method and education for adults, especially farmers. Farmers who have participated in IPM Field School Program have been changed their pest control behavior for the better meaning the method of pest control accordance with IPM principles [29-34].

IPM often seen as a technical solution, but local wisdom takes into account cultural, social and ecological aspects that unique to a region or farming community. By combining IPM knowledge and local wisdom, a more holistic and integrated approach to integrated pest control can be found. It can increase the efficiency and effectiveness of pest control and minimize negative impacts on the environment and human health.

This study showed that local wisdom has a positive and significant effect on farmers behavior in IPM. This means that good or high farmer behavior in integrated pest control is explained by local wisdom. The magnitude of the direct contribution of local wisdom to farmer behavior in pest control is 2.13%. Therefore, local wisdom owned by farmers must be maintained and enhanced in an effort to improve farmer behavior in IPM.

This finding is reinforced by the results of research [35-37] that good and correct agricultural management with local wisdom can reduce agricultural activities that are not environmentally friendly. Local wisdom is the traditional knowledge and practices that have developed in farming communities over the years. Forms of knowledge, beliefs, understanding, and customs about humans, nature and how things are related among all that exist in an ecological community. It can be understood that knowledge contained in the local wisdom can be a valuable resource in IPM [38-41].

Farmers who apply local wisdom in the pest control can take advantage of knowledge about selecting pest-resistant plant varieties, using appropriate cultivation techniques, and pest control based on local experience. This can increase the success of pest control and increase the sustainability of agricultural systems.

Furthermore, the research findings show that IPM knowledge and local wisdom have a direct positive effect on motivation. The indirect effect of IPM knowledge on farmer behavior through motivation also proved significant at 4.24%, as well as the indirect effect of local wisdom on farmer behavior through motivation also proved significant at 6.10%. This means that motivation can improve the relationship between IPM knowledge and local wisdom on farmer behavior in integrated and sustainable pest management.

The higher the motivation of farmers, the knowledge of IPM and local wisdom will further improve farmer behavior in integrated pest control. The direct contribution given by motivation to changes in farmer behavior in pest control is 37.45%. The findings of this study are reinforced by research [42] which concluded that farmer work motivation is a variable that has a dominant influence on farmer behavior in pest control. Furthermore, research [43] emphasizes the importance of motivation in encouraging someone to acquire knowledge. In this case, motivation encourages farmers to acquire IPM knowledge and apply it in pest control practices.

Interventions that involve farmer participation in decision-making and the provision of appropriate incentives can increase the adoption of more effective and sustainable pest control practices. High motivation can encourage farmers to learn and adopt innovative and sustainable pest control practices.

Overall, the findings of this study showed that the influence of IPM knowledge, local wisdom, and motivation on farmer behavior in the pest control interrelated and influence farmer behavior in integrated pest control in accordance with IPM principles. Integrating IPM knowledge with local wisdom and developing strategies that consider motivational factors increasing the success of pest control by farmers that are more environmentally friendly and sustainable. The research provides important insights into the development of sustainable agricultural policies and the development of appropriate education and training programs to support farmers in addressing the challenges of sustainable integrated pest management (IPM).

4. CONCLUSIONS

The results of this study concluded that farmers' behavior in integrated pest control is directly influenced by IPM knowledge (2.43%), local wisdom (2.13%) and farmers' motivation (37.45%). Integration of IPM knowledge with local wisdom and the development of strategies that consider motivational factors can increase the success of pest control by farmers who are more environmentally friendly and sustainable. Increased IPM behavior through motivation proved significant from 2.43% to 4.24% on IPM knowledge and 2.13% to 6.10% on local wisdom. Farmers' behavior in integrated and sustainable pest control can be improved by increasing IPM knowledge, local wisdom and farmer motivation. Further research is needed to better understand other factors such as demographic factors that influence farmer behavior to improve the implementation of IPM in the field.

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