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AGRIBUSINESS

Understanding small farmers' technology adoption and its relation to fruit fly attack: a case study from Gunuang Omeh, Lima Puluh Kota, Indonesia

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ABSTRACT: This research examined the technological adoption of integrated management for healthy citrus orchards by farmers in Gunuang Omeh, a sub-district in Lima Puluh Kota Regency, West Sumatra, Indonesia. The adoption rate, characteristics of farmers at each level, influencing factors, and their association with fruit fly attacks, were measured. The data was obtained through a survey conducted purposively from June to December 2021 involving 351 farmers. The results of the analysis showed that the individual adoption rate was high, but for the handling of fruit flies in group was low, with the emphasis on the need for consolidation. The characteristics different at each level of adoption were: the distance from the farmer's home to the orchard and the difficulty of access to credit. Several factors influence the adoption of this technology individually were from characteristics of the farmers (number of family members and experience); citrus orchard (distance to input, output, extension, plant age); also the difficulty to access information and credit. These results suggested that intervene policies that can be done: (1) facilitate access to credit for citrus farmers, especially for the needs of large plantations. (2) provide easy access to information related to fruit fly handling simultaneously or community-based cooperation, (3) provide ease of transportation access.
Key words: technology adoption, rural development, integrated pest management, extension workers, small farmers.

Adoção da tecnologia pelos pequenos agricultores e a sua relação com ataque de mosca-das-frutas: um estudo de caso de Gunuang Omeh, Lima Puluh Kota, Indonésia

RESUMO: Examinamos a adoção tecnológica do manejo integrado para pomares cítricos saudáveis por agricultores em Gunuang Omeh, um subdistrito na regência de Lima Puluh Kota, Sumatra Ocidental, Indonésia. Foram medidas a taxa de adoção, as características dos agricultores em cada nível, os fatores que influenciam e a sua associação com ataques de moscas-das-frutas. Os dados foram obtidos através de uma pesquisa realizada propositalmente de junho a dezembro de 2021 envolvendo 351 agricultores. Os resultados da análise mostraram que a taxa de adoção individual foi alta, mas para o manejo de moscas-das-frutas em grupo foi baixa, com destaque para a necessidade de consolidação. As características diferentes em cada nível de adoção foram: a distância da casa do agricultor ao pomar e a dificuldade de acesso ao crédito. Vários fatores que influenciam a adoção desta tecnologia individualmente foram desde características dos agricultores (número de membros da família e experiência); pomar de citros (distância até entrada, saída, extensão, idade da planta); também a dificuldade de acesso à informação e ao crédito. Estes resultados sugeriram ser necessário interenções políticas que podem: (1) facilitar o acesso ao crédito para os citricultores, especialmente para as necessidades das grandes plantações. (2) fornecer acesso fácil a informações relacionadas ao manejo simultâneo de moscas-das-frutas ou cooperação baseada na comunidade, (3) fornecer facilidade de acesso ao transporte.
Palavras-chave: adoção de tecnologia, desenvolvimento rural, manejo integrado de pragas, extensionistas, pequenos agricultores.

INTRODUCTION

Gunuang Omeh subdistrict is the largest supplier of tangerine citrus (87%) in the Lima Puluh Kota district, West Sumatra, Indonesia. For over a decade, citrus has been cultivated in this sub-district. The production areas are in one location even though it spread (in the form of spots), with an area of 963 ha and located at 700-1100 m above sea level (BPS, 2019).

In 2018 to 2019 there was an exponential growth in citrus production due to a significant increase in citrus land. The addition of Gunuang Omeh citrus (Jesigo) orchards that carried out in 2017 and 2018, were doubled from the existing land in 2016. This led to an increase in harvest area and production in 2019, when citrus plantation began to learn to bear fruit, from 452 ha of harvest area in 2016 to 959 ha in 2019 (BPS, 2022). The addition of land is carried out by farmers and supported by district government due to the high market demand for this product (Figure 1). In 2021, there has been a significant production decline of citrus production in Lima Puluh Kota District by 35%, where the main producers is Gunuang Omeh subdistrict, from 58.1 thousand tons (in 2020) to 38.3

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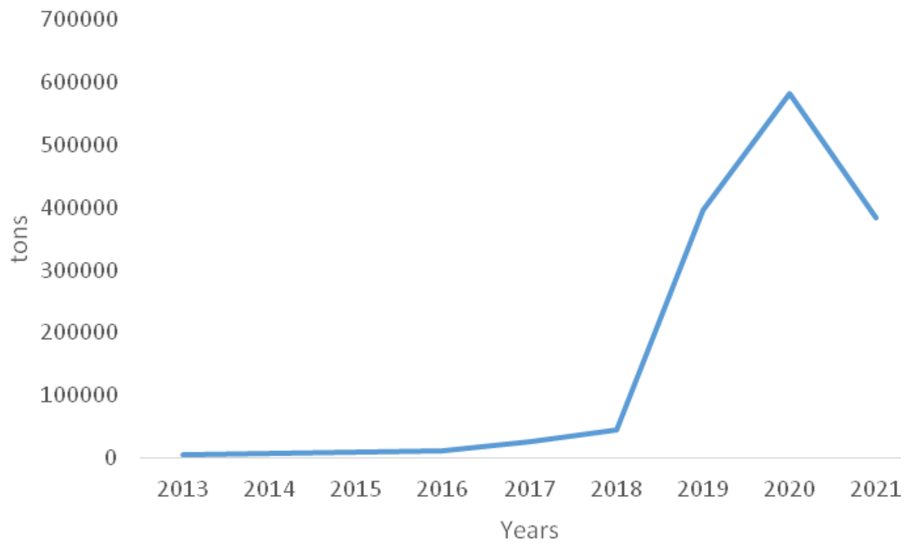

Figure 1 - Production of tangerine citrus in Lima Puluh Kota District.

Source: BPS (2022).

thousand tons. Productivity during the same period, decreased by 55.81%, from 60.29 tonnes/ha to 33.65 tonnes/ha (Figure 1), with similar harvest area. This matter deserves attention, considering around 2590 families depend on their income from citrus cultivation, with each farmer owning around 0.6 ha of land or 230 citrus plants. This underlines the need for the sustainability of citrus cultivation, one of the way is through the adoption of technology.

One of the technologies that has been disseminated in Gunuang Omeh District is integrated management for healthy citrus orchard (IMHCO). IMHCO technology aims to improve production and quality of citrus products by maintaining citrus plant health. The district government supports this through counseling, but has not been able to cover all existing citrus farmers. Conversely, in 2020-2021 the district government is still focusing on agricultural equipment and machinery (PEMERINTAH DAERAH KABUPATEN LIMA PULUH KOTA, 2021).

The potential loss of fruit flies on citrus production in Indonesia is estimated at USD 500 billion. This is also happened in Gunuang Omeh sub-district, where all respondent farmers have also suffered losses, with an average income decline by 53%. To avoid rotten fruit, some farmers harvest earlier, and get a lower price. They ignores the harvest recommendation for Gunuang Omeh citrus (Jesigo), which range around 8.5 months old from flowering.

IMHCO technology itself is related to cultivation practices that can determine ecosystem suitability for the growth of pests and diseases (ZUHRAN et al., 2021), in this case fruit flies. IMHCO application will be effective if implemented completely and simultaneously in the citrus cultivation area. On this basis, consolidation, becomes one of the pressure points to control fruit flies that require complete and simultaneous treatment in one area (area-wide management). Farmers cannot control fruit fly attacks individually—they have to work together as a group (community-based cooperation) . It is highly suggested that farmers make an ecological approach since area-wide management as an implementation of Area-Wide Integrated Pest Management (AW-IPM) can help maintain the population at a certain controllable level within an area for a long time.

The gap between technology adoption and existing technology IMHCO needs to be anticipated. Farmers tend to apply part of the technology component and not adopt it in its entirety, for that it is necessary to look at the adoption rate and the components that are adopted or not (HILMI KAHMIR et al., 2010; PUSPITASARI et al., 2020; ZAMZAMI et al., 2021). Therefore, this study examined the adoption rate of the IMHCO technology by farmers in Gunuang Omeh. Measurements were made of the 19 IMHCO technology items to find out the important items that need to be improved to solve the farmers problems. The characteristics of farmers at each adoption level are identified, along with the dominant factors that influenced the technology adoption levels and the relationship between adoption rates and fruit fly attack rates.

The adoption of IMHCO technology is related to increased productivity and ecosystem suitability for the growth of fruit flies. Some literature that looks at the application of IMHCO in several citrus centers in Indonesia is still limited in the scope of review, descriptive and partial, and uses a small sample, around 24-40 respondents. According to research that has been done, the implementation of IMHCO has reduced the presence of plant pests. However, the application of this technology is relatively low, both in West Sumatra, Bengkulu, East Java, and Bali (HILMI KAHMIR et al., 2010; NURHADI, 2015; SUHARYANTO et al., 2017). This is supported by the attitude of farmers in handling orchards which are still individual, partial, and yet to be in groups.

The IMHCO technology consists of 5 primary components elaborated into 19 items: (1) using virus-free citrus seeds; pest and disease control, including (2) using the yellow sticky trap, (3) using California slurry, (4) spraying with insecticides, (5) applying methyl eugenol as a sex pheromone, (6) bagging, (7) spraying with fungicides; orchard maintenance, including (8) architectural pruning, (9) maintenance pruning, (10) tillage, (11) balanced fertilizing, (12) watering, (13) fruit thinning, (14) weed controlling, and (15) proper harvesting; sanitation, including (16) pruning diseased plant parts, (17) eradicating (throwing plant parts affected by huanglongbing (HLB)), which is regarded as a devastating disease, (18) replacing unproductive plants with labeled seeds, and (19) consolidation of orchard management (SUPRIYANTO & WHITTLE, 1991; WIDYANINGSIH et al., 2019; HARDIYANTO et al., 2021; INDRASTI et al., 2021; TRIWIRATNO et al., 2021; HARWANTO et al., 2023)

METHODOLOGY

Study area

Gunuang Omeh sub-district, which is the main supplier of tangerine in Lima Puluh Kota District, experienced a decline in production in 2021, which resulted in a decrease in farmer revenue. One of the causes of the decline in production is the attack of fruit fly pests. Ninety-seven percent of citrus farmers in this sub-district were affected by this attack. Conversely, IMHCO technology has been disseminated here, and has the potential to stop fruit fly attacks. Therefore, this sub-district was chosen to be a study area (Figure 2).

Data collection

Primary data were collected through a cross-sectional survey involving 351 farmers in Gunuang Omeh Subdistrict. The survey employed a structured questionnaire. Samples representing 2,590 farmers in the sub-district were taken purposively

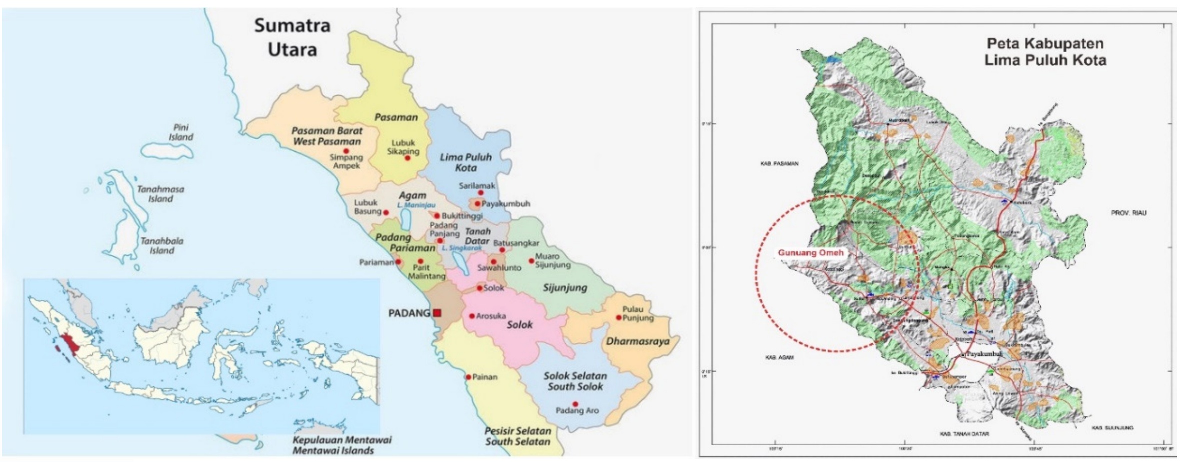

Figure 2 - Gunuang Omeh sub-district map location (red circle).

Source: The Ministry of Public Works and Housing (KEMENPUPR_RI, 2012).

by consulting the extension workers in the area (KREJCIE & MORGAN, 1970).

Theoretical and analytical framework

Technology adoption changes a person's behavior from learning about innovative technology, to adopting it. The adoption rate is to identify aspects of the technology applied from the whole package. The adoption rates were measured using two methods:

(1) Individual approach.

TA = NF/T x 100%

In the formula; TA: individual adoption rate (percentage), NF: adopted/implemented technological unit (unit), T: total suggested technological unit/component (unit).

(2) Group approach

SA = n/N x 100%

Were SA = adoption scattering (%), n: number of adopters (people), N: total number of group members (people),

TA group = SA x IA

Were TA group = group adoption rate (percentage), SA: adoption scattering (%), IA: adoption intensity (%).

Table 1 shows the categories of adoption rates based on the value obtained. Values are in the range of 0 – 100, with four categories. Categories become a mirror of improvements that need to be addressed.

After the normality test of the residuals of the independent and dependent variables, multiple linear regression was done to see the factors influencing the individual adoption rate (RAHAYU & DEWI, 2019). In this study, F test and t-test were used, with the following general form:

$$Y=B_o+B_1X_1+B_2X_2+.......+B_{14}X_{14}+e$$

In which Y is adoption rate (%), X_1: is age (in years), X_2: is the number of family members (people), X_3: is the length of education (year), X_4: is income (IDR million/year), X_5: experience in citrus cultivation (year), X_6: the distance from home to the place of business (km), X_7: the distance from the place of business to the input market (km), X_8: the distance from the place of business to the output market (km), X_9: the distance from the place of business to extension workers (km), X_{10}: land area (ha), X_{11}: plant age (year), X_{12}: plant numbers (plant), X_{13}: difficulty to access to cultivation information, X_{14}: difficulty to access to capital or credit.

Table 1 - Categories of Adoption Levels.

Adoption Level of the IMCHO technology (%)	Category
<25%	Very low
25-50%	Low
51-75%	High
>75%	Very high

Source: (HENDAYANA, 2014).

The first to fifth variables represent the characteristics of the farmers in Gunuang Omeh District. Variables six to twelve show the characteristics of the tangerine citrus orchards owned by farmers. Variables thirteen and fourteen are dummy variable represent the difficulty of access to information and credit felt by farmers. The value if the farmer has difficulties is 1, otherwise the value is 0.

The correlation test was done using Spearman's rank-order correlation with the following formula:

$$r_s = x^2 + y^2 \frac{\Sigma_i^n = 1\, d_1^2}{\sqrt[2]{(x^2)(y^2)}}$$

In which

$$x^2 = \frac{(n^3 - n) - (\Sigma t_x^3 - \Sigma t_x)}{12}$$

$$y^2 = \frac{(n^3 - n) - (\Sigma t_y^3 - \Sigma t_y)}{12}$$

r_s: the Spearman's rank-order correlation coefficient, t_x: the same number of observations on the variable x for a certain rank, d_i: the difference in rank X and Y on the i-th observation: I: I-th observation, for I = 1,2,………n, ∑= sum for the same cases.

RESULTS AND DISCUSSION

Description of respondent farmers and characteristics at each level of adoption

The average age of respondent farmers was 45.9 years, with four family members. The average length of education was 8.8 years, indicating that most respondent farmers completed or graduated Junior High School. In the last two years (2020-2021), their average income was IDR 29.4 million/year. On average, they had 8.7 years of citrus cultivation experience. The average distance between respondent farmers and their citrus plantations (orchards) as their place of business was 1.7 km. Meanwhile, the distance to the location of the extension worker (10.95 km) was farther than the distance that respondent farmers had to travel to the market (5.75 km) to sell fruit and to market input (2.41 km). The average land area owned by respondent farmers was only 0.6 ha, with a total of 232.5 trees with an average plant age of 8 years, which is the productive period of the plant.

Based on the results of individual adoption rate calculations, only 4 farmer respondents were in the very low category in the application of IMHCO, 80 farmer respondents were in the low category, 129 farmer respondents were in the high category, and 138 farmer respondents were very high (Table 2). This is an indication that individual farmers have understood the importance of implementing IMHCO. The difference at each level of adoption lies in: (1) the distance from home to the place of business/orchard and (2) the difficulty of access capital or credit. The closer the distance of the orchards makes farmers can take the time to take more care of the plants. Interestingly, farmers with very high adoption rates are more difficult to access credit; for this reason, it is necessary to examine other characteristics because even though they are not significantly different, they can provide meaningful explanations and fully understand these results. Farmers with a high adoption rate have more plants, plant age, and area than the other three levels. This can be an indication that the financing they need is also greater.

From the farmers' characteristics, the group with the highest adoption rate has a more mature age, experience in citrus cultivation, longer education, and higher welfare, as seen from income and number of family members. This profile supports creativity in agricultural cultivation, thus strengthening that access to financing for citrus cultivation is needed (SUMARTONO & TARUMUN, 2019).

IMHCO adoption rate in group

The high adoption rate in individuals was not followed by the suitability of the main components that should be implemented for handling fruit flies, as seen in the column rank and SA in table 3. Consolidation of orchard management

Table 2 - Descriptive Statistics - Test Results on The 14 Variables.

Variable	The mean of the total and the respective adoption rates						Friedman Test
	Total N (351)	Std. Dev	N=4	N=80	N=129	N=138	Sig.
			0-25%	25-50%	51-75%	>75%	
Age	45.94	14.02	49.25	47.01	46.4	48.63	0.62
Number of family members	4.41	1.62	4.5	4.76	4.58	3.96	0.79
Length of education	8.74	3.7	5.25	8.67	8.67	8.84	0.51
Income (IDR million/year)	29.35	26.67	7.45	19.65	49.77	69.25	0.39
Experience in citrus cultivation (year)	8.75	5.09	7	7	8.33	10.16	0.06
The distance from home to the place of business/orchard (km)	1.71	5.54	1.5	2.81	1.61	1.72	0.04
The distance from the place of business to the input market (km)	2.41	2.21	1.25	2.71	3.25	3.06	0.78
The distance from the place of business to the output market (km)	5.75	14.1	1.38	7.83	5.36	5.6	0.55
The distance from the place of business to extension workers (km)	10.95	14.53	9.13	10.64	11.01	9.01	0.06
Land area (ha)	0.63	0.44	0.63	0.99	0.61	1.02	0.54
Plant age (year)	8	3.2	7	6.48	7.36	8.64	0.21
plant numbers (plant)	232.64	157.98	200	173.74	220.84	276.8	0.49
Difficulty to access cultivation information							0.3
difficulty (%)	61		50	65.8	62.2	56.5	
no difficulty (%)	39		50	34.2	37.8	43.5	
Difficulty to access capital or credit							0.02
difficulty (%)	72		0	39	26.1	90.3	
no difficulty (%)	28		100	61	73.9	9	
IDR: Rupiah - IDR14.338=1 US $	-	-	-	-	-	-	-

Source: Primary data analyzed.

Table 3 - The Adoption Rates of 19 IMHCO Items by Groups.

No	Technological Components	Adopter	SA (%)	Rank	Weight	Weight Value	IA (%)	TA (%)
1	2	3	4	5	6	7	8	9
1	Labelled disease-free citrus seedling planting materials used	252.00	69.04	7.00	4.00	2.37	31.39	21.67
	-----Pest and disease control-----							
2	Using the yellow sticky trap	267.00	73.15	3.00	8.00	4.73	66.52	48.66
3	California paste application	208.00	56.99	6.00	5.00	2.96	32.39	18.46
4	Spraying with insecticides	337.00	92.33	5.00	6.00	3.55	62.97	58.14
5	Applying methyl eugenol as a sex pheromone	190.00	52.05	2.00	9.00	5.33	53.25	27.72
6	Fruit wrapping	92.00	25.21	7.00	4.00	2.37	11.46	2.89
7	Spraying with fungicides	312.00	85.48	9.00	2.00	1.18	19.43	16.61
	-----Orchard maintenance-----							
8	Architectural pruning	231.00	63.29	5.00	6.00	3.55	43.16	27.32
9	Maintenance pruning	334.00	91.51	5.00	6.00	3.55	62.41	57.11
10	Tillage	322.00	88.22	9.00	2.00	1.18	20.06	17.69
11	Balanced fertilizing	240.00	65.75	4.00	7.00	4.14	52.32	34.40
12	Watering	149.00	40.82	5.00	6.00	3.55	27.84	11.37
13	Fruit thinning	262.00	71.78	4.00	7.00	4.14	57.12	41.00
14	Weed controlling	307.00	84.11	4.00	7.00	4.14	66.93	56.29
15	Proper harvesting	264.00	72.33	3.00	8.00	4.73	65.77	47.57
	-----Sanitation-----							
16	Pruning diseased plant par	320.00	87.67	5.00	6.00	3.55	59.79	52.42
17	Eradicating (throwing plant parts affected by HLB)	77.00	21.10	8.00	3.00	1.78	7.19	1.52
18	Replacing unproductive plants with labeled seeds	179.00	49.04	8.00	3.00	1.78	16.72	8.20
19	Consolidation of orchard management	117.00	32.05	1.00	10.00	5.92	36.44	11.68
	Total		1267.00		169.00	100.00		560.73
	Average		66.68					29.51

Source: Primary data analyzed.
Notes:
SA (column 4) is obtained from n (column 3) divided by the total n (30) times 100 %.
Rank (column 5) is compiled based on expert judgment.
The weight (column 6) is set as opposed to the rank. (Rank 1 at weight 10, rank 10 at weights 1).
The weight value (column 7) is calculated by dividing column 6 by total column 6 times 100.
The IA (%) in column 8 is calculated by multiplying n (column 3) x weight value (column 7) divided by the number of recommended technological components.
TA (%) in column 9, is the multiplication of SA (column 4) x IA (column 8) divided by the constant (100).

as the first component refers to fruit flies that can fly as far as 7 km, and there is even literature that says more than 7 km (HICKS et al., 2019). Consolidation only has an adoption scattering of 32.05% and 36.44% adoption intensity, and occupies the fifth lowest adoption rate value.

The partial and low adoption of IMHCO by groups or region (29.51%), especially for handling fruit flies, deserves attention. The other four lowest components correspond to field conditions, where eradication and watering, with adoption rate value of 1.52% and 11.37%, was not carried out due to the use of labeled seeds by farmers, supported by the geographical condition of Gunuang Omeh, that located in the highlands with high rainfall, indirectly inhibits the development of the HLB vector, Diaphorina citri Kuwayama (PÉREZ-VALENCIA & MOYA-RAYGOZA, 2015). Fruit wrapping, with an adoption rate of 2.89%, due to the costs incurred and the characteristics of the tangerine citrus, in which the Gunuang Omeh citrus has an average diameter of 6.7 cm. Replacing unproductive plants with labeled seeds having low adoption rate (8.20%) because most of the farmer's citrus plants are still in productive condition, referring to their average plant age being 8 years old.

Influencing actors

The results of the linear regression analysis in table 4 clarify different variables at each level that affect the adoption rate of IMHCO on the individual approach. First are the characteristics of the farmers: the number of family members and their experience in citrus cultivation. The negative coefficient on the number of family members indicates that farmers paid better attention to increasing citrus cultivation through technology adoption when farmers had fewer dependents or because their welfare was higher. The positive coefficient of farmer experience indicated that their experience did not prevent them from adapting to new technologies. Previous studies also show that experience in cultivation has a positive effect on agricultural technology adoption (HASTUTI et al., 2021; PUTRI et al., 2022). Experience makes farmers better understand the characteristics of the new technology to assess its benefits.

The second is from variables on the characteristics of citrus orchards that have more influence on the adoption rate of farmers, namely (1) The distance from the place of business to the input and output market as well as extension workers. The distance contributes to the adoption rate in rural areas, such as Gunuang Omeh District (RUSLIYADI et al., 2023). From field observations, not all orchards points have accessible communication signals. The farther the distance from the market and extension workers, the lower the adoption rate (MACHMUDAH et al., 2019). Proximity to the output market allows farmers to receive information regarding products that consumers want and stimulates them to apply the required technology. The interesting finding from our study was that the farther the distance farmers had to the input market to obtain production tools, including seeds, fertilizers, and plant medicines, the higher their adoption of IMHCO technology. This might have happened because the suppliers of production tools also provided information and recommendations on their products. In other words, when farmers are close to the suppliers of production tools, they have one more source of information besides extension workers, where the suppliers source recommends their product. (2) Age and number of plants. In citrus, the age of the plant determines productivity and maintenance costs; the more it grows, the need for nutrients also increases, accompanied by productivity up to a certain point. Gunuang Omeh citrus farmers have an average plant age of 8 years old, where productivity should still increase if plants are treated as recommended until around 15 years of age (MUFIDAH et al., 2019).

Third is the difficulty to access cultivation information and capital/credit. These two variables are the dominant factors that influence the level of technology adoption. The more citrus farmers can easily access information related to citrus cultivation, the higher the rate of technology adoption will be. This is supported by data where groups with very high adoption rates have the closest distance to extension workers. Conversely, difficulties in accessing capital/credit have made Gunuang Omeh citrus farmers increasingly apply IMHCO technology. This needs to be examined more deeply because it is the dominant factor influencing adoption and differentiating between group adoption rates. Referring to the previous explanation, this can be made possible due to greater financing needs so that the level of difficulty in accessing capital/credit is more pronounced. This result reaffirmed that microcredit improves farmers' welfare in rural areas, indirectly through technology adoption (MARIYONO, 2019; DARWIS et al., 2023).

IMHCO adoption rate relationship with fruit fly attack

Fruit fly attacks in Gunuang Omeh District have begun to be felt a lot since 2019 by 50% of the respondent farmers. This is also seen in the decline in citrus production in Lima Puluh Kota District (Figure 1.). Most of the respondent's farms had been attacked by fruit flies (97.4%). Most stated (37%) that half of their plantations were attacked and reduced production (37%) and income earned (35%) to half of normal. Several fruit fly controls, according to the IMHCO technology components, have been carried out by the respondent farmers, namely using the yellow

Table 4 - Determinants of IMHCO Adoption Rates by Individuals.

Variables	Regression Coefficient	Standard Error	t-count	Sig
Constant	60.452	7.667	7.885	0.000
Age	-0.084	0.086	-0.979	0.328
Number of family members	-3.045	0.729	-4.178	0.000
Length of education	0.069	0.306	0.226	0.821
Income (IDR million/year)	0.040	0.048	0.791	0.430
Experience in citrus cultivation (year)	0.657	0.273	2.412	0.017
The distance from home to the place of business (km)	-0.103	0.618	-0.166	0.868
The distance from the place of business to the input market (km)	1.008	0.521	1.936	0.054
The distance from the place of business to the output market (km)	-0.331	0.097	-3.400	0.001
The distance from the place of business to extension workers (km)	-0.201	0.084	-2.393	0.018
Land area (ha)	-2.473	4.256	-0.581	0.562
Plant age (year)	1.182	0.501	2.359	0.019
Plant numbers (plant)	0.019	0.015	1.279	0.202
Difficulty to access cultivation information	-9.310	2.421	-3.846	0.000
Difficulty to access capital or credit	16.817	2.879	5.841	0.000
Sig F= 0.00				
IDR: Rupiah - IDR14.338=1 US $				

Source: Primary data analyzed.

sticky trap (69%), spraying with insecticide (79%), and applying methyl eugenol as a sex pheromone (4%). Two additional actions were also carried out by a small number of farmers, namely collecting rotten fruit affected by fruit flies and putting it in a plastic bag (9%), followed by fumigation (3%). The description above shows that the consolidation of the simultaneous handling of fruit flies has yet to be carried out.

The relationship between fruit fly attacks experienced by farmer respondents and the individual IMHCO adoption rate is shown in table 5, which shows the higher the fruit fly attack rate, the more farmer implements IMHCO, with a weak correlation rate (21%). From these results, the respondent farmers still act reactively in orchards maintenance. Respondent farmers were trying to make improvements to prevent fruit fly attacks from spreading but have yet to consolidate with other farmers.

Table 5 - Correlation of Fruit Fly Attack Area with Adoption Rate.

Note	Correlation of fruit fly attack area and adoption rate
Coefficient	0.209
Sig	0.000
N	351

Source: Primary data analyzed.

CONCLUSION

Citrus farmers in Gunuang Omeh do not yet understand the importance of applying IMHCO technology in groups for fruit fly handling. Citrus farmers need to understand the main components (1) applying methyl eugenol as a sex pheromone, (2) using the yellow sticky trap, and (3) proper harvesting need to be implemented simultaneously or community-based cooperation. Here the three components, in group application, are still low. Regarding the area owned by each farmer is relatively small, makes consolidation become an essential benchmark.

Variables that affect the IMHCO adoption rate individually can be an entry point for district government to intervene for improvement. (1) Difficulty to access credit, where it needs to be parsed, and how fulfillment for credit for wider citrus farmers can be met. (2) Difficulty to access information, requires a strategy to provide access to all citrus farmers in Gunuang Omeh District, especially information related to simultaneous handling of fruit flies. (3) The distance from the place of business (orchards) to input and output market also extension workers shows the importance of the ease of road access and transportation in Gunuang Omeh District as a highlands village. Distance is related to the connection of important actors who play a role in technology adoption, farmers and extension workers, farmers and consumers, and farmers with providers of production facilities, which in certain area of Gunuang Omeh cannot be reached by communication signals.

Some of the steps above are expected to suppress or prevent attacks before they become outbreaks. The high adoption of IMHCO individually can be the first step to increase the application of IMHCO, in the context of handling fruit flies, in groups. Assistance regarding implementing improvements from the government, needs to be carried out continuously, in the hope that fruit fly attacks can be overcome, for the sustainable citrus cultivation in Gunuang Omeh District, which became the livelihood of 2590 citrus farmers.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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