INTRODUCTION

Trialeurodes vaporariorum (Westwood) is a polyphagous insect pest responsible for high economic damages in many crops. They damage by secreting honeydew, which leads to growth of sooty mold fungi, and this affect the process of the plant physiology.[1] Also, they transmit plant viruses.[2] The intensive usage of chemical insecticides to control whitefly has also eliminated the natural enemies of whitefly and has led to increase tolerance or the development of insect resistance to pesticides.[3] However, the potential hazards for mammals from synthetic insecticides has caused to a search for new classes of insecticides with lower mammalian toxicity and a lower persistence in the environment in integrated management program.[4] The application of botanical products to control agricultural pests can adversely affect the environment and requirements for safer means of pest management have become critical. Also, these products are now emerging as one of the prime means to protect crops and the environment from pesticide pollution.[5] The essential oils or other plant derived chemicals as potential sources of many common spices plants have also been evaluated for their repellent and insecticidal activities.[6] For example, Kordan et al[7] found the deterrent properties of Achillea millefolium L. against Sitophilus granarius L. and Tribolium castaneum Herbst. Ateyyat et al[8] studied the effect of A. biebersteinii L. on adults of sweet potato whitefly, Bemisia tabaci Genn. The medicinal plants, Artemisia annua L. and A. millefolium have been reported deterrence activities against Pieris rapae L.[9]

ABSTRACT: Introduction: The greenhouse whitefly, Trialeurodes vaporariorum Westwood (Homoptera: Aleyrodidae), is an important cosmopolitan pest of many crops. Methods: The present study investigated the repellent and anti-oviposition activities of plant products from Achillea millefolium and Thymus vulgaris against this pest in greenhouse conditions. Cucumber plants were sprayed with the chemicals at 40 µl/ml concentration and control plants were treated with distilled water. Also, the essential oil of A. millefolium at the same volume (5 ml) was sprayed on the special filter paper (2 x 4 cm) attached at the petiole plant. Four treated plants and four control plants were placed randomly in a cage. Three days after spraying, approximately 250 whitefly adults were released into the cages. Then three and six days after infesting, the number of eggs and adults were recorded. Each experiment was repeated two times at the same greenhouse condition. Results: The results revealed that all plant products affected the oviposition and tropism behaviors of greenhouse whitefly. Amongst the different treatments, the highest anti-oviposition effect was calculated by aqueous extracts of T. vulgaris (62.87 %) six days after treated. Moreover, the aqueous extract of A. millefolium had the highest repellent effect (52.54 %) six days after treatment. Also, the compare repellent activity of the chemicals on greenhouse whitefly adults indicated the highest repellent effect was evaluated by the essential oil of A. millefolium (48.07 %) nine days after treatment. Conclusion: These results showed that A. millefolium and T. vulgaris had relatively long lasting repellent and anti-oviposition activities on the adults of the greenhouse whitefly.

KEYWORDS: Achillea millefolium, anti-oviposition activities, greenhouse whitefly, repellent activity, Thymus vulgaris
α terpinene and thymol) derived from the essential oil of Thymus sp. against the mosquito Culex pipiens pallsen. The essential oils obtained from T. vulgaris L., Satureja hortensis L. and T. satureioides Boiss. Plants were investigated for repellent and anti-oviposition effects of the mosquito larvae C. quinquefasciatus Say. In the another study, the activities of the essential oil of T. vulgaris and Mentha piperita were evaluated by fatalities percentage of greenhouse whitefly (T. vaporariorum). Pavela and Herda investigated the repellent and anti-oviposition activities of pongam oil against the adults of the common greenhouse whitefly (T. vaporariorum).

This paper describes a greenhouse study to assess the potential of essential oils and aqueous extracts for use as repellents. Repellent and anti-oviposition activities of essential oils and aqueous extracts from A. millefolium and T. vulgaris were assessed against the greenhouse whitefly (T. vaporariorum) adults.

MATERIALS AND METHODS

Rearing of insect and host plant
Cultures of greenhouse whiteflies T. vaporariorum were collected from tobacco, Nicotiana tabacum (L.) and tomato, Solanum lycopericum (L.) in the greenhouse of the faculty of agriculture in Shahid Bahonar University of Kerman, Kerman, Iran. They were reared on cucumber plants, cv. Negin in 80 × 60 × 60 cm fine cloth cages as block design experiment. Three days after spraying with the plant products, approximately 250 whitefly adults were released into the cage. Three and six days after releasing greenhouse whitefly, the number of eggs and adults on detached cucumber leaves at similar areas were counted. Two cages as replicates were used for each treatment. The percent effectiveness of repellency (ER) or anti-oviposition index for the plant products was calculated by the formula:

\[ ER = \left(\frac{C - T}{C + T}\right) \times 100 \]

Where ER = percent effectiveness of repellency; C = number of eggs or adults in control treatment; T = number of eggs or adults in plant derived treatment.

Statistical analysis
Statistical comparison among the ER and anti-oviposition index of aromatic plants were conducted using a one-way analysis of variance (ANOVA) followed by a Tukey’s Test (P < 0.05) (StatPlus version 4.9, 2007, Croydon, UK).

RESULTS

Anti-oviposition effects
Results of the anti-oviposition effectiveness of A. millefolium and T. vulgaris are shown in Figure 1. All the aromatic plants selected showed anti-oviposition activity. Among different treatments, the highest anti-oviposition activity on greenhouse whitefly 6 days after treated was caused by aqueous extracts of T. vulgaris [(62.87 ± 4.81) (mean ± SE)] that was significantly different from the effect of essential oil of A. millefolium (P < 0.005).

The Essential oil obtained from A. millefolium had the highest anti-oviposition effect on T. vaporariorum after 9 days (49.33 % ± 5.07) and the aqueous extracts of A. millefolium...
had the lowest (41.80 % ± 0.96). Among different plant products there were no significant differences in the anti-oviposition index 9 days after treatment (P < 0.05).

Repellent activities

Repellent activities for all compounds, 6 and 9 days after treated, revealed in Figure 2. Six days after treated, the aqueous extracts of *A. millefolium* indicated the highest repellence effect (52.54 % ±3.55), while essential oil of *A. millefolium* had the lowest (32.47 % ± 6.16). The repellent effect caused by all plant products after 9 days ranged from 35.69% to 48.07% in aqueous extract of *T. vulgaris* and essential oil of *A. millefolium* treatments, respectively. There were no significant differences among aqueous extract and essential oil of *A. millefolium* as well as *T. vulgaris* treatments (P < 0.05).

**DISCUSSION**

The selected aromatic plants of *A. millefolium* and *T. vulgaris* showed high repellence and anti-oviposition effectiveness on the adults of greenhouse whiteflies. Nevertheless, our research revealed that these plants in the spraying bioassay may successfully control this aggressive pest because of their high volatility, repellent efficacy and safety. Different parts of plants contain a complex
of chemicals with unique biological activity\textsuperscript{[18]} which is thought to be due to toxins and secondary metabolites, which act as attractants or deterrents.\textsuperscript{[7]} Positive results for deterrent activity of these plants were obtained against various pests.\textsuperscript{[10,11,19]} The results of our study are mostly in the agreement with the results of other investigators. Pavela\textsuperscript{[11]} has demonstrated that concentrations of 0.01% and 0.005% \textit{T. vulgaris} were most effective at repelling mosquito larvae \textit{C. quinquefasciatus} with about 99.8 and 62.3% repellence respectively. Moreover, the essential oils made of \textit{S. bortensis}, \textit{T. vulgaris} and \textit{T. satureoides} offer a high potential for the control of \textit{C. quinquefasciatus} as new safety larvicides in the environment. Hasheminia et al\textsuperscript{[7]} proved that the deterrent effect of \textit{Artemisia annua} \textit{L.} and \textit{A. millefolium} \textit{L.} on small cabbage \textit{Pieris rapae} \textit{L.} were 29.82% and 44.18%, respectively. In the another study, Kordan et al\textsuperscript{[7]} assessed that \textit{A. millefolium} can have a high deterrent effect in protecting stored products from \textit{S. granarius} \textit{L.} and \textit{T. castaneum} Herbst. Al-Mazra’awi and Ateyyat\textsuperscript{[20]} have reported that plant extracts of \textit{Urtica pilulifera} \textit{L.} and \textit{T. capitatus} \textit{L.} had repellent effect against \textit{B. tabaci} adults.

Some authors also studied the toxicity effect of these plant derived chemicals on the pests. For example, the persistency of larvicidal affects of some essential oils under different conditions against \textit{Aedes aegypti} larvae. Some oils (for example thyme oil (\textit{T. vulgaris}) stayed effective under certain conditions until the last test and their toxicity remained a long time after preparation.\textsuperscript{[21]} The present study demonstrates a high potential for using the aromatic plants \textit{A. millefolium} and \textit{T. vulgaris} as repellent and anti ovipositional activity against greenhouse whitefly. This may lead to new and more effective strategies to prevent and control this aggressive pest. The high activity of these plants could be used as an active ingredient in the preparation of natural insect repellents or as bioinsecticides. Some of the compounds tested could find a place in integrated pest management programs (IPM), especially where the emphasis is on environmental and food safety and on replacing the more dangerous and toxic insecticides.

ACKNOWLEDGEMENTS

The authors thank Hadi Zohdi at Agriculture Research and Natural Resource Center of Kerman, Iran for his help and support.

REFERENCES


