Entomology

Review on insecticidal activity of plant essential oils on the ectoparasitoid wasp, *Habrobracon hebetor* Say (Hymenoptera: Braconidae)

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Abstract

Habrobracon hebetor Say is one of the most valuable natural enemies of plant pests, especially on the larvae of Noctuidae and Pyralidae moths (order Lepidoptera). This important biocontrol agent is used in the form of mass release to control of the harmful larvae in crops and orchards over the world. This natural enemy first paralyzes its host larvae and then lays on them. The wasps feed on the content of the larvae body and control their population. Plant essential oils are volatile compounds produced by various plants to repel herbivorous insects. Naturally, they are damaged when biological control agents are also exposed to them. To date, there are very limited researches have been studied about the effects of plant essential oils on the demography, functional response, and physiological properties of *H. hebetor*, which we will briefly discuss on them. The science of plant essential oils is an interesting and fascinating one and it is necessary to study plant secondary metabolites from different aspects on the beneficial insects. These studies can be useful in identifying plant species with low toxicity to these agents, but with appropriate toxicity to their host pests for their simultaneous usage in integrated pest management (IPM). The right combination of these agents can provide a bright future for IPM programs by using of essential oils and biological control agents.

Keywords: essential oil, natural enemy, integrated pest management.

Introduction

Totally, there are very limited studies about the effects of plant essential oils on different biological aspects of *H. hebetor* (Figure 1). Seyyedi *et al*. (2011) [9] investigated insecticidal effects of *Ferula gummosa* L. essential oil on the larvae of the Mediterranean flour moth, *Ephestia kuehniella* Zeller, and its parasitoid wasp, *H. hebetor*. They found that the essential oil caused 50% mortality on the pest and its parasitoid wasp under concentrations of 30.78 and 9.17 ppm, during 24h. The highest egg-laying rate in *H. hebetor* was observed on *E. kuehniella* larvae at 7.5 ppm and the highest egg-laying rate from treated parasitoid wasp by the essential oil being at 1.3 ppm. Finally, they found that a concentration of 2.89 ppm from essential oil caused 50% mortality in the eggs of the parasitoid wasp. Regarding the essential oil of another species from the same genus, Hashemi *et al*. (2014) [6] studied the effects of isolated essential oil from *Ferula assafoetida* L. on *H. hebetor* under the laboratory conditions and found that usage of this essential oil made severe negative effects on the demographic parameters of this parasitoid wasp compared to the control wasps. Ahmadpour *et al*. (2021) [1] in study of the effects of essential oils isolated from thyme, *Zataria multiflora* (Boiss); yarrow, *Achillea millefolium* (L.); fennel, *Foeniculum vulgare* (Mill); and Basil, *Ocimum basilicum* (L.) on the adult wasps of *H. hebetor* under the laboratory conditions found that the essential oils of *F. vulgare* and *A. millefolium* have the highest and lowest acute toxicity on the female wasps during 24h, respectively. Also, the life table parameters, reproductive parameters, and stable population parameters were negatively changed compared to the control wasps under influence of the studied essential oils.

Fig 1: *Habrobracon hebetor* Say, a useful insect for control of plant pests

Moawad *et al*. (2015) [7] investigated the effects of five plant essential oils (clove, apricot, parsley, safflower, and orange) on the *Galleria melonella* Olivier with *H. hebetor* wasp and found that all five essential oils reduced 90% egg-producing along with life expectancy in the pest and its parasitoid wasp. Also, clove essential oil caused 100% mortality in eggs of *H. hebetor* compared to the control. Razmjou *et al*. (2018) [8] investigated the effects of essential oils from three medicinal plants including eucalyptus, *Eucalyptus camaldulensis* L.; rampion, *Heracleum persicum* Desf.; and black cumin *Carum*

carvi L. on *H. hebetor* and found that *C. carvi* and *H. persicum* essential oils showed the highest and lowest acute toxicity on this important biocontrol agent, respectively. Also, *C. carvi* essential oil had the most negative effects on various demographic parameters of the parasitoid wasps.

About the functional response, Asadi *et al*. (2018a) [2] as major researchers in this case studied the effects of plant essential oils on the functional response of *H. hebetor* on *E. kuehniella* larvae and obtained the functional response type II in the control, *Piper nigrum* L., *Salvia officinalis* L., and *Glycyrrhiza glabra* L. and type III in *Allium sativum* L. and *Rosmarinus officinalis* L. essential oils treatments. Also, *R. officinalis* essential oil and the control showed the longest and shortest handling time, respectively. They observed the highest and lowest attack rates in the control and *R. officinalis* essential oil, respectively. According to their results, *R. officinalis* and *G. glabra* essential oils showed the highest and lowest negative effects on the functional response in *H. hebetor*, respectively.

About the demographic studies, Asadi *et al*. (2018b) [3] investigated the effects of *R. officinalis* and *S. officinalis* essential oils on the demography of *H. hebetor* on *E. kuehniella* larvae and concluded that *R. officinalis* essential oil showed high acute toxicity on the female wasps of *H. hebetor* compared to *S. officinalis*. Also, the sublethal results confirmed that adult longevity, daily and total fecundity, daily and total fertility, gross reproductive rate, net reproductive rate, intrinsic rate of increase, finite rate of increase, mean generation time, the doubling time, survival rate, probability of survival and death in one age to next age, death rate, cohort survival rate, and life expectancy were negatively affected by two essential oils. Also, Asadi *et al*. (2019) [4] studied the insecticidal activity of the essential oils from three medicinal plants on *H. hebetor* and stated that above-mentioned demographic parameters were negatively affected by these three essential oils. At the same time, their findings indicated that *G. glabra* essential oil has the less severe effect on *H. hebetor* and seems to be a compatible botanical compound on *H. hebetor* for their applying in IPM systems.

About the physiological features, Asadi *et al*. (2021) [5] studied the effects of plant essential oils on the changes of digestive enzymes in the ectoparasitoid, *H. hebetor*, and stated that there were significant differences among the treatments (*A. sativum*, *R. officinalis*, *P. nigrum*, *R. officinalis*, and *G. glabra*) on the enzymatic activity except the protein content. Also, the highest activity observed in the control and the lowest being under *A. sativum* essential oil treatment. Moreover, the highest and lowest proteolytic activities were observed in the control and *S. officinalis* essential oil. According to their results, *S. officinalis* and *G. glabra* due to the lowest negative effects on the digestive enzymes can be applied in integration with this bocontrol agent in IPM programs.

Discussion

As mentioned earlier, research on the effects of plant essential oils on the parasitoid wasp, *H. hebetor*, is very limited. Reasons for this position can be considered such as the fact that essential oils can be used indoors and therefore can't be applied against the pests in open environments unless formulated. The second issue is that the parasitoid wasp has been released on small number of stored pests in Iran and this is one of the reasons for limitation of research in the field; although, most of the research on the essential oils in this case has been done by me. About the plant essential oils, plant species, number of insecticidal compounds, method of studying, laboratory conditions, and several factors are effective that can be examined instead.

Conclusion

Plant essential oils are new tools for pest management. For this, research on them can open new ways to sustainable agriculture with minimum usage of hazardous chemical compounds on agricultural products. As given in the literature review, some plant species have low negative effects on the natural enemies of plant pests and therefore can be used along with these useful agents in IPM designs.

Conflict of Interest

There is no potential conflict of interest.

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