Leaf and Flower Extracts of *Tithonia diversifolia* Against *Aphis gossypii* in Red Chili Plant

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ABSTRACT

Red chili is one of the main commodities in Indonesia. Aphid (*Aphis gossypii*) is one of the pests that cause damage to the red chili plant. *A. gossypii* attacks require control measures using plant-based pesticides from the leaves and sunflowers of Mexico. This study aimed to determine the toxicity of leaves and flower of *T. diversifolia* extracts against *A. gossypii*. This research consisted of five concentrations (0.1, 0.3, 0.5, 0.7 and 0.9%) and four replications. The LC₅₀ and LT₅₀ were calculated by using probit analysis of the Hsin Chi program. The results showed that the *Tithonia diversifolia* flower extract had higher toxicity than the leaf extract of 0.48%, which could cause the death of *A. gossypii* by 50%, while the leaf extract had a concentration of 0.55%. The flower extract caused the fastest 50% mortality (37.42 hours), while leaf extract was 65.63 hours. The leaf and flower extracts can also reduce the number of *A. gossypii* offspring.

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INTRODUCTION

Red chili is one of Indonesia's primary commodities widely consumed on a household or industrial scale (Sativa et al., 2017). Insect pests can reduce crop yields and red chili plants (Chintkuntla, 2015). The pests that cause damage to the chili plants is *Aphis gossypii* (Chintkuntla, 2015). *Aphis gossypii* can cause direct damage to plants by sucking up fluid and taking sap from phloem tissue and cause changes in plant shape and decrease in plant vigor, which can reduce yield. Indirect damage includes the spread of honeydew and the transmission of the virus to host plants (Takaloozadeh, 2010). Because of the *A. gossypii* attack, control efforts are needed to minimize the damage of *A. gossypii*.

The adverse effects of chemical pesticides in controlling pests trigger pesticides made from nat-

ural ingredients to control pests. Biopesticides that can be used are Mexican Sunflower (*Tithonia diversifolia* A. Gray) by utilizing the leaves and flowers. Chemical contents in these plants are alkaloids, saponins, tannins, terpenoid flavonoids, and phenols (Olayinka et al., 2015). This study aimed to investigate the toxicity of leaves and flower of *T. diversifolia* extracts against *A. gossypii*.

MATERIALS AND METHODS

Red Chili Plant Preparation

Red chili was planted in the seed tray until the plant was three weeks old. The planting media used were soil and compost (ratio of 1: 1). After three weeks old, the red chili was transplanted on an 18 x 25 cm polybag media (soil, husk charcoal,

study were red impala varieties. The plants were used in this study were 48 plants.

Insects Test Rearing

Aphis gossypii were obtained from infected red chili plants and were reared directly on the red chili plants used as treatment plants. Red chili plants were used as treatment aged 1.5 months. Each treatment was infested with 10 *A. gossypii*. Infested plants with *A. gossypii* adults were covered with a plastic lid, and the top part was covered with gauze. Adults of *A. gossypii* were allowed to breed in the treatment plants to produce saplings in the form of *A. gossypii* nymphs. The adults were then transferred to the red chili plant, which was not used as a treatment plant, while the *A. gossypii* nymph was maintained on the treatment plant until six days old. The number of *A. gossypii* nymphs for each treatment was 20 adults (4th instar).

Preparation of *T. diversifolia* Extraction Process

Leaves and flowers of *T. diversifolia* were washed and dried until slightly withered. *Tithonia diversifolia* leaves that had wilted were dried using an oven at 40°C for 2-3 days, while *T. diversifolia* flowers were dried for 1 day at the same temperature. Then, the dried leaves and flowers were ground using a grinder for 3 seconds and then macerated with a ratio of 1: 15, which was 10 grams of material with 150 ml of methanol. The sample was stirred using an orbital shaker for 24 hours. Then the filtrate was taken by filtering. The filtrate obtained was separated from the methanol solvent using a rotary vacuum evaporator at 65 ° C.

Application of *T. diversifolia* Leaf and Flower Extract

The application of *T. diversifolia* leaf and flower extract was carried out by spraying. The spray vol-

ume used 10 ml per plant. The volume was obtained from the calibration results. The leaves and flower extracts were then applied to the red chili plants used as treatment plants using a spray bottle. Extract treatment was sprayed using a sprayer and carried out in the morning when the stomata were open.

Research Implementation

The research was carried out consisted of 6 concentrations and four replications. The treatments consisted of controls (0%), 0.1%, 0.3%, 0.7%, 0.9% concentration. A concentration of 0.1% is obtained by taking 0.01 ml solution from the main liquor and put it into a 10 ml volumetric flask and 0.01 ml solution was then added with distilled water, the solution was shaken until homogeneous, and the distilled water was added again to the limit mark of 10 ml.

Data Analysis

The data were analyzed using Analysis of Variance (ANOVA). If the test results were significantly different, further tests were conducted with the Duncan test of 5%. The amount of toxicity (LC₅₀) and LT₅₀ was calculated using the Hsin Chi probit analysis program. The mortality of *A. gossypii* was observed at 3, 6, 12, 24, and 48 hours after application. The percentage of mortality was calculated using the formula (Damayanti et al., 2013).

$$M = \frac{\sum \text{aphids death} \times 100\%}{\sum \text{aphids were observed}}$$

If there is a death in the control, then the % of deaths can be calculated using the Abbott formula (% of deaths corrected), with the condition that the % of deaths is not more than 20%. The formula is (Abbott, 1925):

$$P = X - Y / Y \times 100\%$$

Where: P = Percentage of deaths corrected, X = Percentage of insects that live in control, and Y = Percentage of insects that live on treatment

The percentage reduction in the number of *A. gossypii* was calculated using the formula:

P = Number of offspring in control - number of offspring in treatment / Number of offspring in control

RESULTS AND DISCUSSIONS

Mortality of *A. gossypii*

The results showed that the highest mortality was found in the treatment concentration of 0.9% in both leaf and flower extract in 3 to 48 hours after application (Table 1). The percentage of mortality of *A. gossypii* due to the application of *T. diversifolia* leaf extract was 11.25, 22.5, 41.25, 67.5, and 100%, respectively, while in the flower extract was 8.75, 22.5, 40, 66.25, and 100%, respectively (Table 1). The application of Mexican sunflower leaf and flower extract at 48 hours after application showed the same percentage of *A. gossypii* mortality and showed no significant difference. It was presumably because both extracts contain almost the same active compound. According to (Olayinka et al., 2015), all parts of the *T. diversifolia* crop con-

tained alkaloids, tannins, flavonoids, saponins, terpenoids, and phenols. Increased mortality of *A. gossypii*, both due to *T. diversifolia* leaves and flower extract concentrations were thought to be caused by compounds in leaf and flower extracts that function as stomach poisons. The stomach poison causes the test insect not to die immediately but causes the test insect to die slowly (Alkan et al., 2017). Toxins entered are then absorbed by the digestive tract and eventually lead to death (Dawson, J. E., & Strang, 2000).

LC₅₀ of *T. diversifolia* Leaf and Flower Extract against *A. gossypii*

The results showed that the LC₅₀ value of *T. diversifolia* leaf extract in 0.55% concentration (5500 ppm) could cause 50% mortality of *A. gossypii*, while the flower extract was 0.48% (4800 ppm). The LC₉₀ value of *T. diversifolia* leaf extract in 0.99% concentration (9900 ppm) can cause 90% mortality of *A. gossypii*, while the flower extract was 1.08% (10800 ppm) (Table 2). The chemical compounds in *T. diversifolia* flowers have the highest concentration of α- Pinene until 34.42% (Oludare et al., 2016). That was caused by the content of secondary metabolites collected in many parts of the flower. Secondary metabolites that have been produced by plants will be stored in the main storage

Table 1. Mortality Rate *A. gossypii* Due to the Application of *T. diversifolia* Leaf and Flower Extracts

Plant Extract	Mortality of <i>A. gossypii</i> (%)				
	3 HAA	6 HAA	12 HAA	24 HAA	48 HAA
0.1% Leaf	0 a	0 a	0 a	1.25 a	6.25 a
0.1% Flower	0 a	0 a	0 a	3.75 a	12.5 a
0.3% Leaf	0 a	2.5 ab	6.25 b	12.5 b	22.5 b
0.3% Flower	0 a	2.5 ab	6.25 b	15 bc	27.5 b
0.5% Leaf	0 a	6.25 bc	13.75 c	25 cd	42.5 c
0.5% Flower	2.5 b	11.25 e	21.25 d	36.25 de	60 d
0.7% Leaf	0 a	10 de	22.5 cd	41.25 e	70 d
0.7% Flower	2.5 b	11.25 e	25 d	41.25 e	65 d
0.9% Leaf	11.25 c	22.5 f	41.25 e	67.5 f	100 e
0.9% Flower	8.75 c	22.5 f	40 e	66.25 f	100 e

Note: Numbers followed by the same letter in the same column are not significantly different at the Duncan test level of 5%, and HAA is hours after application

area, namely in flowers and seeds (Taiz and Zeiger, 2002). Phytochemical analysis results of *T. diversifolia* leaf and flower extract, *paitan* leaf extract contains 106 types of compounds, while *paitan* flower extract contains 48 types of compounds. Based on the results of the phytochemical analysis, it was found that the extract of the leaves and *paitan* flowers had the highest content of compounds in the form of hexadecanoic acid and linoleic acid. The highest content of hexadecanoic acid and linoleic acid is found in *T. diversifolia* flower extract. The content of hexadecanoic acid in *T. diversifolia* flower extract was 12.08%, while *T. diversifolia* leaf extract was 12.06%. The content of linoleic acid in *T. diversifolia* flower extract was 20.40%, while *T. diversifolia* leaf extract was 10.83%. Linoleic acid can cause inhibition of the feeding ability of test insects (Khani et al., 2011). Toxic compounds that enter the body of insects through the body's natural hole is the cuticle. Compounds that have entered the insect's body will spread carried by the blood circulation and attack the insect's nervous system so that over time will cause death (James and Xu, 2011). Compounds that can inhibit the ability to eat insects cause insects to stop eating and then cause hunger.

LT₅₀ of *T. diversifolia* Leaf and Flower Extract

The results showed that the LT₅₀ value of *T. diversifolia* leaf extract was 65.63 hours, while *T. diversifolia* flower was 37.42 hours. LT₉₀ value of *T. diversifolia* leaf extract obtained as a concentration

that caused death in *A. gossypii* by 90% was 477.24 hours, while *T. diversifolia* flower extract was 201.64 hours. The *T. diversifolia* leaf extract regression equation's value shows that each time multiple will cause *A. gossypii* death by 1.487%, while the *T. diversifolia* flower extract was 1.752% (Table 3).

Mexican sunflower leaf extract was slower to cause *A. gossypii* mortality caused by the low content of chemical compounds. Jumepaeng et al. (2013) reported that citronella leaf has a low polarity level. The low mortality of the test insects was due to the low content of the active compounds leaves compared to *T. diversifolia* flowers (Moronkola et al., 2007).

Effect of Leaves and Flower Extract on The Number of Pupae and Adults of *A. gossypii*

Tithonia diversifolia leaf and flower extracts were effects on reducing the number of offspring produced by *A. gossypii*. The emergence of *A. gossypii* offspring was marked by the presence of new individuals in the form of *A. gossypii* nymphs. The nymph *A. gossypii* has a smaller size and brighter color than the imago *A. gossypii* (Figure 1). The leaf and flower extract can cause a decrease the number of *A. gossypii* offspring with the highest percentage reduction in the number of offspring found in *T. diversifolia* flower extract, but the results show no significant difference between leaf and flower extract. The highest percentage decline in the number of offspring was found at a concentration of 0.9% both in the treatment with leaf ex-

Table 2. LC₅₀ value of *T. diversifolia* Leaf and Flower Extracts

Plant Extract	Regression	SE	LC ₅₀	LC ₉₀	limit value of LC ₅₀	
					Bottom	Up
Leaf	y = 11.630 x + 2.791	1.513	0.55	0.99	1.499	1.609
Flower	y = 8.716 x + 3.504	1.145	0.48	1.08	1.307	1.911

Table 3. LT_{50} value of *T. diversifolia* Leaf and Flower Extracts

Plant Extract	Regression	SE	LT_{50}	LT_{90}	Limit value of LT_{50}	
					Bottom	Up
Leaf	$y = 1.487 x + 2.297$	0.262	65.63	477.24	57.716	76.495
Flower	$y = 1.752 x + 2.244$	0.269	37.42	201.64	30.889	48.528

tract was 76.01%, and flower extract was 77.5% (Table 4).

The decrease in the number of offspring produced by *A. gossypii* was caused by residue active in *A. gossypii*. These residues can affect the metabolism of nutrients needed to support the development and reproduction of insects. The inhibiting process of insects' growth and development has a relationship with insect growth regulators (IGR) that work on the endocrine system or insect hormones. Most IGRs enter the insect's body and mimic the juvenile hormone produced in the insect's brain. The juvenile hormone then provides insects with information to remain in the immature or mature phase. When insects are sufficient to experience growth, juvenile hormones' production stops to make skin turnover into the adult phase (Valles and Koehler, 2014). Interference with the production of one type of hormone can inhibit cellular respiration in hormone-producing organs and will affect the overall functioning of the hormone system. It causes insects to face obstacles in their growth (Chapman, 1998).

The active ingredient is alleged to affect the number of offspring of *A. gossypii*. The odor contained in *T. diversifolia* flower extract comes from flavonoids. The flavonoids play an essential role in plants' color and aroma (Panche et al., 2016). Meanwhile, essential oils can inhibit the eating power of insects (Jalali sendi and Ebadollahi, 2013). Food inhibiting activities can influence the insect development process to reduce the utilization of nutrients for insect growth and reproduction activities. The decrease in the number of *A. gossypii* offspring due to the application of *T. diversifolia* flower extract shows that *T. diversifolia* flower is effective in influencing the number of *A. gossypii* offspring.

CONCLUSIONS

Tithonia diversifolia flower extract had higher toxicity than leaf extract in 0.48% concentration and can cause 50% mortality of *A. gossypii*, while leaf extract in 0.55%. The flower extract can cause the fastest 50% mortality (37.42 hours), while leaf extract was 65.63 hours. Furthermore, the extracts

Figure 1. *Aphis gossypii* A. Nymphs and B. Adults

Table 4. Percent reduction of the number of offspring after application

Concentration	Leaf extract (%)	Flower extract (%)
0.10%	17.77 a	23.42 ab
0.30%	29.46 ab	36.38 bc
0.50%	47.64 cd	51.25 de
0.70%	61.85 e	62.60 ef
0.90%	76.01	77.50 f

of leaf and flower might cause the number of *A.gossypii*'s offspring to decrease.

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