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The Diversity of Pest Generalist Predator in Potato Plants (*Solanum tuberosum* L.) Treated By Non-Synthetic Chemistry Insecticide on the Medium Plain of Lombok Island

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Abstract: This study aims to determine the diversity, abundance, and dominance of predators in potato plants treated by synthetic non-chemical insecticides on the medium plain of Lombok Island. The research used Randomized Block Design with ten different synthetic non-chemical insecticide treatments such as *Metarhizium anisopliae, Beauveria bassiana, and Bacillus thuringiensis*, Neem extract, tobacco stem extract, soursop leaf extract, babandotan leaf extract, chemical insecticide treatment, and one treatment without insecticide as a control. The insecticide was applied after 37 days of planting eight times at 7-day intervals. The type and population of predators were observed five days after the treatments. The diversity index (H'), abundance (K), and dominance (D) of the predators are then identified and determined. Data were analyzed by using a Diversity analysis followed by a 5% *beda nyata jujur* (BNJ). The yield shows six predatory families: Formicidae, Coccinellidae, Mantidae, Lycosidae, Oxyopidae, and Aranedae. H' and K values are generally classified as the low category, and no species dominates in each treatment (D <0.5). The value of H' and K in *B. thuringiensis* treatment was higher than other treatments. The highest D value was obtained from chemical insecticide treatment. Formicidae is the family with the highest population compared to other families.

Keywords: Biological Insecticide; Diversity; Potatoes; Predators

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Introduction

Potato (Solanum tuberosum L.) is one of the horticultural commodities that become the main priority of food-producing plants because of the high carbohydrates and nutritional content. In the food diversification program, the potato position is crucial to replace rice [1].

Badan Pusat Statistik [2] explained that in 2011 the national demand for potato reached up to 1,318,690 tons. However, the production until 2013 can't fulfill the demand with a production rate of 1,023,381 tons. Therefore, it is necessary to boost the production rate in Indonesia.

One of the ways to raise the production is by planting potatoes in the medium plains. Potato cultivation in the plain medium has various problems such as; temperature, humidity, and rainfall, which could affect the growth and development of potato plants and can stimulate the development of pests (OPT), which cause a yield reduction of up to 40% and also crop failure [3]. Due to that reason, it is necessary to make pest control efforts.

One of the environmentally friendly, effective, and efficient efforts to control pests is by using

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synthetic non-chemical insecticides. The problem that emerges from the use of synthetic non-chemical insecticides is besides eradicates the target insects. It also attacks the natural predators. This study's goal is to assess the impact of synthetic non-chemical insecticides on the presence of predators.

Method

Experiment Design

This study used a randomized block design (RAK) consisting of 10 treatments, such as *Metarhizium anisopliae* (20 g/l), *Beauveria bassiana* (7 g/l) (Bb), *Bacillus thuringiensis* (10 g/l) (Bt), *Imidacloprid* chemical insecticide (0.4 g/l), vegetable insecticide, i.e., neem leaf extract, tobacco stem extract, soursop leaf extract, and babandotan leaf extract and one treatment decided not using any insecticide (TP). Each treatment was repeated four times so that there were 40 experimental plots.

Place and Time

This study was conducted from October 2016 to February 2017 in the medium plain with a height of ± 480 m above sea level, located in the Germ Production Unit (UPB) of Santong Village, Kayangan District, North Lombok.

Tools and Materials

The materials used in this study were *Bliss* potato germ variety, Urea fertilizer, SP-36, TSP, KCl, and petrogenic. The biological insecticide used as *Beauveria bassiana* (By-Vii^{Tm}) with active ingredients as *Beauveria bassiana* (bals viril), *Metarhizium* sp. (Zium OR WP^{Tm}) with active ingredients of *Metarhizium anisopliae*, *Bacillus thuringiensis* (B-TOX^{Tm}), plant-based insecticide such as neem leaf extract, tobacco stem extract, soursop leaf extract, and extract of babandotan chemical insecticide with trademark Qiudor®, 25 WP with active ingredients *Imidacloprid* 25%, and Alcohol 70%.

The tools used in this study were 1-liter capacity sprayers, hoes, pitfall trap traps, specimen bottles, scissors, nylon ropes, bamboo, cameras, and stationery.

Research Plan

Observation

The field observations were conducted in October 2016 at a potato production center located in the Germ Production Unit (UPB) Santong, North Lombok. The location was chosen based on the height of the place that is ± 480 masl.

Plotting Area and Sample Plants Selection

A test plot was made for the plotting area. Land with an area of 195.3 m^2 was used for the study, where the land was divided into 20 partitions with an area of 140x330 cm each. Each experimental partition contained 20 plants and observed 20% of the plant population (4 plants per partition).

Germ Preparation

Bliss potato varieties were used in the study obtained from germ production in Santong and Timbanuh, East Lombok.

Land Preparation

Before the cultivation stage, the soil had been processed with a depth of ± 30 cm. Then beds were made along with the land with a width of 30 cm and height of 10 cm, the distance between the beds is 70 cm.

Cultivation

Each seed was planted in each hole with a depth of 2 cm and a spacing of 70 cm x 30 cm. Every planted seed must have buds around 2-3 cm. Then the seeds were covered with soil until the buds embedded.

Trap Placement

This study used plastic fall pit traps (pit fall traps) placed in each trial plot. The pitfall trap was made of plastic bowls with 18 cm in diameter and 7 cm high that was half-filled with water. This trap is used for active predators that live on the surface.

Maintenance

Primary Fertilization

Fertilizers used in this study were UREA (100kg/ha), SP 36 (100kg/ha), KCL (50kg/ha) and petroganik (3ton/ha) that given before cultivation proccess.

Secondary Fertilization

5 weeks after the potatoes got planted, we gave secondary fertilizer such as ZA (30 kg/are), SP-36 (30kg/are) with a mixture of KNO3 (50 kg/are).

Irrigation

The irrigation process was carried out before cultivation and after the secondary fertilization.

Treatment

The biological insecticide used as *Beauveria bassiana* (By-Vii^{Tm}), *Metharizium anisopliae* (Zium OR WP^{Tm}), *Bacillus thuriengensis* (B-TOX^{Tm}), Chemical insecticide Qiudor® 25 WP with active ingredients *Imidacloprid* 25% with dose of 7 g/l, 20 g/l, 10 g/l, and 1ml / l, respectively.

Neem leaf Extraction 100 g of fresh neem leaves were mashed and dissolved with 1000 ml water. Stir the mixture evenly for 15 minutes. After that, please keep it for 24 hours. Furthermore, the precipitate was filtered by using a sieve with a 0.5 ml mes. The filtered mixture is the neem leaf extract [4].

Soursop leaf extraction to extract soursop leaves, we used procedure from Makal [5]. First, 100 g of soursop leaves need to be washed then added 1 liter of water before got blend. Then the mixture soaked for 24 hours and filtered with a 0.5 ml sieve.

Babandotan Leaf Extraction Babanton leaf is a plant-based insecticidal solution that was introduced by Makal [5]. 100 g Babandotan leaves need to be washed then added 1 liter of water before got blend. After that, the mixture soaked for 24 hours and filtered with a 0.5 ml sieve.

Tobacco Stems Extraction Tobacco stem waste was chopped into small pieces with a size of approximately 2 cm. These pieces are weighted according to the needs of 20 kg then get dried. The dried tobacco stems were blended into the flour 100 g of the flour then mixed with water's 0.9 liters before fermented for 24 hours. The insecticidal material contained in the tobacco stems dissolved [6].

According to the treatment, insecticides were treated 4 weeks after the cultivation process by spraying the insecticide suspensions on plants. The treatment was carried out eight times during the study with seven days of interval.

Observation

Observations were made five weeks after planting (41 days after planting) with an interval of 5 days after application. Specimens (predators) found in the field wrapped up in plastic containers filled with 70% alcohol so that the specimen is in decent condition before being identified.

Harvest Stage

The harvest stage was done when the potato plant already has the characteristics such as the stems turns yellow, the leaf turns brown, or after 95 days.

Data Analysis

Data were analyzed using analysis of variance (ANOVA) and continued with the *Beda Nyata Jujur* test (BNJ) at 5% significance level with Co. stat for windows.

Result and Discussion

In General, based on the Shannon-Wiener criteria in Magurran [7], the diversity (H') and abundance (K) predator index are classified into the low category. In comparison, the value of dominance based on the Simpson Domination Index is close to 0 (<0.5), which means that no species dominates each treatment.

Table 1. Diversity (H'), Abundance (K), and Domination (D) Index of Predators in Potato Plants treated with biological insecticides.

Treatments	H'	K	D
Without Insecticides	0.98 a*)	36.31 a*)	0.19 b*)
Imidakloprid	0.35 c	9.12 c	0.25 a
M. anisopliae	0.65 b	20.1 b	0.21 ab
B. bassiana	0.69 b	22.12 b	0.21 ab
B. thuringiensis	0.88 a	29.9 a	0.18 b
BNJ 5%	0.17	7.30	0.048

Note: * The numbers followed by the same letters in the same column are not significantly different in the 5% BNJ test.

The application of several insecticides affects the diversity and abundance of predators. The analysis result shows that the diversity and abundance index of predators in biological insecticide treatments with *B. thuringiensis* were higher than those with other treatments and were not significantly different from controls (without insecticides). The higher value of diversity and abundance index of predators in *B. thuringiensis* treatment is suspected because it is specific and relatively safe for predator life. Chen [8] reported that the application of plants containing *B. thuringiensis* had no significant effect on nontarget arthropods such as predatory insects because *B. thuringiensis* tended to attack insect pests, especially Lepidoptera specifically.

The analysis also shows that the diversity and abundance index of predators with biological insecticide treatments using *M. anisopliae* and *B. bassiana* were significantly different from controls (without treatment), which meant that the treatment affected the diversity and abundance of predators. Ludwig and Oetting [9] informed that we have to be aware of the type and population of insects on using B. bassiana because laboratory tests show that *B. bassiana* can also directly infect predators or parasites with a high mortality rate (68-100%). In comparison, the chemical insecticide treatment (*Imidacloprid*) shows the lowest diversity and abundance index of predators. This is assumed because, in addition to eradicating insect pests, chemical insecticides also eradicate predators that degrade the ecosystem's diversity. Herlinda [10] stated that insecticides' application is the main cause of the decrease of insects' diversity and abundance a habitat, especially predatory insects.

For the dominance index, a higher index was observed in the treatment with chemical insecticide (*imidacloprid*) and not significantly different from the index in *M. anisopliae* and *B. bassiana*, but significantly different from the control (without insecticide) and biological treatment with *B. thuringiensis*. The higher value of the predator dominance index in chemical insecticide treatment is hypothesized because the diversity and predator abundance index in the treatment are lower because if dominance is high, then diversity is low, and vice versa.

Table 2. Diversity (H'), Abundance (K), and Dominance (D) Index of predators in the treatment of Vegetable Insecticides.

Treatments	Diversity (H')	Abundance (K)	Dominance (D)
P0	1,07 a*	40,18 a*	0,17 c*
P1	0,14 e	3,04 e	0,38 a
P2	0,87 b	25,93 b	0,19 bc
P3	0,54 c	16,28 c	0,19 bc
P4	0,36 d	9,54 d	0,24 abc
P5	0,21 e	5,01 e	0,35 b
BNJ 5%	0.14	4,50	0,16

Note: * The numbers followed by the same letters in the same column are not significantly different in the 5% BNJ test.

The analysis shows that the neem leaf extract has the highest diversity and abundance predator index in the treatment of vegetable insecticides. This is due to neem leaf extract (P2) that is easily absorbed by plants, works systemically, has little contact poison, and is safe for natural enemy insects. Aradila [11] also explained that the extract of neem leaf only attacks insect pests rather than natural enemies through the active compound *azadirachtin* contained in neem leaves. *Azadirachtin* acts as antifeedants by producing chemical receptors (*chemoreseptors*) that interfere with stimulation to reduce eating capability.

Chemical and babandotan insecticide treatments have a low index of predator diversity and abundance. This is hypothesised because chemical insecticides could quickly eradicate insect pests or predators because they are contact, systemic, and stomach toxins. The diversity and abundance values of predators are low. In comparison, the babandotan leaf extract is suspected because babandotan leaf extract contains active compounds consisting of precocene I and precocene II, saponins, flavonoids, polyphenols and essential oils. The precocene I and precocene II compounds in babandotan leaf extract are known as juvenile anti-hormone compounds, the hormones needed by insects during metamorphosis and reproduction. Babandotan leaves can interfere with the process of insects' metamorphosis. Ditjenbun [12] stated that the precocene compounds in babandotan leaves (P5) undergo chemical reactions in the insect's body to become reactive and cause cell protein damage and cell death.

From the calculation of the highest dominance index value in the chemical insecticide treatment (P1) and not significantly different from the others. The high predator index dominance value in chemical insecticides is suspected because the index value of diversity and abundance of predators in the treatment has the lowest value if the dominance value is high and the diversity of predators is also low.

Effect of Treatment on Predator Populations in Potato Plants

In general, treatment with insecticides can affect predator populations, proven with the lower predator populations in all treatments than controls (without insecticides). However, the predator population on chemical insecticide treatments is lower than the predator population on biological insecticide treatments. The analysis shows that the treatment of chemical insecticides (I*midacloprid*) significantly reduced the population of all predators (Table 3).

Table 3. The population of several predators in potato cultivation with various treatments

Treatments	Insect predators					
	Formicidae	Coccinelidae	Mantidae	Lycosidae	Oxyopidae	Aranedae
Without incesticides	2.25 a*)	1 a*)	0.92 a*)	1.67 a*)	0.92 a*)	0.89 a*)
Imidakloprid	0.5 c	0.28 b	0.21 c	0.39 c	0.35 b	0.17 b
M. anisopliae	1.17 b	0.57 ab	0.57 abc	0.85 bc	0.46 ab	0.5 ab
B. bassiana	1.13 b	0.71 ab	0.35 bc	1 b	0.64 ab	0.57 ab
B. thuringiensis	1.64 b	0.89 a	0.75 ab	1.39 ab	0.82 ab	0.78 a
BNJ 5%	0.584	0.466	0.462	0.556	0.495	0.481

* The numbers followed by the same letters in the same column are not significantly different.

Table 3 shows that the highest predator population decline was in treating chemical insecticides (*Imidacloprid*). The high decrease in predator population in this treatment due to the substance of chemical insecticides that eradicate the nontarget organisms such as predatory insects. The analysis shows that, on average, in all predator families, only the treatment of biological insecticides (*B. thuringiensis*) was significantly different from the chemical insecticide treatment (*Imidacloprid*).

Formicidae and *Lycosidae* families have a higher population than other families. The high population of *Formicidae* assumed due to this family is not depending on only one prey, but also has a function as decomposers. Another cause that might spur ants' presence is the ability of ants to follow in the footsteps of their species [13].

Table 4. Effect of Vegetable Insecticide on Predator Populations in Potato Plantations.

Treatments	Predator						
	Db	*Lp*	*Pi*	*Ct*	*Mr*	*Oj*	*Nn*
P0	4,476a*	3,285a*	1,61 a*	1,857a*	1,40 a*	1,47 a*	1,761a*
P1	0,428d	0,142c	0,70 e	0,047d	0,70 c	0, 70 d	0,047d
P2	2,809b	2,428b	1,34 b	1,047b	1, 18 b	1,21 b	1,047b
P3	1,857c	1,714b	1,11 c	0,666bc	1, 09 b	1,01 c	0,666bc
P4	1,190d	0,857c	0,92 d	0,285d	0,80 c	0,83cd	0,571c
P5	0,904d	0,476c	0,78 e	0,047d	0, 70 c	0,75 d	0,095d
BNJ 5%	0,932	0,783	0,170	0,507	0,195	0,193	0,449

Note: * Pi, Mr., and Oj have been transformed using Square Root (root). The numbers followed by the same letters in the same column are not significantly different in the 5% BNJ test. Db (Dolichoderus bituberculatus), Lp (Lycosa pseudoannulata), Pi (Pardosa irriensis), Ct (Coccinella transversalis), Mr (Mantis religiosa), Oj (Oxyopus javanus), Nn (Neoscona nautica).

Based on analysis of variance (ANOVA) it shows that the *Dolichoderus bituberculatus* species in the treatment of P0 were not significantly different from P1, P2, P3, P4, and P5, but P1 was not significantly different from P4 and P5. In comparison, P2 was significantly different from all treatments. *Lycosa pseudoannuation* species P0 treatment was significantly different from all treatments, P2 and P3 were significantly different from P1, P4, and P5 treatments, but P1, P4, and P5 were not significantly different, treatments on P2 and P3 were not significantly different. In the *Lycosa pseudoannuation* species, P0 treatment was significantly different from all treatments, P2 and P3 were significantly different from P1, P4, and P5 treatments, but P1, P4, and P5 were not significantly different, treatments P2 and P3 were not significantly different. In the Pardosa irriensis species, P0, P2, P3, P4 were significantly different from all treatments, but the P1 and P5 treatments were not significantly different. Coccinella transversalis P1, P4, and P5 were not significantly different but were significantly different from treatments P0, P2, and P3. Mantis religiosa species P1, P4, and P5 were not significantly different, but significantly different from the treatments P0, P2, and P3 and P2 were not significantly different from P3 but significantly different from P0. Oxyopus javanus P1 was not significantly different from P4 and P5 but significantly different from P0, P2, while P3 and P4 were not significantly different but significantly different from P2 and P0. Neoscona nautica P1 was not significantly different from P5 but significantly different from P0, P2, P3, and P4 while P2 was not significantly different from P3 but significantly different from P0, P1, P4, and P5.

The high number of Formicidae (D. bituberculatus) is thought to be due to one ant queen's egg reproduction ability to reach 5000 eggs per head within a day and have a group living habit. Yahya [14] stated that the Formicidae family has a very wide distribution and is easily adaptable to the environment so that its existence can live in all habitats. This situation can occur because of food or host plants' availability as a suitable food source for ants. According to Purwaningsih [15], insects' arrival to an area is because of the host plants can originate from plants planted around the experimental field. Besides being a predator that can suppress pests, this Formicidae family also acts as an organic decomposition. Besides, the cause of ants' presence is because of ants' ability to follow in the footsteps of their kind due to a guiding pheromone's presence. Borror [16] and Elzinga [17] stated that insects have pheromones for guidance to find their food source easily.

Lycosidae family (*L. pseudoannulata*) has the highest population because besides being able to adapt well to the environment, it is also thought to have the ability to lay eggs as much as 200-400 in 3-4 months. Shepard [18] explained that Lycosidae lay eggs by 200-400, but from the number of eggs, only 60-80 got hatched, then the newly-born child spider will be on its mother's back. Besides, Lycosidae is active in hunting prey directly without using cobweb and has a relatively large body size that can catch prey. Lycosidae is a spider with high mobility and acting ability at the ground's surface, so it is easier to prey on catching pests and is a generalist predator [19].

Potato Plant Production

Potato crop production was significantly different in each treatment (Table 5)

Table 5. Potato Plants in Each Treatment

Treatments	Average tuber weight / 18.48 m²
Without insecticide	0,552 d
Imidakloprid	1,335 a
M. anisopliae	0,75 c
B. bassiana	0.812 c
B. thuringiensis	1,022 b

* The numbers followed by the same letters in the same column are not significantly different.

Table 5. Shows that the highest potato production was obtained in the chemical insecticide (I*midacloprid*) treatment and was significantly different from the other treatments. The high production in these

treatments can occur because chemical insecticides (*Imidacloprid*) can eradicate all organisms, both pests and natural enemies that can disturb or undermine plants, so it produces optimum growth and development.

In the treatment of *B. thuringiensis* shows the second highest production after chemical insecticide (*Imidacloprid*) and higher than the biological insecticide *M. anisopliae* and *B. bassiana*. This shows that the use of *B. thuringiensis* can be considered as an insecticide in addition to chemicals, because in addition to being able to control pests it is also not harmful to natural enemies such as predators and can obtain relatively high production.

Furthermore, the treatment of *M. anisopliae* production decreased and not significantly different from the treatment of *B. bassiana*. This estimated because of the effectiveness of *M. anisopliae* in suppressing pest attacks is still relatively low and impacted on the reduce crop production. Azis [20] explained that *M. anisopliae* treatment is less effective on production because it has the lowest production compared to other biological insecticide treatments, which are caused by toxic compounds in *M. anisopliae*, which are less able to kill pests in leaf mesophyll such as *L. huidobrensis*. As a result, the number of larvae is quite high and causes the percentage of attacks to increase and lower production.

For the lowest production, it was obtained in control (without insecticide). The low production is thought to occur due to the absence of treatments that can suppress the population of plant-disturbing organisms that can reduce crop production.

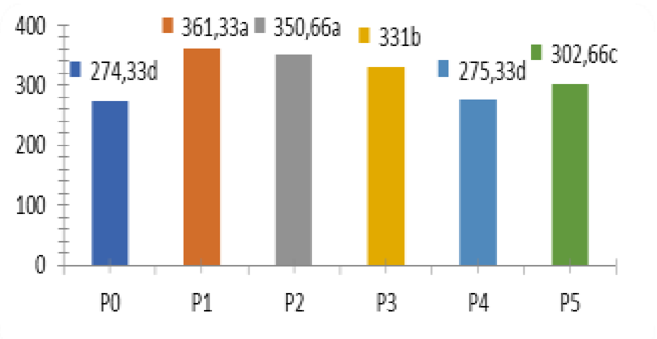

Figure 1. Production of potato plants from several treatments (treatments with the same letter are not significantly different from BNJ test 5% = 16.49).

The high level of chemical insecticides used works quickly, which is contact, systemic, and stomach toxins that eradicate pests and predators quickly so that the chemical insecticide treatment has good and optimal growth, while the second-highest production in the treatment of neem leaf extract (P2) hyphotised because the neem leaf extract (P2) is systemic which can reduce the intensity of pest attacks through the mechanism of repellent eating, disrupt the growth and reproduction of insects that can be antifeedant (repellent) so the growth is not disturbed due to pest attacks. Waridho [21] stated that treatment with neem leaf extract could reduce the intensity of plant pest attacks so that plants can produce optimally.

The lowest production yield is in the P0 treatment this is because there is no insecticide content involved in the plant so that there is no effect that suppresses pest attacks that can reduce production yields.

Conclusion

Considering the findings of this study, the researcher Based on the results of research and discussion, we concluded that: 1) The value of the predator diversity index (H') is generally classified in the low category. 2) Treatment with *Bacillus thuringiensis* shows the highest diversity index value with average, abudance, and a dominance index value of 0.88, 29.9%, and 0.18, respectively. 3) The lowest predator diversity index was obtained in chemical insecticide (*Imidacloprid*) treatment of 0.35 with an abundance of 9.12% and a 0.25% dominance. 4) Formicidae family is a predator family with the highest population of almost every treatment at every observation. 5) There are 7 species of generalist predators such as *Dolichoderus bituberculatus, Lycosa pseudonnullata, Pardosa irriensis, Coccinella transversalis, Mantis religiosa, Oxyopus javanus* and *Neoscona nautica* from 6 predator families, namely *Formicidae, Lycosidae, Coccinellaeidae, Mantidae, Osteoidae, Mantidae, Mantidae, Oeidaeidae, Mantidae O*. 5) In general, the predator diversity index (H') in the potato planting area in Santong Village is classified in the low category. The treatment of neem leaf extract has the highest value, with an average diversity index of 0.87 and an abundance of 25.93. 7) Formicidae family (*Dolichoderus bituberculatus*) has the highest population compared to 5 other families in each treatment

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