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The Influence of Soybean Farmer Characteristics on The Decision To Apply Plant-based Pesticide Technology in Ngaringan District, Grobogan Regency

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ABSTRACT

Plant-based pesticides are environmentally friendly and sustainable pest control technologies. However, the awareness of soybean farmers in Ngaringan District, Grobogan Regency to apply plant-based pesticides is still low. The low application of plant-based pesticides is influenced by the characteristics of the farmers. This research aims to identify the characteristics of soybean farmers; identify the stages of decision-making among soybean farmers in applying plant-based pesticide technology; and analyze the influence of soybean farmer characteristics on the decision to apply plant-based pesticides in Ngaringan District, Grobogan Regency. The research uses a quantitative method with a survey technique. The research was carried out purposively in Ngaringan District, with a sample of 70 soybean farmers selected through proportional random sampling techniques. Data analysis was conducted using multiple linear regression tests with IBM SPSS Statistics 25. The results of the research show that the majority of soybean farmers in Ngaringan District are in the early elderly age category, very small land areas, formal education at the high school level, very low non-formal education, highly experienced in soybean farming, and high level of cosmopolitanism; the decision-making process for the application of plant-based pesticide technology is categorized as high at the knowledge and persuasion stages, while at the decision, implementation, and confirmation stages, it is categorized as very low; and the farmer characteristics of land area and non-formal education have a significant effect on the decision to apply plant-based pesticides, while age, formal education, farming experience, and cosmopolitanism do not have a significant effect.

Keywords: *Decisions, Farmer's Characteristics, Plant-Based Pesticides, Technology Application*

1. INTRODUCTION

Food is a basic need that must be met for human survival. The issue of food is one of the global problems that is a global challenge to be overcome immediately, including in Indonesia with the population which tends to increase every year so that it has an impact on the increasing demand for food. One of the food sources of the community in Indonesia is soybeans which are also a leading food commodity besides rice and corn. Soybeans have a complete nutritional content to meet nutritional needs and beneficial for human health. The protein content in 100 grams of soybeans can reach 40%, higher than the protein content of legumes in general which only ranges from 20-25% [1].

Based on calculations by Badan Pusat Statistik Indonesia in 2023 regarding soybean commodity distribution data, using the 2022 interim population projection approach, the average soybean consumption (both household and non-household) in 2022 in Indonesia still could not be met by domestic soybean production, resulting in a deficit of 81.48 percent [2]. The total production was 241,434.18 tons, while the projected consumption reached 1,303,605.31 tons. This figure indicates a significant production shortfall relative to consumption needs, which will pose a serious issue if not addressed. The government has made various efforts to increase soybean production. One of the major threats that could affect soybean availability and the success of efforts to increase productivity is pest attacks. Pests can lead to lower quality crops and result in low production per unit area. It is

estimated that 15-20% of soybean production is lost annually, either directly or indirectly, due to pest attacks [3].

Agricultural practices with conventional approaches are still widely practiced by farmers in Indonesia, especially the use of chemical pesticides in handling pests and diseases in soybean plants. Farmers in practice often still violate the rules by using chemical pesticides in doses that exceed the dosage and even mix several types of chemical pesticides with the excuse of increasing toxicity to pests and plant diseases that attack their plants. Basically, pesticides are targeted only for pests. However, most active ingredients used are not specific enough in their toxicity, so they can endanger human health [4]. Excessive use of chemical pesticides can also harm the environment and the ecosystem as a whole, such as poisoning humans and animals, killing natural enemies, creating pest resistance and recurrence, and polluting the environment. The effects of unwise use of chemical pesticides can cause long-term adverse effects.

Sustainable and environmentally friendly pest control efforts have long been introduced by the government, such as the use of plant-based pesticides. Plant-based pesticides are an alternative to conventional pesticides and a subcategory of biopesticides in agricultural pest control. Plant-based pesticides have several characteristics, such as selectivity toward beneficial insects, low bioaccumulation and persistence in the environment, and low toxicity to humans [5]. Compared to chemical pesticides, plant-based pesticides are generally safer for humans and the environment [6]. Indonesia is rich in biodiversity, including plants containing active pesticide ingredients. There are more than 2,000 species worldwide that can be used as plant-based pesticides, many of which are found in Indonesia [7].

One of the main soybean production centers in Indonesia is Grobogan Regency in Central Java. Grobogan Regency had the largest soybean harvested area in Central Java from 2020 to 2022. In 2022, soybean harvested area in Grobogan Regency accounted for 54% of the total harvested area in Central Java [2]. Grobogan Regency also achieved recognition as the region with the highest national soybean productivity level, reaching 3.6 tons per hectare. As the main soybean production center in Central Java, Grobogan Regency plays a crucial role in national soybean availability. Ngaringan District is the area with the highest soybean production among the 19 districts in Grobogan Regency.

The issue encountered is that only a small number of soybean farmers in Ngaringan District are using plant-based pesticides. This is due to the lack of awareness among farmers about environmentally friendly pest control, as the majority of farmers still rely on chemical control methods because they are considered faster and more practical. These two reasons are related to the characteristics of the farmers, which influence their decision-making in farming. Several farmer characteristics that affect their decision-making include age, education, land area, farming experience, and cosmopolitanism. The decision-making stages studied include knowledge, persuasion, decision, implementation, and confirmation. This study aims to identify the influence of soybean farmer characteristics on the decision to apply plant-based pesticides in Ngaringan District, Grobogan Regency. By understanding the influence of various farmer characteristics on their decision to use plant-based pesticides, more effective and targeted solutions can be identified to encourage increased use of plant-based pesticides by soybean farmers in Ngaringan District, Grobogan Regency. This knowledge will help stakeholders, such as agricultural extension workers

and local governments, in designing programs that align with the farmers' conditions and needs, so the adoption of plant-based pesticide technology can be more optimal and sustainable in the region.

2. LITERATURE REVIEW

2.1 Farmer Characteristics

Several characteristics of farmers influence how willing and able they are to adopt innovative technologies, including age, education, land size, farming experience, and cosmopolitanism. A farmer's age affects their openness to change, with younger farmers more likely to adopt innovations quickly, even though they may lack experience, while older farmers are slower and tend to stick to traditional practices. Formal education helps shape progressive attitudes, with more educated farmers adopting innovations faster. Non-formal education, such as agricultural extension programs, also plays a role in changing farmers' behavior and mindset. Land size, as an essential economic resource for farmers, makes small-scale farmers more cautious in adopting innovations due to limited resources. Farming experience influences farmers' perceptions of new technologies, with experienced farmers being more careful in adopting innovations to avoid risks of failure. Cosmopolitanism refers to farmers' ability to seek information through media and social interactions, where more cosmopolitan farmers are generally more open to new technologies because they gain more information from outside their farming communities [8].

2.2 Stage of Decision on Technology Application

The innovation decision-making process is the series of stages individuals or decision-making units go through from initial awareness of an innovation, forming an attitude, deciding to adopt or reject it, implementing, and confirming the decision. This process consists of five stages: 1) Knowledge, where individuals learn about the existence and workings of an innovation to reduce uncertainty, with mass media being an effective source of information; 2) Persuasion, where individuals form either a favorable or unfavorable attitude toward the innovation by evaluating its perceived benefits and drawbacks; 3) Decision, where individuals choose to adopt or reject the innovation, with the possibility of changing this decision later; 4) Implementation, when individuals apply the innovation, which may evolve or change over time; and 5) Confirmation, where individuals seek reinforcement of their decision but may reverse it if they encounter conflicting messages [9].

2.3 Plant-based Pesticide

One component of integrated pest control is using plant-based pesticides. Plant-based pesticides are a category of biopesticides derived from several parts or active ingredients of plants which aim to kill insects, sterilize, control weeds and regulate plant growth. The development of plant-based pesticides mostly utilizes secondary plant metabolites, such as flavonoids, alkaloids, and others. Biopesticides greatly reduce environmental pollution caused by chemical residues of pesticides and promote sustainable agricultural development [10]. Plant-based pesticides have the characteristics of being environment-friendly, not easy to produce resistance, specific modes of action, promoting crop growth and improving disease resistance. Due to its

advantages, plant-based pesticides are made into various forms of application for plant protection, especially in the organic sector and for low-input food production, such as plant-based insecticides, fungicides, bactericides, and herbicides [11].

3. METHODS

This research employs a quantitative descriptive method with a survey technique, conducted from April to May 2024 in Ngaringan District, Grobogan Regency. The location was selected purposively as Ngaringan District has the highest soybean production in Grobogan Regency, which is the largest soybean production center in Central Java. he independent variables (X) in this study include respondents' age (X1), which is the respondents' age at the time of the study (in years); land area (X2), which is the area of soybean cultivation managed by the respondents during the most recent planting season (in hectares); formal education (X3), which is the highest level of education completed by the respondents in formal educational institutions; non-formal education (X4), which is the frequency of respondents' participation in soybean cultivation extension programs or training over the past year; farming experience (X5), which is the length of time respondents have been farming soybeans up to the time of the study (in years); and cosmopolitanism (X6), which is the frequency of farmers' interactions with parties outside their farmer group, use of mass media, and activities with related institutions. The dependent variable in this study is the decision to apply plant-based pesticide technology (Y). The sample size was determined using Roscoe's formula, where for multivariate analysis, the minimum sample size is 10 times the number of variables [12]. This study uses 7 variables (6 independent + 1 dependent), so the sample size used is 70 soybean farmers. Three villages were selected based on the largest, middle, and smallest land areas, namely Tanjungharjo Village, Belor Village, and Ngaringan Village. Samples from each village were taken using proportional random sampling. The data sources used include primary and secondary data. Data collection techniques included observation, interviews using questionnaires, and documentation. Data analysis used the Likert scale. The measurement of the influence of soybean farmer characteristics on the decision to apply plant-based pesticides technology in Ngaringan District, Grobogan Regency, was conducted using multiple linear regression, which includes the coefficient of determination test (R^2), simultaneous test (F-test), and partial test (t-test) using IBM SPSS Statistics 25.

4. RESULTS AND DISCUSSION

4.1 Characteristics of Soybean Farmers in Ngaringan District, Grobogan Regency

Each farmer has different characteristics, both in terms of demographic, social, and socio-economic conditions. These differences affect the way they respond, respond, or apply plant-based pesticide technology as an environmentally friendly pest control method. The characteristics of farmers that are suspected of influencing the decision to apply plant-based pesticides include age, formal education, non-formal education, land area, farming experience, and the level of cosmopolitanism.

1. Age (X_1)

Table 1. Distribution of respondents by age

	Age (years)	Category	Score	Frequency (Person)	Percentage (%)
1	56-65	Late elderly	5	17	24,29
2	**46-55**	**Early elderly**	**4**	**26**	**37,14**
3	36-45	Late adulthood	3	18	25,71
4	26-35	Early adulthood	2	9	12,86
5	12-25	Adolescent	1	0	0,00

Total	70	100.00

Source: Primary Data (2024)

The highest distribution of respondents based on the age of farmers who are included in the early elderly category or the age range of 46-55 years is 26 farmers with a percentage of 37.14%. At that age, farmers are still included in the category of the population with productive age. The population that enters the productive age ranges from 15-64 years old [13]. Meanwhile, the distribution of respondents is the lowest aged 12–25 years, this indicates the low regeneration of farmers and the interest of youth to become farmers in Ngaringan District. Most of the respondent farmers belong to the old age category, but they are still actively involved in agricultural activities.

2. Land Area (X_2)

Table 2. Distribution of Respondents Based on Land Area

	Land Area (Ha)	Category	Score	Frequency (Person)	Percentage (%)
1	> 2	Very spacious	5	2	2,86
2	> 1.5 – 2	Broad	4	3	4,29
3	> 1 – 1.5	Quite spacious	3	12	17,14
4	0,5 – 1	Less spacious	2	24	34,29
5	**< 0.5**	**Narrow**	**1**	**29**	**41,42**
	Total			70	100.00

Source: Primary Data (2024)

The highest distribution of respondents based on land area ownership is in a narrow land category. The majority of soybean farmers have less than 0.5 hectares of land, namely 29 farmers with a percentage of 41.42%. Farmers with land ownership of less than 0.5 hectares in Indonesia are called gurem farmers. Even though they are farmers with narrow land, gurem farmers play an important role in providing agricultural needs in Indonesia [14]. The land area in this study includes land managed by respondent farmers for soybean cultivation. The land being studied can be in the form of privately owned land, leased land, sakap, or crooked land in the village.

3. Formal Education (X3)

Table 3. Distribution of Respondents Based on Formal Education

	Level of Education	Category	Score	Frequency (Person)	Percentage (%)
1	College	Very high	5	5	7,14
2	**SMA/Senior High School**	**High**	**4**	**23**	**32,86**
3	SMP/Junior High School	Keep	3	21	30,00
4	SD/Elementary School	Low	2	19	27,14
5	Not finishing elementary school	Very low	1	2	2,86
	Total			70	100.00

Source: Primary Data (2024)

The highest distribution of respondents based on formal education is farmers with senior high school graduates. The number of farmers who have received education up to the senior high school level is 23 farmers with a percentage of 32.86%. This category can be said that farmers have an awareness of the importance of education. The majority of farmers who have a high school education level are already considered to have high knowledge among other farmers [15]. Respondents' level of formal education affects the way they think about managing their farming business and solving problems that arise.

4. Non-formal Education (X4)

Table 4. Distribution of Respondents Based on Non-formal Education

	Frequency of Activities (times/year)	Category	Score	Frequency (person)	Percentage (%)
1	≥ 5	Very high	8,5–10	4	5,71
2	4	High	6,9–8,4	10	14,29
3	3	Quite high	5,3–6,8	8	11,43
4	2	Low	3,7–5,2	18	25,71
5	**1**	**Very low**	**2,0–3,6**	**30**	**42,86**
Total				70	100.00

Source: Primary Data (2024)

The highest distribution of respondents based on non-formal education of farmers is in the very low category. The majority of farmers in Ngaringan District only participate in counseling and training activities once a year, namely 30 farmers with a percentage of 42.86%. Meanwhile, farmers who participated in activities in obtaining non-formal education more than 5 times in 1 (one) year were only 4 people or 8.57% of respondents. Non-formal education for farmers supports farming activities because the learning process involves practice and experience from teaching sources.

5. Farming Experience (X5)

Table 5. Distribution of Respondents Based on Farming Experience

It	Farming Experience (years)	Category	Score	Frequency (Person)	Percentage (%)
1	**> 20**	**Highly experienced**	**5**	**40**	**57.14**
2	> 15–20	Experienced	4	15	21.43
3	> 10–15	Quite experienced	3	6	8.57
4	> 5–10	Less experienced	2	5	7.14
5	≤ 5	Very inexperienced	1	4	5.71
Total				70	100.00

Source: Primary Data (2024)

The distribution of the highest respondents based on soybean farming experience in the very experienced category. As many as 40 respondents have more than 20 years of farming experience with a percentage of 57.14% of farmers. Experienced farmers tend to have a better understanding and knowledge of the land than new farmers [16]. Based on the farmers' recognition, soybean cultivation in Ngaringan District has been carried out for a long time and for generations, because soybeans are a suitable commodity to be planted in their area, considering that Grobogan Regency is the largest soybean contributor in Central Java.

6. Cosmopolitan (X6)

Table 6. Distribution of Respondents Based on Cosmopolitanity

It	Information Search Intensity (times/month)	Category	Score	Frequency (peson)	Percentage (%)
1	≥ 4	Very High	12,9–15,0	7	10,00
2	**3**	**High**	**10,7–12,8**	**23**	**32,86**
3	2	Quite high	8,5–10,6	19	27,14
4	1	Low	6,3–8,4	8	11,43
5	Never	Very low	4,0–6,2	13	18,57
Total				70	100.00

Source: Primary Data (2024)

The highest distribution of respondents based on the level of farmer cosmopolitanity is in the high category, namely farmers in seeking information about agriculture are carried out 3 (three) times in one month with a percentage of 32.86% of farmers. Cosmopolitan is a person's ability to seek information, participate in activities outside the region, as well as change attitude patterns and find solutions to problems [17]. Basically, farmers in rural areas still often socialize outside their villages to meet and communicate with other farmers.

4.2 Decision on the Implementation of Vegetable Petitions in Ngaringan District, Grobogan Regency

The decision to apply plant-based pesticides consists of 5 (five) stages which include the stages of knowledge, persuasion, decision, implementation, and confirmation. The decision-making process starts from the knowledge stage, where a person begins to know about the innovation and how it works. The second stage is persuasion, where a person forms a positive or negative attitude towards the technology. The third stage is the decision to accept or reject the technology. The fourth stage is implementation, where one starts using innovation. The final stage is confirmation, where one seeks reinforcement for the decision that has been made to continue or stop.

Table 7. Distribution of Respondents Based on Decision Making Stages for the Application of Plant-Based Pesticides

	Decision Stage	Category	Score	Frequency (peson)	Percentage (%)
1	Knowledge	Very high	21,5–25,0	13	18,57
		High	**17,9–21,4**	**18**	**25,71**
		Quite high	14,3–17,8	10	14,29
		Low	10,7–14,2	15	21,43
		Very low	7,00–10,6	14	20,00
2	Persuasion	Very high	21,5–25,0	11	15,71
		High	**17,9–21,4**	**21**	**30,00**
		Quite high	14,3–17,8	18	25,71
		Low	10,7–14,2	13	18,57
		Very low	7,00–10,6	7	10,00
3	Decision	Very high	8,5–10	19	27,14
		High	6,9–8,4	1	1,43
		Quite high	5,3–6,8	2	2,86
		Low	3,7–5,2	0	0,00
		Very low	**2,0–3,6**	**48**	**68,57**
4	Implementation	Very high	16,9–20,0	9	12,86
		High	13,7–16,8	10	14,29
		Quite high	10,5–13,6	3	4,29
		Low	7,30–10,4	0	0,00
		Very low	**4,00–7,20**	**48**	**68,57**
5	Confirmation	Very high	16,9–20,0	9	12,86
		High	13,7–16,8	10	14,29
		Quite high	10,5–13,6	3	4,29
		Low	7,30–10,4	0	0,00
		Very low	**4,00–7,20**	**48**	**68,57**

Source: Primary Data (2024)

Based on Table 7, it can be seen that the majority of farmers' knowledge about plant-based pesticides is in the high category (25.71% of respondents), the farmers' knowledge is related to non-formal education that farmers attend, namely counseling, training, discussions in farmer group meetings, and information search by farmers independently. The stage of farmers' persuasion

regarding plant-based pesticides related to the assessment of the suitability of plant-based pesticides to be applied to their soybean farming businesses was mostly in the high category (30.00% of respondents). Although farmers have a high level of knowledge and persuasion on plant-based pesticides, at the stage of decision (68.57% of respondents), implementation (68.78% of respondents), and confirmation (68.78% of respondents) the application of plant-based pesticides is in a very low category. This means that farmers who have a positive assessment of plant-based pesticides do not necessarily decide to apply plant-based pesticides to their soybean farming. This happens because of the internal factors of the farmers themselves and they are too comfortable becoming conventional farmers by using chemical pesticides for the control of their crop pests. Most farmers who are already using plant-based pesticides plan to continue using them in the future. They realize the benefits of plant-based pesticides that are more environmentally friendly and can help reduce negative impacts on human health as well as ecosystems. This plant-based pesticide is not only applied to soybean cultivation, but also to the cultivation of other crops such as rice, corn, and mung beans.

4.3 The Influence of Soybean Farmer Characteristics on the Decision to Apply Plant-Based Pesticides in Ngaringan District, Grobogan Regency

The test used in this study is multiple linear regression analysis which includes a determination coefficient test (R^2), a simultaneous test (F test), and a partial test (t test) with a α value of 5% (0.05) confidence level of 95%. Multiple linear regression analysis is used to measure how much influence the independent variable has on the bound variable [18]. This analysis was carried out using the IBM SPSS application *Statistics* 25.

1. Determination Coefficient Test (R^2)

The determinate coefficient (R^2) is used as a measure to express the regression line match obtained to describe the actual condition. If the value of the determination coefficient is equal to 1, then the independent variable is able to explain its effect on the bound variable by 100%. The R Square value shows the contribution of the influence of the independent variable to the bound variable. The results of the summary model of the determination coefficient (R^2) can be seen in Table 8. as follows:

Table 8. Results *of the Summary* Model Test of Adjusted R *Square Value*

Type	R	R *Square*	*Adjusted* R *Square*	*Std. Error of the Estimate*
1	0,806	0,650	0,617	8,054

Source: Primary Data Processing Results (2024)

Based on Table 8, it is known that the R *Square* (R^2) value is 0.650. This means that the independent variables, namely age (X1), land area (X2), formal education (X3), non-formal education (X4), farming experience (X5), and cosmopolitanity (X6) can explain the decision variables of soybean farmers in the application of vegetable pesticides (Y) by 65%. While the remaining 35% is explained by other factors that were not studied in this study.

2. Simultaneous Test (F Test)

The F test or regression coefficient test is simultaneously used to determine the influence of independent variables simultaneously on the bound variables, whether they have a significant influence or not. The criteria for decision-making are if the probability value (p *value*) is ≤ α, then H0 is rejected and H1 is accepted, meaning that the independent variable simultaneously has a significant effect on the bound variable, while if the probability value (p *value*) is > α, then H0 is accepted and H1 is rejected. The results of the simultaneous test (test F) are shown in Table 9 as follows:

Table 9. Results of Simultaneous Tests (Test F) on the Y variable

Type	*Sum of Squares*	Df	*Mean Square*	F	Sig.
Regression	7598,095	6	1266,349	19,520	0,000
Residual	4087,121	63	64,875		
Total	11685,216	69			

Source: Primary Data Processing Results (2024)

The results of the F test in Table 9 show a probability value (p *value*) of 0.000 with a confidence level of 95% (α=0.05). This shows that the value of *sig.* 0.000 < 0.05 or p *value* ≤ α which means H0 is rejected and H1 is accepted. It can be concluded that the independent variable (farmer characteristics) has a significant simultaneous influence on the variable bound by the decision to apply plant-based pesticides).

3. Partial Test (t-Test)

The t-test was used to determine the influence of independent variables (age, land area, formal education, non-formal education, farming experience, and cosmopolitanity) on the bound variable (decision on the application of plant-based pesticide technology) partially. If the p value is < α, then H0 is rejected and H1 is accepted, meaning that the free variable partially has a significant effect on the bound variable. Conversely, if the p value is > α, then H0 is accepted and H1 is rejected, meaning that the free variable has no significant effect on the bound variable.

Table 10. Results of Partial Test (t-Test) on the Y variable

Variable	Sig.	α	Information
1 (*Constant*)	0,156	0,050	
2 Age (X1)	0,881	0,050	Insignificant
3 Land area (X2)	0,017	0,050	Significant
4 Formal education (X3)	0,281	0,050	Insignificant
5 Non-formal education (X4)	0,000	0,050	Significant
6 Farming experience (X5)	0,529	0,050	Insignificant
7 Cosmopolitan (X6)	0,088	0,050	Insignificant

Source: Primary Data Processing Results (2024)

Based on the results of the analysis, the regression model equation in the multiple linear regression coefficient analysis is obtained as follows:

$$Y= 11,606 – 0.234X1 + 3,022X2 + 1,479X3 + 3,753X4 – 0,937X5 + 1,016X6 + e$$

The equation shows the direction of influence of various variables X on variable Y. Positive constant value of 11.606 shows a unidirectional influence between the independent variable (X) and the bound variable (Y). The values of the regression coefficients of the variables of land area (X2), formal education (X3), non-formal education (X4) and cosmopolitanity (X6) have positive values which indicate the direction of influence in one direction, meaning that each increase in one unit of the variable will affect the decision variable (Y) so that it increases by the same constant as each. Meanwhile, the values of the regression coefficient of the age variable (X1) and farming experience (X5) have negative values which indicate the opposite direction of influence so that every increase in one unit of the variable will affect the decision variable (Y) so that it decreases by the amount of their respective constants.

1) The Effect of Age (X1) on the Decision to Apply Plant-based Pesticides

Based on Table 10, it is known that P value *value* or sig in the age variable (X1) of 0.881 so that the value of p *value* > α is 0.881 > 0.05, then H0 is accepted and H1 is rejected. This means that

age partially does not have a significant influence on the decision to apply plant-based pesticides. Contrary to the statement that age affects the adoption of agricultural technology, the older the farmer the less likely they are to adopt the technology and the more likely they are to not adopt the technology, farmers at a young age increase the likelihood of adopting technology [19][20]. This is because in the application of plant-based pesticides, regardless of the age level of the farmer, both young farmers and old farmers are equally able to apply plant-based pesticides. Plant-based pesticides are relatively low in complexity, the way to make and apply plant-based pesticides is relatively easy to apply because it does not require special expertise or excessive strength, so that the age level does not prevent anyone from applying plant-based pesticides to their soybean farming business.

2) The Effect of Land Area (X2) on the Decision to Apply Plant-based Pesticides

P value *value* or sig in the variable land area (X2) of 0.017 so that p *value* < 0.05 i.e. 0.017 < 0.05, then H0 is rejected and H1 is accepted. This means that the land area partially has a significant influence on the decision to apply plant-based pesticides. Based on conditions in the field, it shows that the area of land ownership planted with soybeans is in a narrow category or called gurem farmers (<0.5 Ha). The majority of farmers in Ngaringan District are smallholder farmers who are afraid of crop failure if they try plant-based pesticides. Smallholder farmers face risks that affect their decisions to increase productivity [14]. Farmers with large plots of land are more daring to try new technologies because their business results are not completely dependent on one land. Farmers with large plots of land are better prepared to face the risk of loss [21]. To convince farmers with narrow land, it is necessary to create an environmentally friendly agricultural demonstration plot that uses plant-based pesticides, so that farmers are more confident in applying them.

3) The Effect of Formal Education (X3) on the Decision to Apply Plant-based Pesticides

P value *value* or sig in the formal education variable (X3) of 0.281 so that the value (p *value*) > α is 0.281 > 0.05, then H0 is accepted and H1 is rejected. This means that formal education partially does not have a significant influence on the decision to apply plant-based pesticides. There is no difference in the stage of introduction of innovation based on the level of formal education [22]. Farmers' sources of knowledge about plant-based pesticides are mostly obtained from outside formal education. Non-formal education, such as counseling and training, plays a more significant role in the decision to apply plant-based pesticides. Counseling is often considered a substitute for formal education in encouraging the adoption of innovation [23]. In addition, access to information is currently easy to reach, and many Ngaringan farmers use social media such as *Google* and *YouTube* to find information about agricultural cultivation.

4) The Effect of Non-formal Education (X4) on the Decision to Apply Plant-based Pesticides

P value *value* or sig in the non-formal education variable (X4) of 0.000 so that p *value* < 0.05 which is 0.000 < 0.05, then H0 is rejected and H1 is accepted. This means that non-formal education partially has a significant influence on the decision to apply plant-based pesticides. The higher the level of non-formal education that farmers attend, the higher their decision to apply plant-based pesticides. Farmers who rarely participate in counseling have less knowledge, while those who often participate are more likely to accept technology. Skills-based non-formal education increases productivity [24]. Non-formal education on plant-based pesticides in Ngaringan District is still rare, with training that is usually only attended by representatives of farmer groups. However, not all representatives spread the knowledge gained to other members. Therefore, the function of farmer groups needs to be activated and improved again as a place for joint learning. Agricultural technology is more effectively applied together by farmer group members, and the role of group

leader is very important [25]. Extension through demonstrations and direct practice is more effective, because farmers can feel and remember the experience [26].

5) The Effect of Farming Experience (X5) on the Decision to Apply Plant-based Pesticides

P value *value* or sig on the farming experience variable (X5) of 0.529 so that the value of p *value* > α is 0.529 > 0.05, then H0 is accepted and H1 is rejected. This means that farming experience partially does not have a significant influence on the decision to apply plant-based pesticides. These results are not in line with the opinion that experienced farmers are more selective in choosing innovations, while less experienced farmers are quicker to make decisions [27]. This is because farmers' awareness of the importance of environmentally friendly pest control is still low. Farmers have long relied on chemical pesticides down generations, and counseling about plant-based pesticides has not reached all farmers. In addition, the consistent use of plant-based pesticides on pilot land is limited, so farmers are not sure of the benefits.

6) The Effect of Cosmopolitan (X6) on the Decision to Apply Plant-based Pesticides

P value *value* or sig. on the cosmopolitan variable (X6) of 0.088 so that p *value* > 0.05 is 0.088 > 0.05, then H0 is accepted and H1 is rejected. This means that cosmopolitanity partially does not have a significant influence on the decision to apply plant-based pesticides. The frequency of farmers in seeking information related to agriculture is in the high category through contact with other people outside their villages and the use of mass media. However, for the frequency of traveling to related agencies such as BPP, the Agriculture Office is still rarely done because it is only adjusted to needs, such as if taking assistance or coordination by group administrators. The results of the study show that cosmopolitanity does not affect the decision to apply plant-based pesticides because the information sought or obtained by farmers is more about agriculture in general, while information about plant-based pesticides is still rarely investigated by farmers in depth. This is not in line with the opinion that interpersonal communication helps farmers gain detailed knowledge about innovation, change opinions, and reduce uncertainty by accessing credible sources [28].

CONCLUSION

The research results show that the majority of soybean farmers in Ngaringan District, Grobogan Regency are in the early elderly age category, work on very small land areas, have formal education primarily at the high school level, have very low non-formal education regarding soybean cultivation, are highly experienced in soybean farming, and have a high level of cosmopolitanism. The decision-making process for the application of plant-based pesticide technology by farmers is categorized as high at the knowledge and persuasion stages, while at the decision, implementation, and confirmation stages, it is categorized as very low. Farmer characteristics that significantly influence the decision to apply plant-based pesticide technology include land area and non-formal education, while characteristics such as age, formal education, farming experience, and cosmopolitanism do not have a significant effect on the decision to apply plant-based pesticides. The recommendations from this research are specific demonstration plots for the application of plant-based pesticides should be established in each village, extension workers and farmer groups should be more active in organizing meetings and training on plant-based pesticides, and support from the government or relevant parties is crucial for the sustainability of plant-based pesticide adoption by farmers.

REFERENCES

[1] M. F. Nikmah and Rosidah, "Pengaruh Substitusi Tepung Kacang Kedelai Terhadap Daya Terima Masyarakat Serta Kandungan Protein dan Serat Pangan Roti Bun," *Food Sci. Culin. Educ. J.*, vol. 12, no. 1, pp. 21–28, 2023, doi: https://doi.org/10.15294/focuze.v12i1.65688.

[2] Badan Pusat Statistik, "Distribusi Perdagangan Komoditas Kedelai Indonesia 2023," Jakarta, 2023. [Online].

Available: https://www.bps.go.id/id/publication/2023/11/22/240a70a50154f74d4e2381d0/distribusi-perdagangan-komoditas-kedelai-indonesia-2023.html.

[3] Rustam, "Keragaan Produksi dan Organisme Pengganggu Tanaman Padi, Jagung, dan Kedelai di Provinsi Riau," *J. Agroteknologi Trop.*, vol. 5, no. 1, pp. 39–54, 2016.

[4] R. Rianto, Anita, and A. Fatmawati, "Edukasi Mengenai Dampak Pestisida Berbahaya Bagi Petani di Desa Layoa, Kec. Gantarangkeke, Kab. Bantaeng," in *Seminar Nasional Hasil Penelitian & Pengabdian Kepada Masyarakat 2019 (SNP2M)*, 2020, pp. 405–409.

[5] G. M. W. Lengai, J. W. Muthomi, and E. R. Mbega, "Phytochemical Activity And Role Of Botanical Pesticides In Pest Management For Sustainable Agricultural Crop Production," *Sci. African*, vol. 7, p. e00239, 2020, doi: https://doi.org/10.1016/j.sciaf.2019.e00239.

[6] C. Laxmishree and N. Singh, "Botanical pesticides – a major alternative to chemical pesticides: A review," *Int. J. Life Sci.*, vol. 5, no. 4, pp. 722–729, 2017.

[7] D. E. Kusumawati and Istiqomah, *Pestisida Nabati sebagai Pengendali OPT (Organisme penganggu Tanaman)*, 1st ed. Malang: Madza Media, 2022.

[8] P. Setyadewi, "Hubungan Antara Karakteristik Petani dan Peran Penyuluh dengan Tingkat Adopsi Inovasi Cara Tanam Jajar Legowo Padi di Kabupaten Klaten," UNS (Sebelas Maret University), 2019.

[9] E. M. Rogers, *Diffusion of Innovation: 5th Edition*. New York: Free Press, 2003.

[10] P. Leng, Z. Zhang, G. Pan, and M. Zhao, "Applications and development trends in biopesticides," *African J. Biotechnol.*, vol. 10, no. 86, pp. 19864–19873, 2011, doi: 10.5897/AJBX11.009.

[11] C. Guo *et al.*, "Advances in research and utilization of botanical pesticides for agricultural pest management in Inner Mongolia, China," *Chinese Herb. Med.*, vol. 16, no. 2, pp. 248–262, 2024, doi: 10.1016/j.chmed.2023.04.002.

[12] Sugiyono, *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, 2014.

[13] W. R. Jati, "Bonus Demografi Sebagai Mesin Pertumbuhan Ekonomi: Jendela Peluang Atau Jendela Bencana Di Indonesia?," *Populasi*, vol. 26, no. 1, pp. 1–19, 2015, doi: 10.22146/jp.8559.

[14] Widiana and A. A. Annisa, "Menilik Urgensi Penerapan Pembiayaan Akad Salam pada Bidang Pertanian di Lembaga Keuangan Syariah di Indonesia," *Muqtasid J. Ekon. dan Perbank. Syariah*, vol. 8, no. 2, pp. 88–101, 2018, doi: 10.18326/muqtasid.v8i2.88-101.

[15] F. H. Wahyudyanti, S. Anantanyu, and E. Widiyanti, "Pengaruh Faktor Sosial Ekonomi Petani Terhadap Tingkat Adopsi Inovasi Pupuk Organik Cair Nitrobacter di Kecamatan Jaten, Kabupaten Karanganyar," *J. Integr. Agric. Socio-Economics Entrep. Res.*, vol. 2, no. 1, pp. 01–07, 2023, doi: 10.26714/jiasee.2.1.2023.01-07.

[16] I. M. Gusti, S. Gayatri, and A. S. Prasetyo, "The Affecting of Farmer Ages, Level of Education and Farm Experience of the farming knowledge about Kartu Tani beneficial and method of use in Parakan Distric, Temanggung Regency," *J. Litbang Provinsi Jawa Teng.*, vol. 19, no. 2, pp. 209–221, 2022.

[17] V. Heristi, J. Sudrajat, and S. Gafur, "The Effectiveness of the Implementation of a Upaya Khusus Program For Corn Commodities in Ketapang District," *J. Teknol. Pangan dan Ind. Perkeb.*, vol. 1, no. 1, pp. 18–30, 2021, doi: https://doi.org/10.58466/lipida.v1i1.1365.

[18] I. Ghozali, *Aplikasi Analisis Multivariate dengan Program IBM SPSS 26*, 10th ed. Semarang: Badan Penerbit Undip, 2021.

[19] A. P. Barnes *et al.*, "Exploring the adoption of precision agricultural technologies: A cross regional study of EU farmers," *Land use policy*, vol. 80, pp. 163–174, 2019, doi: 10.1016/j.landusepol.2018.10.004.

[20] A. Yarashynskaya and P. Prus, "Precision Agriculture Implementation Factors and Adoption Potential: The Case Study of Polish Agriculture," *Agronomy*, vol. 12, no. 9, p. 2226, 2022, doi: 10.3390/agronomy12092226.

[21] S. Bananiek and Z. Abidin, "Faktor-Faktor Sosial Ekonomi Yang Mempengaruhi Adopsi Teknologi Pengelolaan Tanaman Terpadu Padi Sawah Di Sulawesi Tenggara," *J. Pengkaj. dan Pengemb. Teknol. Pertan.*, vol. 16, no. 2, pp. 111–121, 2013, doi: https://dx.doi.org/10.21082/jpptp.v16n2.2013.p%p.

[22] N. E. Faizaty, A. Rifin, and N. Tinaprilla, "Proses Pengambilan Keputusan Adopsi Inovasi Teknologi Budidaya Kedelai Jenuh Air (Kasus: Labuhan Ratu Enam, Lampung Timur)," *Agrar. J. Agribus. Rural Dev. Res.*, vol. 2, no. 2, pp. 97–106, 2016, doi: 10.18196/agr.2230.

[23] S. Ruzzante, R. Labarta, and A. Bilton, "Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature," *World Dev.*, vol. 146, p. 105599, 2021, doi: 10.1016/j.worlddev.2021.105599.

[24] S. Dwirianto, M. Pudjihardjo, and S. Susilo, "Economic empowerment of society through development of non-formal education based on life skill education in Pekanbaru city," *IOSR J. Bus. Manag.*, vol. 16, no. 2, pp. 26–34, 2014.

[25] S. N. Hulyatussyamsiah, R. Hartono, and O. Anwarudin, "Adopsi Pemupukan Berimbang Padi Sawah Melalui Penggunaan Urea Berlapis Arang Aktif Di Majalengka," *J. Penyul. Pertan.*, vol. 14, no. 2, pp. 1–17, 2019.

[26] B. Sunandar, D. Prawiranegara, and A. Suryani, "Faktor-Faktor Yang Mempengaruhi Perilaku Petani Dalam Mengadopsi Inovasi Tanam Jajar Legowo 2:1 Padi Di Purwakarta," *Creat. Res. J.*, vol. 7, no. 1, pp. 17–30, 2021, doi: https://doi.org/10.34147/crj.v7i01.309.

[27] M. K. Agatha and E. Wulandari, "Analisis Faktor-Faktor yang Mempengaruhi Produksi Kentang Di Kelompok Tani Mitra Sawargi Desa Barusari Kecamatan Pasirwangi Kabupaten Garut," *J. Ilm. Mhs. Agroinfo Galuh*, vol. 4, no. 3, pp. 772–778, 2018, doi: http://dx.doi.org/10.25157/jimag.v4i3.1643.

[28] A. S. Mase, H. Cho, and L. S. Prokopy, "Enhancing the Social Amplification of Risk Framework (SARF) by Exploring Trust, The Availability Heuristic, and Agricultural Advisors' Belief in Climate Change," *J. Environ. Psychol.*, vol. 41, pp. 166–176, 2015, doi: https://doi.org/10.1016/j.jenvp.2014.12.004.