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Efficacy of botanical extracts against tomato mealybug *Ferrisia virgata* (Hemiptera: Pseudococcidae)

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ABSTRACT: Mealybugs *Ferrisia virgata (*Hemiptera: Pseudococcidae) are the one of the noxious sucking insect pest infesting horticulture crops including tomatoes. Efficacy of botanical extracts of bird chili *Capsicum frutescens* L., garlic, *Allium sativum* L., black pepper *Piper nigrum* L., and neem, *Azadirachta indica* was investigated on *F. virgata* at the Entomology Laboratory, Suranaree University of Technology, under an ambient temperature of 27 ± 2 ◦C, and relative humidity 60 – 70%. The plant extracts at concentrations 0.2, 0.5 and 1.0 % were applied for tomato and over the mealybugs. Experiment was arranged in a completely randomized design in four replicates. All plant extracts at the highest concentration of 1.0% showed the highest percentage mortality (100%) at 48 hours after an exposure. All concentrations at 24 hours after an exposure, *Az. indica* extract had significantly reduced (*P*<0.05) mealybugs population followed by *P. nigrum, C. frutescens* and *Al. sativum*. The results reveal that extracts from the three botanical plants (*Az. indica, P. Nigrum, C.frutescens*) are effective in controlling *F. virgata* and could serve as an alternative to synthetic insecticides.
Keywords: sucking insect, plant extraction, tomato, mortality, laboratory evaluation

Introduction

Tomato *Lycopersicon esculentum* Mill is a vegetable family in Solanaceae. It can tolerate to a high temperature and low rain fall, and have been brought from America to subcontinents by the European traders in 1955s. Previous studies have associated the lycopene from tomato favorably affecting DNA, skin exposed to ultraviolet radiation (Story et al., 2010). The tomato consumption with a decreased risk of prostate cancer (Giovannucci et al. 2002) and cardiovascular disease (CVD) (Arab and Steck 2000; Ignarro et al. 2007). Tomato is grown in most of the Asian countries, especially Thailand widely grows and consumes tomatoes. However, the production of tomatoes is infested by various arthropods pest species that cause damage to tomatoes include aphids, whiteflies, mealybugs, stink bugs, cutworm and spider mite. The sucking insects feeds on foliage and young fruit of tomato, causing necrosis of leaves, flower and fruit, possible killing the plant (Marcela and Mario2015).

Mealybugs *Ferrisia virgata* (Hemiptera: Pseudococcidae) are small oval, soft-bodied sucking insects. Both nymph and adult of mealybugs affect host leave at all stage of development and suck the sap from lower surface of the leaves and excrete the excess of sugars in the form of honeydew by projecting it downwards onto leaves and fruits. Honeydew is often collected by ants, which establish mutualistic interactions with mealybugs, by protecting them against natural enemies. Direct damage caused by the insect's feeding results in symptoms such as yellowing of leaves and defoliation, reduced growth and in extreme cases death. Indirect damage results from colonization of infested plants by opportunistic and saprophytic fungi, such as sooty mold and *Botrytis cinerea* Pers., or virus transmission (Golan et al., 2015). Farmers are currently using some toxic chemical insecticides against the sucking insect pests. They are various synthetic insecticides that can be used control the

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mealybugs on large and small scale cultivations of tomato. Previously, it has been reported that the insecticide is very effective against different insect pests in vegetables and fruits. (Reddy and Rao 2002; Gupa et al., 2009). However, synthetic chemicals to control pests has given rise to a number of problems such as destruction of beneficial non-target organisms (parasitoids and predators) thereby affecting the food chain and impacting on biological diversity. Moreover, the presence of residue in fruit, vegetables these is major concern about human health (Codex, Alimentarius Commission MRL of Pesticides 2009). The injudicious use of synthetic pesticides can lead to secondary outbreaks of pests that are normally under natural control resulting in their rapid proliferation led to insects have developed a mechanism for resistance to insecticide (Prishanthini and Vinobaba, 2014; Dang et al., 2017).

Nowadays, Within an Integrated Pest Management Program, botanic extracts with insecticidal potential and/or repellent properties could be used, that they have short residual effects and can be compatible with biological control. Many plant extracts and plant product that are eco-friendly (Chaudhary et al., 2017) and control mealybugs as effectively as chemical insecticides. Thai botanical; bird chili (*Capsicum frutescens* L.), garlic (*Allium sativum* L.), black pepper (*Piper nigrum* L.) and neem (*Azadirachta indica*) is a well-used tropical and subtropical medicinal plant. The literature survey revealed bird chili *C. frutescens* fruit extract were used to control 2nd and 3rd instar larvae of *Aedes aegypti* (Vinayaka et al., 2010). Garlic *Al sativum* were used to control mite *Tetranychus urticae* Koch plant pest (Hincapié Ll et al., 2008). Black pepper *P. nigrum* extract has been reported that used to control of insect defoliators of forest and ornamental trees (Scott et al., 2007). For neem *Az indica* has severed studied about *Az indica* extract against to mango mealy bug, *Drosicha mangiferae* (Green), bollworm *Helicoverpa armigera* (Hubner) (Lanjar et al., 2015; Raiput et al., 2003). However, Thai botanical those no information on insecticidal potential against the tomato mealybugs. The main objective of the study was to evaluate the effectiveness of selected botanicals against the mealybugs including, bird chili (*Capsicum frutescens* L.), garlic (*Allium sativum* L.), black pepper (*Piper nigrum* L.) and neem (*Azadirachta indica*) which have possibilities of biological action on mealybugs.

Materials and Methods

1. Insect collection

The mealybugs individuals were collected into the glass petri-dishes from unsprayed infested plant of tomato fields located in the Suranaree University of Technology. They were maintained in the Entomology laboratory of under condition at 27 ± 2°C, and relative humidity 60 – 70%. Healthy and active 3rd instar nymph of 1st generation mealybugs were used in all toxicity bioassays.

2. Preparation of botanical extracts

Extraction of different parts of four indigenous plant; bird chili fruit (*Capsicum frutescens* L.), garlic bulbs (*Allium sativum* L.), black pepper seeds (*Piper nigrum* L.) and neem seeds (*Azadirachta indica*) were collected from location around the study area. The botanical materials were washed thoroughly with distilled water and cut into pieces (<2 cm in size), then left to dried at 60 degrees for 24 hours. Then they were crushed and powdered by using an electrical blender. Using Soxhlet apparatus (Sigma-Aldrich, Germany), ethanol extraction solvents were used for the extraction of phytoconstituents from each sample (Majeed et al., 2018) due to ethanol has been known as a good solvent for polyphenol extraction and is safe for human consumption (Diem Do et al., 2014). The Soxhlet apparatus was extracted for 3-5 h with 1 L of the extraction solvent. Extractions were performed in the laboratory of the Center of Scientific and Technology Equipment, Suranaree University of Technology. Excess of extraction solvent was removed from the botanical extracts using a rotary evaporator set at 40°C then, were stored in airtight dark colored glass vials at 4°C in the refrigerator until their utilization in bioassays.

3. Toxicity bioassay

The top leaves of 2-months-old tomato were cut end of each was wrapped with wet paper towel and keep in polythene bags. Then they were brought to the Entomology laboratory by keeping them inside a regiform container to prevent from heat and mechanical damages during transport. Then put in the 10 cm diameter and 10 cm high plastic cups. The number of leaves on each plant terminal was reduced to 5 (only the upper terminal leaves were allowed to remain) and the 3rd instar nymph stages were transferred to the leaves by using a hand lens and a camel brush. Then the prepared solution of three concentrations of each botanical extract i.e.0.2, 0.5 and 1.0 % was sprayed over the mealybugs and the container was covered with a muslin cloth. The leaves that sprayed with distilled water were used for control. Mealybug mortality was counted at 24 and 48 hours following initial application. The mortality records for all treatments were obtained in percentage values. The experiment was laid out in a completely randomized design (CRD) with four replications for each treatment (100 insects per replication).

Percentage corrected mortality was calculated by following formula described by Schneider-Orelli's formula (1947) in Puntener (1981)

$$\text{Corrected \% mortality} = \frac{\text{Mortality \% in treatment - Mortality \% in control X 100}}{\text{100 - Mortality \% in control}}$$

4. Statistical analysis

For all the data obtained the differences among the mortality of mealybugs at all treatments were subjected to analysis of variance (ANOVA). Means were carried out using DMRT test. Descriptive and analytical statistics were computed using Statistical Analysis System 9.1 (SAS Institute, Inc.).

Results and Discussion

Laboratory efficacy of four difference botanical extract at different concentrations was evaluated against mealybugs *F. virgata* (**Figure 1**). The mortality was observations record on 24 and 48 hours after treatments revealed among the test botanical extract at 0.2, 0.5 and 1.0% were evaluated against mealybugs *F. virgata*. The results revealed that the treatments were significantly differing among themselves in causing mortality of *F. virgate* from the control ($P<0.05$). At 0.2% concentration after an exposure of 24 hours the maximum mortality (66.67 %) was highest of mean percentage mortality in neem *Az. indica*, followed by black pepper *P. nigrum* extract with 56.67%. While, after an exposure of 48 hours the maximum mortality was in neem *Az. indica* of 73.33% followed by bird chili *C. frutescens* with 70.00% (**Figure 1**). At 0.5% concentration of four difference botanical extract, after an exposure of 24 and 48 hours in case of neem *Az. indica* was highest of mean percentage mortality with 76.67 and 90.00%, respectively (**Figure 2**). Mortality rates increased with increasing concentrations for all botanicals. At 1.0% concentration of four difference botanical extract, at 24 hours the neem *Az. indica* extract showed the highest of mean percentage mortality with 100% (**Figure 3**). While, after an exposure of 48 hours, neem *Az. indica*, bird chili *C. frutescens* and black pepper *P. nigrum* gave the highest of mean percentage mortality with 100% (**Table 1**). There was no mortality of 3rd instar nymph stages in the control. Moreover, the results found that, at 0.2% concentration after an exposure of 24 hours, bird chili *C. frutescens* was not effective to the *F. virgate* mortality but effective after an exposure of 48 hours (**Figure 1**). While, black pepper *P. nigrum* and neem *Az. indica* were effective after an exposure of 24 hours. In addition the results show chili *C. frutescens*; garlic *Al. sativum*; black pepper *P. nigrum* were no effective to *F.virgate* mortality at 0.5% and 1% concentration after an exposure of 24 hours but effective after an exposure of 48 hours (**Figure 2 and 3**).

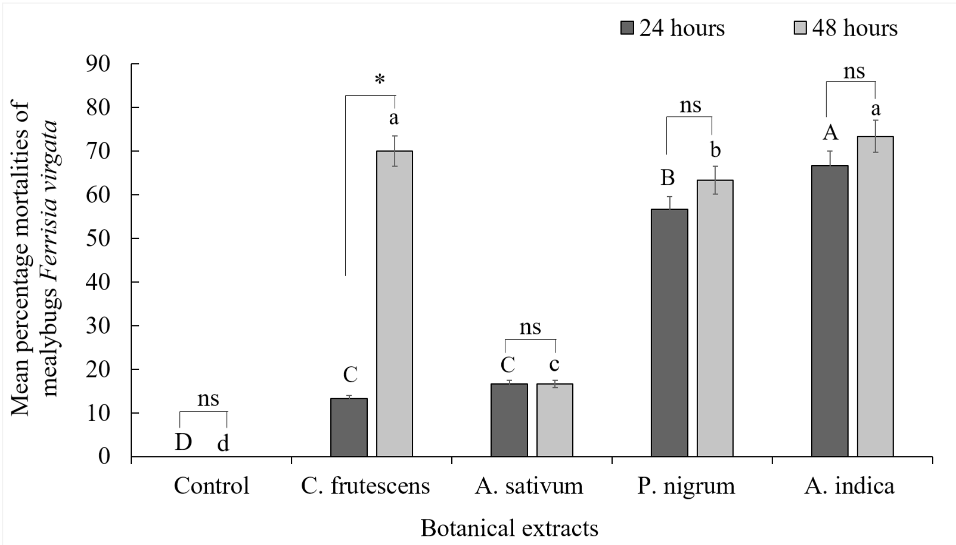

Figure 1 Effect of different botanical extracts on mortalities (mean ± S.E.) of mealybugs *Ferrisia virgate* at 0.2% concentrations after initial application 24 and 48 hours. Significant differences within mortality after initial application are marked with different letters (24 hours, left bar with capital; 48 hours, right bar with small letter). Mortality-based values were compared using DMRT test, analysis results are shown above each bar (*: $P < 0.05$; ns: no significance)

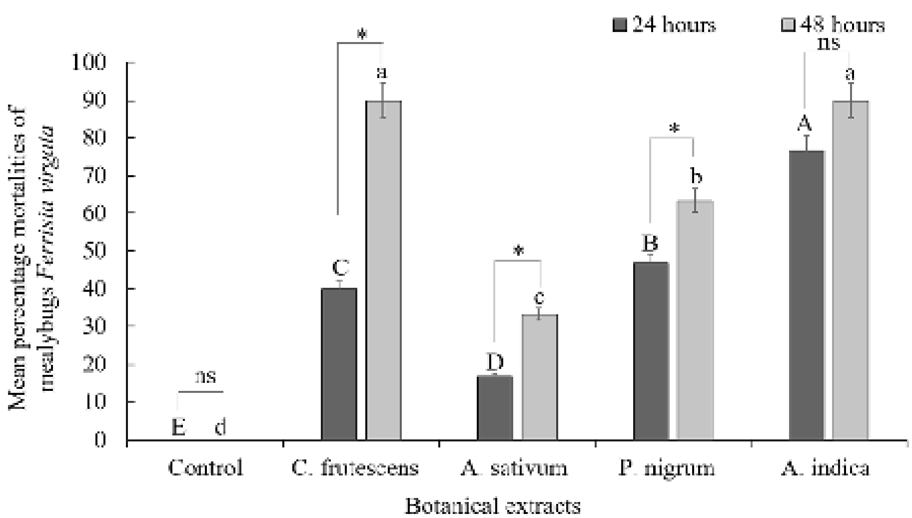

Figure 2 Effect of different botanical extracts on mortalities (mean ± S.E.) of mealybugs *Ferrisia virgate* at 0.5% concentrations after initial application 24 and 48 hours. Significant differences within mortality after initial application are marked with different letters (24 hours, left bar with capital; 48 hours, right bar with small letter). Mortality-based values were compared using DMRT test, analysis results are shown above each bar (*: $P < 0.05$; ns: no significance)

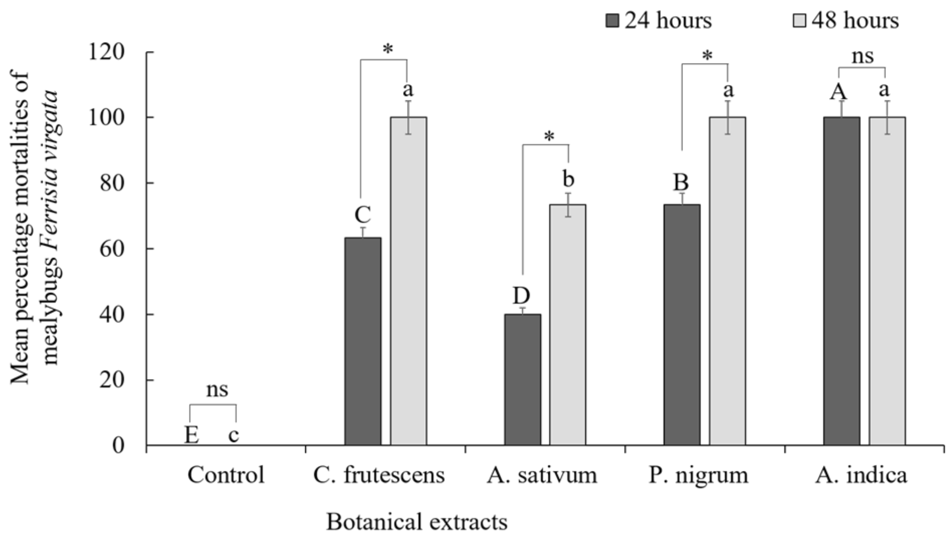

Figure 3 Effect of different botanical extracts on mortalities (mean ± S.E.) of mealybugs *Ferrisia virgate* at 1% concentrations after initial application 24 and 48 hours. (24 hours, left bar; 48, right bar). Significant differences within mortality after initial application are marked with different letters (24 hours, left bar with capital; 48 hours, right bar with small letter). Mortality-based values were compared using DMRT test, analysis results are shown above each bar (*: $P < 0.05$; ns: no significance)

Among of botanicals, neem *Az. indica* was found to be most effective followed by bird chili *C. frutescens*. The better results of neem *Az. indica* may be due to antifeedant and this is has reported that neem extracts deter insects from feeding (Gilani, 2001). Previously, many researchers have reported the effectiveness of neem plant extracts against different insect pests such as whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis gossypii* Glover), jassid (*Amrasca devastans* Distant), mealybug (*Phenacoccus solenopsis* (Tinsley) and *Drosicha mangiferae*) (Prishanthini and Vinobaba, 2014; Majeed et al., 2018), thrips (*Thrip stabaci* Lindeman), red cotton bug (*Dysdercus koenigii* Walk), and dusky cotton bug (*Oxycarenus hyalinipennis* Costa) (Majeed et al. 2016; Kunbhar et al. 2018). Moreover, neem *Az. indica* has various effects insects in a variety of different ways: as an antifeedent, insect growth regulator and sterilant. An understanding of the physiological effects of azadirachtin in neem has excellent attributes including systemic action in plants, rapid degradation in the environment, and minimal effects on biological control agents (Mordue and Nisbet 2000; Arshad et al., 2019). While, neem *Az. indica* found that are quite safer to the predatory coccinellids and *Chrysoperla carnea* (Stephens) in the field and natural enemies in Chilli (*Capsicum annum* L.) (Smitha and Giraddi 2006; Patel et al. 2009; Arshad et al., 2019).

The bird chili *C. frutescens* and black pepper *P. nigrum* extracts also were found to be more effective to the mealybug at 1.0% concentration after an exposure of 48 hours. The observed activities may be due to the chilies contain potassium, magnesium, folic acid and capsaicinoids are responsible for the pungency and are considered as active compounds in chilies. Capsaicin was accounted for about 50 to 70% of the total capsaicinoids. Previous studies reported evidence that capsaicinoids and glucosinolates have biocidal activity against phytophagous insects and store insects

(Olszewska et al., 2010; Tsao et al., 1996). For instance, the pungency of capsicum species was attributed to the presence of capsaicin used to management of the yam moth, *Dasyses rugosella*, a pest of stored yam tubers using plant products (Ashamo, 2010). And, they were against maize weevil *Sitophilus zeamis* Motschulsky with the reported of Asawalam et al. (2007). These found that *C. frutescens* considerably reduced the survival, oviposition and progeny development of Cowpea Bruchid, *Callosobruchus maculatus* (Ileke et al., 2013).

Conclusion and Suggestions

In conclusion, it can be stated that neem *Az. indica* was effective significantly nymph stage mortality at lower concentrations of the neem *Az. indica* solution in the laboratory conditions. The botanicals used in this study such as *Az. indica, C. frutescens* and *P. nigrum* were showed different levels of insecticidal activities. These findings of the present study suggest that neem extract can be used as a botanical spray to control of tomato mealybug *F. virgate.* The significant reduction in pest's numbers on the treated plants was an indication that they can be used as alternatives to chemical insecticides.

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