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Spider Diversity in Potato Plants Applied with Some Concentrations of Botanical Pesticides Virginia Tobacco Stem Waste

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Abstract:

This study aims to determine the effect of applying various concentrations of botanical pesticides derived from Virginia tobacco stem waste on the diversity of spiders in potato plants. The research was conducted in Sembalun Bumbung Village, Sembalun District, East Lombok Regency, West Nusa Tenggara Province. The method employed was an experimental method with field trials, using a Randomized Block Design (RBD) with six treatments: P0 (control), P1 (abamectin), P2 (Virginia tobacco stem extract 2 ml/L), P3 (Virginia tobacco stem extract 4 ml/L), P4 (Virginia tobacco stem extract 6 ml/L), and P5 (Virginia tobacco stem extract 8 ml/L). The experiment was conducted in three blocks, resulting in 18 experimental units. The results showed that the application of various concentrations of botanical pesticides from Virginia tobacco stem waste did not significantly affect spider diversity in potato plants. However, the P3 treatment (Virginia tobacco stem extract 4 ml/L) exhibited a higher tendency in population, diversity index, abundance index, and dominance index compared to other treatments.

INTRODUCTION

Potatoes *(Solanum tuberosum L.)* are one of the staple crops with the fourth largest carbohydrate content after rice, wheat, and barley, making it one of the commodities that can support food diversification (Aria Erlangga, 2023; Rendi Irawan et al., 2024). The large potential of potatoes to support national economic development makes their production must remain are maintained so that they remain stable and do not decline. However, in recent years, there have been fluctuations in potato production in Indonesia, including in West Nusa Tenggara (NTB). including in West Nusa Tenggara (NTB). During the 2017-2021 period, potato production from West Nusa Tenggara fluctuated. In 2017 NTB potato production increased by around 18,038 tons, but potato crop production in 2018-2019 decreased significantly by 15,275 tons (2018)-15,872 tons (2019). In 2020 NTB potato production experienced an increase in production of 17,872 tons, and in 2021 NTB potato production was 20,358 tons. Therefore, NTB potato production has experienced significant fluctuations in production (NTB satu data, 2022). According to (Manurung et al., 2024; Sarjan et al., 2021), some of the things that become obstacles when cultivating plants are (1) poor cultivation techniques, (2) the use of low-quality seedlings and (3) attacks by plant pest organisms.

Plant Pest Organisms on potatoes are generally differentiated into pests, pathogens, and weeds (Lubis et al., 2021). Various types of pests such as tuber borers, leaf borers, whitefly, earthworms, and leaf-eating caterpillars have a significant impact on potato crop production (Syifa et al., 2025; Tasrif et al., 2022). The use of pesticides around the world in order to improve the quality and quantity of agricultural commodity production can be said to be still high. In a study

conducted by (Jumardi & Sulaiman, 2024) stated that the application of pesticides in farming can benefit farmers as long as they are used wisely. However, if the use of pesticides is carried out unwisely by farmers, it will have an impact on human health and environmental sustainability, so efforts are needed to reduce these adverse impacts (Prajawahyudo et al., 2022; Sinambela, 2024) stated that there are several negative impacts caused by the unwise use of pesticides, such as the emergence of pest resistance, pest resurgence, secondary explosions, increased pesticide residues on plants, declining human health, and various other environmental problems. For this reason, it is also necessary to apply control techniques that not only focus on OPT, but also pay attention to its impact on the environment. Control techniques based on the concept of ecological control are known as Integrated pest management (IPM) with the use of various components and compatible control techniques that are environmentally friendly and sustainable (Deguine et al., 2023; Zhou et al., 2024).

One of the efforts that can be applied to reduce the use of synthetic pesticides is to optimize the use of vegetable and biological pesticides that are more environmentally friendly (Li et al., 2024; Zou et al., 2021) One of the plants that has the potential to be used as a plant-based pesticide is tobacco *(Nicotiana tabacum L.)*. The NTB Provincial Agriculture and Plantation Service (2020) stated that tobacco plants that are widely grown in several districts in NTB are virginia tobacco. In 2019, the area of virginia tobacco plantations in NTB reached 27,521.25 hectares, with 50 hectares in West Lombok Regency, 11,230.25 hectares in Central Lombok Regency, 15,606.25 hectares in East Lombok Regency, 9 hectares in West Sumbawa Regency, and 625.75 hectares in Dompu Regency. Wulandari (2013) also mentioned that with such a large land, virginia tobacco waste especially on the island of Lombok is estimated to reach 336 million tobacco sticks or equal to 42 thousand tons of tobacco sticks per planting season. If not used properly, the existence of tobacco stem waste can cause environmental pollution because it is difficult to decompose by soil microorganisms (Bareschino et al., 2021; Sarjan et al., 2024).

The use of plant-based pesticides as plant pest organisms control on plants can have a fairly good impact on the environment. For example, bio-degradable active ingredients (Marnita et al., 2022). In addition, plant-based pesticides also have a rapid effect on insects by inhibiting appetite, have a fairly wide control spectrum, and are able to control pests that have been resistant to the application of synthetic pesticides, and are safe for non-target organisms. Thus, to increase the level of plant pest organisms control in plants, in addition to using plant-based pesticides, it can also be done by taking advantage of the presence of natural enemies and predators. One of the important predators in plant ecosystems is spiders. Spiders are one of the many biological agents that have excellent potential in controlling insect pests in agricultural ecosystems (Aprilianti et al., 2024; Sarjan et al., 2022) Profit-Lobsters are a type of predator that has a wide range of prey and plays an important role in reducing, as well as preventing natural pest explosions in plant cultivation, as well as contributing to increasing biodiversity in agroecosystems (Sidauruk et al., 2022).

The use of plant-based pesticides in controlling potato plant pests is a good way of control because in its application it does not have a detrimental impact on plants and the environment. In addition, the population of potato plants in a land has certainly been inhabited by a variety of natural enemies of pests so that the use of plant-based pesticides is likely to have an influence on the activities of these natural enemies. Therefore, a study was conducted with the title "Diversity of Spiders in Potato Plants Applied with Several Concentrations of Botanical Pesticides from Virginia Tobacco Stem Waste".

MATERIALS AND METHOD

The method used in this study is an experimental method with experiments in the field. The tools used in this study were hoes, pesticide sprayers (pressurized sprayer), machetes, knives, scissors, bamboo, microscopes, cellphone cameras, specimen bottles, label paper, raffia ropes, and writing stationery. The materials used in this experiment are potato seeds of the Dayang Sumbi variety, water, vegetable insecticide virginia tobacco stem waste, organic fertilizer (petroganic), NPK fertilizer, biological fertilizer, 70% alcohol, as

well as materials for making tobacco stem waste insecticides (tobacco stem waste, water, sugar, and colet soap).

Sample Determination

Observations were carried out by census and using pitfall traps to collect spiders that moved on the ground surface.

Observation Parameters of Spider Predator Population

To obtain data on the population of pests and spider predators, a calculation is carried out on the number of pests and spider predators obtained. Pest and predator populations are calculated using hand counters directly in the field.

Spider Predator Diversity Index

The diversity of pest types in potato plants and spider predators is determined from the results of specimen collection obtained during the study, then the diversity index value is calculated with the Shannon-Weiner diversity formula (Soriano et al., 2023).

$$H' = \sum n - pi \ln and\ pi = \frac{ni}{N}$$

The calculation of the Shannon-Weiner diversity index results in several categories of diversity levels, namely (H') less than 1.00, so the diversity is relatively low. If the Shannon index (H') is between 1.00 - 3.00, it is classified as medium diversity, and if the diversity index (H') is greater than or equal to 4.00, it is classified as high diversity (Untung, 1996).

Index of Abundance of Spider Predators

The abundance index was calculated after the high and low populations of pests and predators of spider associations were known at a time, calculated using the formula of (Soriano et al., 2023)

$$(\mathrm{K}) = \frac{\sum \text{Jumlah Individu Spesies ke}-1}{\text{Jumlah Individu Seluruh Spesies}} \text{x}100\%$$

Spider Predator Dominance Index

To determine the dominance of a particular pest and spider predator in potato plantations, it can be calculated using the simpson'a dominance index (Odum, 1998), with the formula:

$$D = \sum_{i=1}^{s} \left[\frac{ni}{N}\right] 2$$

Spider Identification

Spider identification was carried out using a 4 x 10 magnification binocular microscope and referring to Spider identification was carried out based on the reference Borror et. Al (1992). The characteristics of the spider identified are body color and the number and arrangement of eyes.

Data Analysis

The data from the observation results were analyzed for diversity at a real level of 5% and the results of the analysis were tested with a real difference of honesty (BNJ) at the level of 5%. However, if the analysis of the resulting data is not significant, further tests are not carried out.

RESULT AND DISCUSION

From the identification of spider samples that have been carried out, seven spider families were obtained, namely the families *Araneidae, Linyphiidae, Lycosidae, Oxyopidae, Salticidae, Theridiidae, and Thomisidae*. The main characteristics that distinguish one family from another are the number and arrangement of eyes. The following is the data from the spider identification.

Table 1. Spider Family Identification Results

Family	Treatment						Total
	P0	P1	P2	P3	P4	P5	
Araneidae	1	0	1	3	1	1	7
Linyphiidae	3	3	2	23	3	4	38
Lycosidae	1	2	1	0	1	4	9
Oxyopidae	2	1	1	0	1	4	9
Salticidae	0	2	1	1	0	2	6
Theridiidae	3	2	4	2	1	4	16
Thomisidae	2	1	2	3	3	2	13
Total	12	11	12	32	10	21	98

Each spider family found has different characteristics, here's an explanation. Araneidae. Spiders of the *Araneidae family* are mostly found in dense canopies with less light intensity. This type of spider makes webs with a unique circular shape and some have a zig-zag pattern (Macharoenboon et al., 2021). The body color is light brown to yellow with 8 eyes arranged in 2 rows, 2 eyes at the top and 6 eyes at the bottom. The lateral (side) eye is separated somewhat far from the median (middle) eye. ***Linyphidae*** According to (Cuff et al., 2022), spiders from this family generally make wide webs near the canopy of trees that serve to catch prey that falls from the top of trees or leaves. The spiders of the *Linyphiidae family* identified at the research site were bright brown to yellow with 2 rows of eyes totaling 8.

Lycosidae In the observations made, spiders from the *Lycosidae family* have the characteristics of 8 eyes arranged in 3 rows. The posterior eye line is 2, the middle part is 2, and the anterior part is 4 eyes. The anterior part of the eye is small, while the middle and posterior parts are larger. The body color is brown to black. According to (Cuff et al., 2022), members of this family are known as wolf spiders, which are mostly hunting spiders without making webs and are active on the ground.

Oxyopidae The body color of spiders of this family is quite diverse, some are dark and some are light. The number of eyes is 8 fruits of medium size, dark in color and arranged in a circle like an egg. (LO et al., 2021) revealed that spiders from the *Oxyopidae family* have a reddish-brown body color with 4 pairs of spiny limbs. The arrangement of the eyes of this spider is in a hexagonal arrangement and resembles an egg (SANKARAN, 2024).

Salticidae Members of this family have 8 eyes arranged in 3 rows. In the anterior part there are 4 large eyes, in the middle there are 2 small eyes, and in the posterior part there are 2 small eyes. (Wang et al., 2024) said that spiders of this family are hunter spiders and do not have webs. Its large eyes and strong limbs are very supportive for hunting.

Theridiidae The members of this spider are dark in color and make irregular webs between chunks of earth close to the plant canopy. There are 8 eyes, small in size arranged in 2 rows, 6 eyes in the anterior part and 2 eyes in the posterior part. (Schraft et al., 2021) said that members of this family can make nests in three-dimensional shapes and nests in different types of vegetation. The distinguishing feature from other families is that it has fine hair resembling a comb found on the fourth limb tarsus and can only be observed using a microscope (Dupérré, 2023)

Thomisidae Members of this family have a brown to bright yellow color with 8 eyes arranged in 2 rows, 6 eyes in the anterior part, and 2 eyes in the posterior part. According to (Xu et al., 2022), this spider is also known as the crab spider because of its shape similar to that of a crab and walks in a sideways or backward direction. Family *Thomisidae* are hunter-type spiders that do not make nests. Many members of this family are waiting for their prey on flowers and are able to prey on insects larger than their body size. In addition, the body of this spider can also undergo color changes depending on the color of the flower or the place where it lives.

Figure 1. Results of Observing a Spider in the Laboratory

The seven identified spider families can be grouped into two large groups: web spiders and hunting spiders. The spider that makes the nest, only focuses on waiting for its prey on the web that it has made, while the spider hunter, actively searches for prey around its habitat. Members of the Araneidae are the only family classified as nesters, while the other families are classified as hunting spiders (Dupérré, 2023). The high population of hunting spiders found according to (Fauzi et al., 2022)) is due to their high mobility habits that are able to move from one place to another on the ground or in the canopy of plants. The web-making spider is only found on the crown of plants with low mobility.

Population, Diversity Index, Abundance, and Dominance of Spider Predators

The diversity index (H') can be interpreted as a systematic depiction that depicts the structure of

the community and can facilitate the process of analyzing information about the types and numbers of organisms (Nadeem et al., 2023) Abundance is the number of individuals who are in a certain area in a community (Bhede et al., 2023). The dominance index is a parameter that describes the level of individual mastery in a community. The high or low dominance index can determine the level of dominance or dominance of an individual that is not only centered on one individual, but can also be more than one individual. From the data on the diversity, abundance, and dominance index values that have been obtained, the ANOVA test and the BNJ 5% level follow-up test are carried out.

Table 2. Population, Diversity Index, Abundance Index, and Spider Dominance Index.

Poulation	H'	K%	D
12 A	0.375 A	12,245 A	0.006 A
11 A	0.365 A	11,224 A	0.004 A
12 A	0.384 A	12,245 A	0.006 A
32 A	0.580 A	32,653 A	0.065 A
10 A	0.298 A	10,204 A	0.007 A
21 A	0.535 A	21,429 A	0.020 A

Table 2 shows that population, diversity index value, abundance index, and spider dominance index have an insignificant influence on botanical pesticides treatment and chemical pesticide treatment (comparator). This means that the treatment given has no effect on the existence of predatory spiders living in the habitat. The development of spider populations in general follows the development of pest populations. As (Susanti et al. 2022) said, in its development, predator populations in monoculture or polyculture plantations (intercropping) are generally consistent with pest development, if the population. If pests increase, the predator population will also increase, on the other hand, if the pest population decreases, then the predator population will also decrease.

Treatment of several concentrations of plant-based pesticides on plants showed no significant difference. This is because plant-based pesticides are selective and only affect target pests. As stated by Sitompul et al. (2014) that the use of plant-based pesticides only controls target pests and has no effect on natural enemies, especially predators and parasitoids, so that their existence is maintained and certainly does not disturb the stability of the ecosystem. In addition, the active ingredients that make up tobacco stem botanical pesticides such as nicotine only have an effect on insect pests. As stated by (Sarjan et al., 2024) that the nicotine content in tobacco which is a neurotoxin has a fast reaction and can be a contact poison in target insects. The research of (Purwoko, 2024) also stated that spiders that prey on pests that have been exposed to botanical pesticides from tobacco waste extracts do not die.

As for the spider population in the treatment of comparing the chemical pesticide with the active ingredient Amabectin, it turned out that there was no real difference from other treatments. The causative factor is the content that makes up the active ingredient which is not for spiders (Araneae), but for insects and ticks. This is also in line with the opinion of (Purwoko, 2024) who stated that abamectin is an effective pesticide to control insects and mites (acarina) in plants by acting as a nerve agent and is contactive. Another factor that causes the spider population in the comparison treatment of chemical pesticides with the active ingredient Amabectin is not significantly different, namely the physical condition of potato plants. The Dayang Sumbi potato variety is one of the superior varieties of potatoes with low stems and a canopy that is not too wide. The harvest age also includes genjah, which ranges from 90-100 hst. This short life cycle is what makes the leaf condition fast drying out, plus the attack of plant pest organisms that accelerate the scent on the leaves.

Treatment with the synthetic chemical pesticide Abamectin, is able to maintain the stability of the plant canopy for longer than other treatments. With a denser canopy, of course spiders tend to choose this habitat to live in. (Cuff et al., 2022) said that the increase in the area of the plant canopy will also be followed by an increase in the number of spiders. Certain species tend to be more common in plants with complex structures and large spaces, in order to lay trap net construction. The value of the diversity index is less than 1 ($H < 1$) when matched with the Shannon-Wienner diversity index is classified as a low category. The value of the diversity index is very closely related to the population and diversity of spiders living in a

habitat. If the spider population is high and there are many types, then the diversity index will also be high. On the other hand, if the population is low and consists of few types of spiders, then the diversity index will also be small. According to (Cuff et al., 2022), the high and low value of the diversity index is determined by the spider environment. Web-making spiders and hunting spiders are generally found more in plants that have a wide canopy and are quite moist. In addition, the availability of prey is also a major factor in the existence of spiders. Some types of spiders can also be found nesting in chunks of soil.

The high or low abundance index indicates the percentage of abundance of a family in the ecosystem. A high abundance index indicates a high total population, on the other hand, a low abundance index indicates a low total population. (Cuff et al., 2022) said that environmental factors such as the intensity of light, wind, humidity, and temperature in an ecosystem greatly affect the presence of spiders. In addition to environmental factors, biological factors also affect the existence of spiders, for example the availability of food/prey, vegetation and plant canopy, competitors, and their natural enemies. The spider abundance index is also influenced by the treatment of chemical pesticides in potato plantations. Plants applied with chemical pesticides tend to have a lower abundance index when compared to plants treated with plant-based pesticides, although the value is not significant. According to (Sidauruk et al., 2022) The abundance of low arthropod populations in rice paddy ecosystems with the application of synthetic pesticides can affect the abundance of arthropod populations found on the soil surface. This effect is characterized by a decrease in the population of these arthropods as a result of the condition of the body that is susceptible to exposure to synthetic pesticides.

The dominance index values in table 2. in all spider families and all treatments are classified as low and indicate the absence of families that dominate the habitat. In addition, a small dominance index indicates that the spiders in potato plantations are evenly distributed in small numbers. Furthermore (Susilo et al., 2021) said that the value of the dominance index describes the pattern of gender dominance in the community. The highest dominance index value is 1, which indicates that the ecosystem is dominated by one type or concentrated on one type. Although insignificant, hunter-type spiders are more dominating than web-making spiders, specifically members of the Linyphiidae family. In addition to suitable habitat conditions, the presence of prey also affects the dominance of these spiders.

CONCLUSIONS

Based on the results and discussion, it can be concluded that the application of some concentrations of botanical pesticides from virginia tobacco stem waste does not have a significant effect on spider diversity in potato plants. The highest population was found in the third treatment (P3) which was 32 heads and the lowest population was found in the fourth treatment (P4) which was 10 heads. Meanwhile, the diversity index value ranges from 0.298 and 0.580, the dominance index value between 0.004 and 0.065, and the abundance index value between 10.204 and 32.653.

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AUTHOR CONTRIBUTIONS

All authors collaborated in conducting each stage of the research and manuscript writing.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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