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Resistance of Aphids (*Aphis gossypii*) to Synthetic Insecticides: A Case Study in Taktakan and Walantaka District, Serang City

Wina Lestari*, Julio Eiffelt Rossafelt Rumbiak, Yayu Romdhonah, Andree Saylendra

Agroecotechnology Study Program, Faculty of Agriculture, Sultan Ageng Tirtayasa University, Jl. Raya Palka Km 3 Sindangsari, Pabuaran, Serang District, Banten Province

*Corresponding author:
4442210032@untirta.ac.id

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Abstract

This study aimed to determine the level of resistance of aphids to synthetic insecticides that have active ingredients of Carbamate, Organophosphate, Pyrethroid, Neonicotinoid, and Flupyradifurone in Serang City, Banten Province. Aphid pest samples were obtained from Taktakan District (Kalang Anyar and Pancur Villages) and Walantaka District (Pager Agung and Kiara Villages) in Serang City. The parameters observed were the morphology of aphids and the resistance of aphids, by observing 72 hours after the application of synthetic insecticides. The results of the study showed that the level of resistance of aphids to synthetic insecticides that experienced potential resistance at LC_{50} was Flupyradifurone and Carbamate in Taktakan and Walantaka Districts. There was a significant effect of the time needed to kill 50% of the number of test insects in Taktakan District, which was 31.038 hours, and Walantaka District was 29.415 hours.

Keywords: *Aphids gossypii, Insecticide, Morphology, Lethal Concentration, Lethal Time, Resistance*

INTRODUCTION

Aphids are important pests on several groups of plants, including agricultural and forest crops. Aphids are sap-sucking insects that can act as pests and vectors of plant viruses. Worldwide, there are more than 4000 aphid species, of which around 300 can serve as vectors for 300 different types of plant viruses. One of these aphid species commonly attacks horticultural crops, particularly in the production of vegetables and seasonal fruits (Maharani et al., 2020)[5].

Based on data from the Central Bureau of Statistics (BPS) in Serang City, Banten, the production of vegetables and seasonal fruits has experienced a decline from year to year. The types of vegetables and fruits that have seen decreases include chili peppers, tomatoes, and cucumbers. In 2019, chili pepper production reached 196.5 tons, whereas in 2020 it decreased to 92.6 tons. Tomato production in 2019 reached 58.8 tons, but in 2020 it drastically declined to only 0.8 tons. Lastly, cucumber production in 2019 reached 632.4 tons, while in 2020 it decreased to 542.7 tons. The loss in production is caused by pest insect disturbances in horticultural commodity farming, specifically by Aphids.

Aphids are a group of aphid pests that primarily attack horticultural crops (cultivated plants such as vegetables and fruits). Aphid pests develop in large colonies and can cause yield losses of up to 58% in horticultural plants. Aphids have piercing-sucking mouthparts, which they use to extract sap from phloem tissue. They feed on plant sap found in leaves, stems, and pods. The role of aphids as vectors of plant viral diseases is a major concern for practitioners involved in plant protection (Maharani et al., 2018)[6].

Control of aphid pests by farmers generally still relies on the use of synthetic insecticides. Factors driving farmers to apply synthetic pesticides intensively and as a preventive measure include limited access to information on environmentally friendly cultivation practices and concerns over potential crop failure. The use of synthetic insecticides has led to various negative impacts, necessitating effective solutions, one of which is the implementation of Integrated Pest Management (IPM) (Dewi, 2017)[2].

The application of insecticides in this study utilized four concentrations: 5%, 50%, 95%, and 100% for each insecticide. The 5% and 95% concentrations were based on guidelines from the Insecticide Resistance Committee (IRAC), while the 50% and 100% concentrations were derived from nationally standardized products. Information regarding the presence of aphid pests in cultivated plants in Serang City, Banten, has not been previously reported. Based on the background, the author is interested in conducting a research study entitled "Resistance of Aphids (Aphis Gossypii) to Synthetic Insecticides: A Case Study in Taktakan and Walantaka District, Serang City".

RESEARCH METHODOLOGY

This research is an experimental study. It will be conducted from September to November 2024. Aphid pest samples will be collected from Taktakan Subdistrict (Kalang Anyar and Pancur Villages) and Walantaka Subdistrict (Pager Agung and Kiara Villages) in Serang City. Rearing and testing will be carried out in the Basic Science and Plant Protection Laboratory of the Faculty of Agriculture, Sultan Ageng Tirtayasa University.

The implementation flow of this research includes the collection of aphid pest samples (*Aphids gossypii*) using a survey method from agricultural fields in Taktakan Subdistrict (Kalang Anyar and Pancur Villages) and Walantaka Subdistrict (Pager Agung and Kiara Villages) in Serang City. This is followed by rearing *Aphis gossypii* for one month on chili plants until reaching the third generation. Subsequently, test media are prepared along with the formulation of insecticides containing active ingredients, including organophosphates, pyrethroids, neonicotinoids, and flupyradifurone. These preparations proceed with the testing phase aimed at determining the susceptibility of aphids to various insecticide concentrations. The observed parameters include morphology and resistance in *Aphids gossypii*.

A. Response Design

The observations are conducted using two approaches: *Lethal Time* (LT) and *Lethal Concentration* (LC). In the Lethal Time assessment, the time required (in minutes) to kill 50% and 99% of the insect population following treatment is calculated. Observations are carried out starting at 24 hours after treatment up to 72 hours post-treatment, with observation intervals every 12 hours (i.e., at 24, 36, 48, 60, and 72 hours). In the Lethal Concentration assessment, the concentration of insecticide required to cause 50% mortality in the aphid population is determined. Mortality is recorded at exposure times of 24, 48, and 72 hours after application of the various concentrations of the active ingredient insecticides being tested.

B. Data Analysis

The observed data will be presented in tabular form, organized according to the analysis design. The parameters, including *Lethal Time 50* (LT_{50}), (LT_{99}), and *Lethal Concentration* (LC_{50}), will be analyzed using probit analysis with the Statistical Package for the Social Sciences (SPSS) software.

RESULTS AND DISCUSSION

Lethal Time (LT_{50}) and *Lethal Time* (LT_{99})

The *Lethal Time* (LT) observation was conducted by measuring the time required (in minutes) to kill 50% and 99% of the insect population after exposure to insecticides containing active ingredients such as carbamates, organophosphates, pyrethroids, neonicotinoids, flupyradifurone, as well as a control (no treatment). This observation was carried out using probit analysis with SPSS software. The time intervals for observation ranged from 24 hours to 72 hours post-treatment, with observations taken every 12 hours, specifically at 24, 36, 48, 60, and 72 hours (Hasyim *et al*., 2016)[4] .

Lethal Time (LT_{50} and LT_{99}) in Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages). The lowest LT_{50} value was obtained from the synthetic insecticide with the active ingredient organophosphate at 100% concentration, with an estimated time required of 18.417 hours, a lower bound of 71 hours, and an upper bound of 23.976 hours. The highest LT_{50} value was recorded for the synthetic insecticide with the active ingredient flupyradifurone at 100% concentration, with an estimated time of 31.038 hours, a lower bound of 876 hours, and an upper bound of 35 hours. For $LT_{99,}$ the lowest value was observed in the synthetic insecticide with the active ingredient organophosphate at 100% concentration, with an estimated time of 33.948 hours, a lower bound of 28.676 hours, and an upper bound of 603.228 hours. The highest LT_{99} value was found in the synthetic insecticide with the active ingredient pyrethroid at 100% concentration, with an estimated time of 50.169 hours, a lower bound of 43.58 hours, and an upper bound of 208.726 hours, as presented in Table 1.

Table 1. *Lethal Time* (LT_{50} and LT_{99}) Values in Taktakan Subdistrict, Serang City

Concentration (%)	***Lethal Time*** (hours)	**Estimated time (hours)**	**Time (hours)** Lower Bound	Upper Bound
		Control		
0	LT50	0	0	0
	LT99	0	0	0
		Carbamate (Marshal)		
5%	LT50	29. 665	19. 379	34. 146
	LT99	50. 131	42. 701	87. 682
50%	LT50	28. 891	22. 229	32. 834
	LT99	50. 001	42. 636	75. 234
95%	LT50	27. 812	23. 308	31. 09
	LT99	49. 845	42. 514	70. 384
100%	LT50	26. 785	21. 933	31
	LT99	39. 373	33. 538	65. 2
		Pyrethroid (Sidametri)		
5%	LT50	35. 814	23. 459	39. 336
	LT99	58. 698	4,.51	1. 5132
50%	LT50	28. 131	20. 336	32. 674
	LT99	54. 161	45. 126	86. 82
95%	LT50	28. 005	9. 283	35. 219
	LT99	56. 082	43. 033	317. 137
100%	LT50	27. 818	0	37
	LT99	50. 169	43. 58	208. 726
		Flupyradifurone (Sivanto)		
5%	LT50	40. 611	31. 251	45. 189
	LT99	65. 967	56. 948	10. 98
50%	LT50	35. 202	13. 983	38. 544
	LT99	49. 063	42. 626	1055. 774
95%	LT50	35. 051	16. 027	37. 994
	LT99	47. 284	41. 112	3374. 099
100%	LT50	31. 038	876	35
	LT99	47. 265	41. 482	1198. 694

Organophosphate (Curacron)				
5%	LT50	25. 972	21. 928	41. 98
	LT99	38. 05	30. 119	2502. 55
50%	LT50	24. 11	9. 782	29. 075
	LT99	36. 132	29. 619	3275. 38
95%	LT50	23. 41	14. 57	26. 536
	LT99	36. 063	29. 988	211. 022
100%	LT50	18. 417	071	23. 976
	LT99	33. 948	28. 676	603. 228
Neonicotinoid (Confidor)				
5%	LT50	37. 442	31. 873	41.07
	LT99	55. 253	45. 484	2. 5318
50%	LT50	37. 44	004	45. 477
	LT99	51. 937	45. 6	87. 873
95%	LT50	30. 945	8. 615	35. 83
	LT99	49. 785	42. 019	298. 402
100%	LT50	30. 945	8. 615	35. 83
	LT99	49. 785	42. 019	298. 402

The observed *Lethal Time* (LT_{50} and LT_{99}) values in Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages), were influenced by the concentrations applied (5%, 50%, 95%, dan 100%). The results indicate that the most effective concentrations for killing 50% and 99% of the aphid pest (*Aphis gossypii*) were at the 100% insecticide concentration. Specifically, the active ingredients showing the lowest LT_{50} values were organophosphate and flupyradifurone, while those showing the lowest LT_{99} values were organophosphate and pyrethroid (Table 1).

This phenomenon occurs because the higher the insecticide concentration used, the faster the time required to kill the aphid pest (*Aphis gossypii*). When a higher concentration is applied, a greater amount of active compound enters the insect's body. This finding aligns with Sulvia (2015)[10], who stated that the concentration of an insecticide influences the mortality rate of test insects. As the concentration increases, the amount of toxin affecting the pest also increases, thereby inhibiting its growth and leading to faster and more effective mortality.

Insecticides that act rapidly in killing 50% of the test insect population are those containing the active ingredient flupyradifurone, while those effective in killing 99% of the test insects contain the active ingredient pyrethroid. This indicates that insecticides with the active ingredients flupyradifurone and pyrethroid are effective in killing 50% and 99% of the aphid pest (*Aphis gossypii*), respectively, within the following time ranges: flupyradifurone (31.038 hours; lower bound: 876 hours; upper bound: 35 hours) and pyrethroid (50.169 hours; lower bound: 43.58 hours; upper bound: 208.726 hours). According to Rahayu and Dahelmi (2021)[7], the effectiveness of an insecticide in killing test insects is commonly referred to as toxicity. This term denotes the ability of an insecticide to kill half (50%) or nearly all (99%) of the insect population, expressed as LT50 (Lethal Time 50) and LT99 (Lethal Time 99), respectively.

Insecticides that exhibit a longer time to kill 50% to 99% of the test insect population are those containing the active ingredient organophosphate. This suggests that organophosphate-based insecticides may have developed resistance in the agricultural fields observed in Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages). According to Syawal *et al*. (2023)[11], in agricultural technologies such as agrochemical practices, synthetic chemicals like organophosphates are often sprayed on crops even in the absence of pest infestation *(blanket spraying system*). These organophosphate pesticides can leave behind residues and induce resistance in pests, leading to environmental contamination and potential health risks.

Lethal Time (LT_{50} and LT_{99}) in Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages). The lowest LT_{50} value was obtained from the insecticide with the active ingredient carbamate at 100% concentration, with an estimated time required of 24.821 hours, a lower bound of 8.577 hours, and an upper bound of 30.704 hours. The highest LT_{50} value was obtained from the insecticide with the active ingredient flupyradifurone at 100% concentration, with an estimated time of 29.415 hours, a lower bound of 16.084 hours, and an upper bound of 34.93 hours. For $LT_{99,}$ the lowest value was obtained from the insecticide with the active ingredient carbamate at 100% concentration, with an estimated time of 35.349 hours, a lower bound of 36.319 hours, and an upper bound of 387.488 hours. The highest LT99 value was obtained from the insecticide with the active ingredient pyrethroid at 100% concentration, with an estimated time of 48.655 hours, a lower bound of 36.605 hours, and an upper bound of 73.835 hours, as presented in Table 2.

Table 2. *Lethal Time* (LT_{50} and LT_{99}) Values in Walantaka Subdistrict, Serang City

Concentration (%)	*Lethal Time* (hours)	Estimated time (hours)	Time (hours) Upper Bound	Time (hours) Lower Bound
		Control		
0	LT50	0	0	0
	LT99	0	0	0
		Carbamate (Marshal)		
5%	LT50	27. 745	0	35. 349
	LT99	55. 816	41. 371	1753. 108
50%	LT50	27. 561	0	36. 521
	LT99	55. 598	41. 36	1. 55725
95%	LT50	25. 541	1.814	33. 636
	LT99	46. 768	36. 447	5. 82317
100%	LT50	24. 821	8. 577	30. 704
	LT99	35. 349	36. 319	387. 488
		Pyrethroid (Sidametri)		
5%	LT50	29. 506	4. 582	36. 798
	LT99	58. 346	44. 291	344. 294
50%	LT50	27. 775	3. 853	35. 374
	LT99	55. 532	43. 471	745. 023
95%	LT50	27. 492	7. 978	35. 021
	LT99	53. 323	40. 85	994. 129
100%	LT50	25. 776	76	33. 569
	LT99	48. 655	36. 605	738358
		Flupyradifurone (Sivanto)		
5%	LT50	43. 433	9. 197	50. 728
	LT99	78. 443	62. 123	1345. 944
50%	LT50	37. 241	10. 618	43. 88
	LT99	74. 191	55. 412	5734. 309
95%	LT50	33. 308	1. 092	43433
	LT99	53. 297	44. 717	15500. 374
100%	LT50	29. 415	16. 084	34. 93
	LT99	48. 275	39. 514	147. 006
		Organophosphate (Curacron)		
5%	LT50	38. 602	4. 593	45. 628
	LT99	71. 151	50. 019	38604. 362

50%	LT50	26. 712	13. 564	32. 58
	LT99	65. 056	52. 92	3054. 111
95%	LT50	24. 919	19	36. 168
	LT99	47. 047	36. 319	387. 488
100%	LT50	24. 821	8. 577	30. 704
	LT99	45. 505	36. 177	197. 022
		Neonicotinoid (Confidor)		
5%	LT50	30. 473	8. 375	39. 835
	LT99	76. 024	55. 898	439. 551
50%	LT50	29. 761	10. 448	38. 022
	LT99	66. 735	50. 433	287. 023
95%	LT50	27. 909	4. 595	34. 441
	LT99	58. 566	44. 336	241. 066
100%	LT50	25. 755	9. 814	32. 578
	LT99	44. 811	35. 942	991. 019

Lethal Time (LT_{50} and LT_{99}) values in Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages) that are the highest or have the fastest time range in killing 50% of the test insect population are found in the insecticide with the active ingredient flupyradifurone, with a time range of (29.415 hours; 16.084 hours; 34.93 hours) , and for killing 99% of the test insect population, the insecticide with the active ingredient pyrethroid, with a time range of (48.655 hours; 36.605 hours; 73.835 hours) , as presented in Table 3. This is consistent with the results of the *Lethal Time* (LT_{50} and LT_{99}) observations in Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages), which indicate that insecticides with the active ingredients flupyradifurone and pyrethroid are effective in killing 50% and 99% of the aphid pest (*Aphis gossypii*) in agricultural fields.

The lowest *Lethal Time* (LT_{50} and LT_{99}) values in Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages), or those requiring a longer time range to kill 50% to 99% of the test insect population, were observed in the insecticide with the active ingredient carbamate. This suggests that the carbamate-based insecticide may have developed resistance in the agricultural fields observed in Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages). According to Yuantari *et al*. (2015)[13], the use of carbamate-class pesticides has led to resistance in whiteflies and aphids and can also reduce populations of natural enemies of pests. Long-term pesticide use not only affects living organisms and the environment but also impacts the economy through increased pest control costs. Fuadzy and Hendri (2015)[3], state that the occurrence of resistance is influenced by several factors, particularly the prolonged use of insecticides and the application of doses that do not conform to standard recommendations. The frequency of insecticide use is a key factor influencing the rate of resistance development. Therefore, insecticide application must follow standard exposure and dosage guidelines.

***Lethal Concentration* (LC 50)**

The LC_{50} value is calculated based on observed data using probit analysis with SPSS software. The Lethal Concentration (LC50) refers to the concentration of an insecticide that causes mortality in 50% of the tested pest insect population under specific observation conditions. The LC_{50} value is used to express the concentration of insecticide required to kill half of the test insect population (Hasyim *et al*., 2016 [4].

Lethal Concentration 50 (LC_{50}) in Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages), The lowest LC_{50} value was obtained from the synthetic insecticide with the active ingredient flupyradifurone, which was 62. 486 hours, with a lower bound of 35. 209 hours and an upper bound of 77. 781 hours. The highest LC_{50} value was recorded for the insecticide with the active ingredient neonicotinoid, which was 72. 957 hours, with a lower bound of 18. 179 hours and an upper bound of 90. 837 hours, as presented in Table 3.

Table 3. *Lethal Concentration* (LC_{50}) Values in Taktakan Subdistrict, Serang City

Treatment	Estimate (%)	Lower Bound (%)	Upper Bound (%)
Control	0	0	0
Carbamate	65. 668	26. 778	82. 3
Organophosphate	74. 29	694	89. 157
Neonicotinoid	72. 957	18. 179	90. 837
Pyrethroid	72. 956	18. 178	90. 836
Flupyradifurone	62. 486	35. 209	77. 781

Lethal Concentration 50 (LC_{50}) in Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages). The lowest LC_{50} value was obtained from the synthetic insecticide with the active ingredient carbamate, which was 50.427 hours, with a lower bound of 555 hours and an upper bound of 70.38 hours. The highest LC 50 value was recorded for the insecticide with the active ingredient neonicotinoid, which was 62.326 hours, with a lower bound of 24.676 hours and an upper bound of 79.304 hours, as presented in Table 4.

Based on the LC_{50} calculation results from Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages) and Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages), it was found that each insecticide exhibited different LC50 values. Among the tested insecticides, including those with active ingredients of carbamate, organophosphate, pyrethroid, neonicotinoid, flupyradifurone, as well as the control (no treatment), the insecticides that were most toxic to the aphid pest *Aphis gossypii* were those with the lowest LC50 values, specifically those containing the active ingredients flupyradifurone and carbamate. This is consistent with Ahsol Hasyim (2019)[1], who stated that the smaller the LC_{50} value of an insecticidal substance, the more toxic or hazardous it is to the target pest. Conversely, the insecticide with the highest LC_{50} value, and therefore the least toxicity, was the one containing neonicotinoid as the active ingredient. Despite its relatively lower toxicity in this study, neonicotinoid still demonstrated a significant effect in killing aphid nymphs (*Aphis gossypii*) and can be considered effective for use by farmers as an aphid control insecticide.

Table 4. *Lethal Concentration* (LC_{50}) Values in Walantaka Subdistrict, Serang City

Treatment	Estimate (%)	Lower Bound (%)	Upper Bound (%)
Control	0	0	0
Carbamate	50. 427	555	70. 38
Organophosphate	60. 05	13. 097	79. 293
Neonicotinoid	62. 326	24. 676	79. 304
Pyrethroid	57. 51	5. 252	78. 508
Flupyradifurone	54. 219	1. 954	74. 596

Morphological Observation of Aphids (Aphis gossypii)

Aphis gossypii exhibits morphological variation in body size and coloration, which is closely related to its host plants and geographical distribution. The aphids observed at the research sites displayed various body colors, including yellow, green, and yellowish green (Figure 1). They have an oval body shape, and the adult forms (imago) exhibit polymorphism: some possess wings while others do not. The winged imago has dark-colored cornicles extending from the base to the tip, along with small tubercles located between the antennae. This observation aligns with Rahmah (2013)[8], who described the morphological characteristics of Aphis gossypii, including six-segmented antennae that are shorter than the body length, elongated dark cornicles that are longer than the cauda, and a body color ranging from green, yellowish green, to gray. The winged adult form of Aphis gossypii possesses entirely black cornicles from base to tip, small tubercles between the antennae, and lacks additional dorsal abdominal projections. These morphological traits serve as important diagnostic features for species identification and support further studies on their ecological adaptation and pesticide susceptibility.

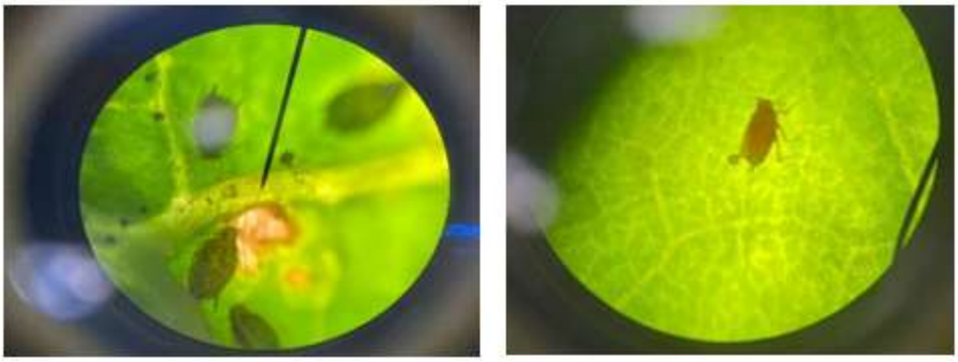

Figure 1. Aphis (*Aphis gossypii*) Before Application of Synthetic Insecticides
Source: (Documentation of Research Results, 2024)

In general, the morphological characteristics observed in *Aphis gossypii* included body shape and color changes both before and after the application of synthetic insecticides. Before Insecticide Application (Figure 1): *Aphis gossypii* exhibited a green to yellowish-green coloration and possessed an oval body shape. The aphids were active in movement, showing normal physiological behavior without signs of stress or intoxication. After Insecticide Application (Figure 2): Significant morphological changes were observed in *Aphis gossypii*. The body color changed from green to dark reddish black. The body appeared shrunken or wrinkled, and the aphids, which were previously mobile, became hardened and rigid. These physical alterations indicate the toxic effects of synthetic insecticides on aphid physiology, leading to paralysis and eventual mortality. These changes are attributed to the impact of synthetic insecticide application, which not only affects the target pest but also alters its behavior and physiological functions, ultimately resulting in death. As noted by Trisyono (2014)[12], the use of broad-spectrum synthetic insecticides not only affects the target pest species but can also harm secondary pests and their natural enemies, potentially disrupting biological control mechanisms in agroecosystems.

Mortality in *Aphis gossypii* is caused by the direct contact (contact toxicity) of synthetic insecticides entering the aphid’s body, leading to systemic infection and disruption of physiological functions. This is consistent with the study by Sukmawati et al. (2020)[9], which states that aphid pests die when they come into direct contact with synthetic insecticides. Contact insecticides penetrate the insect's body through the cuticle and begin to affect internal tissues and nervous systems. Over time, the accumulation of the insecticide within the aphid's body reaches a lethal level, ultimately resulting in death. This mode of action highlights the importance of proper application methods to ensure effective contact between the insecticide and the pest

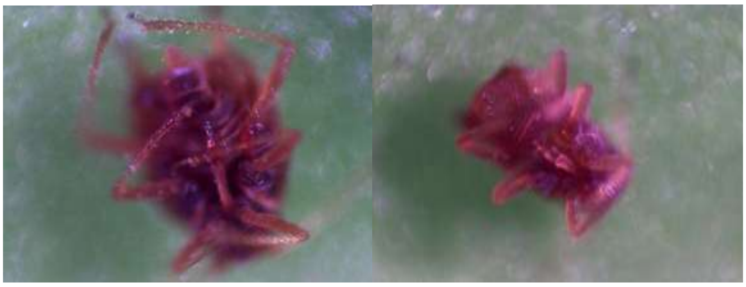

Figure 2. Aphis (*Aphis gossypii*) After Application of Synthetic Insecticides
Source: (Documentation of Research Results, 2024)

CONCLUSION

Based on the results of the study, it can be concluded that there is a significant effect of time in killing the aphid pest (*Aphis gossypii*) using a 50% concentration of insecticides. In Taktakan Subdistrict, Serang City (Kalang Anyar and Pancur Villages), the active ingredient flupyradifurone showed an effective time range of (31.038 hours; lower bound: 876 hours; upper bound: 35 hours). In Walantaka Subdistrict, Serang City (Pager Agung and Kiara Villages), the active ingredient flupyradifurone showed an effective time range of (29.415 hours; lower bound: 16.084 hours; upper bound: 34.93 hours). In addition, resistance potential has been observed at the 50% concentration of synthetic insecticides in both Taktakan and Walantaka Subdistricts, particularly in the active ingredients flupyradifurone and carbamate. The use of these synthetic insecticides has significantly affected the behavior of Aphis gossypii, ultimately leading to mortality. As a recommendation, further research should be conducted on insecticides that show signs of resistance to test for resistance development in *Aphis gossypii*. This is intended to prevent improper dosage application that does not conform to standards and may lead to resistance (tolerance or immunity) in the aphid pest.

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