BIOLOGY, MEDICINE, & NATURAL PRODUCT CHEMISTRY ISSN 2089-6514 (paper)
Volume 14, Number 1, April 2025 | Pages: 267-273 | DOI: 10.14421/biomedich.2025.141.267-273 ISSN 2540-9328 (online)

Effectiveness of Botanical Pesticide from Keji Beling Leaves (*Strobilanthes crispus*) on Spinach Plants (*Amaranthus tricolor* L.) Against Pest Intensity

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Manuscript received: 24 February, 2025. Revision accepted: 20 May, 2025. Published: 24 June, 2025.

Abstract

Crop failure in cultivated plants can be influenced by several factors, including pest attacks. Pest control in plants is often carried out using pesticides made from chemical compounds, which can have negative effects on health and the environment. One alternative to chemical pesticides is the use of botanical pesticides. This study aims to determine the effect of botanical pesticides made from keji beling leaves (*Strobilanthes crispus*) on the intensity of pest attacks on spinach plants (*Amaranthus tricolor* L.). The research was conducted using an experimental method from June to August 2024 in Kelapa Tujuh Village, South Kotabumi District, North Lampung Regency, Lampung Province, and at the Zoology Laboratory, Faculty of Science and Technology, Raden Intan State Islamic University, Lampung. The study used a Completely Randomized Design (CRD) with four treatments: applying botanical pesticides at concentrations of 25%, 50%, 75%, and 0% (control). Each treatment was repeated 16 times, resulting in 64 plant samples. The parameters studied included pest attack intensity, plant height, and root length. Data were analyzed using analysis of variance (ANOVA) and further tested with the Least Significant Difference (LSD) test at a 5% significance level to determine significant differences. Phytochemical screening tests revealed that keji beling leaf-based botanical pesticides contain alkaloids, saponins, and tannins. The results showed that applying botanical pesticides from keji beling leaves influenced all the parameters studied. The treatment with a 75% concentration was the most effective, resulting in the lowest leaf damage at only 10%, a plant height of 22.40 cm, and a root length of 13.47 cm. Based on these findings, keji beling leaf-based botanical pesticides have the potential to serve as an environmentally friendly alternative for pest control in spinach cultivation.

Keywords: Botanical Pesticide; Keji Beling Leaves; Pest Attack Intensity; Spinach Plant.

INTRODUCTION

Spinach is a type of plant in the shrub or bush category. It is widely favored by the Indonesian people, both children and adults (Ihsan et al, 2022). Spinach has a soft texture and a delicious taste. It is also known to aid digestion and provide a cooling sensation to the stomach. In addition to its pleasant taste, spinach contains vitamins A, B, and C, protein, fat, carbohydrates, potassium, amaranthin, and various minerals such as phosphorus, potassium, and iron, which are essential for growth and maintaining health (Sari and Fasta, 2021). Given its numerous benefits, both as a highly nutritious food and as a remedy for certain diseases, it is important to enhance the growth and production of spinach plants (Hidayanti and Kartika, 2019).

According to data published by the Central Statistics Agency (BPS), spinach production in Indonesia reached 171.210 tons in 2022, declining compared to 171.706 tons in 2021. Efforts to increase spinach production often face various challenges. One of the factors contributing to the decline in spinach production in tropical regions is the high presence of Plant Pests and Diseases (OPT) that attack spinach plants (Yusidah and Nurirhani, 2022). Pest control is necessary to reduce damage caused by pest infestations. One way to manage pest attacks is through the use of pesticides. However, excessive use of chemical or synthetic pesticides can negatively affect human health and the environment. The environmental impacts of synthetic pesticides include disrupting natural ecological balance and leading to pest resistance. Pesticide residues in the soil can poison other organisms and may even cause poisoning in animals and humans if they enter the food chain (Rahayu and Widowati, 2020).

One alternative to eradicating pests in plants, besides using synthetic pesticides, is botanical pesticides. Botanical pesticides are pesticides with single or compound active ingredients that function as anti-fertility agents (sterilizers), repellents, or killers of Plant Pests and Diseases, derived from plants and relatively easy to

produce. Botanical pesticides decompose easily in nature because they are made from natural ingredients, making them safe for humans and livestock and environmentally friendly (Siamtuti et al, 2020).

Keji beling leaves (*Strobilanthes crispus*) have long been used by the Indonesian people as traditional medicine. Previous studies have shown that keji beling leaves contain various chemical compounds, including alkaloids, saponins, flavonoids, polyphenols, potassium, sodium, and calcium (Larasati and Putri, 2021). Flavonoids are toxic to insects, have a strong odor, a bitter taste, are highly soluble in water, decompose at high temperatures, and act as feeding inhibitors for insects (Sanjaya et al, 2021). Alkaloids are toxic compounds that effectively eliminate pests by poisoning their bodies (Ainiyah et al, 2023). Saponins and polyphenols function as contact poisons, stomach poisons, and neurotoxins for insects. These compounds—alkaloids, saponins, flavonoids, and polyphenols—are utilized as botanical pesticides (Sanjaya et al, 2021). This study aims to determine the effect of botanical pesticides made from keji beling leaves (Strobilanthes crispus) on the intensity of pest attacks on spinach plants (*Amaranthus tricolor* L.).

MATERIALS AND METHODS

Study area

This study was conducted from June to August 2024 in Kelapa Tujuh Village, South Kotabumi District, North Lampung Regency, Lampung Province, and at the Zoology Laboratory, Faculty of Tarbiyah and Teaching, Raden Intan State Islamic University of Lampung.

Procedures

Approach and Type of Research

The type of research used is descriptive quantitative research with an experimental method. The experiment in this study involved direct testing conducted by researchers on spinach plants sprayed with botanical pesticides made from keji beling leaves. The total number of samples consisted of spinach plants subjected to three treatments and one control, applying keji beling leaf botanical pesticide spray at concentrations of 25%, 50%, and 75%. Each treatment was repeated 16 times, resulting in a total of 64 plant samples.

Observation Parameters

The observed parameters include pest attack intensity, plant height, and root length. The pest attack intensity is calculated using the following formula:

$$IS = \frac{X}{Y} \times 100\%$$

Description:

IS : Pest attack intensity (%)

X : Total damaged leaf area (cm^2)

Y : Total leaf area observed (cm^2)

Tools and Materials

The tools used in this study include a blender, strainer, basin, jar, plastic bottle, spray bottle, polybag, stationery, smartphone camera, measuring glass, digital scale, and microscope.

The materials used in this study include: 1 kg of keji beling leaves, 50 mg of detergent, 1 liter of water, spinach plant seeds, growing media and NPK fertilizer.

Data analysis

The data on pest attack intensity were analyzed using One-Way ANOVA with the SPSS 25 (Statistical Package for the Social Sciences) software. If a significant difference was found between treatments, further analysis was conducted using the Least Significant Difference (LSD) test at a 5% significance level to determine specific treatment differences.

RESULTS AND DISCUSSION

Results

Phytochemical screening results

In this study, a phytochemical test was also conducted. Phytochemical screening was performed on the herbal pesticide solution made from Keji Beling leaves to identify chemical compounds. Among the four types of phytochemical tests conducted, the herbal pesticide from keji beling leaves was positive for alkaloids, saponins, and tannins. These chemical compounds are known to function as natural pesticides. The results of the phytochemical screening of the herbal pesticide made from keji beling leaves can be seen in Table 1 below.

Table 1. Phytochemical screening results.

Compound	Method	Positive Result	Screening Result	Note
Flavonoids	Extract + Mg powder + concentrated HCl	Sample turns dark brown	No color change	–
Alkaloids	Extract + H2SO4 + Dragendorf	Formation of yellowish-brown or brown precipitate	Color changes to yellowish-brown	+
Saponins	Extract + chloroform + heated and shaken + LB	Sample turns yellow-orange or brown precipitate forms	Color changes to yellow-orange, brown precipitate observed	+
Tannins	Extract + FeCl3 solution	Color changes to dark blue, dark green, or dark brown	Color changes to dark brown	+++

In the phytochemical screening results, the most abundant chemical compound found in the keji beling leaf botanical pesticide was tannin. The test results showed a deep blue color change in the botanical pesticide solution after being mixed with the reagent. Tannins are compounds produced by plants that have various benefits. One of their functions is as an anti-nutrient that inhibits the enzyme α-amylase, causing the enzyme to bind with tannins, thereby hindering the starch breakdown process. The disruption of starch breakdown affects insect growth due to a lack of energy sources (Aprilia et al., 2024). In addition to inhibiting enzyme activity, tannins also have an anti-feeding effect, reducing insect appetite. The inhibition of energy production caused by tannins disrupts the hormonal system, leading to impaired insect growth and development (Taufika et al., 2023).

Alkaloids are chemical compounds that act as stomach poisons in insects because they contain more than one basic nitrogen atom, which inhibits insect feeding ability (Akmalina et al., 2023). Alkaloids are commonly found in plant parts such as bark, leaves, roots, tubers, seeds, and twigs (Khafid et al., 2023). One function of alkaloids in plants is to serve as protection against pest attacks (Saputra et al., 2023). Alkaloids act as toxins for pests because their bitter taste discourages insects from feeding (Sumantara et al., 2024). Besides acting as an anti-feeding agent for pests, the stomach toxicity of alkaloids disrupts the pest's metabolic processes (Ikhsan et al., 2021). In the phytochemical test, alkaloids were detected in the keji beling leaf botanical pesticide solution, as indicated by a color change to orange when the solution was mixed with the reagent.

Another chemical compound that inhibits the digestive system of insects is saponin. Saponins function as stomach poisons by circulating the compound into the bloodstream after digestion. This process damages blood vessels, leading to hemolysis of blood cells. In insect control, saponins are secondary metabolites that damage proteins and cell membranes, reduce cholinesterase enzyme activity, and disrupt food absorption, thereby affecting insect metabolism. Additionally, saponins interfere with ATP production, resulting in energy deficiency that can lead to insect death (Ahyanti and Yushananta, 2023). The phytochemical test for saponins was confirmed by stable foam when the botanical pesticide solution was mixed with the reagent.

Research Parameter

Pest Attack Intensity

Table 2. Average Pest Attack Intensity

	Day				Score
	7	14	21	28	
A	3%	6%	10%	39%	2
B	3%	7%	10%	32%	2
C	6%	7%	11%	13%	1
D	3%	6%	6%	10%	1

Description:
1 = Damage <25% (Mild pest attack)
2 = Damage 25-50% (Moderate pest attack)

The research results indicate that, based on the pest attack intensity parameter up to day 28, the highest intensity was observed in treatment A, with a pest attack intensity of 39%, followed by treatment B at 32%. These results were converted into a damage score 2, indicating a moderate pest attack, where leaf damage ranged from 25% to 50%. In treatment C, spinach leaf damage was recorded at 13%, while treatment D had the lowest pest attack intensity at 10%. This corresponds to score 1, representing a mild pest attack, where leaf damage was below 25%. The average pest attack intensity values are illustrated in Figure 1.

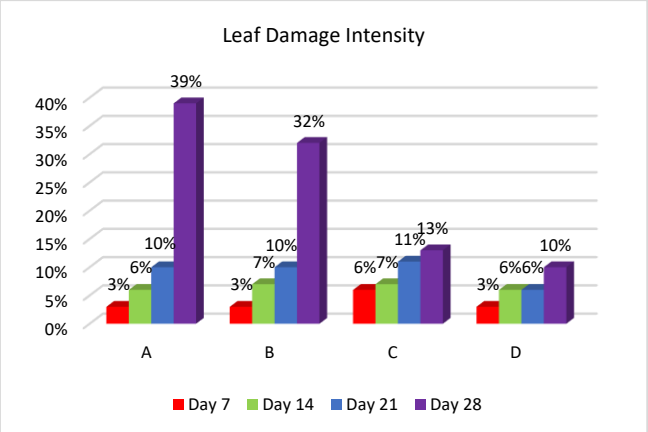

Figure 1. Leaf Damage Intensity.

Table 2. shows that the highest leaf damage in spinach plants due to pest insect attacks was observed in Treatment A with a 0% concentration, reaching 39%. Meanwhile, the lowest damage was recorded in Treatment D with a 75% concentration, with an attack rate of 10%. Research on botanical pesticides derived from *Chromolaena odorata* L. and *Annona muricata* L. extracts has demonstrated a significant mortality rate in diamondback moth larvae (*Plutella xylostella*) reaching 51.72%. (Latifa & Haryadi, 2024). Other studies have also revealed that botanical pesticides from babandotan leaves are effective in controlling brown planthoppers (*Nilaparvata lugens*) (Ajijah et al, 2024), and anthracnose disease in cayenne pepper plants (Suparto et al., 2023).

The higher the concentration of a vegetable pesticide, the higher the toxic content, so that the mortality rate increases (Yudiawati, 2019), in another study revealed that the percentage of mortality of P. xylostella larvae increased along with an increase in the percentage of extract combinations (Latifa & Haryadi, 2024). The higher the amount of active content contained in the vegetable pesticide used, the higher the toxic substances obtained to kill pests (Ajijah et al, 2024). Keji beling leaves are known to positively contain alkaloid compounds, saponins and tannins (Junardin, et al 2024). Table 1. The results of phytochemical screening showed active compounds contained in keji beling leaves, namely alkaloid compounds, saponins and tannins, these compounds are thought to affect the level of intensity of pest attacks. Treatment D with the highest concentration level of 75% showed the lowest level of leaf damage at 10%. The observation results showed a difference in pest attack intensity between treatments. The intensity of pest attacks in this study is in the score 1 value of 25% which is included in mild pest attacks, and score 2 of 25-50% which is included in moderate pest attacks.

Plant Height

Table 3. Average Plant Height.

Parameter	Treatment			
	A	B	C	D
Plant Height (cm)	18,72	19,56	20,66	22,40

For the plant height parameter, the best result was observed in treatment D, with a height of 22,40 cm, followed by Treatment C at 20,66 cm, treatment B at 19.56 cm, and the lowest result in treatment A, with a plant height of 18,72 cm. The average plant height graph can be seen in Figure 2.

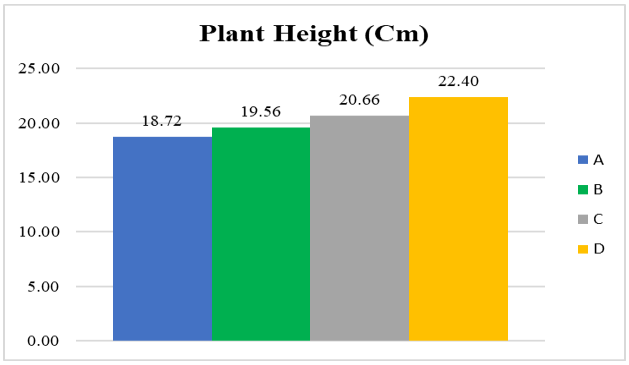

Figure 2. Spinach Plant Height.

Results of the Duncan test can be seen in Table 3.

Table 4. LSD Test for Plant Height

Treatment	Plant Height
A	18,72[a]
B	19,56[a]
C	20,66[b]
D	22,40[c]

pesticides can support plant growth by preventing disturbances from pests and diseases, allowing plants to reach optimal height without experiencing stress or developmental obstacles (Janjić & Mitrić, 2020). Application of botanical pesticides from soursop leaves, neem leaves, and turmeric has been found to affect plant height, with P2 (treatment using neem leaves) being the most effective (Nugroho & Barokah, 2023). Neem leaf extract contains flavonoid compounds that are effective in controlling pests and influence melon growth, particularly by promoting upward growth (Akhiriana et al., 2023). Compounds such as alkaloids found in botanical pesticides from keji beling leaves are suspected to influence the height of spinach plants. Alkaloids from *Jatropha curcas* increase the height and leaf area of okra by reducing nematode activity, allowing plants to utilize nutrients more efficiently (Vincent et al., 2023). Another study found that alkaloids extracted from local lupins significantly enhanced the vegetative growth of sweet peppers, with increased plant height and biomass observed at higher concentrations (Al-Najjar & Khairy, 2022). Additionally, variety is another factor affecting spinach growth besides nutrients. *Amaranthus tricolor* L. is one of the spinach varieties with a higher chlorophyll content than other varieties, allowing it to grow and develop more quickly (Oktavia et al., 2022).

Root Length

Table 5. Root Length of Plants.

Parameter	Treatment			
	A	B	C	D
Root Length (cm)	9.54	9.92	11.04	13.47

The root length parameter showed the best result in treatment D, with a root length of 13,47 cm, followed by treatment C at 11,04 cm, Treatment B at 9.92 cm, and the lowest result in treatment A, with a root length of 9,54 cm. The graph of root length growth results can be seen in Figure 3.

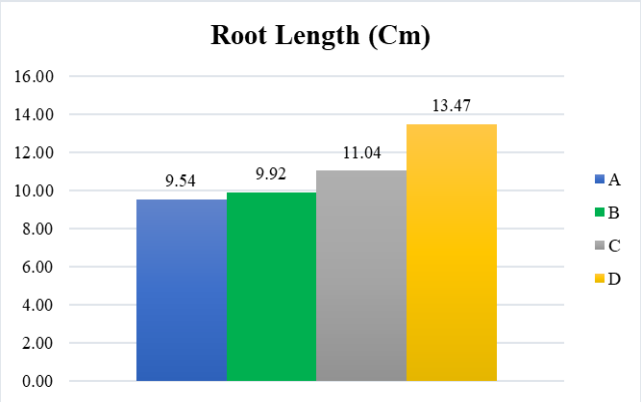

Figure 3. Spinach Root Length.

Results of the Duncan test can be seen in Table 5.

Table 6. LSD Test for Root Length.

Treatment	Plant Height
A	9,54[a]
B	9,92[a]
C	11,04[b]
D	13,47[c]

The best root length parameter was obtained in treatment D, measuring 13.47 cm. A previous study on the root length of tomato plants treated with plant extracts, including *P. betle* L., *C. papaya*, *Nicotiana tabacum* L., *A. sativum*, *C. frutescens* L., *R. communis*, *D. stramonium* L., and *M. citrifolia*, at a concentration of 250 cc/polybag and a control group, showed that the roots of the control plants were shorter than those of the treated plants (Diantari et al., 2015). Another study found that botanical pesticides based on papaya leaf extract increased the root length of spinach to 23.57 cm compared to the control (Bay and Barokah, 2024). Soursop and neem leaf extracts effectively reduced root-knot nematode (*Meloidogyne* spp.) infestations in tomato plants, positively impacting root growth. The difference in root length between treated and control plants was attributed to certain nematicidal compounds in the extracts, which reduced nematode attacks and led to better root development in treated plants compared to the control. These three plant extracts (*Tagetes* spp., *J. curcas* L., *C. papaya* L.) are known to contain alkaloids, flavonoids, saponins, and tannins, which have nematicidal properties or can be lethal to nematodes (Eaggeliony et al., 2023). Tannins can modulate nitrogen release and increase root biomass (at lower concentrations), potentially promoting early growth in some species (Miele et al., 2019). Phytochemical screening of keji beling leaves revealed the presence of alkaloids, saponins, and tannins, which are suspected to influence not only plant height but also root length. The nutrient absorption process in plants is influenced by broader root development, which plays a crucial role in organ formation. Root effectiveness is determined by its length, as an increase in root surface area enhances nutrient uptake and overall plant productivity (Telaumbanua et al., 2023).

CONCLUSIONS

Based on the results of the research that has been carried out, it can be concluded that:

- The use of vegetable pesticides keji beling leaves (*Strobilanthes crispus*) on spinach plants (*Amaranthus tricolor* L.) has an influence on the intensity of pest attacks, plant height and root length.
- The most effective dose of vegetable pesticides from keji beling leaves in overcoming pest attacks is at concentration D (75%). At this concentration, the lowest level of leaf damage compared to other treatments, with a final result of 10%. In addition, the 75% concentration also gave the best results in plant height of 22.40 cm and root length of 13.47 cm.

Recommendation

After researching the application of vegetable pesticides keji beling leaves (*strobilanthes crispus*) on spinach plants (*amaranthus tricolor* l.) on the intensity of pest attacks, the researchers can provide the following recommendation:

- Further research can be done using other types of horticultural crops, such as eggplant, tomato, chili and others.
- Phytochemical tests can be continued to determine the content of active compounds contained in keji beling plants, in addition to flavonoids, alkaloids, saponins and tannins.

Competing Interests: The authors declare that there are no competing interests.

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