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Full Length Research Paper

Using *Ferula assafoetida* essential oil as adult carob moth repellent in Qom pomegranate orchards (Iran)

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Carob moth, *Ectomyelois ceratoniae* (Lep.: *Pyralidae*), is the key pest of pomegranate fruits in most countries like Iran. Chemical insecticides cannot be used for the control of carob moth because they have biological and behavioral traits. Other control methods have no sufficient efficiency. So it is necessary to use new methods. Some pest control management such as application of semiochemicals like repellents are common practices. *Ferula assafoetida* essential oil is a botanical material and its repellency on some pests is proved under laboratory conditions. In this research, its repellency was studied on adult carob moth, in Qom pomegranate orchards, during a two farming seasons study (2007 - 2008). Two orchards (treatment and control) were selected in about 3 km distances from each other. In treatment and control plots, *F. assafoetida* essential oil and ethanol (solvent) were used, respectively. During the farming season, number of rotten pomegranates of treatment and control trees were counted and removed weekly. The percentage of rotten pomegranates on trees was calculated at the end of the season. Two sample t-test showed significant differences between weekly (T = 2.22, df = 38, P = 0.032), (T = 3.11, df = 58, P = 0.003) and end of the season (T = 2.97, df = 16, P = 0.012), (T = 3.54, df = 48, P = 0.001) data of treatment and control orchards in 2007 and 2008, respectively. Number of rotten pomegranates of treatments was lower than control. Comparison of treatment and control orchards data showed damage lessening in treatment plot. Laboratory results proved repellency effect of *F. assafoetida* essential oil on adult carob moth in orchard conditions.

Key words: Carob moth, semiochemicals, *Ferula assafoetida* essential oil, repellency, Iran.

INTRODUCTION

Carob moth, *Ectomyelois ceratoniae* (Lep.: *Pyralidae*), is a polyphagus and key pest of pomegranate fruits in Iran. It is the most important reduction factor of quantitative and qualitative pomegranate yield in this country and its average damage is about 25 - 30%. Larvae, especially from second or third age, feed from internal parts of fruit and cause penetration of pathogenic fungi such as *Aspergillus* and *Penicillium*. The infested fruits either rot and drop or remain on the trees until the end of the season (shakeri, 2005). This situation reveals the necessity of effective control. On the other hand, synthetic insecticides are not efficient because of the biology, oviposition and feeding behavior of carob moth.

Chemical massagers or semiochemicals regulate arthropods interactions with plants or other arthropods and according to behavioral responses that they produce, they are extensively classified as: Attractant, antifeedent, repellent, oviposition deterrent, etc (Law and Regnier, 1971; Dethier et al., 1960; Nordlund and Lewis, 1976; Nordlund, 1981). Many insects, such as moths, are affected by olfaction stimuli. For example, they are dependent on volatiles for finding their mates, food resources and oviposition sites. Every disruption to the olfaction system affects their behavior. So repellent

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Abbreviations: IPM, Integrated pest management; **DEET,** N,N-diethyl-meta-toluamide.

Figure 1. Cap glass vial containing essential oil solution in pomegranate orchards (Qom- 2007).

materials can be used for their successful control in Integrated Pest Management (IPM). The practice of using secondary plant compounds or botanical insecticides as we now know them, in agriculture, dates back to at least two millennia in ancient China, Egypt, Greece and India (Thacker, 2002). Botanicals, reputedly pose little threat to the environment or human health. A part of the secondary plant compounds that are perceived by the insects olfaction sense are repellents. Recent attention has been devoted to traditional plants for post harvest protection and repellency against insects (Belmain and Stevenson, 2001, Boeke et al., 2004). N,N-Diethyl-meta-toluamide (DEET), Neem, Citronella and Pikardin are examples of pest repellents (Katz et al., 2007). Neem, as a biological plant derived preparation, can be suitable for integrated pest management programs, especially in small orchards, parks and on private gardens (Zabel et al., 2002). Another material is *Ferula assafoetida* essential oil. *F. assafoetida* (*Apiaceae*) is a range plant with undesirable odor and its repellency to insects is due to existing disulfide compounds (Kajimoto, 1989). Khajeh et al. (2005) analyzed *F. assafoetida* essential oil by capillary gas chromatography. The major component identified was "E-1propenyl sec-butyl disulfide" (more than 40% of compounds). This component may have effective factor in repellency effect. Nazemi (2002) applied *Nerium oleander*, *Lavandula officinalis* and *F. assafoetida* resin extracts, against adults of *Ephestia kuehneilla* and *Tribolium castaneum*. *F. assafoetida* resin extract showed highest percentage of repellency. Besides, repellency of *F. assafoetida* essential oil on adult Carob moth was documented by Barkhordar (2006) under laboratory conditions.

In this study, we aimed to investigate the repellency of *F. assafoetida* essential oil on adult Carob moth and its effect on prevention of rotten pomegranates in the orchards of Qom province, Iran.

MATERIALS AND METHODS

In the beginning of the farming season, essential oil was extracted from *F. assafoetida* resin in a Clevenger apparatus using hidro-distillation method at the Plant Protection Department, University of Tehran. Two pomegranate orchards, as treatment and control (each one has one hectare area) were selected in Qomrud village of Qom province, Iran. These orchards were three kilometers apart. The orchards had the same variety of pomegranate, distance of culturing rows and irrigation period. In both plots, trees of first and second culturing rows were left as marginal area. From third to last row, the selected trees were numbered from 1 - 20 with aluminum plates. In the first season, when pomegranate leaves germinated in treatment orchard, 4 ml mixture (1:1 v/v) of essential oil and ethanol (as solvent) were poured in screw cap glass vial (Figure 1). They were hanged with a wire in the interior twigs of labeled trees with about 1.5 m height. For evaporation of essential oil, caps of vials were cut with cork borer.

All the processes were the same in control orchard, but only ethanol was used. *F. assafoetida* essential oil solution were

Figure 2. Garment inside the polyca tube for injecting essential oil in pomegranate orchard (Qom- 2008).

recharged in treatment and control orchard monthly. A decline of infestation in pomegranate fruits and reduction of rotten fruits was indicator of adult carob moth repellency by *F. assafoetida* essential oil. Fallen rotten pomegranates under 20 labeled trees, in treatment and control plots were counted, weekly. Rotten fruits under trees were removed in each sampling. At the end of the season, percentage of rotten pomegranates on 10 trees in treatment and 5 in control orchard were calculated.

Preparation of essential oil, selection of treatment and control orchards and leaving marginal rows without treatment, were similar with that of 2007. Because of damage to Qomrud pomegranate orchards by winter frost, treatment and control plots were selected in Qom city suburban, with previous conditions. Sixty trees were numbered alternately, using aluminum plates in two orchards. Dark woolen garments which are double, placed inside the polyca tubes (7 cm diameter and 5 cm height) and impregnated with essential oil solution, had the same ratio as the year before (Figure 2). In the treatment orchard, 2 ml ethanol was injected into garment 2 weeks after experiments started and 10 days later, *F. assafoetida* essential oil in ethanol recharged into garment. In control plot, only ethanol was applied into the garment.

Thirty trees, accidentally, were selected from 60 plated trees in treatment and control orchard. Weekly, counting and removing of rotten pomegranates that fell under the trees, were done in both orchards. Also, at the end of the season, the percentage of rotten pomegranates on trees was calculated in 25, out of 30 trees with essential oil. These trees were selected accidentally, every two orchards. In order to investigate if *F. assafoetida* essential oil molecules affected the neighbouring trees, 5 trees, besides those with essential oil, were selected accidentally and the percentage of infested fruits from the trees was calculated.

To determine the statistical significance for the experiments, data were analyzed by two sample t-test with Mini Tab software.

RESULTS

Results of t-test revealed that there are significant differences in weekly (T = 2.22, df = 38, P = 0.032) and the end of the season (T = 2.97, df = 16, P = 0.012) data, between treatment and control orchards. During the season, average of rotten pomegranates in treatment orchard was significantly fewer than control (Figure 3). Moreover, at the end of the season, the percentage of rotten fruits on trees was calculated, amount of damage in treatment plot was significantly less than the control (Figure 4).

Data analysis during the season, showed significant difference (T = 3.11, df = 58, P = 0.003) between the mean number of rotten pomegranates in treatment and control orchards (Figure 5). At the end of the season, there was significant difference in the percentage of rotten fruits on treated trees and between treatment and control plot (T = 3.54, df = 48, P = 0.001). Percentage of spoiled pomegranates on neighbouring trees of treatment orchard was also significantly less than the control (T 4.37, df = 8, P = 0.002) (Figure 6). Also, treated trees data with neighbouring treatment plot, showed that there was no significant difference in percentage of rotten fruits on trees, (T = 1.31, df = 28, P = 0.200). Therefore, *F. assafoetida* essential oil molecules affected neighbouring trees and decrease in contamination was significantly different from the control.

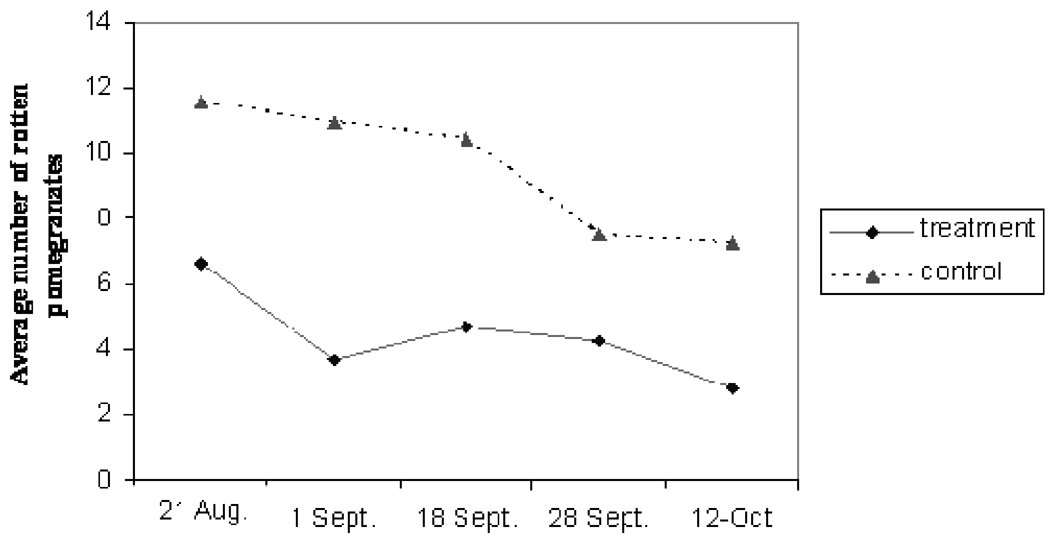

Figure 3. Average numbers of rotten pomegranates in treatment and control orchards during the season (2007).

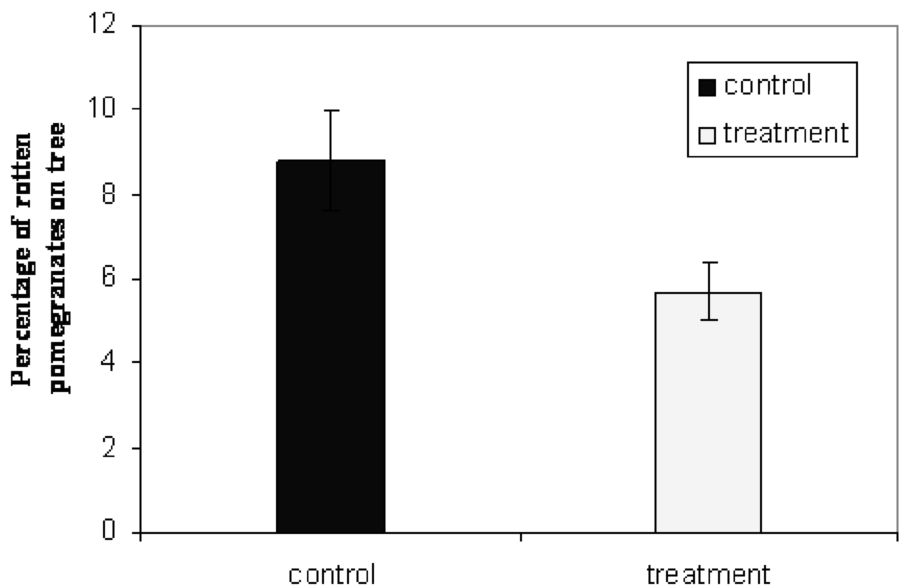

Figure 4. Percentage of rotten pomegranates on trees in treatment and control orchards at the end of the season (2007).

DISCUSSION

Weekly and late season observations and comparing treatment and control orchard data in 2007 and 2008, showed damage decrease in plots treated with essential oil. Barkhordar (2006) reported repellent activity of *F. assafoetida* essential oil to adult carob moth under laboratory conditions. In this study, decrease in carob moth contamination was partly attributed to the repellent effects of *F. assafoetida* essential oil. Another factor for damage reduction was possibly due to disruption in pest reproductive behaviors that led to oviposition reduction. Since there is no similar research on repellency of agricultural pests under field conditions, we compared our findings with the results of studies that were carried out under laboratory or greenhouse conditions. Pavela and Herda (2007) reported repellency of Pongam oil on

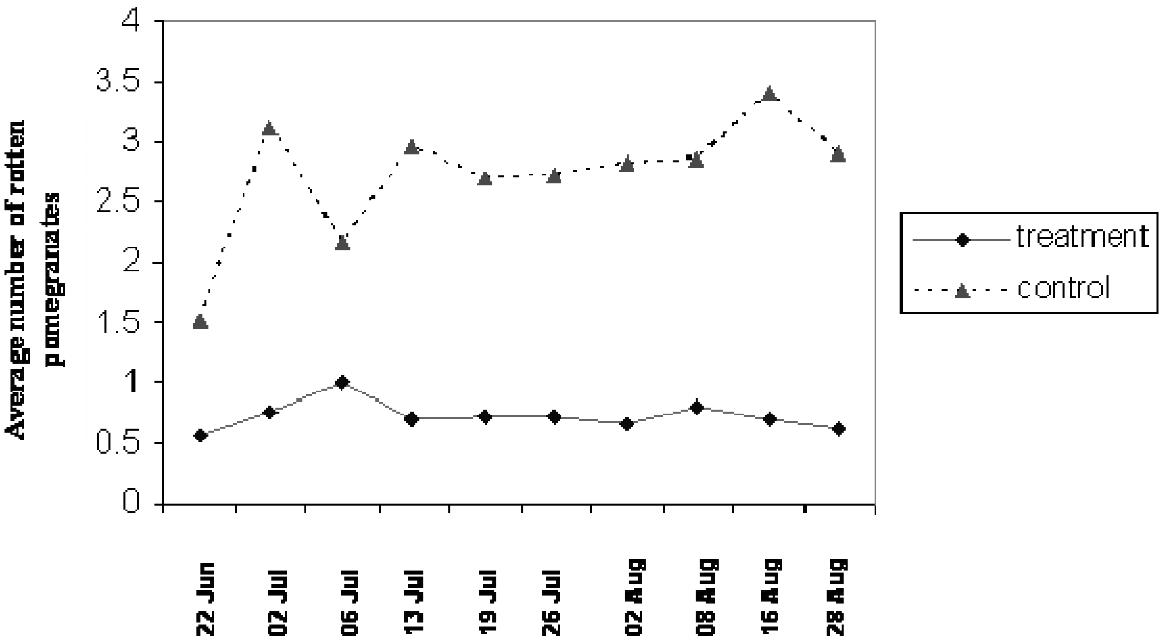

Figure 5. Average numbers of rotten pomegranates in treatment and control orchard, during the season (2008).

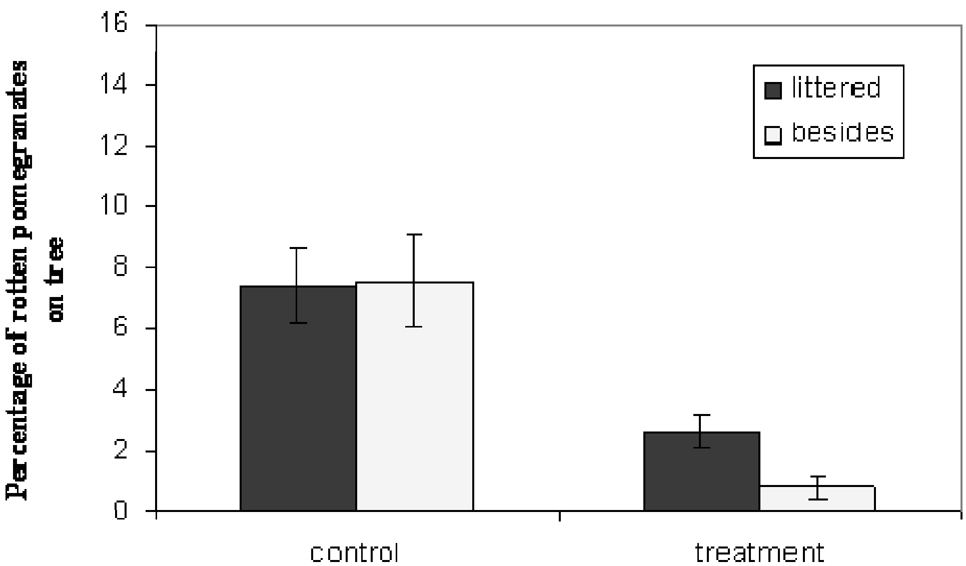

Figure 6. Percentage of rotten pomegranates on plated and neighbouring trees in treatment and control orchards at the end of the season (2008).

Adult whitefly (*Trialeurodes vaporariorum*) under green house conditions. Zhang et al. (2004), investigated repellent effects of ginger oil against adult *Bemisia argentifolii* (Hom.: *Aleyrodidae*) on tomato under greenhouse conditions. They showed that tomato plants that were dipped in ginger oil solution for 24 h settled with 35-42% fewer adult whiteflies than plants which were dipped in between 20%. Similarly, Shakarami (2004) reported repellency effect of *Artemisia auchei*, *Salvia bracteata* and *Nepeta cataria* essential oils on *Callosobruchus maculates*, *T. castaneum*, *Sitophilus oryzae* and *Sitophilus granarius* adults under laboratory conditions. Nazemi (2002) reported that *F. assafoetida* resin extract had high repellent activity on *E. kuehneilla* and *T. castaneum* than other extracts. These results agree with our findings and prove *F. assafoetida* as a high potential plant for producing repellent effects. Barkhordar (2006) showed that *F. assafoetida* essential oil is repellent for adult carob moth under laboratory conditions and makes more behavioral disruption on mated than unmated females. This same author concluded that change in behavior is probably due to extra sensitivity of insect for finding suitable oviposition site. Germinara et al. (2007) examined repellency effects of propionic acid against adults of *Sitophilus oryzae* and *S. granarius*. They observed that this material had repellency even beside the fact that its odor is attractive to these insects. Similarly, when Barkhordar (2006) placed both the pomegranate, that is, attractant for adult carob moth, and *F. assafoetida* essential oil together, close to the two arms of olfactometer, the moths repelled again. In this research, in spite of attractiveness of pomegranate fruits odor, fewer moths were attracted to trees treated with essential oil than untreated trees. Less contamination is an indicator of fewer oviposition on fruits. Negahban (2006) proved that *Artemisia sieberi* essential oil is repellent for *C. maculates*, *T. castaneum* and *S. oryzae* adults under laboratory conditions, and percentage of repellency increased by an increase in the concentration of the essential oil.

Our results at the end of the season (2008) did not show any significant difference between percentage of rotten pomegranates trees that hold essential oil and neighbouring trees, in treatment orchard. Therefore, volatile molecules of essential oil were spread into neighbouring areas. This phenomenon was caused by the increasing evaporation surface from the garment used in this year or increasing times of recharging. As Cook et al. (2007) stated, repellents are used in Push-Pull strategy, so *F. assafoetida* essential oil can be applied in this strategy in future researches, in order to repel pest from orchards and prevent contamination of other orchards.

Conclusions

Overall, we can conclude from this study that *F. assafoetida* essential oil application led to the decrease in carob moth contamination in Qom pomegranates. This compound easily synthesizes and formulates the synthetic chemical insecticides. It is safe for nature, and as a plant derived material, it does not cause physiological resistance to pests. Since common control methods are not effective in controlling this pest, *F. assafoetida* essential oil, as a promising substance for carob moth control, can be investigated. More studies are necessary in finding the suitable matrix and the best formulation method such as "slow-releasing formulations", effective concentration for utilization in orchards and stability of essential oil molecules under natural conditions.

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