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Non-Pesticidal Treatments as Management Practice for Codling Moth *Cydia pomonella* (L.) (Lepidoptera: Tortericidae)

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Abstract.- The study was conducted to find out the combined effect of multiple non-pesticidal treatments to test the commercial dispensers of synthetic chemicals as mating disruptants in conjunction with biological control and spray of organic oils, simultaneously. The eggs of *Trichogramma planteri* were also released in an entire orchard to supplement the other pest management practices. The pheromone traps were fixed with the beginning of the eggs hatching to monitor the population. The results show that the overall effect of non-pesticidal practices were significantly encouraging in decreasing the population of the pests as compared with untreated orchards. The natural enemies alone were not effective in keeping populations below economic levels. Similarly, the organic oils were also mildly effective when applied alone as compared with the phytotoxic spray or applied at higher rates during the hot weather. The early overwintering of larvae, during 3rd week of August was seen in the areas treated with only organic oil as compared to non-treated trees where normally happened in early November. Only two successive generations signalled from the pheromones traps and there was no third generation found in most parts of the state of Jammu and Kashmir. Some of mating disruptants were proved very effective on larger blocks of the trees of uniform size. The factors affecting the trap counts were tree size, trap density, type of trap, trap placement, brand of pheromone and the climatic conditions.

Key words: Codling moth, degree days, mating disruptant, non-pesticidal treatment.

INTRODUCTION

Codling moth *Cydia pomonella* is the most serious insect pest of the apples and pears in north of Pakistan. The codling moth passes winter as a full-grown larva and diapause (winter resting stage) inside a thick, silken cocoon (Gut and Brunner, 1998; Atanassov *et al*., 2002). The codling moth can cause two types of damages: stings and deep entries. Stings are entries where larvae bore a short distance into the flesh before dying. The deep entries occur when larvae penetrate the fruit skin, bore into the core, and feed into the seed cavity (Moffitt and Westigard, 1984). Male moths begin to appear in pheromone traps when temperature is at least 55° F (13° C) at dusk (Delame and Gut, 2006).

Mating does not occur until sunset temperature reaches 62° F (17°C). The moths are active a few hours before and after twilight. Overwintered females will lay 30 to 70 eggs singly on leaf surfaces or on tiny fruit. Eggs of the overwintered population hatch 3 to 5 days after being laid. Newly hatched larvae are pinkish white with a black head (Reuveny and Cohen, 2004). Mating disruption may become an increasingly important component of integrated management programs for Toretricid pests (Delame and Gut, 2006). In fact, application of pheromone-based mating disruption has proven to reduce the number of required co-applied broad-spectrum insecticide sprays for adequate control of codling moth, *Cydia pomonella* (L.) and oriental fruit moth, *Grapholita molesta* (Busck). The study was conducted due to increasing codling moth populations and economic issues facing there on.

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MATERIALS AND METHODS

Bioassay

A bioassay of eight plants essential oils was carried out in controlled temperature (24±1°C) in an Olfactometer to study whether these essential oils serve as barriers arrestants /repellents for the larvae of codling moth. Eggs and larvae of the codling moths were collected from the insectary and the fresh apples from the field. The effective arrestant oils were applied later on to the apple trees in real field conditions.

Field experiments

To carry out a series of field trails, three commercial apple orchards of two acre size each were chosen in Pearl Valley, Rawalakot, Azad Kashmir, Pakistan within a distance of four square kilometers. The orchard a was treated with organic oils. The orchard b was treated with mating disruptant, commercial dispenser and biological control agents were released there in and orchard c was kept intact without use of any pesticide or non-pesticidal treatment for serving as control. The study started in the month of February and lasted till October, 2007. The pheromone traps were fixed with the beginning of the eggs hatching to monitor the population. To evaluate the combined effect in the series of field trials, the first trial was hand-applied sex pheromone dispensers (Isomate-C), which was applied in the start of season at the rate of 4-8 per acre. The second trial was the release and distribution of *Trichogramma* eggs in mid of May. The *Trichogramma* eggs were obtained from IPM laboratory of NARC. The third trial was the spray of pre-tested essential oils in the month of June. All field trials were conducted at private apple orchards comprising of 1-2 acre/each at Pearl Valley, Rawalakot, Azad Kashmir, Pakistan. Prior to bud break, codling moth pheromone traps were placed in all orchards at the rate of five pheromones traps per acre (one in the center and one at each corner). When the first codling moth was trapped the pheromone dispensers were applied. The experimental lay out was carried out using using t-test.

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}} \quad \text{with (n - 1) d.f} \quad \text{where} \quad s = \sqrt{\frac{(\bar{x} - \mu)^2}{n - 1}}$$

The data of all experiments were analyzed using computer based (SAS) statistical package.

RESULTS AND DISCUSSION

Olfactrometer test

All the eight essential plant oils are varied in their effectiveness (Table I). Arrest is indicated by significant reduction in the upcoming movement of the larvae as compared to control. For some essential oils there was no indication of any effect like Eucalyptus (Table I). It was noteworthy in keeping movement upwind distance travelled by *Mentha peprita* (r^2=0.47, F=152, df =1.49 P<0.001). None of the other essential oils have shown any significance in attracting larvae. Similarly in barrier test from the same brand of 8 essential oils, some of them showed a strong repellency in crossing the barrier in one hour time of test (Table II). A significant number of turnarounds were noted on facing the barrier of three essential oils (Garlic, Bitter Orange and Ginger). These essential oils were selected on the basis of previously reported successful results on the other fruit plants and vegetable pests (Jacobson, 1990; Beers *et al*., 1993; Peter *et al*., 1999). The results of present study are more or less in accordance with the previous results of same tested essential oils but against various lepidopterous pests. Basically, the insects follow the chemical cues to chase their host plants and this kind of aromatic and synthetic dispensers disrupts their communication and serves as barrier (Jacobson, 1990; Knight and Larsen, 2004). In nature the male moth uses the pheromone as olfactory cues for mating. Isomate-C is a commercial synthetic pheromone and on releasing in the surroundings of the mating places acts as disruptant. When reproductive cycle of the female disrupted a few viable eggs were laid, resulting in less damage. In present study, the Isomate-C, hand applied sex pheromones from upper canopy treatment gave significantly good results in mating disruption and reduction rate of fruit injury (F= 25.1 and df=3; P <0.001). The pest population was significantly reduced in next generation per trap/acre. The fruit injury was also significantly lower from the treated orchard as compared to the untreated open area (Table III). Isomate-C is an end use of product and consists of 20cm long flexible polyethylene tube containing 155g of formulated

Table I.- Response of codling moth larvae to the apple fruit treated with essential oil in parallel tube olfactometer in 5 minutes bioassay (ten mg essential oil) on a filter paper.

Common name of oil plant	Scientific name	Number of insects	
		Control	Treatment
Coriender	*Corianderum sativum* (L.)	5.05 +0.89	3.78+0.46
Garlic	*Allium sativum* (L.)	5.72+0.94	2.08+ o.43
Pepriment	*Mentha peprita* (L.)	8.20+0.88	3.68+ 0.72
Junipor	*Juniporus communis* (L.)	5.13+0.96	2.95+ 0.70
Bitter orange	*Citrus aurantium* (L.)	6.58 + 1.03	4.70 +0.65
Grape fruit	*Citrus paradise* (M.)	6.84 + 0.95	5.34+ 0.54
Ginger	*Zingiber officnale* (R.)	7.18+ 0.85	2.68+ 0.75
Euclyptus	*Eucliptus globules* (L.)	3.87+ 0.82	4.12 +0.80

Table II.- Time taken by codling moth larvae to cross the barrier of essential oil to cross the treated glass rod and reach the apple fruit.

Common name of oil plant	Scientific name	Time taken by larvae (min.)	
		Control	Treatment
Coriender	*Corianderum sativum* (L.)	1.3+0.2	3.9+0.1
Garlic	*Allium sativum* (L.)	1.5+0.1	18.5+ 0.1
Pepriment	*Mentha peprita* (L.)	1.6+0.8	5.3+ 0.2
Junipor	*Juniporus communis* (L.)	2.2+0.4	4.8+ 0.5
Bitter orange	*Citrus aurantium* (L.)	2.95+ 0.1	12.9+0.6
Grape fruit	*Citrus paradise* (M.)	3.2 + 0.4	4.5+ 0.5
Ginger	*Zingiber officnale* (R.)	2.14+ 0.5	8.5+ 0.8
Euclyptus	*Eucliptus globules*(L.)	3.87+ 0.1	9.5 +0.5

Table III.- Mean number of cage arrest/generation in response to pheromone and mean number of fruit injuries (Mean±SEM).

Infestation	Treated	Untreated
Cage arrest 1st generation	84.6+10.3a*	103.5+10.3a
Cage arrest 2nd generation	23.+8 6.8b	86.9+8.3a
Maid season injury	10.2+8.7b	32.8+ 6.8a
Harvest injury	6.5 + 3.5b	17.5 + 9.3a

*Mean±SEM

Table IV.- Mean number of cage arrest/generation in response to biological control alone and mean number of fruit injuries (Mean±SEM).

Infestation	Treated	Untreated
Cage arrest 1st generation	63+8.5a	70.5+10.6a
Cage arrest 2nd generation	42.+6.8b	86.9+8.3a
Maid season injury	18.4+8.7b	25.8+ 5.8a
Harvest injury	16.5 + 3.5b	23.5 + 7.3a

pheromone. The disruption of pheromone communication (Denald *et al*., 1994) in three sympatric leaf rollers in British Columbia was a successful experiment confirming results of present study on this aspect.

Table IV indicates no significant difference between the results from the orchards where *Trichogramma* eggs were released and those orchids were taken as control. The biological control alone was not effective. All these non-pesticidal practices must be applied in conjunction with each other.

More studies of effectiveness of mating disruptants and efficacy of other programs using insecticide and insecticide plus other mating disruptants for controlling the leaf roller in apple have shown a significantly reduced number of adults which shows the less importance of biological control against Tortericids (Trimble and Apple, 2004; Kovanci *et al*., 2005; Ilichev *et al.*, 2006).

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