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Conference Paper

Utilization of Babadotan (*Ageratum conyzoides* L) as a Botanical Pesticide for Fall Armyworm (*Spodoptera frugiperda* Fab.) (Lepidoptera: Noctuidae) Pest Control

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ABSTRACT

The babadotan plant is a weed plant that can be used as a vegetable insecticide because the chemical compounds contained in bandotan are saponins, flavanoids, polyphenols, coumarine, 5 percent eugenol, HCN and essential oils. The priority for agricultural development is food security, where food is followed by an increase in the amount of production to support the increasing population rate. National food availability can be influenced by several factors such as the presence of pests and the effectiveness of control. The presence of pests in crop cultivation areas can cause significant loss of agricultural production. *S. frugiperda* damages corn plants with a heavy attack rate, the larval population is between 2-10 per plant. This study aims to determine the use of babadotan as a vegetable pesticide to control *S. frugiperda* pests. This research was carried out in December 2021-January 2022 at the Plant Health Laboratory of the Faculty of Agriculture UPN "Veteran" East Java. This study used a non-factorial Completely Randomized Design (CRD), namely, *S. frugiperda* larvae and Babadotan Vegetable Pesticides with 3 doses of 200gr/l (P1), 300gr/l (P2), 400gr/l (P3) and Control (P0). The results showed that the application of the babadotan plant extract was effective in controlling the *S. frugiperda* caterpillar by giving a total mortality value of 100% in the P3 treatment (400 g/l concentration). Symptoms of larval poisons are marked by changes in color, namely at first the caterpillar is green to brown to black and there is mucus around the anus before it dies.

Keywords: Babadotan, botanical pesticides, fall armyworm, Spodoptera frugiperda

Introduction

The paramount objective in agricultural development is food security, wherein food security is closely associated with the need for increased production to support the ever-growing global population (Ulian et al., 2020). The presence of pests in cultivated areas can lead to substantial agricultural production losses, directly jeopardizing crop stability and yield (Windriyanti et al., 2023). *Spodoptera frugiperda*, commonly known as the Fall Armyworm (FAW), inflicts severe damage to maize crops, with larval populations ranging from 2 to 10 per plant. FAW larvae exhibit a voracious appetite, devouring nearly all parts of the maize plant, including roots, leaves, male and female flowers, and cobs (Degaga & Degaga, 2023). Their leaf-feeding behavior, especially in the late instar stages, can result in severe damage, often leaving behind only leaf veins and maize stalks. An average larval population density of 0.2 to 0.8 larvae per plant can lead to yield reductions of 5 to 20 percent (Overton et al., 2021).

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In Indonesia, the predominant method for controlling *S. frugiperda* still relies heavily on the use of chemical insecticides, with 95.29 percent of farmers resorting to chemical pesticides to manage pest organisms (Asfiya et al., 2022). However, the detrimental repercussions of chemical insecticide application are incongruous with the principles of integrated pest management (IPM) (Windriyanti et al., 2023). A reduction in chemical insecticide use, in line with IPM principles, can be achieved through the adoption of environmentally friendly alternative pest control methods, such as the utilization of bioactive substances (Agadhia et al., 2022; Sagala & Kusuma, 2023).

Babadotan, a weed species, holds promise as a botanical insecticide due to its chemical composition, which includes saponins, flavonoids, polyphenols, coumarins, 5 percent eugenol, hydrogen cyanide (HCN), and essential oils (Ramasamy et al., 2021). The plant part primarily employed for botanical pesticide purposes is its leaves. Babadotan exhibits repellent properties and hinders insect development (Septiani et al., 2022).

This research aims to investigate the potential utilization of babadotan as a botanical pesticide for the control of *S. frugiperda* and assess its effectiveness in mitigating the impact of this devastating pest on maize crops, thereby contributing to sustainable pest management practices. The utilization of babadotan as an eco-friendly pest control alternative offers an opportunity to address the ongoing challenges posed by the Fall Armyworm and align pest management practices with sustainable agricultural development goals. This research endeavors to shed light on the efficacy of babadotan as a botanical pesticide and further the understanding of its potential contribution to integrated pest management strategies.

Material and Methods

This research was conducted from December 2021 to January 2022 at the Plant Health Laboratory, Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" East Java, Indonesia. A completely randomized design (CRD) non-factorial approach was adopted for this study, with different dosages of Babadotan extract as treatments, namely: control, 200 gr/l, 300 gr/l, and 400 gr/l. Each treatment was replicated six times, resulting in a total of 24 treatment combinations.

The preparation of Babadotan extract involved harvesting the plant's leaves for each treatment, with P0 as the control, P1 at 200 gr, P2 at 300 gr, and P3 at 400 gr. The leaves were cleaned with running water, cut into small pieces, and air-dried for approximately 7 to 10 days (Achmad et al., 2020). Subsequently, they were blended and mixed with a small amount of sterile distilled water until a smooth consistency was achieved. In each treatment, 1 liter of water was added and thoroughly mixed until fully dissolved. The mixture was left to settle overnight, filtered through Whatman filter paper, and then transferred to a hand sprayer for application. Mustard greens were placed inside rearing boxes, each pre-weighed at 5 grams, for larval feeding.

Larvae were obtained from the Fiber and Sweetener Crops Research Institute (BALITTAS) in Karang Ploso, Malang, East Java. These larvae were then transferred to perforated plastic containers. Before this, the plastic containers were painted black and fitted with black gauze at the center of the box to facilitate the fall armyworm's respiration. Each container was appropriately labeled to match the experimental plots (Gopalakrishnan & Kalia, 2022).

The application of Babadotan extract commenced when *S. frugiperda* larvae reached the second instar stage. In each treatment, 10 *S. frugiperda* larvae were used, with varying dosages of the extract: control, 200 gr/l, 300 gr/l, and 400 gr/l. The application involved spraying the Babadotan extract onto the feed of *S. frugiperda* (stomach poison). The larvae were provided with mustard green leaves that had been sprayed with the respective doses of the Babadotan extract.

Results and Discussion

Based on the results presented in Table 1, it is evident that the parameter of feeding activity reduction had a statistically significant effect on day 4 and day 6. On day 4, treatment P3 exhibited a percentage reduction in feeding activity of 3.83%, demonstrating a statistically significant impact across all treatments. Additionally, treatment P2 showed a statistically significant effect across all treatments, with a feeding activity reduction of 3.5%. However, treatment P1 did not yield a statistically significant difference compared to treatment P0, with a reduction percentage of 2.5%. The highest reduction in feeding activity was observed in *S. frugiperda* larvae subjected to treatment P3, with values of 3.5%, 4%, 4%, 3.83%, 4%, 4.17%, 4%, and 4.3%. This substantiates the potential of Babadotan extract as a botanical insecticide. According to Oguh et al. (2019), biopesticides often act rapidly in inducing insects to cease feeding, a process that may only take a matter of days. Furthermore, biopesticides frequently lead to the immediate paralysis of pests.

Table 1. Reduction in feeding activity of *S. frugiperda*

Treatment	Feeding Activity Reduction (%) (Day -)							
	1	2	3	4	5	6	7	8
P0	3,83	3,33	2,67	2,17a	2,5	3a	3,33	4
P1	3,83	4	3,17	2,50a	2,33	2,83a	3,33	4
P2	3,83	3,83	3,67	3,5b	3,17	3,33a	3,33	4
P3	3,5	4	4	3,83c	4	4,17b	4	4,3
HSD	tn	tn	tn	1,07	tn	0,86	tn	tn

Note: Numbers accompanied by the same letter in the same column indicate no significant difference using a 5% level Tukey's Honestly Significant Difference (HSD) test; ns = not significant

According to Lumowa (2011), flavonoids can be utilized as active ingredients in the production of botanical insecticides. The active components in such botanical insecticides can disrupt feeding activity by reducing the insects' appetite and blocking their ability to feed, causing pests to reject food (Hoesain et al., 2023). Gaol et al. (2019) stated that alkaloids, bitter and toxic compounds, can induce symptoms like dizziness, loss of appetite, and ultimately, death in insects. Furthermore, Giselle et al. (2023) asserted that the active constituents of Babadotan plants include saponins, flavonoids, and polyphenols, which serve as deterrents, preventing pests from approaching plants and inhibiting larval growth. Saponins, belonging to the glycoside compound class, have a characteristic foaming property when agitated. Saponins can damage the nervous system of pests, resulting in decreased feeding behavior and, ultimately, the death of the pests (Ye et al., 2023).

Figure 1. Larvae A) Before Babadotan application, B) After Babadotan application

The most conspicuous difference between healthy and diseased larvae is the level of color brightness, with healthy larvae exhibiting a brighter coloration. In contrast, diseased larvae tend to be darker in color. As they progress from the second instar to older stages, sick larvae assume a dark green to blackish hue, resulting in color changes within the insect attributed to Safirah

(2016). In afflicted larvae, a fluid or mucus often exits through the larval anus. This mucus is frequently observed shortly before larval mortality and at the time of mortality. The mucus exhibits a dark green to blackish coloration, and when larvae have discharged this mucus, they typically appear limp, yet still exhibit slight responsiveness when touched (Mumpuni & Sholichudin, 2022).

Symptoms of impending mortality include reduced feeding activity, a change in body color, a soft and shriveled texture, which is caused by phenolic compounds. Idrees et al. (2021) demonstrated that decreased feeding activity in *S. frugiperda* larvae leads to softening and increased fragility of the larval integument (segmentation). This is followed by a shift in color from pale green to dark green, and in some cases, to a deep black, accompanied by a reduction in body size and the emergence of a pungent odor.

Table 2. Daily mortality of *S. frugiperda* larvae with Babadotan extract application over 8 Days

Treatment	Mortality (%) (Day)							
	1	2	3	4	5	6	7	8
P0	1,67	6,67	3,33	5,00	3,33a	5a	3,33	1,67
P1	5,00	16,67	6,67	10,00	6,67a	15b	6,67	5,00
P2	5,00	8,33	8,33	6,67	8,33a	13,33a	13,33	1,67
P3	10,00	13,33	13,33	13,33	20b	18,33b	8,33	6,67
HSD	tn	tn	tn	tn	8,95	9,89	tn	tn

Note: Numbers accompanied by the same letter in the same column indicate no significant difference using a 5% level Tukey's Honestly Significant Difference (HSD) test; ns = not significant

In Table 2, the parameter of *S. frugiperda* mortality displayed highly significant differences on days 5 and 6. The treatment that yielded the highest values was treatment P3, with a mortality rate of 20% on day 5 and 18.33% on day 6, while the lowest values were observed in treatment P0, with a mortality rate of 3.33%, followed by P1 and P2, both at 5%. It can be concluded that the application of higher concentrations of Babadotan extract results in comprehensive mortality.

The most effective dosage was 20 ml per day, where this concentration of 400 g/liter led to complete larval mortality on day 5. Additionally, at a concentration of 300 g/liter, larval mortality occurred comprehensively on day 7. In the control treatment, where no pesticide was applied, larval mortality did not occur at all until day 8, and some larvae even managed to form cocoons by day 7. The remaining larvae presumably perished due to failed cocoon formation. On day 10, three cocoons successfully developed into young moths, while the others showed signs of damage and decay, as evidenced by their irregular, bent shape, the presence of black areas on the cocoons, a foul odor, and incomplete wrapping. Nofrianti and Salbiah, (2022) revealed that the most effective concentration of Babadotan extract was 400 grams per liter, resulting in complete Fall Armyworm mortality on days 5 and 6. This was followed by a concentration of 300 grams per liter, which achieved comprehensive mortality from day 6 to day 8.

On the first day of treatment with 400 g/liter concentration in each experimental box, there was an average larval mortality rate of 20%. Subsequently, on the first day of the botanical pesticide treatment at concentrations of 300 g/liter and 200 g/liter, an average mortality rate of 10% was observed. By the second day, the mortality percentage increased in each treatment. The 400 g concentration of botanical pesticide resulted in a mortality rate of up to 50%. However, other concentrations, particularly the 10 ml dosage, exhibited slower mortality rates, typically ranging from day 7 to day 9.

Table 3. Total mortality of *S. frugiperda* in each treatment concentration

Concentration	Mortality	(%)
200 g/l	40	66,67%
300 g/l	44	73,33%
400 g/l	60	100%

Based on the *S. frugiperda* mortality results presented in Table 3, it is evident that all concentrations of Babadotan plant extract treatments resulted in significant mortality rates. Overall, *S. frugiperda* exhibited a mortality rate of 66.67% at a concentration of 200 g/l, 73.33% at a concentration of 300 g/l, and 100% mortality at a concentration of 400 g/l. This leads to the conclusion that the application of a 400 g/l concentration (P3) is an effective concentration for the eradication of *S. frugiperda* larvae.

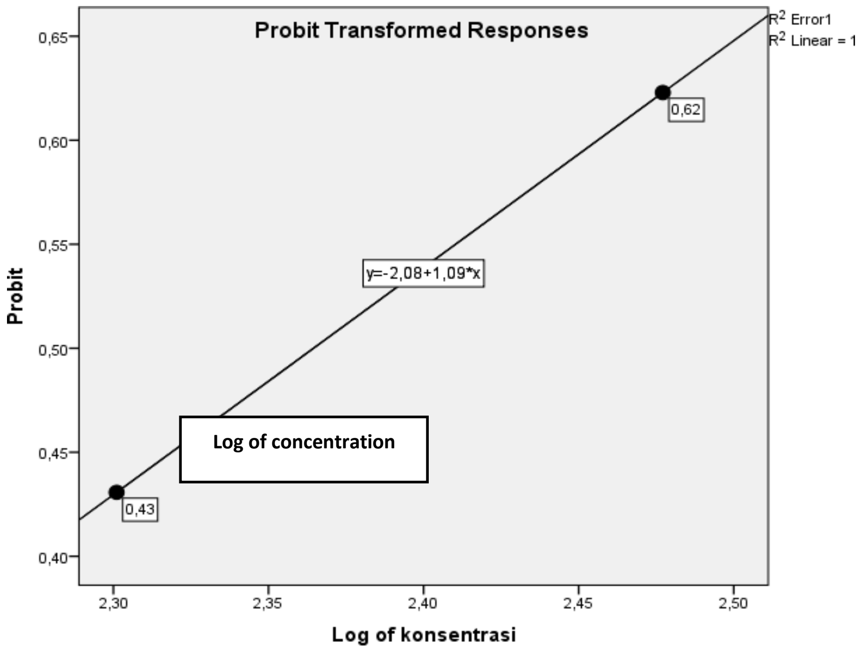

Figure 2. LC50 analysis of babandotan extract against *S. frugiperda* caterpillars

The graph curve in Figure 2 yielded a linear equation y = 1.09x - 2.08 with an R^2 value of 1. The image demonstrates the relationship between concentration and the probit values obtained from the percentage of *S. frugiperda* mortality. Linear regression analysis on the graph reveals that as the concentration increases, the percentage of *S. frugiperda* mortality also increases. Based on the linear regression equation, an R^2 value of 0.971 was obtained. R^2 is the coefficient of determination designed to measure the goodness of fit of the regression equation. R^2 values range from 0 to 1, and a higher R^2 value indicates a better model fit. Therefore, it can be concluded that the R^2 value is deemed good as it approaches 1. The results of the coefficient of determination, R square (R^2), demonstrate a relationship between the variables, where the independent variable is the concentration of Babadotan plant extract and the dependent variable is the mortality of *S. frugiperda*. According to Rumape et al. study (2023), the regression equation for the 24-hour observation was represented as y = 19.643x + 3.66607, with an LC50 value of 1.9916% and an R square (R^2) coefficient of determination of 0.9933. For the 48-hour observation, the equation was y = 21.429x + 10.337, with an LC50 value of 1.3443% and an R square (R^2) coefficient of determination of 0.9677.

Table 4. LT50 calculation result

Treatment	LT50 score
P1 (200 g/l)	Tidak Ada Respon
P2 (300 g/l)	10,22
P3 (400g/l)	5,22

The probit analysis results indicate an LT50 value of 10.22 hours for *S. frugiperda* at a concentration of 300 g/l and 5.22 hours for a concentration of 400 g/l, as well as 1.091. The LT50 analysis was conducted at concentrations of 200 g/l, 300 g/l, and 400 g/l because these three concentrations had values close to the LC50. Damalas and Koutroubas (2020) pointed out that botanical insecticides have certain limitations, including their low persistence and relatively low insecticidal properties. Consequently, to achieve maximum control effectiveness at high pest population levels, repeated applications are necessary. Zhu et al. (2020) reported that a decrease in the insecticidal activity of a compound can also be attributed to sunlight exposure. In this study, all wetland weed extracts were capable of inducing high mortality rates in *S. frugiperda* larvae, although not as high as the chemical insecticide treatment.

Conclusion

The application of Babadotan plant extract proved to be effective in controlling *S. frugiperda* larvae, resulting in a total mortality rate of 100% in treatment P3 (concentration of 400 g/l). Poisoning symptoms or signs of larval mortality were characterized by a color change, initially from green to brown and eventually dark brown to black, along with the presence of mucus around the anus both before and at the time of mortality. Treatments P1, P2, and P3 effectively controlled *S. frugiperda*, achieving mortality rates exceeding 50%. The LC50 value was determined to be 2.23%, and the LT50 value was 10.22 hours.

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