Section 2

Potential for using the monoterpenoid citral alone and in combination with sex pheromone for managing the oriental fruit moth *Grapholita molesta* (Lepidoptera: Tortricidae) by mating disruption.

1. *Introduction*

1.1 *Role of olfaction in insects behavior.*

Insects mainly use olfaction to locate their host plants, egg laying sites and mates (Hartlieb and Anderson, 1999; Witzgall *et al.*, 2008). The olfactory response of insects to sex pheromones is often synergized or enhanced by volatile host-plant compounds (Landolt and Phillips, 1997). Plant semiochemical can also have inhibitory or repellent effects that interrupt insect responses to pheromones and attract predators and parasitoids for defense (Reddy and Guerrero, 2004; Tripathi *et al.*, 2009). The detection of and response to chemical stimuli by insects involves a numerous cuticular, cellular and molecular processes (Mitchell, 2003).

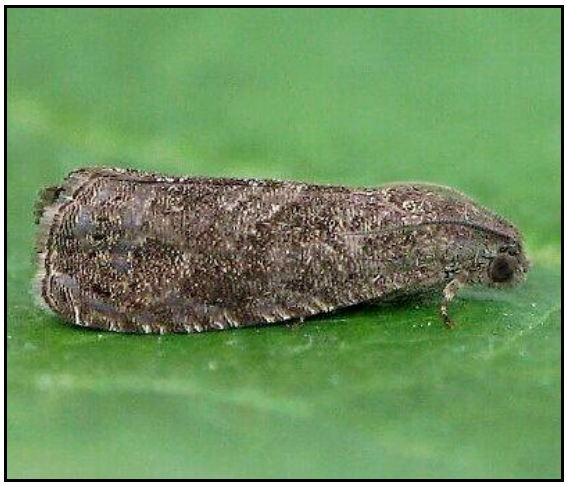
The potential for using attractive and antagonistic pheromone compounds in mating disruption systems has been demonstrated (Witzgall *et al.*, 1997; Hapke *et al.*, 2001; Kirchert *et al.*, 2001; Yang *et al.*, 2004; Party *et al.*, 2009). In addition, sex pheromones have been combined with plant volatile compounds in an attempt to augment the disruptive effect of pheromone. For example, the attractiveness of synthetic codling moth, *Cydia pomonella* (L.) pheromone was reduced by the addition of citral (Hapke *et al.*, 2001) but no additional disruptive effect was detected in an apple orchard when this compound was included in a dispenser with pheromone (Kirchert *et al.*, 2001). The presence of citral also reduced the attractiveness of European grape vine moth, *Lobesia botrana* (Denis et Schiffermüller) pheromone in laboratory tests (Meiwald, 1995). The use of terpenes as inhibitors of the response of moths to pheromone has been patented (de Kramer *et al.*, 2002). The combination of synthetic sex pheromone with a pear ester attractive to both male and female *C. pomonella* did not enhance the disruption of mating in this species (Knight *et al.*, 2011).

1.2 *General information on oriental fruit moth.*

Since its introduction into North America, the oriental fruit moth, *Grapholita molesta* (Busck) (Figg. 23-24) is a worldwide pest of stone and

pome fruits (Rothschild and Vickers 1991) that can be effectively controlled by mating disruption (e.g. Trimble *et al.*, 2004).

Figure 23: Oriental fruit moth adult, *Grapholita molesta* (Busck) (Courtesy of © John Lee).



1.3 *Control of oriental fruit moth.*

Identification of the OFM female sex pheromone structure (George 1965; Cardé *et al.*, 1979) made new management options possible for this pest. Mating disruption based on the release of large amounts of synthetic sex pheromone, restrict the ability of males to locate virgin females. Then the fruit moth can be successful managed by sex pheromone-mediated mating disruption (Cardé, 2007). There are many possible modes of action of mating disruption that have been proposed as well as competitive attraction, which makes a competition between synthetic and natural sources of pheromone, sensory adaptation, which makes a reduction in the responsiveness of antennal pheromone sensory neurons, and central nervous system habituation, where the reduction affects the central nervous system (Bartell, 1982; Cardé, 1990; Cardé, 2007; Cardé and Minks, 1995; Sanders, 1997). Sensory adaptation has been measured in the antennae of *G. molesta* when they are continuously exposed to pheromone

(Trimble and Marshall, 2007). Trimble and Marshall (2010) found that the antennae of *G. molesta* exhibit a very low level of sensory adaptation at the equivalent of 1 ng (*Z*)-8-dodecenyl acetate ((*Z*)-8-12:OAc) per m^3 air, suggesting that sensory adaptation is unlikely to be mechanism of disruption in this species. The work of Stelinski *et al.* (2004) reports the attraction of OFM males to Isomate®-M Rosso pheromone dispensers in an apple orchard, suggesting that competitive attraction is an operative mechanism in this species.

In this paper we report a laboratory assessment of the potential for using citral to modify the sexual behavior of male OFM; the electrophysiological and behavioral effects of short- and long-term exposure to citral, and to combinations of citral and pheromone were assessed using an electroantennogram and a flight tunnel. The pheromone spryer-EAG apparatus of Trimble and Marshall (2007) was used to induce and measure reductions in antennal sensitivity after exposure to aerial pheromone-concentration equivalent to $1.0 \cdot 10^{-6}$ ng/mL air, which is 1 ng/m^3 air (Koch *et al.*, 1999).

Figure 24: Oriental fruit moth adult, *Grapholita molesta* (Busck) (Copyright © 2010 Jerry Powell).

1R *References*

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