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Relationship between the Farmers' Level of Compliance in Using Pesticides and Pests, Diseases, Natural Enemies and Product Safety of Rice

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Abstract: The use of pesticides is one of the control alternatives that is widely used by farmers. However, continuous and inappropriate use of pesticides can have negative impacts on humans and the environment. This research aims to determine the relationship between the level of farmer compliance in using pesticides and pest attacks, disease, natural enemy populations and product safety. The research was conducted in two areas, namely Tanjung Lago and Pemulutan by interviewing farmers and direct observation of rice fields. The variables observed were the percentage and intensity of pest attacks, plant disease. and natural enemy populations. The level of farmer compliance is connected to field data and the correlation efficiency is calculated. The relationship between farmer compliance in the use of pesticides against pests and disease is negatively correlated, and positively correlated with the population of natural enemies. Using herbal pesticides according to the dosage can reduce the negative impact of pesticides on the environment.
Keywords:farmer compliance, pesticides, plant disease, natural enemies, pest

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1. INTRODUCTION

Indonesia is a country rich in natural resources. So the majority of people choose to work as farmers. However, abundant natural resources and fertile land have not been able to meet the high demand for rice. Even though fertile soil is very suitable for planting rice, the cultivation of this food crop often has other obstacles, for example pest attacks [1] . Pest and diseases of rice-plants can attack the vegetative and generative phases. This can cause severe damage to the death of rice plants.

There are various types of pest control that can be carried out by farmers. One control that is often used is chemical control using pesticides. Pesticides are chemical active ingredients used to control pests. The use of pesticides is considered more effective and efficient for farmers [2].

The chemical compounds contained in pesticides can have a negative impact on the environment, insects and humans. Chemical compounds of pesticides can cause damage to the soil, the destruction of natural enemy insects and cause diseases in farmers such as sarcoma and cancer[3].Most farmers use pesticides based on field conditions. This makes it possible to use it beyond the dosage limit. The high doses of chemicals used can actually damage the ecosystem and kill some insects [4]. In addition, chemical residues in pesticides can have a negative impact on farmers. The dangers posed can range from mild poisoning to severe poisoning [5]. Many cases of poisoning result from undisciplined use of pesticides. Some of the symptoms of poisoning that often occur include vomiting, skin irritation, dizziness, diarrhea, shortness of breath and can cause death [6].

The many negative impacts due to the use of pesticides have resulted in control that is environmentally friendly and safe for farmers' health. Integrated pest management (IPM) can be used as an environmentally friendly alternative for pest control[7]. IPM can be carried out by using healthy seeds, using mulch, planting refugia, using natural enemies as pest control, and carrying out land sanitation to control weeds According to the use of botanical pesticides, they can also be used to control plant diseases[8]. Botanical pesticides come from environmentally friendly materials and are without chemicals so they are safer to apply [9].

The use of pesticides can leave chemical residues in rice crop production which are dangerous if consumed [10]. The negative impact of pesticides is not only on the environment and insects, but also on product safety. Chemical residues left on plants due to spraying can cause health problems for consumers. Residues left behind can damage human metabolites and cause health problems [11].Evaluation of pesticide use by rice farmers is important, considering that rice is the staple food for most people. The aim of this research is to determine the level of farmer compliance with pesticide use and its relationship with pests, natural enemies of disease and product safety.

2. MATERIALS AND METHODS

Place and time

This research was carried out in June-December 2023 in 2 areas, namely Pemulutan District, Ogan Ilir Regency and Tanjung Lago District, Banyuasin Regency.

Equipment and materials

The equipment used in this research is: 1) stationery, 2) camera. Meanwhile, the materials used are: 1) plastic, 2) rice plant samples.

Research methods

This research was carried out in 2 stages, namely questionnaire interviews with rice farmers regarding the use of pesticides and observations of pests, diseases and natural enemies in rice plants in the field.

Work procedures

1) Farmer survey

Farmer locations are determined randomly based on several criteria. The criteria in question include a minimum land area of 0.25 ha, farmers who use pesticides to control pests, and farmers' willingness to be interviewed. The number of farmers interviewed was 50 people.

2) Farmer interviews

Farmer interviews were carried out by asking 10 questions from a questionnaire to determine the level of farmer compliance with pesticide use. There are 4 scores for each question that correspond to the farmer's criteria.

3) Observation of sample plants

Observations of sample plants were carried out to determine pests, diseases, predators and symptoms of attack on sample plants. Sample plants were taken at 5 diagonal points. This warning is carried out to adjust the level of farmer compliance with field results.

4) Identify insects, the process of identifying pests and predatory insects is carried out using a macroscopic camera and a guide book.
5) Analysis of pesticide residues in rice seeds

Rice seed samples that have been taken from the field are stored in a closed container. Then the samples are sent to the

Quality and Goods Testing Center for pesticide residue analysis.

Data Analysis

The data analysis used was a correlation and regression test using R Studio to determine whether or not there was a significant relationship between:

1) Farmers' compliance in using pesticides on the percentage and intensity of pest attacks.
2) Farmers' compliance in using pesticides on the percentage and intensity of disease attacks.
3) Farmer compliance in applying pesticides to natural enemy populations.
4) Farmers' compliance in using pesticides is related to product safety.

Table 1. Questions on Farmers' Level of Compliance in Using Pesticides.

No	Question	Weight (W)	Score (S) WxS
1	Farmers' understanding oftypes and usage of pesticide	7.5	
2	Farmers' reasonsin using pesticide	7.5	
3	Farmers'ways in choosing pesticide	10	
4	Farmers' understanding ofpesticide application equipment	10	
5	Farmers' source of information about pesticide	7.5	
6	Farmers' understandingof the procedures of pesticide spraying preparation	15	
7	Farmers's ways in sprayingpesticides in rice fields	10	
8	Farmers' understanding insafety procedures of pesticide application	15	
9	Farmers' ways in handling pesticide remains	7.5	
10	Farmers' action after spraying/applying pesticide to avoid danger pesticide	10	
	Total		

3. RESULTS AND DISCUSSION

Observation results show that farmers' compliance scores with pesticide use have an influencd on pests, diseases and natural enemies of insect. Simple regression analysis of farmer compliance scores in pesticide use on the percentage and intensity of pests showed a negative correlation. This shows that there is a unidirectional relationship between the two. So if the compliance score increases, the percentage and intensity of pest attacks will decrease. The determination value (r2) obtained for the percentage of pest attacks was 0.11, where the farmer's compliance score had an influence of 11% on the percentage of pest attacks, while the intensity determination value was 0.12 so the compliance score had an influence of 12%. Simple regression analysis between farmer compliance scores and disease percentage and intensity showed.

a negative correlation. This shows that there is a unidirectional relationship between the two. So if the compliance score increases, the percentage and intensity of disease attacks will decrease. The determination value (r2) obtained for the disease percentage was 0.09, where the farmer's compliance score had an influence of 0.9% on the percentage of pest attacks, while the intensity determination value was 0.01 so the compliance score had an influence of 0.1%. The results of a simple regression analysis showed that there was a positive correlation between farmers' compliance scores and the average population of natural enemies. This shows that there is a unidirectional relationship between the two. So if the farmer's compliance score increases, the natural enemy population will increase.This is in line with research which states that the relationship between the influence of pesticide use and natural enemy populations is positively correlated[12]. The determination value (r2) obtained was 0.12, where the farmer's compliance score had an influence of 12% on natural enemy populations (Table 3).

Table 3. Simple linear regression test for pests, diseases and natural enemies

Insects and pathogens		Correlation test (r)	Determination test (r^2) (%)
Pest	Percentage	-0.33	11
	Intensity	-0.35	12
Disease	Percentage	-0.30	0.9
	Intensity	-0.10	0.1
Natural enemies	Population	0.35	12

The results of the regression test between farmer compliance in using pesticides and the percentage of pest attacks on rice plants showed a regression with a coefficient of -0.27. This shows that if the farmer's compliance score is 0, the percentage of pest attacks that occur is 27%. The graph (Figure 1) shows that farmers' compliance scores influence the percentage of pest attacks, where the higher the compliance score, the lower the percentage of pest attacks.

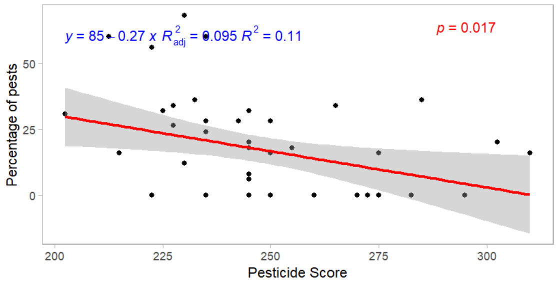

Figure 1. Regression of farmer compliance in pesticide use and the percentage of pest attacks.

The results of the regression test between farmer compliance in using pesticides and the intensity of pest attacks on rice plants showed a regression with a coefficient of -0.095. This shows that if the farmer's compliance score is 0, the intensity of pest attacks is 9.5%. The graph (Figure 2) shows that farmers' compliance scores influence the intensity of pest attacks, where the higher the compliance score, the more the intensity of pest attacks will decrease.This is in line with research[12] which states that the relationship between the influence of pesticide use and pests is negatively correlated.

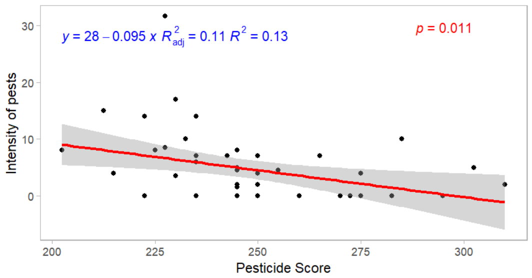

Figure 2. Regression of farmer compliance scores in pesticide use on the intensity of pest attacks.

The results of the regression test between farmer compliance in using pesticides and the percentage of disease attacks on rice plants showed a regression with a coefficient of -0.48. This shows that if the farmer's compliance score is 0, the percentage of disease attacks that occur is 48%. The graph (Figure 3) shows that farmers' compliance scores influence the percentage of disease attacks, where the higher the compliance score, the lower the percentage of disease attacks.

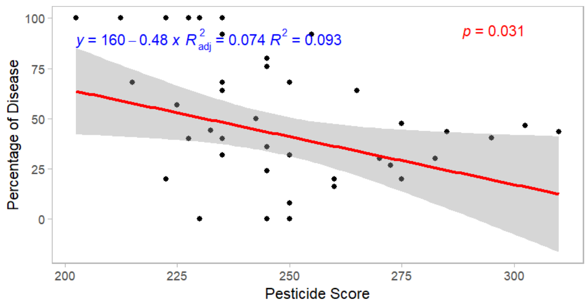

Figure 3. Regression of farmer compliance in pesticide use and the percentage of disease attacks.

The results of the regression test between farmer compliance in using pesticides and the intensity of disease attacks on rice plants showed a regression with a coefficient of -0.063. This shows that if the farmer's compliance score is 0, the intensity of disease attacks is 6.3%. The graph (Figure 4) shows that farmers' compliance scores influence the intensity of disease attacks, where the higher the compliance score, the lower the intensity of disease attacks.This is in line with research [12]which states a negative correlation between farmer compliance in pesticide use and plant diseases, indicating that the higher the compliance score, the lower the incidence of disease attacks.

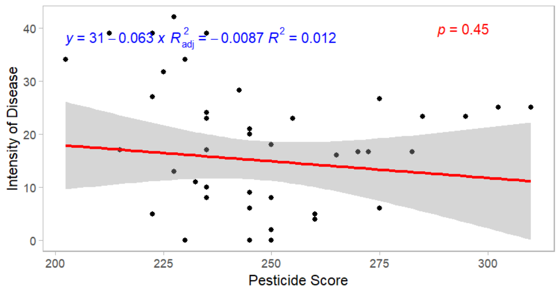

Figure 4. Regression of farmers' compliance in using pesticides and the intensity of disease attacks

The results of the regression test between farmers' compliance in applying pesticides to natural enemies on rice plants showed a regression with a coefficient of

0.048. This shows that if the farmer's compliance score is 0, the population of natural enemies is 4.8%. This shows that the greater the farmer's compliance score in using pesticides, the higher the population level of natural enemies (Figure 5).

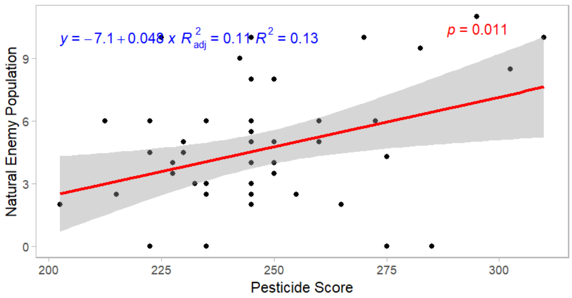

Figure 5. Regression of farmer compliance in using pesticides and the presence ofnatural enemies

There are various types of insects in rice fields. This happens because of the ecosystem formed in the area.. Insect diversity can be formed due to the influence of natural vegetation. Land area does not affect insect diversity, but rather the abundance of food and climate factors affect insect abundance. [10]. Each type of insect has a different role. These different roles can have different impacts on farmers. Some of the roles that insects have include: pollinators such as *Apis mellifera*[13], predators (natural enemies) such as *Paederus tamulus*[14], parasitoids such as *Anaragrrus* sp.[14], decomposers such as *Isotoma* sp.[15] and pests (phytophages) such as *Bemissia tabaci*[15].

Table 4. Diversity Index of Predatory Insects in Rice Fields

Order	Family	Species	Role	Amount
Coleoptera	Coccinellidae	*Coccinellatransversalis*	Predators	22
		Harmoniaaxyridis	Predators	20
		Micraspicefrenata	Predators	17
Odonata	Coegnaridae	*Telebasesalva*	Predators	21
	Argiolestidae	*Austroargiolestesisabellae*	Predators	58
		Austroargiolestesictoremelas	Predators	42
Aranae	Aranidae	*Argiopetrifasciata*	Predators	37
		Argiopeappensa	Predators	32
Total species				249
Total species highest				58
Index diversity species (H')				2.00
Index evenness species (E)				0.96
Index dominance (D)				0.23

Field observations showed that there were 3 orders of natural enemy insects found in rice fields. Several orders of predatory insects found are, Coleoptera, Odonata and Aranae. The total population of predator insects found was 249 with 8 types of insects. The diversity index obtained was 2.00 and the dominance index was 0.23 (Table 4).The diversity index value is usually from 0-4, the low to medium category is at a value below 2. While the medium to high category is 2 to 4.This shows that the condition of the rice field ecosystem is still in good condition, and the diversity of predatory insect species is quite abundant with an even population size or no apparent dominance of certain species.Predatory insects found include koksi beetles, dragonflies and spiders (Figure 6).

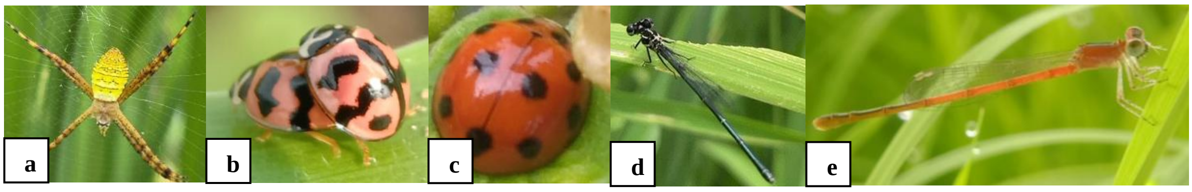

Figure 6. Natural enemy insects found on rice plants, (a) *Argiope appensa*, (b) *Coccinella transversalis*, (c) *Harmonia axyridis*, (d) *Austroargiolestesictoremelas*(e) *Austroargiolestes isabellae*.

The diversity of insects in an ecosystem does not only come from predatory insects, but is also supported by insect pests. Pests are a big problem in agriculture. Pests found in rice fields consist of 3 orders, namely Hemiptera, Lepidoptera, and Orthoptera. The total pest population found was 270 with 4 types of pests. The diversity index obtained was 0.69 while the dominance index obtained was 0.71 (Table 5).This shows that the diversity of pest species is dominated by certain species, namely Leptocorisa acuta.

Table 5. Insect pest diversity index in rice fields.

Order	Family	Species	Role	Amount
Hemiptera	Alydidae	*Leptocorisaacuta*	Pest	193
Lepidoptera	Noctuidae	*Spodoptera* sp.	Pest	71
Orthoptera	Acrididae	*Acrida cinerea*	Pest	3
		Euthystirabrachyptera	Pest	3
Total species				270
Total species highest				193
Index diversity species (H')				0.69
Index evenness species (E)				0.50
Index dominance (D)				0.71

Abundant pest populations with varying types provide different forms and levels of attack for each pest. There are 3 pest families that attack rice plants, namely Alydidae, Acrididae, and Noctuidae. The highest average intensity of attack on rice plants observed was caused by the stink bug pest which comes from the Alydidae family with an intensity value of 10.42. The lowest average attack intensity was caused by armyworms from the Noctuide family with an intensity value of 1.43. Meanwhile, the highest average percentage of pest attacks was also caused by the stink bug pest with a percentage value of 37.16. The lowest average percentage of attacks was caused by armyworms with a value of 6.67 (Table 6). The intensity and percentage of pest attacks have a significant relationship, where when the level of attack intensity increases, the percentage of attacks will also become wider.

Table 6 . Average intensity and percentage of pest attacks on rice sprayed with pesticide.

Family	Intensity	Percentage
Alydidae	10.42	37.16
Acrididae	5.14	21.71
Noctuidae	1.43	6.67

Pests can cause losses in rice production, if the attack is severe, even causing death or crop failure. This is of course an important problem in rice cultivation [12]. An increase in the population of insect pests in an ecosystem can be influenced by the climate and condition ofthe surrounding vegetation[16]. Food availability, adequate climate, and lack of natural enemy populations for example [13]. The pest insect with the highest population in the rice fields observed was *L. acuta* (Figure 7). According to [14]. The high population of *L. acuta* can be influenced by temperature, humidity, light, food availability and also the host plant. Usually these pests will live in groups in an area that is rich in food.

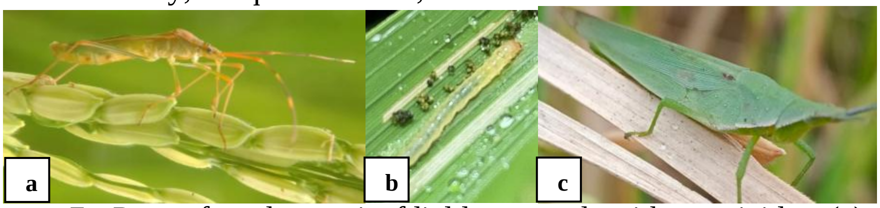

Figure 7. Pests found on ricefdield sprayed with pesticide, (a) *Leptocorisaacuta* , (b) *Spodoptera* sp., (c) *Acrida cinerea.*

Different types of disease, attacks can also vary. Generally, plant diseases occur continuously and are diseases that often attack the plant. This can happen because crop rotation is not carried out or seeds that are susceptible to disease are used[17]. For example, in rice plants there is a leaf spot disease that often attacks rice plants. Apart from leaf spot, there are 2 other diseases that also attack rice, namely leaf blight and tungro. The highest average intensity of attack on rice plants observed was caused by leaf spot disease with an intensity value of 20.08. The lowest average attack intensity was caused by leaf blight with an intensity value of 16.43. Meanwhile, the highest average percentage of disease attacks was also caused by leaf spots with a percentage value of 58.81. The lowest average percentage of attacks was caused by leaf blight with a value of 34.83 (Table 7). The intensity and percentage of pest attacks have a significant relationship, meaning that when the level of intensity of disease attacks increases, the percentage of disease attacks will also increase.

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Table 7 . Intensity and percentage ofdisease on rice sprayed with pesticides.

Disease	Intensity	Percentage
Leaf spot	20.08	58.81
Tungro	21	42
Leaf blight	16.43	34.83

Plant pest organisms (OPT) that attack rice other than pests are diseases. Observations of rice plants carried out on 50 farmers' fields showed that there were 3 diseases that attacked them, namely leaf spot, leaf blight and tungro (Figure 8). The most common attack is leaf spot.This disease, which has symptoms of spots on the leaves, often attacks land in Tanjung Lago District where crop rotation is carried out on the land. This is in line with [15] which states that crop rotation is important to control plant diseases.

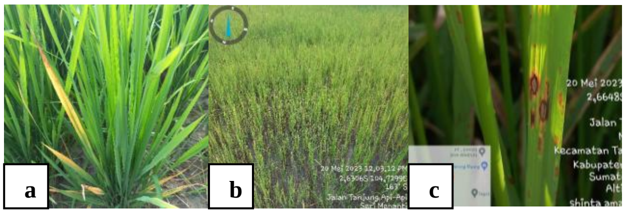

Figure 8. Diseases in rice plants sprayed with pesticide, (a) Leaf blight, (b) Leaf spot, (c) Tungro.

The results of observations on the level of farmer compliance in using pesticides have a significant relationship with pests, diseases and natural enemies. This can be assessed based on the fact that farmers with low farmer compliance scores have high levels of pest and disease attacks and low populations of natural enemies. Meanwhile, farmers with high compliance scores have the opposite condition.The research also explained that farmers with low compliance had a high percentage of pests and diseases[12].This can explain that the use of pesticides that are not as recommended can cause negative impacts such as resistance [18], resurgence [19]and the destruction of natural enemies [20]. Apart from that, excessive use of pesticides can also have a negative impact on human health[21], such as chemicals that can come into contact with farmers and the danger of residues left behind[22].

Table 8. Results of pesticide residue tests on rice grains.

Active ingredients	Unit	Test results
2.4 D- dimethyl amine	mg/kg	Not detected
Isopropyl amine glysophate	mg/kg	Not detected

The chemical residue test on rice grains was carried out to determine the level of residue stored in the rice grains. The chemicals tested consisted of 2 groups, namely 2,4 D-dimethyl amine and isopropyl amine glysophate. These two active ingredients are usually found in herbicides[23]. This group was chosen because it is most widely used by the rice farmers observed. Laboratory results showed that no active ingredient residue was detected in the rice grain samples tested (Table 8). This can occur due to the frequency of spraying, method, dose and also the length of storage of the rice grains [24]. In accordance with the Joint Decree of the Minister of Health and the Minister of Agriculture Number 881/MENKES/SKB/VIII/1996, the maximum residue limit for pesticides with the active ingredient 2.4 D is 0.05 and for the active ingredient glysophate is 0.1The results of the pesticide residue test are above the maximum limit, pesticide residues can be harmful to consumer health if consumed continuously [24]. There are several ways to reduce the potential for pesticide residues on rice to be consumed, namely by using vegetable pesticides, adjusting the frequency of spraying so that it is not close to harvest time and washing the rice until it is clean [25]

4. CONCLUSION

conditions that are lower in pests and diseases Based on the results of research conducted on rice farmers, the use of chemical pesticides by farmers is still very often done and farmer compliance in pesticide application is still low. Farmer compliance scores in pesticide use have a significant relationship with pests, diseases, and natural enemies. Farmers with low compliance scores have land conditions that are high in pests and diseases, while farmers with high compliance scores have land conditions that are low in pests and diseases and more natural enemies. It would be better if in the future the use of chemical pesticides is replaced with botanical pesticides and the application of IPM.

5. KNOWLEDGEMENTS

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