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The Relationship between the Level of Highland Horticultural Farmers' Compliance in Pesticide Application and the Presence of Pests and Diseases

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Abstract

Currently, many farmers are still very unfamiliar with using pesticides correctly and appropriately which lead environment pollution, population reduction of natural enemies and people health. The aims of this research were to determine the impact or influence of farmers obedience in applicating pesticide on the incidence of pests and diseases on highland horticultural cultivation, the presence of natural enemies, and level of pesticide residues in their horticultural products. This research was conducted in highland horticultural cultivation areas in Pagar Alam, South Sumatra. Data on farmers obedience in applicating pesticide was collected by interview-ing eligible farmers by using questionnaires. Data on pests and disease incidence was collected by direct ob-servation on the interviewed farmer's horticultural field. Variable measured were pest population and the in-tensity of damage of each pest, incidence and intensity of each disease and natural enemy type and population. The relationship between the level of farmer obedience in applicating pesticide and incidence of pests and dis-ease on their respected lands was determined by calculating their correlation coefficient. The results showed that there were significant correlations between the level of farmers obedience in applicating pesticide and the incidence as well as intensity of pests and diseases of highland horticultural crops.

Keywords: farmers' pesticide application obedience, highland horticulture, pests and disease.

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1. Introduction

Currently, many farmers are still very unfamiliar with using pesticides correctly, appropriately and safely. Farmers tend to spray their crop with pesticide at high frequency. This behavior causes an impact on agricultural products which can contain pesticide residues, and also reduces natural enemies [1]. Apart from that, the inappropriate use of pesticide has also an impact on farmers' health. Pesticide effect on human health is commonly manifested as nausea, vomiting, dizziness and skin itching [2]. The results of calculating health risk by exposure to pesticide showed a result of 1,505 g/day, with a maximum value of 4,014 g/day and a minimum risk intake of 423 g/day [3]. Quantitative analyze-sis of chlorpyrifos pesticide residues in green chili samples taken from Marino area of Gowa Regency using gas chromatography revealed that the residue concentration of the organophosphorus pesticide chlorpyrifos was 0.25261 mg/kg, and the residue concentration in pepper was 0.5 mg/kg [4].

In this case, there are many ways to reduce excessive use of pesticides, for examples by implementing controls that utilize natural enemies such as predators, parasitoids and other biological agents [5]. However, farmers still do not want to switch to this type of control and still choose to use pesticides with a reason that pests and diseases in the field are too many that prevention or control without pesticides will not be effective [6], and farmers are afraid of crop failure due to pest and disease infestation in their agricultural land. Integrated Pest Management (IPM) which integrates various pest controls into cultural techniques is the safest way to keep pests and disease stay below the economic threshold [7], [8] In addition to methods of identifying and using of natural enemies, the IT-based IPM Decision Support System is aimed at not only to support healthy plant growth, but also to observe and monitor the development of pests and diseases [4].

In agricultural ecosystems, there are natural enemies such as predators and parasites that naturally control pest populations [9]. Excessive or non-selective pesticide use can kill these natural enemies, lead to the reduction of the effectiveness of natural control against pests. [8]. As a result, pest populations can grow rapidly and cause greater losses to crops[10]. Judging from the safety of agricultural products, inappropriate use of pesticides can cause dangerous pesticide residues to accumulate in plants [11]. If these agricultural products are consumed by humans, these pesticide residues can potentially cause health problems, such as poisoning or long-term impacts on the immune system [12]. Therefore, it is important to evaluate farmers' behavior and obedience in the use of pesticides in highland horticultural farming to ensure the safety of agricultural products oh highland areas such as Pagar Alam area and Lahat Regency. The aims of this research were to determine the impact farmers' obedience in the use of pesticide correctly and appropriately on the presence of natural enemies and to determine the level of pesticide residues contained in highland horticultural products.

2. Materials and Methods

Place and time

This research was carried out from May to September 2023 in the highland areas of Pagar Alam City and Lahat Regency.

Equipment and materials

The equipment used in this research wee: 1) Office stationery, 2) high resolution camera, 3) macro lens. The materials used in this research were: 1) Zip plastic, 2) Insect samples for further identification.

Research methods

This research consisted of two main activities, namely (1) interview farmer respondents to collect data regarding the level of pesticide application compliance in horticultural crop cultivation in highland areas, namely the Pagar Alam area and La-hat Regency, South Sumatra Province and their planting conditions, (2) identification of pests, diseases, natural enemies, and neutral insects obtained from the fields of interviewed sample farmers.

Work Procedures

(1) Survey of farmers

Data collection regarding the level of farmer compliance in applying pesticides was carried out at several sample locations. The number of farmers interviewed was 50 people taken at random with the condition that the farmer manages land with a mini-mum area of 0.25 hectares and the farmer uses pesticides to control pests and plant diseases and is willing to answer the questions contained in the questionnaire (Table 1) and allow his horticultural land to be observed. Field observations were carried out after the farmer owner answered all the questions in the questionnaire. Five sam-pling points were determined diagonally, each sampling point consisted of approximately 2% of the crop population being observed so that the overall samples collected in one field would amount to 10% of the existing population. In each sampling point, observation was made to collect data on incidence and intensity of pest and disease, the presence of pest predators and parasitoids, as well as neutral insects present at the sampling location. Plant samples were taken and stored in zip plastic, while insect samples were stored in vials, while plant disease samples were stored in containers provided with tissue moistened with water. Samples taken included all types of pests, diseased plants, predators and parasitoids as well as neutral insects for identification in the laboratory.

(2) Identification

Identification of pest insects, predators, parasitoids and neutral insects is carried out in the Entomology Laboratory using microscopes and identification books as well as guidance. Pathogen identification was carried out in the Phytopathology Laboratory by isolating and culturing the identified pathogen until it produces colonies that meet the requirements for identification. For fungal pathogens we cultured them until produced spores, and for bacterial pathogens until produced pure colonies. The work order is as follows:

Plant Disease Identification

Sample Preparation:

a. Selected samples of plants affected by the disease were taken into laboratory for identification. Samples taken were of different levels of disease severity whenever possible. All equipment used was cleaned and sterilized, including knives, scissors and sampling containers, needles, to prevent cross-contamination between samples.
b. Microscopic observation: A small piece of diseased plant tissue was taken using a sterile knife and then transferred onto sterile object glass or slide. A drop of sterile water or buffer solution was put on the plant tissue to maintain humidity and covered the tissue with cover glass. Sample was ready for examination under a microscope to determine the morphology of the pathogen so it can be identified.
c. Pathogen Isolation: If necessary, isolation of disease-causing pathogens from plant samples was carried out. Fungal pathogen was isolated in PDA media and bacterial pathogen was isolated in NA media; both were done in sterile Petri dishes. Small tissue at the edge of disease symptoms was taken and planted in a suitable medium. Before taking the tissue, the diseased plant tissue was disinfected with Clorox or 7.5% sodium hypochlorite. The preparate was then incubated until the pathogen grows and then separate and multiply the

growing pathogens in 10 Petri dishes. Each pathogen from pure culture was then identified based on the spores produced.

Observation of identified insect morphology was carried out using a magnifying glass if necessary. Identification was done with the help of a picture of this application.

Insect Identification

Table 1. Questions concerning the farmers' compliance in applying pesticides

No	Question	Weight (W)	Scor (S)	WxS
1	Understanding of the types, uses, and application of pesticides.	7.5		
2	Reason for using pesticide	7.5		
3	Sources of information obtained regarding pesticides	10		
4	The way of choosing a pesticide	10		
5	Understanding of pesticide application equipment	7.5		
6	The procedure of mixing pesticide or making spray liquid	15		
7	The way of spraying crops in the field	10		
8	Understanding of the use of protective equipment when applying pesticides	15		
9	The way of handling residual spray liquid	7.5		
10	Post-spraying actions related to safety and avoidance of pesticide hazards	10		
Total		100		

Data Analysis

The data analysis used is correlation and regression tests to see whether there is a significant relationship between:

1. The level of farmer compliance in applying pesticides to the intensity of pests in the field.
2. The level of farmer compliance in applying pesticides to the intensity of disease insects in the field.
3. The level of farmer compliance in applying pesticides to the type and population of pest predators in the field.
4. The level of farmer compliance in applying pesticides to the type and population of parasitoids in the field.
5. The level of farmer compliance in applying pesticides to neutral insect types and populations in the field.
6. The level of farmer compliance in applying pesticides with the level of pesticide residues on the agricultural products produced.

Interpretation of Results: The results of the analysis were interpreted to draw conclusions about compliance with the use of pesticides by horticultural farmers in the highlands and their impact on pests, diseases, natural enemies, and the safety of agricultural products.

3. Results and Discussion

3.1. Results

Correlation test results

The results of the regression test of the farmers' compliance in pesticide application score and the percentage of pests found on their horticultural lands resulted in a regression where the regression equation coefficient of -0.047 which means that if the pesticide score is 0, then the percentage of pest presence is around 47% (Figure 1). As can be seen in the graph results, it can be said that the greater the pesticide score, the percentage of pests will decrease.

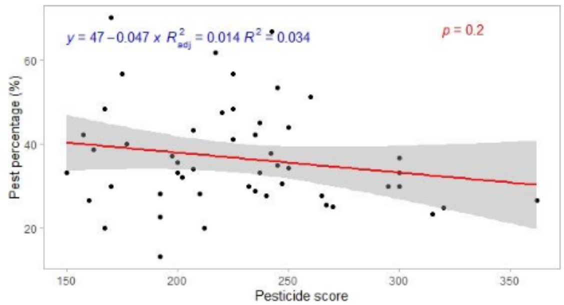


Figure 1. Regression graph of farmers' compliance score with pest incidence

From a simple linear regression correlation test, the percentage of pests found on farmers' land has a negative correlation value of -0.18 and a determination test value of 3.4%. This is in accordance with the situation in the field where high level of compliance of farmers in application are almost always proven by low incidence of pests and diseases.(Tabel.2.).

Table 2. Simple linear regression test of farmers' compliance to pest incidence.

Test	Value	Note
Correlation test (R)	-0.18	Negative correlation
Uji Determination (R^2)	3,4%	Effect of level of compliance

The result of the correlation test of the percentage of disease found on farmers' land with their compliance scores and understanding of pesticides was a correlation coefficient value of -0.025, which means that if the pesticide score is 0 then the percentage of pest incidence is around 25% (Figure 2.)

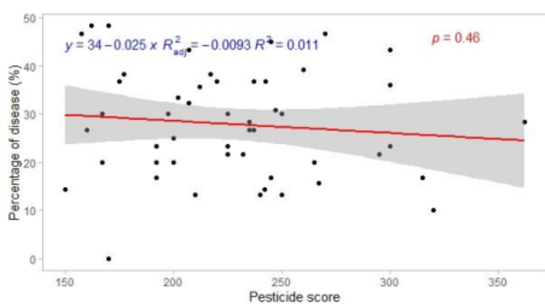


Figure 2. Regression graph of farmer compliance level with disease incidence

From a simple linear regression test, the incidence of disease found on farmers' land has a correlation value of -0.10 with a determination test value of 1.1%. This is by the conditions in the field (Tabel.3.)

Table 3. Simple linear regression test of farmers' compliance to disease incidence

Test	Value	Note
Corelation test (R)	-0.10	Negative correlation
Uji Determination (R^2)	1.1%	Effect of level of compliance

The results of the regression test for the intensity of pest damages found on farmers' land with their compliance scores and understanding of pesticides was a regression coefficient value of -0.016, which means that if the pesticide application compliance level is set to 0 then the percentage of pest presence is only around 16%. From the graph, it can be said that the greater the pesticide use compliance score, the percentage of pest damages will decrease (Figure 3).

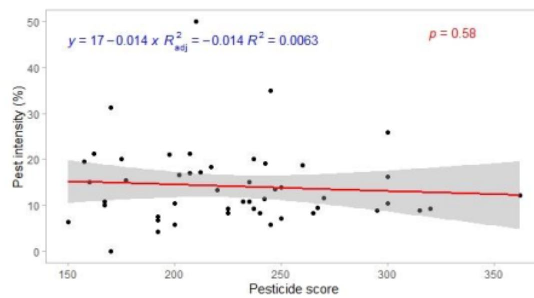


Figure 3. Regression graph of farmers compliance score with pest intensity

From a simple linear regression test, the intensity of pests found on farmers' land has a correlation value of -0.12 and a determination test value of 1.5% and is by the conditions in the field (Tabel 4).

Table 4. Simple linear regression test for .pest intensity

Test	value	Note
Corelation test (R)	-0.12	Negative correlation
Determination test (R^2)	1.5%	Effect of farmer compliance level

The results of the correlation test of disease intensity on farmers' land with their compliance and understanding scores towards pesticide use was a regression coefficient value of -0.014, which means that if the pesticide score is set to 0 then the percentage of pest presence is only around 14%. The results of the correlation test of disease intensity on farmers' land with their compliance and understanding scores towards pesticide use was a regression coefficient value of -0.014, which means that if the pesticide score is set to 0 then the percentage of pest presence is only around 14%. From the graph results, it can be said that the greater the pesticide score, the disease intensity will decrease (Figure 4.).

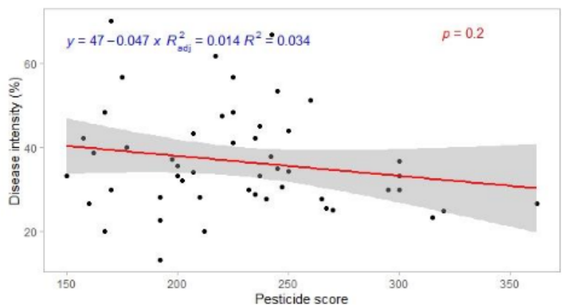


Figure 4. Regression graph of PHT scores with disease intensity

From the simple linear regression test, the intensity of the disease found in farmers' fields has a correlation value of -0.7, indicating a negative correlation. The determination test value is 1.4%, indicating the influence of PHT. This aligns with the conditions observed in the field. (Table 5.)

Table 5. Simple linear regression test of disease intensity

Test	value	Note
Correlation test (R)	-0.07	Negative Correlation
Determination test (R^2)	1.4%	Effect of Farmer Compliance Level

Correlation test

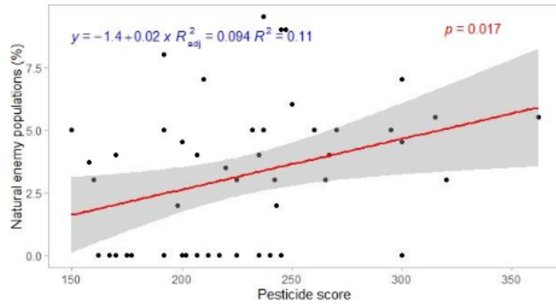


Figure 5. Regression graph of pht scores with natural enemy populations

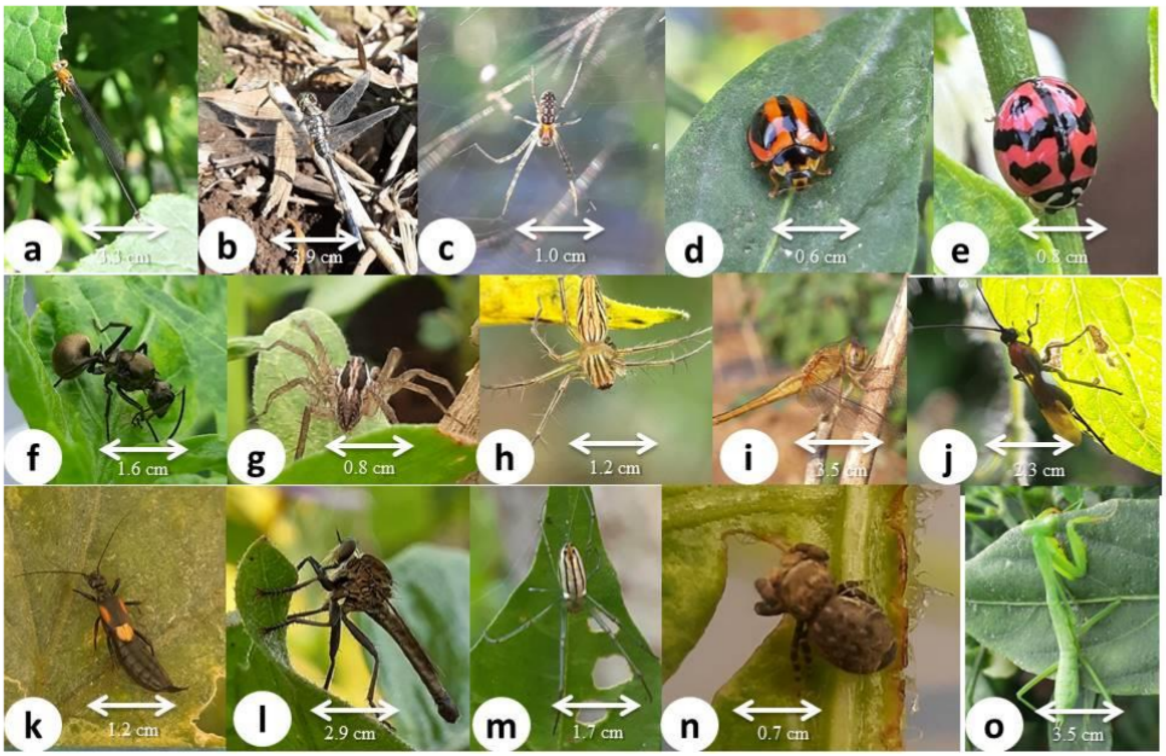
From a simple linear regression test, the population of natural enemies found on farmers' land has a correlation value of 0.33 with a positive correlation statement and a determination test value of 2.0% with information regarding the influence of pesticide application compliance. This is following the conditions in the field. The greater the farmer's score, the higher the population of natural enemies on the farmer's land (Figure 5).

In the field of agriculture, insects play various roles, including as phytophages, predators, parasitoids, vectors of plant diseases, and pollinators. When insects act as phytophages, they can attack host plants by piercing and sucking (using haustellate mouthparts) or by biting and chewing (using mandibulate mouthparts) (Herlinda et al., 2021; S. Djoewari, *et al*, 2019).

Table 6. Population diversity index of natural enemies.

Order	Family	Species	Role	Amount
Anisoptera	Libellulidae	*Crocothemis servilia*	Predator	7
Araneae	Lycosidae	*Pardosa pseudoannulata*	Predator	7
	Oxyopidae	*Oxyopes* sp.	Predator	13
	Tetragnathidae	*Leucauge celebesiana*	Predator	7
		Leucauge tessellate	Predator	12
	Salticidae	*Rhene flavigera*	Predator	17
Coleoptera	Coccinellidae	*Menochilus sexmaculatus*	Predator	72
		Micraspis lineata	Predator	9
Dermaptera	Forficulidae	*Timomenus karmovi*	Predator	45
Diptera	Asilidae	*Machimus sadyates*	Predator	3
Hymenoptera	Braconinae	-	Parasitoid	2
	Formicidae	*Polyrhachis dives*	Predator	11
Mantodea	Mantidae	*Hierodula formosana*	Predator	27
Odonata	Coenagrionidae	*Agriocnemis femina*	Predator	8
	Libellulidae	*Orthetrum Sabina*	Predator	34
Total species			274	
Hioghest total species			45	
Species diversity index (H')			0.96	
Species evenness index (E)			0.35	
Dominance index (D)			0.16	

There are 16 species of natural enemies, namely from the order Araneae 5 species, Coleoptera 2 species, Odonata 2 species, Hymenoptera 2 species, Anisoptera 1 species, Dermaptera 1 species, Diptera 1 and Mantodea 1 species which were found through visual observation in the sampled farmers' fields. The total population of all species was 201 with the highest total species value being the Timemenus karmovi species amounted to 45 individuals. The species diversity index value is 0.96 and the species evenness index value is 0.35 then the dominance index value is 0.16. (Tabel 6).



Gambar 5. Natural enemies found in sampled farmers field through visual observation. (a). Needle dragon fly (*Agriocnemis femina)*, (b). Big dragon fly (*Orthetrum Sabina*), (c) Spider (*Leucauge tessellata*), (d). ladybird beetle (*Micraspis lineata*), (e). Lady beetle (*Menochilus sexmaculatus*). (f). Ant (*Polyrhachis dives*), (g). Spider (*Pardosa pseudoannulata*), (h). Spiders (*Oxyopes* sp.), (i). *Crocothemis servilia*, (j). *Braconinae parasitoids*, (k). Cocopet (*Timomenus karmovi*), (l). Savage fly (*Machimus sadyates*), (m). Spider (*Leucauge celebesiana*), (n). Spider (*Rhene flavigera*), (o). Praying mantis (*Hierodula formosana*).

As we know, pest and disease attacks can reduce the productivity of cultivated crops, which will cause losses for farmers [3] To deal with this, farmers would use pesticides to control pests and plant diseases. However, excessive use of pesticides by farmers would have a negative impact on natural enemy populations, the environment and also human health [13].

There were 25 species of pest insects found from visual observations on the sample farmers' land, of which the whitefly (*Bemisia tabaci*) had the highest population number from direct observations. This happened due to the influence of the weather, which at the time of field observations was entering the dry season, resulting in an explosion of the whitefly population. The relationship between the environment and temperature also greatly influences the life and development of insects such as those from the Aleyrodidae, Thripidae and Aphididae families, where during the dry season there will be an explosion in the populations of these three families due to an increase in faster metabolic processes which causes faster pest development and at the end, the pest development time becomes shorten and the population increases rapidly (Agastya, *et al*. 2020). The results of field observations showed that there were 7 orders of pest insects and 1 order of mollusca, consisted of 1 Thysanoptera species, 8 Hemiptera species, 3 Diptera species, 4 Orthoptera species, 2 species Coleoptera, 6 species Lepidoptera, and 1 species Stylommatophora. The total pest population was 3683 with a species diversity index of 2.45, the species evenness index value is 0.76, and the dominance index value was 0.37 (Tabel 7).

Table 7. Pest diversity index

Order	Family	Species	Role	Amount
Coleoptera	Chrysomelidae	*Aulacophora similis*	Fitofag	82
	Coccinellidae	*Henosepilachna vigintioctopunctata*	Fitofag	229
Diptera	Tephritidae	*Bactrocera* sp.	Fitofag	239
	Agromyzidae	*Liriomyza* sp	Fitofag	6
	Neriidae	*Telostylinus lineolatus*	Fitofag	6
Hemiptera	Aleyrodidae	*Bemisia tabaci*	Fitofag	1378
	Cicadellidae	*Empoasca fabae*	Fitofag	8
	Coreidae	*Leptoglossus*	Fitofag	11
		Gonocerus acuteangulatus	Fitofag	5
	Pentatomidae	*Plautia stali*	Fitofag	56
		Nezara viridula	Fitofag	133
	Aphididae	*Aphis gossypii*	Fitofag	584
	Alydidae	*Leptocorisa* sp.	Fitofag	16
Lepidoptera	Noctuidae	*Spodoptera litura*	Fitofag	199
		Spodoptera frugiperda	Fitofag	77
		Helicoverpa sp.	Fitofag	21
		Leucinodes orbonalis	Fitofag	44
		Maruca testulalis	Fitofag	84
		Chrysodeixis eriosoma	Fitofag	11
Orthoptera	Acrididae	*Oxya chinensis*	Fitofag	11
		Xenocatantops humilis	Fitofag	23
		Trilophidia annulata	Fitofag	11
	Grylidae	*Nisitrus vittatus*	Fitofag	7
Thysanoptera	Thripidae	*Thrips tabaci*	Fitofag	392
Stylommatophora	Bradybaeninae	*Bradybaena similaris*	Fitofag	50
Total species				3683
Hioghest total species				1378
Species diversity index (H')				2.45
Species evenness index (E)				0.76
Dominance index (D)				0.37

The results of field observations showed that there were various types of pests in the highland horticultural cropping areas in Pagar Alam and Lahat Regency, as follows.

In field observations, it was found that the results of scores obtained from interviews regarding farmers' compliance with pesticide use ranged from 150 to 350. From the field observation results, it was revealed that the lowest scores among farmers indicate a significant condition in the fields. This is evident from the many traces of pest and disease attacks found in the farmers' cultivation land. Furthermore, the presence of natural enemies is very minimal, and in some cases, not found at all. This is likely due to the excessive and improper use of pesticides or the use of non-selective pesticides [5]. There are numerous losses incurred due to the excessive use of pesticides, one of which is the decline in the population of natural enemies, high pesticide residue levels, and health disturbances [6], [7]. The use of pesticides can be reduced by utilizing natural enemies. The first step to achieve this is by creating a suitable habitat or living space for natural enemies, which involves planting refuge crops[8]. Meanwhile, the observation results from farmers with the highest scores revealed that the cultivated land significantly reflects the farmers' compliance with pesticide use. In these cultivation areas, very few plants are affected by pests and diseases, while the population of natural enemies remains quite high. The overall total of pests identified from the research or observations conducted on 50 farmers in the highland areas of Pagaralam City and Lahat District is 25 species (Figure 6). On the other hand, the total overall number of identified population types is 15 species (Figure 5).

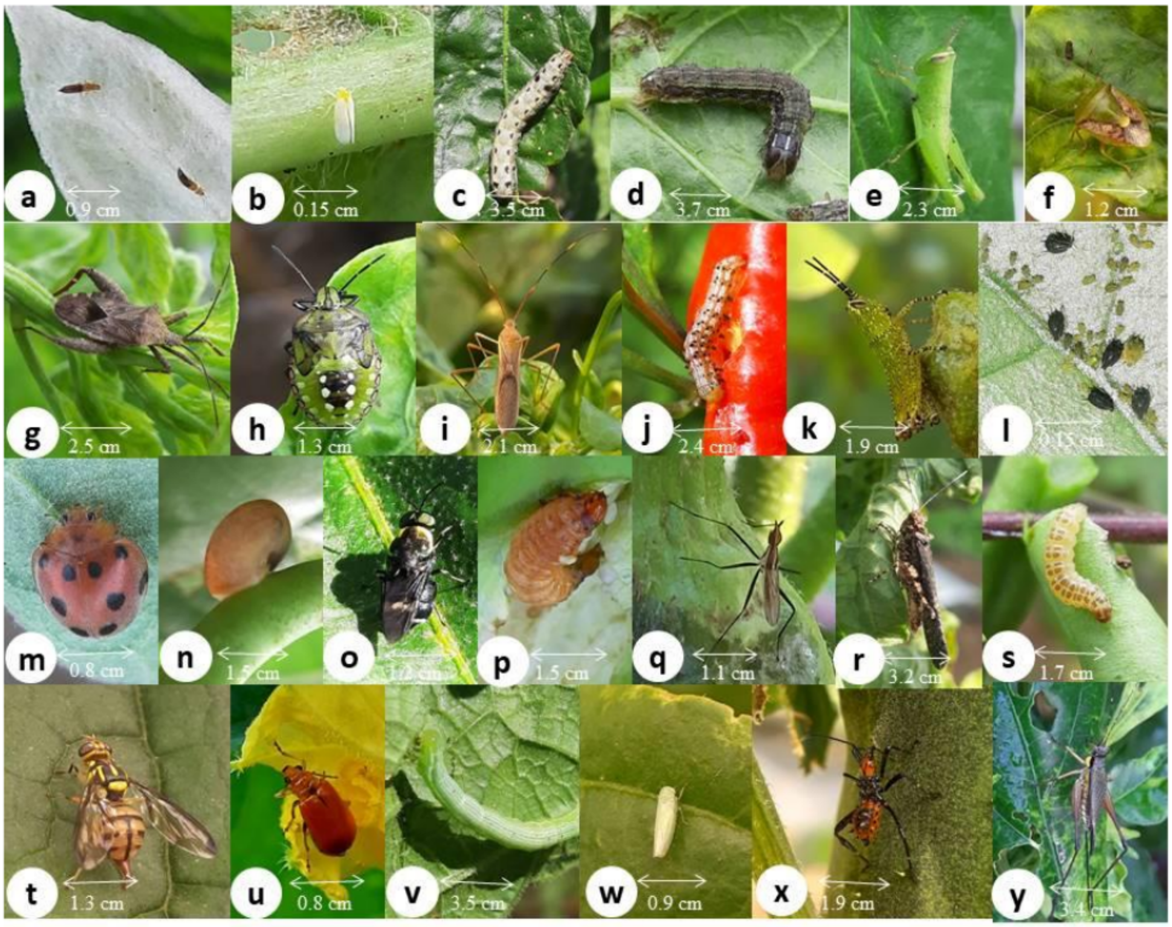


Figure 6. Results of visual identification of pests in the farmers' fields observed (a) Thrips (*Thrips tabaci)*, (b) White fly (*Bemisia tabaci*), (c) Army worm (*Spodoptera litura*), (d) Army worm (*Spodoptera frugiperda*), (e) Grasshopper (*Oxya chinensis*), (f) Bug (*Plautia stali*)*,* (g) Box bug (*Gonocerus acuteangulatus)*, (h) Green stink bug (*Nezara viridula*), (i) Rice earhead bug (*Leptocorisa* sp.), (j) Pod caterpillar (*Helicoverpa* sp.), (k) Grasshopper (*Xenocatantops humilis)*, (l). Aphid (*Aphis gossypii*), (m). Ladybird (*Henosepilachna vigintioctopunctata*) (n). Snail (*Bradybaena similaris*), (o). Leaf miner (*Liriomyza* sp.), (p). Fruit borer (*Leucinodes orbonalis*), (q). Banana stalk fly (*Telostylinus lineolatus*), (r). Grasshopper (*Trilophidia annulata*), (s). Pod caterpillar (*Maruca testulalis*), (t) Fruit fly (*Bactrocera dorsalis*), (u). Leaf beetle (*Aulacophora similis*), (v). Green garden looper (*Chrysodeixis eriosoma*), (w). Potato leafhopper (*Empoasca fabae*), (x). Leaffooted bug (*Leptoglossus*), (y). Common bush cricket (*Nisitrus vittatus*).

4. Conclusion

Based on the results of the research conducted, it was found that the scores of farmers' compliance in pesticide application had different impacts between farmers who had low scores and farmers who had high scores. Farmers who had low scores in the level of compliance in using pesticides have poor results, while farmers who have a high compliance score have a better effect compared to farmers who have a low compliance score. Apart from that, due to excessive use of pesticides, there are not many types or diversity of insect pests, neutrals and natural enemies.

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