Utilization of wood vinegar as plant based insecticide in mulberry (Morus sp)

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Abstract. Successful maintenance of silkworms (Bombyx mori) depends on the supply of mulberry leaf feed (Morus sp). In practice, mulberry plants are not safe from pests and diseases. In the early rainy season, mulberry plants are easily attacked by whitefly (Trialeurodes vaporiorum and Bemissia tabaci). Mulberry leaves that are attacked by whitefly can no longer be given to silkworms because the nutrients are reduced. The use of plant-based insecticides in the resolvent of whitefly pests has not been widely practiced. Wood vinegar is an organic material derived from wood waste that can be used as a plant-based insecticide. The objectives of this study are to determine the percentage of whitefly attacks on mulberry plants and the application of plant-based insecticides on mulberry plants towards whitefly attacks reduction. The study was employed by field observation for 12 weeks. The results showed that the percentage of whitefly attack was 33.34%. Application of wood vinegar as insecticide with a dose of 2.5% (v/v) increased the pest resistance and induced the growth of mulberry plants.

1. Introduction

Successful maintenance of silkworms (Bombyx mori) depends on the supply of mulberry leaf feed (Morus sp) [1]. Mulberry leaves are the main feed for silkworms [2]. Therefore, the availability of healthy mulberry leaves is an important factor in the activities of natural silk management. The quality and quantity of mulberry leaves affect both of the health of silkworms and the silk cocoon’s quality [3] [4]. Mulberry plants were not free from various types of pests, including pests that attack the leaves [5]. The consequence of pest infestation are highly affect the leaves quality and health of silkworms. [6] Furthermore, these impacts are absolutely affecting both of the cocoon production and the silk threads.

One challenge in the cultivation of mulberry plants is the interference from plant-disturbing organisms such as whitefly. Initially, the whitefly only attack vegetables and crops, but now it is widespread in attacking mulberry plants [6]. The whitefly on mulberry plants occurs often evenly in almost all areas of natural silk management both in Java and Sumatra [5]. The whitefly occurs at the beginning of the rainy season until the middle of the dry season [6].

Whitefly is an insect from the family Aleyrodidae, sub order Sternorothyancha, Hemiptera [7] reported that several species of whitefly infestation become plant pests in Indonesia, such: Aleurolobus barodensis, Aleurolobus citripedus, Aleurolobus voglumi, Neomaskellia andropogonis, Aleurocanthus
sp, Bemisia tabacci, Aleyrodicus dispersus, Trialeurodes vaporiorum. 4 species of whitefly found that attacked plants in Bogor, Cianjur and Sukabumi areas, namely: Bemisia tabacci, Aleyrodicus dispersus, Trialeurodes vaporariorium and Dialeurodes sp [8] The Whitefly that attacked mulberry in the Dramaga, Bogor is only one species Trialeurodes vaporariorium [5].

Losses caused by whitefly attack on mulberry plants is a failure in harvesting [5]. The whitefly attack reduced crop productivity to 80% [6,9]. Mulberry leaves that have been attacked by whitefly cannot be used as feed for silkworms due to the nutrients forfeit. Mulberry’s rich of water, carbohydrate and protein [10]. Recently, handling of whitefly attack still using mechanical approach and chemical insecticides [9]. However, mechanical approach requires more time, energy, and cost compared to chemical insecticides. Meanwhile, the use of chemical insecticides are considered dangerous in terms of the environmental issue and the remaining chemicals left on the leaves endanger the health of silkworms [11]. Hence, the use of natural-based insecticides is needed to resolve those issues.

Wood vinegar as a product of wood pyrolysis. Wood vinegar is liquid smoke obtained from the charcoal production [12]. It is potential to be used as natural-based insecticide due to its chemical components. Wood vinegar chemical components such as acetic acid is effective in inducing growth and prevent pest attack and plant diseases. Methanol as an accelerator of growth, phenols and their derivatives as inhibitors or prevention of pests and plant diseases. The use of wood vinegar is expected to reduce the use of chemicals that are toxic and environmentally friendly. This study aims to determine the percentage of whitefly attack on mulberry plants and the response of infected mulberry plants by applying wood vinegar as insecticides.

2. Materials and Method

2.1. Materials
Materials used in this study were 1 month mulberry crop plot, wood vinegar solution with a concentration of 2.5% (v/v), equates, ropes, gauges, sprays, cameras, and stationery. This research was conducted at field research plot in Dramaga, Bogor, West Java from January to April 2016.

2.2. Method
Data collection consists of primary and secondary data. Primary data were obtained through field observations of the whitefly attack intensity on mulberry plants. Secondary data were obtained from literature studies related to the research. The observed parameters were: calculation of the whitefly attack intensity and physic observation of mulberry plants which were attacked by whitefly after 2.5% wood vinegar application (leaves counting and height measurement). Plant-based insecticide was applied in 2 times/week for 3 months of observation. The intensity of whitefly attack can be calculated based on the comparison of the number of infected mulberry plants with the total number of plants in the observation plot. The formulation of the Intensity of Attack (IS) as described in formula [13]:

\[ IS = \frac{Nh}{Nt} \times 100\% \]

where, IS: Intensity of attack (%), Nh: Number of infected plant, Nt: Total number of observed plants in the plot

3. Results and Discussion

3.1. Intensity of whitefly attack on mulberry plants
Whitefly develops through the stages of eggs, nymphs, pupae, and imago. Female insects generally lay eggs on the underside of the leaf by inserting their limbs into the leaf epidermal tissue so that the eggs are located perpendicular to the leaf surface. The whitefly eggs are elliptical with a size of 0.2-0.3 mm. The whitefly eggs turn pale yellow and then turn dark brown. The whitefly has nymphs with three instar stages. The white nymphs are elliptical, green in color, and on the edges of the body of the nymph are fine hairs with a thin waxy coating. Instar nymph I lasted for 3.14 ± 0.24 days, Instar nymph II lasted for 3.21 ± 0.16 days and Instar nymph III lasted for 3.14 ± 0.16 days. Imago or adult insects are small
between (1-1.5 mm) in white, and their wings are clear covered with a layer of starchy wax. Adult insects are usually clustered on the underside of the leaf, if the plant is touched will usually fly like fog (Figure 1).

![Figure 1. Whitefly attached on mulberry leaves](image1)

Based on observations in the field, the symptoms observed on mulberry plants that attacked by whitefly are preceded by the number of white lice attached to the leaves and stems of mulberry plants. Mulberry leaves begin to blacken due to necrotic spots and sooty dew on the leaves. Mulberry leaves which are attacked by whitefly are generally cannot be given as silkworm feed. Whitefly infestation on mulberry plants will disturb plant growth if the attack is not handled properly.

The whitefly attack imposes direct damage to the host plant. Imago and nymphs attack plants by sucking the leaves and stems of liquid plants and cause necrotic spots on the leaves. These necrotic patches occur because of leaf tissue and damaged leaf cells. The whitefly excretion of honey liquid is a medium for soot dew formation. The whitefly attack caused photosynthesis is inhibited due to the black sooty dew covering the stomata (Figure 2).

![Figure 2. Whitefly attack caused leaves damage and nutrients forfeit](image2)

Results indicated that the intensity of whitefly attack on mulberry plants aged 1 month after pruning was 33.34% (Table 1). The intensity of whitefly infestation on mulberry plants is in medium category where the intensity of pest attacks about 33.34 % of amount of mulberry plants [13,14]. Handling of whitefly attack is necessary to protect mulberry plants and prevent the risk of failure in harvesting mulberry leaves. The use of organic and environmentally friendly plant-based insecticides is expected to be a solution in handling whitefly attack on mulberry plants.
Table 1. Intensity of whitefly attack on mulberry plants

| Age of mulberry       | Number of trees | Intensity of attack (%) |
|-----------------------|-----------------|-------------------------|
| 1 month after pruning | 50 Good, 25 Infected | 33.34                   |

3.2. Application of plant-based insecticides (Wood Vinegar)

Plant-based insecticides have been widely used to replace chemical pesticides because they are considered more environmentally friendly. Wood vinegar is a plant-based insecticide that can be used to treat pests and plant diseases. Several benefits of wood vinegar as food preservatives, pest and plant diseases, organic liquid fertilizer, plant fertilizers, disinfectants, and microorganism inhibitors, and prevention of fungi and bacteria [12]. Wood vinegar used in this study was dissolved in water at a dose of 1:40 (2.5% v/v).

Solution of wood vinegar with a concentration of 2.5% was applied on all parts of the mulberry plants attacked by whitefly. Wood vinegar application was employed 2 times/week for 12 weeks of observations. Results showed that plant growth improved after wood vinegar application.

Figure 3. Wood vinegar with concentration 2.5% (v/v)

In the observation, after plant-based insecticide was applied on the attacked mulberry plants and physically the growth of plants gradually improved and became healthy again. After 12 weeks applied of wood vinegar with concentration 2.5% (v/v) 25 mulberry plants that have been healthy have an average plant height of 61.24 cm and an average number of leaves of 40.92. (Figure 4 and 5).

Application of wood vinegar or pyroligneous acid made an impact on plant growth and health. Pyroligneous acid stimulate cell growth and acids as catalyst for growth microbes and enzymes activation. It is the key of biochemical and physiological processes in plants such as photosynthesis, nutrient absorption and cell growth [15].

Figure 4. Height of mulberry after 12 weeks applied of wood vinegar with concentration 2.5% (v/v)
Whitefly is important pests in many crops worldwide [16]. Using synthetic chemical is the most common approach for handling whitefly infestation. Insecticides with active ingredients like profenofos, lamdasihalotrin, and tiamektosan are effectively suppress the whitefly population [14] but application of synthetic chemicals has negative impact on environment, ecological system and the health of all life form [15]. Wood vinegar from plants have been used in agriculture in an attempt to reduce the dependence on the use of chemicals [17]. The use of wood vinegar as a natural insecticide is very potential to be used for handling whitefly infestation. Mulberry leaf crop failure can be prevented, so mulberry leaves can be given to silkworms.

4. Conclusion
The application of wood vinegar on mulberry plants which infected by whitefly attack was effective at dose of 2.5%. Intensity of whitefly attack in the plot was 33.34% after applying of wood vinegar as natural-based insecticide. The results of this study induced the use of natural-based insecticide as a potential agent in whitefly attack handling.

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