Assessment of Aegle marmelos Fruit Extracts as Organic Insecticide for Spodoptera exigua on Allium ascalonicum

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Abstract Allium ascalonicum L. is a commodity household Indonesian consume for daily cooking. However, the constraint on shallot production is attacked by Spodoptera exigua (Hübner, 1808)). So far, farmers have relied a lot on control methods using chemical pesticides, which negatively impact the environment. The fruit of Aegle marmelos L. contains a fatty substance called tannin, one of the compounds with a bitter taste that insects can dislike. This content is why A. marmelos is highly recommended as an organic pesticide. The study assessed the concentration of A. marmelos extracted which was effective in controlling S. exigua. The study was arranged to use a randomized block design, consisting of five treatments of A. marmelos fruit extract concentration, namely: 2 mL L⁻¹ of water (K1); 4 mL L⁻¹ of water (K2); 6 mL L⁻¹ of water (K3); 8 mL L⁻¹ of water (K4); 10 mL L⁻¹ of water (K5) and without A. marmelos treatment (K0). The results showed that a concentration of 4 mL L⁻¹ of water effectively suppresses the development of S. exigua and can increase A. ascalonicum production.

Keywords: Environmentally-friendly, onion, shallot, tannin, vegetable insecticide.

1 Introduction

Shallots (Allium ascalonicum L.) are a spice commodity Indonesian households use for daily cooking. Given the high consumption needs, the production of onions in Indonesia has increased yearly [1–3]. The Central Statistics Agency of the Republic of Indonesia (Badan Pusat Statistik) noted that shallot production in Indonesia reached 1.82 × 10⁶ t in 2020. That number increased by 14.88 % from the previous year’s, i.e., 1.58 × 10⁶ t. However, in April 2020, it decreased by 22.95 % to 1.28 × 10⁶ t [1, 4]. The decrease is not only caused by unfavorable growing environmental conditions (rainy season) but also by armyworm (Spodoptera exigua Hübner, 1808) attack [5, 6]. S. exigua is a polyphagous insect that has spread widely and attacks many host plants, including A. ascalonicum [2, 3, 5, 6]. S. exigua is the primary pest that commonly damages shallot plants [7]. This pest attack can cause a decrease in shallot production or significant yield loss if prevention and control efforts are not carried out [2, 3]. So far, farmers have relied heavily on control methods using chemical pesticides without considering environmental aspects.

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The fruit of the "maja" plant — bael fruit, bilva, stone apple, wood apple (common name in English), or *Aegle marmelos* L. contains a fatty substance called tannin with a bitter taste that insects dislike [8–12]. Tannins are secondary metabolites of various plants with multiple uses, such as plant protectors and for human health [13–15]. Considering this reason, *A. marmelos* fruit is highly recommended as a vegetable or organic pesticide [16, 17].

Several previous studies have reported the positive effect of *A. marmelos* fruit extract on *Leptocorisa acuta* (Thunberg, 1783) in paddy field [18, 19], *Spodoptera litura* (Fabricius, 1775) [20], *Aphis gossypii* (Glover, 1877) on *Capsicum annuum* L. var. *taro* [21], a pest of *Parmarion martensi* (Simroth, 1893) on *Brassica oleracea* L. var. *capitata* [22], *Brassicca juncea* (L.) Czern. [23], *Epilachna admirabilis* (Crotch, 1874) [24], main pest on *Solanum melongena* L. [25], *Conopomorpha cramerella* (Snellen, 1904) [26], and even in *Rigidoporus microporus* (Sw.) Overeem (1924) disease [27]. Therefore, this study was carried out to assess the concentration of *A. marmelos* fruit extracted, which was effective in controlling the *S. exigua* on *A. ascalonicum*.

## 2 Material and methods

### 2.1 Material

The research was carried out in the Agrotechnology laboratory, Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang, on December 2020 to February 2021. The study was arranged to use a randomized block design, consisting of five treatments of *A. marmelos* fruit extract concentration, namely: 2 mL L⁻¹ of water (K1); 4 mL L⁻¹ of water (K2); 6 mL L⁻¹ of water (K3); 8 mL L⁻¹ of water (K4); 10 mL L⁻¹ of water (K5) and without *A. marmelos* fruit treatment (K0). Each treatment was repeated three times.

### 2.2 Methods

The study used young and old *A. marmelos* fruit, with the consideration that it was somewhat difficult to distinguish them because the skin color was both greens. It's just that the unripe fruit has hard skin, and the old ones have soft skin. However, the extraction method is different. First, the young fruit is sliced into small pieces and then crushed using a Philips blender, while the old *A. marmelos* fruit is kneaded by hand. After both of them are crushed, they are mixed together and added with water in a ratio of 1:1, then soaked for 1 × 24 h to ferment.

After fermentation, it was filtered using a nylon filter with a density of 200 meshes to obtain an extract solution, while the dregs were discarded. The filtered filtrate is accommodated for treating organic pesticides according to the treatment [28–30].

*A. ascalonicum* var. *bima brebes* was planted with treatment plots measuring 2 m × 3 m, and spacing of 15 cm × 20 cm, so that each treatment plot contains 200 clumps of shallots. After 2 wk old plants were sprayed with *A. marmelos* fruit extract according to the treatment, namely: 2 mL L⁻¹ of water (K1); 4 mL L⁻¹ of water (K2); 6 mL L⁻¹ of water (K3); 8 mL L⁻¹ of water (K4); 10 mL L⁻¹ of water (K5) and without *A. marmelos* fruit treatment (K0). Spraying *A. marmelos* fruit extracted is carried out once a week starting at 2 wk after planting.

Determining the sample plants is done randomly based on the diagonal. *S. exigua* are not invested because shallots are planted out the rainy season and usually there is an immediate attack by shallot caterpillars.

The observed variables included: larval population per plot, wet weight of shallot bulbs per plot, dry weight of shallot bulbs per plot and intensity of *S. exigua* attacks. The wet weight of the shallot bulbs was calculated based on the weight of the bulbs at harvest, while the dry weight was determined based on the constant weight after drying. The drying process is carried out naturally in a place with stable air circulation and sunlight. The yield of wet weight of shallot bulbs and dry weight of shallot bulbs per plot was converted to hectares with an effective area of 90%.

Observation of caterpillar population by counting larvae after spraying vegetable pesticides, namely 3 wk after planting. Observation of the intensity of *S. exigua* attacks was carried out by counting the parts of the affected sample plants using the Moekasam et al. [6] in Equation (1), namely:

\[
I = \frac{n}{N} \times 100 \%
\]

Description:  
- **P** = intensity of army worm attacks  
- **n** = number of affected clumps  
- **N** = number of sample plant clumps
Observational data were analyzed using analysis of variance, and if there was a difference, Duncan's 5% further test was carried out [31, 32]

3 Results and discussion

3.1 Results

3.1.1 Larvae population per plot

The results of the analysis of variance showed a significant difference between the treatment concentration of maja fruit extract from the army worm population per plot. To find out the difference in treatment, the DMRT 5% test was carried out and the results are presented in Figure 1.

![Figure 1](image-url)

**Figure 1.** Average number of larva population per plot for each treatment of *A. marmelos* fruit extracted concentration.

Note: *A. marmelos* fruit extract concentration, K1: 2 mL L⁻¹ of water; K2: 4 mL L⁻¹ of water; K3: 6 mL L⁻¹ of water; K4: 8 mL L⁻¹ of water; K5: 10 mL L⁻¹ of water and K0: control.

dap: days after planting.

Figure 1 shows that the population of *S. exigua* larvae if not controlled can reach more than 60 larvae per plot. This was very significantly different (5% DMRT test) compared to that treated with *A. marmelos* fruit extracted. The treatment for a concentration of 8 mL L⁻¹ water (K4) was not significantly different from the treatment for a concentration of 10 mL L⁻¹ water (K5) at each age of observation. Likewise, the treatment for a concentration of 3 mL L⁻¹ water (K2) and treatment for a concentration of 6 mL L⁻¹ water (K3) did not show a significant difference at each age of observation. Thus, the treatment for a concentration of 8 mL L⁻¹ water (K4) was the best because it was able to suppress the increase in the population of *S. exigua* larvae until the *A. ascalonicum* plants were 49 d old.

3.1.2 Wet weight of shallot bulbs per hectare

The results of the analysis of variance showed a significant difference between the concentration of *A. marmelos* fruit extract and the wet weight and the dry weight of shallot bulbs ha⁻¹. To find out the difference in treatment, the 5% DMRT test was carried out. In Figure 2, it can be seen that the treatment without pesticide of *A. marmelos* fruit K0 showed the lowest wet weight of shallot bulbs (t ha⁻¹), and the highest wet weight of shallot bulbs (t ha⁻¹) was the pesticide treatment of *A. marmelos* fruit concentration 10 mL L⁻¹ water (K5). However, the results of the 5% DMRT analysis showed that the concentration of *A. marmelos* fruit extracted from a concentration of 10 mL L⁻¹ water (K5) was not significantly different from the treatment of 8 mL L⁻¹ water (K4) and 6 mL L⁻¹ water (K3). Thus the pesticide treatment of *A. marmelos* fruit with a concentration of 6 mL L⁻¹ water was good for controlling the *S. exigua*, because the results were not significantly different from the concentration of 8 mL L⁻¹ water and a concentration of 10 mL L⁻¹ water in Figure 2, it can be seen that the...
treatment without pesticide of *A. marmelos* fruit. K0 showed the lowest wet weight of shallot bulbs (t ha\(^{-1}\)), and the highest wet weight of shallot bulbs (t ha\(^{-1}\)) was the pesticide treatment of fruit *A. marmelos* concentration 10 mL L\(^{-1}\) water (K5). However, the results of the 5 % DMRT analysis showed that the concentration of *A. marmelos* fruit extracted from a concentration of 10 mL L\(^{-1}\) water (K5) was not significantly different from the treatment of 8 mL L\(^{-1}\) water (K4) and 6 mL L\(^{-1}\) water (K3). Thus the pesticide treatment of *A. marmelos* fruit with a concentration of 6 mL L\(^{-1}\) waters was good for controlling the *S. exigua*, because the results were not significantly different from the concentration of 8 mL L\(^{-1}\) water and a concentration of 10 mL L\(^{-1}\) water.

3.1.3 **Intensity of severe *S. exigua* attacks**

The results of the analysis of variance showed a significant difference between the concentration of *A. marmelos* fruit extract and the intensity of severe army worm attacks. To find out the difference in treatment, the DMRT 5 % test was carried out and the results are presented in Figure 3.

![Fig 2](image2.png)

**Fig 2.** Average wet and dry weight of shallot bulbs (t ha\(^{-1}\)) for each treatment of *A. marmelos* fruit extracted concentration.

Note: *A. marmelos* fruit extract concentration, K1: 2 mL L\(^{-1}\) of water; K2: 4 mL L\(^{-1}\) of water; K3: 6 mL L\(^{-1}\) of water; K4: 8 mL L\(^{-1}\) of water; K5: 10 mL L\(^{-1}\) of water and K0: control.

![Fig 3](image3.png)

**Fig 3.** Average of intensity severe attacks of *S. exigua* per plot against each treatment of *A. marmelos* fruit extracted concentration.

Note: *A. marmelos* fruit extract concentration, K1: 2 mL L\(^{-1}\) of water; K2: 4 mL L\(^{-1}\) of water; K3: 6 mL L\(^{-1}\) of water; K4: 8 mL L\(^{-1}\) of water; K5: 10 mL L\(^{-1}\) of water and K0: control.

dap: days after planting.

Figure 3 shows that the population of *S. exigua* larvae if not controlled can reach more than 60 larvae per plot. This was very significantly different (5 % DMRT test) compared to that treated with *A. marmelos* fruit.
extracted. The treatment for a concentration of 6 mL L⁻¹ water (K3) was not significantly different from the treatment for a concentration of 10 mL L⁻¹ water (K5) at each age of observation. Likewise, the treatment for a concentration of 3 mL L⁻¹ water (K2) and treatment for a concentration of 8 mL L⁻¹ water (K4) did not show a significant difference at each age of observation. Thus, treatment for a concentration of 6 mL L⁻¹ water (K3) was the best because it was able to suppress the intensity of S. exigua attack by less than 20 % until the onion plants were 49 d old.

3.2 Discussion

S. exigua is a shallot pest that is active at night and hides during the day. This pest lives in groups, attacking both young and old leaves, so that if not controlled, it can destroy the entire plant [2, 3]. The symptom is the emergence of transparent white spots on the leaves because the larvae drill the inside of the leaves and leave an epidermal layer, so the leaves appear transparent when exposed to sunlight [5]. The intensity of the severe attack causes the leaves to dry up and even attack the shallot bulbs [6].

The results showed that spraying treatment of A. marmelos fruit extract from various concentrations could reduce the larval population of S. exigua as shown in Figure 1, so as to reduce the intensity of the shallot caterpillar attacks as shown in Figure 3. Spraying treatment of A. marmelos fruit extracts from various concentrations can increase the yield of shallot bulbs in the form of wet weight of shallot bulbs per hectare, and dry weight of shallot bulbs per hectare (Figure 2). A. marmelos contains active chemical substances that are toxic and can repel insects even though their use is still limited [33–37]. This is reinforced by the opinion [38, 39] that A. marmelos fruit can be used as an insecticide because it can kill insects in the adult phase, larval phase and egg phase, where the fruit extract acts as repellents, antifeedants and phytotoxins. Even according to [40, 41, 34], A. marmelos fruit extract has potential as a pesticide because the results of the study showed that the activity of the fruit extract was able to kill larvae and pupae of Filarial vector Culex quinquefasciatus. A marmelos fruit contains vegetable essential oils with toxic bioactivity so that it is able to control Tribolium castaneum (Herbst, 1797) [30] and has the potential to be developed as an organic pesticide [42, 18–27].

The other results showed that there are secondary metabolites in plants that can be used as a mechanism for interaction between plants and animals, namely phytochemicals [43–45], so they can be used as biopesticides, for example papaya leaves. Papaya leaves contain the enzyme papain which when it enters the trachea of insects, then spreads and can interfere with the performance of the nervous system of these insect pests [46]. Secondary metabolites also play a role in the process of plant interaction with other plants. This metabolite is an allelochemistry that is toxic to other plants that grow beside it, namely Octadecanoic acid, methyl ester and 9,12-Octadecadienoic acid (Z, Z) -methyl ester found in plants Saccharum officinarum L. and Mimosa invisa Mart. as natural herbicides [47].

For further action, control with organic pesticides [48, 49, 46] should be linked to applying organic farming to A. ascolanicum cultivation. All organic waste —agricultural waste, livestock waste, kitchen waste, leftover food, and human excrement from pit latrines and septic tanks [50–55] can return to A. ascolanicum plantations to maintain and increase soil fertility. With anaerobic processing in individual or communal biogas digesters [56–58], a double benefit will be obtained, i.e., biogas —clean and renewable energy, and two types of organic fertilizers, i.e., solid and liquid fertilizers which are beneficial for agricultural crops [59–62]. Based on an environmentally friendly, this organic fertilizer should be combined with a biological fertilizer – Plant Growth Promoting Rhizobacteria (63–67).

4 Conclusions

It can be concluded, base on the results of this research, that a concentration of 4 cc L⁻¹ of water was effective against suppressing the development of Spodoptera exigua L. and can increase onion production.

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